Misr J. Ag. Eng., 21 (1): 86 – 102

PRECISION LEVELING EFFECTS ON STRIP AND FURROW IRRIGATIONS FOR MAIZE

By

Awad, M. A. and Gomaa, M. R.*

ABSTRACT

Two field experiments were conducted in clay soil during the 2000 and 2001 seasons at the Agricultural Research and Experiment Center of the Faculty of Agriculture, Moshtohor, Kalubia.

The main aim of this study is to evaluate long strips and long furrows of three lengths 50, 100 and 150 m, laser-leveled field compared with traditional land leveling on:

- Irrigation water requirements for maize.
- Water application efficiency, crop yield and itscomponents and water use efficiency.
- Investment costs of methods.

The experimental results show that:

The amount of the applied water increased when the furrow or strip length increased for the same discharge rate.

The water application efficiencies (Ea) decreased by increasing the furrow length at constant flow rate. The 50m-furrow length for laser-land leveling had the best water application efficiency of 82.9%.

Ear weights, weight of grains/ear and grain yield/fed were significantly affected by different treatments under study in both seasons. Laser land leveling, furrowing and 50m-furrow length was the best treatments. Plant heights, ear length, number of rows/ear, number of kernels per row and 100-kernels weight were affected only by 50m-furrow length in both seasons. Ear length only in 2000 and plant height in 2001 increased by laser land leveling.

Water use efficiency (WUE) of maize increased by laser leveling, furrowing and 50m furrow length in both seasons.

The optimum economically treatment was including laser land leveling combined with furrowing and 50m furrow length, where the net farm return valued 1727.68 and 1793.40 LE/fed in 2000 and 2001, respectively.

I-INTRODUCTION

In Egypt, maize (Zea mays L.) has a special importance. Egypt is importing annually more than 4 million tons.The production of maize can be increased by using new techniques for all cultural practices from planting till harvest. Water is the limiting factor which plays a significant role in increasing maize yield. Surface irrigation is the most widely used irrigation method in Egypt. One of the difficult problems is the poor efficiency of surface irrigation system, which causes the loss of water recourses used for irrigation.

---

* Resp. Lec. Agric. Eng., and Assoc. Prof. Agron., Fac. of Agric. at Moshtohor, Zagazig Univ. (Benha Branch).

A successful water management of the limited irrigated land will certainly lead to rationalization of water use and save a considerable amount of water. Precision land leveling, design of basin size and irrigation water discharge are the main factors affecting directly irrigation efficiency of surface irrigation system. Several researchers studied the effect of land leveling on the crop yield and irrigation efficiency. Hanna and El Awady (1970) ran an early analysis on the irrigation with long furrows. They recommended furrow lengths of 20 to 70m for slopes of 10^{-4} to 10^{-3} in clay loam, with furrow spacing of 0.6m. The analysis showed also how recommended length varies with furrow slope and spacing, and soil hydraulic conductivity. Clyma and Ali (1977) mentioned that a properly leveled border can be irrigated in 1/3 to 1/2 the time for un-leveled field, besides reducing the amount of irrigation water.

Abd El-Hafez et al. (1984) found that a hundred meter irrigation run could be used under precision land leveling with dead level practice (zero level) and the long borders (150m or more) could be used under the ground surface slope of 0.1% or more to achieve a good water management for berseem. On the other hand, Egypt's Water Use and Management Project Teem (EWUP, 1984) concluded that precision land leveling (dead level) with long level basin and long level furrows are practices which can produce improvements to the conventional farm systems used in Egypt. Also, El-Mowelhi (1988) found that the highest values of water application efficiency were achieved with 0.1% ground surface slope followed by the dead level treatment, while the lowest values were obtained from the traditional land leveling treatment. El-Hadidi and Abd El-Hafes (1989) found that precision land leveling with 0.2% ground surface slope and irrigation discharge of 1 m^3/min achieved high grain yield of maize and decreased water consumptive use which recorded high value of water use efficiency.

El-Saharigi et al. (1993) found that land leveling using laser grade control equipment showed significant water savings and yield increases over the conventionally leveled land and reduced the average costs of production by 6.3 to 15.4 % for wheat, beans, cotton, and maize. So, the most important factors for proper water management are the slope of furrows and furrow length.El-Haddad (2000) reported that the precision land leveling by laser improved water use efficiency. It increased from 2.7 to 4.7 kg/m^3 of water for wheat. Saadawy (2000) indicated that 0.04% slope and 3 Lps irrigation discharge/ furrow received less amounts of irrigation water for maize than the traditional (2566.2 and 3152.7m^3/fed). The treatment with 0.04% slope and 1.5 Lps/ furrow irrigation discharge at 80% shut off gave the highest water application efficiency (81.7%). Also, water use efficiency 1.31 kg/m^3 was higher than other treatments when using 0.04% slope and 3 Lps/furrow at 80% shut off time.

Kassem and El-Khatib (2000) found that the maximum crop yield of corn occurred for the 0.1% soil surface slope and 2.1 l/s discharge rate for furrow length 100m and 150m, while it occurred for the 1.4 l/s for the 50 m furrow length the application efficiency and water distribution efficiency increased by increasing the discharge rate and soil surface slope and by decreasing the furrow length.

The aim of the present investigation was to study the effect of different long-strip and furrow lengths (50, 100 and 150m) for corn under laser-leveling field compared with traditional land leveling on the amount of the applied water, the water application efficiency, yield and its components of maize, water use efficiency and economic evaluation of studied treatments.

II-MATERIAL AND METHODS

2.1 Field experiments:

To achieve the objectives of this work two field experiments were carried out in the 2000 and 2001 seasons.

- Location: Agricultural Research and Experiment Center of the Faculty of Agriculture, Moshtohor, Kalubia.
- Soil type: the soil was clay loamy with pH 7.8 and 2.9% organic matter.
- Field treatments: twelve treatments were applied as follow:
  - i- Two methods of land leveling, laser and traditional.
  - ii- For each leveling method, two irrigation methods were used, strip surface and long furrows.
  - iii- For each method of irrigation three lengths were considered 50, 100 and 150 m.

2.2 Experimental design:

A split split plot design was used in this design. Each treatment was replicated three times. The two land leveling methods were assigned to the main plot, irrigation methods (furrow and strip), to the subplot and strip length to the sub-subplot.

2.3 Crop variety:

Three ways cross 310 seeds were sown on 6 and 10 June in 2000 and 2001 growing seasons, respectively. A pneumatic planter (Gamma 90) was used for planting maize on flat soil.

Planter had four 0.6m apart units operated at a rate of 16.5 kg/fed. Planting spacing was 20 cm in each row. The preceding crop was wheat in both seasons. All the experimental units received the same agricultural practices as usual in the area.

2.4 Measuring facilities:

Irrigation water was supplied through a small fiberglass RBC flumes reading directly in liters per second, (Bos et al., 1984).

Station along the instrumented furrows, having synchronized stopwatches when the inflow was initiated, noted the time versus flume reading.

Water flow rate was turned off when water reach about 0.8 of the length of the strip or furrow.

Before planting, soil samples were taken from three locations, at the head, middle and tail of the experimental field in both seasons. These soil samples were taken for the determination of soil physical properties which were: soil mechanical analysis, bulk density, field capacity and wilting point as shown in table (1). All the above mentioned soil analysis was carried out at the Central Lab. of Faculty of Agric. at Moshtohor.

Table (1): Results of the soil mechanical analysis and soil moisture characteristics.

Depth cm	Particle size distribution				Textural Class	Calcium Carbonate %	Soil			Bulk Density g/cm³
	Coarse sand %	Fine sand %	Silt %	Clay %			Field capacity %	Wilting Point %	Available water %	
0-20	2.50	18.83	22.2	52.67	Clay	3.9	52.6	17.8	34.8	1.08
20-40	2.31	18.81	23.0	52.76	Clay	3.91	49.7	17.3	32.4	1.15
40-60	2.32	19.01	22.1	51.81	Clay	3.78	51.3	17.6	33.7	1.21

2.5 Field application efficiency (Ea):

Field application efficiency is defined as the amount of water required by the crop in a field at the time of irrigation, divided by the amount of irrigation water applied to that individual field. (Finkel, 1982)

2.6 Water use efficiency (WUE):

Water use efficiency was calculated as follows: (James, 1988).

$$\text{Water use efficiency (WUE), kg/m}^3 = \frac{\text{Grain yield, kg/fed}}{\text{Total applied water, m}^3\text{/fed}}$$

2.7 Maize yield components and yield:

Ten plants were chosen at random from each sub-subplot to determine plant height (cm), ear length (cm), number of rows per ear, number of grains per row, 100-grain mass (g), grain mass (g/ear) shelling percentage and grain yield (kg/fed) was recorded on a whole plot basis.

2.8 Total irrigation cost:

Irrigation cost differs according to the different treatments under study. Irrigation water in Egypt is not priced. So the total cost of irrigation was calculated through the growing season using the following relations.

$$\text{Total time of irrigation (h)} = \frac{\text{Total amount of applied water}}{\text{Discharge rate of irrigation pump, m}^3\text{/h (185m}^3\text{/h)}}$$

$$\text{Total irrigation cost (LE/fed)} = \text{Total time of irrigation} \times \text{Operating cost of pump per hour}$$

In the area, the rental fares of similar pumps are 5 LE/h., which is considered as the operating cost.

2.9 Economic evaluation:

In the present study, the economic evaluation included three estimates as follows:

1- Average input variables as well as total costs of maize production as affected by two methods of land leveling, different strip lengths with and without furrowing.
2- Net farm income of maize production as affected by the different treatments studied. Net farm income is the value of grain yield according to the actual price.
3- Net farm return of maize production as affected by different studied treatments. It is the difference between grain yield value according to the actual price and the total costs including land rent.

All estimations are based on the official and actual market prices determined by the Ministry of Agriculture and the Agricultural Credit and Development Bank. Costs of all mechanized operations were estimated according to prices given by the Agricultural Mechanization Service for the Locality (Toukh District).

III-RESULTS AND DISCUSSIONS

3.1. Amount of the applied water:

The averages amount of the applied water to corn under studied treatment of 2000 and 2001 seasons are shown in Figs.(1, 2 and 3). The maximum values were delivered at 3rd irrigation where plants were at maximum growth (July), were potential evapotranspiration (ETo) was maximum (6.98mm/day) as shown in table (2). The minimum value of the total (seasonal) applied water was (2112.0m^3/fed) for treatment of the 50m furrow length with laser-land leveling and the maximum value was at 150 m furrow length with traditional-land leveling (4142.1m^3/fed), at the same discharge rate and the soil surface slope (zero land-leveling).

As expected, the amount of the applied water was increased when the furrows or strips length increased at the same discharge rate (Fig.4).

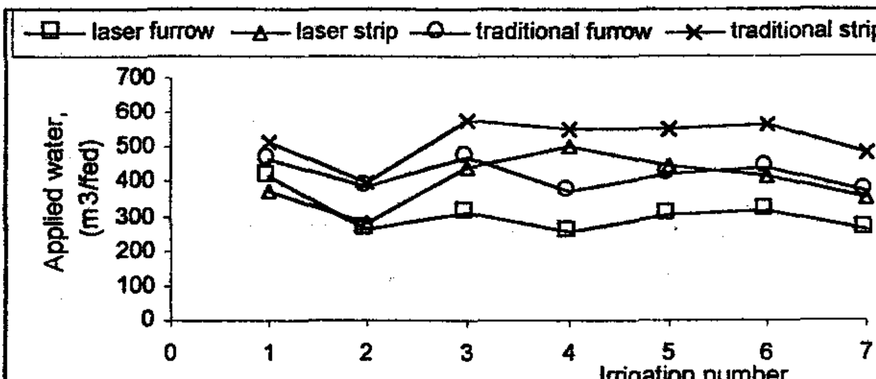

Fig.(1): The applied water as affected by irrigation number for 50 m length.

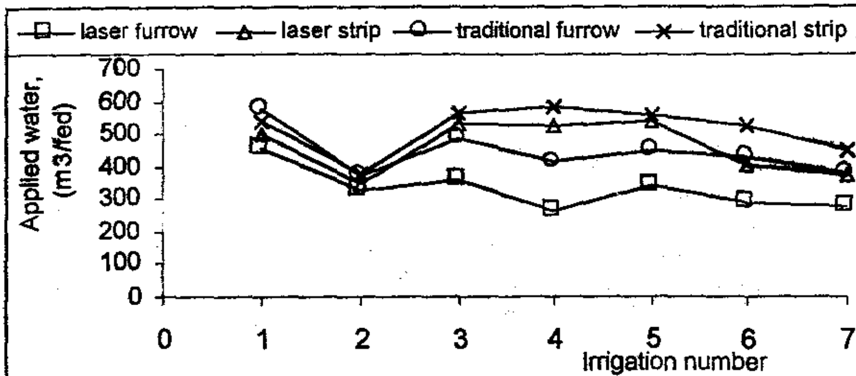

Fig.(2): The applied water as affected by irrigation number for 100m length.

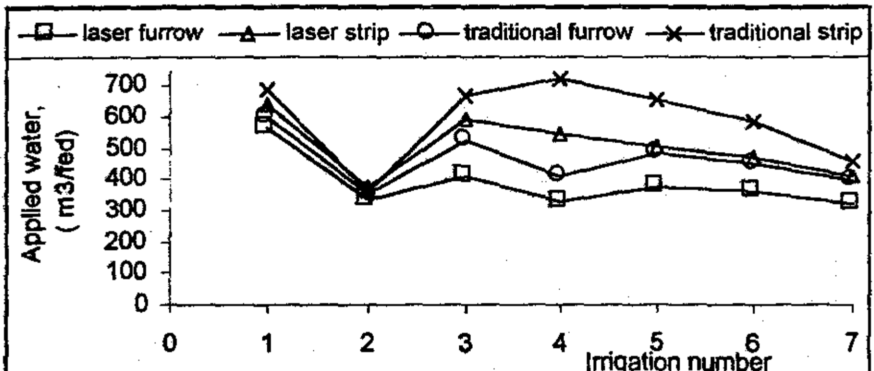

Fig.(3): The applied water as affected by irrigation number for 150m length.

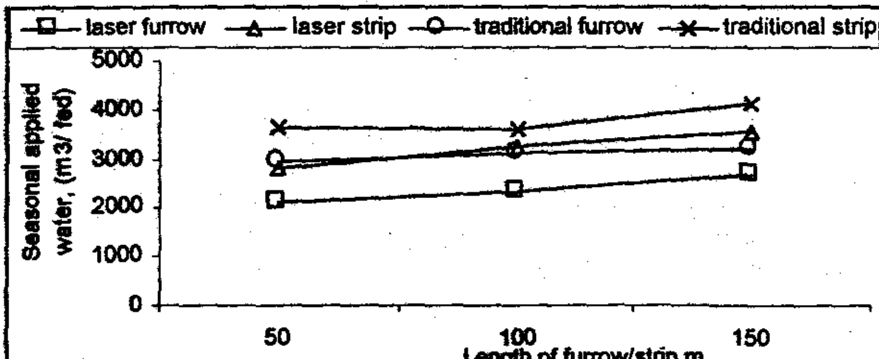

Fig.(4): The seasonal applied water as affected by different treatments.

3.2. Field application efficiency, (Ea):

Table (2) shows the estimated crop water consumptive use for maize (ETc mm/day) during the growth stages at each irrigation time according to the potential evapotranspiration ETo and crop factor Kc data estimated by FAO-49 CLIMWAT for CROPWAT(1993) cited after Ismail (2002). The crop factor ranged between 0.3 - 1.01 with average of 0.655.

Table (2): Calculated crop water consumptive use (ETc) mm/day of maize*.

Growth stage	Potential evapotranspiration (ETo mm/day)	Crop factor (Kc)	Water consumptive use (ETc mm/day)
10 / 6	6.57	0.30	1.97
30 / 6	6.77	0.43	2.91
10 / 7	6.98	0.67	4.68
25 / 7	6.57	0.89	5.84
05 / 8	6.33	1.01	6.39
16 / 8	5.80	0.80	4.64
02 / 9	5.50	0.54	2.97

* Cited after Ismail (2002).

The estimated water consumptive use (ETc) values were calculated for each irrigation for all the treatments as shown in table (3). According to table (2) the field application efficiency (Ea) was calculated by dividing the consumptive use by the water applied for each treatment.

Data in table (3) indicate that laser leveling increased field irrigation efficiency for both furrow and strip irrigation methods compared with traditional leveling.

The average seasonal field application efficiencies were 82.9%, 76.54% and 65.7% for laser leveled furrows of 50, 100 and 150m lengths respectively, compared with 58.2%, 55.6% and 54.4% for traditionally leveled furrows respectively, (Table 4).

The corresponding efficiencies for strip irrigation treatments were 61.58%, 53.74% and 49.47% for laser leveling comparing with 47%, 47.7% and 43% for traditional leveled strips at 50, 100 and 150m lengths respectively.

It is clear that field irrigation efficiency under furrow irrigation method was higher than that under strip irrigation methods for all laser and traditional treatments and as well as for all the three field lengths.

Comparing furrow irrigation methods with strip irrigation methods indicates that furrow methods have higher efficiency than strip methods under all studied field lengths, and under both of laser and traditional leveling methods. Furrows efficiency was higher by about 20% than strip method under laser leveling conditions, while this difference was less (about 10%) under traditional leveling condition.

So, laser leveling improves irrigation efficiency in furrow and strip methods, but the improvement was better in furrow method.

Table (3): The amount: of applied water (m³/fed. irri) and application efficiency (Ea) as affected by different treatments and irrigation gifts.

Land leveling	Laser					Traditional			
Irrigation method	Furrows			Strips		Furrows		Strips	
Furrow/ strip length, m	ETc m³/fed	Applied water m³/fed.irri	Ea %	Applied water m³/fed.irri	Ea %	Applied water m³/fed.irri	Ea %	Applied water m³/fed.irri	Ea %
50	165.46	413.28	40.04*	372.40	44.43*	465.92	35.51*	511.56	32.34*
	244.44	258.72	94.48	280.00	87.30	386.26	63.28	393.66	61.47
	294.84	306.88	96.08	437.92	67.33	470.40	62.68	577.22	51.08
	245.28	252.56	97.12	705.40	48.72	369.60	66.36	550.37	44.57
	268.38	305.20	87.94	445.76	60.21	422.52	63.52	553.00	48.53
	292.32	313.88	93.13	416.36	70.21	441.84	66.16	561.12	52.10
	187.11	262.08	71.39	354.20	52.83	373.80	50.06	483.84	38.67
100	165.46	456.96	36.20*	502.04	32.96*	579.46	28.55*	541.60	30.55*
	244.44	328.58	74.39	439.86	69.87	371.70	65.76	381.02	64.15
	294.84	359.94	81.91	534.66	55.16	491.26	60.02	567.70	51.94
	245.28	261.66	93.74	527.10	46.53	420.00	58.40	585.34	41.90
	268.38	337.68	79.84	536.34	50.04	449.68	59.68	556.92	48.19
	292.32	286.58	102.0*	407.68	71.70	432.60	67.57	523.88	55.80
	187.11	274.82	68.08*	374.92	49.91	379.96	49.24	448.98	41.67
150	165.46	566.52	29.21*	639.53	25.87*	596.75	27.73*	685.96	24.12*
	244.44	337.00	72.53	373.11	65.51	354.25	68.99	359.56	67.98
	294.84	405.86	72.64	593.25	49.70	525.09	56.15	670.57	43.97
	245.28	330.47	74.22	546.36	44.89	409.55	59.89	722.65	33.94
	268.38	374.79	71.61	505.78	53.06	486.37	55.18	657.49	40.82
	292.32	361.07	80.96	473.03	61.80	448.12	65.23	589.47	49.59
	187.11	320.67	58.35	411.73	45.44	393.91	47.50	456.42	41.00

*Preplanting irrigation, (Tafi Sharaki طفى شراقى)

** Irrigation water applied was less than ETc (under irrigation)

Table (4): The seasonal applied water and average field application efficiency as affected by different treatments.

Land leveling	Laser				Traditional			
Irrigation method	furrows		Strips		Furrows		Strips	
Furrow / strip length, m	Seasonal applied water m^3/fed	Ea %	Seasonal applied water m^3/fed	Ea %	Seasonal applied water m^3/fed	Ea %	Seasonal applied water m^3/fed	Ea %
50	2112.0	82.88	2810.1	61.58	2930.3	58.22	3634.8	46.97
100	2306.2	76.54	3232.6	53.74	3124.7	55.6	3605.4	47.74
150	2696.4	65.65	3542.8	49.47	3214.1	54.38	4142.1	43.06

Studying the effect of furrow or strip length on the irrigation efficiency, the data in table (4) indicate that 50m length had the highest efficiency among the three lengths 50, 100 and 150m, which agrees with lengths resulting from analysis of Hanna and El Awady (1970).

The data also reveal that as furrow or strip length increased the application efficiency decreased either under laser or traditional land leveling treatments. This is expected since the water inflow was the same and constant (10 L/s, for either 3m width strip or 4 furrows) in all the treatments, and irrigation was considered be completed when water advance reached the 80% of field length. So, water was cut-off at 80% of the field length.

The highest irrigation efficiency was the laser leveled furrows with 50m length (82.9%), while the lowest efficiency was with traditionally leveled strip method of 150m length (43%)

3-3 Yield and its components

3-3-1 Land leveling effects:

Ear weight, weight of grains /ear and grain yield /fed in both seasons as well as ear length in 2000 season and plant height in 2001 season, significantly increased when soil was leveled by laser, table (5 and 6).

Furthermore, laser leveling increased grain yield (kg/fed.) by 3.67 and 2.56% in 2000 and 2001 seasons, respectively. Although the increase of maize production by laser was slight, the least quantity of water was consumed by this treatment, table (4). Consequently, the laser treatment achieved the highest value of water use efficiency (WUE) compared with traditional treatment, table (7).

It could be concluded that soil leveling by laser leads to ease irrigation as well as to regulate water distribution. This helps seed germination and crop growth, which positively reflects on yield. The present results are also in accordance with those reported by El-Sharigi et al. (1993), El-Mowelhi et al., (1995) and Kassem and El-Khatib (2000).

Table (5): Yield and its components of maize for different treatments in 2000 season.

Treatment	Plant height cm	Ear length cm	No. of rows /ear	No. of kernels/ row	100-kernels mass, g	Ear mass (g)	Mass of grain /ear (g)	Shelling %	Grain yield kg/ fed.
Land leveling:									
Laser	205.17	19.56	13.14	37.15	30.50	196.73	155.61	79.30	3078.89
Traditional	201.00	19.06	12.99	35.76	29.89	188.69	150.16	78.95	2969.89
L.S.D at 5%	N.S.	0.21	N.S.	N.S.	N.S.	5.69	2.63	N.S.	26.06
Irrigation method									
Furrowing	205.22	19.43	13.15	37.12	30.50	195.34	155.34	79.75	3084.56
Strip	200.94	19.18	12.98	35.79	29.80	190.07	150.43	78.50	2964.22
L.S.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	3.40	N.S.	89.11
Strip Lengths:									
50	208.75	20.37	13.59	40.08	31.58	212.35	167.69	78.18	3270.50
100	201.83	19.18	13.02	35.19	30.33	191.80	155.60	81.34	3095.33
150	198.67	18.38	12.60	34.09	28.67	173.96	135.37	77.86	2707.33
L.S.D. at 5%	5.04	0.73	0.39	2.83	0.84	6.99	5.13	3.11	91.94

Table (6): Yield and its components of maize for different treatments in 2001 season.

Treatment	Plant height cm	Ear length cm	No. of rows /ear	No. of kernels/ row	100-kernels mass, g	Ear mass (g)	Mass of grain /ear (g)	Shelling %	Grain yield kg/ fed.
Land leveling:									
Laser	202.33	20.09	13.41	37.51	30.78	210.17	178.53	85.25	3166.05
Traditional	194.30	19.54	13.09	36.96	29.72	201.86	171.76	84.78	3087.00
L.S.D at 5%	8.00	N.S.	N.S.	N.S.	N.S.	5.78	6.43	N.S.	20.82
Irrigation method									
Furrowing	201.11	19.93	13.33	38.05	30.67	209.22	177.58	84.88	3148.44
Strip	195.56	19.70	13.17	36.41	29.83	202.81	172.71	85.16	3104.6
L.S.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	5.43	2.02	1.18	28.57
Strip Lengths:									
50	208.75	20.78	13.70	39.95	32.00	221.61	186.33	84.04	3280.25
100	198.08	19.88	13.20	36.61	29.92	203.67	174.32	85.57	3136.00
150	188.17	18.78	12.85	35.13	28.83	192.76	164.78	85.45	2963.33
L.S.D. at 5%	6.83	0.66	0.29	1.59	1.23	8.97	2.46	N.S.	45.65

3.3.2 Irrigation methods:

Furrowing increased significantly weight of grain /ear and grain yield /fed. in both seasons as well as ear weight and selling % in 2001 season only table (6). Such results reflect the important of furrowing for control irrigation water quantity and facilitates water passage to all field which in turn increases the growth and yield of maize plants.

3.3.3 Strip length effects:

Data in tables (5 and 6) show highly significant differences for all studied traits during both seasons except shelling % in 2001 season. The best treatment was that of 50m-furrow length, whereas the 150m furrow length gave the lowest values for all studied traits. Moreover, 50m-furrow length out yielded 100 and 150m furrow lengths by 5.66 and 20.80% in 2000, compared to 4.59 and 10.96% in 2001, respectively. It could be concluded that the 50m furrow length rendered irrigation water reaches for all the field and this raises water use efficiency. Similar results were also obtained by Kassem and El-Khatib (2000), and agree with the analysis of Hanna and El Awady (1970).

3.4 Water use efficiency (WUE):

3.4.1 Effect of land leveling:

Results presented in table (7) and Fig (5), indicated that values of (WUE) by maize plants in 2000 season were 1.16 and 0.88 kg grains /m^3 of water consumed for laser and traditional levelings, respectively. The corresponding values in 2001 season were 1.18 and 0.92 kg grains/m^3 for the same respective treatments. It is clear that the highest value of (WUE) was obtained with soil leveled by laser. This trend was found to be true in both seasons. It can be concluded that leveling by laser is necessary to maximize crop production per unit area planted.

3.4.2 Effect of irrigation methods:

Data presented in table (7) pointed out that furrowing treatment had a great effect on (WUE) by maize in both seasons. Data showed also that the highest value of (WUE) was 1.17 and 1.20 kg grains/m^3 in 2000 and 2001 seasons, respectively. It can be concluded that furrowing controls quantity of irrigation water as well as it helps seed germination, crop growth and seems to be more efficient in water use.

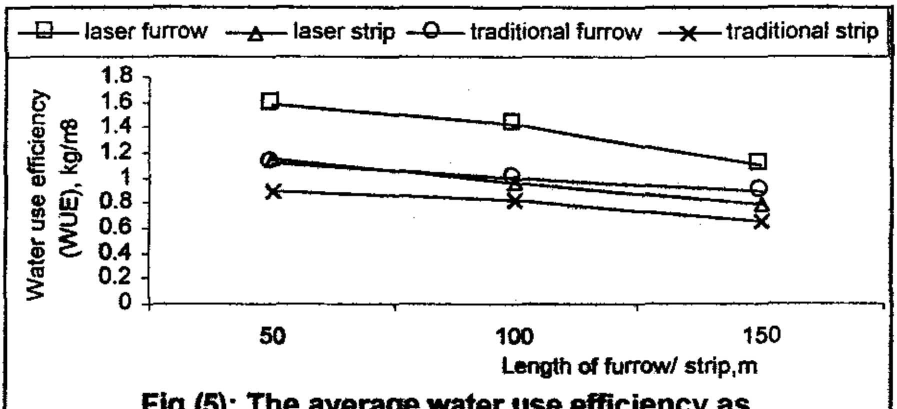

Fig.(5): The average water use efficiency as affected by different treatment.

3.4.3 Effect of strip length:

In table (7), it was clear that the maximum (WUE) value was 1.19 kg grain/m^3, recorded by 50m furrow length in both seasons. Meanwhile, the minimum values of (WUE) were 0.83 and 0.90 kg grain/m^3 obtained by 150 m furrow length in 2000 and 2001 seasons, respectively. It can be concluded that 50 m furrow length raises water's using efficiency than the other two lengths under this study.

Table (7): Water use efficiency (kg grain/m^3 of water use) as affected by different treatments.

Treatment	Land leveling						Irrigation methods		Strip length
	Laser			Traditional					
	Furrow	strip	Average	furrow	strip	average	furrow	strip	
2000 Season									
Strip length									
50m	1.57	1.17	1.37	1.12	0.88	1.00			1.19
100m	1.43	0.94	1.19	0.99	0.82	0.91			1.05
150m	1.05	0.76	0.91	0.84	0.63	0.74			0.83
average	1.35	0.97	1.16	0.98	0.78	0.88	1.17	0.88	
2001Season									
Strip length									
50m	1.60	1.14	1.37	1.12	0.89	1.01			1.19
100m	1.41	0.98	1.19	1.00	0.84	0.92			1.06
150m	1.13	0.83	0.98	0.93	0.69	0.81			0.90
average	1.38	0.98	1.18	1.02	0.81	0.92	1.20	0.90	

3.5. Economic evaluation:

3.5.1 Effect of land leveling methods, furrowing and different strip lengths on the total costs of maize production:

Total costs include values of production tools and requirements such as seeds, fertilizer, man power, machinery and other general or miscellaneous costs as well as land rent (average of 2000 and 2001 seasons), are shown in table (8) and the costs of the different land leveling, furrowing and strip length treatments included in the study are given in table (9).

The cost of laser leveling was 120 LE/fed. calculated on the basis of two hours by laser leveler per fed. and the cost of one hour was 60 L.E.

Table (8): Costs of tools and requirements of maize production (average of 2000 and 2001 seasons.)

Treatment	Costs per fed. in LE.
Chisel plow (twice)	35.24
Disc harrowing	13.20
Laser leveling	20.00*
Furrowing	13.20
Land ridging	13.20
100 kg N/fed as urea (46% N)	121.80
Seeds	120.00
Man power	234.00
Land rent**	480.00

* Estimated from LE 120 per feddan and as it is normally carried out every three years so cost per crop is LE 20.

** Land rental was estimated on the basis of renting one third (4 months) of a normal growing season in the area.

Ridging the land into different length strips (50, 100, and 150 meter) costed nearly the same expense, which was 13.20 L.E. The price of one kilogram three way cross 310 seeds was 8.00 L.E. Man power was calculated on the basis of 39 workers per fed for all other practices and wage of 6.0 L.E. for the worker.

Costs of treatments under study included also the cost for soil tillage (chisel plow twice) and disc harrowing, table (9).

Table (9): costs of land leveling methods, furrowing and different strip length treatments included in the study (in LE/fed.) (average of 2000 and 2001 season)

Treatment	Land leveling			
	Laser		Traditional	
	Furrow	Strip	Furrow	Strip
Strip lengths				
50 m	94.84	81.64	74.84	61.64
100m	94.84	81.64	74.84	61.64
150m	94.84	81.64	74.84	61.64

Table (10): The total costs of maize production in (LE/fed.) as affected by the different treatments (average of 2000 and 2001 seasons).

Treatment	Land leveling			
	Laser		Traditional	
	Furrow	Strip	Furrow	Strip
Strip lengths				
50 m	1107.74	1113.39	1109.79	1115.64
100m	1112.99	1124.79	1115.09	1114.89
150m	1123.54	1133.19	1117.49	1129.39

Table (10) shows the total costs of maize production per fed. as affected by the different treatment (average of 2000 and 2001 seasons). Total costs of maize production included also total irrigation cost. Irrigation cost differs according to the different treatments under study.

From table (10) it is clear that the minimum total costs were obtained from the laser land leveling treatment with furrowing and 50m-strip length, being 1107.74L.E. and the maximum total costs were that of laser leveling and 150m strip length without furrowing which was 1133.19 L.E.

3.5.2 Value of maize grain yield as affected by the different treatments:

Value of maize grain yield in L.E. per fed, as affected by the different treatments in 2000 and 2001 seasons, are shown in table (11). The price of maize was 857.14 L.E. per ton as given by "Extension Service" information (average of 2000 and 2001 seasons).

Table (11): Value of maize grain yield (in LE/fed.) as affected by the different treatments in 2000 and 2001 seasons.

Treatment	Land leveling			
	Laser		Traditional	
	Furrow	Strip	Furrow	Strip
2000 Season				
Strip lengths				
50 m	2835.42	2827.99	2815.99	2733.71
100m	2832.00	2604.57	2645.72	2530.29
150m	2427.43	2306.85	2306.85	2241.15
2001 Season				
Strip lengths				
50 m	2901.14	2755.14	2813.14	2777.14
100m	2780.28	2705.14	2679.71	2586.86
150m	2610.57	2530.28	2553.14	2466.00

From results it is clear that the highest values were 2835.42 and 2901.14 LE./fed. in 2000 and 2001 seasons, respectively for laser land leveling treatment with furrowing and 50 m strip length. On the other hand, the lowest values were those of the traditional land leveling and 150 m strip length without furrowing, being 2241.15 and 2466.00 LE/fed with reductions of 594.27 and 435.14 LE. or 26.52 and 17.65% compared with the highest treatments in 2000 and 2001, respectively.

3.5.3 Net farm return of maize production and net return per one invested LE:

Results in tables (12 and 13) revealed that the highest net farm return was achieved by the traditional land leveling with furrowing and 50 m strip lengths, which were 1727.68 and 1793.40 LE. /fed, making a net return ratio of 1.55 and 1.61 LE/one invested pound in 2000 and 2001, respectively.

Table (12): Net farm return* in LE per fed of maize as affected by the different treatments in 2000 and 2001 seasons.

Treatment	Land leveling			
	Laser		Traditional	
	Furrow	Strip	Furrow	Strip
2000 Season				
Strip lengths				
50 m	1727.68	1714.60	1706.20	1618.07
100m	1719.01	1479.78	1530.63	1415.40
150m	1303.89	1173.66	1189.36	1111.76
2001 Season				
Strip lengths				
50 m	1793.40	1641.75	1703.35	1661.50
100m	1667.29	1580.35	1564.62	1471.97
150m	1487.03	1397.09	1435.35	1336.61

*Net farm return (LE per fed) = Grain yield value – total costs.

Table (13): Net farm return* per one invested LE of maize as affected by the different treatments in 2000 and 2001 seasons.

Treatment	Land leveling			
	Laser		Traditional	
	Furrow	Strip	Furrow	Strip
2000 Season				
Strip lengths				
50 m	1.55	1.53	1.54	1.45
100m	1.54	1.31	1.37	1.30
150m	1.16	1.03	1.06	0.98
2001 Season				
Strip lengths				
50 m	1.61	1.47	1.53	1.48
100m	1.49	1.40	1.40	1.32
150m	1.32	1.23	1.28	1.18

* Net farm return per one invested LE. = (Net farm return / total costs of production (per fed.))

It is worth mentioning here that there aren't definite differences observed between traditional and laser land leveling (combined with furrowing and 50m strip length).

The lowest net farm returns were 1111.76 and 1336.61 LE. /fed with net return ratios of 0.98 and 1.18 LE/pound, which were recorded by the traditional land leveling and 150m strip length without furrowing in 2000 and 2001, respectively.

It could be concluded that under the conditions of the experiment and from an economic point of view, laser or traditional land leveling combined with furrowing and 50 m strip length is the bast treatment for producing the highest maize grain yield and consequently the highest net farm return.

The present results indicate clearly the importance of land leveling practice especially by laser with furrowing and 50 m furrow length as a means for increasing maize yield and consequently net farm return.

IV-CONCLUSION

1- Laser leveling increases field irrigation efficiency by 29.3%, saves water by 19-39%, increases maize yield by 3.67% and consequently increased crop-water use efficiency by 18-26% compared with traditional leveling.
2- Maize production under furrow irrigation method gave higher yield (3116kg/fed), irrigation efficiency (82.9%) and less applied water (2112 m^3/fed), and higher water use efficiency (1.585kg/m^3) compared with strip irrigated maize production.
3- In this study, increasing furrow / strip lengths 50, 100 and 150m at constant water inflow rate (10L/s, for either 3m width strip or 4 furrows) resulted in low irrigation efficiencies and less crop yield.

V-REFERENCES

Bos, M. G.; J. A. Replogle and A. J. Clemmens (1984). Flow measuring flumes for open channel system. John Wiley and Sons, New York, NY. pp 321.

Clyma, A. and M. Ali (1977). Traditional and improved irrigation practices in Pakistan. Proc. Water Management for irrigation and drainage ASCE/ Reno, Nevada. July.: 20-22.

EWUP, Egypt Water Use and Management Project (1984). Improving Egypt's irrigation system in the old lands. EWUP Final Report I. Press.

FAO (1993). Irrig. and Drain. Paper No. 49. CLIMWAT for CROPWAT.

Finkel, H. (1982). CRC Handbook of Irrigation Technology, volume 1. CRC Press, Inc. Boca Raton, Florida p.73

Haddad, Z. (2000). To whomt my concern. Agricultural modernization is a must for future saviral. El-Ahram Pub. No 1689/2002: p.37.

Hadidi, E. M. and S. A. Abd El-Hafez (1989). Effect of land leveling and irrigation flow rate on maize yield, water consumptive use and water use efficiency J. Agric. Sci. Mansoura Univ. 14 (2): 1253-1258.

Hafez, S. A; A. M El-Bershamgy; M. A El-Abaseri; M. N. El-Mowelhi and F. N. Maahrous (1984). Effect of ground surface slope and irrigation run length on yield, consumptive use and water application efficiency of berseem clover. Agric. Res. Review Vol. 62, No. 4A.

Hanna, K. F., El Awady, M. N. (1970). Analysis of the irrigation with long furrows, Fac. Ag Ain-Shams U., Res. Bul. 674: p 20 .

Ismail S. M. (2002). Design and management of field irrigation systems. The 1st Ed., Agric. Eng. Dept., Fac. of Agric., Alex. Univ.: 173-188.

James, L. G. (1988). Principal of farm irrigation design. Washington state Univ.,: 61-109.

Kassem, M. A. and El-Khatib S. I. (2000). Mathematical determination of the effect of the major engineering factors on the efficiency of long furrows irrigation for corn crop. Misr J. Agric. Eng. MSAE, 17 (3): 569-588.

Mowelhi, N. M. (1988). Field studies on sodic soil reclamation to determine the most effective placements in terms of soil location and time. 10th Ann Rep. AC-ARS, 88-FG-EG-196.

Mowelhi, N. M.; Abo Soliman M. S. M.; Abd El-Hafez, S. A. and E. A. Gazia (1995). On-farm water management in soil of Kafr El-Sheikh. Evaluation of land leveling practices. The 2nd Conf-Farm Irrigation and Agroclimatology : 172-186.

Saadawy, M. A. (2000). Evaluation of some effective factors on surface irrigation. Misr J. Agric. Eng. MSAE, 17 (1): 248-254.

Saharigi, A. F., M. N. Saif El-Yazal and A. A. M. El-Gindy, (1993). On-farm improved irrigation management using laser technology, farm mechanization and irrigation systems" Agri. Eng. Res. Inst., Agri. Res. Center, Ministry of Agriculture and land reclamation, Egypt.

الملخص العربي

تأثير التسوية الدقيقة على الرى فى شرائح و خطوط لمحصول الذرة الشامية

منتصر عبد الله عواد و محمد السيد رياض جمعة*

أجريت تجربتان حقليتان خلال موسمى ٢٠٠٠و٢٠٠١ فى أرض طينية بمركز البحوث و التجارب الزراعية بكلية الزراعة بمشتهر ـ محافظة القليوبية، وذلك لدراسة تأثير الأطوال المختلفة للشرائح و الخطوط (٥٠-١٠٠-١٥٠م) عند التسوية الدقيقة للأراضي باستخدام الليزر والمقارنة بالتسوية التقليدية على الاحتياجات المائية لمحصول الذرة الشامية، و كفاءة إضافة المياه و المحصول و مكوناته و كفاءة استخدام المياه و كذلك التقييم الاقتصادي للمعاملات المذكورة.

و أوضحت النتائج الآتي:

١) زيادة كمية المياه المضافة بزيادة طول الشريحة أو الخط عند نفس معدل التصرف.

٢) انخفاض كفاءة إضافة المياه بزيادة طول الخط عند معدل تصرف ثابت.

٣) كانت افضل قيمة لكفاءة استخدام المياه (٨٢,٩%) عند التسوية بالليزر و التخطيط بطول ٥٠م للخط.

٤) تأثير كل من وزن الكوز و وزن حبوب الكوز و محصول الحبوب للفدان معنويا بالمعاملات تحت الدراسة خلال موسمي الزراعة- كانت افضل المعاملات التخطيط بطول ٥٠م للخط عند التسوية بالليزر.

٥) تأثر معنويا كل من طول النبات و طول الكوز و عدد الصفوف بالكوز و عدد الحبوب بالصف و وزن ١٠٠حبة فقط لطول الخط ٥٠م خلال موسمي الزراعة- في حين تأثر بالزيادة طول الكوز فقط خلال موسم ٢٠٠٠ و ارتفاع النبات فقط خلال موسم ٢٠٠١ عند التسوية بالليزر.

٦) ازدادت كفاءة نباتات الذرة لاستخدام مياه الرى عند التخطيط ٥٠م للخط و التسوية بالليزر خلال موسمى الزراعة.

٧) تعد أفضل معاملة لاعداد و زراعة الأرض بالذرة الشامية هى التسوية بالليزر و التخطيط بطول ٥٠م للخط حيث بلغ صافى الدخل المز رعى١٧٢٧,٦٨، ١٧٩٣,٤جنيها للفدان خلال موسمى ٢٠٠٠، ٢٠٠١ على التوالي.

* مدرس الهندسة الزراعية وأستاذ المحاصيل المساعد على الترتيب - كلية الزراعة بمشتهر - جامعة الزقازيق/ فرع بنها.