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IMPACT OF LASER TECHNIQUE AND TILLAGE DEPTH ON IRRIGATION USE EFFICIENCY UNDER SURFACE IRRIGATION ON CALCAREOUS SOIL

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ABSTRACT: In Egypt, about of 50 % of the newly reclaimed areas are calcareous soil in nature and about of 3 million fed calcareous soil under reclamation. The main problem in this soil is high calcium carbonate content which hence crop production. The main objective of the present work is optimizing of barley and sorghum productivity in the calcareous soil in respect to study the effect of leveling method [Light Amplification Simulation Emission of Radiation, (LASER) 0.05%, traditional and non-leveling], tillage depths of 13.6,18.4 and 23.2 cm and the border length of 25,50 and 75 m on water use efficiency in calcareous soil .The obtained results can be summarized as follows:

Using LASER leveling created re-distribution of $CaCO_3$ % to be concentrated in deep layer away of the root zone, the values of $CaCO_3$% after using LASER leveling were 29.38, 33.60 and 35.86 % at soil layers of 0-10, 10-20 and 20-30 cm.

Soil bulk density and penetration resistance increased after land leveling operation especially in the surface layer of 0-10 cm. The highest bulk density and penetration increasing were 13.04 and 26.83 % at soil layer of 0-10 cm by using LASER leveling and tillage depth of 13.6 cm. While the lowest values were 1.42 and 5.35% at soil layer 20-30 cm by using traditional leveling and tillage depth of 13.6 cm. The average infiltration rate decreased after land leveling operation, the highest infiltration rate decreasing was 22.95% after using LASER leveling and tillage depth of 13.6 cm.

The performance of chisel plow (field capacity, fuel consumption, slip and power requirement), during the second season, improved by using LASER leveling as compared with traditional leveling and non-leveling methods.

Both of barley and sorghum (forage fresh) yields increased by using LASER leveling in calcareous soil. The highest values of barley and sorghum yields were 2.02 and 42.96 Mg/fed by using LASER leveling, tillage depth of 23.2 cm and border length of 25 m. The highest values of saved irrigation water were about 31.4 and 26.7 % of barley and sorghum accomplished by using LASER leveling, tillage depth of 13.6 cm and border length of 25 m. The highest values of water use efficiency were 1.38 and18.62 kg/m^3 of barley and sorghum by using LASER leveling, tillage depth of 18.4 cm and border length of 25 m.

The cost of LASER leveling use decreased by 18.53 % as compared to the traditional leveling for period of 3 years.

Key words: LASER leveling- traditional leveling- calcareous soil- irrigation - barley- sorghum.

INTRODUCTION

Reclamation of desert soil is one of the main principles of Egypt's strategy to face down the agricultural demands of over increasing population.

About of fifty percent of the newly reclaimed areas are calcareous soil in nature and about 3 million feddan calcareous soil are under reclamation (El-Bagouri, 1994). The main problem in calcareous soil is high calcium carbonate content, which affected distinctly soil properties and hence crop production. Improvement of that soil depends mainly on two important processes, improvement of soil structure and irrigation management (El-Sersawy, 1989). To optimize some crops production in the calcareous soil, El-Kot (2003) studied the effect of different tillage system in calcareous soil. The highest values of grain yield were 1.13 and 2.22 Mg/fed of bean and barley respectively by using chisel plow at depth of 19.7 cm. Abdou (1996) concluded that the use of chisel plough (two passes) at 18 cm depth gave grain and straw yields of 14.7 and 22.7%, respectively, these were higher than those obtained at the same conditions and 10 cm depth for wheat crop.

Micheal (1990) found that leveling operation significantly increased the soil bulk density at the surface layer. This increment could be attributed to the effect of land leveling on breaking, loosening and compacting of soil particles. Also, it is evident that the change in soil bulk density was higher at the surface layer of 0-10 cm. Youseef (1991) found that the values of bulk density after using LASER leveling and traditional leveling methods were higher in the bottom layer of 20-30 cm than the upper layer of 10-20 and 0-10 cm. The difference in bulk density values between laser and traditional leveling were 23.68, 9.16 and 8.27% at the 0-10 , 10-20 and 20-30 cm layers , respectively. Abdel-Maksoud *et al.* (1993) found that the increasing in penetration resistance were 18.5 and 41.5 % by using traditional leveling and LASER leveling. The main reason for higher compaction was due to time of traffic of leveling equipment under LASER leveling. Ibrahima *et al.* (1995) found that ploughing increased infiltration by 20% resulting faster and greater water recharge in the root zone. Sorghum yield from ploughed plots 30% was higher than those obtained with the traditional method (unploughed plots). El-kot (2002) indicated that hydraulic conductivity increased by increasing tillage depth. Tillage practices generally lead to an overall improvement of hydraulic characteristics in the calcareous soil. Thus they were helping to create optimal vegetative crop conditions and greatly reducing surface water erosion processes. Sewell (1970) indicated that the obtained advantages from land leveling are reduce wear and damage to equipment working in the field, Increase field capacity of machine by increasing forward speed and Improve surface conditions favoring mechanization of agricultural operations for crop production. El-Khatib (1992) stated that the moving capacity of LASER leveling scraper 3 m width was 17.3 m^3/h at using forward speed of 5.2 km/h and field efficiency was 77% in average while that moving capacity of traditional leveling was 14.5 m^3/h at using forward speed of 4.5 km/h and field efficiency was 61% in average. Gabber (2001) found that the minimum value of field capacity of chisel plow after land leveling was 0.57 fed/h for unleveled area. While the values after land leveling were 0.60, 0.63, 0.65, 72 and 0.75 fed/h for traditional land leveling and precision land leveling at slopes of 0, 0.01, 0.02 and 0.03% respectively. El-Raie *et al.* (2003) indicated that when precision leveling index (P.L.I.) decreased from 2.16 to 0.54 cm, tractor wheels slip decreased from 10.76 to 5.7% for traditional land leveling and 0.03% slope, respectively. Fuel consumption, engine power, energy requirement decreased form 10.76 to 9.5 l/h, from 34.00 to 30.02 kW and from 29.31 to 14.72 kW.h/fed for traditional land leveling and 0.03% slope respectively. El-Sahrigi *et al.* (2001) indicated that the highest barley grain productivity was 1.5 to 1.95 Mg/fed by using LASER land Leveling and the lowest yield was 0.966 Mg/fed by using traditional leveling. Water requirement of barley crop decreased by 22.5% by using LASER land leveling method as comparing with traditional leveling method. Abdel–Rahaman (1994) found that water use efficiency was higher by using LASER than that obtain by using traditional scraper compared with unleveled land. It was 44.1% (for wheat) and 47.2% (for maize) with leveling by LASER. While it was 12.2% and 17.5% for wheat and maize crops, respectively, with blade-box land leveling system compared with unleveled field. El-Gindy *et al.* (1996) concluded that precision land leveling at 0.03% slope along with seedbed preparation by two passes with a chisel plough, one pass with a disk harrow had the following advantages:

Water saving by 20% and 22%, increased application efficiency by 28% and 27%, increased yield by 30% and 47%, increased water use efficiency by 44% and 59% and reduced irrigation time by 35% and 33% for wheat and maize, respectively. El-Saadawy and Mohamed (1998) studied the effect of furrow length and tillage depth on water use efficiency (WUE). The results indicated that the amount of irrigation water increased under deep plowing (0-60) cm treatment as compared by surface ploughing (0-20) cm. They added that furrow length of 25 m treatments achieved the highest values of (WUE) followed by furrow length of 50 m treatments, while the lowest one were obtained by furrow length of 100 m.

El-Sahrigi *et al.* (1992) reported that effect of precision land leveling using LASER grade control rest on soil surface for period of about three years. They added that the average costs of production reduced by 6.3 to 15.4% for wheat, broad, beans, cotton and maize. Gabber (2001) found that the total cost of traditional leveling was 240 LE/fed but cost value of laser land leveling by using forward speed of 5.2 km/h were 204, 180, 168, 150 L.E/fed for slopes of 0, 0.01, 0.02 and 0.03% respectively. The total cost decreased by increasing slop and forward speed for LASER land leveling.

The main goal of this investigation was optimizing of barley and sorghum productivity in the calcareous soil and increasing water use efficiency by suitable tillage depth, suitable border length and precision land leveling by using laser technology in the calcareous soil of Maryuit area.

MATERIALS AND METHODS

Field Experimen

The experiments were carried out in a calcareous soil in an area of 4 fed. Cultivated by barley crop (Winter season of 2001-2002) and sorghum crop (Summer season of 2002) at Agricultural Experimental Station of the Desert Research Center, at Maryut, Alexandria Governorate. Table 1 shows some physical and chemical properties of the experimental soil.

The variables of the present study may be summarized as the following:

1-Land leveling method: [LASER leveling at 0.05% slope, traditional leveling (tractor + scraper) and non-leveling (unleveled plot as control)].
2- Tillage depth: Three depths of tillage (13.6, 18.4 and 23.2 cm).
3- Border length: Three lengths of borders (25, 50 and 75 m). Each treatment was replicated three times in a split-split design. The experiments were conducted through two successful agricultural seasons. Barley crop planted in 17th Nov. 2001 at seed rate of 50 kg/fed and received six irrigations and harvested manually in the first week of May 2002. Sorghum crop planted in 12th May 2002 at seed rate of 25 kg/fed and received nine irrigations and

Table 1: Some physical and chemical properties of the experimental soil

Particle size distribution %			Texture class	F.C., %	W.P., %	A.W., %	pH	E.C, ds/m	CaCo$_3$ %	O.M, %
sand	silt	clay								
50.28	21.55	28.17	S C L	23.8	9.4	14.4	7.53	9.3	32.6	0.39

In general, the soil texture was sandy clay loam (SCL) and the soil kind was calcareous soil (32.6% calcium carbonate).

harvested (first cut) in 12th July, second cut 15Aug.and the third cut in 18th Sept.2002. Concert channel was established to determine water discharge for each treatment. Irrigation water was stopped in the border when water reach up to 85% of border length. All the experimental treatments received the same agricultural practices as usual in the area.

Materials

The following tractors, implements, tools and instruments were used in the present study:

1. Unit of Laser Control Equipment

The unit of LASER control equipment consists of the following parts.

a) Transmitter

The transmitter is the heart of the system generates thin red LASER beam rotates in a horizontal plane. Specifications of transmitter:

Transmitter kind: Spectra precision

Model: 114

R.P.M. : 300 cycle/moment

The radius of light plane: 1000 ft (300 m).

Power requirement : 12 Volts, DC, and 1.3 Ampere.

b) Receiver

Output: from the receiver is proportional time command with high fine, on grade, low fine and low signals.

In put: In put signals to the receiver comes from the LASER transmitter rotating at 300 RPM.

c) Control box

In put: Proportional time command with high, on grade and low signals.

Out put: 12V, DC to solenoid valve master blade.

Mass: 4.5 kg.

d) Hydraulic mast:

In put: 12 v, DC supplied by the control unit operates the solenoid valve.

Out put: Elevation information to the control box.

e) Manual mast

It was used with transmitter to measure the difference points levels during execution of a net leveling.

2. Tractors

a- Massey Ferguson tractor of MF 399 model, made in England, four cylinders, Diesel engine, four strokes, 76.44 kW, 4 WD and water cooling.

b- Ford tractor, made in USA, 6610 model, four cylinders, Diesel engine, four strokes, 53.4 kW, 2 WD and water cooling.

3. Implements and Instruments

a) The land levelers

1-LASER leveler, local manufactured with two wheels, 4.2 m working width and 2.69 m^3 capacity

2-Traditional leveler, local manufactured with two wheels, 3 m working width and 1.26 m^3 capacity.

b) Chisel plough

Mounted Chisel plough of 7 shanks with 1.75 m width.

c) Soil penetrometer

Japanese soil penetrometer model (SR-2,DIK-500) was used in the present work.

d) Infiltration rate

Average Infiltration rate was determined in the field using a local double ring 30 and 60 cm diameter.

Efficiency Indicators

1. Calcium carbonate content

Total calcium carbonate in the soil were determined volumetrically using Collin's Calcimeter, Paper (1950)

2. Soil bulk density

Soil bulk density values before and after leveling were determined according to Black (1965) $B_d = W_d / T_v$........(1)

Where:

W_d: Dry soil mass, g and T_v: Total soil volume, cm^3.

- The percentage of change in bulk density (PCB_d) was calculated as follows: $PCB_d = 100\ (B_{d1} - B_{d2}) / B_d$........................(2)

Where:

B_{d1} and B_{d2}: bulk density before and after treatments, g/m^3

3. Total soil porosity

$S_p = [1 - (P_b / P_s)]\ 100$ ....(3)

Where :

S_p: Total soil porosity, %; B_b: soil bulk density, g/cm^3 and P_s: density of solid substance, it was assumed to be 2.65 g/cm^3.

- The percentage of change in total porosity (PCS_p) was calculated as follows:

$PCS_p = 100 (S_{p1} - S_{p2}) / S_{p1}$ ...(4)

Where:

S_{p1} and S_{p2}:total porosity before and after treatments, %

4. Soil penetration resistance

The penetration resistance calculated by using the following formula: $R = F / A$ ....(5)

Where:

F: force required, N and A: area of cone cm^2.

- The percentage of change in penetration resistance (pR) was calculated as follows: $pR = 100 (R_1 - R_2) / R_1$ ....(6)

Where:

$R_1$and R_2 : penetration resistance before and after treatments, N/cm^2

5. Infiltration rate

Infiltration rate was calculated by kostiakov equation:

$I = C T^n$ .... (7)

Where:

I: The infiltration rate. and C, n: constants depend on soil properties.

T: The time after infiltration started.

The percentage of change in infiltration rate (PCI) was calculated as follows:

$PCI = 100 (I_1 - I_2) / I_1$ ....(8)

Where:

$I_1$and I_2 : infiltration rate before and after treatments, cm/h.

6. The theoretical field capacity (TFC) was calculated by using the following formula (Embaby, 1985)

T.F.C. = 0.238 W.V, fed/h ....(9)

Where :

W: the working width of implement, m.

V: average working forward speed, km/hr.

7. The effective field capacity

(EFC) was calculated by using the following formula (Embaby, 1985)

A.F.C. = 1 / Effective total time required per fed ....(10)

8. Field efficiency

$\eta_f = (EFC / TFC) \times 100$ % ..(11)

9. Slip percentage

The slip was determined by the following formula (El-Raie, 1982 :

$S \% = (L_{th}-L_{act})/ L_{th} \times 100$ %(12)

Where :

L_{th}: the calculated advance per 10 wheel revolutions, at no load m.

L_{act} : the calculated advance per 10 wheel revolutions under load m.

10. Specific fuel consumption (SFC)

SFC=(Fuel consumption, l/h /Power requirement, kW), l/kW.h .....(13)

11.Power requirements

Power requirements determined for each operation by using the following relation (Embaby, 1985) :

PR = (F_c x (1/3600)) P_f x LCV x 427 x η_{th}xη_mx(1/1.36) x (1/75).(14)

Where:

PR: power requirements from fuel consumption, KW; F_c: fuel consumption rate, l/h; P_f: Density of the fuel, kg/L (for solar = 0.85 kg/ l); L.C.V: Lower calorific value of fuel (for solar = 10000 k cal/ kg);427:Thermal-Mechanical equivalent, (kg.m/k cal)

η_{th} : Thermal efficiency (40% for diesel engine) and η_m : Mechanical efficiency (80 % for diesel engine).

12. Energy requirements:

The energy requirements calculated as follows: ER = PR / EFC ....(15)

Where :

ER: energy requirements, kW.h / fed; PR: power required for a particular operation, Kw and EFC: Actual field capacity, (fed./ h)

13. The water use efficiency

WUE = (crop yield, kg / applied water, m^3) 100....... (16)

Where :

WUE: water use efficiency kg/m^3

14. Water discharge

Concert channel was established to determine water discharge for each treatment as the following:

Q = A.V ....(17)

Where:

Q: discharge of water from irrigation channel m^3/s; A: Cross section area of irrigation channel m^2 and V: velocity of irrigation water in channel m/sec calculated by used Manning equation:

$V = 1/n \cdot R^{2/3} \cdot S^{1/2}$ .... (18)

Where:

n: The roughness coefficient, 0.011 for concert channel.

R: Hydraulic radius, m. Where R = A/p S: channel slope.

A: Cross section of channel, m^2

P: Wetted perimeter, m.

Irrigation water was stopped in the border when water reach up to 85% of border length. Applied irrigation water was determined for each treatment in every irrigation. Soil moisture content was determined at depths of 0-10, 10-20 and 20-30 cm before and after irrigation to calculate the water consumptive use according to Israelson and Hansen (1962):

$Cu=(\theta_1-\theta_2)/100 \times D \times Bd$ ....(19)

Where:

Cu: Water consumptive use, cm

θ_1: Soil moisture % before irrigation D: Soil depth, cm

θ_1: Soil moisture % after irrigation Bd: Bulk density,g/cm^3

15. Cost analysis

Costs were estimated according to prices of 2001/2002 given by the agricultural mechanization service (El-Nobaria Agricultural Engineering Co.) the costs of one hour of LASER leveling unit was 60 LE while it was 40 LE for traditional leveling (tractor + scraper), 30 LE for ploughing operation and (4 L E) for irrigation pump

Operation cost = [machine cost, L.E/h/AFC, fed./h],L.E/fed ..(20)

RESULTS AND DISCUSSION

1. Effect of Land Leveling Method on Calcium Carbonate ($CaCo_3$) Distribution in Calcareous Soil

Soil calcium carbonate content determined before leveling and after (2 years) of leveling to study the effect of land leveling method on calcium carbonate ($CaCo_3$) distribution in calcareous soil. It was noticed that calcium carbonate content values increased by increasing soil depth. These values were 32.65, 34.82 and 35.44% at soil depths of 0-10, 10-20 and 20-30 cm respectively by using non-leveling as shown in Table 2.

Table 2: Effect of land leveling method on calcium carbonate ($CaCO_3$) distribution values in calcareous soil

Soil depth cm	Non-leveling	After 2 years of leveling	
		Traditional leveling	LASER leveling
0-10	32.65	30.42	29.38
10-20	34.82	33.75	33.60
20-30	35.44	35.78	35.86

While after 2 years it was noticed that by using LASER leveling calcium carbonate content decreased in the surface layers of 0-10 and 10-20 cm by using ploughing and leveling operations, the values were 29.38, 33.60% respectively, while the values increased in the bottom layer of 20-30 cm, it was 35.86%. This decreasing resulted from the down movement of calcium carbonate from the surface layers to accumulation in the lowest layers. So using LASER technology after a suitable depth of ploughing accomplish improvement of calcareous soil. This obvious that how mechanization can play an important role in solve many problem of calcareous soil.

2. Effect of Land Leveling Method and Tillage Depth on Some Physical Properties of Calcareous Soil

a. Soil bulk density

The values of soil bulk density in the calcareous soil increased by increasing soil depth and land leveling accuracy, while it decreased by increasing tillage depth. These values of bulk density were 1.23, 1.18 and1.15 g/cm at tillage depths of 13.6, 18.4 and 23.2 respectively at (10-20) cm soil layer in non-leveling plot. From Fig 1, it was noticed that the increasing percentage was higher at the upper layer of (0-10) cm than that obtained in the bottom layer of (10-20) and (20-30) cm. The highest value of the increasing percentage in soil bulk density was 13.04 % at upper soil layer of (0-10) cm by using LASER leveling and 13.6 cm tillage depth. While the lowest value was 1.42 % at (20-30) cm soil layer by using traditional leveling and 13.6 cm tillage depth. These results may be attributed to the compaction resulted from the heavy equipment of land leveling practice.

b. Soil porosity

The total porosity decreased by increasing soil depth and land leveling accuracy while it was increased by increasing tillage depth when using traditional leveling and 18.4 cm tillage depth, the total porosity decreased from 55.47 to 53.21% at 10-20cm soil layer. While, by using LASER leveling LASER leveling at the same tillage depth 18.4 cm and the same layer 10-20 cm, the total porosity decreased from 55.85 to 52.07%. the highest value of soil porosity was 59.24% by using non-leveling and 23.2 cm tillage depth a 0-10 cm soil layer, while the lowest value was 45.66% by using LASER land leveling and 13.6 cm tillage depth at 20-30cm soil layer.

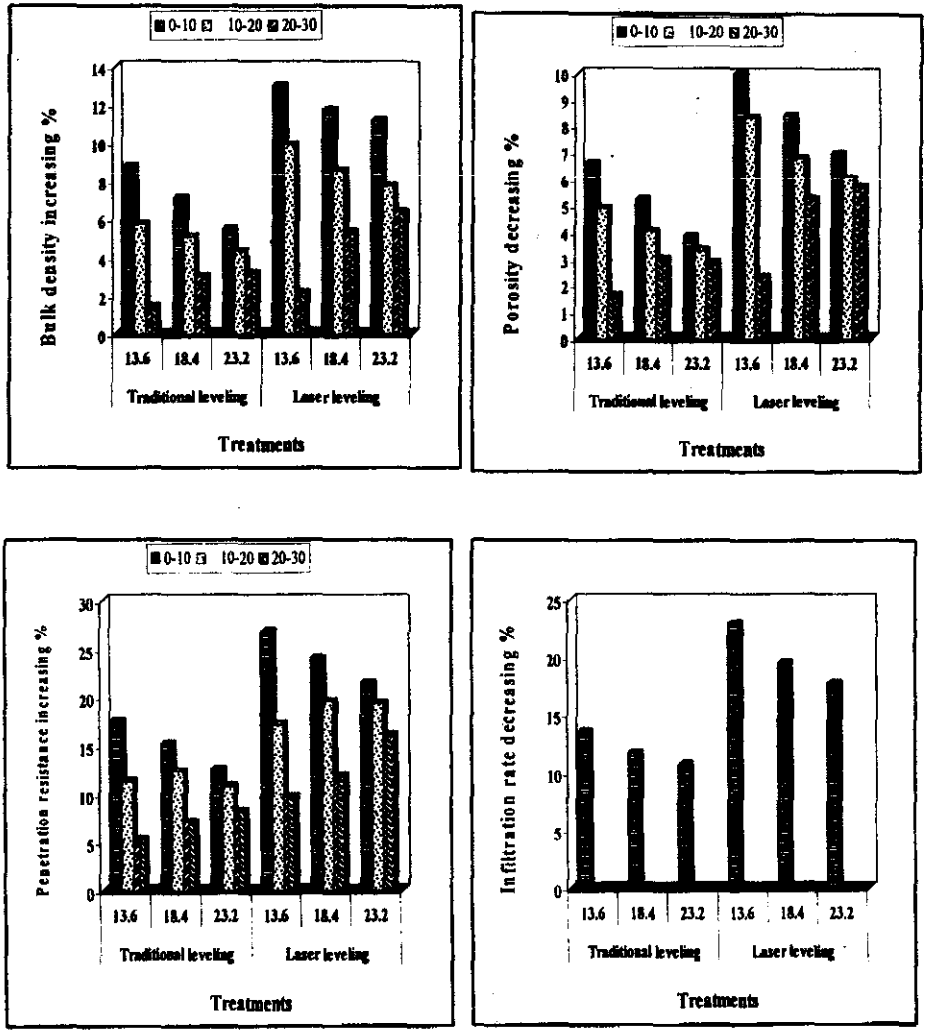


Fig. 1: Effect of leveling method and tillage depth on some soil physical properties

c. Soil penetration resistance:

Fig. 1 shows that soil penetration resistance increased by increasing soil depth and land leveling accuracy. While, it decreased by increasing tillage depth. The highest value of soil penetrations resistance was 54.54 N/cm^2 by using LASER land leveling, 13.6 cm tillage depth at (20-30) cm soil layer. While, the lowest value was 24.15 N/cm^2 by using non-leveling, 23.2 cm tillage depth at (0-10) cm soil layer.

The highest value of the increasing percentage in soil penetration resistance was 26.83 % by using LASER leveling, 13.6 cm tillage depth at (0-10) cm soil layer. While, the lowest value of the increasing percentage was 5.35 % by using traditional land leveling, 13.6 cm tillage depth at (20-30) cm soil layer.

d. Average infiltration rate:

Infiltration rate increased by increasing tillage depth while it decreased by using leveling, The values before leveling operation were 9.40 , 13.56 and 18.73 cm/h at tillage depths of 13.6 , 18.4 and 23.2 cm respectively. LASER land leveling recorded the lowest values of infiltration rate 7.25, 10.91 and 15.37 cm/h as compared with traditional leveling, at the same tillage depths. The highest value of the decreasing in infiltration rate was 22.95% by using LASER land leveling and 13.6 cm tillage depth while the lowest value was 10.75% by using traditional land leveling and 23.2 cm tillage depth.

3. Effect of Land Leveling Method and Tillage Depth on Chisel Plough Performance in the Calcareous Soil During the Second Season

Effective field capacity

From Table 3, it was noticed that plot which leveled by LASER accomplished the highest values of field capacity 0.76, 0.67 and 0.58 fed/h at tillage depths 13.6, 18.4 and 23.2 cm respectively, that may be due to the precision leveling and smoothing of soil surface which causing decreasing in slip percentage.

Field efficiency

LASER leveling plot recorded the highest values of field efficiency of chisel plow 65.52, 57.76 and 50 % at tillage depths of 13.6, 18.4 and 23.2 cm respectively as compared with traditional leveling and non-leveling methods at the same tillage depths.

Slip percentage

The values increased by increasing tillage depth at different land leveling methods while it decreased by increasing land leveling accuracy as shown in Table 3. The highest value was 13.87 % with non-leveling method and tillage depth of 23.2 cm while, the lowest value was 8.12% by using LASER land leveling methods and tillage depth of 13.6 cm. That may be due to smoothing and good structure of soil surface by using LASER land leveling which causing decreasing in slip and by increasing tillage depth the draft force increased causing increasing in slip percentage.

Specific fuel consumption

From Table 3, it was noticed that the specific fuel consumption values increased by increasing tillage depth at different land leveling methods while, it decreased by increasing land leveling accuracy. These values of specific fuel consumption were 0.22, 0.23 and 0.25 l/kW.h at tillage depths of 13.6, 18.4 and 23.2 respectively with LASER land leveling, The highest specific fuel consumption value was 0.30 l/kW.h in non-leveling plot and tillage depth of 23.2 cm, while the lowest value was 0.22 l/kW.h in LASER leveling plot and tillage depth of 13.6 cm. These may be due to low drawbar pull, slip percentage and high field capacity comparing with the other two methods of land leveling.

Table 3: Effect of leveling method and tillage depth on chisel plough performance

Leveling methods	Tillage depth, cm	Field capacity, fed/h A.F.C.	Field capacity, fed/h T.F.C.	Field efficiency %	Slip %	Specific fuel consumption l/ kW.h	Energy requirement kW.h/fed
Non-leveling	13.6	0.66	1.16	56.69	10.24	0.25	62.77
	18.4	0.54	1.16	46.55	11.33	0.27	85.41
	23.2	0.46	1.16	39.65	13.87	0.30	110.83
Traditional land leveling	13.6	0.70	1.16	60.34	9.34	0.23	55.34
	18.4	0.61	1.16	52.59	10.81	0.25	70.31
	23.2	0.53	1.16	45.69	12.03	0.28	88.02
LASER land leveling	13.6	0.76	1.16	65.52	8.12	0.22	48.49
	18.4	0.67	1.16	57.76	9.64	0.23	59.00
	23.2	0.58	1.16	50.00	11.23	0.25	73.17

Energy requirement

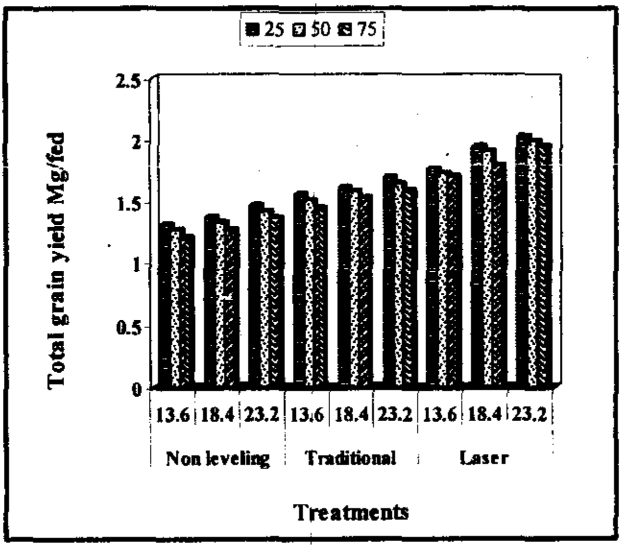
The values increased by increasing tillage depth at different land leveling methods. While it decreased by land leveling accuracy, as shown in table, LASER land leveling plot recorded the lowest values of energy requirement for chisel plow 48.49, 59 and 73.17 kW.h/fed at tillage depths of 13.6, 18.4 and 23.2 cm respectively. The highest value of energy requirement was 110.83 kW. h/fed in non-leveling plot at tillage depth of 23.2 cm while the lowest value was 48.49 kW. h/fed in LASER leveling plot at tillage depth of 13.6 cm. That may be due to the increasing of the effective field capacity and decreasing of slipe percentage and fuel consumption.

4. Effects of Land Leveling Method, Tillage Depth and Border Length on Yield

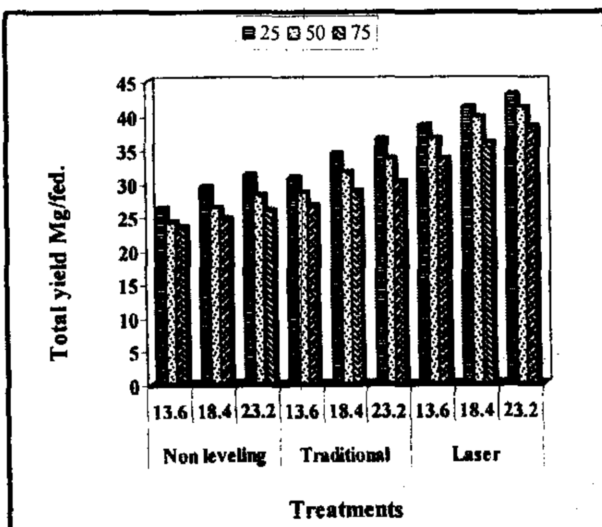
a. Barley crop

Barley yield (grain and straw) increased by using LASER leveling in calcareous soil as shown in Table 5. The values of grain yield were (1.37, 1.61 and 1.94 Mg/fed) by using non-leveling, traditional leveling and LASER leveling respectively at 18.4 cm tillage depth and 25 cm border length. The increasing percentage of barley grain yield when using LASER leveling values were 41.6 and 20.5 % at 18.4 cm tillage depth and 25 m border length, as compared with unleveled and traditional leveling methods respectively The highest values of barley grain and straw yield were 2.02 and 2.63 Mg/fed respectively, by using LASER leveling method, 23.2 cm tillage depth and 25 m border length. While the lowest values of barley grain and straw yield were 1.20 and 1.73 Mg/fed, respectively by using non leveling method, 13.6 cm tillage depth and 75 m border length. The optimum border length is 25 m where the values of grain yield were the maximum as shown in Fig 2.

Yield increased as ploughing depth increased, When ploughing depth increased from 13.6 to 18.4 cm at using LASER leveling and border length of 25 m barley yield increases from 1.76 to 1.94 Mg/fed respectively, recording an increasing percentage of 10.2 %, but inconsiderable when ploughing depth increased from 18.4 to 23.2 cm, barley yield increased from 1.94 to 2.02 Mg/fed respectively recording an increasing percentage of 4.1 %.at the same treatments .This result emphasized that there is no need to plough more than 18.4 cm.



First season



Second season

Fig. 2: Effect of leveling method, tillage depth and border length on yield

b. Sorghum crop

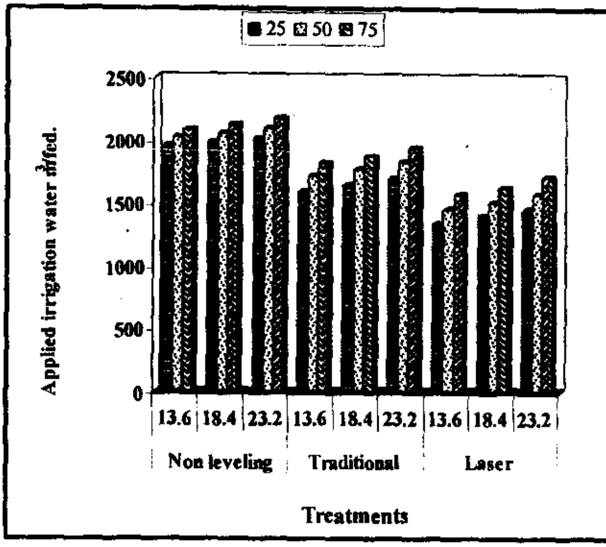
The values of sorghum yield increased by increasing land leveling accuracy and tillage depth, while it decreased by increasing border length. The increasing percentage in sorghum forage fresh yield under using LASER technique were 39.90 and 20.06 % as compared with non-leveling and traditional land leveling respectively, at tillage depth of 18.4 cm and border length of 25 m. The highest value of sorghum forage fresh yield was 42.96 Mg/fed at using LASER leveling, 23.2 cm tillage depth and 25 m border length, while the lowest value of sorghum (forage fresh) yield was 23.38 Mg/fed by using non-leveling, 13.6 cm tillage depth and 75 m border length. These results may be due to using LASER land leveling technique that accomplished high water use efficiency, reducing $CaCo_3$ % in root zone and good distribution of irrigation water in borders under calcareous soil conditions.

5. Effect of Land Leveling Method, Tillage Depth and Border Length on Applied Irrigation Water and Water Use Efficiency

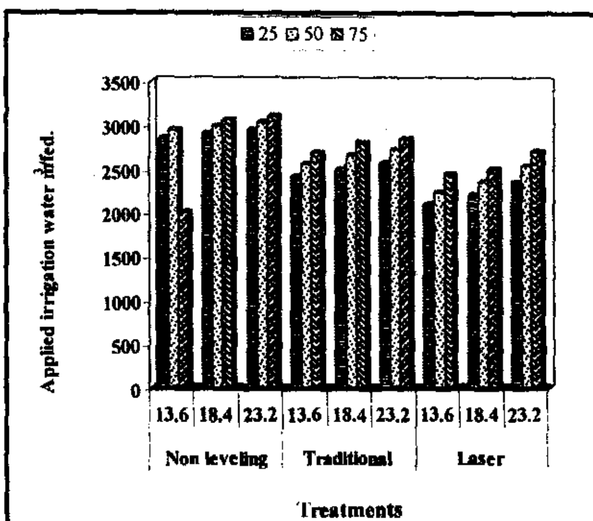
a. The applied irrigation water

Irrigation water was stopped in the border when water reach up to 85% of border length in all treatments. The applied water increased by increasing border length and tillage depth, while it decreased by increasing land leveling accuracy as shown in Fig . The values of applied water were 1977, 1644 and 1402 m^3 /fed by using non-leveling, traditional leveling and LASER leveling methods, respectively, at tillage depth of 18.4 cm and border length of 25 m in the first season. At the ploughing depths of 13.6, 18.4 and 23.2 cm. The applied water values were 1455, 1506 and 1570 m^3 /fed, respectively, at using LASER leveling and border length of 50 m in the first season. The highest values of applied water were 2174 , 3110 m^3/fed by using non-leveling, 23.2 cm tillage depth and 75 m border length for barley and sorghum crops respectively. While the lowest values were 1335, 2092 m^3/fed by using LASER leveling, 13.6 cm tillage depth and 25 m border length for barley and sorghum crops respectively.

The border length of 25 m is more acceptable than lengths of 50 and 75m, The applied water through borders of 25, 50 and 57 m were 1402, 1506 and 1619 m^3/fed respectively by using LASER leveling method at tillage depth of 18.4 cm in the first season. Also, in



First season



Second season

Fig. 3: Effect of leveling method, tillage depth and border length on applied irrigation water

the second season The values of applied water increased by increasing border length, when border length increased from 25 to 50 and 75 m these values were 2211, 2354 and 2503 m^3/fed respectively by using LASER leveling method at tillage depth of 18.4 cm in the second season. These results may be due to the low accuracy of leveling operation in case of unleveled and traditional leveling plots, that required more quantities of water to reach up to the end of border, causing loss a lot of water by infiltration through soil layers. But, using LASER leveling in the calcareous soil improved the distribution of irrigation water and increased water advance time in the border, causing saving in irrigation water.

b. The saved irrigation water

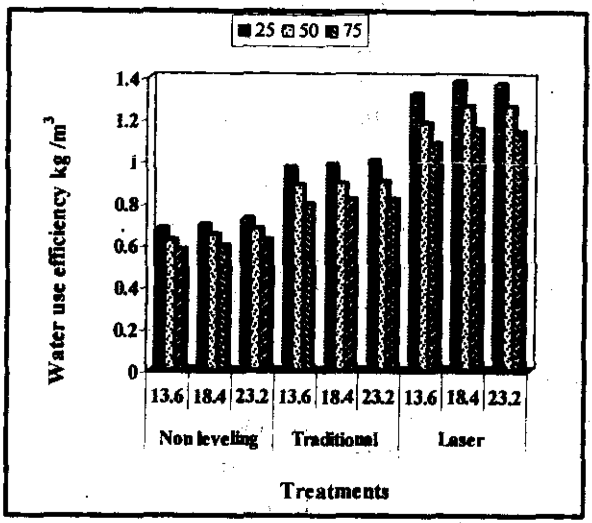
The saved Irrigation water increased by increasing land-leveling accuracy while it decreased by increasing tillage depth and border length during the two seasons. In the first season, saved irrigation water were 290 and 551 m^3/fed. by using traditional leveling and LASER leveling, respectively, 18.4 cm tillage depth and 50 m border length.

It was noticed that the highest percentages of saved irrigation water were 31.4 and 26.7 % by using LASER leveling, 13.6 cm tillage depth and 25 cm border length for barley and sorghum crops respectively. While the lowest values were 10.7 and 8.3 % by using traditional leveling, 23.2 cm tillage depth and 75 m border length for barley and sorghum crops, respectively.

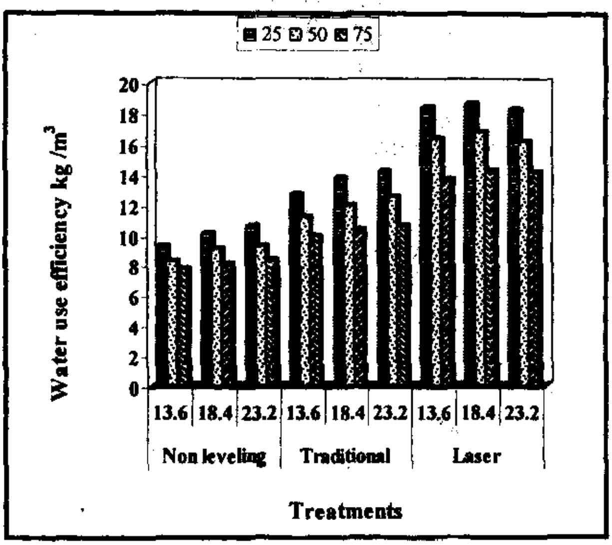
c. Water use efficiency

Water use efficiency (WUE) increased by increasing land leveling accuracy during the two seasons. The values of WUE were 0.64, 0.89 and 1.26 kg/m^3 at using non-leveling, traditional leveling and LASER leveling methods, respectively, at 18.4 cm tillage depth and 50 m border length. While, in the second season, the values of WUE were 9.05, 11.89 and 16.8 kg/m^3 at the same conditions.

From Fig. 3, it was noticed that water use efficiency values decreased by increasing border length, These values were 1.38 , 1.26 and 1.15 kg/m^3 at border length of 25 , 50 and 75 m , respectively by using LASER leveling method at tillage depth of 18.4 cm in the first season (barley



First season



Second season

Fig. 4: Effect of leveling method, tillage depth and border length on water use efficiency

crop). While it were 18.62, 16.8 and 14.29 kg/m^3 at the previous border lengths, respectively, by using LASER leveling at tillage depth of 18.4 cm in the second season (sorghum crop).

The highest values of WUE during the two seasons were 1.38 and 18.62 kg /m^3 at using LASER leveling method, 13.6 cm tillage depth and 25 m border length for barley and sorghum crops, respectively. While the lowest values of WUE were 0.57 and 7.75 kg /m^3 at non-leveling, 13.6 cm tillage depth and 75 m border length for barley and sorghum crops, respectively. These results may be due to the high yield per fed and saving water when using LASER land leveling technology in the calcareous soil.

6. Effect of Ploughing, Land Leveling Method and Irrigation Operations on Total Cost

The costs were calculated for period of 3 years (6 seasons) under the conditions of calcareous soil, considering the effect of LASER leveling which rest on the soil surface for three years meanwhile, the traditional method had to be applied yearly.

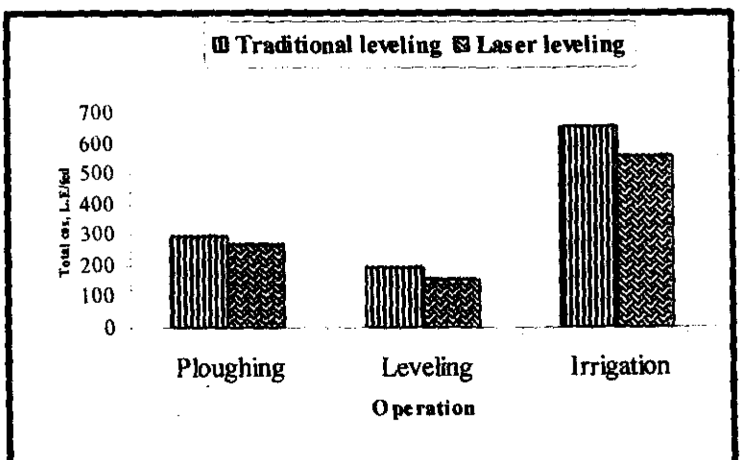


Fig. 5: Effect of ploughing, land leveling method and irrigation operations on total cost

From data in Fig. 5, it was noticed that the cost of the traditional leveling cost for period of 3 years was 189.6 LE/fed higher than the obtained by using LASER leveling (154.8 LE/fed) So it could be saved 18.53% from the cost of leveling operation by using LASER leveling technology.

The costs of ploughing operation were calculated at the optimum tillage depth 18.4 cm. The ploughing cost for period of 3 years (6 seasons) in the traditional plot was 295.2 LE/fed higher than that obtained in LASER plot 268.2 L E/fed, recordingan increasing of 9.15 %.

The costs of irrigation operation were calculated at the optimum tillage depth 18.4 cm and border length of 25 m. The irrigation cost for period of 3 years in the traditional plot was 658.6 LE/fed higher than that obtained in LASER plot 561.6 LE/fed, recording increasing of 14.6 %.

Recommendation

1-Using LASER leveling under the condition of calcareous soil increased barley and sorghum yield, improve the performance of chisel plow, saved irrigation water and save cost.

2-The tillage depth of 18.4 cm is acceptable than 13.6 and 23.2 cm where the increasing of WUE and yield recorded the maximum values.

3-The optimum border length is 25 m where the values of yield, the saved water and the saved workable hours recorded the maximum values.

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تأثير أستخدم تقنية التسوية بالليزر وعمق الحرث على كفاءة استخدام مياه الري تحت نظام الري السطحي فى الأراضي الجيرية

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تمثل الأراضي الجيرية في مصر حوالي ٥٠ % من الأراضي التي استصلحت حديثا حتى الآن. ومع ذلك فقد لوحظ انه بعد حوالي ٢٥ عاما من بدء عمليات استصلاحها واستزراعها أن إنتاجيتها لا تزال دون الحد المأمول نتيجة تدنى أساليب الخدمة التي لا تناسب هذه الأراضي. ولذا كان هدف هذا البحث تعظيم إنتاجية محصولي الشعير والذرة السكرية و استخدام مياه الري في الأراضي الجيرية بمنطقة مريوط وذلك باستخدام تقنية تسوية الأرض بالليزر والتسوية التقليدية بالمقارنة في أرض لم تجرى لها عملية التسوية وأعماق مختلفة لعملية الحرث ٦.١٣ ، ٤.١٨، ٢.٢٣ سم وأطوال مختلفة لأحواض الرى(٢٥ ، ٥٠، ٧٥مترا. وقد أمكن استخلاص النتائج التالية:

- وجد أن التسوية بالليزر تساعد على إعادة توزيع كربونات الكالسيوم وترسيبها في طبقات التربة العميقة بعيدا عن منطقة انتشار الجذور فكانت قيم كربونات الكالسيوم بعد الحرث والتسوية بالليزر ٢٩,٣٨ ، ٣٣,٦٠ ، ٣٥,٨٦ % علي أعماق (٠-١٠)، (١٠-٢٠)، (٢٠-٣٠) سم علي الترتيب.

- وجد ان الكثافة الظاهرية ومقاومة التربة للاختراق تزداد فى الأراضى الجيرية باستخدام التسوية بالليزر وتقل بزيادة عمق الحرث خاصة في الطبقة السطحية منها ٠ - ١٠ سم وكانت أعلى نسبة زيادة للكثافة الظاهرية ومقاومة التربة للاختراق ١٣,٠٤ و ٢٦,٨٣ % على الترتيب عند التسوية بالليزر مع عمق حرث ١٣,٦سم . اما معدل التسرب وجد أنة يقل عند إجراء التسوية بالليزر حيث كانت أعلى نسبة انخفاض ٢٢,٩٥ % باستخدام التسوية بالليزر وعمق حرث١٣,٦ سم.

- تحسن أداء المحراث الحفار (السعة الحقلية - نسبة الانزلاق - معدل استهلاك الوقود - القدرة المطلوبة للحرث- الطاقة المطلوبة) فى الموسم الثاني فى الأراضى المسواة بالليزر بالمقارنة بالتسوية التقليدية وبدون تسوية.

- حققت التسوية بالليزر مع عمق حرث ٢٣,٢ سم وطول الشريحة ٢٥ مترا أقصى قيمتين لإنتاجية الشعير والذرة الرفيعة(علف اخضر) حيث كانت ٢,٠٢ ، ٤٢,٩٦ ميجا جرام/ فدان على الترتيب.

- حققت التسوية بالليزر مع عمق حرث ١٣,٦سم وطول الشريحة ٢٥ مترا أعلى نسبتى توفير لمياه الرى فكانتا ٣١,٤ ، ٢٦,٧ % للشعير والذرة السكرية على الترتيب.

- أقصى قيمتين لكفاءة أستخدم مياه الرى كانتا ١,٣٨ – ١٨,٦٢ كجم/م^3 للشعير والذرة السكرية عند استخدام التسوية بالليزر مع عمق حرث ١٣,٦ سم وطول الشريحة ٢٥ مترا

- وجد أن استخدام التسوية بالليزر يقلل من تكاليف الحرث والتسوية والرى بنسب ٩,١٥، ١٨,٥٣ ، ١٤,٦ % على الترتيب بالمقارنة بالتسوية التقليدية في الموسم الثاني.