Appendix

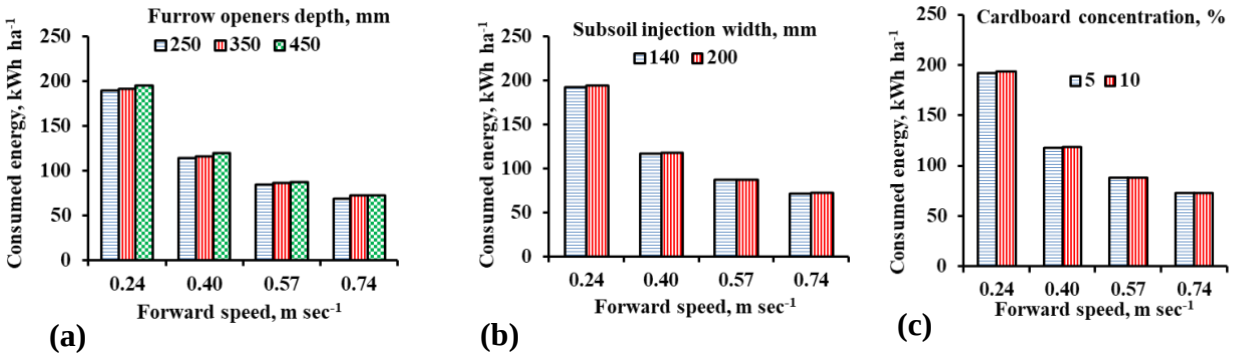

Figure 1. The effect of forward speeds on the consumed energy at various: (a) furrow openers depths, (b) subsoil injection widths and (c) cardboard concentrations.

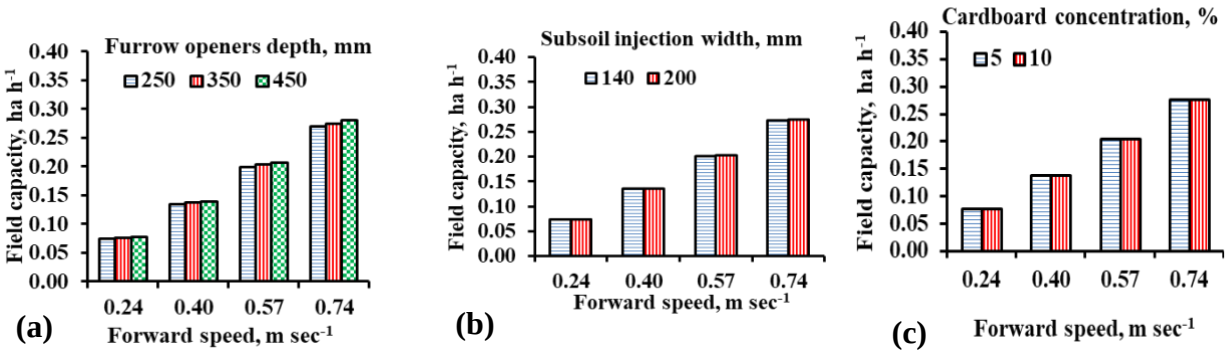

Figure 2. The effect of forward speeds on the field capacity at various: (a) furrow openers depths, (b) subsoil injection widths and (c) cardboard concentrations.

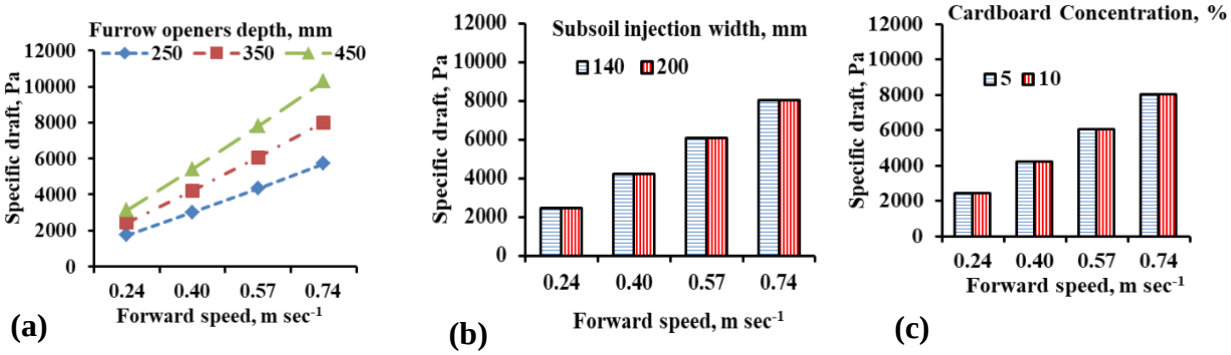

Figure 3. The effect of forward speeds on the specific draft at various: (a) furrow openers depths, (b) subsoil injection widths and (c) cardboard concentrations.

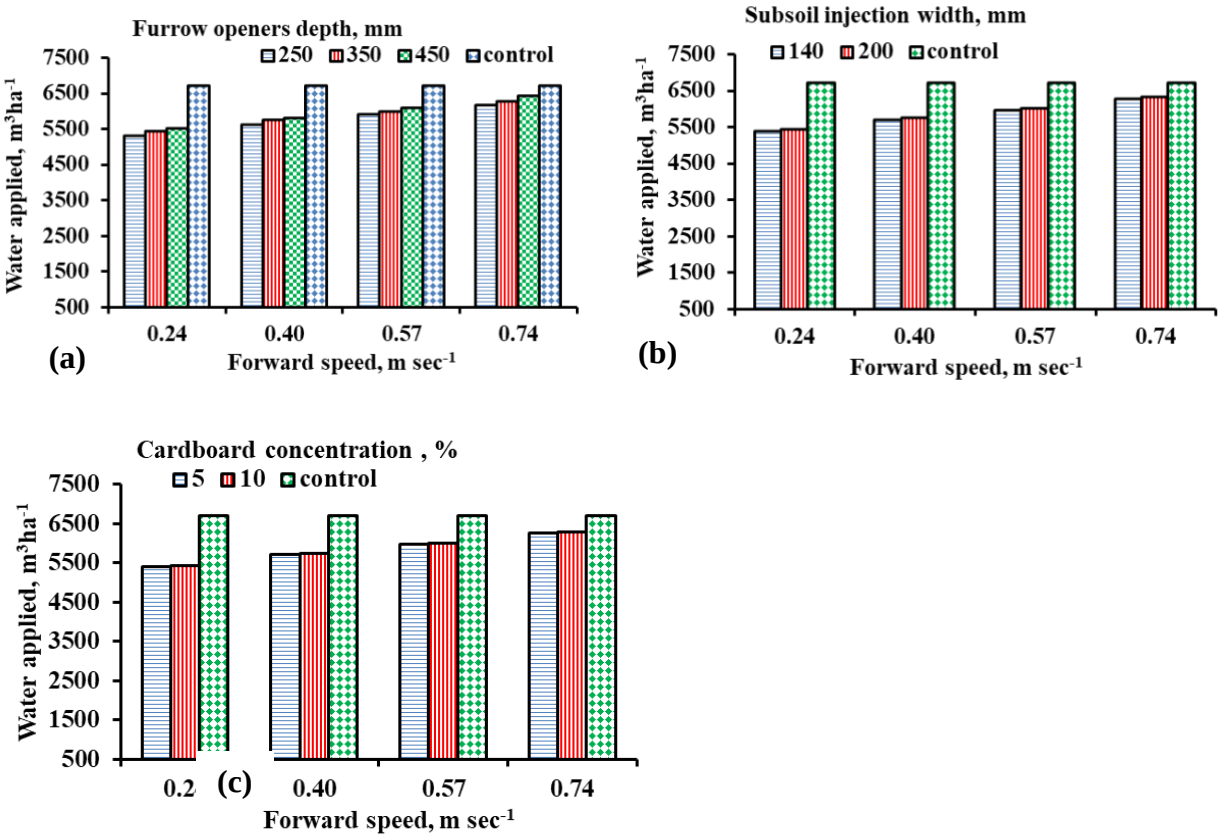

Figure 4. The effect of forward speeds on the total water applied at various: (a) furrow openers depths, (b) subsoil injection widths and (c) cardboard concentrations.

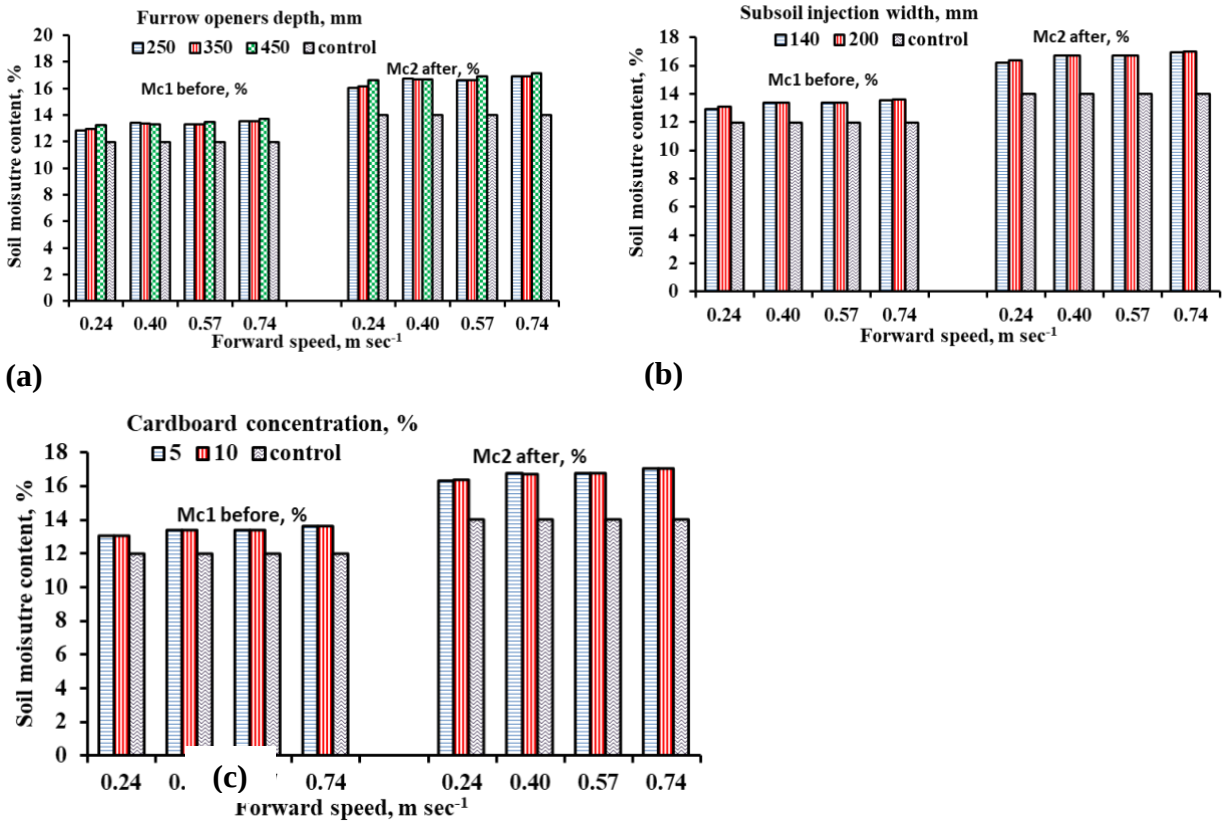

Figure 5. The effect of forward speeds on the moisture content before and after irrigation at various: (a) furrow openers depths, (b) subsoil injection widths and (c) cardboard concentrations.

Table 1. The tested soil properties.

Soil Depth (mm)	Particle size distribution			Soil Texture	Bulk Density, t m^{-3}	Field capacity, %	Wilting point, %	Electrical conductivity, dSm^{-1}
	Sand,%	Silt,%	Clay,%					
0-250	66.6	17.3	16.1	**Sandy loam**	1.47	16.59	8.44	3.72
250-350	64.2	19.1	16.7		1.46	15.93	8.25	3.51
350-450	65.4	18.7	15.9		1.47	16.07	8.65	2.89

Table 2. The mechanical specifications for the injection cardboard prototype.

Chassis dimensions	**Width**	**Length**	**Total height**	**Height from ground**
	1.25 m	1.0 m	1.93 m	0.65 m
Operation width	2 rows 0.65 to 1.20 m		**Operation depth**	From 0.3-0.6 m under ground
Using tractors	60-120 hp		**Forward speeds**	0.24, 0.40, 0.57 and 0.74 m sec^{-1}
Net weight	0.17 t		**Consumed power**	Up to 196.08 kWh ha^{-1}
Cardboard tank capacity	50 L		**Stirring rotation speed**	Up to 600 RPM

Table 3. The stirring AC motor specifications.

Model	Yueqiu - Japanese	**Power**	80 – 205 W
Operating voltage	220 V AC, 50 Hz	**Rotating speed**	Variable from 600 RPM
Operating current	1.0 A	**Reduction ratio**	1:4
Starting torque	0.78 - 1.15 Nm	**Maximum torque**	1.2 -1.95 Nm
Capacitance	8 – 65 UF	**Stator**	Single phase

Table 4. The cardboard discharge rate setting.

Forward speed, (m sec^{-1})	**0.24**	**0.40**	**0.57**	**0.74**
Timer setting, (sec)	**1**	**2**	**3**	**4**
Discharge rate, (L sec^{-1})	**0.25**	**0.5**	**0.75**	**1.0**

Table 5. The mean values of prototype fuel consumbtion, field efficicency, draft force, consumed energy and crop yield.

Measurement	**Mean value**	**Speed (*S*), m sec^{-1}**	**Depth (*W*), mm**	**Mean value**	**Width (*W*), mm**	**Mean value**	**Concentration (*C*), %**	**Mean Value**
***F*, L h^{-1}**	**Max.**	**0.74**	**450**	**6.47**	**200**	**6.28**	**5**	**6.25**
	SD.			**0.03**		**0.24**		**0.24**
	Min.	**0.24**	**250**	**4.42**	**140**	**4.54**	**10**	**4.56**
	SD.			**0.07**		**0.15**		**0.15**
***Fe*,%**	**Max.**	**0.74**	**450**	**89.05**	**200**	**87.60**	**5**	**87.54**

	SD.			**0.41**		**1.57**		**1.54**
	Min.	**0.24**	**250**	**73.58**	**140**	**74.90**	**10**	**75.03**
	SD.			**0.34**		**1.31**		**1.35**
***df*, N**	**Max.**	**0.74**	**450**	**8390**	**200**	**6530**	**10**	**6530**
	SD.			**1.50**		**1.49**		**1.47**
	Min.	**0.24**	**250**	**4440**	**140**	**6210**	**5**	**6210**
	SD.			**1.56**		**1.57**		**1.56**
***CE*, kWh ha^{-1}**	**Max.**	**0.24**	**450**	**196.08**	**200**	**193.57**	**10**	**193.06**
	SD.			**1.09**		**2.49**		**2.76**
	Min.	**0.74**	**250**	**69.96**	**140**	**71.85**	**5**	**72.09**
	SD.			**0.45**		**1.85**		**2.09**
***Y*, t ha^{-1}**	**Max.**	**0.74**	**450**	**42.74**	**200**	**42.05**	**10**	**42.02**
	SD.			**0.16**		**0.75**		**0.74**
	Min.	**0.24**	**250**	**35.32**	**140**	**35.95**	**5**	**36.01**
	SD.			**0.20**		**0.63**		**0.64**
F: fuel consumbtion rate, L h^{-1}; *Fe*: prototype field efficiency, *df*: draft force, N; *CE*: consumed energy, kWh ha^{-1}; *Y*: crop yield, t ha^{-1}; %; *SD*: stander deviation.								

Table 6. The mean values of opearting costs.

Cost, USD ha^{-1}	**Control value, USD ha^{-1}**	**Speed (*S*), M sec^{-1}**	**Depth (*D*), mm**	**Mean value, USD ha^{-1}**	**Width (*W*), mm**	**Mean value, USD ha^{-1}**	**Concentration (*C*), %**	**Mean value, USD ha^{-1}**
***OC* Max.**	**379.13**	**0.24**	**250**	**246.37**	**140**	**242.09**	**5**	**241.69**
Min.		**0.74**	**450**	**65.30**	**200**	**66.40**	**10**	**66.45**
***IC* Max.**		**0.24**	**450**	**60.52**	**200**	**71.19**	**10**	**60.52**
Min.		**0.74**	**250**	**23.58**	**140**	**19.42**	**5**	**23.58**
***TC* Max.**		**0.24**	**250**	**269.95**	**140**	**269.84**	**5**	**265.28**
Min.		**0.74**	**450**	**125.81**	**200**	**116.24**	**10**	**126.96**
Reduction ratio to control, %	**30 to 66.51**							
OC: prototype operating cost, USD ha^{-1}; *IC*: injection cost, USD ha^{-1}; *TC*: total cost, USD ha^{-1}.								

Table 7. The mean values of water saved percentages and the water storage efficiency.

Measurement	**Mean value**	**Speed (*S*), M sec^{-1}**	**Depth (*D*), mm**	**Mean Value, %**	**Width (*W*), mm**	**Mean Value, %**	**Concentration (*C*), %**	**Mean value, %**
***Ws*, %**	**Max.**	**0.74**	**450**	**35.80**	**20**	**34.76**	**10**	**34.72**
	SD.			**0.38**		**1.17**		**1.21**
	Min.	**0.24**	**250**	**18.01**	**14**	**19.10**	**5**	**19.24**
	SD.			**0.24**		**1.35**		**1.36**
***Sη*, %**	**Max.**	**0.74**	**450**	**85.85**	**20**	**85.17**	**10**	**85.09**
	SD.			**0.36**		**0.76**		**0.73**
	Min.	**0.24**	**250**	**80.46**	**14**	**81.0**	**5**	**81.38**
	SD.			**0.37**		**0.81**		**1.34**
Ws: water saved percentages, %; *Sη*: water storage efficiency, %; *SD*: stander deviation.								

Table 8. The soil chemical analysis for the experimental sites.

Chemical analysis	pH	EC, dSm^{-1}	Ca^{++}, me L^{-1}	Mg^{++}, me L^{-1}	Na^{++}, me L^{-1}	K^{+}, me L^{-1}	Co_3^{--}, me L^{-1}	Hco_3^{--} ,me L^{-1}	Cl^{-}, me L^{-1}	So_4^{--}, me L^{-1}
Before season	7.92	5.13	11.55	5.77	6.78	1.92	2.49	2.89	6.36	14.28
After season	4.96	2.26	13.25	7.81	3.33	2.75	3.55	3.14	5.41	15.04
pH: acidity of soil suspension; *EC*: electrical conductivity, dSm^{-1}.										