

JAE

vol. XLIV s1
2013 September

Official Journal of the Associazione Italiana
di Ingegneria Agraria



Member of the International Commission
of Agricultural Engineering



Abstracts of the 10th Conference of the Italian Society of Agricultural Engineering
Horizons in agricultural, forestry and biosystems engineering

Viterbo, Italy, September 8-12, 2013

Guest Editors: Danilo Monarca, Massimo Cecchini

Journal of Agricultural Engineering

open access journal - ISSN 1974-7071 - www.agroengineering.org

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Journal of Agricultural Engineering

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- European Commission, 1994. Commission Decision of 27 June 1994 concerning certain protection measures with regard to bovine spongiform encephalopathy and the feeding of mammalian derived protein, 94/381/EC. In: Official Journal, L 172, 07/07/1994, pp 23-24.

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Autorizzazione Del Tribunale Di Bologna N. 4045 Del 3 Febbraio 1970.

Journal of Agricultural Engineering

Rivista trimestrale registrata al Tribunale di Pavia n. 9/2012/Reg.

Stampa: Press Up s.r.l.

via La Spezia, 118/C 00055 - Ladispoli (RM)

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Unione
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Journal of Agricultural Engineering volume XLIV, supplement 1, 2013



Abstracts of the 10th Conference of the Italian Society of Agricultural Engineering Horizons in agricultural, forestry and biosystems engineering

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PRINTED WITH THE SUPPORT AND THE PATRONAGE
OF THE CARIVIT FOUNDATION OF VITERBO, ITALY



PRESENTATION

The Board of Directors of the Italian Association of Agricultural Engineering, following the well-established tradition to organize every four years a Conference, has chosen Viterbo as venue for the tenth edition which will be held on September 8-12, 2013.

The closer and closer integration of scientific know how, that is demanded in the use of the environmental resources and it is driven by the new developing models, has addressed the agricultural engineering toward the bio-systems engineering, therefore expanding its former expertise-area by incorporating living systems related to both the agriculture and to natural systems. As a consequence, the interests of the Association now span even over the application of engineering principles to processes governing territorial phenomena with the aim to study, to model, to manage and to set off biology systems toward an optimal agricultural development, crop production, the use of the soil and the environment.

Within such a context the conference, by accomplishing the actual and future needs of the world population, represents an important chance to bring together engineers and researchers to let meeting people working in different, although similar, environments.

In particular, the 2013-conference will focus on: new horizons in agricultural, forestry and bio-systems engineering and, to better homogenize discussions, presentations will be organized according to the listed below sessions:

- 1 Forest-wood chains
- 2 Hydrology and dynamics of water and sediments in agricultural and mountain basins: monitoring, modeling and risk analysis
- 3 Hydraulics and hydro-morphological processes for stream and river restoration and management
- 4 Information technology, automation and precision farming and forestry
- 5 Structures and technologies for livestock production: technical, energy and environmental aspects
- 6 Structures and technologies for protected crop production: technical, energy and environmental aspects
- 7 Post harvest, food and process structures and technologies
- 8 Power and machinery in agriculture and forestry
- 9 Analysis, modeling and planning of rural areas
- 10 Renewable energy, biomass and biological residues
- 11 Safety, health and ergonomics - SHWAnet international meeting
- 12 Sustainable planning and management of soil and water resources

Prof. Alessandro SANTINI
AIIA President

Dear colleagues,

it is my pleasure to welcome you to the 10th AIIA Conference: “AIIA13 – Horizons in agricultural, forestry and biosystems engineering”, and to welcome you to Viterbo.

For the first time the AIIA conference will be held in English. The purpose of this choice is to involve academics and researchers coming from other nations.

This conference will then be a unique opportunity for scientists, researchers, experts, students and people representing the business world to show, share and discuss the results of their researches. Another goal of this conference is the promotion of the cooperation and networking in the field of Biosystems Engineering, also trying to include the business world in it.

By doing that, we will be able to take on the new challenge of Horizon 2020, the new European Framework Programme. This programme attributes a capital and fundamental role to research and innovation, seen as important means to guarantee an intelligent, sustainable and comprehensive growth to Europe.

Horizon 2020 is articulated on 3 strategic objectives

- 1) Excellent science, intended to secure Europe's leadership in science worldwide.
- 2) Industrial Leadership , aimed at supporting research and innovation of European industry, with a strong focus on industrial technologies and investments for SMEs,
- 3) Societal challenges , aimed at tackling major global challenges in the following areas: health, demographic change and wellbeing, food security, sustainable agriculture, secure, clean and efficient energy, smart, green and integrated transport, climate action, resource efficiency and raw materials, inclusive, innovative and secure societies.

In all these fields Agricultural, Forestry and Biosystems Engineering in the coming years will have a major role.

I conclude by saying that AIIA13 is also an opportunity to know the Tuscia, a still intact territory, in which culture and respect for the land, innovation and tradition come together in a truly original model of sustainable development. I wish all the participants a pleasant stay in Viterbo and Italy.

In closing this brief greeting I want to thank:

- CEFAS, Special Agency of the Chamber of Commerce, for the logistic support to the Conference,
- the Tuscia University, which offered the beautiful and historic seat of the Conference
- the Ministry of Agriculture, the Lazio Region, the Provincial Administration and the Municipality of Viterbo, UNACOMA and CRA-Ing, for their support,
- CIGR and EURAGENG, for their sponsorship,
- FACMA and Enama, sponsors of the Conference.

A special thanks to the Carivit Foundation of Viterbo, whose contribution has enabled the printing of the Conference Proceedings.

Danilo Monarca
AIIA 2013 CONVENER

Journal of Agricultural Engineering

2013; volume XLIV(s1)

FOREST-WOOD CHAINS

001

CHESTNUT: FROM COPPICE TO STRUCTURAL TIMBER. THE CASE STUDY OF “USO FIUME” BEAMS SAMPLED IN LIGURIA

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Recently, the Agriculture Department of Liguria Region had supported studies and researches on the timber quality of living trees in local coppice chestnut forests, with the prospect to produce also timber for structural use. Under some ad-hoc funds a 30 years old coppice forest in the high Bormida Valley, never thinned after the last utilisation, has been chosen for sampling. 18 selected trunks were felled and the assortment called “Uso Fiume” (UF) was chosen, getting 49 beams (cross-section from 12x12 to 24x24 cm), by way of saw-mill operations. The UF-beam is a structural element, derived from Italian tradition. Such elements are used in Italian buildings over the time, in substitution to structural sawn timber, principally for roofing. The UF-beam is a square edge log with wane; more precisely it is a full log, edged on four sides, maintaining boxed heart and an approximately central pith. Today the features of such a beam is established according to the specific Italian standard UNI 11035-3 for spruce and fir and to the CUAP (Common Understanding of Assessment Procedure) n. 03.24/22 for chestnut. The beams were visually graded according to the Visual Strength Grading procedure and the physical and mechanical properties (density-MV, modulus of elasticity-E0 and modulus of rupture-fm) were determined according to the standard requirements (EN 408, EN 384, ISO 3131), disregarding the moisture content: the mechanical tests were performed with wood in green state (M.C.>30%) because it is the actual condition of use in building, due to the very low permeability of the chestnut heartwood which entails long seasoning time of large cross section beams. The study showed very high yields considering stems-beams volume ratio, close to 70%. Characteristics values of the sample resulted: MVk 517kg/m³, E0,mean 10,3GPa and fm,k 28,7MPa. These results can be considered very promising because the data match the Strength Class D24 (EN 338), same Class as full cross-section chestnut beams (M.C.=12%). From January 2013 an European Technical Approval (ETA-12/0540) has been approved and now the endorsement covers the specification of this structural products. 21 plant in Italy are enabled to produce Chestnut UF beams, CE marked.

002

HARVESTING TECHNIQUES FOR NON-INDUSTRIAL SRF BIOMASS PLANTATIONS ON FARMLAND

De Francesco F.,¹ Spinelli R.,¹ Schweier J.²*¹CNR IVALSA, Sesto Fiorentino (FI), Italy; ²Institute of forest utilisation and work science, Alberts-Ludwigs-University, Freiburg i. B., Germany*

The goal of this study was to compare the technical and economic performance of terrain chipping and roadside chipping, applied to short rotation biomass plantations. The null hypothesis was that no significant difference are in the performance of the two work systems, when applied to short rotation coppices. Those systems especially designed for non-industrial SRF plantations, were used for conventional logging operations. The difference on the above mentioned systems consisted especially in the chipping location: chipping was performed directly to the field (containers reach the chipper in the field) or at the field's edge (roadside chipping). Both systems were tested on two of the most common SRF poplar clones in Italy, namely: AF2 and Monviso. Plots were allocated randomly to the two treatment levels (roadside or field chipping) than blocked for two main clone types (AF2 and Monviso) so that each of the 4 treatments level and clone types has a minimum repetition plot of 6 times (total of 24 replications). The Plot were identified with paint markings at the stump so each plot area could be identified at the ground. Net weight of each charge was obtained by a certified weightbridge, so each plot has its own productivity in terms of weight and time consumption. Results were encouraging: harvesting cost varied from 16.3 to 23.2 € tonne-1, and was lower for terrain chipping and for the most productive clone (Monviso). Despite its higher cost, roadside chipping was preferred for its better terrain capability and for the superior storage quality of uncomminuted biomass. Both systems were suboptimal in their current configurations. They could offer a better performance, subject to minor improvements

003

ANALYSIS OF A DOUBLE STEERING FOREST TRAILER FOR LONG LOGS TRANSPORTATION

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Forest road network represents a key issue for the efficiency on wood transport. In mountainous condition forest roads are often narrow and with frequent switchback curves. Such characteristics affect the transportation feasibility of high value long logs. In order to avoid unwanted shorter log assortments, transportation means must offer the opportunity to overpass the smallest radius of curvatures. Typically, in the Italian Alps, log transportation along forest roads is performed through tractor and forest trailer. The performance in terms of maneuverability of such system is in general acceptable when logs are up to

6 m long: when length exceeds 8-10 m, maneuverability sensibly worsens. In the present work a cost effective technical solution of a forest double steering trailer is studied and tested, allowing to decrease the radius of curvature and enhance the maneuverability, independently from the length of logs. Such system improves the so called "stinger-type truck" configuration using an articulated frame; through a rearward hinge, the front wheels direction mechanically controls and adapts the direction of back twin wheels. The study was based on CAD simulations considering the dimensions of the trailer with different lengths of logs up to a maximum of 12 m. For different log lengths the simulation analyzes the total maneuver area, in terms of minimum curve radius and curve widening. A field test is eventually carried on a prototype operated for transport of long logs along a representative forest road in the Alps. The results confirm the improvements foreseen by CAD simulations, with allowed radius of curvature down to 6 m, even with 12 m logs.

004

EXPOSURE TO WOOD DUST AND EXHAUST GASES IN TREE CUTTERS

Marchi E.,¹ Cambi M.,¹ Neri F.,¹ Fabiano F.,¹ Sciarra G.²

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In 2010 according to the new legislation on work and safety, (Legislative decree 81/2008) the Tuscany Region promoted a new research project on the evaluation of the forest operators' hard wood dust and exhausts gases exposure in chainsaw cutting operation and in chipping operation, using a standardized survey methodology. Project partners were: CNR Ivalsa (National Council for research – Tree and Timber Institute), focusing on chipping operation; the University of Florence (GESAAF Dept.) for chainsaw operation and the Public Safety Laboratory of the Provincial Health and Safety Agencies n°7 of Siena province in Tuscany for the samples analysis. The primary aim of this project is to correlate the chainsaw working time with the dust polluting amounts measured in different forest sites and working operations (coppice clear cut, softwood thinnings or sanitary cut) and to highlight the operational aspects and the operator behaviours that may maximize the exposure to the polluting agents. The mass concentration of respirable particles and total dust at the workplace was determined by the method of personal collectors connected to different air pumps. The surveys were focused on the collection of: the hard wood dusts, the polycyclic aromatic hydrocarbons (PAHs) and the values of benzene, toluene, etilbenzene and xilene present in the exhaust gases. One of the most important result expected is the reduction of the polluting agents (benzene, toluene, etilbenzene and xilene) concentration using the special fuels (alkylate petrol) for chainsaws in comparison to the normal fuels usually adopted. Concerning the hard wood dusts concentration analysis, an influence of the survey season (winter or summer), the operators' working methods and the tree species were also recorded. Keywords: Wood dust, chainsaw, safety, exhaust gases

005

FOREST HARVESTING IMPACTS ON CLAY AND SANDY SOILS

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Several studies investigated the impact caused by forest vehicles on soil. Many mechanized forest operations generate stress on soil due to applications of heavy loads. Often these stresses are associated at soil degradation and soil compaction that are linked at number of passages, silvicultural treatments and at type of soil. Soil structure and its physi-

cal properties may affect the type and extent of damage. The aim of this study is to evaluate the impact on soil, with particular attention to soil compaction, caused by different harvesting operations on different type of soil. Two areas with different type of soil were selected. The first area, characterized by a sandy soil, was located inside the Regional Park of Migliarino-San Rossore-Massaciuccoli (Central Italy). In this area the silvicultural treatment was a clear cut on small forest of Umbrella pine (*Pinus pinea* L.). Soil impacts of cuts carried out in 2006 and 2011 were investigated in order to evaluate the effect of time on the recovery of physical properties of soil. The second area was selected on a clay soil on Apennines (Central Italy) in a conifer mixed stand (*Picea abies*, *Pseudotsuga menziesii*, *Abies alba* and *Chamaecyparis*). The silvicultural treatment in this area was a thinning carried out in 2013. In both area samples of soil were collected by means a steel cylinder of known volume (after litter removal). The samples were placed in plastic bins and transported to the laboratory where for each soil sample collected were determined bulk density and porosity. Close to each sample point, penetration resistance and shear resistance were measured by means of penetrometer (H-4200) and scissometer (16-T0174). In both areas measurements were done on trafficked and control areas. The results showed the differences in soil degradation in relation to soil characteristic and silvicultural treatment

006

DECISION ANALYSIS FOR THE DETERMINATION OF BIOMASS IN THE TERRITORY TUSCIA ROMANA BY GEOGRAPHIC INFORMATION SYSTEM AND FOREST MANAGEMENT PLANS

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The growing interest in the development of chains for the use of agroforestry biomass for energy demand, is due to the awareness they are a crucial element to mitigate the global climatic change effects. The true effort is to have a reliable estimation of biomass availability by some instruments like forest management plans, which allow to locate the forest supply and to know the forest biomass availability in a medium period. In this paper we carried out a decision analysis by geographic information system, in Tuscia Romana area comprising 11 municipalities for a total amount of 813 km². An estimation was carried out taking into account the bibliographic data on the analyzed species, reporting the biomass in weight taken out by the forest cut utilization. A comparison was also performed in field on chestnut trees cut in a sampling area near Bracciano and in a close sawmill. The results show long, medium and short-term dynamics, but some critical points were found related to the process of estimation and to the real procurement of biomass in some years. The results suggest to be care in a possible project of a biomass plant.

007

FOREST RESIDUE BUNDLES HARVESTING

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Forest residues are defined as all above ground biomass material, excluding merchantable logs and stumps, that arise during timber harvesting operations. The residues include treetops, branches, foliage and unmerchantable stem pieces. Bundling is a technology used to create a compressed and uniform handling unit from logging residues and other small size energy wood. The bundles may be handled and transported with the same equipment that is used for conventional roundwood. They are usually delivered to a facility where they are chipped and then burned for heat or power production. There are considerable quantities of residue produced on clearfelled spruce sites in Ireland (> 100 green tonnes/ha) of which a certain amount could be available for bundling, depending on the site, harvesting and replanting system. Integrating the brush baling operation into a conventional mechanised clearfell harvesting operation, without compromising timber production or environmental standards is the crucial problem of this kind of operation. Sites for residue bundling require careful selection in relation to lack of nutrients to the soil and to their machine carrying capacity. The introduction of forest residue bundling into Ireland need to acknowledge the fact that on many sites the brush mat is an essential component of the harvesting system. The working method on most clear fell sites, where wheeled or tracked harvesting machines are used, is to create brush mats to aid machine floatation and travel. This also reduces the risk of soil damage. This study comes from a Short Term Scientific Mission (COST Action FP0902) included in a project on wood for energy evaluation that involves the University College of Dublin, the Waterford Institute of Technology and Coillte (The Irish Forestry Board). The project has already collected the primary data on forest residue bundle weight and moisture content, and in order to correlate the energy bundle recovery per ha with the site analysis, in this STSM the harvested and bundled sites have been analysed again to evaluate the effective bundled area and to correlate the biomass recovery with stand and site conditions. Results could be useful for estimation of forest biomass production potential in the future.

008

FORESTRY BIOMASS TO ENERGY SUPPLY CHAINS: POTENTIALS AND BUSINESS MODELS IN PUGLIA REGION

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The area covered by forests in Italy is around 10.5 million ha (of which about 2 million ha of new forests), representing one third of Italy's area. Around 81% of this area is available for harvesting, subject to licence requirements, but the relatively low levels of extraction reflect extensive under management of forests, as a result of high costs and low profitability. Timber felling is mainly carried out in privately owned forests, which also have smaller logging areas. Forest ecosystems are also extremely sensitive to atmospheric pollutants and to changing soil conditions, and currently overall 30.5% of trees have suffered damage. Moreover, forest fires in Italy, as in all Mediterranean countries, represent a dramatic problem, in particular in Southern Italy regions. Timber production is mainly from plantations, mostly of poplar, and from productive high forests, located in the north-east. However,

more than half the production of forestry areas is fuel wood, mostly from broadleaf coppice in Central and Southern Italy, and in several cases by means of low efficiency conversion systems and logistics of supply. The energy conversion of forestry products for heat and power production by means of high efficiency energy systems and smart logistic infrastructures can offer a great contribution to the achievement of national security, sustainability and diversification of supply targets, and at the same time can contribute to the limitation of fire risk in forest areas, rural development and job creation, optimal management of forestry resources and biodiversity. This paper aims to overview the forestry resources and biomass potentials of Puglia Region, assessing the harvesting, conditioning and processing costs of forestry products for energy production. Different business models and levels of supply chain integration (biomass production-processing-conversion-sales of energy to end users) are illustrated and compared, on the basis of the national legislative scenario, available technologies, biomass potentials and costs, in order to define optimal deployment scenarios and policy measures to be implemented to maximize energy, environmental and economic benefits for the community.

009

COLOUR MODIFICATIONS AND HYPERSPECTRAL IMAGING: NON-INVASIVE ANALYSIS OF PHOTO-DEGRADED WOOD SURFACES

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The aim of this investigation is to study the changes occurring on the surface of poplar wood exposed to solar irradiation, in a controlled environment. The irradiation produces changes on the surface colour and in the chemical composition. Poplar has been selected due to the widespread use in Italy for the manufacturing of statues, painted panels, ceilings, furniture and indoor frames. Poplar is poor of coloured extractive, so that the surface changes are attributed to the main wood constituents' modifications and the contribution of extraneous substances to holocellulose and lignin can be considered negligible. The poplar wood samples were irradiated at 550 W/m², 55°C in Solar Box chamber equipped with a 280 nm UV filter (model 1500E, Erichsen Instruments), at different intervals until reaching 504 hours. The colour changes were monitored with the reflectance spectrophotometer of X-Rite CA22 according to the CIELAB system. The surface chemical modifications were evaluated by measuring the infrared spectra with a Nicolet Avatar 360 Fourier Transform Infrared spectrometer (FT-IR) equipped with a DTGS detector operating in DRIFT modality. Hyperspectral imaging (HSI) was also applied to study the surface wood changes by using a SisuCHEMA XL Workstation (Specim, Finland) operating in the SWIR range (1000-2500 nm). The data obtained from the different techniques applied were put in comparison in order to find possible correlations between them also with the aim to evaluate the applicability of the HSI technique to the investigation of wood modifications, in a totally non-invasive modality. In fact, especially in cultural heritage, the monitoring of wood surfaces should be performed by non-destructive methods, in order to avoid the paradox of damaging a work of art while monitoring its preservation state. For this reason colour measurements and HSI were chosen as possible methods to evaluate wood surface chemical changes comparing them with the most traditional FT-IR spectroscopy. The possibility to find a correlation between colour changes and chemical modifications, investigated both

with traditional and innovative methodologies, in wood surfaces can have practical application in cultural heritage and contemporary objects.

010

FINITE ELEMENT MODELLING OF DOWEL-TYPE GLULAM JOINTS FOR WINDOW FRAMES

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Wood is enjoying increasing popularity in the building sector. In order to fully exploit the potential of this material, particularly in two and three-dimensional structures, improved knowledge of the mechanical behaviour of the material and more complex constitutive models are required. The mechanical performances of timber joints are particularly important for the design of wood structures. In general, joints are one of the weakest points in timber structures. In particular, in the case of glulam profiles for window frames, dowel-type joints are often used to achieve higher stiffness of the profile in comparison to mortise-tenon joints. In this paper, a finite element model for a dowel-type glulam joints is proposed to investigate the mechanical performances of various typologies of joints for wooden profiles. The numerical prediction of the proposed finite element method is compared to experimental results of mechanical testing. Moreover, failure mechanisms are assessed, in order to predict the strength of such joints.

HYDROLOGY AND DYNAMICS OF WATER AND SEDIMENTS IN AGRICULTURAL AND MOUNTAIN BASINS: MONITORING, MODELING AND RISK ANALYSIS

011

CARBON BALANCE AND ENERGY FLUXES OF A MEDITERRANEAN CROP

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This paper is based on the analysis of a long-term mass (CO₂, H₂O) and energy (solar radiation) balance monitoring programme carried out during 2010-2012 in an irrigated orange orchard in Sicily, using the Eddy Covariance (EC) method. Orange (*Citrus sinensis* L.) is one of the main fruit crops worldwide and its evergreen orchards may have a great potential for carbon (C) sequestration, but few data are currently available. In the study, the role of the orchard system in sequestering atmospheric CO₂ was analyzed, thus contributing to assess the carbon balance of the specie in the specific environment. Net ecosystem exchange (NEE) and ecosystem respiration (ER) were computed from the complete series of the CO₂ fluxes measured by the Eddy Covariance method. During 2010, NEE and ER reached -7.9 t(C) ha⁻¹ year⁻¹ and 8.4 t(C) ha⁻¹ year⁻¹, respectively. The gross primary productivity (GPP), or ecosystem assimilation, was the difference between NEE and ER. It has a value of -16.3 t(C) ha⁻¹ year⁻¹ during 2010. NEE and ER were varied with the fluctuation of the meteorological variables at the experimental site. The vertical energy fluxes of net radiation R_n, soil heat G, sensible heat H and latent heat (LE) fluxes were measured at orchard scale by EC. A Bowen ratio-based method (BR) was proposed to resolve the lack of closure of the EC method to obtain reliable sensible (H) and latent heat (LE) fluxes. Evapotranspiration (ET) values determined from the BR method were compared with up-scaled transpiration data determined by the sap flow heat pulse (HP) technique, evidencing the degree of correspondence between instantaneous transpirational flux at tree level and the micrometeorological measurement of ET at orchard level.

012

RUNOFF AND SEDIMENT YIELD MODELING IN A MEDIUM-SIZE MEDITERRANEAN WATERSHED

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The AnnAGNPS model was used to estimate runoff, peak discharge and sediment yield at the event scale in the Carapelle watershed, a Mediterranean medium-size watershed (506 km²) located in Apulia, Southern Italy. The model was calibrated and validated using five years of runoff and sediment yield data measured at a monitoring station located at Ortona – Ponte dei Sauri Bridge. A total of 36 events was used to estimate the output of the model during the period 2007-2011, in comparison to the corresponding observations at the watershed outlet. The model performed well in predicting runoff, as was testified by the high values of the coefficients of efficiency and determination during the validation process. The peak flows predictions were satisfactory especially for the high flow events; the prediction capability of sediment yield was good, even if a slight over-estimation was observed. Finally, the model was used to evaluate the effectiveness of different

Management practices (MPs) on the watershed (converting wheat to forest, using vegetated streams, crop rotation corn/soybean, no tillage). While the maximum reduction in sediment yield was achieved converting wheat to forest, the best compromises between soil conservation and agriculture resulted to be crop rotations. Key Words: watershed modeling, AnnAGNPS, suspended sediment transport, Best Management practices, crop rotation.

013

RUNOFF GENERATION PROCESSES IN A MEDITERRANEAN RESEARCH CATCHMENT (SARDINIA)

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A natural catchment with shallow and steep soils in Sardinia (Italy), was chosen for a long term field study focused on the runoff generation processes through observations of rainfall, soil water content, valley bottom water-table depths, and stream discharge. The aims are: to identify the main characteristics of stream discharge and water-table dynamics in this small Mediterranean catchment; to simulate these characteristics with a simplified hydrological modelling which neglects the unsaturated flow processes; to verify if this model is appropriate for predicting simultaneously stream discharge and water-table dynamics. The relationship between rainfall and storm-flow depth at the event scale resulted strongly non-linear. The storm-flow coefficient was strongly seasonal, with values higher than 2% only during the wet winter period, and was mainly related to the seasonal dynamics of soil moisture and water-table depth. This suggests that saturated subsurface flow plays a primary role in runoff production. This mechanism gives rise to base-flow, controls the saturated areas formation and enters streams quickly enough to contribute to storm-flow together with the saturation overland-flow, while the Hortonian overland-flow is negligible. The distributed physically-based model used a limited number of parameters to represent the subsurface and surface flow, ignoring the vertical distribution of soil moisture and the unsaturated flow processes. This allowed us to reduce the 3D subsurface flow simulation to a 2D sub-horizontal scheme, limited only to the saturated soil, which was very advantageous for implementing and resolving the numerical scheme. Despite a smoothing effect on the observed water-table, the model was able to simulate efficiently stream discharge and water-table dynamics continuously for a four year period. Our results show that even a model with a simplified framework of the soil moisture dynamics may be adequate for simulating subsurface and surface flow in this kind of Mediterranean catchment.

014

APPLICATION OF THE NEW MORPHOLOGICAL QUALITY INDEX (MQI) IN THE CORDEVOLE RIVER (BL, ITALY)

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The evaluation of the morphological quality of rivers is essential to define the level of alteration and for implementing future management strategies that consider also hazards related to fluvial processes and channel dynamics. This type of evaluation is particularly significant for the Italian rivers, that, as in many other European countries, have a very high level of human pressure. Recently, in Italy, the National Institute for Environmental Protection and Research has promoted a methodology named IDRAIM for hydromorphological analysis of

streams that pursues an integrated approach aimed at a harmonized implementation of both the EU Water Framework Directive (WFD, 2000/60/EC), and the EU Floods Directive (2007/60/EC). In this paper we present the application of the Morphological Quality Index (MQI) protocol, which is part of IDRAIM, to determine the assessment of the morphological quality of the Cordevole River. The water network (only collectors greater than third-order were considered), has been divided, through GIS software, into 137 river reaches of homogeneous morphological characteristics, according to the first phase of the method. At this stage the semi-automatic calculation of lateral confinement (defined by "degree of confinement" and a "confinement index") was tried, in order to reduce the implementing time. The application of 28 indicators was made for 42 reaches representing the major river types and human pressures in the site investigation. The results showed that 48% of the analyzed reaches have a very good or good quality status, 38% have a moderate morphological quality, while only 14% have the characteristics of poor or very poor quality. The main causes that lead to a strong alteration of the terms of reference are linked to i) poor connectivity between hillslopes and river corridor, that is very important for the natural supply of sediment and large wood; ii) absence of vegetation in the river corridor, that is functional to a range of geomorphic processes; iii) presence of artificial elements, particularly the bedload interception structures in the catchment, bank protection along the reach, and the removal of sediment, large wood and vegetation.

015

DISPLACEMENT LENGTH AND VELOCITY OF TAGGED LOGS IN THE TAGLIAMENTO RIVER

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Large wood enhance the dynamics of geomorphic processes in river systems, increases the morphological complexity of the channel bed, and provides habitats for fish and invertebrates. On the other side, if transported during high-magnitude events, large wood pieces can increase flood risks in sensible places such as bridges and narrow cross sections prone to outbank flows. However, the dynamics and mobility of logs in rivers is poorly understood, especially in wide gravel-bed rivers. Recent studies have employed fixed video cameras to assess logs velocity, but little evidence is still available about travel length during flood events of different magnitude. This study was conducted in a valley reach of the Tagliamento river, located in the North East of Italy. The Tagliamento river is approximately 800 m wide in the study area, and is characterized by relatively high natural conditions and complex fluvial dynamics. Log mobility have been studied from June 2010 to October 2011, a period characterized by a relatively high magnitude flood in November 2010. Log mobility and displacement during floods have been measured by implanting active radio transmitters (RFID) in 113 logs and GPS track devices in 42 logs. The first devices allow to recover the log after flood events by using a portable antenna, and to derive the displacement length over the monitoring period, whereas the second devices allows to calculate instantaneous (1 sec) and average log velocity of moving logs. Recovery rate of logs equipped with RFID and GPS was 50% and 60%, respectively. A preliminary analysis of the data collected indicates that there is a positive relationship between displacement length and the peak of flood events, as well as a positive relationship between log velocity and the flood magnitude. Also, a critical flow rate over which logs stranded on active bars can be transported has been identified. The ability to predict wood mobility in gravel-bed rivers could allow to define better strategies of river management and restoration, by improving the ability to understand wood transport processes and calibrate budgets of wood in rivers.

016

USING A NEW PROCEDURE COMBINING THE SCS-CN METHOD AND THE GREEN-AMPT EQUATION FOR FLOOD HAZARD MAPPING: A CASE STUDY IN CENTRAL ITALY

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A new procedure, referred to as Curve Number For Green-Ampt (CN4GA), combining the Soil Conservation Service - Curve Number (SCS-CN) method and the Green-Ampt (GA) infiltration equation was recently developed, aiming to distribute a sub-daily time resolution the information provided by the SCS-CN method. In the procedure the initial abstraction and the total volume of rainfall provided by the SCS-CN method are used to identify the ponding time and to quantify the hydraulic conductivity parameter of the GA equation, in doing so employing the GA infiltration model to distribute the total volume of the rainfall excess provided by the SCS-CN method. The new procedure is here tested on a real case study in Central Italy: starting from gross rainfall observations, two net rainfall scenarios (CN4GA and SCS-CN) are derived and routed with a 2D model on the case study area, producing two flooded areas that are compared with the real recorded one. Results show that the new procedure is particularly suitable for ungauged basins in terms of for flood hazard mapping.

017

EROSION – DEPOSITION EVALUATION THROUGH HYBRID DTMS DERIVED BY LIDAR AND COLOUR BATHYMETRY: THE CASE STUDY OF THE BRENTA, PIAVE AND TAGLIAMENTO RIVERS

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Risk management and flood protection are frequently assessed through geo-morphometric evaluations resulting by floods events. The analysis of erosion and deposition pattern in gravel-bed rivers through differencing of digital elevation models (DoD) can represent a “basis” to improve and validate bi- or tri-dimensional hydraulic modelling, sediment budgets and river restoration strategies. If we aim at elevation models with high resolutions and covering large areas, airborne LiDAR surveys can represent a good compromise among costs, time and uncertainty. The major limitation of the non-bathymetric LiDAR surveys consists in the detection of wet areas. Indeed, accounting for more than 20 cm of water depth, LiDAR signal increases exponentially its error. In this paper we present a comparison of the results concerning the application of a colour bathymetry methodology for the production of hybrid DTMs (HDTM). These elevation models were derived by merging LiDAR data for the dry areas and colour bathymetry for the wet areas. The methodological approach consists in a statistical regression between water depth and RGB band intensity values from contemporary aerial images. This methodology include the use of filters in order to reduce possible errors due to the application of the model, to estimate precise “in-channel” points. The study areas are three differently human impacted gravel-bed rivers of the North-East of Italy. This methodology has been applied in three sub-reaches of Brenta River,

two of Piave River and two of Tagliamento River. Potentials and limitations of the applied bathymetric method, the comparison of its use in different fluvial contexts and its possibility of employment for geo-morphometric evaluations, were then tested. The methodology was carried out considering two years, 2010 and 2011. In the middle of this period, two relevant floods on each river with recurrence intervals also greater than 10 years were registered. DGPS control points were finally used to evaluate the accuracy of wet areas. Results showed that, in each model, wet areas vertical errors were comparable to those featured by LiDAR data for the dry areas.

018

THE CONTRIBUTION OF CHESTNUT COPPICE FORESTS ON SLOPE STABILITY IN ABANDONED TERRITORY: A CASE STUDY

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Sweet chestnut for many centuries has been fundamental for the Italian mountainous economies where this kind of forest was traditionally managed in short rotation to rapidly produce wood biomass. Due to the social and economic changes which made such management unprofitable, especially on steep and remote slopes, such practice has been mainly abandoned and most of chestnut forests became over aged and very dense, causing an increase of localized slope instability. In this work the effect of the abandon of chestnut coppice practice on shallow landslides triggering has been analyzed by means of the estimation and comparison of mechanical contribution to soil shear strength provided by root systems in differently managed chestnut stands. The study area is located in Valcuvia (Lombardy Prealps) where three different stands, one managed and the others abandoned (over 40 year aged), on cohesionless slopes (quaternary moraine deposits) have been chosen paying attention for homogeneity in terms of substrate, aspect and elevation. As slope steepness strongly affects forestry practices and steeper stands are more frequently abandoned, the considered stands have different terrain inclination, 35° in abandoned stands and 13° in the managed one. The slope stability of the three stands have been evaluated applying the infinite slope approach and including the additional root cohesion, whose values have been estimated through the Fiber Bundle Model approach by collecting roots in the field and measuring their resistance in laboratory, and by measuring root diameter and number distribution with depth in the field. The results, as expected, showed that forest management does not affect root mechanical properties, whereas it significantly affects root distribution within the soil. In terms of additional root cohesion the values for the first 50 cm of soil profile resulted higher in the managed stand than in the abandoned ones, where however roots reached deeper soil layers (100 cm). Despite the greater depth reached by the root systems, however, the abandoned stands resulted prone to instability also in the case of a very small level of saturation, mainly because the great steepness, making coppicing fundamental to prevent shallow landsliding.

019

A SIMPLE FIELD METHOD TO MEASURE THE HYDRODYNAMIC PROPERTIES OF SOIL SURFACE CRUST

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In many arid and semi-arid regions, the combination of high intensity rainfall and unstable soil aggregation frequently leads to the development of a surface crust characterized by higher bulk density and lower porosity than the underlying soil. It acts as a barrier to water infiltration, hampers germination of seeds and reduces root aeration and water availability. Characterization of the soil surface crust in the field is complicated by the nature of the thin sealing layer that is easily disrupted under minimal mechanical action. The hydraulic resistance of the surface crust was determined by a combination of two infiltration techniques: first, a surface measurement of steady-state infiltration rate is conducted by a mini-disk tension infiltrometer (MDI); then, the surface crust is removed, its thickness is measured, and a ponded infiltration test is performed at the same site. The BEST method is applied to estimate the hydraulic properties of the underlying soil provided the particle-size distribution and the bulk density are known. Then, under the assumption of a unit gradient of hydraulic head below the soil crust, the pressure head at the interface crust-soil is derived. Finally, the hydraulic conductivity of the crust is calculated from the steady-state water flow measured by the MDI and the Darcy law. The method was tested in a sandy loam and a clay soil after a prolonged rainfall period that was supposed to allow development of a surface crust. In the sandy loam soil, a 2-3 mm thick slaking crust was visually observed, but no increased surface hydraulic resistance was detected in 10 out of 11 cases. In the clay soil, a 5-6 mm thick crust was formed by gradual coalescence of the plastic, wet aggregates by rainfall compaction. In 10 out of 15 tests, the steady-state infiltration rate with the crust was lower than the underlying soil saturated hydraulic conductivity, denoting an increased hydraulic resistance of the surface crust. The mean value of the hydraulic resistance of the surface crust of the clay soil was 86 min. The developed method appears suitable to discriminate between different levels of the hydraulic resistance of the surface crust.

020

EVALUATION OF SHORT-TERM GEOMORPHIC CHANGES ALONG THE TAGLIAMENTO RIVER USING LIDAR AND TERRESTRIAL LASER SCANNER SURVEYS

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In the recent years a change in the predominant morphology of several river environments has taken place, consisting in a reduction of the braided pattern in favor to wandering or straight configurations. This evolution seems to be due, according to the scientific community, to anthropic causes and, in particular, to the alteration of flow regimes as well as the reduction of sediment transport. Braided rivers are characterized by two or more active channels, separated by bars and fluvial islands and normally feature a high morphological dynamism. This dynamism is the result of the interaction among different elements as sediment supply, flow regime and in-channel and perfluvial vegetation. These factors have a fundamental role in the erosion and deposition

processes which are the basis of the morphological changes. The aims of this study are the assessment of the short period geomorphic and volumetric changes occurred along a reach of the Tagliamento River and the comparison between the results obtained from LiDAR (Light Detection and Ranging) and TLS (Terrestrial Laser Scanner) data. The Tagliamento river is a natural gravel-bed river located in the NE of Italy, characterized by a relatively low degree of human disturbances. The analyses were carried out considering two different scales (a reach of about 430 ha and a sub-reach of about 25 ha) and were based on two subsequent datasets in order to investigate the short-term geomorphic changes due to eight significant floods. The surveys were performed using two different datasets derived from LiDAR and TLS technologies and used to analyze the reach and sub-reach respectively. The short-term estimates of geomorphic and volumetric changes were performed using DEMs of Difference (DoD) based on a Fuzzy Inference System. The results have confirmed the high dynamism of the Tagliamento river, estimating a prevalent deposition at reach and a predominant erosion at sub-reach levels. Finally, a comparative qualitative assessment of the output derived from the different data sources was performed, showing little differences between the two survey methods that proved to be both precise and reliable.

021

LIDAR-DERIVED HIGH RESOLUTION TOPOGRAPHY: THE NEXT CHALLENGE FOR THE ANALYSIS OF TERRACEMENT STABILITY AND VINEYARD SOIL EROSION

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The soil erosion in the vineyards is a critical issue that could affect their productivity, but also, when the cultivation is organized in terraces, increase the risk due to derived slope failure processes. If terraces are not correctly designed or maintained, a progressively increasing of gully erosion affects the structure of the walls. The results of this process is the increasing of connectivity and runoff. In order to overcome such issues it is really important to recognize in detail all the surface drainage paths, thus providing a basis upon which develop a suitable drainage system or provide structural measures for the soil erosion risk mitigation. In the last few years, the airborne LIDAR technology led to a dramatic increase in terrain information. Airborne LiDAR and Terrestrial Laser Scanner (TLS) derived high-resolution Digital Terrain Models (DTMs) have opened avenues for hydrologic and geomorphologic studies (Tarolli *et al.*, 2009). In general, all the main surface process signatures are correctly recognized using a DTM with cell sizes of 1 m. However sub-meter grid sizes may be more suitable in those situations where the analysis of micro topography related to micro changes is critical for slope failures risk assessment or for the design of detailed drainage flow paths. The Terrestrial Laser Scanner (TLS) has been proven to be a useful tool for such detailed field survey. In this work, we test the effectiveness of high resolution topography derived by airborne LiDAR and TLS for the recognition of areas subject to soil erosion risk in a typical terraced vineyard landscape of "Chianti Classico" (Tuscany, Italy). The algorithm proposed by Tarolli *et al.* (2013), for the automatic recognition of anthropic feature induced flow direction changes, has been tested, in addition to few other simple morphometric analysis on topographic attributes. The results underline the effectiveness of LiDAR and TLS data in the analysis of soil erosion signatures in vineyards, and indicate the high resolution topography as a useful tool to improve the land use management of such areas.

The stability conditions have been analyzed under the influence of the measured geometry alterations of the wall structure.

022

ACTUAL EVAPOTRANSPIRATION ESTIMATION FROM INFRARED MEASUREMENT OF SURFACE TEMPERATURE

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The estimation of the actual evapotranspiration from potential evapotranspiration often requires the knowledge of vegetation morphology parameters and vegetation cover, which can be missing or incomplete in many database leading to the impossibility to estimate the actual evapotranspiration. Moreover the infrared surface temperature can be found in recent database or can be obtained from satellite remote sensing data. The aim of this study is to develop and validate a method for the estimation of actual evapotranspiration based on commonly available meteorological data and infrared surface temperature measurements (IR method). The dataset used in this study were collected during three measurement campaigns. The first measurement campaign was on a sandy soil in Grugliasco, River Po plain (Italy) at 292 meters above sea level during the growing season 2009. Hourly measurement of air temperature, wind speed, infrared surface temperature, soil heat flux, and soil water content were measured. The second campaign was performed at the same site from the 9th to the 13th September 2010. Latent heat flux measurements, performed with an eddy covariance meteorological station, were performed in addition to the measurements performed the first campaign measurement, but infrared surface temperature data were not collected. The third measurement campaign was performed on a Southeast facing slope located in Cogne, Aosta Valley (Italy) at 1730 meters above the sea level during the growing season 2011. During the third campaign were performed all the measurement conducted during the first two campaigns. The IR method is composed of two steps. First, the potential evapotranspiration is estimated employing methods based on meteorological data. Second, a correction factor, to be multiplied by the potential evapotranspiration, is calculated from infrared surface temperature. Results from the dataset collected at the Grugliasco experimental field show that the differences between the latent heat flux measurements and the results of the energy balance method are comparable to the differences between the results of the proposed methods and the results of the energy balance method. Results from the Cogne dataset show a good agreement between the results of the proposed method and the latent heat flux measurements.

023

IDENTIFICATION OF WATER SOURCES IN A HIGH-ELEVATION CATCHMENT: AN ENVIRONMENTAL TRACER APPROACH

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Snow- and ice-dominated catchments are of a great socio-economic importance in high elevation regions and are particularly vulnerable to climate change. Snowpack, glaciers and permafrost serve as a natural reservoir for cold-season precipitation storage and release of water during the warmer months. Therefore, a better understanding of the role of glacier melt, snowmelt and permafrost on streamflow regime and groundwater recharge is essential for the correct management of water resources. This work takes advantage of the tracer capability of water stable isotopes, electrical conductivity (EC) and water temperature in order to: i) investigate the role of snowmelt, glacier melt and rainfall on the seasonal streamflow response; ii) identify the origin of spring water; and iii) describe the role of snowmelt on groundwater recharge in a glacierized alpine catchment. Field surveys took place during summer and early autumn of four years (2007, 2010, 2011 and 2012) in the Upper Val de La Mare basin (36 km², Ortles-Cevedale massif, Eastern Italian Alps). Water temperature of 52 springs was measured in 2007. Samples for EC (measured in the field by portable meters) and isotopic analysis (by means of laser absorption spectroscopy) were collected at 47 springs and 6 streams in 2010, and 55 springs and 9 streams in 2012. In 2011 two springs and one stream were sampled at higher temporal resolution. Bulk precipitation for isotopic analysis was collected on a monthly base. Snow, snowmelt, glacier melt and ice samples were collected occasionally. Results highlighted a high spatial variability in isotopic and EC composition of streams, revealing possible different origins. Particularly, directly glacier-fed streams were clearly recognizable by their unique tracer signature. Statistical analysis conducted on the sampled springs showed that water temperature could be used to effectively identify permafrost-related springs, whereas EC and isotopic composition provided weaker information about the origin of spring water. Stream water and groundwater tended to have higher EC values and enriched isotopic values, suggesting the depletion of snowmelt contribution over the season. Summer rainfall determined a marked runoff response at the event scale, without affecting significantly the streamflow response at the seasonal scale.

024

EFFECTS OF RAINFALL AMOUNT AND ANTECEDENT MOISTURE CONDITIONS ON THE RAINFALL-RUNOFF RESPONSE OF A FORESTED MOUNTAIN CATCHMENT

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In forested watersheds in mountain regions, topography and seasonal changes in climatic conditions and vegetation control the streamflow response to precipitation events. In this study, we used hydrometric measurements and environmental tracers (stable isotopes of water and electrical conductivity) in a small forested catchment in the North-Eastern Italian Pre-Alps to investigate: i) the role of antecedent soil moisture conditions, rainfall amount and groundwater levels on runoff generation; and ii) the dominant controls on the fraction of event water during rainfall-runoff events. Hydro-meteorological data (rainfall, air temperature, water temperature, soil moisture and piezometric level) were collected from August to December 2012 in the 2-ha Ressi catchment. Samples from bulk precipitation, streamflow, groundwater and soil water were collected on a weekly basis. Additional samples were collected during twelve rainfall-runoff events. The runoff coefficients for 23 rainfall-runoff events ranged from 0.03 to 0.95. Small runoff coefficients occurred during short summer thunderstorms during dry conditions, associated with little rainfall and significant vegetation water uptake from the unsaturated zone. On the contrary, long precipitation events in autumn that were characterized by high rainfall amounts, high antecedent conditions and negligible transpiration resulted in high runoff coefficients. Runoff coefficients were strongly correlated with the peak groundwater level (R^2 between 0.75 and 0.96, $n = 23$, for the different piezometric wells) and showed a threshold relation with hillslope soil moisture, revealing the influence of subsurface flow and hillslope saturation on streamflow responses to rainfall. The fraction of event water in storm runoff was primarily correlated with rainfall amount ($R^2 = 0.90$, $n = 10$) and, especially during the summer events, rainfall intensity ($R^2 = 0.88$, $n = 9$). Moreover, the event water contribution during streamflow was highest during the rising limb of the hydrograph, whereas the recession was dominated by pre-event water. All of these observations suggest that event water was mainly derived from rainfall falling on the relatively wet riparian areas and the stream, whereas pre-event water was related to the contribution of hillslope subsurface flow and riparian groundwater.

025

ESTIMATING THE CONTRIBUTION OF RAINFALL, IRRIGATION AND UPWARD SOIL WATER FLUX TO CROP WATER REQUIREMENTS OF A MAIZE AGROECOSYSTEM IN THE LOMBARDY PLAIN

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In agricultural areas with shallow groundwater tables capillary rise plays a crucial role in the satisfaction of crop water requirements. While monitoring the root zone inflows and water status allows the evaluation of most of the water balance variables, capillary rise cannot be directly measured; therefore, hydrological models are often employed for its estimation. In the agricultural seasons 2010 and 2011, an intensive monitoring activity (founded under the Lombardy Agricultural Research Program 2007-2009) was carried out in a 10 ha experimental field located in Landriano (Pavia), characterized by a shallow groundwater table depth (0.6 to 1.5 m). The site included six Intensive Monitoring Plots (IMPs in the following), each equipped with instrumentation for continuous monitoring of moisture, water potential and groundwater table depth, and an eddy covariance tower. In the two seasons, periodic campaigns were conducted in the IMPs measuring crop biometric parameters and soil hydrological parameters. In 2010 the field was watered by border irrigation, while in 2011 no irrigation was applied. Monitoring data were used to carry out simulations with the physically based hydrological model SWAP, in order to assess the relative contribution of the various water fluxes to maize water requirements. While most parameters and inputs necessary for the SWAP implementation were directly measured in the field, it was impossible to detect with sufficient accuracy the saturated hydraulic conductivity (K_s) of a four layered profile. An automatic calibration of these variables was then performed using the optimization algorithm SCEM-UA, which is one of the most powerful algorithms for the search of the global optimum currently available. Results presented in this contribution involve one of the IMPs for year 2010. The calibration procedure identified narrow K_s ranges for all the layers well in agreement with some K_s measurements carried out in the top soil. SWAP simulations run with the 100 best K_s sets show a mean contribution of the upward water flux amounting to 50% of the crop water requirements.

026

SOIL AND METEOROLOGICAL MONITORING FOR WATER BALANCE DETERMINATION AT PLOT SCALE

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To provide adequate answers to recurring problems in land and water resources management, nowadays the use of physically based models is widespread. The reliability of the responses of this kind of model is closely linked to the precision with which model parameters are determined, such as soil hydraulic characteristics and meteorological variables. In this work, we set up a complete station for the monitoring of both meteorological and soil variables, as well as a soil hydraulic characterization. The experimental site shows vertic characteristics and is in Guardia Perticara, Basilicata region, Italy.

027

STABILITY OF VEGETATED SLOPES UNDER MEDITERRANEAN CLIMATIC FORCING

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Vegetation can enhance the stability of shallow soils by means of two fundamental mechanisms: i) the mechanical reinforcement provided by the plant roots to the soil; ii) the increase of the soil suction by means of the root water uptake. Assessing stability enhancement due to vegetation is an important aspect for a reliable assessment of the spatial and temporal distribution of these shallow landslide hazards, as well as for a proper evaluation of the best forest management strategies for hazard mitigation. This paper discusses the relative role of these two effects with a numerical experiment applied to pyroclastic deposits of the Campania Region, covered by deciduous *Castanea Sativa* (Mill.). The root distribution is assessed by an eco-hydrological model, which predicts the root density as function of local climatic conditions in growing season and soil hydrological properties. The predicted root distribution is employed for assessing the vertical variability of both the apparent soil cohesion provided by roots and the root water uptake. A one-dimensional model of vertical soil water dynamics is employed for simulating soil suction regime, assumed representative of well-drained pyroclastic deposits soils on steep forested plane slopes. The geo-mechanical and the soil-hydrological effects on slope stability are examined with an infinite slope stability model, generalized for unsaturated conditions. We show that in the case of a loamy-sand soil under a Mediterranean climatic regime, the geo-mechanical effect tends to be more relevant than the soil-hydrological effect during the rainy season, within depths up to twice the average root depth.

028

SELF-CLEANING EFFICIENCY OF OPEN RETENTION CHECK DAMS: THE RIO RUDAN CASE STUDY

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Filtering check dams are hydraulic structures widely adopted in mountain streams to partly retain debris-flows volumes. Their large use is mainly due to the function of reducing peak discharge and sediment concentration of the debris-flow surge. If their function is optimal, a progressive emptying of the storage basin occurs thanks to the more watery flow after the peak or on the occasion of successive ordinary floods. Different criteria have been proposed in literature to correctly design the filter openings, but performance analyses are scarce in the field. The aim of the research is to verify the functionality in terms of self-cleaning capability of a multiple-slit check dam. The analysis is based on: (i) field monitoring of the storage basin topography (laser scan survey) of the Rio Rudan (Belluno Province) retention check dam, (ii) analysis of the grain-size distribution of the deposited volumes along with the associated form of sediment transport, (iii) and on parallel investigation of the hydrological events via a rainfall-runoff model. During the time period under analysis, a small debris-flow event occurred in the Rio Rudan partially filling the retention basin behind the slit-check dam. The successive storm events did not trigger other debris flows but only weak bedload transport floods, which favored a self-cleaning of the storage basin. The topographic survey after the debris-flow occurrence has shown a gradual self-maintenance of the retention basin thanks to the correct design of the check-dam openings. Results suggest that the ratio between the size of the coarsest components of the bed material and minimum cross-stream opening is a key factor in the hydraulic design. Time sequence of flood events, stream morphology, and debris-flow characteristics show also a great influence on the self-emptying behavior. With regard to the case study a pattern of conditions has facilitated the self-cleaning of an open retention check dam during one year of observation. This fact has proven a reduction of the maintenance costs and the safeguard of the sediment continuity. Further monitoring actions are necessary to analyze the interaction between the filter and flood events of different magnitude.

029

WITHDRAWN

HYDRAULICS AND HYDRO-MORPHOLOGICAL PROCESSES FOR STREAM AND RIVER RESTORATION AND MANAGEMENT

030

A 2D HYDRODYNAMIC-SEDIMENTOLOGICAL MODEL FOR GRAVEL BED RIVERS. PART II, CASE STUDY: THE BRENTA RIVER IN ITALY

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A 2D depth average model has been used to simulate water and sediment flow in the Brenta River so as to interpret channel changes and to assess model predictive capabilities. The Brenta River is a gravel bed river located in Northern Italy. The study reach is 1400 long and has a mean slope of 0.0056. High resolution digital terrain models have been produced combining laser imaging detection and ranging data with colour bathymetry techniques. Extensive field sedimentological surveys have been also carried out for surface and subsurface material. The data were loaded in the model and the passage of a high intense flood (R.I. > 9 years) was simulated. The model was run under the hypothesis of a substantial equilibrium between sediment input and transport capacity. In this way, the model results were considered as a reference condition, and the potential trend of the reach was assessed. Low-frequency floods (R.I. 1.5 years) are expected to produce negligible changes in the channel while high floods may focalize erosion on banks instead than on channel bed. Furthermore, the model predicts well the location of erosion and siltation areas and the results promote its application to other reaches of the Brenta River in order to assess their stability and medium-term evolution.

031

A 2D HYDRODYNAMIC-SEDIMENTOLOGICAL MODEL FOR GRAVEL BED RIVERS. PART I: THEORY AND VALIDATION

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This paper presents a novel 2D-depth average model especially developed for gravel-bed rivers, named Lican-Leufú (Lican=pebble and Leufu=river, in Mapuche's language, the native inhabitants of Central Patagonia, Argentina). The model consists of three components: a hydrodynamic, a sedimentological, and a morphological model. The flow of water is described by the depth-averaged Reynolds equations for unsteady, free-surface, shallow water flows. It includes the standard *k*- ϵ model for turbulence closure. Sediment transport can be divided in different size classes (sand-gravel mixture) and the equilibrium approach is used for Exner's equation. The armour layer is also included in the structure of the model and the surface grain size distribution is also allowed to evolve. The model simulates bank slides that enable channel widening. Models predictions were tested against a flume experiment where a static armour layer was developed under conditions of sediment starvations and general good agreements were found: the model predicted adequately the sediment transport, grain size of transported material, final armour grain size distribution and

bed elevation. Key words: gravel-bed rivers, 2D depth-average model, hydrodynamic-sedimentological model, bed load, armour layer, bed evolution.

032

CHARACTERIZATION OF FLUVIAL ISLANDS ALONG THREE DIFFERENT GRAVEL-BED RIVERS OF NORTH-EASTERN ITALY

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River islands are defined as discrete areas of woodland vegetation located in the riverbed and surrounded by either water-filled channels or exposed gravels, exhibiting some stability and remaining exposed during bank-full flows. Islands are very important from both morphological and ecological points of view, representing the most natural condition of a fluvial system and are strongly influenced by human impacts. This study aims at analyzing the morphological and vegetation characteristics of three different typologies of islands (pioneer, young and stable) in three distinct rivers in the NE of Italy, affected by different intensities of human pressure. The study was conducted on several sub-reaches of the Piave, Brenta and Tagliamento rivers. The first is a gravel-bed river, which suffered intense and multiple human impacts, especially due to dam building and in-channel gravel mining. The same alterations can also be observed in the Brenta river, which also presents bank protections, hydropower schemes and water diversions. On the other hand, the Tagliamento river is a gravel-bed river characterized by a high level of naturalness and very low human pressures. The analyses were conducted using aerial photographs and LiDAR data acquired in 2010 in order to define and distinguish the three different island typologies and to obtain a characterization of ground and vegetation features. The results suggest that the fluvial islands lie at different elevations and this fact implies a different resistance capacity during flood events. Pioneer islands and young islands lie at lower elevations than stable islands causing a lower capacity to survive during considerable flood events, in fact in most cases those islands typologies were removed by ordinary floods. Stable islands lie at higher elevations and only intense and infrequent flood events (RI > 10-15 years) are able to determine considerable erosions. Regarding the characteristics of vegetation, we can observe a strong distinction between the three typologies. Stable islands always exhibit the greatest vegetation height and the presence of these plants, sometimes higher than 30 m, contributes to increase the resistance and the stability of these components of fluvial systems.

033

EVALUATION OF SHORT-TERM GEOMORPHIC CHANGES USING IMPROVED DEMs OF DIFFERENCE: A COMPARISON BETWEEN DIFFERENTLY IMPACTED RIVERS, PIAVE AND TAGLIAMENTO

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The evaluation of the morphological dynamics of rivers is increasingly focusing, in recent years, to the achievement of quantitative estimates of change in order to identify geomorphic trends and forecast targeted restoration actions. Thanks to the development of more effective and reliable survey technologies, more affordable Digital Elevation Models (DEM) can be produced and, through their consequent differencing (DoD), extremely useful geomorphic analyses can be carried

out. In this situation, a major role is played by uncertainty, especially in the final volumetric rates of erosion and deposition processes, that may lead to misinterpretation of spatial and temporal changes. This paper aims at achieving precise geomorphic estimates derived from subsequent hybrid (LiDAR and bathymetric points) surface representations. The study areas consist of gravel-bed reaches of two differently impacted fluvial environments, Piave and Tagliamento rivers, that were affected by two severe flood events (Piave, R.I. of 7 and 10 years and Tagliamento, R.I. of 15 and 12 years) in the inter-surveys period. The basic Hybrid Digital Elevation Models (HDTM) were processed accounting for spatially variable uncertainty and considering, beside slope and point density input variables, a novel component measuring the quality of the bathymetric output. In fact, since the major changes occur within river channels, the integration of this variable evaluating the precision of the bathymetric-derived points in the HDTMs, has allowed, through the creation of targeted FIS (Fuzzy Inference System) rules, to obtain reliable geomorphic estimates of change. Volumes and erosion and deposition patterns were then analyzed and compared to outline the different dynamics among the sub-reaches and the two river systems. Moreover, the short-term effects of the two considered flood events were detected, showing particular and fluctuating evolutionary trends depending on site specific characteristics of the study reaches.

034

COMPARISON OF DIFFERENT METHODS TO PREDICT THE MEAN FLOW VELOCITY IN STEP-POOL CHANNELS

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Steep mountain streams have irregular bed topography, where the mean flow velocity is heavily affected by the coarsest bed components and by their arrangement to form step-pools, cascades and rapids. According to literature findings the mean flow velocity is usually linked to water discharge, channel slope, and grain-size related variables through power relationships. Several approaches consider dimensionless hydraulic geometry terms to develop the analysis over a wide range of channel sizes and hydraulic conditions. The aim of this research is to test the performance of some literature formulas to directly compute the mean flow velocity (V) in step-pool sequences. The study area deals with two fish ladders located in the Vanoi torrent (Trento, Italy), which were built by mimicking the step-pool morphology. Three reaches were selected to cover different channel slopes (2.6-10%). Data collection entailed three phases: topographical surveys, granulometric analysis, and flow discharge measurements (salt dilution method). Geometric and hydraulic variables were measured for the following step-pool cross-sections: step head, pool center, intermediate position between pool end next step. Particular attention has been reserved to determine the effective mean flow velocity over the whole path of each step-pool sequence. The performance of different literature equations to predict V has been verified. The relations have been shared in three groups: dimensional (V), dimensionless with respect to the grain-size (V^*) or to a combination of grain-size and slope (V^{**}). The V^{**} group has produced the highest errors between computed and measured values. The V and the dimensionless V^* groups have shown the best performance. In particular the V^* equations, which use unit discharge and channel slope, have provided the better fitting, and the lowest mean relative errors. The results highlight the difficult to estimate flow velocity in step-pool sequences, and the attitude of this channel-bed morphology to be highly dissipative. The good performance of some dimensionless equations to predict V could also support the hydraulic designer in case the 'morphological rebuilding' of mountain creeks is opportune. Further analyses are required to better understand flow behavior in

streams where rough bed-forms and hydraulic drops are the primary sources of flow energy dissipation.

035

SHEAR STRESS RESISTANCE OF WORKS FOR MOUNTAIN CREEK STABILIZATION

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The methods to characterize the stability thresholds of river training works are limited in the literature. Shear stress thresholds result quite low for channel-bed soils ($<12 \text{ N/m}^2$) and also for vegetated soils or soil bioengineering works ($25\text{-}400 \text{ N/m}^2$). Similar values have been highlighted by USDA (2007), which defined thresholds in the National Engineering Handbook. After the occurrence of destructive floods, decision makers and designers must assess the necessary protection works to mitigate the consequences of future flood events. These decisions are not immediate due to many factors such as unfavorable meteorological composition of rain events and different possible responses in terms of efficiency of the protection works. The aim of this study is to analyze the shear stress resistance of consolidation works (e.g. vegetated double-fence timber walls) in mountain creeks in order to better their design phase. Methodology: Study areas are located in four Prealpine streams of the Veneto Region (November, 2010 flood) and in an Alpine torrent of the Bolzano Province (Gadria torrent, 2010). The shear stresses, which were imposed by several floods in five mountain streams, have been assessed through post event back analysis and field survey. After the calculation of maximum shear stress at the bottom and at the banks, a dedicated database was created. This last was used to verify the efficiency responses of the protection works and to estimate their vulnerability accounting for contour shear stresses and form of sediment transport. Results: The database from field observations resulted of practical use to interpret the overall behavior of the works and in particular to assess the high values which could have loaded the banks during the flood events ($>500 \text{ N/m}^2$ for Prealpine creeks, and $>1000 \text{ N/m}^2$ for the Alpine stream). The data analysis has also shown a relation between the back calculated shear stress and morphological cross-section index. Conclusion and perspectives: The resistance limits of soil bioengineering techniques for river stabilization resulting from this study have been markedly raised and have proved to be conditioned by the form of sediment transport. This outcome encourages the use of the 'forest-engineering works' as well as further field investigations on their design hypotheses.

INFORMATION TECHNOLOGY, AUTOMATION AND PRECISION FARMING AND FORESTRY

036

PROPOSAL OF A LOCAL TELEMETRY NETWORK FOR THE MONITORING THE THERMODYNAMIC AND ENVIRONMENTAL PERFORMANCES OF FARM TRACTORS

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The TRAKTnet.one project of the Free University of Bolzano aims to identify and develop new solutions to remotely monitor the efficiency of farm-tractors engines included in a local voluntary network all along their lifespan. The knowledge of tractors' efficiency can give important information concerning machines' consumption, emissions and need for servicing, thus contributing to a more environmentally-sustainable agriculture. Engines will be monitored by measuring rpms, exhaust gases' temperature and oxygen content (as indexes indirectly estimating consumption and efficiency) and then analysing and inferring the data through procedures, which algorithms will be an integral part of the project's results. This implies the existence of a service centre controlling all farm machines and managing a Farm-Information-Systems network through simple logical connections according to a client-server approach.

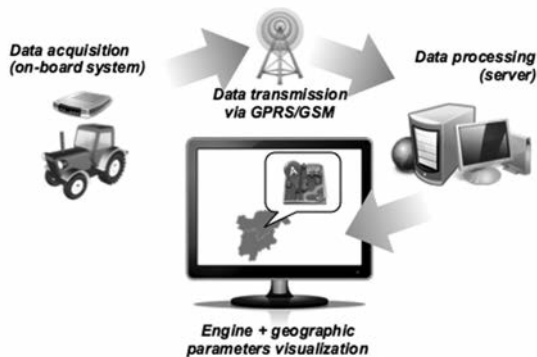


Figure 1. Scheme of the telemetry system for the engine parameters.

The project includes four steps: (1) preliminary assessment of sensors features (e.g., number, type, position); (2) numeric modelling of a compression-ignition engine to understand the effects of ageing and bad maintenance on its performances; (3) evaluation of possible modifications of commercial sensors (e.g., thermocouples, lambda sensor); (4) execution of bench and field tests to validate the system. Trials will be performed on different engines (e.g., naturally-aspired/turbocharged, with/without EGR/SCR) and at different speeds/loads. The choice of the thermocouple type (band/rod) and installation point (manifold/pipe) must be done carefully for not influencing sensor's sensitivity and response time. The combustion quality can be related to the oxygen concentration in exhaust gases, measured through lambda sensors. The final outcome of the project is expected to be an automatic system, based on an inference software-engine able to correctly interpreting the sensors outputs. It could be used by tractors' owners for being advised about the need for servicing their vehicles but also by local authorities for monitoring tractors' environmental impact in a territory and maybe tailoring the subsidies to the farmers (e.g., on a rewarding-score in accordance to the detected performances). The

advantage of this proposal is to exploit a farm monitoring network, previously designed for managing the information related to the automatic compilation of records in the country, by simply equipping data loggers with two additional sensors.

037

SPEEDING UP INNOVATION IN AGRICULTURAL IT

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An OECD funded research was conducted where methods and processes for speeding up innovation in agriculture were assessed. A global web-based questionnaire was sent to experts in agricultural engineering, research, marketing, education and users of new technologies. Interviews of selected experts were done to deepen the analysis. The results show that considerable part of the relatively slow innovation comes from the fact that users do not trust in new technologies or that the usability of them is unacceptable. The experts suggest that education of the engineers and designers should include more elements from User-Centered Design (UCD) and also User-Driven Innovation methods should be more used. As a conclusion a new 'Dream Team' of agricultural innovation was developed where user interaction and marketing professionals were given more role.

038

GNSS-BASED OPERATIONAL MONITORING DEVICES FOR FOREST LOGGING OPERATION CHAINS

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To control the performance of forest mechanisation chains is proposed and discussed. The solution is based on GNSS tools that form the core of a data-logging system that - in combination with a specific inference-engine - is able to analyse process times, work distances, forward speeds, vehicle tracking and number of working cycles in forest operations. As a consequence the operational monitoring control methods could provide an evaluation of the efficiency of the investigated forest operation. Several study areas were set in the Italian alpine region, mainly in Trentino-Alto Adige, Veneto and Friuli Venezia Giulia regions. Each study area was selected according to different forest characteristics and different terrain morphology that required the application of different logging systems. The study has monitored productivity and performance during logging operations. The field surveys consisted on the installation of the GNSS directly on the forest machine or equipment for monitoring the movements. Simultaneously the field survey considered the integration of the GNSS information with a time study of work elements based on the continuous time methods supported by a time study board or a handheld computer with a specific software. Additionally, where possible, the on-board computer of the forest machine was also used in order to obtain additional information to be integrated to the GNSS data and the time study. All the recorded GNSS data integrated with the work elements study were thus post-processed through GIS analysis. Thanks to the development of a specific algorithm the inference-engine is able to compensate, to correct and to interpret any satellite's signal loss or multipath phenomena. The use of GNSS installed on forest equipment, integrated with the inference-engine and also with an interface for data communication or data storage, will permit an operational monitoring automatic or semi-automatic, improving the quantity of data and reducing the engagement of the surveyor.

039

SUSTAINABLE MANAGEMENT OF WASTE IN GREEN NURSERY: THE TUSCAN EXPERIENCE

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The green nursery sector in Europe involves 90,000 ha of cultivated land and 120,000 ha for the nurseries, reaching 19.8 billions of Euros in 2011. Every year, nurseries products waste about 4 kg of the residual biomass for each m² of the potted plants cultivation. Green waste products in nurseries and the derivatives of dried and unsalable plants, of lifting plants and pruning, make up a substantial quantity of organic materials (wood biomass-substrate), which could be retrieved and valorized. The wastes of farm that works on full field cultivations, are usually made up of dried plants and pruning byproducts while the reverse is the case for those raising crops in containers, whose waste is mainly substrate. Moreover, the latter fraction shows a high concentration of controlled-release-fertilizers, which gives great potential and high economic value to the recycled substrate. With the expansion of potted plants cultivation and the resulting increase in discarded products a number of companies have begun to setting up solutions for the management of materials accumulated. Current management involves various treatment methods in relation to their features. Two are the most widespread techniques: shredding and subsequent burying while the other is made by substrate recovery, the greater part, and returning it to the virgin substrates. The components, which can be recovered with industrial yards, following bio shredding take on characteristics which make it difficult to get two fractions (wood biomass-substrate) of optimum quality. On these bases, the University of Florence research unit worked on the VIS project (Sustainable Plant Nurseries Project) on a study to identify solutions for separating substrate and wood biomass components with processes, which do not allow interaction. Analysis led to the development of a separating system based on trunk vibration technology. To this end, two shaker heads were identified, developed and tested for an efficient use on trees with a mass of up to 800 kg. With these solutions, green waste can be easily grasped by a clamp device able to convey strong vibrations to the trunk (or to the aerial part of the plant) to the point that the soil materials are detached from the vegetable portions.

040

SELECTIVE SPRAYING OF GRAPEVINE'S DISEASES BY A MODULAR AGRICULTURAL ROBOT

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In current viticulture protection of grapevine is obtained with uniform distribution of fungicides, typically repeated according a regular calendar. This continuous protection approach can easily result in ten to fifteen treatments per season in vineyards of several wine-producing regions. Primary infections exhibit nevertheless discrete foci, with uneven spatial distribution. Hence it can be argued that detection of symptoms at early disease stages and their targeted treatment would

reduce the spread of the infection to wider patches in the vineyard, while enabling reduced use of pesticides. Within the UE-project CROPS, a modular and multifunctional agricultural robot system for specialty crops is being developed and one of the tasks that has to accomplished is selective spraying of diseases. The robotic system set-up integrates a six degrees of freedom manipulator, an optical sensor system and a precision spraying actuator. After a brief description of the requirements of the system, this contribution gives a detailed description of its components and discusses the results obtained in first experiments. As case study we consider here the automatic detection and selective spraying of grapevine canopy areas exhibiting symptoms of powdery mildew (*Erysiphe necator*), one of the major diseases for this crop. Based on optical sensing feedback, the precision spraying actuator is positioned by the manipulator to selectively and accurately apply pesticides solely to infected areas. Disease foci identification and localization is based on on-the-go processing of images sensed by a multispectral camera inspecting the vertical structure of the grapevine canopy. At the end of the manipulator arm is located the precision spraying actuator, constituted by an axial fan with a flow straightener and an axially mounted spraying nozzle. The sprayer can deliver an air-carrier flow with an adjustable velocity, producing a circular spraying pattern of a constant diameter of 0.15 m over a wide range of spraying distances. A first experiment was conducted in an experimental greenhouse, where vineyard canopy conditions were recreated by aligning plants of grapevine grown in pots. Within the recreated canopy, diseased plants with different levels of disease symptoms were used as targets of automated selective spraying performed by the robot.

041

SELF-PROPELLED AUTONOMOUS UNMANNED UNIT FOR PRECISE AND TARGETED PHYSICAL WEED CONTROL IN MAIZE

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Innovative technologies associated with precision agriculture are increasingly applied in the field of crop protection. The European project "RHEA" (Robot Fleets for Highly Effective Agriculture and Forestry Management) falls within this context with the aim of providing a fleet of autonomous robots for the execution of precision agriculture techniques related with crops protection in three different scenarios. The activities of the research group of the University of Pisa within this project concerned with the design and the realization of an automatic implement for precise and targeted thermal weed control on maize to be mounted on an autonomous unmanned ground mobile unit. Methodology This operative machine is able to perform mechanical (not selective) and thermal treatment at the same time in order to remove weeds mechanically from inter-row space and actuate in row selective and targeted cross flaming, since maize is quite tolerant to thermal treatment. The ground mobile unit is provided with artificial vision based perception system (in order to detect weed patches and the rows of the crop), real time GPS system and other facilities in order to communicate with a fixed base station, that contains all the hardware and the software related to the general coordinator and the control systems. The machine is implemented with a proper automatic guidance system in order to continuously perform mechanical inter-row weed control following the rows of maize without damaging crop plants. The autonomous appliance will perform cross flaming treatment only on weed patches detected by the detection system mounted on the ground mobile unit. Moreover, the thermal weed control will be achieved with two level of intensity (LPG dose per unit surface) varying

the working pressure of the gas that will feed the burners according to the level of weed cover detected by the perception system. Conclusion and perspectives Since this system will allow to perform flaming only on the weed patches, the application of precision thermal treatment will reduce relevantly LPG consumption and the cost of flaming application per unit surface with respect to the values related to the use of conventional "low-tech" flaming machines.

042

OPEN PROBLEMS IN TRACEABILITY: FROM RAW MATERIALS TO FINISHED FOOD PRODUCTS

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Even though the main EU regulations concerning food traceability have already entered to force since many years, we still remark very wide and impacting product recalls, which often involve simultaneously large territories and many countries. This is a clear sign that current traceability procedures and systems, when implemented with the only aim of respecting mandatory policies, are not effective, and that there are some aspects that are at present underestimated, and therefore should be attentively reconsidered. In particular, the sole adoption of the so-called "one step back-one step forward traceability" to comply the EC Regulation 178/2002, where every actor in the chain handles merely the data coming from his supplier and those sent to his client, is in fact not sufficient to control and to limit the impact of a recall action after a risk notification. Recent studies on lots dispersion and routing demonstrate that each stakeholder has to plan his activities (production, transformation or distribution) according to specific criteria that allow pre-emptively estimating and limiting the range action of a possible recall. Moreover, these new and very recently proposed techniques still present some limits; first of all the problem of traceability of bulk products (e.g. liquids, powders, grains, crystals) during production phases that involve mixing operations of several lots of different/same materials. In fact, current traceability practices are in most cases unable to deal efficiently with this kind of products, and, in order to compensate the lack of knowledge about lot composition, typically resort to the adoption of very large lots, based for instance on a considered production period. Aim of this paper is to present recent advances in the design of supply chain traceability systems, as well as novel results related to the problem of tracing bulk products. The proposed set up is well suited for applying optimization methods, recently introduced in literature, to minimize the amount of product to be recalled in case of crisis.

043

DEVELOPMENT AND TESTING OF A BIRTH ALARM SYSTEM FOR GRAZING COWS: RESULTS FROM A PRELIMINARY STUDY

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In dairy farming, calving time represents one of the most crucial moment. During this event human assistance to the cow and the unborn is important to guarantee their health and, as a consequence, to preserve the livestock. A reliable prediction of the calving time is fundamental enabling the operator to act quickly and reduce calf potential injury caused directly by the mother or by environmental factors. This prediction is of particular importance for cows bred in wide grazing areas where, cause to the territorial extension, is difficult to

quickly intervene when needed. To overcome these calving problems a birth alarm called GPS-CAL (GPS-Calving Alarm) was designed, developed and tested. The device can identifies accurately the time when delivery begins and advise the farmer via SMS message. The SMS includes birth event date and hour, animal ID and geographical coordinates of the point where the delivery is carried out, measured through a GPS receiver embedded in the calving alarm device. The GPS coordinates are expressed in a Google Map compatible format in order to make possible to display the point where the birth took place on a digital map. Importing such GPS coordinates into a common application for mobile phones and following the visual instructions, it is possible to reach the point of birth. This possibility is useful above all for extensive breedings. The system can prove interesting also for farmers with cows kept in loose housing because it allows to monitor effectively risk situations (*i.e.* primipara) or to intervene exclusively when the event is started sparing pointless wakes, especially during the night hours. The system was patented by the Authors with the collaboration of Università degli Studi di Milano and of a private company (Sistec, Sassuolo - MO, Italy).

044

REGIO BIOCONTROL, A COLLABORATIVE PROJECT FOR THE CONTROL OF INVADING PLANT PESTS

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The fast development of the trade of agricultural commodities during the past years led to the increasing number of pest introductions. Several of these pests are spreading out very fast causing heavy economical damages to important crops. This the case in Europe of insects such as *Diabrotica* in the 90th, but more recently *Drosophyla suzukii* on numerous fruit crops or *Rhagoletis completa* on nuts. The chemical control of these pests either is difficult due to their specific attributes, or restricted for regulatory reasons. Regio Biocontrol intends to build up a collaborative operation in order to control these crops using the Sterile Insects Release Technique (SIT). The area concerned by the project covers over 6 million hectares in several crops and many regions in Europe. The implementation of large scale biological pests control operation requires indeed the cooperation of several organisations : sterile insects producers, technical field operators, production organisations and naturally research organisations (INRA, USDA-ARS, IAEA) aiming at stewarding the project and solving important scientific related questions. However, the mass release of sterile insect as « natural enemies » of pests must be carefully scheduled: this will be made with the use of the electronic decision support tools eProtecta which will include specific models for both the targeted pests and the crops. Agrometrix ICM, Basel Switzerland, as a company specialised in biocontrol engineering, is the initiator of Regio Biocontrol. The paper will explain how such a collaborative project is initiated, which kind of technical and regulatory aspects are solved and its implementation steps.

045

AN AUTOMATIC SYSTEM FOR THE DETECTION OF DAIRY COWS LYING BEHAVIOUR IN FREE-STALL BARN

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In this paper, a method for the automatic detection of dairy cow lying behaviour in free-stall barns is proposed. A computer vision-based system (CVBS) composed of a video-recording system and a cow lying behaviour detector based on the Viola Jones algorithm was developed. The CVBS performance was tested in a head-to-head free stall barn. Two classifiers were implemented in the software component of the CVBS to obtain the cow lying behaviour detector. The CVBS was validated by comparing its detection results with those generated from visual recognition. This comparison allowed the following accuracy indices to be calculated: the branching factor (BF), the miss factor (MF), the sensitivity, and the quality percentage (QP). The MF value of approximately 0.09 showed that the CVBS missed one cow every 11 well detected cows. Conversely, the BF value of approximately 0.08 indicated that one false positive was detected every 13 well detected cows. The high value of approximately 0.92 obtained for the sensitivity index and that obtained for QP of about 0.85 revealed the ability of the proposed system to detect cows lying in the stalls.

046

ECONOMIC AND ENVIRONMENTAL BENEFITS OF USING A SPRAY CONTROL SYSTEM FOR THE DISTRIBUTION OF PESTICIDES

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Agrochemical distribution accuracy is critical for an effective intervention with a significant impact both on production costs and on the environment. Here we present the results obtained on processing tomato crops using a sprayer boom with and without nozzle control integrated with an RTK (Real Time Kinematic) automatic guidance system. The trials were carried out on tomato crops cultivated in fields of different shapes in a farm located in the Po' Valley (Piacenza), using a self-propelled sprayer with a capacity of 1000 L and a 14 m opening boom, with a three-channel direct injection distribution system. The self-propelled sprayer was equipped with an automatic guidance system and integrated nozzle control on each boom section. Several parameters were recorded including the speed (km/h) and treated surface (ha). The analysis of the data collected shows an average overlap reduction of 15% compared to conventional guidance, a value that increases with the irregularity of the field. This technology can improve the environmental sustainability of agrochemical distribution due to the reduction in the consumption of pesticides and can improve the overall welfare of the operator as well.

047

ANALYSIS OF POULTRY EATING AND DRINKING BEHAVIOR BY SOFTWARE EYENAMIC

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Constant presence of at least one operator in livestock buildings for broilers would allow a perfect control of animal behaviour and, especially, deviations in feeding and drinking patterns, in the perspective of a high welfare status. However, as nowadays it is quite difficult for a farmer to be present in the farm all day long, automatic monitoring systems are required. The purpose of this paper is to introduce a system for automatic monitoring and analyzing broilers' behavior in a farm located in the Limburg province, The Netherlands. eYeNamic is a camera system introduced and produced by Fancom BV, a company operating in the field of automation of livestock facilities. It includes three cameras located on the ridge of the broiler house and able to monitor chickens' behaviour twenty-four hours a day. Through eYeNamic it is possible to process the images and to obtain a measure of animals' distribution and activity, which can be conceived as valuable indicators of animal welfare. The work program has been divided into several phases: data collection, images visualization, observation of the distribution and activity of the chickens, and statistical analysis of the observations. eYeNamic is a good system to observe animal behavior and, especially, to take care of their welfare. A satisfactory correspondence between eYeNamic remote and traditional operator imaging depends on a correct definition of animals' feeding. In our case, this correspondence is established for the manual labeling, only if a broiler maintains its whole head inside the pan for a period lasting 20 seconds. The analysis of correlation between the number of 14 days old broilers near the feeding line (manual counted) and the average occupation density measured with eYeNamic indicates that the best conditions have occurred with a 50 cm by 75 cm surface around the feeding pans. With reference to the drinking line, the best response was found in an area 50 cm wide and the whole drinking line long. For the activity behavior, there is no significant correlation between activity and number of chickens eating for all the pans: this confirms that broilers while feeding reduce their activity.

048

EXPERIMENTAL COMPARISON BETWEEN TWO SATELLITE GUIDANCE SYSTEMS: EZ-STEER/RTK AND AUTOPILOT/EGNOS

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The precision agriculture (PA) is a form of agriculture technologically advanced and multidisciplinary, which manages every factor of production to varying degrees, by treating small areas inside the lot as if they were separate surfaces. By so doing, one can increase the margin of economic crops by reducing the input of technical means and to an improvement of the quality characteristics, and quantitative production. Also is significantly reduced environmental impact, as it contracts the quantity used of factors of production, such as pesticides and fertilizers. The object of this paper is to investigate about two different devices and satellite-guided with two different systems of correction of the GPS signal: the EZ-Steer / RTK Autopilot and / EGNOS. In carrying out the tests, the tractor used was the New Holland T7060, and, as operating machines have been employed the rotary harrow, Alpego DG-400 and the Buriers, Forigo DG-45 in order to determine which of the two pairs of systems are able to ensure the best quality of work. The measurements were performed over several days in the countryside thanks to 80 observations for each of the systems examined, evaluated of the analysis of variance or ANOVA. Based on the results obtained it is clear that the system EZ-Steer/RTK, despite the RTK corrections, ensures a lower bond strength of the theoretical trajectory with respect to the system Autopilot/EGNOS, top of 1.77%. Elaboration, instead, the data relating to the behavior of the two guidance systems in manage only the width of transposition, it is observed that the system EZ-Steer/RTK is able to guarantee a better approximation of the trajectory of the tractor to the theoretical path compared to Autopilot system/EGNOS, which provides a greater mistake than the total width of 1.64 m and transposition of 2 cm on the average width of transposition. Analyzing, then, the data relating to the behavior of the two guidance systems, in managing the surface of transposition normalized, it is observed that the system Autopilot/ EGNOS is capable of ensuring a better quality of work compared to the system EZ-Steer/RTK.

STRUCTURES AND TECHNOLOGIES FOR LIVESTOCK PRODUCTION: TECHNICAL, ENERGY AND ENVIRONMENTAL ASPECTS

049

NEW SOLUTIONS FOR HORSE SHELTERS TO CONNECT TO THE EQUESTRIAN PATHS

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A rational and modern network of riding trails involves the building of specific structures for the horses according to the new needs of equestrian tourists. These shelters require appropriate technical models that today cannot be found easily in the Italian or foreign literature. Over the years this gap has led to the development of the practice "do it yourself" and following old techniques of construction, not able to meet the new demands of the market of horse tourism. This research has highlighted two different models, with solutions that can meet the needs of tourists riding today and have correspondence with the laws about the construction and the health part. These structures, preferably made with traditional materials and according to correct criteria of insertion into the landscape and reducing environmental impact, are: 1) temporary horse-shelter: buildings to put in resting places of interest along the path (historic villages, monasteries, etc.), where it's possible to arrange the horses for a few hours and allow to the riders to make a careful visiting of places of interest; 2) horse-shelter for the night: structures to put in particular points where it is possible to spend the night for horses and riders. This research has pioneered a new type of horse barn with attached storage feed and saddle-room. These structures are very dynamic, due to the possibility to change quickly the position of the horses (max 8 places). This research also aims to create a sort of guideline for the construction of models to be put inside the municipal law. The structures were designed following the general principles of the Code for the Protection and Management of Horses prepared by the Italian Ministry of Labour, Health and Social Policies. The code provides the essential criteria for the proper management of horses, in accordance with good practice and ethical behaviour to protect the health and the welfare of the horses. For the design were observed the following principles: low impact, low cost, easy installation, complete reuse.

050

ENVIRONMENTAL ASSESSMENT OF INDIVIDUAL AND COLLECTIVE MANURE MANAGEMENT SYSTEMS

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The environmental impact related to intensive livestock farming is often determined by manure management systems that do not use best available techniques. Furthermore, in areas with a high density of animals, the load of nutrients exceed crop requirements, causing a relevant environmental problem. In this framework and considering the regulatory constraints (Community directives 91/676/EEC 2010/75/EU), the application of different techniques of collective treatment and management of manure, represents a possible solution to the sustainability of livestock farms. The aim of this study was to evaluate the environ-

mental effects of the introduction of a collective treatment plant for energy production and nitrogen removal. For this purpose an assessment methodology, for individual farms and collective treatments plants, has been defined and implemented to estimate the emissions of the main pollutants to the air (CO_2 , CH_4 , N_2O , NH_3) and to the soil (N and P). The method devised has been assessed in a case study. We considered a facility located in the area of Bergamo who receives the effluent from ten farms (pigs, cattle and poultry) located in the neighboring area. The centralized treatment plant has a first step of anaerobic co-digestion with biogas recovery for energy production followed by a solid-liquid separation of the digestate and a biological nitrogen removal from the clarified fraction in a sequentially batch reactor. The effluent is returned to the farms for agronomic use. The main effect of the introduction of the collective management system from the environmental point of view is a reduction of CO_2 emissions due to the renewable energy production. Furthermore, it reduces the amount of nitrogen to be applied to land from 500 kg ha^{-1} to about 250 kg ha^{-1} , decreases the emission of ammonia in the air by about 20% due to lower amount of nitrogen that is managed by farms in the storage and spreading operations. The results obtained confirm the usefulness of appropriate evaluation tools for the environmental assessment of alternative management systems of livestock manure.

051

A PARTIAL LIFE CYCLE ASSESSMENT APPROACH TO EVALUATE THE ENERGY INTENSITY AND RELATED GREENHOUSE GAS EMISSION IN DAIRY FARMS

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Agricultural and livestock activities are important sources of primary greenhouse gases (GHGs) and have been estimated to contribute for about 10-12% to global anthropogenic GHG emissions. Furthermore, agriculture is responsible of indirect emissions in other industrial sectors which supply the resources consumed in the agricultural processes. Dairy farming is constantly evolving towards more intensive levels of mechanization and automation which increase energy consumptions and result in higher economic and environmental costs. The usage of fossil energy in agricultural processes contributes to climate change both with on-farm emissions from the combustion of fuels, and off-farm emissions due to the use of grid power. Therefore, an efficient use of fossil resources and renewable energies can play a key role in developing more sustainable production systems. The aims of this study were to evaluate the energy requirements (fuels and electricity) in dairy farms, define the energy demands among the different farm operations, identify the critical point of the process and estimate the amount of CO_2 associated with the energy consumption. The inventory of the energy uses has been outlined by a partial Life Cycle Assessment (LCA) approach, setting the system boundaries at the farm level. All the flows of materials and energy associated to milk production process were investigated in 20 dairy farms over a period of one year. Self-produced renewable energy was also accounted as it influence the overall balance of emissions. Data analysis was focused on the calculation of energy and environmental sustainability indicators (EUI, CO_2eq) referred to functional units. On average the production of 1 kg of FPCM required 0.044 kWhel and 0.251 kWhth, generating a total emission of 0.085 kg CO_2eq . Farm activities that contribute most to the electricity requirements were milk cooling, milking and slurry management, while animal feeding and crop cultivation were the largest fuel consuming operations and the heaviest in terms of environmental impact of milk production (73% of energy CO_2eq emissions). The results of the study assist in the development of dairy farming models based on more efficient and profitable use of resources.

052

IMPLEMENTATION OF A GENETIC ALGORITHM FOR ENERGY DESIGN OPTIMIZATION OF LIVESTOCK HOUSING USING A DYNAMIC THERMAL SIMULATOR

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A Genetic Algorithm (GA) is an optimization process inspired to natural systems ability of surviving in many different environment through the mechanisms of natural selection and genetics. The pairing of GA-based optimization techniques with dynamic thermal models is a common and effective practice to find energy efficient design solutions. In this paper a genetic algorithm with the ability to dialogue with a dynamic thermal model is implemented. The algorithm, coded in Matlab, works with populations of strings. Each string, that represent a complete design solution, is initially randomly generated by the GA and evaluated in terms of energy performances by the dynamic thermal simulator. A new population is then generated using three different GA stochastic operators, reproduction, crossover and mutation, by selecting, mixing and randomly modifying the fittest solutions of the previous generation. Each generation is evaluated by the thermal model and thus the fitness of the strings, that represent the energy efficiency of the design solutions, improves every cycle till eventually converge to the best solution. This whole methodology is well documented and applied in residential buildings design but can be easily extended to livestock housing. In this paper the algorithm is coded to be applied on a simple sheepfold model in order to optimize only passive design solutions.

053

INFLUENCE OF FEED DELIVERY FREQUENCY ON BEHAVIOURAL ACTIVITY OF DAIRY COWS IN FREESTALL BARN

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Research on feeding management in more competitive free-stall settings indicates that frequency of delivery of fresh feed stimulates feed bunk attendance and can affect other aspects of cows' time budgets apart from feeding such as time spent standing vs. lying down. The objective of this study was to examine how the frequency of feed delivery affects the behavior, the feed intake, and milk production lactating dairy cows in two farms, one with a conventional and one with automatic milking system (AMS). The feeding frequency was varied from two to three times per day in the conventional dairy farm; one to two times per day in the AMS farm. The experiment was carried out in two different seasons. All behaviours of the cows were monitored in continuous by video recording. As expected, behavioral indices have been significantly affected by environmental conditions both in conventional farm and AMS farm. Although the THI values were not particularly high also in the hot period (<73) the differences in the behavioral activity in comparison to the cool period were marked: average lying time decreased of 10-15% while cows were standing longer (23-50%). Although the environmental conditions seem to have influenced similarly the two herds, the effect on milk yield has been different. In the conventional farm the yield was not affected while in conventional farm decreased significantly. The variation in the frequency of feed delivery seems to affect the cow behavioural activity only in a limited way and modify only slightly the daily averages of the time spent in different activities. The results obtained confirm that increasing number of

deliveries can increase the feed intake and the milk production without affecting the cow lying time. Further investigations are however required to evaluate other aspects like the number of bouts and the duration of each lying period. Of course, in farms where the feeding operations are not automatized, the farmer should evaluate carefully if the higher cost of an extra feeding delivery is compensated by the increase in milk production.

054

A SURVEY ON ITALIAN COMPOST DAIRY BARN

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Compost-bedded pack barns, generally known as compost dairy barns, are alternative housing systems for dairy cows. In these barns, the whole surface of the resting area is covered with a deep-bedded pack that is frequently stirred in order to incorporate fresh manure into the pack and enhance the evaporation of water. Experiences with compost bedded pack barns for dairy cows are reported in literature from USA, Israel, Netherlands and Denmark. The main advantages of these housing systems regard animal welfare and manure management. Since 2006, this housing system has been applied consistently in Italy. However, scientific knowledge about Italian compost barn is still lacking. This study aims at describing housing system, assessing producers satisfaction and measuring performances of dairy cows housed in compost bedded pack barns. Ten commercial dairy farms in northern Italy was involved in the study. All pens in each farm were surveyed to determine the surface of total available area and bedded area. In order to investigate management practices, labor requirement, consumption of bedding materials and producers satisfaction, a questionnaire was submitted to each farm manager. The temperature of the bedded pack was measured in each farm during summer and winter. Moreover, data from Dairy Herd Improvement Association were collected in each farm over a period of one year (from September 2011 to September 2012). For the ten compost barns involved in the study the average total available area was 10.9 m² per cow and the average pack area was 6.7 m² per cow. The bedded pack was aerated 1.4 times per day. The most commonly used bedding material in these farms was sawdust. The consumption of bedding materials was 8.1 m³ per cow per year. An inverse relationship was found between the amount of bedding needed and the space per cow ($r=-0.63$). Operations related to pack management require 4.1 hours of labor per cow per year. Performance of cows housed in compost barns we studied resulted encouraging and although some concerns about the cost of bedding, overall, producers were satisfied with this housing system.

055

USE OF A PROACTIVE HERD MANAGEMENT SYSTEM IN A DAIRY FARM OF NORTHERN ITALY: TECHNICAL AND ECONOMIC RESULTS

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Reproductive and economic data were recorded before and one year after the installation of Herd Navigator™ in a dairy farm with AMS (Automatic Milking System) located in a mountain area of Northern Italy. Number of days open reduced from 166 to 103 days, number of days between the first and second insemination decreased from 45 to 28 days, and days for identifying an abortion were 80 % less, from 31 to 6 days. The preliminary results highlight the usefulness of the proac-

tive herd management system installed for the reproduction management. A basic economic model is proposed to evaluate the potential economic benefits coming from the introduction of this technology. The model considers the benefits deriving from the reduction of reproduction problems and, consequently, of days open. Considering the effects related to the above mentioned aspects, in a case study involving 70 dairy cows, a return on investment over 5 years has been calculated.

056

OPTIMIZATION OF SUSTAINABLE BUILDINGS ENVELOPES FOR EXTENSIVE SHEEP FARMING THROUGH THE USE OF DYNAMIC ENERGY SIMULATION

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Extensive sheep farming can be seen as a marginal market, compared to other livestock and agricultural activities, taking into account only the economic absolute values. But for many rural areas within the European Community member states, in particular for those located in the Mediterranean area, extensive sheep farming is not only the longest practiced animal farming activity but also the most interesting considering the particular morphology of many of these areas and the restrictions that have been established over the years in terms of sustainable rural development practices. At the moment, most of the structures used in this type of farming are built using low cost and sometimes recycled, but often unsuitable, materials. Few specific studies have been carried out on this particular issue assuming, presumably, that the very low profit margins of these activities made impossible any restructuring. Taken this into account, the new Rural Development Plans that will be issued in 2014 will surely contain some measure dedicated to innovations in farming structures and technology towards facilitating the application of the principles of energy optimization. This is the framework in which the present research as developed. The selected tool that has been applied to perform the energy optimization analysis is the dynamic energy simulation engine Energy Plus. A case study farm has been identified, situated in Central Italy in the small village of Ceseggi (PG), and optimum thermo hygrometric conditions have been identified as well, that have been used afterwards in the calculation with the goal of minimizing the energy request of the structures. For what concerns the envelopes, various materials have been taken into consideration and their effectiveness in term of maintaining the optimal conditions has been assessed. The grater goal is to verify the possibility of reaching the point, through design and construction choices, in which no HVAC system is needed for maintaining optimum temperature conditions inside the buildings. Keywords: Dynamic energy simulation; sustainable building envelopes; extensive sheep farming.

057

DEVICES TO PROVIDE POST-WEANING AND FATTENING PIGS WITH WOOD AS MANIPULABLE MATERIAL

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The European Union Directive 2008/120/EC, laying down minimum standards for the protection of pigs, among the practices to adopt imposes that pigs have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities, which does not compromise the health of the animals. The Directive suggests some materials such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of them. However in Italy, especially in the

North where pig farms are widespread, the slatted flooring is the most common type of floor. Therefore the use of some materials identified by the Directive as manipulable is not simple. To prevent the occlusion of slots, only wood and compressed sawdust can be taken into account. The study aims to investigate some systems to provide wood material to the pigs in a cost effective way for the Italian pig farms. Wood essences and kind of saw timber have been selected taking into account the necessity to avoid that the health of the animals is compromised by contact or ingestion. Core of veneer poplar logs and wood sawdust pressed briquettes have been considered the best resources available. The design process of the devices have taken into account several issues, in particular the maximum interaction with material by animals and the lowest labour by the farmer to supply the material. The systems consist of a fixed structural component to install inside the pen to which logs or briquettes can be added and replaced quite effortlessly. Different devices have been designed depending on the age of the animals and tested in 3 pens with 72 post-weaning piglets and in 4 pens involving 349 growing pigs. Among the several devices tested in field trials, in post-weaning phase the system with log placed horizontally (in such a way that the animal can rotate it) and the system with fixed vertical log have resulted the most attractive. During the growing-fatening phase the wall grid containing logs of poplar timber to raise with the snout, to spin and to bite seems to be the most desirable device.

058

BEEF CARCASS ANATOMICAL CUTS YIELD PREDICTION USING STANDARDIZED INDICES: PRELIMINARY RESULTS

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At present the determination of the yield at the slaughter of live animals is estimated on the basis of coefficients reported in the literature and, therefore, of public domain. There are, however, no data on the performance of the individual anatomical cuts. It represents a limitation for the planning of the business and supply to various sales channels. The aim of this study was to define standardized indices, according to gender, category and race of the animals to predict the yields at the slaughter of the individual carcass and of the different anatomical cuts. The use of an open web platform developed for the automatic data flow management of the traceability for the bovine meat chain in a cooperative with a slaughterhouse and two dissection areas of northern Italy, has allowed to extrapolate the data of a sample of 500 animals, about one-third of the number of subject slaughtered per year by the structure. Animals were divided according to race (Limousine, Charolais, French Cross-breeds, Italian cross-breeds and Italian Friesian), gender (male and female, entire and castrated) and categories (<12 months, 12-18 months, > 18 months). Statistical analysis of the data has allowed to develop the indices forecasting of the carcass weight, of the half-carcass, of the front and rear portion and its division into anatomical cuts. To improve the traceability performances of the open web platform, a new software interfaces integrating the indices will be soon developed.

059

INFLUENCE OF LOW VACUUM LEVELS ON MILKING CHARACTERISTICS OF SHEEP, GOAT AND BUFFALO

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Different settings of the operating parameters (pulsator rate, pulsator ratio and vacuum) are used for milking dairy species in different parts of the world. The level of the operating vacuum in machine milking is one of the principal factors which influence the integrity of the tissues and the milk quality. High vacuum levels (>42 kPa) are often used to facilitate the opening of the teat canal by overcoming the biological closing forces within the teat sphincter, but can result in severe machine-induced teat tissue damage. In this study characteristics and performances of mechanical milking at low vacuum levels have been investigated in different dairy species. Milking times and milk productions have been obtained from milk emission curves, recorded by electronic milk-meters (LactoCorder®) during the milking at different vacuum levels of sheep, goats and buffaloes. The results of the comparative experiments clearly indicate that a low vacuum level modifies the kinetics of milk emission, the machine-on time and, thus, the throughput of milking system, in all the dairy species considered. Milk yield was satisfactory at any level tested, showing that low vacuums can be adequate to completely empty the udder. Slight differences were found across species concerning the increase in the milking time per animal associated with low levels of milking vacuum. Our study represents a contribution to encourage the decrease of the working vacuum during mechanical milking, also for those dairy species generally considered hard to be milked, as buffaloes. Milking should be performed applying the lowest vacuum level, compatible with not excessively prolonging milking time, in line with the animal welfare on dairy husbandry.

STRUCTURES AND TECHNOLOGIES FOR PROTECTED CROP PRODUCTION: TECHNICAL, ENERGY AND ENVIRONMENTAL ASPECTS

060

BIODEGRADABLE FILMS AND SPRAY COATINGS AS ECO-FRIENDLY ALTERNATIVE TO PETRO-CHEMICAL DERIVED MULCHING FILMS

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The world consumption of low density polyethylene mulching films in horticulture is at present around 700,000 tons per year, causing the serious drawback of huge amount of wastes to be disposed of at the end of their lifetime. Recently biodegradable materials based on raw materials coming from renewable sources have been developed to satisfy people's awareness of environmental protection. These materials have been designed in order both to retain their mechanical and physical properties during their using time and to degrade at the end of their lifetime. The biodegradable materials can be integrated directly in the soil where the bacterial flora transforms them in carbon dioxide or methane, water and biomass. Several pre-competitive research products were made to be used as biodegradable materials for soil mulching. The innovative materials can be obtained by thermal film forming processes, casting and spraying techniques, using natural polymers, such as starch, cellulose, chitosan, alginate and glucomannan. Biodegradable extruded mulching films were performed by means of thermo-plasticizing process. Other mulch coatings were realized directly in field, by spraying water solutions based on natural polysaccharides, thus covering the cultivated soil with a protective thin geomembrane. In this paper a focused overview on the formulation development, processing understanding, field performance and mechanical and radiometric properties of these innovative materials for soil mulching is presented, in comparison to oil-based non renewable mulching materials. During their using time in field, the biodegradable soil mulching materials showed suitable and efficient mechanical properties if compared to the low density polyethylene films. The radiometric properties and their effect on the temperature condition and on weed control in the mulched soil were evaluated too. At the end of their lifetime the biodegradable materials were shattered and buried into the soil together with plants. The film residues disposed of in the soil biodegraded in almost 1 month for the water borne coatings and in about 12 months for the biodegradable starch- based extruded films.

061

HYDROGEN AND RENEWABLE ENERGY SOURCES INTEGRATED SYSTEM FOR GREENHOUSE HEATING

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A research is under development at the Department of Agro-Environmental Sciences of the University of Bari "Aldo Moro" in order to investigate the suitable solutions of a power system based on solar energy (photovoltaic) and hydrogen, integrated with a geothermal heat pump for powering a self sustained heated greenhouse. The electrical

energy for heat pump operation is provided by a purpose-built array of solar photovoltaic modules, which supplies also a water electrolyser system controlled by embedded pc; the generated dry hydrogen gas is conserved in suitable pressured storage tank. The hydrogen is used to produce electricity in a fuel cell in order to meet the above mentioned heat pump power demand when the photovoltaic system is inactive during winter night-time or the solar radiation level is insufficient to meet the electrical demand. The present work reports some theoretical and observed data about the electrolyzer operation. Indeed the electrolyzer has required particular attention because during the experimental tests it did not show a stable operation and it was registered a performance not properly consistent with the predicted performance by means of the theoretical study.

062

VARIATION OF PHYSICAL PROPERTIES OF LDPE COVERING FILMS DUE TO AGROCHEMICALS

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The agrochemical substances based on sulphur and chlorine lead to a degradation of the covering plastic materials. The film degradation due to agrochemicals is influenced by their active principles, method and frequency of application, and greenhouse ventilation. A research was carried out by field and laboratory tests to evaluate the influence of agrochemicals contamination and solar radiation on the mechanical and radiometric properties of low density polyethylene (LDPE) films. For research purpose LDPE films were manufactured adding different anti-UV stabilizer systems. The films were tested at the experimental farm of the University of Bari (Italy; 41° 05' N) during 2009. Each film type was exposed to natural outdoor weathering as covering of two low tunnels: one was sprayed from inside with commercial agrochemicals containing iron, chlorine and sulphur while the other one was not sprayed and used as control. Mechanical and radiometric tests were carried out on the new films and on samples taken during the trial. Analyses on absorption of the selected contaminants were carried out in laboratory on the samples taken at the end of the film exposure in the field in order to compare the relative effectiveness of the stabilizing systems under evaluation and to suggest threshold values of contamination, if any, that could be assumed as allowable, based on the residual mechanical strength of the films. Additional accelerated aging tests were performed in laboratory on samples taken at the end of the film exposure in field in order to better differentiate the films tensile properties. The tests showed that at the end of the field exposure the stress and the strain at break decreased slightly for the control and sprayed stabilised films while the artificial weathering induced a sharp decrease of their mechanical properties. Radiometric tests showed that the natural weathering together with the agrochemicals did not modify significantly the radiometric properties of the films in the solar and in the PAR wavelength range; within 6 months of experimental field tests the variations of these radiometric characteristics were at most 10%. Significant variations were recorded for the stabilised films in the LWIR wavelength range.

063

COMPARISON OF DIFFERENT ESTIMATION PROCEDURES FOR THE HYDRAULIC PROPERTIES OF HORTICULTURAL SUBSTRATES BY ONE-STEP OUTFLOW TECHNIQUE

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The improved iterative method for the simultaneous determination of the hydraulic properties of growing media, from One-Step experiment by Bibbiani, is performed and compared with the simplified equations by Valiantzas and Londra. Brooks and Corey equation for water retention, and Kozeny power equation for hydraulic conductivity characterized the hydraulic properties of the porous media. The iterative procedure is applied on pure peat, pumice, and their mixes. The One-Step method has been previously optimized: processing the mean cumulative outflow curves recorded versus time, an estimation of diffusivity, and subsequently of the hydraulic functions, is derived. Estimated water retention curve is compared with nine experimental data, and with the estimation of the Van Genuchten model, via the RETC code. Bibbiani's and Van Genuchten's models overlap except for the "very wet" range near saturation, whereas the Valiantzas and Londra's procedure doesn't get satisfactory results. In regard to diffusivity, a good similarity between Bibbiani's and Van Genuchten-Mualem's curves can be pointed out, whereas Valiantzas and Londra's procedure generally results in higher values. Due to the lack of estimation of the water retention curve, the latter procedure fails to estimate the hydraulic conductivity function, while the former curves match together in most cases.

064

PRODUCTION AND REUSE OF WASTE IN RURAL AREA WITH HIGH DENSITY OF GREENHOUSE

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Agricultural activities cause the production of considerable amounts of waste sometimes dangerous that must be properly handled to avoid negative impacts on rural areas and on agroecosystems. The estimation of qualitative and quantitative characteristics of agricultural waste and the capacity of rural land of transposing organic matter deriving from the processes of composting, is a key point for the planning and management of the waste integrated cycle. The aim of this study was to evaluate the quantities of various types of agricultural waste on territorial scale and of compost usable in rural areas affected by different cultures. These assessments were carried out in an area of study characterized by a high spatial density of greenhouse. The methodological procedure used is based on the use of agricultural waste production coefficients and maximum application rates of compost for cultivation. The results show the role and potential of the agricultural areas in the waste cycle from production to the potential reuse of recovered material.

065

WITHDRAWN

066

EVALUATION OF SOME PLANT EXTRACTS AS ANTIBACTERIAL AGENTS AGAINST *RATHYIBACTER TRITICI*, INCITING TUNDU DISEASES OF WHEAT (*TRITICUM AESTIVUM* L.)

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There are concerns about the widespread use of chemicals in crop production in developing countries because of their possible adverse effects on human health. According to a World Health Organization survey, more than 50,000 people in developing countries are poisoned annually and 5,000 die as a result of the effects of toxic agrichemicals. In India 35,000 – 40,000 tons of hazardous chemicals are sprayed on crops every year and this is considered to increase the risk of cancer, sterility and death. There is an urgent need, therefore, for the development of safer and more sustainable methods of crop production. Plants are known to possess antimicrobial secondary metabolites that can inhibit the growth of plant pathogens and it is possible that these compounds could be used to combat plant diseases. In the present study, the aqueous extracts of twenty plants were screened by agar diffusion methods for their antibacterial activity against *Rathyibacter tritici*, a causal organism of tundu diseases of wheat. The combined extracts of leaf extracts of *Datura stramonium* and stem extracts of *Acacia catechu* in general showed a strong enhancement in activities over the individual extracts of leaves extracts of *Datura stramonium* and stem extracts of *Acacia catechu* against the bacteriam growth respectively. Some of the other plants such as *Dedonia viscosa*, *Ficus glomarata*, *Acacia arabicae* and *Dalbergia sisoo* also showed the inhibitory effect against the test bacteria.

067

ECONOMIC PROFITABILITY IN SEEDLING SOTOL PRODUCTION (DASYLIRION SPP.) FOR COMMERCIAL PLANTATIONS IN THE STATE OF CHIHUAHUA, MEXICO

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The sotol (*Dasyliirion spp*) is a wild plant native of the state of Chihuahua, which has its origin in the desert of northern Mexico and the southern United States. It is a non-timber forest plant that has many uses such as: livestock feed, as raw material for handicrafts, and in its most common use as a feedstock for the production of alcoholic drink called sotol. Currently this drink is produced in the desert of northern Mexico in the states of Chihuahua, Coahuila and Durango, where he has obtained a designation of origin (DOF Designation of Origin Sotol, 29/11/2001). In recent years there has been a great increase in the demand for this beverage in the international market, generating an increase in raw material requirements, sotol plant, causing severe pressure on wild populations. For its use in natural conditions, the plant needs to have between 12 and 15 years old, with low growth population, and even though sotol stocks are limited, to date have not been established commercial plantations. Field research was conducted; the information was obtained of seedling producers, mainly forest, determining the variables and unit costs that affect the total cost of seedling production, obtaining profitability based on indicators such as NPV, IRR and P/C ratio. The sotol represents a growing potential for use in various regions of the Chihuahuan Desert. However it is necessary to establish commercial plantations, where stands the need to identify technology and economic profitability of sotol seedling production as an alternative to preserve the species and to reforest areas of sotol, and to devote to this growing in those areas where have the potential for this, but they are very limited for other production alternatives and usually correspond to the population with the lowest income, and most vulnerable areas for government support. So while it is doing protecting wild populations will improve the quality of life for families in these areas, participating by a better future.

068

BUILDING GREEN COVERING FOR A SUSTAINABLE USE OF ENERGY

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Nowadays the growth of the cities increased built and paved areas, energy use and heat generation. The phenomenon of urban warning, called heat island, influences negatively outdoor comfort conditions, pollutants concentration, energy demand for air conditioning, as well as increases environmental impacts due to the demand of energy generation. A sustainable technology for improving the energy efficiency of buildings is the use of green roofs and walls in order to improve the energy consumption for conditioning in summer and the thermal insulation in winter. The use of green roofs and walls can contribute to mitigate the phenomenon of heat island, the emissions of greenhouse gases, and the storm water runoff affecting human thermal comfort, air quality and energy use of the buildings. Recently, a number of municipalities started to adopt regulations and constructive benefits for renovated and new buildings which incorporate green roofs and walls. The aim of this paper is to describe the green roofs and walls plant technology, the technical characteristics, and the existing certification framework.

069

TEMPERATURE CONDITIONING IN ORNAMENTAL PLANT PRODUCTION WITH A PROTOTYPE DEVICE: ROOT ZONE COOLING IN PROTECTED ENVIRONMENTS

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In the greenhouse floriculture one of the major expenses is as energy. To reduce energy costs for thermal conditioning was created an innovative system of cooling baseline characterized by the presence of coaxial pipes with hydraulic flows countercurrent putting it in comparison with a traditional system with hydraulic flows cocurrent. For cooling in summer the plant was equipped with coolers and were measured energy consumption as a function of cooling baseline for obtaining flowering in the summer period by a culture of *Alstroemeria spp*. The tests also focused on a particular change, made during the heating tests of previous years, which allows the system coax to turn their operation flows countercurrent to cocurrent flow. The results obtained show that the baseline coaxial cooling system allows to obtain, with respect to the system of traditional type, a better uniformity of the temperature of the ground and when it is used with countercurrent flows both when it is used with co-current flow. The system also allows a slight overall reduction in energy consumption.

POST HARVEST, FOOD AND PROCESS STRUCTURES AND TECHNOLOGIES

070

A NEW METHOD FOR ESPRESSO COFFEE BREWING: CAFFÈ FIRENZE

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Espresso coffee is the most popular choice for Italian coffee consumers. It has been estimated that every day, in the world, over of 50 million of Espresso cups are taken. As a consequence of this success, a large number of devices to make Espresso have been developed. In this scenario, a new device has been recently developed and patented (Eu. Patent 06 023 798.9; US 2010/0034942 A1). This brew method, named “Caffè Firenze”, uses a sealed extraction chamber, where water and gas provides pressure higher than the other extraction methods. Three main parts compose the apparatus: the gas source, the extraction chamber and the heat exchanger. The gas source provides the pressured gas required to raise the pressure of the system. The extraction chamber is cylindrical and made with chrome-brass, two glow plugs allow to heat it. Many are the factors affecting Espresso quality: it is known that, coffee type, roasting conditions and degree, grinding and storage strongly affect the obtained brew. Also, several studies have been carried out on the effect of the setting parameters on quality, for example water pressure, water temperature, and brew time. Among the characteristics that determine Espresso quality, the main attribute for the visual analysis is, without doubts, the foam, also called “crema”. Indeed, height, aspect, and persistency of foam are features much appreciated by consumers. Two distinguish Espresso foam parameters are the persistency and foam index. Equipping a commercial bar machine with the new designed extraction chamber, make feasible the comparison between the traditional way to brew Espresso and the new device. The comparison was made holding the previous mentioned conditions, and differences were evaluated in terms of physical parameters and aromatic profiles. Caffè Firenze shows pronounced differences compared with traditional Espresso in term of foam-related parameters. Also, the new extraction device produces coffees with higher values of body-related parameters, such density and viscosity. The two kinds of Espressos are perceived different at visual analysis and taste by a panel test.

071

SCREENING OF GRATED CHEESE AUTHENTICITY BY NIR SPECTROSCOPY

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Parmigiano-Reggiano (PR) cheese is one of the oldest traditional cheeses produced in Europe, and it is still one of the most valuable Protected Designation of Origin (PDO) cheeses of Italy. The denomination of origin is extended to the grated cheese when manufactured exclusively from whole Parmigiano-Reggiano cheese wheels that respond to the production standard. The grated cheese must be matured for a period of at least 12 months and characterized by a rind content not over 18%. In this investigation the potential of near infrared spectroscopy (NIR), coupled to different statistical methods,

were used to estimate the authenticity of grated Parmigiano Reggiano cheese PDO. Cheese samples were classified as: compliance PR, competitors, non-compliance PR (defected PR), and PR with rind content greater than 18%. NIR spectra were obtained using a spectrophotometer Vector 22/N (Bruker Optics, Milan, Italy) in the diffuse reflectance mode. Instrument was equipped with a rotating integrating sphere. Principal Component Analysis (PCA) was conducted for an explorative spectra analysis, while the Artificial Neural Networks (ANN) were used to classify spectra, according to different cheese categories. Subsequently the rind percentage and month of ripening were estimated by a Partial Least Squares regression (PLS). Score plots of the PCA show a clear separation between compliance PR samples and the rest of the sample was observed. Competitors samples and the defected PR samples were grouped together. The classification performance for all sample classes, obtained by ANN analysis, was higher of 90%, in test set validation. Rind content and month of ripening were predicted by PLS with a determination coefficient greater than 0.95 (test set). These results showed that the method can be suitable for a fast screening of grated cheese authenticity. Keywords: Parmigiano Reggiano cheese, NIR spectroscopy, artificial neural network, multivariate statistics.

072

APPLICATION OF COMPUTER VISION FOR QUALITY CONTROL IN FROZEN MIXED BERRIES PRODUCTION

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Computer vision is becoming increasingly important in quality control of many food processes. The appearance properties of food products (colour, texture, shape and size) are, in fact, correlated with their organoleptic characteristics and/or the presence of defects. Quality control based on image processing eliminates the subjectivity of human visual inspection, allowing rapid and non-destructive analysis. However, most food matrices show a wide variability in appearance features, therefore specific image elaboration algorithms have to be implemented for every specific product. For this reason, quality control by visual inspection is still rather diffused in several food processes. An example is the production of frozen mixed berries. Once frozen, different kind of berries are mixed together, in different amounts, according to a recipe. The correct quantity of each kind of fruit, within a certain tolerance, has to be ensured by producers. Quality control relies on bringing few samples for each production lot and, manually, counting the amount of each species. This operation is tedious and time consuming, while a computer vision system (CVS) could determine the amount of each kind of berries in a few seconds. A preliminary study of a CVS for quality control in frozen mixed berries is presented in this paper. In detail, the system has to be able to automatically count the number of the different kind of fruits that compose a sample of mixed berries randomly arranged on a white plane. Images have been acquired by a digital camera coupled with a dome lighting system, which gives a homogeneous illumination on the entire visible surface of the berries. The morphological features as well as the berries colour have been considered for separating them in classes, corresponding to the different fruits. Colour measurement by a CVS needs a colour calibration process to transform RGB device dependent data in a colorimetric colour space, such as CIE Lab. A target-based characterization, using a 24 patches X-rite Color Checker, has been considered with the implementation of polynomial colour calibration. First results have demonstrated the applicability of computer vision in fruits sorting in different samples of frozen mixed berries.

073

NEAR-INFRARED SPECTROSCOPY IS FEASIBLE TO DISCRIMINATE HAZELNUT CULTIVARS

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The feasibility of Near-Infrared (NIR) spectroscopy for classification of hazelnut varieties (*Corylus avellana* L. cv. Tonda Gentile Romana, Tonda di Giffoni e Nocchione) is demonstrated. Feature datasets comprising raw absorbance values, raw absorbance Ratios ($Abs[\lambda_1] : Abs[\lambda_2]$) and Differences ($Abs[\lambda_1] - Abs[\lambda_2]$) for all possible pairs of wavelengths from 1100 nm to 2500 nm were extracted from the spectra for use in an iterative LDA routine that computed the optimal set of features for classification. For each dataset, several spectral pretreatments were tested. Full spectra of each group was subjected to Partial Least Squares Discriminant Analysis (PLS-DA), Receiver Operating Characteristics (ROC) analysis, and evaluation of performance through the Area Under ROC Curve. The best result (0.0% false negative, 2.0% false positive, 1.0% total error) was obtained using a Savitzky-Golay filter with 45 smoothing points on the dataset of raw absorbance differences. The optimal features without any pre-treatment were $Abs[2000\text{ nm}]$ and $Abs[2060\text{ nm}]$. A colorimetric classification of hazelnut kernel were also performed and the results were compared to discrimination error obtained from NIR spectroscopy. In conclusion, the results indicate the feasibility of a rapid, online detection system, with a very-low discriminant error.

074

ASSESSMENT OF THE ENERGY AND SEPARATION EFFICIENCY OF THE DECANter CENTRIFUGE WITH REGULATION CAPABILITY OF OIL WATER RING IN THE INDUSTRIAL PROCESS LINE USING A CONTINUOUS METHOD

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The third era in olive oil extraction sees a new generation of decanter that give the operator the possibility to chose time by time the type of working: two or three phase shifting from one solution to the other without stopping the machine and even intermediate solutions between two or three phase, making the most suitable adjustments, following olive variety, just as the machine works. A decanter centrifuge was employed during the experimental tests with variable differential speed between bowl and screw conveyor (n) and with regulation capability of oil-pulp ring levels. Thus permit to shift from three to two phase, reducing water added and discharging the following by-products: dehydrated husk similar to that of three-phase and recovers a wet pulp that is the between the liquid phase and the solid phase. This paper aims to report the preliminary results of the energy and functional efficiency of the decanter when it works in the industrial scale plant and using a continuous method. The trials were carried out at two different flow rate values; for each flow rate the different variable differential speed between bowl and screw conveyor was varied at 15,50, 17,50 and 19,50. Quality olive, operating speed of the crusher machine and relative feed flow rate of the machine, the malaxing time and the degree of dilution of the paste, as well as the oil-pulp ring level were the same for all the trials. Irrespective of the flow rate and D_n used, the machine tends to stabilize energy consumption in a very short time and

values were quite similar to each other. The reductions in flow rate do not involve reductions of energy consumption indeed lead to the increase of absorption per unit mass of product worked. For all thesis studied, no significant changes of the oil recovery efficiency were found, indeed changing the flow rate and the D_n a different distribution of the not extracted oil was found in the pulp and in the husk. To complete the knowledge, a set of trials changing also the oil-pulp ring levels, has been provided for the next olive oil season.

075

AN INTEGRATED MECHANICAL-ENZYMATIC REVERSE OSMOSIS TREATMENT OF DAIRY INDUSTRY WASTEWATER AND MILK PROTEIN RECOVERY AS A FAT REPLACER: A CLOSED LOOP APPROACH.

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The dairy industry can be classified among the most polluting of the food industries in volume in regard to its large water consumption, generating from 0.2 to 10 L of effluent per liter of processed milk. Dairy industry effluents usually include highly dissolved organic matter with varying characteristics, and a correct waste management project is required to handle. In a framework of natural water resource availability and cost increase, wastewater treatment for water reuse can lower the overall water consumption and the global effluent volume of industrial plants. Moreover, correct dismissal of dairy industry wastewater is sometimes neglected by the operators, increasing the environmental impact due to the chemical and biological characteristics of such effluents. On the other hand, in the case of whey effluents, several by-products are still present inside, such as lactose and milk proteins. Membrane technology has some advantages including a high degree of reliability in removing dissolved, colloidal and particulate matter, like the selectivity in size of pollutants to be removed and the possibility of very compact treatment plants. For example, Reverse Osmosis (RO) technology has been successfully applied for the treatment of dairy wastes (1), and as a technology for concentration and fractionation of whey. In this work a membrane treatment approach using reverse osmosis technology is investigated and implemented: the permeate obtained can be reused as clean warm water for cleaning and sanitation of production plants, while concentrated milk proteins are modified by using transglutaminase enzyme obtaining a high temperature resistant fat replacer to be used in different low-fat products like for example mozzarella cheese. Process parameter effects on membrane fouling, operation costs compared with correct dismissal cost, concentrated protein characteristics and their properties in the final commercial products are investigated. Results show that the use of reverse osmosis treatment is not only a powerful technology to reduce environmental impact but also provides high value secondary by-products.

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076

KINETIC DESCRIPTION OF SENSORIAL AND COMPOSITIONAL ATTRIBUTES AND SHELF LIFE ESTIMATION OF FRESH-CUT 'ICEBERG' LETTUCE STORED IN ISOTHERMAL CONDITIONS

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Changes in the most important sensorial and physico-chemical properties of fresh cut 'Iceberg' lettuce were mathematically described with the aim to better define the most critical factors affecting final quality and give a more accurate shelf-life prediction by using non linear models. After cutting, samples were packaged in commercial conditions with a gas composition of 5% O₂ and 20% CO₂ in nitrogen, and monitored for 10 days at three temperatures (0, 5, and 15°C). Overall appearance, color, odors, off-flavors, off-odors, sweetness, bitterness, and firmness were evaluated using anchored subjective scales. In addition samples were analyzed for total phenolic content, antioxidant activity, and Vitamin C content. The kinetics of sensorial and chemical attributes and their temperature dependence were modeled using a Weibull-logistic model. Moreover the fraction of samples rejected by 15 panelists were recorded and modeled by a logistic model. Potential shelf life was also estimated taking into account both the effect of temperature and the sample thermal history. Results showed that kinetics of sensorial indexes were well described by the "Weibullian" power law model. Particularly, appearance scores for each temperature could be described with a fixed kinetic order of 1.627 showing correlation coefficients always greater than 0.972. Moreover, an increase of temperature from 0 to 5 °C did not significantly accelerate degradation reactions of the majority of sensorial and chemical attributes which, generally showed low constant rates. Shelf life defined as the limit of marketability based on overall appearance (score 3) was estimated in 13.4, 11.9 and 4.6 days for samples stored at 0, 5, and 15 °C respectively. On the other side, considering the odor score, which was the quality attribute with the highest kinetic rate, a shelf-life of 6.7, 6.4 and 2.8 days was estimated at 0, 5, and 15°C respectively. Vitamin C degraded faster at higher temperature, but due to its scarce amount (about 1 mg/100 g) was not used to define shelf-life. In conclusion models applied in this study allowed an accurate estimation of cut lettuce shelf-life and highlighted that shelf-life estimation should be based also on aroma, in addition to the sole external appearance.

077

POSTHARVEST CHARACTERIZATION OF OLIVE OIL FRUITS TEXTURE BY NIR AND VIS/NIR SPECTROSCOPY

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Growing consumption of olive oil and table olives has recently determined an expansion of olive (*Olea europaea L*) cultivation in the world. Maturation control is essential for high quality production. During olive oil fruits ripening, biochemical processes occur: sugar content decreases with time while the oil accumulation increases in an opposite trend, fruit weight increases, fruit skin colour and firmness change. This work studied the applicability of vis/NIR (400-1000 nm) and NIR (1000-2000 nm) spectroscopy as rapid techniques for the characterization of olives texture, directly to the mill just before oil extrac-

tion process. Mechanical analyses were performed on fruit flesh (breaking point force, N; total deformation energy, N×mm; stiffness, N×mm⁻¹) using a laboratory dynamometer. Moreover, a superficial firmness (N) analysis was done using a digital penetrometer. According to external colour, olives were divided in four colour classes (green berries; less than 50% black-pigmented samples; 50% to completely black-pigmented berries; samples completely colored). The destructive analyses and the optical acquisitions were carried out on 100 olives harvested in November 2012, 25 fruits for each ripening class. Principal component analysis (PCA) was performed on vis/NIR and NIR spectra to examine sample groupings and partial least square (PLS) regression algorithm was used to correlate samples spectra and physical properties. Regarding the vis/NIR results, PCA pointed out a good separation among the four ripening classes and according with texture parameters. The best PLS models, in validation, were elaborated for stiffness (R² = 0.85 and RPD = 2.53) and firmness (R² = 0.86 and RPD = 2.67). Slightly better results were obtained for NIR spectroscopy. PCA showed a fairly good separation among classes and the best PLS models were achieved again for stiffness (R² = 0.86 and RPD = 2.72) and firmness (R² = 0.87 and RPD = 2.62). The study provides the sector with postharvest methods and sorting systems for a quick evaluation of olive oil fruits texture. Therefore, the vis/NIR and NIR spectroscopy could give support to producers for preliminary decisions about the destination of olives before the oil extraction process.

078

APPLICATION OF VIS/NIR SPECTROSCOPY FOR NON DESTRUCTIVE MONITORING OF GRAPE WITHERING

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In traditional withering grapes are placed on trays in a single layer and stored at ambient conditions in barns (*fruttai*) for approximately three months. During withering, grapes undergo a weight loss up to 30% due to water evaporation. Wineries need new practical and quick instruments, non-destructive and able to quantitatively evaluate during withering the parameters that impact product quality. The aim of the work was to test an optical portable system (vis/NIR spectrophotometer) in the wavelength range of 400-1000 nm for prediction of quality parameters of grape berries during withering. The chemometric analysis was focused on the correlation between the vis/NIR spectra and the classical destructive quality parameters (texture and soluble solid content, SSC), in order to validate the effectiveness of the system. Sampling was performed two times a month on berries stored at 8-18°C and 50-80% RH for 70 days. A total of 360 red grape samples (*Vitis vinifera L.*, Corvina cultivar) harvested in vintage year 2011 from Valpolicella area (Verona, Italy) were analyzed. Principal component analysis (PCA) was performed on vis/NIR spectra to examine sample groupings within sampling dates. Vis/NIR spectra were correlated with the quality parameters using the partial least square (PLS) regression algorithm. To evaluate model accuracy, the statistics used were the coefficient of determination in calibration (R²cal), the coefficient of determination in cross-validation (R²cv), the root mean square error of calibration (RMSEC), and the root mean square error of cross-validation (RMSECV). PCA showed a clear sample grouping for the different withering stages. PLS models gave encouraging predictive skills for SSC (R²cv = 0.63 and RMSECV% = 5%) and texture (R²cv = 0.62 and RMSECV% = 15%). The work demonstrated the applicability of vis/NIR spectroscopy as a rapid technique for the analysis of the grape quality directly in barns, during withering. This could provide the sector with simple and inexpensive optical systems which can be used to monitor

the withering degree of grape for a better management of wine production process.

079

DEVELOPMENT OF A SOLAR TUNNEL DRYER FOR DRYING WHOLE LIMES IN OMAN

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A half-circled solar tunnel dryer having 16 meter long and 2 meter width was designed and constructed to dry about 300 kg of freshly harvested limes per batch in a single layer. The prototype solar tunnel dryer consists of a flat plate air heating solar collector and drying tunnel, fabricated as a single unit. The length of the collector and dryer portions of the tunnel are 5 m and 11 m, respectively, thus making the total length of the tunnel is 16 m. The light-weight aluminum frames were used as the upper structure for the entire tunnel to support the transparent plastic cover. The tunnel was placed on concrete block sub-structures 550 mm above the ground surface. Over the wooden base, black painted corrugated metallic sheets (0.9 × 2.0 m) of thickness 0.25 mm was used as the absorber plate in the collector section of the tunnel. A solar powered fan of 40 watt capacity was installed at the holes made on the wooden cover plat, 150 mm above the absorber metallic sheet at the air input side of the tunnel. Thus the drying air was forced from the collector region to the dryer region where the product is to be dried. The drying temperature could be easily raised by some 5-300C above the ambient temperature inside the tunnel at an air velocity of approximately 0.5 m/sec. The test was conducted with approximately 300.0 kg freshly harvested limes with initial moisture content of 86.0% (wet-basis) to analyze the performance of the dryer. The limes were dried to a final average moisture content of 8.0% (wet-basis) within less than seven days (\approx 70 hours) whereas it took more than the 30 days in open air natural sun drying to reduce the moisture content to 18% (w.b.). The results indicated that the drying was much faster in solar tunnel dryer than the natural open air sun drying. The improvement in the quality of limes in terms of color, brightness and flavor were distinctly recognized.

080

SAFETY PERFORMANCE ASSESSMENT OF FOOD INDUSTRY FACILITIES USING A FUZZY APPROACH

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The latest EU policies focus on the issue of food safety with a view to assuring adequate and standard quality levels for the food produced and/or consumed within the EC. To that purpose, the environment where agricultural products are manufactured and processed plays a crucial role in achieving food hygiene. As a consequence, it is of the utmost importance to adopt proper building solutions which meet health and hygiene requirements and to use suitable tools to measure the levels achieved. Similarly, it is necessary to verify and assess the level of safety and welfare of the workers in their working environment. The safety of the workers has not only an ethical and social value but also an economic implication, since possible accidents or environmental stressors are the major causes of the lower efficiency and productivity of workers. However, the technical solutions adopted in the manufacturing facilities in order to achieve adequate levels of safety and wel-

fare of the workers are not always consistent with the solutions aimed at achieving adequate levels of food hygiene, even if both of them comply with sectoral rules which are often unconnected with each other. Therefore, it is fundamental to design suitable models of analysis that allow to assess buildings as a whole, taking into account both health and hygiene safety as well as the safety and welfare of workers. Hence, this paper proposes an assessment model that, based on an established study protocol and on the application of a fuzzy logic procedure, allows to assess the overall safety level of a building. The proposed model allows to obtain a synthetic and global value of the building performance in terms of food hygiene and safety and welfare of the workers as well as to highlight possible weaknesses. Though the model may be applied in either the design or the operational phase of a building, this paper focuses on its application to certain buildings already operational in a specific productive context.

081

USING WAVELET TRANSFORMATION FOR PREDICTIVE DETECTION OF DISTURBANCE IN EXTRUSION PROCESSING LINE

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Extrusion cooking is used for the manufacture of food products such as snack-food, breakfast cereals and bread crumbs (in this case the "Japanese bread crumbs"). The co-rotating twin-screw extruder were used to bread crumbs production. Tests were carried out, varying process temperature, dough moisture and mass flow. Early detection of disturbance in extrusion process is an essential goal of this work. It were used different forms of wavelet functions for analysis the color space in manufactured extrudate to estimate the early changes in extrudate properties. Besides the monitoring of wavelet coefficients which can be considerate as indicators of extrusion process evolution were to correlate changes of this parameters with the changes extrudate parameters: expansion, crispness, hardness final product color. There are strong similarities between crispness and hardness and suspect surface color distribution after applying the wavelet transform.

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WAVELENGTH SELECTION WITH A VIEW TO A SIMPLIFIED HANDHELD OPTICAL SYSTEM TO EVALUATE FRESH-CUT VALERIANELLA LOCUSTA LATERR

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In recent years ready-to-eat vegetables consumption has increased in European countries. Fresh-cut fruit and vegetable sector could be greatly helped by new analytical methods that are accurate, rapid and integrated into the production process to meet consumer demand. The aim of this work was to study the feasibility of a simplified handheld and low-cost optical device. This study was focused on identifying the most significant wavelengths able to discriminate freshness levels during the shelf life of fresh-cut Lamb's lettuce. The experimental plan monitored the shelf-life of Valerianella leaves using a portable commercial vis/NIR spectrophotometer (Jaz Modular Optical Sending Suite). Traditional analyses were carried out to characterize the product and to use these parameters as reference data: total soluble solids content (TSS), pH and polyphenols. The Valerianella samples (100 g packs) were stored at three different temperature: 4°C, the best storage tem-

perature; 10°C, temperature that simulate the store conditions; 20°C, improper storage conditions. The packs were analyzed at 20°C only for 7 days starting from the date of packaging and for 15 days, regarding the other two temperatures. Chemometric analyses were performed for the spectra elaboration. Correlation between normalized spectral data matrix and technological parameters (TSS, and pH) and polyphenols were carried out using partial least square (PLS) regression in order to identifying relevant wavelengths sorted from the whole vis/NIR data. Regression coefficients analysis (RCA) was applied on standardized regression coefficients of PLS model in order to select the relevant variables, representing the most useful information of full spectral region. RCA was coupled with qualitative evaluation of the average spectra and PCA (principal component analysis) loading plot to confirm the efficiency of the variable selection. The three selected wavelengths were 520 nm, reflection wavelength for the green colour; 680 nm, corresponding to chlorophyll absorption peak; and 710 nm, representing the third overtone of OH bond stretching. PCA and Multiple Linear Regression (MLR) were applied to effective wavelengths in order to verify the effectiveness of the selection. Results demonstrate the feasibility of a simplified, low-cost handheld device for quickly monitoring the shelf life of fresh-cut Lamb's lettuce.

083

UHF-RFID SOLUTIONS FOR LOGISTICS UNITS MANAGEMENT IN THE FOOD SUPPLY CHAIN

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The availability of systems for automatic and simultaneous identification of several items belonging to a logistics unit during production, warehousing and delivering can improve supply chain management and traceability control. Radio frequency identification (RFID) is a powerful technique that could potentially help to reach this goal, but some aspects as, for instance, food product composition (e.g. moisture content) and some peculiarities of the production environment (high moisture, high/low temperatures, metallic structures) have prevented, so far, its application in food sector. In the food industry, composition and shape of items are much less regular than in other commodities sectors. In addition, a wide variety of packaging composed by different materials are employed. As material, size and shape of items to which the tag should be attached strongly influence the minimum power requested for tag functioning, performance improvements can be achieved selecting suitable RF identifier for each combination of food product and packaging. When dealing with logistics units, the dynamic reading of a vast number of tags originates simultaneous broadcasting of signals (tag-to-tag collisions) which could affect reading rates. In EPC Gen2 protocol, which is nowadays the widespread adopted UHF standard, interrogation phase is controlled by the reader varying some key-parameters that influence the duration and the accuracy of a complete tag inventory. The tuning of these parameters is crucial in dynamic applications as the collisions must be quickly solved, while the objects to be identified are still in the reading area. This paper reports the results of an extensive analysis of the reading performance of UHF RFID systems for multiple dynamic electronic identification of food packed products in controlled conditions. Products were considered singularly or arranged on a logistics pallet. The effects on reading rate and reading zone due to different factors, among which the type of product, the number and position of antennas, the field polarization, the transmitter power output, the interrogation protocol configuration as well as the transit speed, the number of tags and their interactions were analysed and compared.

084

HISTORIC OIL MILLS IN CALABRIA: RETROSPECTIVE ANALYSIS AS A TOOL FOR SUSTAINABLE BUILDING DESIGN

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In Calabria (South Italy) olive oil production has a centuries-old tradition that over time has constructed an agricultural landscape of great cultural value. Here they can be found more than 1100 active olive mills, many of which are historic buildings. Other old building facilities for the production of olive oil, although not in use for their original function, still house and support complementary farm-based activities (tourism, commerce, etc.); other more are redundant and their potential for reuse needs to be considered. Recently the growing interest towards this historic building heritage has been accompanied by the need to develop a sustainable approach to the planning, design and management of new food production facilities. From the point of view of sustainability the reuse of a redundant building, if equally suitable or easily convertible for the specific designated function, is to be preferred to the construction of a new purpose-built facility. Moreover, sustainability requires farsighted building choices; these can be greatly helped and addressed by retrospective analysis carried out on the existing building stock. The present work investigates from this point of view a significant sample of historic purpose-built olive mills in Calabria by studying the changes occurred in them over time periods spanning more than 100 years. Specific attention has been given to those buildings serving agricultural concerns which are still active in the sector of olive oil production, so as to give a more precise description of the evolutionary dialectic between the technical requirements related to production and the corresponding building performance. Observation over a wide time span of the performance offered by specific building organisms helped defining the obsolescence/renovation cycles characterising their subsystems (site, structure, envelope and partitions, machinery, plants, etc.). Moreover, the study of the evolution over time of the productive functional needs, seen in relation to the corresponding capacity to match them shown by different types of buildings, offered important data and information. These last are useful not only for the evaluation of the suitability for reuse of the present building stock, but also for the definition of design-criteria for new olive-oil building facilities in view of sustainability.

085

A CONTINUOUS MALAXING MACHINE FOR HIGH QUALITY OLIVE OIL EXTRACTION

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Oil extraction from olives is a well-established process which consists of several steps: olive defoliation and washing, olive milling, olive paste malaxation, oil separation from water and pomace, oil filtration. In traditional plants, each phase of the process was temporally divided from the other ones, so that each operation required a stop of the whole working line to be performed. As a result, only one lot of olives at a time could be handled. In the last decades, a number of semi-automatic systems were implemented in order to handle different olive lots at the same time, increasing working capacity of mills while reducing manpower and, con-

sequently, operating costs, improving the whole economic sustainability of olive oil production chain. Moreover, the use of these systems allowed the mill conductor to control each phase of the extraction process, monitoring extraction plant operative setting continuously, in order to increase quality of the final product. For what concerns malaxation, a number of studies have been recently carried out to design innovative malaxing machines capable of performing the operation of drop coalescence while reducing operating times significantly. In this context, the Dipartimento di Gestione dei Sistemi Agrari, Alimentari e Forestali (GESAAF) of the University of Florence has started an applied research project for the design and the construction of an experimental malaxing machine which should fulfill the previous requirements. Attention is particularly focused on the design of an efficient thermal control system of the paste. This system is achieved by assembling four cylindrical tubes equipped with a heat exchanger made of a double inner/outer jacket filled with running water. Olive paste continuously flows along the four tubes, enters the upper tube from the olive crusher and is carried along the tubes by four independent screw conveyors, whose rotating velocities can be varied to set the mass flow. This allows one to perform malaxation without interrupting the working line, achieving a fully continuous process. Details of this research project are presented and discussed in this paper, together with some preliminary results.

086

AN OVERVIEW OF EMERGING TECHNIQUES IN VIRGIN OLIVE OIL EXTRACTION PROCESS: STRATEGIES IN THE DEVELOPMENT OF INNOVATIVE PLANTS

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Currently the systems for mechanically extracting virgin oils from olives are basically of two types: discontinuous-type systems (obsolete and dying out) and continuous-type systems. Systems defined as “continuous-type” are generally comprised of a mechanical crusher, a malaxer and a horizontal-axis centrifugal separator (decanter). The “continuous” appellation refers to the fact that two (mechanical crusher and decanter) out of the three machines making up the system operate continuously; the malaxer, which actually is a machine working in batches, is located between these two continuous apparatuses. Consequently the malaxation represents the bottleneck of the continuous extraction process. The entire virgin olive oil (VOO) process has changed very little over the last 20 years. One of the essential challenges of VOO industrial plant manufacturing sector is to design and build advanced machines in order to transform the discontinuous malaxing step in a continuous phase and improve the working capacity of the industrial plants. In recent years, rapid progress in the application of emerging technologies in food processing has been made, also in VOO extraction process. Ultrasounds (US), microwaves (MW), and pulsed electric fields (PEF) are emerging technologies that have already found application in the VOO extraction process on pilot scale plants. This paper aims to describe the basic principles of these technologies as well as the results concerning their impact on VOO yields and quality. Current and potential applications will be discussed, taking into account the relationship between the processing, the olive paste behavior and the characteristics of the resultant VOO, as well as recent advances in the process development.

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MILD SEPARATION SYSTEM FOR OLIVE OIL: QUALITY EVALUATION AND PILOT PLANT DESIGN

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Olive oil, a vegetable oil very important in the ‘Mediterranean diet’ (due to its valuable composition) is obtained from olive fruits (*Olea europea*) by mechanical extraction, carried out using a continuous process based on centrifugation. The entire process involves the breakage of olive fruits to obtain a paste (composed by a mixture of raw oil, water and an heterogeneous solid phase), the kneading of the paste, and a centrifugation, which occurs in a horizontal screw conveyor centrifuge (decanter), to separate the different phases. Extracted raw oil yet contains a small amount of vegetation water and suspended small solid particles (0.5% to 1.0%), so it requires a further cleaning, performed by a disc stack centrifuge, which could decrease the quality and stability of the final product (due to oil heating and dissolved oxygen). In this research, in order to evaluate the effect of final centrifugal separation on olive oil quality and to define and design the settings of a innovative separation system, olive oil was separated off from water using an accelerated separation process, tested in comparison with a disc centrifuge. The laboratory plant used for the trials was constituted by a twin cylindrical separator (arranged in series with the following dimensions: 2 meter high, 0.27 m internal diameter, 0.29 m external diameter, 114 dm³ total volume), was equipped with 4 variable frequency inverters, in order to regulate the fluid flow rates in the plant. Oil samples were collected during the trials to evaluate the influence of the proposed innovative process on oil quality; measured parameters were free acidity, peroxides, specific extinction coefficients K232 and K270, chlorophylls, carotenoids, total polyphenols and turbidity. Results showed statistically significant differences ($P < 0.05$) in some parameters as polyphenols, peroxides, and ultraviolet absorption K232. Oil obtained by the innovative plant showed an higher polyphenols content (181.76 mg/L *vs.* 178.95 mg/L) and a lower peroxides value (2.90 *vs.* 5.11); also the K232 extinction coefficients were found to be lower. Considering the general increasing of olive oil quality induced by non-centrifugal final separation of olive oil an innovative plant was designed using the collected data.

Table 1. Kruskal-Wallis test on the relative differences respect to the reference treatment Control. Multiple comparison tests at 10% significance level. In the bracket the relative percentage variation. Same letter in each row means no significantly difference at stated significance level.

Parameter	Control	Sedoil	Cenoil	P
Free acidity [g/100 g]	0.34	0.28 (-16.78%) ^a	0.31 (-7.57%) ^a	0.724
Peroxide value [meq/kg]	3.4	2.9 (-16.15%) ^a	3.9 (14.63%) ^b	0.001
Total polyphenols [mg/dm ³]	185.2	180.9 (-2.35%) ^a	171.2 (-7.57%) ^b	0.009
Chlorophyll [mg/kg]	23.24	21.28 (-8.43%) ^a	14.44 (-37.86%) ^b	0.003
Carotenoid [mg/kg]	12.29	11.06 (-10.00%) ^a	8.87 (-27.78%) ^b	0.009
K ₂₃₂ [AU]	1.614	1.489 (-7.72%) ^a	1.693 (4.89%) ^b	0.001
K ₂₇₀ [AU]	0.231	0.183 (-20.70%) ^a	0.205 (-11.03%) ^b	0.024
Turbidity [NTU]	129.6	94.1 (-27.38%) ^a	93.7 (-27.69%) ^a	0.825
Water content %	3.0	0.9 (-69.56%) ^a	0.7 (-76.51%) ^a	0.566
Temperature [°C]	33.3	29.8 (-10.42%) ^a	34.0 (2.10%) ^b	0.000

088

NUMERICAL MODELS OF MASS TRANSFER DURING RIPENING AND STORAGE OF SALAMI

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Ripening, in the dry sausages manufacturing process, has an influence over the main physical, chemical and microbiological transformations that take place inside these products and that define the final organoleptic properties of dry sausages. A number of study about the influence of ripening conditions on the main chemical and microbiological characteristics of dry sausages is available today. All these studies indicate that the final quality and safety standards achieved by the sausage manufacturing process can be considered to be strictly dependent from the specific ripening conditions. The water diffusion inside a seasoned sausage is surely an aspect of primary importance with regard to the quality of final product. As a consequence the aim of this research was to develop two parametric numerical models, concerning the moisture diffusion physics, describing salami ripening and storage. Mass transfer equations inside the sausage volume were numerically solved using a finite element technique. A first model describes diffusion phenomena occurring inside the salami and the exchange phenomena involving the surface of the product and the environment. After the ripening, the salami are stored in waterproof packaging, consequently an additional model able to describe also the evaporation and condensation phenomena occurring between the salami surface and the air in the package, was developed. The moisture equilibrium between salami surface and conservation atmosphere is mainly ruled by the temperature changes during storage. Both models allow to analyze the history of the moisture content inside the salami and is parametrised on product size and maturation/storage conditions. The models was experimentally validated, comparing the numerical outputs of the simulations with experimental data, showing a good agreement.

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MECHANICAL CALIBRATION IN "PGI TROPEA RED ONION" POST HARVEST OPERATIONS

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The growing interest expressed by consumers toward food products quality as well as toward their linkage to the territory, has led producers to fit to the continuous rising demand for "typical products", and to look for new and more efficient production and marketing methods. An emblematic case is represented by Tropea red onion that, as a typical product, plays an important role in the economy and the promotion of the territory to which it is linked. The alimentary quality offered by "Tropea-Calabria Red Onion", PGI certified, have to be associated also, to the quality of services that accompany its processing. Technology application in post-harvest operations, has certainly contributed to make faster and less tiring all processing tasks. The main problem related to the mechanization of Tropea red onion post-harvest operations lies in the removal of the various layers of the external tunic, making it impossible for optical or electronic sorting to achieve it in a satisfactory way since the sensors are not able yet to separate the "bulb" from its involucre. In this context, the current study aims to assess the functionality of three different machines used for round

Tropea red onion calibration, and determine their work efficiency. The carried out analysis highlighted the ability of the studied machines to ensure a high work capacity, while maintaining a high level of precision during calibration procedure. Such precision allows to decrease laborer employment and increase processing chain speed, rising as well the annual use of the machines, favoring consequently processing cost savings. For a more profitable employment of such machines, it is, however, necessary from one hand, to properly form the technicians responsible of plants management, and from the other hand to be able to take advantage of a capillary technical assistance network, able to serve users in a short time.



Figure 1. Calibrating machine with inclined belts.



Figure 2. Lift roller sizer



Figure 3. Continuous screen sizer.

090

TECHNICAL AND ECONOMICAL EVALUATION OF MACERATION OF RED GRAPES

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For red wines, a fundamental aspect covers the phase of maceration which affects important features such as color, aroma and flavor. For wines for daily consumption these features must provide an easily drinkable product with a good quality basis over consistent time. In

recent years two methods of maceration seem to guarantee better than others these objectives, while also allowing good organization and automation of work: the thermal maceration and pneumo-carbonic replacement. An evaluation of these techniques has been made in a large cellar, defining for the two operational lines the productive potential, the need for labor, energy consumptions and economic costs. Chemical and sensory evaluations were carried out for wines produced from grapes with the same characteristics.

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THE USE OF HYPERSPECTRAL IMAGING IN THE VIS-NIR TO DISCRIMINATE 'ITALIA' TABLE GRAPES FROM DIFFERENT HARVEST TIMES

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This study evaluated the feasibility of using a spectral scanner VIS-NIR (DV Srl, ver 1.4., Italia) with a detector in the region between 400-1000 nm to discriminate 'Italia' table grapes from different harvest times (HT). Fifteen clusters were harvested for 4 HT between October and November 2010; spectra were acquired on 15 intact berries from each bunch, which were averaged resulting in a total of 60 spectra. Classification models were constructed comparing 2 methods: SIMCA (Soft Independent Modeling of Class Analogy) and PLS-DA (Partial least squares discriminant analysis). The SIMCA model was developed building individual PCA models for the spectra of each HT. Different pre-treatment methods were tested in order to enhance the power of the model, thus enhancing the score differences among samples from different HTs. To this aim scores for the first principal component (PC1), obtained after each transformation, were subjected to one-way analysis of variance (ANOVA), and means were separated using Tukey's test. The transformation which allowed the best separation among scores of grape from different HT was the Second Derivate of Savitzky Golay, therefore the PCA model obtained from the spectra subjected to this pre-treatment were used for SIMCA classification. The PLS-DA model were developed applying the PLS2 algorithm and using the "discriminant equation" option in the WINISI II (version 1.50). In order to construct discriminant models to classify bunch spectra by the 4 HTs, spectral variations were correlated with the 4 established categories. All models were constructed using full cross-validation (leave-one-out), suitable for small sample sets. No pre-treatments were applied in this last case since they did not improve the final result. The SIMCA method was unable to correctly classify grapes from the III HT (33% of correct classification), resulting less efficient compared to the PLS-DA model. With PLS-DA model, all the grapes were correctly classified (100%) with the exception of those from the II HT which were classified at the 87%. The overall results demonstrate that this instrument has excellent potential for the discrimination of grape quality. In particular, this approach can be considered a fast methodology that allows growers to improve fruit harvesting.

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STEEL SIEVES FILTER AND STRIPPING FOR THE QUALITY OF EXTRA VIRGIN OLIVE OIL

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Filtration is a widely spread procedure adopted after the olive oil extraction process to remove the suspended solids and to eliminate humidity, making the oil more brilliant and more stable. In Tuscany, the most common filtration equipment are filter-presses. Those devices are able to reach the aims of filtration but they show some disadvantages. First of all, filter-presses consume not re-generable filter sheets. These represents a direct purchasing cost as well as an indirect cost due to the trapping of a relevant oil amount. Furthermore, the use of filter sheets implies complications for their disposal. To partially overcome these issues a new filtration equipment able to reduce the filter sheets consumption has been designed. The main idea is the addition of steel sieves before the filter-press capable to retain the suspended solids. In this way, the filter sheets only have to hold the humidity of oil. The addition of the sieves increases the amount of processed olive oil up to about five times before the filter sheets has to be substituted. In addition, the opportunity of performing the stripping techniques to remove the dissolved oxygen from the olive oil is provided. The dissolved oxygen is shortly consumed by the oil in a few days and seems to act as a starter for the subsequent autoxidation reactions. This was confirmed by the faster quality decay kinetics during shelf-life of the oils with higher dissolved oxygen concentration, according to previous researches. In the presented device, the adoption of the stripping technique was able to halve the dissolved oxygen concentration in the treated extra virgin olive oils. Thus, the innovative filter should be able to considerably reduce the filter sheets consumption, and to improve the olive oil shelf-life through the reduction of the dissolved oxygen amounts. However, before the adoption of this kind of devices at the industrial scale, further investigations are necessary.

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SHELF LIFE MONITORING OF FRESH-CUT VALERIANELLA LOCUSTA LATERR USING NON-DESTRUCTIVE TECHNIQUES

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The aim of this work was to select the main quality parameters to be used for the shelf life assessment of fresh-cut *Valerianella locusta* Laterr., among the mostly requested baby-leaf commercialized in the Italian market. Fresh-cut *Valerianella locusta* Laterr. samples were purchased directly from the producer, the day of the packaging, and stored at three temperatures (4°C, 10°C and 20°C). The sampling was performed for 15 days for the *Valerianella* samples preserved at 4 and 10°C, and for 7 days for the samples preserved at 20°C. The research was focused on testing non-destructive analytical systems for quality monitoring during the shelf life. A sensory device (electronic nose, EN) and two optical systems (vis/NIR spectroscopy and fluorescence) were applied. Moreover conventional chemical (pH and humidity) and nutritional (total phenolic content, TP) parameters were investigated. EN

was applied in order to evaluate the ability of the instrument to monitor changes in the aroma profile of samples during storage. Data collected were elaborated by principal component analysis (PCA) and the loading analysis demonstrated that W5S was the relevant sensor in the discrimination of Valerianella samples during the shelf life. The Valerianella spectra derived from vis/NIR spectroscopy were processed with PCA and the results showed that this technique could be effective in discriminating samples among the different sampling dates. Moreover the vis/NIR device was tested for the quick estimation of the chemical parameters measured at each sampling date for each storage temperature, using partial least square (PLS) analysis. PLS models were good for the prediction of pH, humidity and TP, with R2 values in cross-validation equal to 0.81, 0.84 and 0.80, respectively. Regarding the fluorescence results, the PI. (indicator of the leaf photosynthetic activity) proved to be an effective index for the control of the fresh-cut Valerianella freshness. The results demonstrated that EN and the optical systems could be suggested as rapid and non-destructive methods for evaluating the quality decay of Valerianella leaf during storage. The information provided could be useful for a better management of the product along the distribution chain, ensuring the product quality to the consumer.

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CONTROL OF MIXING STEP IN THE BREAD PRODUCTION WITH WEAK FLOUR AND SOURDOUGH

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Recently, several old Italian grain varieties have been reinstated, and the market seems to reward the breads made with these flours. Among such varieties, cultivar Verna appears to be interesting because the regular consumption of bread obtained by this variety and sourdough provides beneficial effects on human health such as the improving of the lipid, inflammatory, and hemorheological profiles. However, flours derived from Verna shows low technological performances. For example, the W value of these flours, obtained with alveographic tests and considered as the commercial standard for the flour "strength" evaluation, is largely inferior than the W values of the commercial flour blends currently used in the bread making process. Moreover, the W values broadly change among the batches of Verna flours, whereas, usually, commercial blends are provided to bakeries with standard technological properties. Hence, these properties of Verna flour could lead to developed or overworked doughs and therefore to breads of worse quality. In addition, the previous mentioned large variability of flours from Verna can affect also the sourdough microbiota. For these reasons the composition and activity of the sourdough microorganisms should be controlled while the mixing process should be able to adapt to the different flour properties. Some works, in literature, report that monitoring the electrical consumption could provide useful information about the dough rheology, and this could be used to monitor the mixing step. In the present work the effect of different mixing times are evaluated on breads made with Verna flour type 2 leavened with sourdough. Tests were carried out at industrial scale in two different days. During the tests the electric consumption was monitored to highlight some features suitable for the mixing phase control. The breads were evaluated in terms of loaf volume measurement, crumb image analysis and losses of moisture content during storage. The results show that the composition of the sourdough microbiota and the mixing time affects

the produced bread, especially when it is baked with low technological performance flours. Bread baked with an appropriate mixing time shows higher loaf volumes and lower water losses during storage.

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KINETIC AND THERMODYNAMIC PROPERTIES OF SOYBEAN DURING THE DRYING PROCESS

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This study aimed to fit different mathematical models to experimental data of soybean grain drying cultivar Valiosa determine and evaluate the effective diffusion coefficient, to obtain the activation energy and the thermodynamic properties for the process during drying under several air conditions. The experiment was conducted at the Instituto Federal de Educação, Ciência e Tecnologia Goiano – Câmpus Rio Verde. The soybean cultivar Valiosa, with an initial moisture content of 0.56 dry basis (d.b., decimal) were dried in an oven with forced air ventilation in five temperatures of air conditions: 40, 55, 70, 85 and 100 °C until the moisture content of 0.133 ± 0.019 (d.b.). Among the models tested, the Page model was selected to represent the phenomenon of drying. The effective diffusion coefficient of soybeans grains increase with increasing air temperature and was described by the Arrhenius equation, which has an activation energy for liquid diffusion of 22.77 kJ mol⁻¹. The enthalpy and entropy decrease with increasing temperature, while the Gibbs free energy increase with increasing drying temperature.

POWER AND MACHINERY IN AGRICULTURE AND FORESTRY

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TRACTION PERFORMANCE SIMULATION FOR MFWD TRACTORS: TOWARDS A PRACTICAL COMPUTER TOOL

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An analytical model to simulate the traction performance of mechanical front wheel drive MFWD tractors was developed at the Agroscope Reckenholz-Tänikon Research Station ART. The model is based on an analysis of the stress-strain interaction at soil-tyre contact surface. This analysis assumes the soil to behave as a plastic non-linear medium, the wheel to roll in steady-state motion at a low velocity, and the tyre to deformation in linear elasticity. The soil-tyre contact surface in the longitudinal direction has a parabolic form with the apex at the rear point of contact, and the wheel-soil interaction is two dimensional (plane-strain problem). The model was validated via several field tests in which the relationship between drawbar pull (net traction) and wheel slip was measured for four MFWD tractors of power ranging between 40 and 123 kW on four arable soils of different texture (clay, loamy silt, silt loam, and sand). The pulling tests were carried out in steady-state controlling the pulling force along numerous corridors. Different configurations of tractors were considered by changing the wheel load and the tyre pressure or using dual tyres. Both soil and tyre mechanical parameters are required as input data for the model. The soil strength and stiffness were calculated from results of vertical plate penetration tests and horizontal plate shear deformation tests executed with a tractor-mounted bevameter. The tyre dynamic stiffness was calculated with an empirical equation. Simulations of traction performance matched experimental results with good agreement, particularly when single tyres were used (mean error of 9% with maximum and minimum values respectively of 39% and 1%). The model presented was used as framework for developing a new module for the excel application TASC3.0.xlsm. This module simulates the traction performance of MFWD tractors on the basis of three practical in-situ tests which allow a fast mechanical characterization of the topsoil. With this module, TASC3.0.xlsm offers a valuable support to compare different tractor configurations, soil textures and conditions and determine variants which make for better traction performance, this resulting in saving fuel and time, reducing tyre wear and limiting topsoil damage.

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SOIL MANAGEMENT EFFECT ON SOIL PENETRATION RESISTANCE IN THE VINEYARD

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In environments characterized by steep slopes or arranged in terraces, among the shallow tillage systems, rototilling is extensively used. However, the effect of the repeated use of rototilling has a considerable influence on soil characteristics; it appears finely powdered, soft and without structure. In order to limit these inconveniences, an

innovative self-propelled machine equipped with working tools as a spade, to be used in steep slopes or arranged in terraces areas, was designed by the Mechanics Section of the SAF (Scienze Agrarie e Forestali) Department of the University of Palermo in cooperation with Agrotec company, Padua, Italy. The aim of this study is to compare the effects of three machines for shallow tillage: a chisel plough (CP), a rototilling (RT) and a spading machine (SM) on penetration resistance in semi-arid environments of the Mediterranean basin. No tillage was also included. Penetration resistance (PR) was surveyed for all the treatments to a depth of 300 mm with an electronic dynamometer. The treatments consisted in the execution of a shallow tillage to a depth of 150 mm. SP treatment allowed us to obtain PR lower values throughout the tillage profile than RT, CP and NT. It follows that the type of machine used influences soil PR, and then the soil water storage capacity, key factor for the agricultural productions in semi-arid environments as in Sicily.

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STUDY OF A TEST METHODOLOGY TO ASSESS POTENTIAL DRIFT GENERATED BY AIR-ASSISTED SPRAYERS

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Spray drift may cause diffuse contamination of the environment with agrochemicals, therefore in recent years several measures have been adopted to prevent it and to mitigate its pollution risks. In some European countries buffer zones are already prescribed with specific widths that are defined according to the spraying equipment employed and its conditions of use. This criteria will soon be extended to all EU countries to comply with the requirements of EU Directive 128/2009 on sustainable use of pesticides. It will be therefore necessary to foresee a classification of all sprayers types and configurations according to drift risk. The only available methodology to assess spray drift using air-assisted orchard sprayers is actually the ISO 22866, which is difficult to apply for drift classification purposes and is expensive. In order to provide an alternative to this method, a set of preliminary tests were made aimed at defining a new methodology for the assessment of potential drift generated by fruit crop sprayers. As already experimented with field crop sprayers, ad hoc test benches – developed by University of Torino and Salvarani-AAMS company – were used to assess potential drift generated by air-assisted sprayers in open field and in absence of wind. The fallout footprint was assessed spraying a water solution of E 102 Tartrazine tracer on permanently discovered samplers (plastic Petri dishes 150 mm diameter); the persistence of the spray cloud in the atmosphere after the sprayer pass was evaluated measuring the deposits of sprayed solution on samplers discovered only after the sprayer pass. Preliminary tests were made employing different air-assisted sprayers models (either for vineyards or for orchards), comparing the use of conventional and air induction nozzles and different air settings. Results of these first tests pointed out that the method proposed is able to provide information useful to estimate the potential drift generated by each sprayer type and configuration, but they also enhanced some difficulties in obtaining a good reproducibility of results between test replicates. Further studies are under way to optimize the methodology in order to get an affordable classification of sprayers according to drift risk.

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REPAIR AND MAINTENANCE COSTS OF 4WD TRACTORS AND SELF PROPELLED COMBINE HARVESTERS IN ITALY

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Purchasing and maintaining tractors and operating machines are two of the most considerable costs of the agricultural sector, which includes farm equipment manufacturers, farm contractors and farms. In this context, repair and maintenance costs (R&M costs) generally constitute 10-15% of the total costs related to agricultural equipment and tend to increase with the age of the equipment; hence, an important consideration in farm management is the optimal time for equipment replacement. Classical, R&M cost estimation models, calculated as a function of accumulated working hours, are usually developed by ASAE/ASABE for the United States operating conditions. However, R&M costs are strongly influenced by farming practices, operative conditions, crop and soil type, climatic conditions, etc. which can be specific for individual countries. In this study, R&M cost model parameters were recalculated for the current Italian situation. For this purpose, data related to the R&M costs of 100 4WD tractors with engine power ranging from 59 to 198 kW, and of 20 SP combine harvesters (10 straw walkers combines and 10 axial flow combines) with engine power ranging from 159 to 368 kW working in Italy were collected. According to the model, which was obtained by interpolating the data through a two-parameter power function (proposed by ASAE/ASABE), the R&M cost incidence on the list price of Italian tractors at 12,000 working hours (estimated life of the machines) was 48.6%, as compared with 43.2% calculated through the most recent U.S. model while, for self propelled combine harvesters, the R&M cost incidence at 3,000 working hours was 23.1 % as compared with 40.2% calculated through the same U.S. model.

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THE RHEA-PROJECT ROBOT FOR TREE CROPS PESTICIDE APPLICATION

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The sustainable use of PPP (Plant Protection Products) and the need of a renewed integrated system of agricultural knowledge and management, focus the designing of the EU FP7 RHEA Project (Robot fleets Highly for Effective Agriculture and forestry management – www.rhea-project.eu). The objectives are the design, development, and testing of a new automatic generation of robotic systems to perform field operations for the sustainable crop management. The project affects three case study: chemical, physical, mechanical and thermal effective weed management in maize and wheat cultivations and chemical pesticide management in woody crops. To achieve the goals, a fleet of small and heterogeneous robots – ground and aerial – equipped with advanced sensors, innovative end actuators and decision control algorithms were realized. Six integrated modules make up the RHEA system: Mission Manager (MM), Perception System (PS), Communication and location System (CS), Actuation System (AC) divided into High Level and Low Level Decision, Mobile Units (MUs) and the Base Station and Graphic User Interfaces (GUI). Present work is related to the third case study considered *i.e.* the spraying in woody crops specifically in olive trees.

The plantation pattern was 4.0 m inter-row and 1.5 m distance on the row to reach a foliar wall as flat and regular as possible. With these variables, different solutions about pesticide spraying and air vector devices management were investigated. The final decision on woody perennial crops treatment device system, was oriented toward a complete double side air blast sprayer with eight separate spraying modules on four vertical bands of the canopy. The system consist of a detection system composed of eight ultrasonic sensors, to detect data on canopy width in four vertical band and innovative solution to control air blast and flow rate. Finally, actuation rules for each devices to better fit optimum spray features (air and liquid flow rate) on each vertical bands of the canopy were defined. Rhea air blast sprayer introduces some important innovations in the studies concerning the pesticide variable rate treatment, *i.e.* the management possibility of air flow in site specific way and in real time in function of the target.

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EXPERIMENTAL TESTS ON A NEW HARVESTING SYSTEM FOR BURLEY TOBACCO

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The globalization of the tobacco production has led to a drop in competitiveness of the Italian tobacco on the world market. Burley is the main variety of tobacco cropped in Campania region of Southern Italy. Its leaves have to be sewn, in the curing phase. Aim of this work is to show the results of the implementation of a new harvest machine prototype. Basically, the machine used for Bright tobacco, totally mechanical harvested, which doesn't need to be sewn because it requires an indirect-fire treatment into the curing furnaces. The machine was modified in order to mechanize harvesting of Burley tobacco, and tested on four cultivars of Burley tobacco under three different planting layouts. The Burley tobacco leaves can be harvested mechanically by pulling individual leaves off the stalk; leaves are then sorted and tied in bundles prior to sewing. A mechanical burley tobacco harvesting system was evaluated. This machine consists in realizing a leaves orientation system based on the different weight between the leaf blade and the stalk enhanced by an air flow. The measurements taken were harvest timing, work capacity, and quality standards of the work carried out. The results, in terms of user time, range from 6.67 h/ha to 7.80 h/ha while in terms of operational efficiency are between 88% and 89%. The average user capacity recorded for the four cultivars is equal to 0.14 ha/h, a value far from the one recorded for the same harvesting machine used for Bright tobacco (0.25 ha/h). The harvest timing capacity, range from 5.06 q/h to 9.94 q/h. The work productivity goes from 1.69 q to 3.31 q per hour of human unit respectively. The average number of detached leaves, depending on the cultivar, has been between 523 and 744. Concerning the leaf orientation, a general percentage of 73% was achieved.

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NUMERICAL AND EXPERIMENTAL ANALYSIS OF VERTICAL SPRAY CONTROL PATTERNATORS

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The experimental vertical spray control walls have the purpose of picking up the liquid delivered by trained sprayer for providing the liquid distribution profile in height. Theoretically this should correspond

to the ideal profile, which consists in a uniform distribution on the vegetation. If the profile is different from the ideal, a parameter setup is required on the sprayer. Nonetheless, some problems are hidden in the aforementioned statements: 1) no wall measures exactly the distribution profile (ie the flow through the sections in the vertical plane, parallel to the direction of advancement of the sprayer). Compared to real profile, sensitive errors are introduced: the evaporation of the drops, the deviation of the air flows caused by the sensors panel themselves; by the possibility that the drops bounce on the wall panels, also due to the current of air that can push the liquid veil laterally or upwards. Moreover, everything varies depending on the geometry of the sensors, air velocity, air humidity; 2) no one knows what exactly is the optimal distribution profile. It is often considered as optimal a profile that reflects the amount of leaf area subtended by each section absorber: however, it is evident that the path of the droplets changes according to the sprayer typology (eg. radial-flow or horizontal flows). In this work a combined numerical-experimental approach is adopted, in order to assess some of the aforementioned issues: numerical data obtained by using computational fluid dynamics models are compared and validated with experimental data, in order to assess the influence as some of the operating parameters which are difficult to analyze using an experimental setup.

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PRELIMINARY EVALUATION OF A SRF POPLAR BIOMASS SUPPLY CHAIN IN EMILIA ROMAGNA

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Woody Biomasses (from agriculture and forestry activities) are among the most promising renewable energy sources. Current literature describes woody biomass feedstock supply chains supporting bio-fuels and utilities industries: the potentially productive land area overheads required for biomass production may result in a complex logistic within the whole chain. Its effective enhancement requires significant changes in the logistics environment of energy plants for sustainable energy production and these changes are furthermore complicated by the sequence-dependent procurement chains for biomasses. According to this, optimizing harvesting and supplying operations turns out to be strategic within the framework of the current energy policy. In this work we present a case study carried out monitoring 53 short rotation forestry (SRF) production sites placed in Emilia Romagna, all supplying the harvested biomass to the same biomass power plant placed in the province of Ravenna (Italy). The overall average yield of these sites was 55 t/ha and the site surfaces ranged from 0.3 to 20 hectares and the distance from the power plant ranged between 8.2 to 102 km with one production site only within 10 km from the power plant. Harvest and transport costs were calculated according to two different harvesting scenarios: i) single phase harvesting (one cutting/chopping machine + tractors and trailers); ii) double phase harvesting (cutting/mowing machine followed after 80 days by chopping machine + tractors and trailers). Results show that, according to

the first scenario, at increasing distances overall harvesting and transport costs ranged from 8.9 to 21.0±1.3 €/t, while, with reference to the 2nd scenario, they increased from 10.3 to 23.8 ± 1.5 €/t with the transportation costs "weighing" from 16 to 70% of the total costs. The Authors acknowledge the role of the "SUSCACE Project" (Scientific Support to Agricultural Conversion towards Energy Crops) for funding the study.

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CHIPPING MACHINES: DISC AND DRUM ENERGY REQUIREMENTS

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Air pollution and fossil fuel reserves exhaustion are increasing the importance of the biomass-derived products, in particular wood, as source of clean and renewable energy for the production of electricity or steam. In order to improve the global efficiency and the entire production chain, we have to evaluate the energetic aspects linked to the process of transformation, handling and transport of these materials. This paper reports results on a comparison between two chippers of similar size using different cutting technology: disc and drum tool respectively. During trials, fuel consumption, PTO torque and speed, processing time and weight of processed material were recorded. Power demand, fuel consumption, specific energy and productivity were computed. The machine was fed with four different feedstock types (chestnut logs, poplar logs, poplar branches, poplar sawmill residues). 15 repetitions for each combination of feedstock-tool were carried out. The results of this study show that the disc tool requires, depending on the processed material, from 12 to 18% less fuel per unit of material processed than the drum tool, and consequently, from 12 to 16% less specific energy. In particular, the highest difference between tools was found in branches processing whereas the smallest was in poplar logs. Furthermore the results of the investigation indicate, that, in testing conditions, the productivity of drum tool is higher (8%) than disc tool.

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TRACTOR ACCELERATED STRUCTURAL TEST ON TEST RIG

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The experimental tests performed to validate a tractor prototype before its production, need a substantial financial and time commitment. The tests could be reduced using accelerated tests able to reproduce on the structural part of the tractor, the same damage produces on the tractor during real life in a reduced time. These tests were usually performed reproducing a particular harsh condition a defined number of times, as for example using a bumpy road on track to carry out the test in any weather condition. Using these procedures the loads applied on the tractor structure are different with respect to those obtained during the real use, with the risk to apply loads hard to find in reality. Recently it has been demonstrated how, using the methodologies designed for cars, it is possible to also expedite the structural tests for tractors. In particular, automotive proving grounds were recently successfully used with tractors to perform accelerated structural tests able to reproduce the real use of the machine with an acceleration factor higher than that obtained with the traditional methods. However, the acceleration factor obtained with a tractor on proving grounds is in any case reduced due to the reduced speed of the tractors with respect to

cars. In this context, the goal of the paper is to show the development of a methodology to perform an accelerated structural test on a medium power tractor using a 4 post test rig. In particular, several proving ground testing conditions have been performed to measure the loads on the tractor. The loads obtained were then edited to remove the not damaging portion of signals, and finally the loads obtained were reproduced in a 4 post-test rig. The methodology proposed could be a valid alternative to the use of a proving ground to reproduce accelerated structural tests on tractors.

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DEVELOPMENT OF A PROTOTYPE OF HAZELNUT HARVESTER SUITABLE FOR ORCHARDS IN SLOPED AREAS

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This work deals with the problem of hazelnut harvesting in sloped areas and the aim consist in suggesting a solution through the development of small machinery. The developed prototype consists of a small transported vacuum machine, equipped with its own combustion engine and a small hopper for the product. To allow it to be transported and used in unfavorable conditions, as a self-propelled machine, it was assembled to a mini crawler transporter with hydrostatic transmission. The power can be derived both from its own engine and from the transporter engine, however the best use is with the two different motors, taking into account the costs not so high of the engines. Strengths of the machine are its ease of use and versatility: thanks to the use of easily interchangeable accessories, and ease of handling and transportation, the machine is able to significantly reduce business costs. The experimental research has been realized both in Piemonte, in the Langhe area in the province of Cuneo, and in Sicily in the park of Nebrodi, where harvesting tests have been carried out to determine the working capacity of the prototype. The tests revealed excellent behaviours according to the orography of the areas and fairly good working capacities of the machine (from 40-50 kg/h in difficult conditions to 100-120 kg/h in orchards characterized by medium accidentality and not irregular). The research was carried out under the project "SICIL-NUT" funded by the Italian Ministry for Agriculture (MIPAAF).

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MONITORING OF THE TRACTOR WORKING PARAMETERS FROM THE CAN-BUS

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The analysis of the tractor mission profile is one of the main objectives for tractor manufacturers. The mission profile has usually been estimated through the use of questionnaires submitted to consumers. This procedure is time-consuming and not totally reliable due to the trustworthiness in the questionnaire compilation. In all the high power tractors numerous transducers are fitted to monitor some parameters to optimise the operation of the machines. All of these transducers are connected to an electronic central unit or with the tractor CAN-Bus. In this context, a system able to monitor the working parameters of the machines capitalising the existing transducers could represent the optimal solution for monitoring tractors distributed in different regions. The high number of signals are in any case difficult to memorise without a high quantity of memory. The goal of the paper is to define a methodology to memorise the operation parameters useful to

define the mission profile of a tractor using a small memory. A tractor of a nominal power of 170 kW was selected and a system able to measure the signals acquired by the transducers fitted on the tractor was connected to the CAN Bus of the tractor. After a detailed analysis of the parameters measured on the tractor, the useful parameters were defined and acquired in different working conditions. The analysis of the parameters stored in the memory has allowed a detailed analysis of the operational parameters of the tractor in different applications. These parameters could be used by engineers to design tractors with a higher quality and reliability and also to define predictive maintenance criteria and reduce unexpected tractor failures.

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HARVEST OF TABLE OLIVES BY MECHANICAL OLIVE HARVESTING TOOLS

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The use of an labor saving machine that beating the branches with sticks or canes to make all the mature olives causes a lot of damage to the fruits that depreciate the product in the assignment phase and during the transformation and they can originate a loss of product consistency leading to poor quality. In this work three different type of coating materials (Silicon, Vulcanized rubber and Natural rubber), thickness of materials (7 mm; 14 mm and 19 mm) and velocity (2000 rpm; 3000 rpm and 4000 rpm) of undulate teeth was tested to evaluate the damage of intact drupes. The aim of this paper was to evaluate the combination, in terms of the best performance, of the machines used for mechanized harvesting of table olives in order to assess the damage caused to the olives after being harvested. In terms of the best performance of the materials, during the harvest, the silicon at 7mm and 14mm determine the small percentage of damage on the fruits respected to the natural rubber and to the vulcanized rubber. The paper shown that it is possible use a combination of speed to rotation mechanical tools and different plastic materials for harvest table olives by direct contact with the crown. These reduced the damage of the fruits harvested in all the theses and will be applicable at all the types of drupes and plants that had an high of the plants by to 2.5 meters and 3.5 meters. The working conditions that were used, allowed a variation of rotational speed up to 3000 rpm without modifying significantly the results of the percentage of intact fruits. Furthermore, the theses, with low rotational speed, silicon and natural rubber coatings and with a minimum coating of undulating teeth (S1V1S and S1V1C), show a percentage of intact fruits significantly different from all the other ones.

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EXPERIMENTAL TESTS ON WINTER CEREAL: SOD SEEDING COMPARED TO MINIMUM TILLAGE AND TRADITIONAL PLOWING

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In comparison to the traditional plowing and the minimum tillage, the sod seeding technique has been tested on winter cereal in order to evaluate the differences in energy consumption, labour and machinery requirements, CO₂ emission reduction. The tests regarded the wheat seeding over mais and alfa Alfa, by: the sod seeding anticipated by weeding in the case of the plots over alfa-alfa; traditional plowing at 35 cm depth followed by a rotary tilling and combined seeding(seeder + rotary tiller); minimum tillage based on ripping at the same depth (35 cm) and

combined seeding (seeder + rotary tiller). The following farm operations - fertilizer, and other agrochemicals distributions- were the same in all the theses. The results, statistically significant ($P < 0.001$) in terms of yields, highlighted moderate differences: the best data in the case of the traditional plowing both over mais and alfa alfa (6.75 and 8.44 t/ha); moderate lower yields for the sod seeding (6.23 and 7.99 t/ha for mais and alfa alfa respectively); lower for minimum tillage (5.87; 7-97 t/ha in the two situations). Huge differences in energy and oil consumption have been recorded : in the case of wheat over mais 61.47; 35.31; 4.27 kg oil/ha respectively for, the traditional plowing, the minimum tillage and the sod seeding; in the second case, over alfa-alfa, 61.2; 50.96; 5.14 kg oil/ha respectively for the traditional plowing, the minimum tillage and the sod seeding. The latter highlighted an huge energy saving with an oil consumption equal to the 92 % and 89% ($P < 0.001$) of what occurs in the traditional powing and minimum tillage. Large differences concern also the labour and the machines productivity. These parameters joined to the oil consumption and the machines sizes (kW,t) lead to even greater differences in terms of energy consumption, efficiency and CO2 emissions savings. Considerations related to the different mechanizations chains , the investment required and some new practice to be introduced, such as the low pressure tyres or crawlers, ideal lanes, GPS and automatic guide , conclude the study.

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WATER SENSITIVE PAPERS SIMULATION TO ASSESS DEPOSITS ON TARGETS

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In a previous study the Authors evaluated the possibility to use water sensitive papers to estimate, beside the superficial coverage, also the spray features and the amount of deposit on the target. Producing, by means of simulation, some images of water sensitive papers sprayed with droplets of different pulverisation degree and different coefficients of variation of the droplet diameter, it was found a significant correlation between spray volume collected by the water sensitive papers and data achieved from the images. In the present paper the Authors intend to investigate this aspect thoroughly, by extending the study to sprays characterised by wider ranges of mean diameters and to water sensitive papers with greater superficial coverage. Specifically, they were considered sprays with droplet diameters log-normal distributed and mean diameter ranging from 100 up to 500 μm with step of 20 μm , coefficient of variation equal to 50%, and theoretical values of superficial coverage (not considering overlapping), ranging from 10 up to 100% with step of 10%. For each value of mean diameter and theoretical superficial coverage, they were carried out three replicates, so producing a total of 630 images. The images were produced by using the open source software R by adopting some simplifying hypotheses and their analysis, as effective water sensitive papers, was carried out by means of the ImageJ software. The study demonstrated that, according to the assumptions (effective covered surface not exceeding 70%) the volume used to produce the images is related to the percentage of covered surface by a quadratic relation, but influenced by the mean droplet diameter, achievable from the images themselves. This implies that the reading of the percentage of covered surface only allows the determination of a more complex parameter as the unitary deposit. Moreover, beside the superficial coverage, and then the deposit, the image analysis of the water sensitive papers offers other information such as the impact distribution, all parameters strictly related to the efficacy of a phytosanitary treatment. The data examination is still in progress and the whole results will be reported in the full paper.

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WEAR RESISTANCE ENHANCEMENT OF TOOLS FOR AGRICULTURE AND FOREST APPLICATIONS

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One of the causes that mainly affect durability and working efficiency of many tools commonly implemented in agricultural and forest operations is wear. Wear is in general associated to different physical events occurring at tools interface, mainly ascribable to abrasion, erosion, fatigue, adhesion and fretting phenomena. For agriculture and forest operations, the tools typically come into contact with soil, soil residuals, coarse or fine gravel, moss with high silica content, bark and wood of different density and composition: therefore wear can be most typically associated to abrasion and erosion. The possibility of enhancing tools mechanical properties is of the highest importance, implying two important results. Firstly it would allow increase of tools life, with not only minor investments for tools renewal or substitution, but also with reduced machine downtimes and time losses. Secondly the minimization of tools distortions can improve the quality and/or speed up agricultural or forest operations. A cost effective choice for enhancement of tools mechanical properties is the implementation of coating technologies. Coatings have been studied and applied for many years in many technological fields, but only in the last decade they have reached a mature level, with process quality and costs suitable for high performance low-cost demands of agriculture and forest applications. In the present study different coatings technologies (thermal spray, plasma and welding coatings) were selected and compared, to quantify the increase in tools performance, in terms of duration increase and wear reduction. Coatings were chosen so as to have the same cost incidence: in particular it was set to a maximum of 60% of the total tool cost. Field tests were carried out on two different machines, a harrow and a chipper, highlighting interesting improvements on tools performance.

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BAND-STEAMING A NEW SOLUTION FOR SEEDBANK DEPLETION IN LOW COMPETITIVE VEGETABLES

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Weed competition is a major problem in organic agriculture, because the use of herbicides is prohibited. Vegetable crops are generally the most sensitive from this point of view, especially the sown ones, because they often need plenty of time for emergence. This often implies a large effort for hand weeding in the rows, which are very difficult to be treated physically in a selective way. Soil steaming could be a possible solution for preventive weed control/weed seedbank depletion in organic/integrated low-competitive vegetable crops, in order to reduce labor time for in-row hand-weeding. The effect of bioflash system (consisting in the distribution of steam and CaO) on weed seedbank was “exploited” to develop a new machine for “band-steaming”. In this case, steaming is performed just in strips, where the crop will be successively sown. Each strip corresponds to one crop row. The machine is drawn and is equipped with a water tank, a hopper containing the exothermic compound (CaO) and an industrial steam generator providing an outflow of about 1300 kg h⁻¹. The steam generator unit is connected to a 5.10 m wide, PTO-driven rotary cultivator with 12

units. Each unit is connected to a steam pipe and is characterized by the rotating tool and a carter which bears the steaming bar. The tested working speed ranged from 0.2 to 0.5 km h⁻¹. The steam injection is superficial in order to kill the weed seeds till a depth of about 5 cm. The prototype has been tested on carrot in four organic farms spread throughout Italy. The results are encouraging as the soil temperature peak was about 80 °C and the weed emergence reduction, 10 days after planting, ranged on average from 70% up to over 90%. On average the 50% of labour demand for hand weeding was saved (about 200 h ha⁻¹). However the machine needs to be improved in order to make the steam injection more efficient and this treatment more sustainable (more effective and cheaper).

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BERMUDAGRASS TRANSPLANTING: A NEW TECHNIQUE FOR PROFESSIONAL FOOTBALL PITCH INSTALLATION IN UNTILLED SOIL

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Warm-season species are more and more replacing the "common" cool-season turfs for sports and recreational uses, in Italy, according to the excellent adaptability to the Mediterranean environment. Turf establishment can be performed in many different ways, like seeding, stolonizing/sprigging or sodding. An innovative technique of planting was recently patented in Italy ("Erbavoglio system"). It consists in transplanting pre-cultivated warm season turgrass plants (similar to horticultural nursery). It is based on the quickly ground cover capacity of these species by means of stolons and rhizomes. "Erbavoglio system" allows to easily convert from a cool-season turf to a warm season turf. Transplanting can be performed both in tilled and untilled soil. This second option allows the site to be used immediately after planting, as the better soil carrying capacity is provided by untilled soil. The work yard for the conversion from a cool season turf to bermudagrass (*Cynodon dactylon* (L.) Pers x *transvaalensis* Burt-Davy) of the "Stadio Comunale Sant'Elia" placed in Cagliari, Italy, was assessed from the may 31st 2011 to June 1st 2011. The work yard was characterized by the following machines/operators:

- a 41 kW 4WD tractor;
- a common 4-row mechanical transplanter, which was adjusted to work in the untilled mowed football pitch and accommodates 4 back-seated operators (one per row, planting distance: 25 cm inter-row and 24 cm intra-row);
- 4 walking operators who manually transplanted the plants in case of failure.

The working speed of the tractor was about 0.7 km h⁻¹, the theoretical working time about 15 h ha⁻¹, the actual working time 28 h ha⁻¹, thus the work efficiency was about 0.52. The fuel consumption was about 28 kg ha⁻¹. The planting regularity of the transplanter was very low because of the stolons-net, which made very tough the work of the back-seated operators, who had to move the plants from polystyrene trays to the delivery device of the operative machine. This parameter improved considerably after the pass of manual transplanting. In this concern, an automatic transplanter was modified in order to work in untilled soil within a second specific trial.

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DESIGN OPTIMIZATION OF ROTARY TILLER'S BLADE

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Now a days due to continuous increase in the price of fossil fuels resulted tremendous increase in the cost of land preparation. This directly increases the cost of food. The situation is becoming worsened day by day because of prevalent use of the conventional tillage system in the preparation of seedbeds, particularly for deep tillage. This system of tillage escalates land preparation costs because it requires a series of operations using passive tillage tools to realize an acceptable tilth quality. It also ties down capital in the form of additional machinery and tillage tools; thus increasing significantly the cost of land preparation. Rotary tiller or rotavator is a tillage machine designed for seedbed preparation. It offers an advantage of rapid seedbed preparation and reduced draft compared to conventional tillage. Nowadays, utilization of rotary tillers has been increased in agricultural applications because of simple structure and high efficiency for this type of tillage implements. By taking advantage of rotary tillers, the primary and secondary tillage applications could be conjugated in one stage. This results in a decrease in the number of machinery passes, causes a decrease overall costs for land preparation. However, in a Rotary tiller, Blades are the main critical parts which are engaged with soil to prepare the land. These blades interact with soil in a different way than normal plows which are subjected to impact and high friction which ultimately creates unbalancing and non uniform forces on the rotary tiller which results wearing of the blades as a whole. The continuous fluctuating impact of soil crust / clods / stone develops high stress areas on blade tip or blade critical edges which in turns decreases the service life of a blade. Therefore, it is necessary to optimize the design of blade so that these blades experience less stress and at the same time service life also enhanced. This paper aims at design optimization of rotary tiller blades using latest design tool like CAD/CAM, FEA etc. The paper also suggests the optimized design of blade through the analysis results.

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PROCEDURE AND LAYOUT FOR THE DEVELOPMENT OF A FATIGUE TEST ON AN AGRICULTURAL IMPLEMENT BY A FOUR POSTER TEST BENCH

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The increasing demand in power requirements, payloads and driving speeds of agricultural vehicles increases problems related to the exposure of tractor and implements to solicitations. One of the main question of testing agricultural machines is to take into account the heterogeneity of the environment and activity in which the tractor operates. In particular, for contractors is significant also the use in transport conditions, both on terrain, both on road. Considering transport, the factors that mainly influences solicitations on carried implement are the roughness of the soil profile, the tractor setting and the forward speed. This work aims to analyze the possibility of creating a standard profile of solicitation by a four poster test bench for a fatigue test on a carried implement simulating the transport condition. The project foresees to:

1) acquire, during transport on field, time histories representatives of severe conditions, 2) reproduce these situations in laboratory at a four poster test bench, 3) create a "standard" time history, 4) replicate it for a required number of hours. Four terrain test bench different as roughness and hardness, an agricultural tractor and a carried combined implement were used for the tests. Accelerations at the hubs of the tractor were acquired and reproduced at an electro-hydraulic four poster test bench on a dummy of tractor developed for carrying the implement. The displacement of the plates defined the simulation of the vertical input of the fields' surfaces. The worst case scenario was selected. Evaluations were made with the manufacturer for choosing the level of amplitude of the time history respect to the nominal 100% of the field. Artificial bump were mathematically created and introduced in the time history for simulating squares solicitations. Twelve hour of test were carried out. The experience confirmed the possibility of carrying out in laboratory fatigue test on agricultural implements by a four poster test bench.

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OPTIMIZATION OF THE SURFACE SHAPE OF THE CHESTNUTS HARVEST NETS

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The most part of the zones of interest for the chestnut cultivation, is characterized by excessive soil slope and by difficulty of access. The mechanical harvest machines available on the market still have notable operational limits as it regards the steep zone of the soil considered, sensibly reducing their performances with soil slope higher than 20%. In such case, only the harvest by mean harvest nets it is possible. Indeed in this research chestnuts harvest and conveyance nets have been considered and the optimization of the surface shape of the chestnuts harvest nets has been performed. Indeed, a steep zone with chestnut trees has been considered, of around maximum length of 90 m and maximum width of 60 m and the geometric model of the considered zone has been obtained, by mean Archicad 14 program code, obtaining also the local slope distribution. The chestnuts fallen has been simulated by mean a "rain device" available in Sitetopo program code. This program has allowed to evaluate the rain draining in function of the considered surface slope. Further, the zone with lower quote, for the considered surface, is the zone in that the chestnuts have to be conveyed, "basin zone". Indeed, by mean Sitetopo program code, it has been possible to evaluate the rain draining contour-plot, and the conveyance effect, that is, where the rain flow is conveyed, performing changing of the net surface slope on that, the rain (simulating the chestnuts) fallen. By mean iterations, it has been possible to obtain the optimal net geometric shape that convoyed the rain (chestnuts fallen) in the desired "basin zone". Indeed the nets have been located following the determined optimal surface. In such way all the chestnuts have been picked in an only determined zone, "basin zone", and subsequently they have been loaded on the truck for the following workmanships. The evaluated losses have been of around 6-8% due to chestnuts entangle or little branches obstacle.

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AERODYNAMIC PROPERTIES OF SIX ORGANO-MINERAL FERTILISER PARTICLES

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Agricultural fertilisers are generally applied by means of centrifugal disk spreaders. The machinery, the working conditions and the physical characteristics of fertilizers (including the aerodynamic characteristics of particles) may affect the behaviour of particles after the discarding from the spreader. We investigated the aerodynamic properties of organo-mineral fertilisers (a class of slow release fertilisers that are less investigated since they are relatively new in the market) using a vertical wind tunnel similar to an elutriator. In the same time, the morphological characteristics of individual fertilizer particles were measured by means of an image analysis procedure. In the study we compare six different fertilisers and we discuss the suitability of the employed methods. The results provide the terminal velocity – V_t – (the velocity value that overcome the gravity force of the particles) of the particles, ranging from 8.60 to 9.55 m s⁻¹, and the relationships between V_t and some physical properties (mass, shape, dimensions) of the fertilizers. Moreover, the results of field distribution trials show the behaviour of the tested fertilizers during practical use. Such data can contribute to enhance the quality of application of these products in field.

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DYNAMIC-ENERGETIC BALANCE OF AGRICULTURAL TRACTORS: ACTIVE SYSTEMS FOR THE MEASUREMENT OF THE POWER REQUIREMENTS IN STATIC TESTS AND UNDER FIELD CONDITIONS

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Modern tractors are characterized by the introduction of devices designed to increase the operative performances of the machines, such as systems for monitoring and controlling various functions (through a massive use of electronics and hydraulics), or deputed to improve the comfort of the driver (paying more attention to ergonomics, air-conditioning, noise and vibration). Such devices need energy to be operated, affecting the energetic balance of the tractor. In this context, the availability of suitable methodologies and instrumental systems could be useful to provide objective, accurate and reliable measurements of the performances of the tractors under different conditions, also considering the power requirements from ancillary services and/or simulating the coupling with operating machines. The tests on the performances of tractors are now made using different methods, including the trial codes issued by the OECD Codes. Beyond their undoubted validity, they fix standard test conditions that often do not adequately represent the operative reality, so that, much remains to investigate on the actual performances provided by the tractors. From this point of view and with reference to fixed point tests, a test bench was developed for the measurement of the power required by various devices, such as transmission and air conditioning. It was used in experimental tests a tracked tractor and on a wheeled tractor, aimed at validating the test device, measuring the power absorption related to the rotational speed of the

organs of propulsion and to the characteristics curves, in order to quantify the power drawn by the transmission and by the air conditioning and assess the residual power for other tractor functions. As to field conditions, a study is being conducted at CRA-ING, within the project PTO (MiPAAF), to develop a mobile test bench aimed at evaluating the power required by different operations, such as self displacement, traction, use of power take off, their combination. The system simulates such operations by applying to the tractor, by means of a system of sensors and actuators operated by feedback signals, working cycles combining force of traction, pto torque, hydraulic power, derived from data recorded during real field test with agricultural machines.

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EFFECT OF DIFFERENT WINTER PRUNING SYSTEMS ON GRAPES PRODUCED

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The purpose of these trials was to evaluate possible changes in the physical and mechanical properties of grapes depending on the winter pruning system. The following pruning techniques were carried out: manual pruning (m); mechanical pruning (M); mechanical pre-pruning and fast hand finishing, this method had a wagon facility with two operators equipped with pneumatic scissors (M + m). The trials were carried out on Sangiovese trained by cordon spur. During the trials were measured: time and cost of pruning, quality of pruning and the vegetative-productive response of vines. During grape harvesting a consolidated analytical method of texture analysis was applied to evaluate the physical parameters of grapevine cultivar: pedicel detachment, skin perforation, skin thickness, grape features as hardness, cohesiveness, springiness. Analysis of working time showed that the manual pruning (m) determined a greater commitment of time, while the mechanized pruning (M) presented a time reduction of 94%. The mechanized pruning associated with manual finishing (M+m) reduced the time of 67%.



Figure 1. Texture Analyzer used.

The lowering cost is less evident but important anyway. Regarding the quality of pruning compared with the manual pruning, the mechanical one gave an increase of spurs and buds density. It was also detected a higher percentage of damaged spurs and in wrong position. Generally, the increasing of mechanization levels of pruning gave origin to more

bunches, more sparse with smaller berries. The study of mechanical properties of berries showed significant differences in the mechanical behaviours of the different pruning tests. The mechanized pruning (M) presented higher values for the pedicel detachment, skin perforation, cohesiveness and springiness. The results showed that mechanical pruning can modify properties of the berries which can influence other mechanical interventions on vineyard.

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SOIL TILLAGE QUALITY OF A SPADING MACHINE IN COMPARISON WITH A TRADITIONAL PLOUGH AND HARROW COMBINATION

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Due to the roughly good clods production into the tilled soil layer, the spading machine is a tool frequently used in open-field horticultural cultivations. In defined conditions, it is considered an interesting alternative to the traditional plough and harrow combination in primary soil tillage, for the possibility of creating in just one pass a suitable seedbed, or at least a good soil layer for transplanting. The advantages of adopting a spading machine could be represented by: - a better timeliness in soil working, especially in case of poor weather trend (*i.e.* long rainy periods); - no creation of a compacted bed at the bottom of the tilled layer (typical of the ploughing); - no reversal of the worked soil, so preventing the emergence of infertile layers; - good incorporation of the crop residues (*i.e.* organic matter) along the entire tilled layer and not only in its bottom; - production of clods of various dimensions, so preventing an excessive shredding of the soil that could led to shallow crust creation in case of a dry period subsequent to heavy rain (typical of rotary hoe working). On the other hand, the tractor coupling with the spading machine is characterized of no (or poor) need of traction pull, but a remarkable PTO power request and a low travelling speed. The performances of a 1.5 m working width spading machine manufactured by Selvatici (S. Lazzaro di Savena, BO - Italy) were compared to a traditional plough and harrow combination in terms of: - working capacity: surface tilled, worked soil volume and elevation; - working quality: superficial clod dimensions, crop residues incorporation; - fuel consumption: related to the working time, surface and soil volume; - tractor power efficiency: - traction pull and slip; - noise and vibration level at the tractor's driving place. The results confirm the suitability of the spading machine in representing a profitable alternative to the traditional soil tillage solutions especially when a timeliness soil preparation is requested for transplanting.

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THE CROSS-BORDER PROJECT BETWEEN FRANCE AND ITALY MARS +. SUB-PROJECT "INNOVATIVE TECHNOLOGIES FOR THE MECHANIZATION OF THE AREAS HARD TO REACH"

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The care and protection of the mountain areas and their traditional crops were some of the reasons that led regional governments of Liguria and Tuscany to participate in the strategic project "Sea, Countryside and Land: potentiate the strategic unitarily" (MARS +). This project has also involved the participation of the four cross-border regions: Tuscany (leader), Sardinia, Liguria and Corsica. The aim was to promote the development of the innovations and entrepreneurship in the rural areas in order to increase competitiveness. In particular, the subproject SC has provided the transfer of innovations to facilitate the processes of mechanization in vineyards and olive orchards in contexts defined as "heroic", areas of high landscape and environmental value in which the typical cultures has been always carried out, generally, on terraces or slopes. These conditions require a great effort by the farmers and result in high production costs. The transfer of the innovations has provided the organization of demonstration days in which the technological solutions for the management of the farming operations in vineyards and olive orchards were proposed and tested. During these events, the participative process was fundamentally reconfirmed, not only as a means to expand the knowledge of innovative products, but also as an opportunity for farmers, retailers, manufacturers, researchers, and local administrators to interact and facilitate the development of other technologies. The parameters that led to the innovative solutions included: the small size, user-friendliness, agility, and the ability of operating on systems not easily accessible. These products must also ensure the ergonomics and safety of workers performing all the growing operations. A thorough research of the available technologies and prototypes, still under development, affirms the presence of many innovations. These innovations not only allow the execution of all the field operations in the vineyard and olive orchards and significant time and cost reduction but also ensure the performance in complete safety. This research has shown the constant development of these products and how the use of electronics and mechatronics is becoming more prevalent.

ANALYSIS, MODELING AND PLANNING OF RURAL AREAS

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STATIC CONSOLIDATION OF A RENAISSANCE PALACE BY RESINS, PINS AND CONNECTING RODS

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The paper reports the results of a research on the static consolidation of an important XV century tower by Bramante belonging to an important monumental complex located in the Po Valley which was showing worrying structural conditions. The tower, 19 m high, very thin, lacking connections in the highest part, showed overturnings of the four façades not in plumb by over 150 mm; Due to the presence of architectural terracotta elements, it was not possible to intervene on the external facades. This is why the authors decided to create a sort of hoop from inside using a U (120 mm) steel profile fastened to the walls by means of steel pins anchored with epoxy resins. The pins (12 mm, 350 mm length) have been positioned at a distance of 50 cm inclined by 30° alternatively downwards and upwards in order to get at minimum of 2+2 courses of bricks. Then, by a series of steel tie rods it was possible to tie the opposite walls. Finally, triangular frames have been positioned on the 4 corners in order to avoid teething collapse in case of great stress. Before starting with the strengthening work, as described above, experimental tests, supported by the Bossong company, were conducted to verify tensile stress resistance of each pin. The tests studied different solutions in terms of diameter and anchoring material. The tensile tests, carried out by using a specific hydraulic puller equipped with a dynamometer and a displacement transducer, showed very high allowable loads, between 20 and 60 kN/pin depending on the pin and fastening type. According to data obtained, the most suitable solution was chosen; it was also used in other parts of the castle. The behavior of the reinforced structure, which withstood the February 2012 earthquake without any problem demonstrated the validity of the proposed technique which is an interesting, non invasive solution for historical buildings. Key words: historical building restoration; anchoring means; static consolidation

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THE STUDY OF RURAL LANDSCAPE AT THE FARM SCALE: CHANGES IN TRADITIONAL SIGNS AND STRUCTURES

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The importance of cultural, historical and identity values of traditional rural landscapes is widely acknowledged in the legislation and scientific fields. Furthermore, knowledge of their evolution represents a fundamental basis in order to manage landscape transformations appropriately. The work is part of a broader research aimed at developing and testing a method for the systematic high time and spatial resolution assessment of changes in traditional rural landscape signs. We describe here the main phases of this original quantitative method and some of the first results of an Italian case study. A set of parameters allows to provide complementary information about the evolution of the main characters of rural settlements and their components. This proves to be essential to achieve a deep

understanding of the traditional physiognomy of places, and to support landscape management and restoration, and the definition of transformation projects.

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HISTORICAL ROAD SYSTEM AND FARMHOUSES IN APULIA

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Human settlements often originate from the presence of such natural sustaining water bodies as springs, rivers, or rather from the proximity of relevant infrastructure (roads, harbours, etc.). Rural residential buildings, however, are generally closely linked to the cultivated fields of a farm. A significant example of rural buildings, that particularly identifies some national or regional areas, is that of the Apulian farmhouses known as “masserie”, which are considered as an important cultural heritage in the rural territories of that region. These buildings, featuring relevant architectural and landscape characteristics, encompass several functions within them and often host more than one family living there permanently. Territorial distribution of rural buildings and farmhouses in Apulia is diversified and, in general and as already stated, it can depend on the close relationship between the building and its adjacent agricultural lot. Moreover, in the case of the Apulian farmhouses, owing to their specific role in overseeing the territory and asserting land tenure rights, this distribution may have “genetic” origins influenced by other elements, too. The efforts of the present work regarding this issue are to investigate the existing relationships between the Apulian farmhouses system and the “historical” roads already existing when they were built (XII-XIX centuries). Particularly, the study proved if there are any correlations among the Roman roads, the sheep’s paths (tratturi) crossing the Apulia region and the farmhouses, both from the point of view of the distance from the roads and the importance of the individual farmhouses. Using GIS software and overlay mapping procedures it was possible to quantify the amount of farmhouses and their concentration within the catchment areas of the aforementioned historical roads, while through historical and territorial in-depth analysis those elements characterizing the most interesting farmhouses from the historical and architectural point of view were identified. The research provided interesting information on the existing relations between historical roads and farmhouses, leading to further considerations on the possibility to enhance some of these monuments, located in rural areas, through the promotion of the “integrated” asset represented by the historical road system, with particular reference to the sheep’s paths (tratturi).

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LAND USE CHANGE IN THE VENETO FLOODPLAIN AND CONSEQUENCES ON MINOR NETWORK DRAINAGE SYSTEM

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Anthropic pressure has been proven to be one of the most evident forces able to alter landscapes. Its impact on the surroundings can be easily detectable especially in a high-density populated country such as Italy. Among the most evident anthropic alterations, the most important are the urbanization processes but also changes in cultural techniques that have been occurring in rural areas. These modifications influence

the hydrologic regimes in two ways: by modifying the direct runoff production and by having a strong impact on the drainage system itself. The main objectives of this work are to evaluate the impact of land cover changes in the Veneto region (north-east Italy) on the minor drainage network system, and to analyze changes in the direct runoff in the last 50 years. The study area is a typical agrarian landscape and it has been chosen considering its involvement in the major flood of 2010 and considering also the availability of data, including historical aerial photographs, historical information, and a high resolution LiDAR DTM. The results underline how land cover variations over the last 50 years have strongly increased the propension of the soil to produce direct runoff (increase of the Curve Number value) and they have also reduced the extent of the minor network system to the detriment of urbanized areas and changes of plots of land boundaries. As a consequence, the capacity of the minor network to attenuate and eventually laminate a flood event is decreased as well. These analysis can be considered useful tools for a suitable land use planning in flood prone areas.

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URBAN-RURAL GRADIENT DETECTION USING MULTIVARIATE SPATIAL ANALYSIS AND LANDSCAPE METRICS

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The gradient approach allows for an innovative representation of landscape composition and configuration not presupposing spatial discontinuities typical of the conventional methods of analysis. Also the urban-rural dichotomy can be better understood through a continuous landscape gradient whose characterization changes accordingly to natural and anthropic variables taken into account and to the spatio-temporal scale adopted for the study. The research was aimed at the analysis of an urban-rural gradient within a study area located in central Italy, using spatial indicators associated with urbanization, agriculture and natural elements. A multivariate spatial analysis (MSA) of such indicators enabled the identification of urban, agricultural and natural dominated areas, as well as specific landscape transitions where the most relevant relationships between agriculture and other landscape components were detected. Landscapes derived from MSA were studied by a set of key landscape pattern metrics within a framework oriented to the structural characterization of the whole urban-rural gradient. The results showed two distinct sub-gradients: one urban-agricultural and one agricultural-natural, both characterized by different fringe areas. This application highlighted how the proposed methodology can represent a reliable approach supporting modern landscape planning and management. Keywords: Urban-rural gradient, agriculture, spatial indicators, multivariate spatial analysis, LULC, GIS, landscape metrics.

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DETERMINANTS OF SEA EFFECTIVENESS: AN EMPIRICAL INVESTIGATION OVER MUNICIPAL MASTER PLANS

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The Autonomous Region of Sardinia has adopted the regional landscape plan (in Italian, Piano paesaggistico regionale, PPR) in 2006. PPR is a coordinative planning instrument about protection and promo-

tion of sustainable landscape transformations and requires that its instructions are implemented by provincial and municipal bodies. Currently, municipal master plans (in Italian, Piano Regolatore Generale, PRG) are being adapted according to the new regulations introduced by PPR. The administrative procedure of adaptation implies Strategic Environmental Assessment (SEA) in order to evaluate environment and landscape effects of territorial transformations. The aim of this paper is to scrutinize the level of application and effectiveness of SEA over municipal spatial planning in Sardinia. We develop an empiric exercise that regards the interpretation of personal statements of public officials involved in SEA procedures. Information is drawn from structured on-line interviews powered through Google Drive applications. The process includes three stages: i) a preliminary telephone interview directed to check officials' prior agreement to participate in the survey; ii) completion of an on line questionnaire revolving around 20 issues clustered into four key themes; and iii) interpretation of the results, reflections about the strengths and weaknesses, and outlook discussion on the perspectives of SEA processes in Sardinia and Italy. The first stage has started in December 2012: so far, 75 out of 196 municipal officials (38%) have been contacted. Among the municipalities that implemented the SEA process, only four officials have filled out the questionnaire. Municipalities contacted in the first stage have been grouped into six clusters in order to present a preliminary taxonomy of SEA implementation in Sardinia at the level of local spatial planning. In the next few months, we will scrutinize the questionnaire's answers through a comparative analysis and present the results of this study.

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CONSEQUENCE OF LAND USE CHANGES INTO ENERGY CROPS IN CAMPANIA REGION

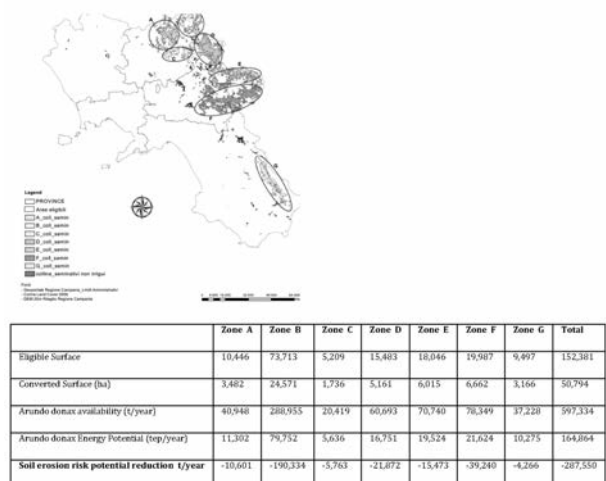
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Campania region is undergoing a new and important land use change (LUC). Large areas under tobacco are experiencing a severe economic crisis and cereal areas, especially in the hill, are cultivated with increasing difficulty, with poor economic results (yield value of 2.5 t/ha/year) and under the risk of erosion. No-food crops suitable in these contexts are the poliennial and in this case, the land use change would certainly lead to a positive impact on reducing erosion, but also on the reduction of nutrient requirement, on fuel consumption and perhaps it would also lead to an increase in profitability. The aim of this work is to identify the areas in which the land use change could be realistic and ecologically compatible and to evaluate the main consequence of the LUC. The study area includes the entire Campania region. It has been assumed that the areas that will undergo the LUC will be the hilly, not-irrigated cereal crop, with altitudes between 400 and 750 m a.s.l., not included in natural parks, in the Site of Community Importance and in the Special Protection Areas. Through the climate model, inferred from the Ground Water Protection Plan, the area to be examined was classified as 'cold Lauretum' (Pavari), which is a good area for the *Arundo donax* crops up to 750 m a.s.l., with recoverable biomass yield in the order of 12.6 t/year. The erosion has been estimated with RUSLE applied to the whole region. Using the Arcgis software seven large areas, partially convertible, were identified (Figure 1). The area that is realistic to convert amounted to approximately 500 km². The value of the biomass production has been evaluated in the order of 25 million euro a year; actual wheat production would be 33 million euro a year but the production costs are far greater. With LUC there is a reduction in soil erosion in the

order of 300000 t/year. This would lead a saving, on global scale, in the order of 10 million tonnes of CO₂ per year.

Shape 1: Macroareas resulting from the study



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DETECTION OF LANDSCAPE PATTERNS IN AIRBORNE LIDAR DATA IN THE NATURE RESERVE OF CASTELPORZIANO (ROME)

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During the last decades the protection of nature has become a very important aspect due to the anthropogenic interference and structural alteration of the environment, especially in the peri-urban areas. Therefore, for a sustainable forest planning it is fundamental to get information about the actual state and the variation in landscape patterns of the forest layers. To this aim, an airborne laser scanning (LIDAR), a type of sensor which explicitly measures canopy height, was used to measure structure of broadleaf oak forest and for detecting the monumental trees in a peri-urban Natural Reserve: the Presidential Estate of Castelporziano (Rome). Methodology A data set developed in GIS environment of airborne LIDAR scanning, aerial photographs and sampled fields was used to detect the different landscape patterns and the census of the monumental trees in the Presidential Estate of Castelporziano. For detecting the different landscape patterns, we used POURING algorithm to establish the trees crown for the different layers of the forest and for the census of monumental trees. Results In this study, we identified and quantified the different landscape patterns present in the Estate of Castelporziano by determining the different layers of the forest. It was also possible to identify all the monumental trees and their main characteristics. Conclusion and perspectives The methodology used represent a strategic tool for forest management aimed at conserving landscape diversity and its characterizing features that make it a unique landscape. The data collected in this study provide a useful knowledge base for future monitoring.

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THE ASSESSMENT OF THE VISUAL PERCEPTION IN VIEWSHED ANALYSIS FOR THE LANDSCAPE SETTINGS

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Visibility studies for rural and forest landscape are well established and conducted by means of standard GIS tools that compute the viewshed (a binary representation of the visibility of a location from a certain viewpoint) and cumulative viewsheds (integer representations of the visibility of a location from more viewpoints obtained with raster algebra) analyses. However, in order to go beyond the sole geometric information if a cell is visible or not, some authors have introduced various concepts that are based on the visual magnitude or visual exposure. These concepts also take into account the target magnitude, the atmospheric extinction, the colour difference to the background and the visual acuity. However, these calculations may be complex, extremely time consuming and not affordable with standard GIS tools, because they require specific programming tools. Besides, depending on the application, the factor that affects the visibility may be the distance, the atmospheric extinction, the contrast, etc. In this work, we concentrate on the problem of the calculation of the visual attenuation with the distance that must be taken into account in order to produce more realistic results, also when using standard GIS tools. The visual attenuation depends not only on the visual acuity, but also on the contrast between the target and the surrounding, the atmospheric visibility and the recognition process of the subject. For every reason, a limit visibility distance may be defined. This distance may be time dependent and is a function of the target size, of the atmospheric conditions and on the subject preferences. Various examples in rural settings are presented in order to demonstrate the problems that arise in real applications and the possible solutions.

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EVOLUTION OF SOME MEDITERRANEAN CULTURAL LANDSCAPES FROM HISTORICAL AERIAL PHOTOGRAPHS

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Aerial photos represent the main existent database providing evidence of landscape changes with high detail. The analysis of land cover changes plays a key role in understanding a great variety of phenomena in several research fields. Landscapes are made by society and reflect the changing society and attitude towards the environment. The reorientation of farming system, the practical results of planning processes, the rate and magnitude of the changes in the landscape are some of the most important factors relating to the evolution of our landscapes and are very helpful for the understanding of evolution processes and consequently for the design of landscape-orientated policies. Pressures upon the landscape and values of our landscapes can be defined according to their traditional characteristics; traditional landscapes can be defined as those landscapes having a distinct and recognizable structure, which reflect relations between the composing elements and have a significance for natural, cultural or aesthetical values. In most cases, such landscapes evolved slowly and took centuries to form their values. Sometimes land changes happen fast and spread in vast areas so that some agricultural or natural landscapes, widely perceived as tradition-

al, have very recent origin. In this paper, some preliminary observation and case-studies performed on a set of historical photos are dealt with. In 1935, the Italian Land Register Department commissioned SARA company to survey Viterbo province between 1935-1938 through aerial photographs. During the survey, 5,000 photographs on glass plates were taken at a very low altitude, featuring a very high resolution. Thus, they represent a valuable source of information for documenting past and present land-use practices, local cultural heritage and changes in the landscape. Processing this set of historical photos has started, aimed to quantitatively and qualitatively analyse the 1935-1938 landscape patterns and their role in the development of nowadays landscapes.

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IDENTIFICATION OF RURAL LANDSCAPE CLASSES THROUGH A GIS CLUSTERING METHOD

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The paper presents a methodology aimed at supporting the rural planning process. The analysis of the state of the art of local and regional policies focused on rural and suburban areas, and the study of the scientific literature in the field of spatial analysis methodologies, have allowed the definition of the basic concept of the research. The proposed method, developed in a GIS, is based on spatial metrics selected and defined to cover various agricultural, environmental, and socio-economic components. The specific goal of the proposed methodology is to identify homogeneous extra-urban areas through their objective characterization at different scales. Once areas with intermediate urban-rural characters have been identified, the analysis is then focused on the more detailed definition of periurban agricultural areas. The synthesis of the results of the analysis of the various landscape components is achieved through an original interpretative key which aims to quantify the potential impacts of rural areas on the urban system. This paper presents the general framework of the methodology and some of the main results of its first implementation through an Italian case study.

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LOMBARDY REGION FONTANILI FUNCTIONAL ASSESSMENT

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The "fontanili" are springs made and managed by humans. They are characteristic elements of the Po valley rural landscape. The fontanili have been dug for irrigation purposes from the XII century, and over time they have also taken on ecological and landscaping role. They have an ecological role because they can host typical wetlands animals and plants, otherwise disappeared in the Po Valley. The fontanili are a characteristic feature in the rural flat landscape, formed by a succession of crops, irrigation canals, rows of trees and wooded areas with inside these springs. Starting point of this work was the Lombardy Region Fontanili database, including about 1150 points checked and classified by direct survey under the project named "FonTe" funded by Lombardy Region. The aim is to define which functions a fontanile can still play today and to identify those indicators that allow to characterize different functions. The identified functions are three: recreational, ecological and irrigation. The methodology used consists in the analysis of the surrounding area of the springs, identified by 100, 300 and 500 meters buffers from the head of the spring. For the three functions, elements that contribute to the assessment were chosen, these elements have

been mapped, measured and evaluated by definition of synthesis indicators. The ray of influence was identified for the three functions. Finally point values were interpolated to identify groups of fontanili spatially close and with values of similar indicators. In this way areas more important to protect fontanili system were identified. This approach has enabled us to produce for the first time a functional assessment of fontanili standardized and valid for all 1150 Lombardy springs: the results can be used as assessment tool included in the rural planning activities both at regional and provincial level. Every fontanile can be protected and recovered in accord with its main function.

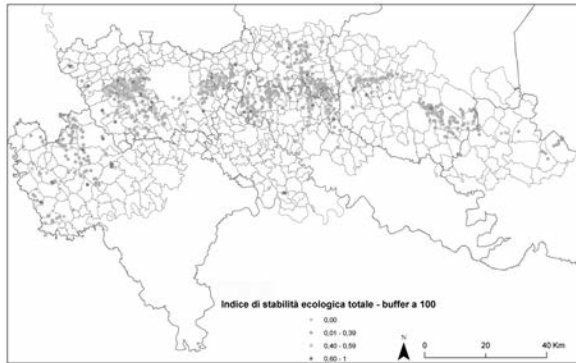


Figure 1.

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APPLICATION, VALIDATION AND COMPARISON IN DIFFERENT GEOGRAPHICAL CONTEXTS OF AN INTEGRATED MODEL FOR THE ECOLOGICAL NETWORKS DESIGN

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The issue of the fragmentation of natural habitats is increasingly at the core of the scientific debate, yet it is not taken into account in planning tools, with particular reference to the dynamism and complexity of landscapes. As it has been recognised at a European level, in order to enable different species to remain in good functional status, a network of green infrastructures is required. The concept of “ecological island” is no longer sufficient to adequately protect the fauna and the ecosystem it lives in. As a consequence, ecological islands must turn into ecological networks. The Ecological connectivity refers to the way habitats are physically connected to each other and how easy it is for species to move in. Good ecological connectivity is fundamental to the effective conservation of biodiversity considering that most species and ecological functions provided by ecosystems (ecosystem services) require a much wider space than that available within the boundaries of a single protected area. The main objective of this paper is to critically compare the application of a model for the design of ecological networks to two very different environmental contexts. This model was first tested in a Mediterranean area (the Province of Reggio Calabria) in 2008; the goal was to integrate the traditional (physiographic, biological and planning) approaches into the design of ecological networks by taking into account biological and orographic elements as well as the anthropic structure of the territory. In 2011, within the ECONNECT European project, the model was applied to the pilot region of South-Western Alps (including the French region of Provence-Alpes - Côte d’Azur and the Italian regions Piedmont and Liguria), which is one of the richest transnational districts in Europe in terms of biodiversity. In such a

region, the issue of multidisciplinary ecological connectivity was tackled in order to provide a series of proposals aiming at the development of the ecological potential of the area. The two applications allowed to further investigate the strengths and weaknesses of the implemented model by integrating its validation with information on faunal presence, which obviated one of the major limitations occurred in the first application.

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CHARACTERISING OF CONTEMPORARY RURALITY: A CHALLENGE FOR THE MANAGEMENT OF RURAL AREAS

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Due to deep changes in agricultural and open space settings modern rurality has become a complex matter over the last decades (Antrop, 2004; Gulincx, 2004). Today’s agriculture sector still plays a pivotal role within rural areas. Moreover its traditional provision of goods it is also committed to provide new “social” functions (e.g. environmental services, landscape conservation, human well-being and leisure). The relentless pace of change in open spaces has also pushed the agricultural sector to improve and strengthen its relationships with other sectors (human and industrial settlement, commerce, tertiary and services, etc.). For the way CAP is implemented it has a huge influence on the quality of rural areas management. Its reforms - during last decades the CAP since 2003- have delivered new tools on the rural development playground (*i.e.* Cross-Compliance and Gaec). That has improved the multifunctional agriculture and sustainability concepts, but CAP is essentially driven by economic arguments still and many “curative side-policies” (Gaec, rural policy, etc.) and tends to remain incremental. They do not have a territorial vision developed enough. But there is some hope in the new CAP progress for post 2013. This considerations are at the base of our research framework which is currently implementing efforts to better characterize the degree of rurality of a specific place. The method takes advantage of a set of sound methodologies based on structural and spatial analyses as well as on the socio economic descriptors. This makes the purposes able to capture the new-rurality fashion of studied places. The outcomes of the methodological stages are the baselines for the subsequent planning considerations, whose ultimate purpose is to support decision makers and land managers. Along with the scope of the meeting the methodological approach inspiring our research will be shown, as well as main results for some case study in Marche Region will be illustrated and discussed.

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PLANNING AND MANAGEMENT OF PERI-URBAN AGRICULTURAL AREAS: THE BIO-ENERGY POTENTIAL

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Renewable Energy Production has strongly increased due to achieve of the European Union goals. Agro-energy appears as one of the most promising energy chain for Italy. In this work, the energetic and environmental assessment of biomass potential is analyzed according to the instruments of urban planning. Most of the scientific production focuses on the energy yield of the purely agricultural areas. But the climate change mitigation can not take place only through sectorial plan-

ning, keeping separate the urban from the rural. In fact this article takes into account the potential of peri-urban agricultural areas, within a holistic energy planning body city. According to the provisions of the Road Map 2050, 80% of the world's population will live in cities. Urban planning has adopted only recently Sustainable Energy Action Plans, taking into consideration clearly separated from urban areas and agricultural. Within a logic efficient proximity, it is necessary to evaluate the bio-energy potential of these areas and the relationship with the urban environment. The article explores as a case study of the district of Rome, the first agricultural community in Europe. The study proposes a new energy policy, in accordance with the legislative planning and energy instruments in force.

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LIVESTOCK SYSTEM AS A MITIGATION MEASURE OF A WIND FARM IN A MOUNTAIN AREA

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The study concerns a mountain territory, bordering Liguria, Piemonte, Lombardia and Emilia, where a high power 151 MW wind farm, with 42 tower of 3.6 MW power, has been proposed. As a measure of environmental mitigation, the realization of a livestock system of a herd of sucker cows pasturing in the wind farm areas is proposed. This has implications for environmental maintenance, employment in a territory gradually losing its population, and for tourism. The study, having focused on those aspects that reduce landscape impact and carrying out an analysis of the individual areas to evaluate forage resources and the different pastoral indexes, identifies the maximum sustainable load of animals (335 UBA/ha) in the current conditions of neglect. So, some measures to improve and increase sustainable herds have been proposed and examined. The operations include: stone removal; light harrowing; overseeding; creation of fodder reserves for periods of shortage; and grazing will be managed by taking turns. Based on the results of two other studies, both previous tests carried out on site, encourage us to think that we will be able to increase the maximum sustainable seasonal load for the current situation by more than 50%. This means a herd of 500 UBA equal to a gross PLV, for the grazing period of 180 days, of €400,000 and so guarantee an adequate income to 3-4 UL (labor unit), and of €650,000/year in case the chain is completed during the winter months in structures located in the valley. In this case, the PLV obtained could assure income to 6-7 employees, which would be extremely important for the socio-economic conditions of the valley; in consideration of the induced activities- meat processing, marketing and tourism facilities- which could be made available. Experimental tests of the technical improvements described will be carried out in the next season.

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GEOMATICS TECHNOLOGIES FOR VIRTUAL TOURISM APPLICATIONS

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The most recent technological revolution, concerning the web and so called ICT, has had an impressive growth, that's not only changed individual and collective behaviors, but has also allowed experiences no possible before: a real time communication, regardless of the distances; an extended access to disjointed data and sources; the shift in different realities – missing or entirely imaginary. Nowadays, we can think about a new concept of museum, much more inclusive than the “objects container”, enclosed by walls: now the museum involves entire countries, entire ecosystems, entire regions. We can speak of “museo fuori dal museo” (“museum outside of the museum”), that defines the extension of the museum “storytelling” on a regional scale, beyond the walls of the traditional museum. On a regional scale experiments entirely convincing have not yet been carried out, but from this point of view the cultural lands can be visited as great open air museums, with transversal or theme paths, to find objects, artworks or signs: the whole land is a “collection” to be preserved, to be presented and to be interpreted. Thus the visit allows to elicit outstanding objects, to read into landscapes with different filters. Both the physical and virtual visit seem to be a “tour”. For creating virtual tourism prototypal station, we need several and unconventional geometrical data (shared geographic databases, DTMs, digital orthoimages and angle shots, modeling with spherical cameras, ...), thematic data (artistic, historical, natural, ...) and no conventional input units to move and to observe how and where the observer prefer (walking, biking, but also turning his eyes and his head). Authors report here their experience and knowledge on the state-of-the-art in relation to a prototypal station for virtual tourism, able to relate geomatics references to cultural content and to offer a whole experience, involving users also from the sensory point of view. That's nowadays a specific purpose of new technologies applied to cultural heritage.

RENEWABLE ENERGY, BIOMASS AND BIOLOGICAL RESIDUES

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PRODUCTION OF RENEWABLE ENERGY IN AGRICULTURE: CURRENT SITUATION AND FUTURE DEVELOPMENTS

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In recent years there has been growing interest in the development of renewable energy due to the need to solve problems related to the increase in energy consumption and the instability of prices for raw materials of fossil origin, and because of concerns about pollution and the effects on climate change. In order to solve these problems there have been extensive studies to research systems and processes capable of limiting the increase in "greenhouse" and so-called "climate changing" gases and, at the same time, to make countries increasingly independent from the energy point of view. In Italy, similar considerations have taken on a special significance, precisely because of the increasing dependence on foreign energy (equal to over 83% in 2009), the cost of energy and emissions harmful to the climate, all running counter to the objectives laid down at international level on the subject of global warming. Faced with this scenario, the agricultural sector can also play an important role in contributing to increased production of energy from renewable sources. It can be argued - albeit with the caution we must exercise in processing data of theoretical approaches - that in the future, the entrepreneur will have interesting opportunities for plants with different power capacity in the context of scenarios that use biological products. In addition, the operating margin that can be obtained also allows us to consider the possible expensive supply of biomass, in the case where the installed power is to be increased. Conversely, the risks run will be serious if the system is to be powered exclusively with dedicated biomass, especially with cereal silage.

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DETERMINING WOOD CHIP SIZE: IMAGE ANALYSIS AND CLUSTERING METHODS

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One of the standard methods for the determination of the size distribution of wood chips is the oscillating screen method (EN 15149-1). Recent literature demonstrated how image analysis could return highly accurate measure of the dimensions defined for each individual particle, and could promote a new method depending on the geometrical shape to determine the chip size in a more accurate way. A sample of wood chips (8 litres) was sieved through horizontally oscillating sieves, using five different screen hole diameters (3.15, 8, 16, 45, 63 mm); the wood chips were sorted in decreasing size classes and the mass of all fractions was used to determine the size distribution of the particles. Since the chip shape and size influence the sieving results, Wang's theory, which concerns the geometric forms, was considered. A cluster analysis on the shape descriptors (Fourier descriptors) and size descriptors (area, perimeter, Feret diameters, eccentricity) was applied to observe the chips distribution according to their descriptors derived from image analysis. The UPGMA algorithm was applied on Euclidean distance. The obtained dendrogram shows a group separation according with the original three sieving fractions. A comparison has been

made between the traditional sieve and clustering results. This preliminary result shows how the image analysis-based method has a high potential for the characterization of wood chip size distribution and could be further investigated. Moreover, this method could be implemented in an online detection machine for chips size characterization. An improvement of the results is expected by using supervised multivariate methods that utilize known class memberships. The main objective of the future activities will be to shift the analysis from a 2-dimensional method to a 3-dimensional acquisition process.

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SICILIAN POTENTIAL BIOGAS PRODUCTION

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This study is aimed at predicting the Sicilian potential biogas production, using the Organic Fraction of Municipal Solid Waste (OFMSW), animal manure and food industry by-products, in a region where only one biogas plant using MSW and one co-digestion plant are nowadays available. The statistical data about OFMSW, the number of animals bred in medium and large farms and the amounts of by-products of food processing industries were evaluated, in order to compute the Sicilian potential biogas and energy production. The OFMSW produced in Sicily, that is 0.8 million tons ca. per year (37% of MSW), could be used in a bio-reactor, together with other raw materials, for Anaerobic Digestion (AD) process, producing biogas and "digestate". Moreover, 3.03 million tons ca. of manure, collected in medium and large animal husbandry farms (where cows, pigs and poultry are bred), and 350 thousand tons ca. of by-products, collected in food processing industries (pomace from olive oil mills and grape marc from wineries), might be used for AD process. The Sicilian potential biogas production from the AD of the above raw materials is 170.2 millions of m³, that is equal to 1023.4 GWh of energy per year, of which 484 GWh from animal manure, 303 GWh from OFMSW and 236.4 GWh from food industry by-products. The highest biogas production is in the province of Palermo (35.6 millions of m³), Ragusa (30.8 millions of m³) and Catania (22.8 millions of m³), having a potential energy production of 213.8, 185 and 137 GWh, respectively.

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ANAEROBIC DIGESTION AND CO-DIGESTION OF SLAUGHTERHOUSE WASTES

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The use of renewable energy is becoming increasingly necessary in order to address the global warming problem and have become an high priority for many countries. Biomass is a clean and renewable energy source with increasing potential to replace conventional fossil fuels. Among biomass, residual and waste one represent a great resource if used to produce energy because permits both to eliminate a possible waste and to obtain energy. In this work the case of slaughterhouse wastes have been studied. One of the most important processes to produce energy from organic matter and biodegradable wastes in a sustainable way is anaerobic digestion. Biogas is the principal product of this bio-chemical process and it mainly consist of methane and carbon dioxide, therefore it can be used to produce thermal and/or electric energy. In this paper some previous study on anaerobic digestion and

co-digestion of slaughterhouse wastes are considered and compared in order to fix a starting point for future tests on co-digestion of this wastes in a pilot-scale small digester, aimed at supplying ratio optimization for biogas methane percentage increase.

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ENERGY AND PRESSURE REQUIREMENTS FOR COMPRESSION OF SWINE SOLID FRACTION COMPOST

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The excessive amount of pig slurry spread on soil has contributed to nitrate water pollution both in surface and in ground waters, especially in areas classified as vulnerable zones to nitrate in accordance with European Regulation (91/676/CEE). Several techniques have been developed to manage livestock slurries as cheaply and conveniently as possible and to reduce potential risks of environmental pollution. Among these techniques, solid-liquid separation of slurry is a common practice in Italy. The liquid fraction can be used for irrigation and the solid fraction, after aerobic stabilization, produces an organic compost rich in humic substances. However, compost derived from swine solid fraction is a low density material (bulk density less than 500 kg m^{-3}). This makes it costly to transport composted swine solid fraction from production sites to areas where it could be effectively utilized for value-added applications such as in soil fertilization. Densification is one possible way to enhance the storage and transportation of the compost. This study therefore investigates the effect of pressure (20-110 MPa) and pressure application time (5-120 s) on the compaction characteristics of compost derived from swine solid fraction. Two different types of material have been used: composted swine solid fraction derived from mechanical separation and compost obtained by mixing the first material with wood chips. Results obtained showed that both the pressure applied and the pressure application time significantly affect the density of the compacted samples; while the specific compression energy is significantly affected only by the pressure. Best predictor equations were developed to predict compact density and the specific compression energy required by the densification process. The specific compression energy values based on the results from this study ($6\text{-}32 \text{ kJ kg}^{-1}$) were significantly lower than the specific energy required to manufacture pellets from biomass feedstock (typically $19\text{-}90 \text{ kJ kg}^{-1}$).

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BIOGAS YIELD FROM SICILIAN KITCHEN WASTE AND CHEESE WHEY

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The aim of this study is to determine the chemical composition of kitchen waste and cheese whey, as well as the biogas yield obtained from the Anaerobic Digestion (AD) tests of these two raw materials. Since the separated waste collection is performed in the town of Marineo (Palermo), a sample of kitchen waste, different from food industry one and included in the Organic Fraction of Municipal Solid Waste (OFMSW), was collected from the mass stored at the households of this town. Moreover, a sample of cheese whey was collected in a Sicilian mini dairy plant, where sheep milk is processed. This investigation was carried out inside laboratory digesters of Aleksandras

Stulginskis University (Lithuania). Total Solids (TS) resulted 15.6% in kitchen waste and 6% in cheese whey, while both the raw materials showed a high content of organic matter, 91.1% and 79.1%, respectively. The biogas yield resulted 104.6 l kg^{-1} from kitchen waste and 30.6 l kg^{-1} from cheese whey. The biogas yield from TS resulted 672.6 l kg^{-1} using kitchen waste and 384.7 l kg^{-1} using cheese whey. The biogas yield from Volatile Solids (VS) resulted 738.9 l kg^{-1} using kitchen waste and 410.3 l kg^{-1} using cheese whey.

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ASSESSMENT OF ENERGY RETURN ON ENERGY INVESTMENT (EROEI) OF OIL BEARING CROPS FOR RENEWABLE FUEL PRODUCTION

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Because of increase in the petroleum prices and availability, there is a notable interest in oil bearing crops for vegetable oil fuels production to use in diesel engines. Moreover the vegetable oil fuels make up renewable and clean fuel engine alternative. In order to assess the sustainability of Brassica carinata, Camelina sativa, Linum usitatissimum cultivation for biodiesel production in terms of energy used compared to that obtained, the index EROEI (Energy Return On Energy Invested) has been used. At this aim, an experimental field of three plots, each of 5000 m^2 , was realised in the south-eastern Sicilian marginal land. During the autumn-winter crop cycle, no irrigation was carried out and some suitable agricultural operations have been carried out: tillage (shredding, harrowing and hoeing), seeding, fertilizing, weeding and rolling after sowing and finally harvesting, taking into account the peculiarity of each type of used seeds. The total energy consumed for the cultivation of oil bearing crops from sowing to the production of biodiesel represents the Input of the process. In particular, it has concerned the energy embodied in machinery and tools utilized, in seed, chemical fertilizer and herbicide but also the energy embodied in fuels and lubricants. In addition, the energy consumption relating to machines and reagents required for the processes of extraction and transesterification of the vegetable oil into biodiesel have been calculated for each crops. The energy obtainable from biodiesel production represents the Output of the process. This was derived from a mechanical extraction and a subsequent vegetable oil transesterification by means of a prototypal plants. The ratio Output/Input gets the EROEI index which in the case of Camelina sativa and Linum usitatissimum is greater than one. These results show that the cultivation of these crops for biofuels production is convenient in terms of energy return on energy investment. The EROEI index for Brassica carinata is lower than one. This could mean that some factors, concerning mechanisation and climatic conditions, were not suitable to ensure higher crop yields.

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HARVESTING OF SOUTHERN PIEDMONT'S ORCHARDS PRUNING RESIDUES: EVALUATIONS OF BIOMASS PRODUCTION AND HARVESTING LOSSES

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In recent years there has been increasing interest regard to farming residues including orchard pruning residues. The masses and dimension of branches pruned depends of several factors as fruit variety, active strength plant, training systems, intensity and periodicity prun-

ing. Many studies (ENAMA 2011, ENEA 2010, ISTAT 2010, etc...) were performed to determine this type of biomass availability, however they're not up-to-date farming situation and usually are lacking of accurate surveys. A detailed knowledge of current pruning biomass availability, both qualitative and quantitative, is also necessary for economic sustainability evaluation of energetic exploitation. In this context in order to provide an assessment of the real chain potential of energy renewable production, from Cuneo territory pruning residues, was conducted a research on two different orchards species *Actinidia* (Kiwi tree) and *Malus* (Apple tree): the first is arbor trained and pruned in the traditional way, the second is spindle trained and pruned in two different ways, "traditional system" and "taille longue system". For each species, pruning residues amount were quantified together with their diameter. The surveys were performed at least on four half trees placed on the same row spacing with three randomized replications in the crop. The amount of cut off branches were determined by a dynamometer whereas the diameter has been detected at the base of the same using a twentieths caliper. Subsequently was performed pruning residues windrowing by rotating rake and the harvest of the same by fixed chamber round baler suitably modified. At the end of these operations have been determined harvesting losses with the same methodology. Data processing is still in progress, but the first result shows that with the "traditional pruning system" the biomass average availability is of 5,4t/ha and 2,7t/ha, respectively for kiwi and apple tree. For the latter, the average values are significantly lower (30%) with "taille longue" pruning system. The harvesting losses has been on average of about 18% (10-25%) in kiwi tree and of about 40% (34-48%) in the apple tree. In both crops the variation of harvester losses are due mainly to the size and conformation (straight) of pruned branches.

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FIRST TESTS OF USING AN ELECTRONIC NOSE TO CONTROL BIOGAS PLANT EFFICIENCY

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The demand for online monitoring and control of biogas process is increasing, since better monitoring and control system can improve process plants stability and economy. A number of parameters in both the liquid and the gas phase have been suggested as process indicators (gas production, pH, alkalinity, VFA and H₂). For different reasons these indicators do not offer sufficient information to build a consistent feedback control able to promptly forecast and solve plants functioning problems. The present study proposes the use of unconventional complex sensors as a possible solution to engineer a consistent control system. Tests were performed using an electronic nose Airsense PEN 2, AIRSENSE Analytics GmbH to analyze the biogas coming from a biogas plant in which conditions of pre-overloading and overloading were artificially induced. In particular, a 108 olfactometric fingerprinting reference database obtained by different combination of VFA (acetic, propionic e butyric acids, pure or in solution with water) was initially determined. 476 biogas samples representing different induced functioning conditions were fed into the analyser and compared with the fingerprinting database. The different induced functioning conditions were recognised using a FOS/TAC tester. Statistic multivariate analysis confirm that the nose can distinguish different plant functioning conditions, demonstrating the possibility of using this technology as possible base for a biogas control system.

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EVALUATION OF HERBACEOUS CROPS IRRIGATED WITH TREATED WASTEWATER FOR ETHANOL PRODUCTION

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The competition for freshwater between agricultural, industrial, and civil uses has greatly increased in Mediterranean basin characterized by prolonged dry seasons. The aim of this study was to evaluate biomass production and the potential ethanol production of promising "no-food" herbaceous crops irrigated with low quality water at different ETc restitutions (0%, 50 and 100%). The research was carried out, in 2011 and 2012, in an open field near the full-scale constructed wetland (CW) municipal treatment plant located in the Eastern Sicily (Italy). The CW effluent has been applied in a experimental irrigation field of *Vetiveria zizanioides* (L.) Nash, *Miscanthus x giganteus* Greef et Deu. and *Arundo donax* (L.). Physical, chemical and microbiological analyses were carried out on wastewater samples collected at inlet and outlet of CW and pollutant removal efficiencies were calculated for each parameter. Bio-agronomical analysis on herbaceous species were made with the goal to evaluate the main parameters such as the plant dimension, the growth response and the biomass production. Biomass dry samples were processed with a three-step chemical pretreatment, hydrolysed with a mix of commercial enzymes and next fermented to obtain the yield of ethanol production. Average TSS, COD and TN removal for CW were about 74%, 67% and 68%, respectively. Although the satisfactory *Escherichia coli* removal, about 3.5 log unit for both beds on average, CW didn't achieve the restrictive Italian law limits for wastewater reuse. As expected, irrigation was beneficial and the full ET replenishment increase the biomass productivity as compared to the other two treatment. The mean productivity of *Vetiveria zizanioides* and *Miscanthus x giganteus* were about 9, 26 and 38 t ha⁻¹ and 3, 7 and 12 t ha⁻¹ in 0%, 50% and 100% ETc restitutions, respectively. *Arundo donax* gave higher values of dry biomass (78 t ha⁻¹ in 100% ETc restitution in 2011 season), and potential ethanol production (about 3,744 kg ha⁻¹). These results suggest the interest in the use of constructed wetland effluents for the irrigation of energy crops to obtain second generation ethanol, particularly in semiarid regions such as the Mediterranean area.

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MODELLING AND OPTIMIZATION OF A LOCAL SMART GRID FOR AN AGRO-INDUSTRIAL SITE

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A smart grid is defined where different elements are interconnected between them and with the public utility grid. The development of smart grids is considered a strategic goal at both national and international levels and has been funded by many research programs. Within the BEE (Building Energy Ecosystems) project, funded by the Piedmont Region under the European POR FESR 2007-13 scheme, the creation of an electricity smart grid at a local level in a small agro-industry was done. This industry is one of the so-called prosumer, that is both a pro-

ducer and a consumer of energy. The energy production is done by means of solar photovoltaic and biomass. In this local smart grid, the elements were subdivided in two main groups: loads (process machineries in the case study) and generators (PV and biomass in the case study). The loads may be further subdivided into permanent loads, mandatory loads and shiftable loads. The objective of the smart grid is the minimization of the exchanges between the local grid and the public utility grid. Even though no financial savings occur, this is important for the community grid. The problem is therefore to find the conditions that let the net exported energy going to zero at each time step, so arriving close to a self-sufficient system by modifying the shiftable loads. In a first phase of the study, the consumers were studied and, according to some characteristics of the machineries employed and the production requirements, grouped into production lines that can or not be switched off for intervals of time in order to compensate the smart grid fluctuations. The smart grid balancing may be done on an instantaneous basis, or in a predictive way considering the future weather forecasts and the future production requirements. The test bed was equipped with measurement instrumentation, data acquisition tools and a user interface that may be used to visualize all the quantities that are measured but also to perform the actions suggested by the optimization strategy (start/stop machineries, organization of production, etc).

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DEVELOPMENT PERSPECTIVES FOR BIOGAS PRODUCTION FROM AGRICULTURAL WASTE IN FRIULI VENEZIA GIULIA (NORD-EAST OF ITALY)

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The Italian Energy Action Plan of 2010 set a target of at least 17% of total energy generated from renewable sources by 2020. In this context biogas from waste and biomass is a potential energy source that can be used for the production of heat, electricity and fuel. In 2012, some 600 plants in Italy were producing biogas, 58% of which working in co-digestion of manure with energy crops and agro-industrial residues, with about 350 MW(e) of installed power. In July 2012, Italy adopted a new regulation for the production of electricity from biomass, where the economic support is higher if the production of biogas is derived from animal waste and agricultural by-products in comparison to the use of the energy crops (*i.e.* corn silage). In this study, biogas amount which can be obtained from animal waste was calculated for all municipalities in the Friuli Venezia Giulia Region (North-East of Italy). The total number of cattle, pig and egg poultry and the type of breeding were determined using available data for 218 municipalities in Friuli Venezia Giulia (Istat, 2011). Calculations were performed according to the standards set by Italian Law 109/2007 (wet waste per body weight of each type and age of the animals). The biogas yields from cattle, pig and poultry were calculated based on dry matter content and the ratio of volatile solids to total solids. A map of biogas potential production has been produced using a GIS-based software. Results The calculated regional biogas potential is about 24 (N)Gm³ when using only animal waste, where 68% of total biogas potential is of cattle origin, 31% from pig and only 4% of poultry origin. This work has been a first step in a more complete evaluation of the biogas potential in Friuli Venezia Giulia, which will analyse biogas yields depending on different feedstocks (triticale, straws, agro-industrial waste), plant sizes and logistic solutions, in order to evaluate the full technical and economic convenience of biogas plants in the regional area.

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THE USE OF CO-DIGESTED SOLID FRACTION AS FEEDSTOCK FOR BIOGAS PLANTS

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Several anaerobic digestion plants (A.D.P.) have been realized in Italy in the last few years. A.D.P. are generally built inside livestock farms and are fed mostly with animal manure, energy crops and agricultural by-products. Co-digestate is one of the final products of A.D.P. and contains mostly water, undigested organic matter and readily available inorganic compounds (e.g., nitrogen, phosphorus, potash) to crops. Due to the construction of the A.D.P. often inside intensive livestock production units with insufficient arable land for nutrient recycling, export of nutrients to outside farm areas may be necessary to avoid excess load of nutrients, with special regards to nitrogen. Thus, the mechanical separation of co-digestate is becoming a common practice as a possible solution to the above-mentioned problems. Nevertheless, the co-digested solid fraction still contains residual and undigested volatile solids due to the presence of low-degradable organic compounds in the co-substrates. It can thus be reused as A.D.P. feedstock. With the goal to assess the convenience and technical feasibility of such an option a laboratory scale study was carried out within the "Multi-regional Solutions to improve the Environmental and Economic Sustainability of PIG manure management in the Regions of the Po and Veneto basin (SEESPIG)" project. The biogas yields of two feedstock different mixtures (A and B) were assessed in mesophilic conditions (40°C) using 8 lab-scale continuous stirred-tank reactors (CSRT). All digesters were fed simultaneously, three times a week, over a period of nine month. A set of three digesters (controls) were fed with feedstock mixture A (pig slurry, 70%; farmyard manure, 4%, sorghum silage, 12%; maize silage, 14%), while the others five digesters were fed using the same mixture as the controls plus the solid fraction derived from the mechanical separation of the output digestate collected on daily basis from the digesters (feedstock mixture B). According to the study results, the reuse of the co-digested solid fraction as feedstock, could increase the methane yield by approximately 4%. However, A.D.P. efficiency evaluation (e.g., daily yield of methane per m³ of digester) suggest to limit this practice to a period of not more than 120 days.

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LIFE CYCLE ASSESSMENT OF MAIZE CULTIVATION FOR BIOGAS PRODUCTION

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Interest for Renewable Energy Sources has gained great importance in Europe due to the need to reduce fossil energy consumption and Green Houses Gases emissions. For the achievement of European Union objectives, the Anaerobic Digestion of energy crops and agro-industrial by-products appears a promising way. Agricultural raw materials, such as straw and manure, are commonly used for biogas production. Nevertheless, the main feeding materials for digesters are often represented by cereal silages (of maize, wheat and triticale in particular). Environmental effects due to energy crop cultivation come, not only from field operations, but also from raw material (fuels, fertilizers, pesticides, etc.) extraction, production and transportation. Therefore, in order to perform a complete evaluation of the system all these

aspects must be taken into account. The aim of this study was to analyze the environmental performances of corn (maize FAO Class 700) cultivation (single crop) in Northern Italy to produce biomass for energy purpose (biogas). The LCA method was chosen to perform the environmental analysis. The environmental performances of maize were assessed using the software Simapro. In particular, besides the Cumulative energy demand, 10 impact categories (example Global Warming Potential, Acidification, Abiotic depletion, Ozone layer depletion, Human toxicity, and Eutrophication) were evaluated. A detailed life cycle inventory was carried out by means of farmer interviews and surveys on field. Data are referred to year 2011. 1 tonne of ensiled biomass was chosen as functional unit. The environmental impact due to the different inputs and outputs as well as to each field operations was evaluated. The factors that have the greater influence on the overall environmental burden are: fertilizers emissions, diesel fuel emissions, diesel fuel production and pesticides production. The fertilizer emissions (example volatilization and leaching) strongly affect the eutrophication and acidification impact categories. Diesel fuel utilization is responsible for about 70% of global warming potential. Regarding the different field operations, the fertilization has the greater effect on eutrophication and acidification while ploughing and harvesting strongly affect global warming potential and abiotic depletion.

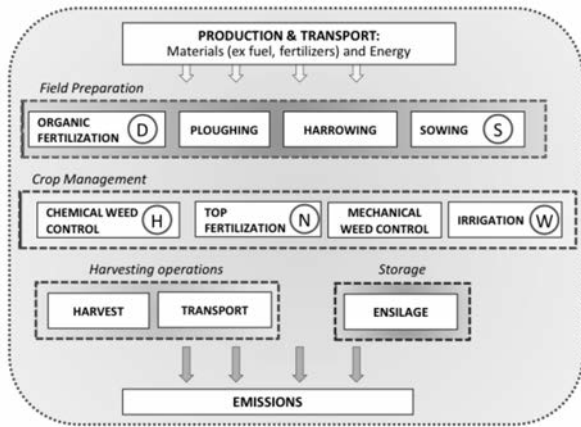


Figure 1. System boundaries.

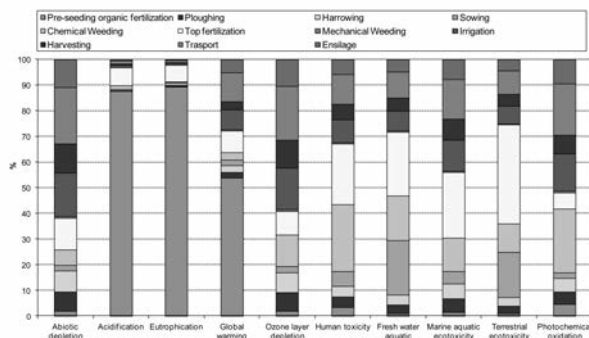


Figure 2. Impact of operations on the different impact categories

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A FARM-SCALE PILOT PLANT FOR BIOHYDROGEN AND BIOMETHANE PRODUCTION BY TWO-STAGE FERMENTATION

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Hydrogen is considered one of the possible main energy carriers for the future, thanks to its unique environmental properties. Indeed, its energy content (120 MJ/kg) can be exploited virtually without emitting any exhaust in the atmosphere except for water. Renewable production of hydrogen can be obtained through common biological processes on which relies anaerobic digestion, a well-established technology in use at farm-scale for treating different biomass and residues. Despite two-stage hydrogen and methane producing fermentation is a simple variant of the traditional anaerobic digestion, it is a relatively new approach mainly studied at laboratory scale. It is based on biomass fermentation in two separate, sequential stages, each maintaining conditions optimized to promote specific bacterial consortia: in the first acidophilic reactor hydrogen is produced production, while volatile fatty acids-rich effluent is sent to the second reactor where traditional methane rich biogas production is accomplished. A two-stage pilot-scale plant was designed, manufactured and installed at the experimental farm of the University of Milano and operated using a biomass mixture of livestock effluents mixed with sugar/starch-rich residues (rotten fruits and potatoes and expired fruit juices), a feedstock mixture based on waste biomasses directly available in the rural area where plant is installed. The hydrogenic and the methanogenic reactors, both CSTR type, had a total volume of 0.7 m³ and 3.8 m³ respectively, and were operated in thermophilic conditions (55+/-2°C) without any external pH control, and were fully automated. After a brief description of the requirements of the system, this contribution gives a detailed description of its components and of engineering solutions to the problems encountered during the plant realization and start-up. The paper also discusses the results obtained in a first experimental run which lead to production in the range of previous laboratory results, with a typical hydrogen and methane specific productivity of 2.1 and 0.5 Nm³/m³reactor per day, in the first and second stage of the plant respectively. At our best knowledge, this plant is one of the very first prototypes producing biohydrogen at farm scale, and it represents a distributed, small scale demonstration to obtain hydrogen from renewable waste-sources.

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PARAMETRIC EXPERIMENTAL TESTS OF STEAM GASIFICATION OF PINE WOOD IN A FLUIDIZED BED REACTOR

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Among Renewable Energy Sources (RES), biomass represent one of the most common and suitable solution in order to contribute to the global energy supply and to reduce greenhouse gases (GHG) emissions. The disposal of some residual biomass, as pruning from pine trees, represent a problem for agricultural and agro-industrial sectors. But if the residual biomass are used for energy production can become a resource. The most suitable energy conversion technology for the above-mentioned biomass is gasification process because the high C/N

ratio and the low moisture content, obtained from the analysis. In this work a small-pilot bubbling-bed gasification plant has been designed, constructed and used in order to obtain, from the pine trees pruning, a syngas with low tar and char contents and high hydrogen content. The activities showed here are part of the activities carried out in the European 7FP UNIFHY project. In particular the aim of this work is to develop experimental test on a bench scale steam blown fluidized bed biomass gasifier. These tests will be utilized in future works for the simulations of a pilot scale steam fluidized bed gasifier (100 kWth) fed with different biomass feedstock. The results of the tests include produced gas and tar composition as well gas, tar and char yield. Tests on a bench scale reactor (8 cm I.D.) were carried out varying steam to biomass ratio and operative temperature from 0.5, 0.7 and 1 at 830°C.

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ENVIRONMENTAL AND ENERGY ANALYSIS OF BIOMASS TECHNOLOGIES

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The increasing environmental and economic cost of fossil fuels, during the last years, allowed us to obtain a major environmental awareness and to shift the focus on alternative energy sources. For this reason the authors of this study realized a critical review based on the state of the art in the field of bio-energy cogeneration sources, with specific regards to the biological residues treatment technologies. Considering the short distribution chain's principle as an inspiring theory, reflections have been made on socio-economic maximization of the local resources. This has been considered achievable just through an energy planning proved to be deeply tied to the particular agricultural and forestry vocation of the involved area, in agreement with the energy community's socio-economic theory. Occupational benefits, life cycle products optimization and agricultural cycle production optimization could be attained due to a local approach for the logistic and economic management of energy plants for the native biomass treatment. Such a distributed energy generation turns out to be intensely coherent with the natural spatial dispersion of the renewable energy sources and seems to represent the true keystone for the current energy crisis. According to this policy, the anaerobic digestion of organic residues with biogas production, the pyrolysis of dry biomass with production of syngas, and the carbonaceous biomass combustion have been considered as the most interesting solutions from an environmental and economic point of view. Each one of the so defined hypothesis has been economically analyzed considering the incentive schemes and financing solutions, and even studied focusing on its sustainability and its environmental impact, under the hypothesis of best practice adoption (BAT). In the end, according with Carbon Capture and Storage European Directive (2009/31/CE), looking forward to a national incentive policy, for each of the plant solutions described, has been estimated the potential of CO₂ capacity coming from the respective energy processes.

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FULL SCALE COMPOSTING TESTS OF ORGANIC MIXTURES BASED ON "TWO PHASE" POMACE USING A PROTOTYPE OF TURNING MACHINE

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Two phase system has changed the quantity and chemical-physical

characteristics of the olive-oil by-products: pomace is quite moist, so pomace oil extractors don't always remove it. We used this by-product as source of carbon in composting tests carried out, using rabbit manure as source of nitrogen. The farm, where the experiments were carried out produces 105 ton of meat/year, 3000 kg of manure/day and 1500 kg of slaughtering waste products/week. The used composting plant is an industrial horizontal axe reactor with a prototype of turning machine. The trough is approximately 90 m long, 4 m wide and 60 cm deep. Three heaps 2 m length were made, corresponding to 5 m³ of treated biomass, with different carbon/nitrogen ratios. The experiment lasted 85 days; each of the heaps was moved 1 meter a day; every day the outside and inside the plant temperature were measured, both at the surface and on the bottom of the pit; every 15-30 days routine analyses were carried out on the composting heap; at the beginning and at the end of the experiment the content of heavy metals and the main fertility parameters were established. Due to the high polyphenols content, the ratio 6 (pomace)/1 (manure) is a critical limit that tends to slow down the process considerably. It should however take specific plant solutions: aeration in the first stage, moisture control in the mesophilic phase and the turn-over machine must allow a greater aerating and homogenisation of the mass. So, on the most suitable mixture (1/1 ratio) similar tests were carried out, welding blades with two different profiles to the reel of the turn-over prototype. The results show that the plant limit is not represented by the shape of the turn-over elements, but by turning frequency of the specific biomass. More precisely, the machine would be designed to allow for a better penetration into the mass and to obtain a better turn-over over a shorter distance; in this way, it is possible to effect more trips compared to the covered distance, thereby mixing better the upper layers as well as the lower layers.

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ASSESSMENT OF THE ENERGETIC POTENTIAL BY HAZELNUTS PRUNING IN VITERBO'S AREA

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In this work the amount of biomass available by the hazelnuts pruning in the province of Viterbo was investigated. At present, the pruning's residues are destroyed by farmers directly in the field, at the end of the pruning; in this way a large quantity of biomass, represented by hazelnut's prunings, is lost; the residues obtained from the hazelnut's pruning, are an important source of biomass that could be used for thermal energy production. The aim of this work is to realize a map with the estimated energy potential from hazelnut pruning biomass, in the province of Viterbo. In the first phase the amount of biomass obtained from a hectare of hazelnut's cultivation was estimated: sampling were carried out in some municipalities of Viterbo while hazelnut pruning was taking place, from January to March. In the field, biomass was weighed and some pieces of wood were collected for laboratory analysis; in particular humidity of biomass, low calorific value, ash and the content of carbon (C), hydrogen (H) and nitrogen (N) were determined. In the calculation of the biomass were considered the age of the plants and the number of plants per hectare. The results show that the amount of biomass obtained from pruning of hazelnuts varies with the age of plants, but even more so by the number of plants per hectare. The average value of biomass obtained from pruning of a hectare of land is just under 0,9 t. Knowing the net calorific value of the hazelnut wood and the number of hectares cultivated for each municipality, a map of thermal potential energy has been realized.

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SUSTAINABILITY OF GRAPE-ETHANOL ENERGY CHAINRiva G.,¹ Foppa Pedretti E.,¹ Toscano G.,¹ Duca D.,¹ Pizzi A.,¹ Saltari M.,¹ Mengarelli C.,¹ Gardiman M.,² Flamini R.²¹*Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Università Politecnica delle Marche;* ²*Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per la Viticoltura (CRA-VIT), Italy*

The aim of this work is to evaluate the sustainability, in terms of greenhouse gases emission saving, of a new potential bio-ethanol production chain in comparison with the most common ones. The innovation consists of producing bio-ethanol from different types of no-food grapes, while usually bio-ethanol is obtained from matrices taken away from crop for food destination: sugar cane, corn, wheat, sugar beet. In the past, breeding programs were conducted with the aim of improving grapevine characteristics, a large number of hybrid vine varieties were produced and are nowadays present in the CRA-VIT Germplasm Collection. Due to technological and legal reasons, the grapes from these vine varieties cannot be used for winemaking and are not significantly used as table grapes. Some of them potentially are interesting for bio-energy production because have high sugars production, good resistance to diseases, and ability to grow in marginal lands. Methodology LCA of grape ethanol energy chain was performed following two different methods: (i) using the spreadsheet "BioGrace, developed within the "Intelligent Energy Europe" program to support and to ease the RED implementation; (ii) using a dedicated LCA software. Emissions were expressed in CO₂ equivalent (CO₂eq). The results showed that the sustainability limits provided by the normative are respected to this day. On the contrary, starting from 2017 this production will be sustainable only if the transformation processes will be performed using renewable sources of energy. The comparison with other bio-energy chains points out that the production of ethanol using grapes represents an intermediate situation in terms of general emissions among the different production chains. Among the steps constituting the production chain, the cultivation is responsible of more than half the overall CO₂eq emitted, so that the achievement of an optimization between production inputs and crop yields proves to be one of the most important aspects to be taken into account. Conclusions The results can still guide the research and development of new biofuel chain, which can make a significant reduction in CO₂eq emissions.

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TORREFACTION OF RESIDUES AND BY-PRODUCTS FROM SUNFLOWER CHAIN

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Currently great interest is shown in the reuse of residual and waste materials to improve the sustainability of production chains both in environmental and economic terms. The energetic use is one of the possible choices and generally the most achievable. Some problems however are related to their practical realization, such as the heterogeneity of materials, the poor storability and the logistic aspects. A method to solve these problems could be the torrefaction process because of its rather simple technology and because of the interesting results it produces in terms of improvement of material properties. Torrefaction determines changes on ligno-cellulosic products,

such as decrease of moisture content, increase of energetic density, strong decrease of hygroscopicity, changes of the mechanical properties. Torrefied products hence show to have characteristics interesting for combustion, storage and transport of materials, and their manipulation with low energy consumption. This study aims to evaluate results which can be obtained if employing torrefaction treatment to residues and by-products deriving from the mechanically extracted sunflower oil production chain. The residual materials used were stalks deriving from cultivation and sunflower cake deriving from the extraction phase. Further tests were performed on sunflower husks deriving from a dehulling step. The work consisted in performing previous thermogravimetric analyses to stress the thermal behavior of different materials and to establish the operating conditions to adopt during the torrefaction tests. Then the torrefaction tests were performed and both the starting materials and the torrefied materials were analyzed for their energetic characterization to evaluate the possible improvement of characteristics. Results show a general increment of carbon concentration and decrease of oxygen content. It is noted that the more the process conditions are severe, the more the torrefied products structure tend to acquire a composition similar to those of traditional solid fuels. Some differences are noticed among the materials due to the different starting chemical structure, in particular between stalks and extraction cake. According to analytical results it is possible hence to evaluate on which tested materials is more suitable to perform a torrefaction treatment and the best operating conditions.

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GIANT REED (*ARUNDO DONAX* L.) HARVESTING SYSTEM, AN ECONOMIC AND TECHNICAL EVALUATION

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The giant reed is a herbaceous energy crop that demonstrates a good adaptability for areas of central-northern Italy. However, its size and stem resistance to cutting pose problems for harvesting in relation both to the availability of suitable machinery and costs of the operation. A technical and economic evaluation has been conducted of a harvesting system based on an experimental machine, the biotriturator, developed by University of Bologna in collaboration with the Nobili Company (Bologna, Italy) and adapted to field operating conditions. The harvesting system consists of cutting-shredding and baling in a single pass. The system was evaluated by performing a winter harvest when the crop was in quiescence and had a low moisture content. The total harvesting costs were evaluated as 11.6 € Mg⁻¹ dry biomass. Given that the estimated area that can be covered by the harvesting system was 123 hectares per year the system represents an effective solution for not very large areas and is therefore suitable for the Italian environment where average farm sizes are slightly over seven hectares (ISTAT, 2011).

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TWO PROTOTYPES FOR MEDIUM ROTATION FORESTRY HARVESTING

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Five years old poplar (*Populus spp.*) plantation represents an interesting model of productivity. The most attractive characteristics of this

energy crop are the handling flexibility, the high yield of biomass per area unit and the good quality of the chips obtainable. The mechanical harvesting of five-years old poplar plantations requires the use of specialized forest machineries such as harvester, feller, forwarder and chipper. Usually, after felling, the working phases consist of extraction, stacking and chipping. Generally, the last one is carried out in a "static phase", where the product is taken from staked logs by using a hydraulic arm having a gripper that feed the chipping machine. In order to introduce technological innovations for the medium rotation forestry harvesting, the Consiglio per la ricerca e la sperimentazione in agricoltura, Unità di ricerca per l'Ingegneria agraria (CRA-ING) of Monterotondo (Rome, Italy) has developed a five years poplar cut-windrower and a self-propelled chipper equipped with a pick up system. The prototype of cut-windrower is a semi-trailed machine powered by a 95 kW tractor (at least). It mounts a cutting system and a double pincer with variable positioning. During the cutting phase the plant is grasped by the double pincer which conveys and unloads the stem along the inter-row. The trees are placed parallel to the progress of the tractor, but oriented in the opposite direction. The biomass windrowed is then chipped in a dynamic phase directly from the inter row using the self-propelled chipper equipped with the pick-up head. In the first tests the cut-windrower has reached an operative working capacity of 0,22 ha h⁻¹, with an operative production of 44 t h⁻¹. On the other hand, the self-propelled chipper has showed an operative working capacity equal to 0.18 ha h⁻¹, and an operative production of 35 t h⁻¹ about. Both machines have shown good quality of the work performed and the results obtained indicates that the work phases could be simplified in order to reduce both the time of use and the harvesting costs.

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PALMS (*PHOENIX CANARIENSIS*) INFESTED BY RED PALM WEEVIL (*RHYNCHOPHORUS FERRUGINEUS OLIVIER*): INSECTICIDAL EFFICACY TESTS OF CHIPPING TREATMENT

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The provision n° A6505/29-11-2010 of the Lazio Region Agricultural Department states that the plant material resulting from the felling of palms infested by RPW (*Rhynchophorus ferrugineus* Olivier) must be disinfested by heat treatment or fine mechanical chipping, ensuring that the resulting materials obtained are of a size smaller than 2 cm. This paper describes changes made on one machine chipper FARMi mod. FOREST CH260 for use in the cutting of trees and palm leaves in accordance with the above mentioned provision. The analyzes carried out on the plant material shredded, according to methodology UNI CEN/TS 15149-1 2006, show that 94,78% of the fragments is smaller than 16 mm and a water content of 52.5%. In all fragments of the material shredded at least one of the three dimensions was less than 2 cm. A mix of chipped stipes and leaves of palm tree was tested at ENEA facilities to evaluate the ability of RPW larvae to feed and survive on this substrate. Ten plastic containers (130 liters) were filled up with 26 kg each of chipped matter and infested with larvae grouped by weight into 3 classes ranged from < 0.15 g, 0.15 ÷ 0.35 g and > 0.35 g till 2 cm (3 containers for each class and 1 as control; 30 larvae for each container). Containers, covered with a metallic net, were kept in an isolated

chamber, controlling temperature in order to maintain the substrate around 30°C. The substrate was inspected at 45 dd after infestation. No survival was recorded on the larvae, indicating that chipping technique could be a suitable method to destroy infested palm avoiding potential risks of re-infestation from the disposal sites. Additional replicates will be carried out to confirm the results.

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INDUSTRIAL HEMP FOR BIOMASS PRODUCTION

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Interest for possibilities of the industrial hemp (*Cannabis sativa* L.) growing in Latvia is increasing year by year and they are considered as one of the most promising renewable biomass sources to replace non-renewable natural resources for manufacturing of wide range industrial products. The aim of this research was the evaluate of biomass potential of some industrial hemp varieties to be recommended to grow in Latvia and clarify carbon content. The biometrical parameters of ten industrial hemp cultivars ('Bialobrzeskies', 'Futura 75', 'Fedora 17', 'Santhica 27', 'Beniko', 'Ferimon', 'Epsilon 68', 'Tygra', 'Wojko' and 'Uso 31') have been investigated at the Research and Study farm "Peterlauki" of the Latvia University of Agriculture in 2011-2012. The carbon content was determined. The results of investigation show that industrial hemp is promising plant for biomass production in Latvia. Depending on the variety the green over-ground biomass varies from 36-54 t ha⁻¹ in 2011, and from 48 - 75 t ha⁻¹ in 2012. The highest green over-ground biomass was obtained cultivar 'Futura 75' up to 75 t ha⁻¹. The carbon content in hemp stems was found from 41.62-43.67% and it depend on cultivars. Results of investigation of biomass potential of all ten industrial hemp cultivars are presented.

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PRODUCT CONTAMINATION AND HARVESTING LOSSES FROM MECHANIZED RECOVERY OF OLIVE TREE PRUNING RESIDUES FOR ENERGY USE

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Biomass represents the fourth largest source of energy and already satisfies about 14% of the energy needs of human society. Large quantities of ligneous biomass can be obtained from pruning operations carried out in Mediterranean orchards. These residues are usually destroyed by in field burning or crushing on the soil. This is due to unsolved technical problems that occur during the harvesting operations, as well as to the lack of information concerning the quantity and the quality of residue biomass potentially obtained from different plantations. In Italy, a large amount of biomass can be obtained from olive pruning, in particular, it is estimated that in region Puglia these orchards could yield over 800,000 tons of dry biomass per year. This study aims to quantify the amount of biomass producible from olive groves in Salento and contribute the promotion of the bioenergy sector. The objective of this research is that to analyze and evaluate how the commercially available machineries would be effective for collecting pruning residues of olive trees. The work took place at the farm of "Fratelli Caracuta", in Castrigliano de' Greci (Le) southern east Italy. The testing area was an olive grove of 0,45 ha characterized by a flat conformation and by a very compact sandy soil with no weeds. Have been tested six commercial pruning harvesters; these use a mechani-

cal pick-up to collect the residues and a shredder to reduce them into chips. Three different pick-up settings were tested. Each one designed to study the harvesting losses and product contamination (ash) of each machine in different conditions, namely: thesis A (1 cm above ground level), thesis B (manufacturer's specification) and thesis C (3 cm above ground level). Ash content in shredded residues varied between 4.5% and over 5.5%, for the shortest and the longest distance between the pick-up and the soil surface, respectively. In contrast, harvesting losses were weakly (but significantly) related to pick-up setting, and mainly depended on machine type.

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A GIS APPROACH FOR THE QUANTIFICATION OF FOREST AND AGRICULTURAL BIOMASS IN THE BASILICATA REGION

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The exploitation of renewable energy showed in recent years a substantial growth thanks to the development of new technologies able to achieve lower environmental impacts. Renewable energy technologies are important to control national and international climate change, energy security, affordability, power generation, resource efficiency, waste disposal and pollution control.

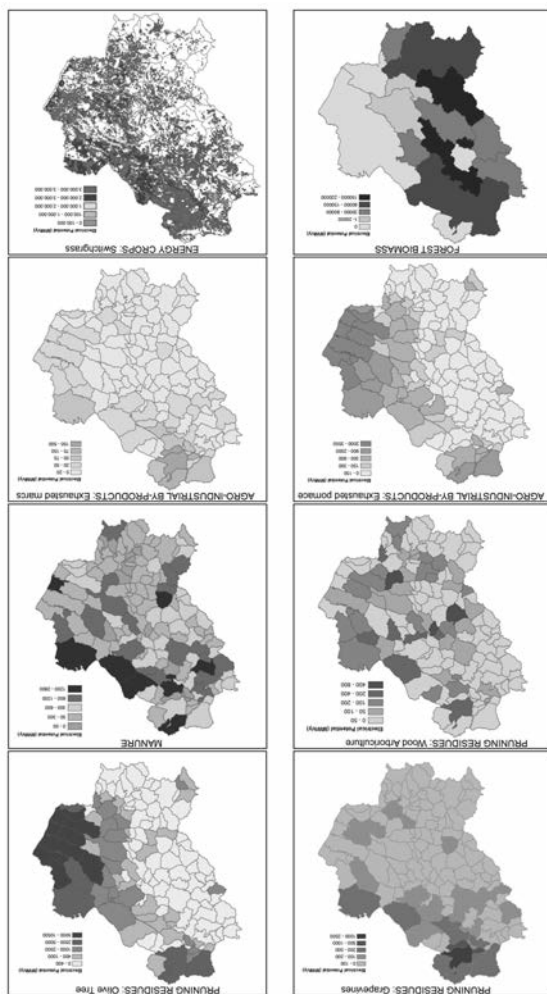


Figure 1. Estimation of Electrical Potential .

From the data of a previous work, wherein the general availability of renewable energy sources over the Basilicata Region - wind, solar and biomass energy - was determined, the attention has been now focused on energy only from biomass by-product, including forest biomass and agricultural production, waste and other sources of renewable energy. In order to determine the quantity of extractable biomass from the forests of the region, data from the "Carta Forestale della Regione Basilicata" (Forestry Map of the Basilicata Region) and plans for forest management have been retrieved. These data were imported in a Geographic Information System, in order to determine in which part of the Region there is the possibility to find greater quantity of biomass. As for the determination of the quantities of agricultural biomass, the energy crops and the agricultural waste (such as crop residues, grass cuttings, pruning, manure, waste coming from agro-food industries) were considered too. The reuse and exploitation of these wastes, while contributing to the solution of problems related to their disposal, promote their recovery as an important source of energy. Once estimated the annual amount of biomass, the subsequent step was the determination of the percentage of the annual energy contribution which this kind of by-product is able to ensure in economic terms. As a final result it could be concluded that renewable energy, in addition to reducing harmful emissions and not compromising the availability of natural resources, might also be considered as a valid economic option, that may significantly contribute to the development of the agro-forestry sector.

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SEED LOSSES DURING THE HARVESTING OF OILSEED RAPE (*BRASSICA NAPUS* L.) AT ON-FARM SCALE

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The oilseed rape (*Brassica napus* L.) is one of the more utilized crop for biodiesel production. In Italy its cultivation is restrained by the significant seed losses due to mechanical harvesting and meteorological events: the siliques may loss until 60% of their water content becoming prone to shattering and leading to a significant seed losses. Unlike other agricultural contexts, in Italy the oilseed rape is harvested in one passage, using combine harvesters with different types of heads and accessories. The accurate set up of the combine, heavily reducing the seed losses, may determine substantial gains in yield. Aim of this study was the evaluation of the yield losses of the oilseed rape caused by harvest operations and the identification of the amount of losses which could be ascribed to each aspect of the harvesting process on open field conditions and at on-farm scale. A common wheat head was compared with a head specifically equipped for rapeseed. This latter had a hydraulic sliding cut-bar and two vertical electric blade on both sides in order to reduce the pulling and tearing action between the cut plants and those still standing. The seed losses were evaluated analyzing single sectors of the combine by means of trays placed between the crop rows on the ground, before and during the harvesting. The average losses in the sectors monitored were always lower for the rapeseed-dedicated head than the one for wheat, with a difference always statistically significant. Some key outcomes were also obtained: the losses are localized on the head borders, where the plants are intertwined; they are significantly reduced by the application of advanced blades and by the increase of working width; a lower work speed ensures a more uniform feeding to the combine and picks the plants up less vigorously. To our knowledge, this is the first work on seed losses of oilseed rape at on-farm scale. The use of a dedicated head may lead to a reduction

of seed losses (0.97% on total production) below the values reported in literature.

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ENHANCEMENT OF PALM RESIDUES (PHOENIX CANARIENSIS) FOR A POTENTIAL USE IN RUMINANT FEED

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The increase of biological residues from numerous fellings of palms (*Phoenix canariensis*) infested by red palm weevil (*Rhynchophorus ferrugineus* Olivier) in central Italy and around the Mediterranean basin, has created an important disposal problem. This issue could provide a further use by introducing it as a food in diet of ruminants, beyond that represented by the use as fuel in biomass power plants for heating or electrical energy. The shredded material of palm can be employed to animal nutrition, resulting in interest for the feed industry and livestock sector. Analysis, carried out on samples of shredded palm, made using a chipper machine modified to obtain a product of small size (according to the phytosanitary measures of Lazio county: n. 390, June 5, 2007), showed an high water content (79%) and therefore a not easy conservation. A conservation technique could be dehydration, in order to make product as flour, pellets, to introduce in unifeed together with the other compounds of the diet (forage, concentrates, etc.). Given the high water content, the dehydration process causes a very high production cost. About nutritional value, analysis showed 0.65 UF/ kg on dry matter basis, higher than the straw and hay of stable grass in an advanced stage of maturation (0.20 to 0.30 UF/kg). These values are similar to a good hay obtained from mixed grass. As consequence it is possible to use shredded palm as part of energy of the ruminants diet. Is still not clear which component allows the achievement of this value, probably derives in small part by the lipid component and largely by the fibrous component. Moreover data showed that the presence of fatty acid precursors of CLA (Conjugated Linoleic acid) such as oleic acid and linoleic acid, is much higher than the values of Italian pastures. Utilization of these fatty acids in animal diets improves quality of the final products (milk, cheese, meat). The possibility of introducing shredded palm in ruminants diet, may be topic of interested to feed animal in arid areas of the Mediterranean basin, where it is difficult to find good forages.

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PERFORMANCE ANALYSIS OF THREE PHOTOVOLTAIC SOLAR PLANTS INSTALLED IN A LIVESTOCK FARM AND VALIDATION OF A PREDICTIVE MODEL.

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The production of energy by means of solar collectors has a great potential in farms. The aim of our work was to analyze the electrical yields given by three plants installed in a livestock farm and compare them with the outcomes of a predictive model to implement the theoretical estimation procedure. Methodology The electricity production of the different photovoltaic plants was recorded for a full year and analysed. The incident solar energy, the air temperature at the panel level and the climatic data were measured at intervals of 10 minutes (for one plant only daily). These data have been related together in order to determine the actual energy performance as a function of solar radiation, exposure and inclination of the panels. The data were compared with the theoretical values calculated by means of a computer program available on the web (Institute for Energy - Joint Research Center of the European Community, 2012) that provides the energy performance depending on the location of and the features of the plants. Data analysis has allowed the identification of the deviations between the theoretical values and the actual performance values. An overall superiority of the latter ones with respect to the first ones has been ascertained. Hence the hypothesis, to be tested further, that the mentioned model underestimates real yields or, more likely, the solar radiation. Furthermore it has been possible to determine the real influence on the nergy production of the design parameters of the system (exposure and slope) and the different construction technologies. The observations have provided the basis for a preliminary assessment of the correspondence between the performance values given by the theoretical model and the real measured data. Through a more prolonged observation some indications to implement the model (and in general the models to estimate the performance of the PV panels) will be found out. At the same time a guidance on the most effective mode of installation of such facilities will be provided with special reference to the roofs of farm buildings.

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INVESTIGATION OF BIOGAS PRODUCTION FROM MSW WITH GARAGE-TYPE BIOREACTOR

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Biogas, dry fermentation, municipal solid wastes, Jelgava

Over the past two decades the topical issue for the European Union countries as well as the rest of the word is usage of biomass for energy and biogas production. Dry fermentation is a new introduction in Latvia. The goal of the investigation was to identify how suitable is the garage-type bioreactor and production technology for biogas production from MSW (municipal solid wastes) and to identify biogas obtaining potential. Biogas output was investigated at 37-38°C. The garage-type bioreactor and production technology is suitable for biogas production using MSW. The fermentation process was measured on pH 7.21- pH 7.99 levels. The obtained biogas value of 1 ton wastes in 4 weeks: Investigation A – average 23.21 Nm³/biogas, Investigation B – average 34.23 Nm³/biogas, Investigation C - average 40.89 Nm³/biogas.

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AGRICULTURAL BIOGAS FACILITIES – A CHALLENGE TO THE RURAL AREA DEVELOPMENTKlepacka A.M., Ekielski A., Florkowski W.J.¹*Warsaw University of Life Sciences, Poland; ¹The University of Georgia, USA*

Two types of agricultural biogas facilities have been used in Europe, *i.e.*, a single plant that uses local feedstock and produces primarily for local users, and centralized facilities that utilize feedstock from a larger area (from farmers and the local food or agricultural commodity processing plants). Biogas plants attached to a single farm are feasible mainly in the case of large commercial farms due to the limited construction cost constraint. In turn, for the family farm operators the only opportunity is offered by the Rural Area Development Program (known under the Polish acronym PROW), where a farmer can apply for a grant to cover the selected expenses of maximum 200,000 zlotys or 300,000 zlotys, respectively, depending on the nature of the investment. For example, Polandor S. A. (the owner of eight biogas facilities out of the total 32 facilities operating in Poland in 2013) invested 4.3 mln zlotys. In comparison, the cost of 1 kW installed capacity in Germany or Denmark is 3,500 euros. Financial benefits resulting from renewable energy sales, the guarantee of fixed price and the increasing demand attract many potential investors (*e.g.*, Bio-power, Energia SA). The program “Energy Secured County – Biogas Energy” envisions the establishment of several hundred biogas plants in the northern and central Poland contributing to the infrastructure development, new job creation and establishment of markets for local agricultural production. Biogas plants could become an important source of clean energy on a national scale in Poland, enhance farm revenues by utilizing the food and agricultural processing waste, solve waste disposal (waste resulting from the fermentation of the stored biomass) and facilitate the compliance with the EU obligations regarding the CO₂ and other greenhouse gas emission reduction. The current study aims at measuring the influence of subsidy system and biogas utilization technology on the increase in the investment into agricultural biogas plants. The calculation of the economic and environmental biogas plant benefits included the structure of investment, operating expenses excluding depreciation, biogas plant revenues and the reduction in greenhouse gas volume.

SAFETY, HEALTH AND ERGONOMICS - SHWANET INTERNATIONAL MEETING

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WORKING TIME REQUIREMENTS OF THE FARROWING PEN WELSQuendler E.,¹ Pötz P.,¹ Hagmüller W.²*¹Department für Nachhaltige Agrarsysteme, Institut für Landtechnik, Wien, Austria*

These days, especially in organic piglet production, it is necessary to reduce the production costs to be competitive on the market. A large proportion of the production costs are caused by labor and construction costs to ensure a high level of animal welfare. The farrowing pen of Wels, a consisting prototype, was constructed to fulfill the organic farming requirements and to minimize the costs. The housing system is characterized by four separate functional areas, the lying area, the excretion and moving area and the feeding area for the sow and a piglet nest. For identification of the working time requirements of routine and special tasks was done a time study, based on the work element method and electronic time recording system (ortim b3). The collecting of the influencing variables and the time measurements were carried out by a direct observation of work processes in the farrowing unit which had 5 farrowing pens, over a period of 21 days at the “LFZ Raumberg Gumpenstein”. The data were descriptive and statistical analyzed to obtain planning data on the element basis and the time requirements were modeled task-related and in total over the suckling period. The routine tasks consisted in transport of the feed to the pen, the feeding of the sows, the checking of the sows and piglets, the mucking out of the dung corridor with the tractor and the straw sprinkling in it as well as filling up of the hay rack. The working time requirements for these tasks were 3.99 AKmin per sow and day in total. The special tasks were the inoculation of the piglets, marking with earmarks, castration of the male piglets, washing of the whole pen and the dung corridor, and preparing of the farrowing pen for the next sows. They caused working time requirements of 25.9 AKmin per sow over the keeping period of 21 days. The total working time requirements over the period of 21 days were 1.82 AKh per sow. Overall, the farrowing pen of Wels caused low time requirements and can be seen as a good alternative to the consisting organic ones.

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HEALTH AND SAFETY CHALLENGES ASSOCIATED WITH IMMIGRANT DAIRY WORKERS

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Faced with increasing industrialization, high demands on production, and decreasing domestic participation in the labor force, dairy producers are employing an immigrant workforce to help meet operational demands. There is little data regarding the number of immigrant workers in the dairy industry, but the trend of hiring immigrant workers in some of the world's highest producing countries is increasing. There are many challenges associated with managing immigrant workers including how to effectively train this workforce about safe and efficient work practices. Ethnographic methods from the anthropology field served as the primary tool to identify barriers and facilitators of safe work practices in large-herd dairy operations in the United States. Following a weeklong immersion by the research anthropologist at a selected dairy, focus groups were organized at three large-herd dairies.

All focus group conversations were tape-recorded, transcribed and translated into English. The focus group transcripts were then coded for specific themes related to issues that participants felt were barriers or facilitators of worker health and safety. Twenty-two Latino workers 18 to 58 years of age participated in the three focus groups conducted at one Colorado and two South Dakota dairies. Six major themes relating to barriers and facilitators of worker health and safety were identified and included: communication, integration owner and worker cultures, work organization, leadership, support for animal health, and attention to safety culture within the organization. Although not often considered by agricultural engineers, an anthropological perspective to challenges involving an immigrant workforce may assist with improved work methods and safe work practices. Through this approach, agricultural engineers may better understand the cultural challenges and complexities facing the dairy industry. Successful integration of immigrant workers relies not only on cultural awareness but also the ability to integrate cultural knowledge, beliefs, values, and traditions into management and work practices.

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THE RISK OF MUSCULOSKELETAL DISORDERS DUE TO REPETITIVE MOVEMENTS OF UPPER LIMBS FOR WORKERS EMPLOYED IN HAZELNUT SORTING

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In the agro-industrial sector there are many activities whose urgent rhythms can cause a considerable exposure to bio-mechanical risk factors. In the hazelnut sorting, the workers are subject to several biomechanical risks, with repetitive movements, and operations that require a remarkable degree of strength. A thorough study of the workers' exposure to repetitive manual movements has been carried out, with the aim of setting up the necessary measures to reduce the risk factors. The aim of the research is to assess the risk of WMSDs due to repetitive work, for workers employed to hazelnut shells sorting. The research was carried out in an agricultural cooperative in the Viterbo's area. For risk assessment authors used a method ("OCRA index" according to ISO 11228-3:2009, Ergonomics - Manual handling - Part 3: Handling of low loads at high frequency) which keeps into consideration several risk factors (such as repetitiveness, prehension force, posture). The risk was assessed for 16 female workers (in eight workplaces and in two different shifts) through this classification: workers with experience less than 1 year, from 1 to 10 years and more than 10 years. This classification is very important for knowing if the professional experience could be considered a "prevention measure" for the risk reduction. The results show a high risk level for the right and left limb. The factors which more have contributed to reach such risk level are the great number of movements and the lack of recovering time.

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THE OCCUPATIONAL SAFETY ON THE CONSTRUCTION SITES OF THE FARM PRODUCTION BUILDINGS IN FINLAND

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The size of farms has increased considerably during Finland's EU membership. The growth has meant big investments in the new pro-

duction buildings. The buildings have been switched to big industry-hall-like constructions from small-scale ones which have contained own timber and own work contribution. The objective of the project financed by Farmers' Social Insurance Institution was to improve occupational safety on farm building construction and renovation sites by disseminating current safety practices and by developing ways of action which are better than the prevailing ones. The project consists of a literature review, statistical analysis, as well as a farmer and designer interviews. In the statistical analysis the MATA occupational injuries insurance claims database on farmers' claims during construction and renovation work for the years 2005–2008 was compared with the register of Federation of Accident Insurance Institutions on the construction workers' injuries. In comparing the culprits of the accidents a clear difference was found; poor scaffoldings and ladders are still the main culprits on farm accidents. Farmer interviews were used to assess occupational safety measures on the construction site, occurred injuries and their types, near-miss situations and the underlying factors which have led to the injuries. Also construction safety deficiencies as well as the direct and indirect costs caused for instance because of the delay in completion of construction project were discussed. Designer interviews aimed to find out how to occupational safety and health considerations are taken into account in farm building planning and counseling, and how this experience of the designers should be taken into account in order to improve safety at the situation at the construction sites on farms. Farmers knew their obligations on occupational safety poorly. The situation was further aggravated by the fact that on the site the supervisor tasks were only nominally executed. The designers knew the occupational health and safety legislation better but this did not help the situation on the sites because they are not generally involved in the actual implementation of the construction project.

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METHODOLOGICAL APPROACH TO ASSESS TRACTOR STABILITY IN NORMAL OPERATION IN FIELD USING A COMMERCIAL WARNING DEVICE

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Since Roll-Over Protective Structures (ROPS) are mandatory on tractors, the number of fatalities caused in the event of an upset is definitely reduced. Nevertheless, fatal accidents caused by machine loss of stability are still of great concern. In fact, despite ROPS have reduced injury to agricultural operators, tractor stability is still a complex issue due to its high versatility in use, especially considering normal operations in field, when interactions with the environment such as soil morphology and climatic conditions are involved, as well as interactions with operator skills and experience.

Table 2. Tractors, engine power and working areas.

Tractor code	Power (kW)	Area	Field operations
1	107	hill	harrowing, mowing
2	74	hill	baling, liquid manure spreading
3	200	plain + hill	plowing
4	103	plain	subsoiling, harrowing, baling
5	63	plain	mowing, hay making

With the aim of collecting data on different variables influencing the dynamics of tractors in field, a commercial device that allows the con-

tinuous monitoring of working conditions and the active configuration of the machines was fitted on standard tractors in normal operation at the experimental farm of the Bologna University. The device consists of accelerometers, gyroscope, GSM/GPRS, GPS for geo-referencing and a transceiver for the automatic recognition of tractor-connected equipment. A microprocessor processes data and provides information, through a dedicated algorithm requiring data on the geometry of the tested tractor, on the level of risk for the operator in terms of probable loss of stability and suggests corrective measures to reduce the potential instability of the tractor.

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SIMULATED STABILITY TESTS OF A SMALL ARTICULATED TRACTOR DESIGNED FOR EXTREME SLOPED VINEYARDS

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A new reversible wheeled articulated tractor, designed to address the problem of working in terraced vineyards trained with the so-called "pergola" system, very common in mountain areas, is here described in its latest version (Figure 1) and analysed through numerical simulations. The operating environment for this small tractor is characterised by: i) very narrow inter-rows, often lower than 1.00 m and with the risk of roll-over, ii) reduced spans under the arbours (commonly ≤ 1.80 m, often 1.60 m); iii) steep and very tight curves in row heads, with great difficulties of manoeuvre.



Figure 1. Draft of the wheeled articulated tractor in the reverse drive configuration.

The tractor resulting from these design requirements has small dimensions, necessary to operate in this environment, and presents a central articulation having two rotational degrees-of-freedom. This joint allows a great manoeuvrability on the horizontal plane and the overcoming of the soil harshness. The described features are surely strong design points but could be potentially critical for the stability of the vehicle both in static and in dynamic conditions, as affecting the supporting base dimensions and shape. Therefore, a mathematical description of vehicle-ground interactions was implemented to deeply inquiry the tractor's behaviour in different vehicle configurations (straight, angled) by increasing the values of the ground slope; a safety stability index was then computed and used for comparisons with traditional tractors. Thanks to the low centre of gravity, the resulting rollover angle with the vehicle in straight configuration is promising (43.8° 96%), as it is greater than the maximum angle of lateral (20° 36%) and of frontal slope (38° 78%) ever recorded on terraced crops.

However, the same angle is lower when the two halves of the vehicle are angled (when the tractor is turning): the rollover of the vehicle can indeed start from the instability of its upstream part. Hence, a new automatic safety system was proposed: a self-locking articulation activated by contact sensors on the wheels. This device makes the vehicle partially-rigid in case of lateral unbalancing, so that the rollover can happen only by overcoming the mass of the whole vehicle. As the simulations gave very good results, this active safety device is now part of the latest version of the tractor.

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ENGINEERING SOLUTIONS APPLIED TO PNEUMATIC DRILLS TO REDUCE LOSSES OF DUST FROM DRESSED SEEDS

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Neonicotinoid insecticides (imidacloprid, clothianidin, thiamethoxam) and fipronil for maize (*Zea mays* L.) seed dressing have been claimed to play a role in honey bee (*Apis mellifera* L.) decline, since pneumatic precision drills used for sowing contribute to the dispersion of the abrasion dust produced by dressed seeds. The active ingredients (a.i) can contaminate the environment and can lead to the exposure of operators and bystanders during sowing operations. To achieve a significant reduction of dust drift and to enhance the safety for the operators, CRA-ING studied and developed novel engineering solutions applicable to drills, based on an air-recycling/filtering system. In the first system, the air's excess is forced outward through suitable filters placed on the modified lid of the seed hopper. It can be easily applied to commercial drills in use. The second system was specifically designed for new drills. It consists of a collector duct that receives the air expelled from the vacuum fan opening, creating constant pressure conditions. Part of the air is recycled into the seed hoppers, as the air in excess is directed outward through a single main filter. A third system, based on the second one, entails the use of an electrostatic filter to improve its efficiency. Moreover, to avoid the operator's exposure to the dust during the seed loading, we show an integrated solution based on the use of a modified pre-charged plastic container that replace the drill's hoppers. After preliminary tests to ascertain the regular seed distribution with the drills equipped with the prototypes, some trials have been carried out at fixed point and in field, for detecting the amounts of the drifted a.i., using commercial maize seed dressed with thiamethoxam, imidacloprid, clothianidin and fipronil. The test results show powder and a.i. drift reductions up to a maximum of 94.5% measured at ground level (with fipronil as a. i.) as a consequence of the use of the prototypes.

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EXPOSURE TO VIBRATIONS IN WINE GROWING

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Apart winter period, the activity in specialized agricultural cultivations (*i.e.* wine- and fruit-growing) is distributed for a long period of the year. Some tasks, such as pesticide distribution, are repeated several times during the growing season. On the other hand, mechanization is one of the pillars on which is based the modern agriculture management. As a consequence, in wine growing the tractor driver has to be considered a worker potentially subjected to high level of vibrations,

due to the poor machinery conditions often encountered, and sometimes to the rough soil surface of the vineyard combined with the high travelling speed adopted in carrying out many operations. About vibrations, the Italian Decree 81/08 basically refers to the European Directive 2002/44/CE, that provides some very strict limits of exposure, both for whole body and hand-arm districts. In Oltrepo pavese, a large hilly area located the south part of the Pavia province (Lombardy - Italy) wine growing is the main agricultural activity; for this reason, a detailed survey on the vibration levels recorded at the tractor driver's seat was carried out, in order to ascertain the real risk to which the operators are exposed. The activity in wine growing has been classified into 6 groups of similar tasks, as follows: 1. canopy management: pruning, trimming, binding, stripping, etc.; 2. soil management: harrowing, hoeing, subsoiling etc.; 3. inter-row management: chopping of pruning, pinching, grass mowing, etc.; 4. crop protection: pesticides and fungicides distribution, sulfidation, foliar fertilization, etc.; 5. grape harvesting: manual or mechanical; 6. transport: from the vineyard to the cellar. For each group of tasks, the vibration levels on 3 the traditional axes (x, y and z) were recorded, and then an exposure time was calculated for each of them, in order to ascertain the risk level in comparison to what provided by the dedicated standard. Finally, a detailed study was conducted on the most dangerous working conditions, with the goal to offer solutions able to reduce the overall exposure, as improving the comfort level, as to shorten the working time when possible and/or to provide suitable periods of rest.

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STUDY ON THE POSSIBILITY OF APPLICATION OF A COMPACT ROLL OVER PROTECTIVE STRUCTURE FOR AGRICULTURAL WHEELED NARROW TRACK TRACTORS

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Since occupational accidents often occur in farm tractor drivers, it is extremely important to focus the attention on specific devices in order to avoid risks from tractor overturning. This phenomenon is actually considered as the leading cause of deaths or injuries related to agricultural work. The system adopted to reduce the above-mentioned risk consists of passive protection devices aimed at preventing the hazardous event which may affect workers' health. More precisely, the tractor chassis (*i.e.* ROPS) and the proper seat belt define a "safety volume" around the worker. The aim of the present research is to carry out tests on narrow-track wheeled tractors with fixed roll over protective structures in those areas – such as hazel and olive groves and vineyards - where problems related to under-tree activities occur. This is to implement planting layout and/or cultivation techniques which can be considered suitable for tractors with roll over protective structures. According to that, their project parameters – *i.e.* safety volume, seat position and typology, test methods – can be successfully modified and improved. The results show that nowadays only a few agricultural vehicles are provided with specific fixed devices able to work under tree without damaging orchards.

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ACCIDENT INVESTIGATION RELATED TO THE USE OF THE CHAINSAW

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Operating in woods might be highly dangerous as it takes place in hard environments because of slopes, uneven ground and the presence of the underwood that may prevent machines and operators from moving. The chainsaw is a widely-used tool in agriculture, in forestry as well as for professional and hobby-related purposes. This article has the aim to highlight the state of injuries both for professional and domestic uses. The research focused on web-based report of news published between 2007 and 2012 about mortal and non-mortal accidents occurred in Italy and involving people who were using a chainsaw. On the whole, 336 cases were collected over a 5-year period. The results of the work are represented by a series of thematic maps related to the causative agent, the age of the injured and the seat of the injury. Furthermore, it is confirmed that the operator's head is the most exposed area of the body and is often correlated with the death of the operator (death is often due to collision against the chainsaw blade, facial traumas as well sudden contact with parts of the plant). The study shows the dangers of chainsaw. Even workers experts are involved in serious injury and death. The study highlights the need be in search of technical solutions but also of procedures for specific training also for unskilled worker.

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A WII-CONTROLLED SAFETY DEVICE FOR ELECTRIC CHAINSAWS

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Forestry continues to represent one of the most hazardous economic sectors of human activity, but in the last years the scenario has changed. Historically, the operation of chainsaws has mainly been restricted to professional lumberjacks, but in recent years, because of low cost, chainsaws have become popular among unprofessionals, e.g. for cutting firewood and trimming trees. Today, over 300 000 chainsaws are sold annually in Italy, while many millions of older models are still in use. Even new models have, however, some inherent dangers associated with their operation that could result in serious and sometime fatal injuries. Serious or lethal lesions due to the use of chainsaws or electric chainsaws are often observed by traumatologists or forensic pathologists. Such serious accidents often occur during occupational activities, or more rarely during suicidal events. Accidental injuries are essentially due to kickback or uncorrected use of the tool, or when the operator falls down losing the control of the implement. A new device in order to stop a cutting chain and was developed and adapted to an electric chainsaw. The device is based on a Wiimote controller (Nintendo™), including two accelerometers and two gyroscopes for detecting rotation and inclination. A Bluetooth wireless technology is used to transfer data to a portable computer. The data collected about linear and angular acceleration are filtered by an algorithm, based on the Euclid norm, capable to distinguishing between normal movements and dangerous chainsaw movements. The result show a good answer to device and when happen a dangerous situation an alarm signal is sent back to the implement in order to stop the cutting chain. In all situation tested the signal was send. The device show to a correct behavior in

tested dangerous situations and is envisaged to extend to combustion engine chainsaws, as well as to other portable equipment used in agriculture and forestry operations.

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ERGONOMIC ISSUES IN EWE CHEESE PRODUCTION: RELIABILITY OF THE OCRA AND STRAIN INDEX

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Occupational ergonomists often use a variety of methods to identify jobs that are considered at high risk for the development of work-related musculoskeletal illnesses. The Strain Index (SI) and the Occupational Repetitive Actions (OCRA) Checklist are two popular upper limb risk assessment tools used in many industries, including the agro-food industry. Both methods are based on similar biomechanical, physiological and epidemiologic principles, but their approach to quantification and estimation of risk factor magnitude is quite different. The purpose of this study was to assess the inter-method reliability of SI and OCRA Checklist. Twenty-one jobs were video recorded in a Sardinian cheese manufacturing facility. Eight raters were recruited to assess job exposures to physical risk factors using the SI and OCRA Checklist. Inter-method reliability was characterized using proportion of overall agreement, Cohen's kappa, and Spearman and Pearson correlations. Results: Strain Index and the OCRA Checklist assessments produced generally reliable results, classifying the risk of 35 of 42 (83%) job exposures similarly. The OCRA Checklist and SI risk assessments are reliable upper limb measures of physical work exposures. Both measures appear useful for assessing risk of upper limb disorders of work tasks in the agro-food industry. However, the SI is specific to disorders of the distal upper limb and perhaps most useful for assessing risk in work primarily involving the wrist and fingers. Whereas the OCRA Checklist, which includes an assessment of the shoulder, may be more appropriate for evaluating jobs that also require extended periods of reaching and shoulder activity.

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NOISE RISK ASSESSMENT IN A BOTTLING LINE OF A MODERN SICILIAN WINERY

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In wine industry, bottling is a phase of the production cycle characterized by high levels of noise mostly due to repeated collisions between the bottles. In Italy the Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a number of procedures to be adopted at different noise levels to limit workers exposure. This study aims at evaluating the equivalent and peak noise level inside the bottling plant area of a modern Sicilian winery. In particular, the influence of the working capacity (number of bottles produced per hour) on noise levels was evaluated. We considered three test conditions: T1 with working capacity of 4,000 bottles per hour, T2 with working capacity of 5,000 bottles per hour and T3 with working capacity of 6,000 bottles per hour. Fifteen measurement points were identified inside the bottling area. The instrument used for the measurements is a precision integrating portable sound level meter, class 1, model HD2110L by Delta OHM, Italy. The tests were performed in compliance with ISO 9612 and ISO 9432 regulations. The results show that as bottling plant working capacity increases, noise level increases. The measured sound levels exceed the limits allowed by the

regulations in all the test conditions; values exceeding the threshold limit of 80 dB(A) were recorded coming up to a maximum value of 95 dB(A) in test T3. In this case, the operator working along the bottling line is obliged to wear the appropriate Personal Protective Equipment.

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A SURVEY OF SAFETY ISSUES IN TREE-CLIMBING APPLICATIONS FOR FORESTRY MANAGEMENT

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Trimming is a very common operation in arboriculture, in city park as well as in forestry management. For large trees, this operation is often not possible from ground using ladders or elevators. Ladders can be dangerous and since most forestry areas are almost inaccessible, the use of mechanical elevators can be difficult/dangerous. Work activities at height, as tree-climbing, in Italy are regulated by Legislative Decree 81/08. Article 17, obliges the employer to the assessment of any risks for the health and safety of workers in workplaces. Article 71 obliges the employer to periodically inspect the used work equipment. The employer maintains all used PPE with periodical checks in accordance with instructions provided by the manufacturer. Tree-climbing activities expose operators to fall from height risk. Moreover these workers are exposed to other risks like Harness Hang Syndrome, exposure to physical factors, risk due to ergonomics issues, bad work-site organization, poor training. About the latter, Article 37 obliges employers to train workers, while Attachment XXI, specify all the features the courses must fulfil. Optionally workers can obtain a certification recognised at European level. Devices to be used as protection against falls from a height, are reported in Article 115. Their choice rely on two main concepts: security chain and suitability/mutual compatibility. These two different concepts will have to be considered by the employer while selecting the correct PPE. The term "security chain" is referred to all the devices that support and sustain at height the operators and are represented by the anchor point, ropes, harness, shock absorbers and so on. If any of these fails, the entire security chain fails also, so a redundant security line could be used. Suitability/mutual compatibility concepts are referred to specific directives the device is compliant with. Only devices for work use are admitted along the entire security chain. For example different ropes, compliant to EN892, EN1891A or EN1891B directives, are currently available. Among these, only ropes compliant to EN1891A are admitted for work use (suitability). On the other side, in working contest, an EN1891A rope is not compatible with an harness compliant with EN12277C (mutual compatibility).

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VIBRATION RISK EVALUATION IN HAND-HELD HARVESTERS FOR OLIVES

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Vibration is probably the most important risk connected with the use of portable harvesters. Its reduction can be achieved after a proper design or an optimal selection of the operating parameters. Many makers, in fact, trying to increase the operator's comfort and to respect the threshold limit values imposed by the recent regulations, have put on the market portable harvesters powered by electric motors, characterised by greater lightness, greater handiness and which resulted very effective in reducing the noise level with respect to those powered by two-stroke engines. This research aims to evaluate the vibration trans-

mitted to the hand-arm system by two electric portable harvesters, different for size of the harvesting head. As the bars of the two machines are telescopic, they were operated by considering minimum and maximum length. The acceleration was measured, at different times, in two points, 1 m apart, next to the hand positions. Moreover, measurements were carried out both at no load, in standard controlled conditions, and in field, under ordinary working conditions. To smooth the influence of external factors, the machines were operated by the same person. The results showed that the greater and heavier harvesting head produced significantly higher acceleration at no load (10.7 m/s^2 vs. 5.5 m/s^2), and comparable acceleration at load (13.9 vs. 14.2 m/s^2). On average, the vibration was significantly higher at load (14.0 vs. 8.1 m/s^2). The difference between the two bar lengths was not statistically significant: 9.4 m/s^2 when using the minimum length and 9.8 m/s^2 when using the maximum one. Finally, the difference between the two measuring points was affected by the bar length: it was statistically significant when using the bar at its minimum length only. As far as the components are concerned, at no load the highest acceleration was measured along the bar axis for both harvesting heads (9.2 m/s^2 for the greater head and 4.2 m/s^2 for the smaller one). At load all the three components were comparable in the grater head (about 7.8 m/s^2) whereas the x component was predominant in the other one (11.4 vs. 4.8 (y) and 6.6 m/s^2 (z)).

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WHOLE BODY VIBRATIONS DURING FIELD OPERATIONS IN THE VINEYARD

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Human exposure to mechanical vibration can be a significant risk factor for exposed workers and this also occurs in the agricultural sector, in particular with reference to the driver of the tractor during field operations. The aim of this paper is the evaluation of Whole Body Vibrations for the operator driving tractors during the field operations in the vineyard.

The experimental tests were performed using a wheeled and a track-laying tractor. They were coupled to four different machines: rototilling (RT), chisel plough (CP), flail mowers (FM) and vibro farmer (VF). Two homogeneous plots of vineyard, about 200 m long, were identified different only for slope: 0% and 30%. The tests were performed during the execution of the cultivation operations in flat conditions, uphill and downhill. For the evaluation of whole-body vibration we referred to ISO 2631-1:2008 standard. We used the portable vibration analyzer HD2070 by Delta Ohm, Italy. The mean square frequency-weighted acceleration [m sec^{-2}] was evaluated along each of the three axial components of the acceleration vector (aw_x , aw_y , aw_z). The vibration total value to which the body is exposed (av) was determined by the following relationship:

$$av = (kx^2 aw_x^2 + ky^2 aw_y^2 + kz^2 aw_z^2)^{1/2}$$

where $kx = ky = 1.4$ and $kz = 1$.

The study allowed to point out that during the use of the above mentioned operating machines coupled both with a track-laying tractor and a wheeled tractor, A(8) values were always higher than 0.5 m/s^2 therefore, included in the "risk threshold" identified by the Italian Law Decree 81/2008. The machines coupled to the wheeled tractor always registered higher vibration values on the driving seat than the same machines coupled to the tracklaying tractor. The operating machines showing higher vibration values are rototilling and vibro farmer in both tractors. Finally, the soil conditions in terms of slope caused no partic-

ular differences of vibration levels for all the machines used in the tests.

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THE HEAT STRESS FOR WORKERS EMPLOYED IN A DAIRY FARM

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The Italian dairy production is characterized by high heterogeneity. The typology quantitatively more important (80% of national production) is represented by cow's milk cheeses (Grana Padano cheese, string cheese, Parmesan cheese, etc.), while the cheese from buffalo milk (especially string cheese such as mozzarella) and cheese from sheep and goats represents respectively 4% and 8% of the national dairy production, and are linked to specific regional contexts. Some phases of the cycle of milk processing occur at certain temperatures that are not comfortable for the operator also in relation to possible problems due to thermal shock. The aim of this study was to evaluate the risk of heat stress on workers operating in a dairy for processing of buffalo milk. The research was conducted at a dairy farm located in the province of Viterbo during the spring-summer period. To carry out the research were detected major climatic parameters (air temperature, relative humidity, mean radiant temperature, air velocity) and the main parameters of the individual operators (thermal insulation provided by clothing and the energy expenditure required from the work done by employees in the work areas investigated). Subsequently were calculated main indices of heat stress assessment provided by the main technical standards. In particular have been calculated Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) in moderate environments, provided by the UNI EN ISO 7730 and the wet bulb globe temperature (WBGT) in severe hot environments required by UNI EN 27243. The results show some phases of risk from heat stress and possible solutions to improve the safety of the operators.

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SPECTRAL ANALYSIS OF A STANDARD TEST TRACK PROFILE DURING PASSAGE OF AN AGRICULTURAL TRACTOR

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Italian statistics on work safety are pointing out a decrease about injuries and fatalities but an increasing number of reports about professional diseases. A mean value has been observed of 36% more in the last 5 years but data in agricultural environment are increased of 383% in the last 5 same period. It's difficult to associate these data specifically to some causes well identified but it is sure that the interest about the occupational diseases is increasing. In this frame are also considered the mechanical vibrations. In particular, whole-body vibrations (WBV) could affect an operator driving an agricultural tractor depending on intensity, duration and frequency. European Parliament Directive 2002/44/EEC sets the minimum requirements for protection of workers from risks to their health and safety arising from exposure to mechanical vibrations; moreover, in 2008, Italy adopted a specific national regulation on safety (Decree no. 81/2008). Although most of the studies are directed to meas-

ure comfort, vibration dumping and developing models, one of the most important parameter as the surface profile, is not analyzed as expected, above all for the difficult of the measurement. This study aims to analyse the profile of a standard surface (ISO 5008) during the passage of a tractor for defining potential correlations between the surface contour and the effects on vehicle dynamic and driver comfort by analysis of the signals acting under the tractor tires. An agricultural tractor, in four setting conditions and four different forward speed, was tested on ISO 5008 standard test track. The accelerations at the hubs of the tractor were acquired and subsequently reproduced on a four hydraulic actuators test bench, at CRA-ING laboratories. The vertical displacement of the hydraulic actuators were driven, by specific electronics, for reproducing the profiles defined as the vertical input of the surfaces. The analysis of the spectrums have shown that a roughness surface induces a transformation of the forward speed of the vehicle in vertical acceleration that excites the elastic parts (*i.e.* tires, suspensions, ...). These phenomena seem to indicate that vehicle's vibration entity is due to the combination of surface roughness and forward speed as amplitude and to the elastic properties of the tires as frequency.

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VIBRATION TRANSMITTED TO OPERATOR'S BACK BY MACHINES WITH BACK-PACK POWER UNIT: A CASE STUDY ON BLOWER AND SPRAYING MACHINES

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To correctly evaluate the vibration transmitted to the operators, it is necessary to consider each body's point interested by the vibratory stimulus produced by machines. All the body's part in contact to the vibration, when a portable device with internal combustion engine is used, are: hands, back and shoulders. Some information for whole-body vibration are available in the ISO 2631-1997 standard, which otherwise refers to a seated operator. 'C' type standards for the vibration analysis exist for some portable machines with an internal combustion engine which is comprehensive in the machine (chainsaw, brush-cutter, blower). If the engine is not inside the machine, but it is on the operator's back, 'C' type standards on vibration measurements are quite incomplete. The IMAMOTER institute of CNR, the DISAFA Department (University of Turin) and the Occupational Medicine Department of the University of Catania started some tests to verify the vibration levels transmitted to an operator working with backed engine devices. Two machines have been examined: a blower and a spraying machine. Two operative conditions have been considered during all the tests: idling and full load. Three operators have been involved and each test has been repeated three times. The spraying machine has been tested both with the empty tank and with 10 litres of water, to simulate the load to be caused by the presence of liquid inside the tank. In this work the comfort condition of ISO 2631-1 standard was considered, using the frequency weighting W_c curve with the weighting factor 0.8 for X axis (back-ventral direction) and the W_d curve for Y and Z axis (shoulder - shoulder and buttocks - head) with weighting factors 0.5 and 0.4 (respectively for Y and Z axis). Data were examined using SPSS 10 software package. The statistical analysis underlined that the running condition is the main factor to condition the vibration levels transmitted to the operator's back, while the ballast and the operators are influent when the running conditions are distinguished. Concerning medical investigation, lower back and shoulders are the main critical part of the body interested by vibration transmitted to each operator.

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ERGONOMIC ANALYSIS FOR THE ASSESSMENT OF THE RISK OF WORK-RELATED MUSCULOSKELETAL DISORDER IN FORESTRY OPERATIONS

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The risk to run into a Work-Related Musculoskeletal Disorder (WMSD) is very high when operating in the primary sector. As a matter of fact the professional illnesses related to the WMSD in Italy are increasing. Nowadays the assessment of the WMSD in the primary sector is performed mainly in the agricultural sector, considering different agronomical activities; for the forestry sector, only few documents reported an ergonomic evaluation. The lack of available information on this topic in the forestry sector, as well as the similarity with the agricultural sector, drives the interest to the assessment of the conditions that expose workers to WMSD risks in forestry operations. Four different assessment approaches were applied in this study. These tools permitted to classify which are the exposures and if there is the presence of WMSD risk for forest operators. The approaches are respectively the OCRA checklist and the RNLE equation, both recognized as ISO standards, as well as OWAS and REBA, recommended by ISO standards. The first approach focusses on the risk due to repetitive and stressed movements, while the second evaluates the risk of injuries due to the manual movement of loads. Meanwhile OWAS and REBA detect the possibility of injuries due to wrong postures during the work. These approaches were applied for the cutting operations with chainsaw. Since the evaluation requires high levels of attention and also because it was necessary to gain a good level of safety for the surveyor, a digital camera was used to film the operative activities. Then, the movies were analysed in office. Aim of the research is to analyse if it is possible to apply the approaches suggested by ISO standards in order to assess the most dangerous activities that, when not properly carried out, could be the cause of WMSD in forestry operations. The study showed that during the use of the chainsaw the index of risk of professional injuries was overpassed several times, compromising the operator's safety.

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FITTING AND TESTING OF ROLL OVER PROTECTIVE STRUCTURE ON SELF-PROPELLED AGRICULTURAL MACHINERY

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Roll-Over Protective Structure (ROPS) represents the state of art for the driver's protection in case of tractors roll-over. Despite their real risk of overturning, the ROPS approach for the Self-Propelled agricultural Machinery (SPM) is quite recent. Due to the several SPM categories available on the market, characterized by very different mass, dimension and working functions, the fitting of a ROPS and consequently the ascertainment of its protection level is quite complicated. SPM could be preliminarily divided into at least two categories: - large SPM: combine, forage, potato, sugar-beet and grape harvesters; sprayer; etc.; - small SPM: ride-on tractor, mower, comb side-delivery rake, etc. The most popular approach is to check preliminarily the overturning behavior of the SPM considering its longitudinal and lateral stability; if a real risk of overturning is ascertained, in order to minimize the likelihood of driver's injury the manufacturer often installs a ROPS. The consequent need is to provide some test criteria of them. Sprayers between large SPM, and comb side-delivery rake between

small SPM were the machines on which ROPS were tested, applying in both cases the Code 4 issued by the Organization for Economic and Cooperation Development (OECD), dedicated to ROPS fitted on conventional agricultural and forestry tractors. Notwithstanding the very different dimensions of these two SPM, this standard was selected considering the predictable roll-over behavior, also in relation with the front and rear track values. On the 4950 kg mass sprayer was fitted a closed cab, while on the 690 kg mass comb side-delivery rakes a 3-pillars frame was applied. In both cases the response of the tests was positive, so indicating a general suitability of OECD Code 4 to assure a ROPS good driver's protection level in case of overturning. On the other hand, to ascertain more in detail the roll-over behavior of the SPM, some further questions need to be deeply examined, such as the driver's place location, the height of the centre of gravity from the ground in different machine configurations (*i.e.* with crop tanks empty or full), the external silhouette, the axles mass distribution of the laden/unladen machine, etc.

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ANALYSIS OF THE BUILDING SYSTEM OF FOUR MILLS AND THEIR SUITABILITY FOR HEAT TREATMENT PEST DISINFESTATION

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In the last century researchers at Kansas State University demonstrated the validity of the heat treatment as a method of pest control in more than 20 mills. The scientific literature highlights some of the factors that limit the efficiency of the treatment. This is related to aspects of the buildings and the plants and the environment of the buildings. The structure of the buildings appear to have an enormous impact on energy consumption, because this depends on the amount of heating time and the methods that have to be used when establishing a heat treatment regime. These factors are important if the fumigation temperatures are to be reached in the shortest possible time and can affect the choice of the technique used with current fumigants, especially when this is combined with the amount and cost of the energy consumed. The aim of this work is to analyze four Sicilians mills that intend to use the heat system for fumigation and pest control in order to identify those aspects of the buildings, plant and their environment which are "critical elements" and may discourage the use of this technology. Metadesign methods were used to extrapolate, from the building systems used, the environmental systems, typologies and technological standards of the four standard mills. Particular attention was paid to the type of construction materials and their thermal conductivity (roof, floors and walls), the number and volume of the buildings and the distance between them, the entrances and the links between different parts of the plant and the type of equipment used and its spatial organisation inside the buildings. Results and conclusions The study identifies the heat distribution in the buildings and between the different floors and the heat loss, It also identifies which equipment or parts of the plant are suitable for heat treatment. Thus this work provides the base for future actions which will be aimed at improving the performance of the buildings and reinforce the use of heat treatment in pest control.

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SAFETY IN THE HOUSING OF HORSES

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The objective of this study is to facilitate the ideal conditions of safety for horses and operators, both at the time of a new construction that under renovation of existing buildings. It takes just a few tricks for working spaces to promote good ergonomics, from which spring better working situations and well-being for horses. Safety within an equestrian facility is given also by the sizes of the places in which horses are lodged. The boxes are considered to be the basic modular element of breeding and hosting places, but in Italy there are no specific references about the most appropriate surface related both to different breeds and safety of the workers taking care of them neither of a dedicated fire prevention system. We sought to determine the size of individual spaces, based on the height at the withers of horses, and to formulate a specific forming and informing course for employees on the likely risks of contact which could generate traumatic events. Detailed study of all phases of work and all the manual work involving horses, led to the determination of ideal characteristics of farms and stables. This way you will have a model to follow as much as possible, trying not to deviate too far from the guidelines. It emerged with satisfaction that in the stables and farms where the given safety indications were taken, the reduction of accidents both of operators than of horses has been remarkable.

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LEVELS OF VIBRATION TRANSMITTED TO THE OPERATOR OF THE TRACTOR EQUIPPED WITH FRONT AXLE SUSPENSION

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In recent years the comfort and the preservation of the health of the operators became central issues in the evolution of agricultural machinery and led to the introduction of devices aimed at improving working conditions. Thereby, for instance, the presence of air conditioner, soundproof cab and driver seat suspension became normal on agricultural tractors. The vibrations are one of the most complex issues to deal with, being determined by the characteristics and interaction of elements such as tyres, axles, mainframe, cab and seat suspension. In this respect, manufacturers are trying to improve their products, even integrating these elements with new devices such as the suspension on the front axle of the tractor, aimed at reducing the level of vibrations during the transfers at high speed. One of these underwent tillage tests at CRA-ING. Since its purpose is to reduce the level of vibration transmitted to the driver, their measurements in different points of the tractor and in different operating conditions, were compared in order to evaluate the effectiveness of the device, expressed as time of exposure. The suspension system of the front axle is designed to absorb the oscillations (especially pitching) determined by irregularities in the road surface, allowing an increased control of the vehicle at high speed, as demonstrated by the test results and confirmed by the driving impressions outlined by the operator. The action of the device under these conditions results in an increase of the exposure time, important fact

because of the the relevance of the road transfer operations of tractors with mounted implements or trailers to tow and of the tendency to increase the speed limit for the road tractors (in Germany were brought to 50 km h⁻¹ for several years). The action just described is less evident with increasing irregularity of the road surface and with the decrease of the travel speed. Nevertheless, in such conditions, the device appears to positively work along the other directions, in particular in the z axis, improving the action of the suspension of the driver seat.

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FIRST INVESTIGATION ON THE APPLICABILITY OF AN ACTIVE NOISE CONTROL SYSTEM ON A TRACKED TRACTOR WITHOUT CAB

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In last years, several research teams pointed their attention on the application of active noise control systems (ANC) inside the cabs of agricultural tractor and industrial vehicles, with the purpose of reducing the driver exposition to noise, that is only partially controlled by the frame of the cab. This paper reports the results of a first experience that aimed at verifying the applicability of an ANC on a medium-high power, tracked tractor without cab. The tested tractor was a Fiat Allis 150 A, equipped with rear power take off, used in the execution of deep primary tillage in compact soils. It is a tracked tractor without cab, with maximum power of 108.8 kW at 1840 min⁻¹ of the engine. The ANC consists of a control unit box based on a digital signal processor (DPS), two microphones, two speakers and a power amplifier. The study aimed at evaluating the behaviour of the ANC by means of tests carried out under repeatable conditions, characterized by pre-defined engine speed values. Three replications have been made for each engine speed. The sampling time was 30 s. Two series of tests were performed in order to compare the results observed with the ANC on and off. The engine speed adopted in the study ranged from 600 min⁻¹, up to 2000 min⁻¹ (maximum speed) with steps of 100 min⁻¹. The ANC proved to be effective particularly in the interval of speed between 1400 and 1700 min⁻¹, where the samplings have been intensified, adopting steps of 50 min⁻¹. In such an interval, the attenuation observed with the ANC system on appeared evident both as weighed A sound pressure level (from 1.29 up to 2.46 dB(A)) and linear (from 4.54 up to 8.53 dB). The best performance has been observed at the engine speed of 1550 min⁻¹, with attenuations, respectively of 2.46 dB(A) and 7.67 dB. Outside of the engine speed interval 1400 - 1700 min⁻¹, the attenuations always resulted lower than 1 dB(A) for the weighed A sound pressure level and between 0.66 and 7.72 dB.

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SAFETY SETTINGS IN EQUESTRIAN FACILITIES

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In recent years an increased attention has been paid to the risks that can emerge within the equestrian environment. In fact, the activities that are carried out every day, whether of working or sport nature, can cause serious traumatic events. The main problems are related to the

following risks: biological, physical contact, chemical, electrical, mechanical and can be contained through proper training and information of workers. The likelihood of accidents can be reduced also applying appropriate behavioural requirements and certain quality and construction parameters used in structures. Inside the equestrian facilities all the main safety systems should be well indicated, also through appropriate signs. Analysis and definition of risks involves great difficulties due to the presence of horses both in permanent structures, that in an unknown environments such as a sport or show event. Safety rules should always be known to all the operators and put into effect in every phase of any activity that contains an interaction between man and horse or horses' dedicated structures and should be respected, in every least detail, during the carrying out of any procedure. Beyond this it is very important to check out the construction characteristics of the facility, laying on eye on dimensions of stalls, doors, passages and every place where a horse must transit along with a person. All kind of plant, installation and machinery, such as treadmills, drying lamps and so on, must strictly respond to the rules and be maintained in perfect conditions of use and each worker must know how to use them correctly. Analyzing the procedures aims to encode and teach management habits for every workers' life and safety in the contact with horses and at the same time they assure to the facility good operating conditions and productivity that will make it competitive towards those firms in which safety fundamental concepts are lacking. A working activity based on safety of structures, plants and procedures and on the application of rules of prevention surely brings to the appeasement of operators involved which will be able to operate in greater serenity conditions.

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NOISE LEVELS OF A TRACK-LAYING TRACTOR DURING FIELD OPERATIONS IN THE VINEYARD

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Noise in agriculture is one of the risk factors to be taken into account in the assessment of the health and safety of workers; in particular, it is known that the tractor is a source of high noise. The Italian Low Decree 81/2008 defined the requirements for assessing and managing noise risk identifying a number of procedures to be adopted at different noise levels to limit workers exposure. This paper concerns the analysis of the noise risk arising from the use of a track-laying tractor during field operations carried out in the vineyard. The objective of this study was to evaluate the noise level that comes close to the ear of the operator driving the tractor measuring the values of equivalent sound level (Leq (A)) and peak sound pressure (LCpk (C)). We considered four options related to the same tractor coupled with the following tools to perform some farming operations: rototilling, chisel plough, flail mowers and vibro farmer. We considered three test conditions: T1 in flat (slope 0%), T2 uphill and T3 downhill (both 30% slope). The instrument used for the measurements is a precision integrating portable sound level meter, class 1, model HD2110L by Delta OHM, Italy. Each survey lasted 2 minutes, with an interval of measurement equal to 0.5 s. The tests were performed in compliance with the standards ISO 9612 and ISO 9432. The results show that the measured sound levels exceed the limits allowed by the regulations in almost all the test conditions; values exceeding the threshold limit of 80 dB(A) were recorded coming up to a maximum value of 92.80 dB(A) for flail mowers in test T1. When limits imposed by the regulations are exceeded, the operator is obliged to wear the appropriate Personal Protective Equipment.

THE ASSESSMENT OF THE SAWMILL NOISE

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Noise is a serious and widespread problem in many workplaces like in sawmill. Analyzing the data for the year 2010 it is noted that for the phenomenon deafness due to noise affects, the total number of pathologies from work in Italia, for a total of 39.93% for cases of 5222 divided by sex, in fact for females there are instances in number of 221 while the male has a number of cases is equal to 4961. The aim of this work was to detect the sound level caused by the use of the machineries in a sawmill. The measurements were carried out through an instrument known as noise level meter, equipped with a microphone and connected to a computer for data processing and analysis of variance to a factor in excel, and able to assess noise levels at any particular point in the mill. The machines were subjected in relief and with several different types of wood materials. Obviously, in our case a fundamental role takes the moisture of wood. The drying operation is intended to obtain that degree of humidity of the wood, generally it must be between 7 and 16%, compatible with the type of glue used and, above all, appropriate to the target structures. The machines that have the highest sound pressure levels are optimizing of 4-sided planer and profiling, with values ranging between 85 dB (A) and 110 dB (A). Finally, it's possible conclude that the sound pressure level increases when the suction of dust is turned on, the noise of machinery decreases during the processing of wood and that increasing the thickness decreases the noise emitted by the machine.

OCCUPATIONAL ILLNESS DUE TO PHYSIOLOGICAL STRAINS AND ERGONOMIC PROBLEMS IN MANUAL SUGAR BEET HARVESTING

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The aim of this pilot study was to determine physiological strain problems in manual sugar beet harvesting in countries characterized by a low level of mechanization. This practice has always been one of the most labour-intensive activities in which workers usually become fatigued in a few hours. Experimental trials achieved in the experimental farm of the University of Natural Resources and Applied Life Sciences in Groß Enzersdorf, Lower Austria, considered a group of three men whose anthropometric characteristics varied in age from 23 to 46 years, in body weight from 72 ± 2 kg, in height 1.78 ± 0.05 m, while body fat was of 22.72 ± 2 kg/m², for a fifty-minute simulations of manual sugar beets harvesting, over a roughly 8 to 10 hours per day. The experimentation was designed to identify the systematic postures and oxygen uptake related to this activity. Laborers' subjective feeling was assessed achieving a qualitative interview, while oxygen consumption and heart beat frequency were measured by a portable metabolimeter (K4b2) to determine the physiological strain of dynamic work according to UNI EN ISO 8996, moreover, an evaluation of postures was obtained using the OWAS method, NIOSH code and force evaluation by mean of Apalys 4.0 software. The qualitative interview demonstrated that each operator suffered neck and dorsal pain and fatigue while sugar beet harvesting. The pointed out results were a $\dot{V}O_2$ of 200 ± 7.9 l O₂ /h, a $\dot{V}CO_2$ of 176 ± 10 l CO₂/h, a heart rate of 141 ± 7.6 b/min with a maximum value of 190 ± 9.1 b/min. The energetic equivalent and body surface area were respectively of 5.7 W h/O₂ and 1.90 m² on average. The average operators' metabolic rate was very high, 600 W/m² showing that manual sugar beet harvesting tasks were energy intensive. This activity appertained to class three and four according to OWAS. The force output for each task at L5/C1 was 2633.33 N for fork insertion into the soil, 2900 N for sugar beet removal from the soil, and 2600 N for lifting the vegetable to the gathering place. NIOSH indexes for the same tasks were respectively 1.40, 1.43, 1.39.

SUSTAINABLE PLANNING AND MANAGEMENT OF SOIL AND WATER RESOURCES

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ASSESSMENT OF LINEAR ANIONIC POLYACRYLAMIDE (LA-PAM) APPLICATION TO IRRIGATION CANALS FOR SEEPAGE CONTROL

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Mediterranean climate of Chile determines a high use of water for agricultural production. Irrigation water is distributed through long channels which have high water loss difficult to control by conventional techniques. The objective of this work was to quantify water loss in channels and to evaluate the use of Linear Anionic Polyacrylamide (LA-PAM) to reduce seepage losses. The study was carried out in south-central area of Chile, in 300 km of channels whose flow varied between 0.12 and $25 \text{ m}^3 \text{ s}^{-1}$. Water users indicated channel sectors with potential leaks, which were selected for LA-PAM application. In 11 sectors of channels between 0.4 and 3 km in length, 1 to 3 LA-PAM applications were performed at rates of 10 kg ha^{-1} , considering wet perimeter area as basis of calculation. Thirty-one LA-PAM applications were performed over a 30.5 km length. Most of channels were large enough to allow motorboat moving against the current to carry-out LA-PAM application. Water flow was measured (StreamPro ADCP) at both ends of selected sectors, before and after granular LA-PAM application. Weekly measurements were made to quantify treatment effect duration. Water turbidity and temperature were measured. Channels showed variable losses up 13%. Two channels showed 6% water gains. In more than 80% cases LA-PAM effect was positive, achieving loss reductions of 15 to 760 L s^{-1} . In other cases LA-PAM had a negative effect since it mainly affected water entry into the channel. It was determined that field conditions referred by users as indicators of leakage are not always correct and vary in time according to climatic conditions. Water loss was confirmed and it was possible to reduce seepage through LA-PAM applications provided that losses were known and correctly determined when applying the polymer. This could allow increasing irrigation security in critical periods, especially under drought conditions.

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ANALYSIS OF RAINFED ALFALFA EVAPOTRANSPIRATION MEASURED BY AN EDDY COVARIANCE SYSTEM

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The aim of this study was to quantify the evapotranspiration (ET_{ec}) of a rainfed alfalfa crop using the eddy covariance technique. The study was carried out during the alfalfa growing seasons (April-August 2009, April-August 2010) at the experimental farm of the University of Perugia. In central Italy alfalfa is grown for 3 to 4 years continuously, with at least 3 cutting cycles for year (usually between April and August) and a dormant period in winter. For the quantification of ET_{ec} an open-path eddy covariance system (EC) was used. The derivation of water and energy fluxes starting from raw wind, temperature and gas concentration data by means of the EC technique implies a remarkably long sequence of operations including calibration, corrections and statistical tests for assessing data quality. These operations were carried out by the EddyPro® software. After that, the output data were used for the flux-partitioning and all original data, flagged with a quality indica-

tor with non-turbulent conditions, were dismissed. Then the gap-filling of the EC and meteorological data was performed to obtain reliable values. Furthermore the test of the energy balance closure gave satisfactory results. The ET_{ec} dynamics were consistent with the growth stages and the cuttings during both 2009 and 2010. Furthermore the comparison between the tabulated crop coefficient values (K_c) and the ratio of ET_{ec} to reference evapotranspiration (ET_0) was performed. This analysis showed a good agreement during the second cutting cycle (May-June) for both 2009 and 2010, whilst during the third cutting cycle (July-August) the ratio ET_{ec}/ET_0 was considerably lower than K_c for both years. The reason of this behavior was found in the presence of water stress conditions during the last cutting cycle. This fact was confirmed by the application of a bucket soil water model, used as an exploratory, not confirmatory, tool to analyze the soil water availability dynamics during the growing season. Additional measurement campaigns will be carried out in order to deepen the knowledge about the K_c dynamics in rainfed crops and to assess the productivity of water under various meteorological and agricultural conditions.

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A NEURO-FUZZY MODEL TO PREDICT THE INFLOW TO THE GUARDIALEFIERA MULTIPURPOSE DAM (SOUTHERN ITALY) AT MEDIUM-LONG TIME SCALES

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Intelligent computing tools based on fuzzy logic and artificial neural networks have been successfully applied in various problems with superior performances. A new approach of combining these two powerful tools, known as neuro-fuzzy systems, has increasingly attracted scientists in different fields. Few studies have been undertaken to evaluate their performances in hydrologic modeling. Specifically are available rainfall-runoff modeling typically at very short time scales (hourly, daily or event for the real-time forecasting of floods) with in input precipitation and past runoff (*i.e.* inflow rate) and in few cases models for the prediction of the monthly inflows to a dam using the past inflows as input. This study presents an application of an Adaptive Network-based Fuzzy Inference System (ANFIS), as a neuro-fuzzy-computational technique, in the forecasting of the inflow to the Guardialefiere multipurpose dam (CB, Italy) at the weekly and monthly time scale. The latter has been performed both directly at monthly scale (monthly input data) and iterating the weekly model. Twenty-nine years of rainfall, temperature, water level in the reservoir and releases to the different uses were available. In all simulations meteorological input data were used and in some cases also the past inflows. The performance of the defined ANFIS models were established by different efficiency and correlation indices. The results at the weekly time scale can be considered good, with a Nash-Sutcliffe efficiency index $E = 0.724$ in the testing phase. At the monthly time scale, satisfactory results were obtained with the iteration of the weekly model for the prediction of the incoming volume up to 3 weeks ahead ($E = 0.574$), while the direct simulation of monthly inflows gave barely satisfactory results ($E = 0.502$). The greatest difficulties encountered in the analysis were related to the reliability of the available data. The results of this study demonstrate the promising potential of ANFIS in the forecasting of the short term inflows to a reservoir and in the simulation of different scenarios for the water resources management in the longer term.

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WATER BALANCE OF RICE PLOTS UNDER THREE DIFFERENT CULTIVATION METHODS: FIRST SEASON RESULTS

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In the last years the rice cultivation methods has experienced worldwide a dramatic change as a consequence of the introduction of new water-saving methods in addition to the traditional flooded approach. This change concerned also the ancient rice-cultivated territories of North-West of Italy, where rice has been traditionally cultivated as flooded and where paddy fields are probably the strongest landscape landmark and represent a central feature in the nature protection networks. The new techniques introduced in these territories consist in a dry seeding followed by field flooding after about one month (third-fourth leaf), and in a full aerobic cultivation with intermittent irrigations. Despite the potential consequences of an extensive adoption of the new techniques on water requirement and on environment and landscape characteristics, as well on irrigation service organization, the dynamics of water fluxes related to the cultivation methods is still poorly investigated, especially in Italian ancient rice systems. This paper, aiming to contribute in filling such gap, presents the results obtained after the first year of a monitoring activity carried out at the Ente Nazionale Risi Experimental Station of Castello d'Agogna (PV) on three experimental plots, where each plot has been cultivated following one of the three above mentioned techniques. The monitoring system, presented in a companion paper, in fact allowed to collect all the data (by direct measurement or by indirect estimation) required for the water budget calculation. The results showed that the water requirement in terms of evapotranspiration is fundamentally the same in the case of traditional flooded cultivation and dry seeding, whereas it is about 17% less for the aerobic rice. More relevant, the aerobic technique fundamentally annul the vertical flux towards groundwater, greatly reducing the global water requirement of rice, but at the same time eliminating any recharge of the water table. This evidence on one hand represents a significant point in reducing water requirement at field scale, but on the other the absence of the ground water recharge term should be seriously considered when the global water budget has done at the regional scale.

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EFFECT OF DIFFERENT PLANT SPECIES IN PILOT CONSTRUCTED WETLANDS FOR WASTEWATER REUSE IN AGRICULTURE

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In this paper the first results of an experiment carried out in Southern Italy (Sicily) on the evapotranspiration (ET) and removal in constructed wetlands with five plant species are presented. The pilot plant used for this study is made of twelve horizontal sub-surface flow constructed wetlands (each with a surface area of 4.5 m²) functioning in parallel, and it is used for tertiary treatment of part of the effluents from a conventional municipal wastewater treatment plant (trickling filter). Two beds are unplanted (control) while ten beds are planted with five different macrophyte species: *Cyperus papyrus*, *Vetiveria zizanioides*, *Myscanthus x giganteus*, *Arundo donax* and *Phragmites australis* (*i.e.*, every specie is planted in two beds to have a replication). The influent flow rate is measured in continuous by an electronic flow meter. The effluent is evaluated by an automatic system that measure

the discharged volume for each bed. Physical, chemical and microbiological analyses were carried out on wastewater samples collected at the inlet of CW plant and at the outlet of the twelve beds. An automatic weather station is installed close to the experimental plant, measuring air temperature, wind speed and direction, rainfall, global radiation, relative humidity. This allows to calculate the Reference ET (ET₀) with the Penman-Monteith formula, while the ET of different plant species is measured through the water balance of the beds. The first results show no great differences in the mean removal performances of the different plant species for TSS, COD and E.coli, ranged from, respectively, 82% to 88%, 60% to 64% and 2.7 to 3.1 Ulog. The average removal efficiency of nutrient (64% for TN; 61 for NH₄-N, 31% for PO₄-P) in the *Paustralis* beds was higher than that other beds. From April to November 2012 ET measured for plant species were completely different from ET₀ and ET_{control}, underlining the strong effect of vegetation. The cumulative evapotranspiration highest value was measured in the CWs vegetated with *Paustralis* (4,318 mm), followed by *A.donax* (2,706 mm), *V.zizanioides* (1,904), *M.giganteus* (1,804 mm), *C. papyrus* (1,421 mm).

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MONITORING WATER FLUXES IN RICE PLOTS UNDER THREE DIFFERENT CULTIVATION METHODS

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In the last years the rice cultivation methods has experienced worldwide a dramatic change as a consequence of the introduction of new water-saving methods in addition to the traditional flooded approach. This change concerned also the ancient rice-cultivated territories of North-West of Italy, where rice has been traditionally cultivated as flooded and where paddy fields are probably the strongest landscape landmark and represent a central feature in the nature protection networks. The new techniques introduced in these territories consist in a dry seeding followed by field flooding after about one month (third-fourth leaf), and in a full aerobic cultivation with intermittent irrigations. With the aim to study water fluxes under the three above mentioned techniques, three experimental plots at the Ente Nazionale Risi Experimental Station of Castello d'Agogna (PV) have been instrumented. In this paper the experimental framework, which presents some degree of innovation, is described in detail. In each plot (about 2000 m²) the following instruments have been installed: 1) a long throat flume with a pressure transducer for inputs, 2) an interchangeable double shaped (V-notch and rectangular) thin plate weir with a pressure transducer for outputs, 3) two piezometers and one double-depth piezometer with pressure transducers for groundwater levels, 4) one water level transducer for field water level measurement (only in flooded fields), 5) one and three groups of four tensiometers respectively in flooded and aerobic fields, 6) one multiple depth probe for water content measurement coupled with each tensiometer group (in flooded fields only for the dry period), 7) one eddy covariance station for vapour fluxes estimation (a full meteorological station was already available at few hundred meters from experimental plots). All the instruments of each plot have been connected by cables to a wireless data logger that, in turn, send the data to a PC placed within ENR offices and web-connected by a LAN. In this way, besides the automatic download of data, it was possible to remotely control the devices, to quickly fix troubles, and to better plan the field trips. The management of the whole framework was done by a specifically developed software.

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EFFECTS OF WATER DISTRIBUTION UNIFORMITY ON WAXY CORN (ZEA MAYS L.) YIELD: FIRST RESULTS

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To face climatic changes, the increase of frequency and severity of droughts, and economic development pressures, Water Management Institutions point at the necessity of water conserving. A sustainable demand-led approach is the most viable option, focusing on achieving more efficient irrigation practices instead of less sustainable expansion of supply. The aim of this work is to investigate on some aspects of the rational water management for the irrigation of corn in order to evaluate the actual possibility of introduction of drip irrigation systems on the Venetian Plain. Trials were carried out on a farm located in Isola della Scala (Verona, Italy) in an area of about 13 ha (12 ha with a drip irrigation system and 1 ha with a solid-set sprinkler system); the effects of the performance of the two systems on waxy corn yield were considered. In particular, water distribution uniformity, water use efficiency, and yield performance of irrigation systems were evaluated. DU_q and CU coefficients for distribution uniformity and IWUE and WUE_b indexes for water use efficiency were calculated. To visualize and better analyze the distribution uniformity, the crop yield and the efficiency parameters, ArcGIS 10 (ESRI®) with IDW interpolation were used to create maps. First results show a good water uniformity distribution in the drip irrigation system but only with a careful and proper design of the entire system. As regards the water use efficiency, drip irrigation values are lower than those of sprinkler irrigation (-46% for IWUE and -25% for WUE_b), probably due to different irrigation management and water volumes used: in fact, drip irrigation was scheduled every three days, while only supplemental operations were done for sprinkler irrigation. No statistical correlation was found between application rate and yield for both irrigations systems, while a significant correlation was found between irrigation volume and crop water use efficiency. The profitability of the two irrigation systems was compared. The results show that the income of drip irrigation is slightly lower than sprinkler irrigation, mostly due to the use of “throw away” drip lines.

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AN ANALYTIC-GEOSPATIAL APPROACH FOR SUSTAINABLE WATER RESOURCE MANAGEMENT: A CASE STUDY IN THE PROVINCE OF PERUGIACasadei S.,¹ Bellezza M.,² Casagrande L.,² Pierleoni A.²*¹Department of Civil and Environmental Engineering, University of Perugia, Italy; ²T4E S.r.l. one Technology four Elements, Spin-Off UNIPG, Perugia, Italy*

Water is a strategic, but also highly vulnerable, natural resource. This because the increasing demand from multiple uses, in many cases competing amongst them, seems to influence the concepts of sustainability of the exploitation. From the operational point of view, the PIVRID system (Italian for: *PRELIEVI IDRICI E VALUTAZIONE DELLA RISORSA IDRICA DISPONIBILE*) is an integrated DSS. It is not only a platform to exchange information and assessments, but also a tool for conflict resolution, in the management of water resources, and consensus reaching among all participants in the decisional processes. So the canonical “top-down” approach has been replaced with a “bottom-up” approach where all stakeholders become decision makers themselves. The application of the aforementioned approach was studied for the

Tiber River basin and has been applied to the Province of Perugia area. The study focused to the building of a spatial database of hydrological data and multipurpose water withdrawals, together with the setting of the evaluation model for the surface water resources. This model bases its algorithms on regionalization procedures of flow parameters. For the definition of the river condition, hydrological indices such as BFI, Q7,10, Q355, Q347, entire FDC, calculated from the hydrological database have been used, while for the existing withdrawals, an analysis procedure has been developed, that from the point of interest directly selected on the map, finds out the upstream basin and, by means of overlay procedures, identifies the upstream water uses and the total flow that could be extracted. The potential of the system and the technologies used are contained in a WEB platform that allows the analysis of the database of water uses/withdrawals on the cartography, and the comparison with the hydrogeological characteristics of the sub-basin examined. The purpose of this study is to provide software tools that can be used as a support in water resource evaluation and management policies at the basin scale, with particular attention given to the development of mathematical models that are easy to use, both for the interpretation of output data and for the choice of management hypotheses.

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FARMS AS RESILIENCE FACTORS TO RURAL LAND DEGRADATION INDUCED BY URBAN PRESSURES

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The aim of the work was the analysis of the effects induced by urban pressures on the socio-economic and territorial characteristics of the rural areas in order to identify planning and intervention strategies aimed at enhancement and qualification of the landscape. A survey was conducted in the Parma (North Italy) surroundings by means of questionnaires administered to farms located in the proximity of urban centers. The structural, productive and social characteristics of the family-farm units were analyzed. The survey updated an identical survey, carried out in 1986, where a sample of 208 farms was examined. The surveyed units were evaluated in two aspects: the “vitality”, which takes into account the structural characteristics (size, production, labor force, etc.), and the “stability”, where a decisive role is played by the age of the conductor and the presence of a successor. It was found that only 25% of the original sample is still alive, one third has disappeared, 30% was absorbed by existing farms, 8% was abandoned. The factors most favorable to the survival resulted, as well as the physical and economic size of the farm, the presence of cattle, the percentage of land in property, the presence of young labor. In addition, given the high rate of aged farmers, a role of some importance is played by the presence in the farm of families not active in agriculture but in family relationship with the conductor being able to provide a supplement of work. Among the factors that predispose to abandonment, the urbanization processes were found to be determinants, in terms of expansion both of the built-up area and of the planned as urbanisable. The research has highlighted the importance of two fundamental aspects for maintaining the typical characteristics of rural areas: the economic vitality of the farms and the quality of land use planning and government. From these acquisitions useful indications for protection and enhancement of the rural areas exposed to urban stress can be obtained.

ALTERNATIVE METHOD FOR VEGETABLES CULTIVATION IN BENIN

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In the developing countries populations, which are already vulnerable and food insecure, are likely to be the most seriously affected by the effects of climate change, e.g. yield decreases and price increases for the most important agricultural crops. The IPCC's Fourth Assessment Report for Africa describes a trend of warming at a rate faster than the global average and increasing aridity: in many parts of Africa it seems that warmer climates and changes in precipitation will destabilise agricultural production and aggravates food security. The present work concerns the vegetables cultivation in the Parakou region in Benin, where agriculture employs approximately 70% of the active population and contributes to 36% of the GDP and 88% of export earnings. However, the agricultural sector has been regarded as unproductive with low adaptation capacities because of structural factors (e.g. high level of poverty among rural populations, weak mechanization and intensification of production modes), but also because of natural constraints (e.g. poor management of water and soils, leading to soil degradation). Considering the aridity, the low carbon content and the reduced level of nutrients available in the soil, the use of an hydroponic module has been hypothesised. In this way sufficient yields of the crops may be assured and no agricultural machines will be needed for the tillage operations. In addition the nutrients can be added to the growing solution using residual materials as poultry manure, ashes and green wastes. In order to verify if some construction or maintenance problems can occur and if a growing solution can be easily obtained using agricultural wastes, some tests have been carried out. Moreover laboratory analyses have been done for different water solutions that may be adopted mixing with different shares of water, poultry manure, ashes and green wastes. The tests have indicated that the hydroponic module could be used in Benin without incurring in technical problems and that a growing solution containing poultry manure, ashes and green wastes can supply to the crops a significant amount of nutrients.

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AERATED LAGOONING OF AGRO-INDUSTRIAL WASTEWATER: DEPURATION PERFORMANCE AND ENERGY REQUIREMENTS

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Intensive depuration plants have often shown low reliability and economic sustainability, when utilised for agro-industrial wastewater treatment, due to the particular wastewater properties: high organic load and essential oil concentrations, acidity, nutrient scarcity and qualitative-quantitative variability of effluents. Aerated lagooning systems represent a suitable alternative, because they are able to assure good depurative performance and low energy requirements, avoiding the drawbacks shown by the intensive depuration plants. In order to optimize performance of the lagooning systems, particularly in terms of energy requirements, depuration processes of aerobic-anaerobic aerated lagoons were investigated, both at full- and laboratory-scale. Citrus processing wastewater were subject to mechanical or fine bubble aera-

tion with low flow rates and limited time; the removal efficiency of organic load was evaluated and energy requirements of different depuration schemes were compared. The experimental investigations in full-scale aerated lagoons showed an adequate equalisation capability and constantly good depurative performance also with high concentrations of essential oil (500-1000 ppm), beside a low energy supply (0.38 kWh per kg of COD removed). The experimental investigations in lab-scale aerated tanks under controlled conditions indicated the possibility of decreasing energy requirements (down to 0.32 kWh kgCOD⁻¹) by reducing aeration power (down to 0.6 W m⁻³) and limiting aeration time to night 12 hours only, when energy price is lower. In spite of the low aeration, the COD removal rates were on the average six-fold higher compared to the anaerobic tank. The investigation confirms the tolerance to essential oil concentrations up to 1.400 ppm in tanks simulating aerated lagoons, while sludge settleability strongly decreased over 40-70 ppm of essential oil in a tank simulating an activated sludge plant. Other outcomes indicated an ability of the spontaneous microflora to adapt to high concentrations of essential, which however did not provide an increase of the removal rate of the organic load in the experimented scheme.

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MEASURING DIELECTRIC PERMITTIVITY BY MEANS OF TIME DOMAIN REFLECTOMETRY (TDR), TO DETECT SOIL NAPL CONTAMINATION-DECONTAMINATION PROCESSES

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Contamination of soils with non-aqueous phase liquids (NAPLs), constitutes a serious geo-environmental problem, given the toxicity level and high mobility of the organic compounds. To develop effective decontamination methods, characterisation and identification of contaminated soils are needed. The dielectric permittivity of soils can be significantly modified by the presence of NAPLs in the pore fluids. Thus the non-destructive techniques based on the propagation of electromagnetic waves may be used to detect contaminant plumes and to evaluate decontamination processes. This paper presents results of experimental study on the possibility of calculating the volumetric content of NAPL (vNAPL) in soils from measurements of dielectric permittivity with TDR technique in soil-water-air-NAPL mixtures. Mixing models reported in the literature are extended from two to three and four phases in order to model the measured dielectric response of the contaminated soil samples. The results allow to study the effect of volumetric water (vw) and NAPL (vNAPL) content on the dielectric permittivity of the mixtures. It is concluded in this study that the value of dielectric permittivity in soils is sensitive to the detection of contaminants when the vNAPL is higher than 0.2. Finally a decontamination process is mentioned with TDR in a laboratory flow-cell. The results show that the evaluation of vNAPL during a remediation process is easily detectable.

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A SIMPLIFIED METHOD TO DETERMINE THE PRIMARY DRYING AND WETTING CURVES OF THE SOIL WATER DIFFUSIVITY

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Within the framework of a research project examining the spatial variability of hydraulic characteristics of soil intended for irrigation, a verification has been made of some of the more frequently used analytical expression describing the laws linking diffusivity D to the water content of the soil δ . By studying the flow field of the soil samples tested in laboratory, under one-dimensional wetting and drying cycles, it has been found that the laws of hydraulic diffusivity of the exponential types can be ascribed to them. Finally a simplified laboratory method has been proposed which, with the aid of nomographs, allows the definition of the law $D(\Delta)$ to be arrived at easily.

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ASSESSMENT OF EVAPOTRANSPIRATION MODELS FOR A MAIZE AGRO-ECOSYSTEM IN IRRIGATED AND RAINFED CONDITIONS

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A high level of accuracy in the estimation of crop evapotranspiration (ET) may lead to significant savings of economic and water resources in irrigated agriculture. Although ET is a fundamental process in many applications, it cannot be directly measured but it has to be estimated by monitoring the exchange of energy/water above the vegetated surface (micrometeorological methods), or as a residual term of the hydrological balance (lysimeters, soil water budget). The techniques to be adopted are often complex, costly and require specific equipment. Thus, since the '50s, many researchers have devoted their activity to the development of models for its estimation. The available approaches can be classified in "direct" methods, based on the original Penman-Monteith (PM) equation, in which the canopy resistance r_c is modelled, and "indirect" methods, based on the preliminary calculation of ET for a well-watered reference grass (ET₀) with a constant r_c , which is then multiplied by a crop coefficient K_c and, in case, by a stress coefficient K_s to obtain ET. Even if the latter approaches are more widely adopted for their practical simplicity, many authors show that the former often provide better ET estimates in absence of calibration of crop parameters. In this study the performances of different direct and indirect methods were evaluated in the case of a surface irrigated and of a rainfed maize grown in the Padana Plain (Northern Italy). The following models were considered: the "one-layer" original PM equation with three different models for r_c (Monteith, Jarvis, Katerji-Perrier), the "two-layers" PM model proposed by Shuttleworth and Wallace, the "single" and "double" crop coefficient models illustrated in the Paper FAO-56. Latent heat fluxes measured in 2006 and 2011 in an experimental maize field by eddy-covariance were used to evaluate the models accuracy. Crop, soil and meteo data monitored contextually were used for the implementation of the different models. Results confirm that direct methods are more performing for both irrigated (2006) and rainfed

(2011) conditions, with the SW model providing the best results and the FAO-56 models with generalized crop coefficients overestimating ET, especially during the middle growth stage.

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MANUALLY OPERATED PILE DRIVER TO USE IN THE SOUTH IRAQI MARSHLANDS

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The marshes of southern Iraq are of great local and global importance, because of their extension and their specificity. For some years the re-flooding of marshes is in progress. The sustainable development of their use for agricultural and zootechnical purposes, and to some extent also for tourist purposes, has to be accompanied by the creation of micro-infrastructures having very low environmental impact and not significantly altering the existing natural status. These micro-infrastructures consist mainly of riparian fixings, small channels dams, small earth roads, moorings, piers, walkways and other similar constructions. To be an effectively part of a sustainable development, these infrastructures must be characterized by a slight environmental impact in relation to their construction, permanence, deconstruction and disposal. As we can see in every part of the world, the infrastructures having these qualities are mainly made in natural materials, primarily wood. For their construction the insertion of wooden poles in the ground is practically required. For obvious environmental, economic and technical reasons in Iraqi marshlands the vibrating pile driver mounted on the arm of excavators are not proposable. For this reason, a manually operated pile driver, which operates according to the model used by man for millennia, have been designed and built. Moreover, to allow the use in water, a simple floating pier, that can accommodate the pile driver, have been designed. The pile driver has been planned taking into account the below boundary conditions: manually operated; made of elements easily transportable and easily assembled on the site of use, therefore hand movable and not longer than 3 m; made from very simple mechanical parts and able to be built in a basic blacksmith workshop, so that it can be replicated on site. An executive design was drawn up. The pile driver was built in the workshops of Department (GESAAF) and then transported to Iraq for use in the field.

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EXPERIENCES OF IMPROVING WATER ACCESS IN RURAL AREAS IN GUATEMALA

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The GESAAF Department of the UNIFI has been involved in the project "Gestione ambientale e del rischio nel dipartimento di Sololà" in the period 2011-'12 aiming at guaranteeing water access to people leaving in rural areas in the Sololà Department in Guatemala, in collaboration with the two NGOs Movimento Africa '70 and Oxfam Italia. Methodology Appropriate technologies, such as EMAS pump and well drilled with the Bautista-Boliviana technique, have been proposed and utilized for improving water access in areas where lack of water represented a limiting factor for the human development. They can be both considered compatible with local, cultural and economic conditions: in fact locally available materials are used and the tools can be maintained and operationally controlled by the local users. Monitoring activities on the 52 installed pumps have been carried out in order to check the performances of the pumps and the knowledge level acquired by the users.

More than 70% of the pumps were correctly functioning and the required maintenance activities have been carried out in collaboration with the local users. In order to analyze the project results, a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) has been carried out for developing a strategy able to tackle the weaknesses and threats of the procedure. At the end of the project, 52 EMAS pumps have been installed and 18 wells drilled, 34 pumps have been installed in already existing wells tank. Formation activities of local people played an important role: diffusion actions of the methodology started from schools, 20 workers participated to an in class course and more than 100 participated in the field work. The application of the SWOT analysis showed to be an useful tool to analyse the current situation coming from the ended project. It has been helpful to gauge how the project performed. The analysis results may be also utilized for exploring strengths and weaknesses of a possible transferring of the methodology to other sites.

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SOIL EROSION MEASUREMENT METHOD FOR THE PREDICTION OF HAZARD OF SOIL EROSION IN FOREST ROADS

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Soil erosion is the deterioration of soil by the physical movement of its particles from a given site and it is a major problem in agriculture and for the forest production. This not only reduces crop production, the soil acts as a pollutant to rivers, lakes, and other water systems. The topographic factor LS, provides greater influence on the variation of the soil loss.[1] This experiment was carried out at an eucalyptus forest area located in Botucatu, São Paulo, Brazil, and its aim was to determine soil loss along a forest road skirting a gully, in a region characterized by an undulated to heavily undulated relief, to show the impact of soil erosion in a area of risk, and to describe the soil erosion measurement method used as its control technique, based mainly, in the slope and the length of the ramp, applying the LS factor from the Universal Soil Loss Equation. Data were collected from a single road totaling almost 2 km with steepness of 0 till 15%. Transversal lines in the road direction were established in each 20 meters. To each imaginary transversal line was stretched a line of nylon connecting the original height of soil surface. The road bed depth was measured from the vertical distance of this line till the soil surface, those measures were taken in each 10 centimeters. The same procedure was done after the rain influence in the same forest road, allowing to compare the values to indicate the hazard zones. The results prove that the knowledge of this technique can help in a better management of the plantation area.

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