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A MODIFIED LASER SCRAPER AND ITS EFFECT ON PERFORMANCE AND CAPABILITIES

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ABSTRACT

Field experiment was carried out during the agricultural season of 2004 at the sugar factory farm, clayey soil, at Kom-Ombo, Aswan Governorate to evaluate the performance of a modified LASER scraper compared to that of the original one. The modification consisted of adding 8 chisel shanks on the main frame of the scraper at equal distances along the whole width of the scraper. That modification was a result of the firm, un-chiseled, spots that normally appear during leveling with the ordinary LASER scraper. In such case, a chisel plow has to be used to loosen the soil before the scraper does another run to level these spots, which increases the operational costs. Leveling was performed at two slopes; 0% and 0.03%.

Results indicated that leveling at 0% slope with the modified LASER scraper resulted in more homogeneous land surface with no firm, un-chiseled, spots. Also, it was clear that the leveled field at 0.03% using the ordinary LASER scraper was more homogenous than that leveled with the same scraper at zero level. Leveling with the modified scraper gave better results compared to that of the ordinary one at the same slope, 0.03%. However; it resulted in a small area with higher level than the surrounding. Modified LASER scraper resulted in better soil physical properties such as higher porosity and lower soil bulk density. Also, it resulted in better soil pulverization.

Although the modified LASER scraper required relatively more power, it had lower operational cost by about 32% than the ordinary LASER scraper for both slopes. In summary, using the modified LASER scraper gave more precise leveling, however; increasing the depth of the chisel shanks would help to overcome any chance of leaving firm, un-chiseled soil.

INTRODUCTION

Leveling is regarded as a very important practice for efficient surface irrigation. It helps to efficiently utilize water, labor, and energy resources. On the other hand, compared to some other agricultural practices, land leveling may be regarded as the most disrupting practice that will be applied to the field. One of the most significant advances which provide the capability for achieving a precise operation has been the adoption of LASER control equipment (Walker and Skogerboe, 1987). It was reported that using LASER controlled scraper, the water penetration in a leveled field promotes uniform distribution (Dedrick et al., 1982). The leveling has commonly been represented by the standard deviation (Sd) of the field surface elevations. For basins finished with LASER controlled scrapers in the United States, the (Sd) was usually 1.2-cm or less (Dedrick et al., 1982, and Dedrick, 1983). It was stated that when using LASER controlled drag scraper, the elevation difference of a field surface on a 15-ha field was usually within 2.5 to 3.0 cm (Anderson, 1983). The effect of the LASER technology on application uniformity, water use efficiency and farm economics was great (Dedrick et al. 1978; Daubert and Ayer, 1982 and El-Hammamy, 1988). Clyma and Reddy (1984) stated that uniform water penetration of leveled field encouraged efficient water distribution. Plants in such fields developed more irrigation water uniformity than in unleveled fields. McClung et al. (1985) reported that precision land leveling increased on-farm irrigation efficiency; nevertheless, yield is not significantly increased. It was reported that the time after which the land needed re-leveling was directly influenced by the required slope of land leveling. In a cultivated wheat plot, the advantage of LASER leveling was lost after 3 years in plots which were leveled with zero level and 2 years in plots which were leveled 0.03 % slope, and for corn crop the advantage of LASER leveling was lost after 2 years in the plots which were leveled with zero level and 0.03 % slope (El – Sahrigi et al., 2002).

The bulk density of soil was reported to affect plant growth, water infiltrate and drainage, power required to till soil and performance of tillage tools (Erbach, 1987). Michael (1990) found that leveling operation significantly increased the soil bulk density al soil layer depth of 10 cm. 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 more at the surface layer (from 0-10 cm). This change might be due to effectiveness of working depth of land levelers usage, which actually did not exceed the first layer (0-10 cm). While the load and compaction forces of the equipment usually influenced deeper layers with damped effect causing an increase in soil bulk density. Michael (1990) showed that the change in bulk density and the total porosity show a reverse behavior at different leveling treatments. It was clear that the mean relative decrease in total porosity was due to the compaction effect resulting from land leveling, which increased soil bulk density and consequently decreased soil porosity. The values of void at surface layer (0-10 cm) under different leveling uniformity coefficients indicated that void ratio was influenced by leveling operation, as it was decreased with different amounts depending upon the type of land leveling. This change was expected since void ratio is oppositely related to soil bulk density. Walker and Chong (1986) found that, soil compaction increased tillage power requirement. The degree of soil compaction was dependent on soil water content and soil texture as well as the use of heavy machinery. One of the major problems during the LASER leveling that was responsible for leaving firm soil spots was encountering a compacted, un-chiseled, soil. The un-chiseled spots normally force the blade of scraper to be lifted up without affecting the soil. The authors of this paper suggested solving such a problem through achieving the following objectives:

1. Modifying the LASER scraper by attaching a group of chisel shanks to the main frame of the LASER scraper.
2. Studying the effect of this modification on precision of land leveling.

3. Studying the effect of leveling slope on performance of modified and ordinary LASER scraper.
4. Estimating the effect of modified and ordinary LASER scrapers on soil physical properties.

MATERIALS

Field experiment was carried out during the agricultural season of 2003 at the sugar factory farm, clayey soil, at Kom-Ombo, Aswan Governorate to evaluate the performance of modified LASER scraper unit compared to that of the original LASER scraper. Five random samples were taken from the soil to do mechanical analysis using the hydrometer method. Mechanical analysis was done at the land and soil research institute. Results of the mechanical analysis indicated that the soil had 58.4%, 30.9% and 10.7% of clay, silt and sand, respectively. The soil texture was clayey soil. It had moisture content that ranged from 10.3-13.3% during the leveling process.

LASER system equipment

Specifications of LASER system equipment used in the present investigation were as follows:

1. Eagle 3- system Transmitter

The Eagle-3 transmitter generates a long-range, rotating LASER beam that can be accurately and easily positioned to provide a control plane in X and Y-axis. It is the ideal transmitter for LASER operated machine control system, and should work with any LASER receiver, although operating range will vary depending on the specific receiver and jobsite conditions. Specifications of system transmitter were listed in table 1.

Table 1: Characteristics of system transmitter

Specification	Characteristic
Beam	Visible LASER diode, 670 nm.
BRH classification	Class III LASER product.
Operating range, ft (m)	Up to1500- (457) radius.
Power requirements:	Removable battery pack.
Rotating head speed, rpm	0 to 1000, variable speeds.
Self leveling system	Dual-axis Auto. beam / rotor shutoff when out of level.
Self-leveling range, rad. (deg)	± 0.1004 (±5.75) (10 inclination).
Slop Range, %	-5 to 10, dual axis.

1. LASER Receiver

The LASER receiver was omni-directional, which was sensitive to the transmitted LASER beam. Other light being received was filtered out mechanically or electronically. The receiver had at least three different vertical sensing sectors. The middle sector indicates that the receiver is aligned with the center of the transmitted beam; the top sector indicates that the receiver is below grade and the bottom sector indicates that the receiver is above grade. The central "on grade" part of the receiver had two modes of operation, which were "wide" and "narrow" band operations. The wide band mode can reduce the number of responses of the sensing system. This reduces wear on the hydraulic system. The wide band mode makes it easier to balance a paddock at the expense of the surface finish. This can produce small reverse grades, especially on the flatter slopes.

1. Control box

The control box accepted and processed signals from the machine mounted receiver. It displayed these signals to indicate the drag bucket's position relative to the finished grade. When the control box was set to automatic, it provided electrical output for driving the hydraulic valve. The control box mounts on the tractor within easy reach of the operator. The three control box switches were On/Off, Auto/Manual, and Manual Raise/Lower, which allowed the operator to manually raise or lower the drag bucket.

1. The level eye

The alignment level eye was used along with eagle -3 LASER transmitter to survey an area for elevation reading or for direct cut or fill readings

2. Hydraulic Control System

The hydraulic system of the tractor was used to supply oil to raise and lower the leveling scraper. The oil supplied by the tractor's hydraulic pump was normally delivered at 2000 to 3000 psi pressure. As the hydraulic pump was a positive displacement pump and always pumping more oil than required, a pressure relief valve was needed in the system to return the excess oil to the tractor reservoir. If this relief valve was not large enough or malfunctioned, damage could have happened to the tractors hydraulic pump.

LASER scrapers

The modified and ordinary scrapers were K-10 Beheira model. They were mounted types with hydraulic depth control and a capacity of 1.44 m^3. The modified scraper had bigger distance between tires and higher weight (320 cm, 816 kg) compared to the ordinary one (280 cm, 770 kg). The scrapers had a height of 60-cm and a longitudinal depth of 68-cm, figure 1. Eight chisel shanks were supported on the main frame of the modified scraper at equal distances, which were responsible for the higher weight. Elevation and plane views of the modified LASER scraper were posted in figure 1.

METHODS

The main experiment was carried out in clayey soil. The experimental area, 8-feddans, was divided into 4 plots, 2-feddans (0.84 ha) each. The four plots were chiseled twice before performing the land leveling. The high power tractor (New Holland 110-90, 78.2 kW) was operated in the four experimental plots at a speed that ranged from 4.91 to 5.62 km/h with Eagle 3- system transmitter. Ordinary LASER scraper was used in the first plot; however, the modified one was used in the second plot, both at zero slope. On the other hand, the ordinary LASER scraper was used in the third plot at 0.03 % slope, while the modified one was used in the fourth plot at the same slope. Evaluation of the modified LASER scraper performance compared with the ordinary LASER scraper was achieved through comparison of soil topography, soil bulk density (ρb), machine productivity, energy requirements and cost.

Measuring instruments

1. The soil clod sample box

A rectangular open metal box (50x25x15-cm) was pushed in the tilled soil to the bottom. Its direction should be perpendicular to the travel direction in order to have a representative sample of the tilled soil. Three samples were taken from each experimental treatment and were let to dry in air for 48 hours and then weighed. The box had to be pressed smoothly in the tilled soil and when encountering a clod that was on the way of the box edge, it would be considered inside if more than 50% of it was inside, otherwise it was considered out. The box was pushed continuously and gently in the soil until it reached the bottom of the tilled layer.

1. Sieves and core samplers

Three random samples were taken from soil to determine main weight diameter using the five mesh sizes of 30, 20, 10, 5 and less than 2-mm. Steel cylindrical cores were used to take representative soil samples to estimate the soil moisture content and soil bulk density after leveling. All cores had the same volume of 100-cm^3 with a sharp sloped outer side to avoid any resistance with the soil during taking samples and to prevent any soil compaction inside the cores.

Measurements

1. Soil topography:

Soil topography was studied in terms of surveying grid and standard deviation before and after land leveling using equation (1).

$$\text{Standard deviation} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \rightarrow (1)$$

X_i = Elevation value;

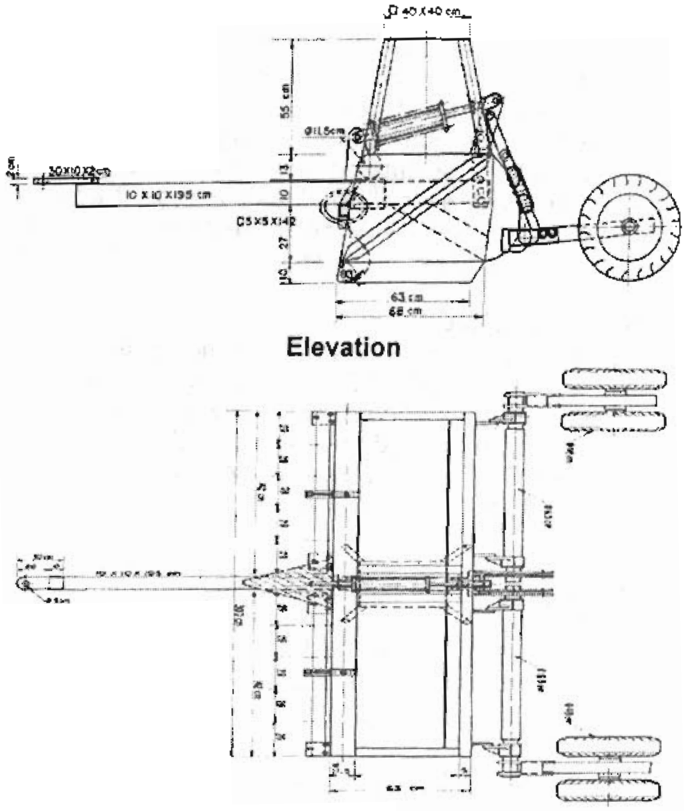
$\bar{X}$ = Arithmetic Mean and

n = Number of replication

2. Soil moisture content, soil bulk density (ρb) and porosity:

Soil samples were taken using a core sampler with a special hand. It was smoothly pushed in the soil to the desired depth. After removing the core sampler, the excess soil was cut from both ends using a knife. Then the outer surface of the core, with the sample inside, was cleaned and weighed then put in the oven at 105°C for 24 hours. After cooling, the core was weighed and the difference between the wet and dry weight gave the water content (W_c) of the sample. The dry weight of the soil (W_d) equaled the weight of core filled with dried soil minus the weight of the empty core. Moisture content in percent (θ_m) was calculated using equation 2.

$$\theta = \frac{w_c}{w_d} x100 \rightarrow (2)$$



Plane

Figure 1: Side and Plane views of the modified LASER scraper

The soil bulk density was measured by taking 3 samples randomly from different places of the experimental area after land leveling using the core sampler (100cm^3). The soil samples were taken and the dry weights were calculated as explained before. Then, knowing the volume of the core sampler, the soil bulk density could be calculated using equation 3.

$$\rho b = \frac{W_d}{V_c} x100 \rightarrow (3)$$

ρb = The bulk density, g/cm^3.
Wd = Dry weight of the soil sample inside the core, g.
Vc = Volume of the soil sample inside the core, cm^3.
Soil Porosity (f) was calculated through equation 4.

$$f = \frac{\rho_s - \rho_b}{\rho_s} = 1 - \frac{\rho_b}{\rho_s} \rightarrow (4)$$

f = Porosity, fraction.
ρ_b = Bulk density.
ρs = Density of solids, ≈2.65 g/cm^3.

1. Power requirements:

The required power (P) in kW was calculated by using the formula of Barger, et al. 1963, equation 5.

$$P = Fc \frac{1}{60 \times 60} \times \rho_f \times L.C.V \times 427 \times \frac{1}{75} \times \frac{1}{1.36} \times \eta_{th} \times \eta_{m} \rightarrow (5)$$

Fc = Fuel consumption, l/h,
Pf = Density of fuel, kg/l (for diesel fuel = 0.85 kg/l),
L.C V. = Calorific value of fuel (≈ 10000 k cal/kg),
427 = Joules constant (thermo mechanical equivalent),
η_{th} = Thermal efficiency, ≈ 40 %,
η_m = Mechanical efficiency of the engine ≈ 80 % for diesel engine.

Cost analysis:

The cost of LASER leveling processes was based on the initial cost of machine, interest on capital, cost of fuel consumed, cost of maintenance, and the wage of operator according to the formula of Awady (1978), equation 6.

$$C = \frac{P}{h} \left(\frac{1}{e} + \frac{i}{2} + t + r \right) + (1.2\, W \times F \times S) + \frac{m}{144} \rightarrow (6)$$

The different variables of this equation are listed in table 3.

Table 2: Definition of the variables of Awady's equation

C	Hourly cost, L.E./h,
P	Capital investment, L.E.,
H	Yearly operating hours, h,
e	Life expectancy,
i	Interest rate,
t	Taxes and overheads ratio,
r	Repairs ratio of the total investment,
1.2	A factor including reasonable estimation of the oil consumption in addition to fuel,
W	Power of engine, kW,
F	Specific fuel consumption, lit/kW.h,
S	Price of fuel per liter,
m	Labor wage rate per month in L.E.,
144	Reasonable estimation of monthly working hours.

RESULTS AND DISCUSSION

Soil topography:

Soil topography was studied in terms of surveying grid and the standard deviation of the level values. The surveying grids of the four plots, under investigation, 2-feddan plots (70-m x 120-m each), before and after LASER leveling are shown in figures 2 through 5. Notice that the higher level represented the low spots, consequently the fills. On the other hand, the lower level represented the high spots, consequently the cuts. The highest and lowest spots in plot1 had level values of 3.30 and 3.50 m, respectively, with an average level of 3.38 m and a standard deviation of ±0.0495 m.

This surveying grid of plot1 before LASER leveling was shown in Fig.2. It was clear that high and low areas were in alternative order along the longitudinal direction. Consequently it was chosen as the direction of leveling process. By leveling in that direction, the scraper would cut from the higher area and filled the following low area, which led to a reduction in the power needed and consequently, relieved the scraper during the leveling process. Most of the heterogeneity of the soil level was seen in the longitudinal direction. Symmetry was observed in some sections perpendicular to the longitudinal direction of the field. This specification pinpointed the leveling process to be along the longitudinal direction which was appropriate for the LASER leveling system to ensure a higher field capacity and to minimize the required power. Going in the right pass during the leveling process would reduce the amounts of cuts and fills. Consequently, it reduced the required passes and the needed work-done and increased the accuracy during the leveling process. The more accurate the land leveling, the less irrigation water amount is required. As mentioned before, the maximum difference in the level values was .0.20 m, 3.50-3.30. In other words, certain spots are higher than others with 0.20-m which means a difference of 0.10-m from the average level. Accordingly, a depth of 0.10-m has to be cut and transferred to a lower area. As a result, the scraper would reduce or empty the high areas of the chiseled soil or at least it would be covered with a few quantity of pulverized soil. Therefore the un-chiseled soil was observed at a very shallow depth.

On the other hand, the surveying grid after land leveling with ordinary LASER scraper at zero level was posted in Fig. 2. An average level of 2.502 m and a standard deviation of ±0.0074 m were recorded. An un-chiseled soil was observed after the leveling was achieved. It was obvious that the majority, ≈90% of the leveled land, had a level range of 2.49-2.51 m, while, the rest of the filed, ≈10%, had a level of less than 2.49-m represented by three dark spots in figure 1. These three spots, which were located in a relatively higher area in surveying grid of the field before leveling, might have had high level values due to the high compaction of the un-chiseled soil. The scraper might tend to leave the cut areas close to be un-chiseled with a compacted soil and a higher level than the surrounding areas. The higher the compaction of the soil, the lesser it is affected after irrigation. The irrigation would result in decreasing the land level at a degree dependent upon the soil pulverization, positively proportional, and bulk density, inversely proportional.

The surveying grid of plot 2 before LASER leveling was shown in Fig. 3. The difference between the highest and the lowest spots (3.31 – 3.49 m), was 18 cm, where the average level of all the spots was 3.39-m and the standard deviation was recorded as ±0.0498-m. The grid showed a low level area near to the northern part of the field. Moving in the longitudinal direction of the field, a higher level area, containing three low spots, was observed. Then finally a lower area was seen close to the southern side of the field.

The surveying grid after land leveling with modified LASER scraper at zero level was indicated in Fig. 3. An average level of 2.499 m and a standard deviation of ± 0.0049 were observed and no un–chiseled soil was detected. The modification resulted in a more homogeneous field with level values from 2.49 to 2.51 m. Only a small spot, ≈2% of the field, showed up at a lower land level, more than 2.51-m. That spot may have had a relatively lower level compared to the rest of the field such that the moved soil by the scraper was not sufficient to cover it. From the surveying grid of the area that was shown in Fig. 2, it was clear that the area was absolutely leveled except a small spot, ≈ 150-m, which was low with a level difference of about 1-2 cm. The difference in level might be a measurement error due to the effect of the rod weight on the pulverized soil. It was observed that this low area was located in a low region in the same position of field before leveling. This resultant small unleveled area shows the superiority of the modified over ordinary LASER scraper. Where, the regular LASER scraper left a larger un-chiseled area of about 450-m^2 at a level higher than the homogeneous land of about 1-2 cm, as shown in Fig. 1. These results support the new modification of the scraper.

The surveying grid of plot 3 before LASER leveling was shown in Fig. 4. The difference between the highest and the lowest spots (3.3 – 3 51 m), was 0.21-m with an average level of 3.41 m. and a standard deviation of ±0.0578. This figure shows the whole area as it was divided laterally in two longitudinal halves. The northern half was higher than the southern half except a small spot of about 120-m^2, which was more than 0.1-m lower than the average level of the higher half. Also, it was indicated that the leveling process might go in longitudinal direction beginning from the northern part of the field and going toward the south to achieve the required slope.

The surveying grid of plot 3 after land leveling with LASER scraper at a slope of 0.03% was illustrated in Fig. 4. The average level of all the spots was 2.401 m and the standard deviation was calculated as ± 0.0049. An un-chiseled soil was observed too. It was clear that the leveled field was more homogenous than that leveled with the same scraper at zero level. Nevertheless, only two spots with an area of about 4% of the experimental field had less than the average level. The spots with the higher levels appear to be towards the side drain. The slope of 0.03% would result in a difference of elevation of about 4-cm along the whole the length, 120-m. At the same time the height difference before leveling was about 20-cm that indicated a cutting height of about 8-cm was required and the same height has to be filled. It was clear in figure 4 that the high level area was in the northern section of the field. Nonetheless, the area with the lower level was located in the southern section that did not have enough soil to be filled. That resulted in two spots, 500-m^2, which were lower in their level by about 1-cm. Nonetheless, this lower level might be a result of measurement error due to the weight of the measuring rod. Excluding these spots, the whole area was absolutely leveled.

The surveying grid of plot 4 before LASER land leveling was illustrated in Fig. 5. The difference between the highest and the lowest spots (3.33 – 3.5) m, was 17-cm with an average level of the total spots of 3.412-m. Also, a standard deviation of ±0.0441 was recorded. The field was divided into two halves with a maximum level difference of 16-cm. The higher half was in the northern part of the field and the lower half was located in the southern half. Similar to the other three plots, the soil had to be moved longitudinally from north to south during the leveling process. However, the proper slope had to be taken into consideration for proper irrigation. The level difference due to the 0.03% slope was about 4-cm for the total length of the field, 120-m. Consequently, about 6-cm had to be cut from the end of the northern section to fill the end of the southern section. Two high leveled areas, dark spots, were observed in the northern section of the surveying grid. Since there spots had un-chiseled soil, the cutting process was a very difficult task to be achieved.

The surveying grid after land leveling with modified LASER scraper at a slope 0.03% was indicated in Fig. 5. The difference between the highest and the lowest spots (2.48 – 2.5 1-m) was 3-cm with an average level of 2.49-m and a standard deviation of ± 0.0037. Unlike the leveling with the ordinary LASER scraper, un-chiseled soil was not observed. The majority of the filed had a level of 2.49 - 2.51-m. However, heterogeneous spots with levels less than 2.49-m, by about 1-cm, was observed on the same places before leveling. In general, the area seemed to be well leveled with the desired slope except the two spots which were higher than the whole area with difference of about 2-cm. These two spots had an area of a bout 700-m^2 in the same place in the field before the leveling Fig. 5 as discussed before. This phenomenon of leaving some heterogeneous spot after land leveling using the modified LASER scraper indicates the need for increasing chisel shank depth than the suggested depth in the present study to avoid any future heterogeneity.

The soil bulk density (ρb)

The soil bulk density after leveling at 0.0%, 0.03% using ordinary and modified LASER scraper as affected by forward speed at moisture content from 10.3 to 13.3 % was illustrated in Fig. 6. The soil bulk density decreased with increasing the forward speed for both LASER scrapers which might be due to decreasing the number of LASER signals per time unit received by the antenna.

The less the received number of signals, the less pulverization of soil was achieved and consequently, the less the bulk density values were obtained. The soil bulk density was lower with the modified at all forward speeds due to the lower number of leveling cycles, passes, required for each unit area compared to the ordinary scraper. The difference between the soil bulk density values of both the LASER scrapers increased by increasing the forward speed that might be due to the double effect of decreasing the number of signals and the lower number of passes required for the modified scraper.

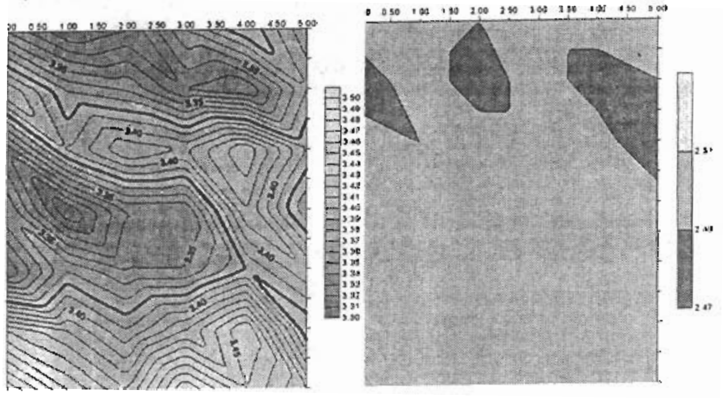


Figure 2: Surveying grid of plot (1) before and after land leveling at zero level with ordinary LASER scraper

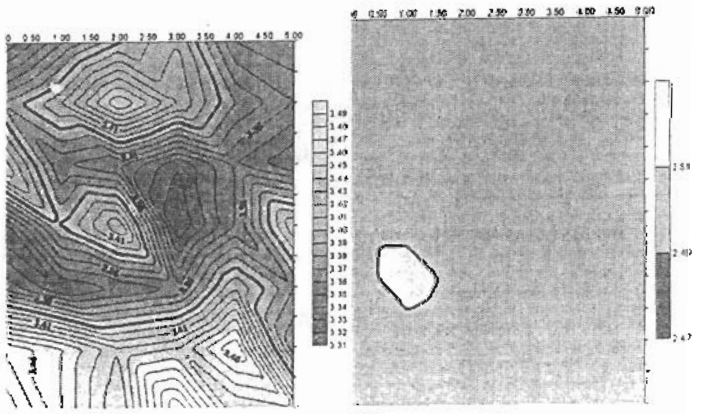
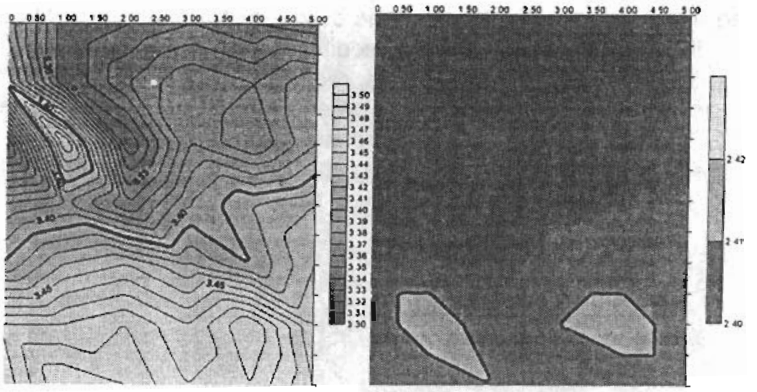
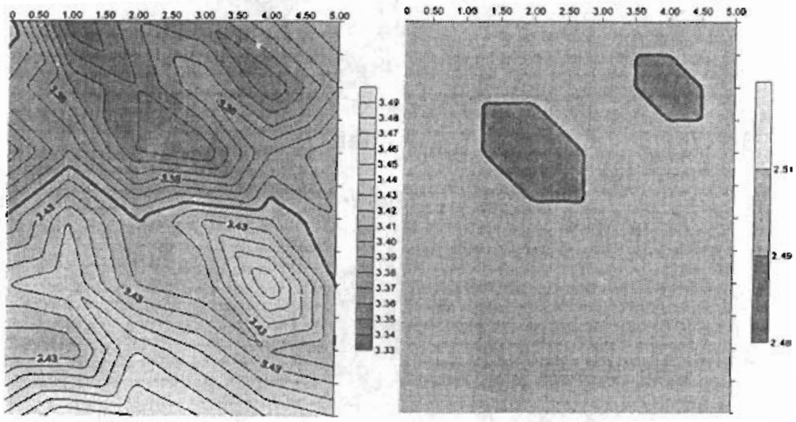


Figure 3: Surveying grid of plot (2) before and after land leveling zero level with modified LASER scraper



Before After

Figure 4: surveying grid of plot (3) before and after land leveling at 0.03% slope with ordinary LASER scraper



Before After

Figure 5: Surveying grid of plot (4) before and after land leveling at 0.03% slope with modified LASER scraper

LASER leveling at 0% resulted in the minimum value of soil bulk density of 1.363 g/cm^3 that was obtained by using modified LASER scraper at a forward speed of 5.62 km/h, while the maximum value of soil bulk density of 1.412 g/cm^3 was achieved by using ordinary LASER scraper at a forward speed of 4.91 km/h at zero level, 5. At 0.03% slope, the minimum value of soil bulk density of 1.421 g/cm^3 was accomplished by using modified LASER scraper with forward speed of 5.62km/h, while the maximum value of soil bulk density of 1.489 g/cm^3 was reached by using ordinary LASER scraper with forward speed of 4.91 km/h, Fig. 5. In general, the leveling at 0% and 0.03% resulted in the same decreasing trend with increasing the forward speed. However, the leveling at 0% resulted in lower bulk density compared to the leveling at 0.03% which might be due to the lower cut and fill quantities required for the leveling at 0.0% slope and, consequently, lower pulverization. On the other hand, the 0.03% level needed more cycling, passes, for each unit area; which resulted in a higher percentage of fine particles of soil and consequently, higher soil pulverization.

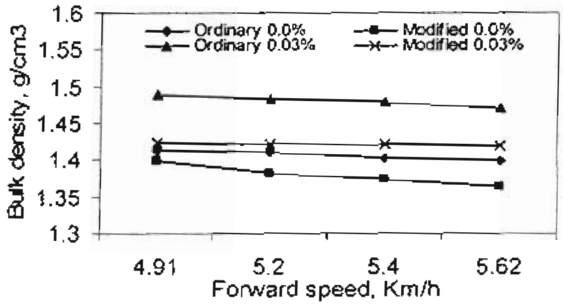


Figure 6: Soil bulk density as affected by LASER land levelling using the modified and ordinary scrapers at 0 and 0.03% slopes

Soil porosity

The effect of forward speed on soil porosity at zero land leveling was shown in Figure 7. Results indicated that soil bulk density and total soil porosity were inversely related. It was clear that increasing soil bulk density was accompanied by a decrease in soil porosity. The porosity values were influenced by leveling operation, as they were decreased at different magnitudes depending upon the type of land leveling. The increase in soil porosity with forward speed was expected since porosity is oppositely related to soil bulk density. The higher values of the soil porosity mean better aeration, consequently, better seed bed that is proper for growing plants. The minimum value of soil porosity of 46.7% was reached by using ordinary LASER leveling system with forward speed of 4.91km/h, while the maximum soil porosity value of 47.2% was achieved by using same system with forward speed of 5.62 km/h at zero level. The minimum value of soil porosity of 47.24% was reached by using modified LASER leveling system with forward speed of 4.91km/h، while the maximum value of soil porosity of 48.56% was reached by using the same system with forward speed of 5.62 km/h at zero level Fig. 7.

The minimum value of soil porosity of 43.81% was reached by using 0.03% ordinary LASER land leveling system with forward speed of 4.91km/h, while the maximum value of soil porosity of 44.49% was obtained by using same system at forward speed of 5.62 km/h at 0.03% slope, Fig. 7. The minimum value of soil porosity of 46.3% was achieved by using modified LASER land leveling system, 0.03% slope, with forward speed of 4.91km/h، while the maximum value of soil porosity of 46.41% was accomplished by using same system with forward speed of 5.62 km/h, Fig 7. Results indicated that the soil porosity of the modified LASER scraper was higher than that occurred by the ordinary one. Both of them were relatively affected by increasing the forward, which was related to the soil bulk density. The resultant soil porosity at the zero leveling was higher than that achieved at 0.03% slope. In summary increasing of the land slope and decreasing forward working speed decreased the value of soil porosity.

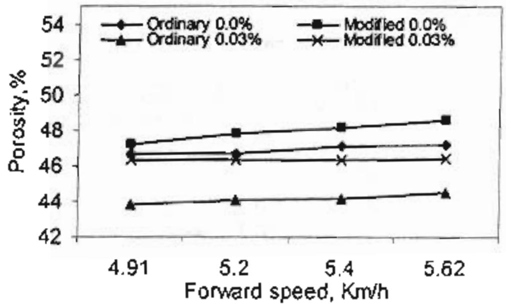


Figure 7: Soil porosity as affected by LASER land leveling using the modified and ordinary scrapers at 0 and 0.03% slopes.

Soil aggregate distribution

The soil aggregate distribution was measured under modified and ordinary LASER land leveling and results were shown in figure 8. Clods with average diameters higher than 30-mm were very rare in the collected soil samples, <2%, so they were included within the category of 20-30 mm. It was obvious that the ordinary LASER scraper had higher percentage of soil clods with average diameters less that 10-mm. Nonetheless, clod average diameters of higher than 5-mm, were higher with the modified scraper. Clods with average diameters higher than 5-mm were about 82.8% for the modified scraper compared to 77.2% for the ordinary one at 0.0% slope. Also, clods with average diameters higher than 5-mm constituted about 83.44% for the modified LASER scraper compared to 77.72% for the ordinary one at 0.03% slope. Consequently, the modified LASER scraper resulted in better soil pulverization than the ordinary. Therefore, it was evident that the modified scraper resulted in more desired soil structure than the ordinary scraper at both slopes. The ordinary LASER scraper might cause more fine pulverized soil due to the need for more circulation in the field to achieve the required leveling. The replication of the leveling cycles was required as a result of the presence of the high spots which were emptied from the chiseled soil. Accordingly, the scraper moved on these high spots without cutting, therefore, more runs were required for proper land leveling.

This scenario that happened with the ordinary LASER scraper was overcome with the modified one that gave less fine pulverized soil. Since there was no need for repeated runs because of the accompanying chisel shanks, which disturbed the firm soil before the cut action, less fine soils was obtained. Increasing the quantity of fine pulverized soil was accompanied with a decrease in the large clod quantity for both scrapers and vise versa. For leveling purposes, less fine pulverized soil quantity and relatively more large clods are preferred. A little difference in the fine pulverized soil occurred with 0.03% leveling than that occurred at zero slope.

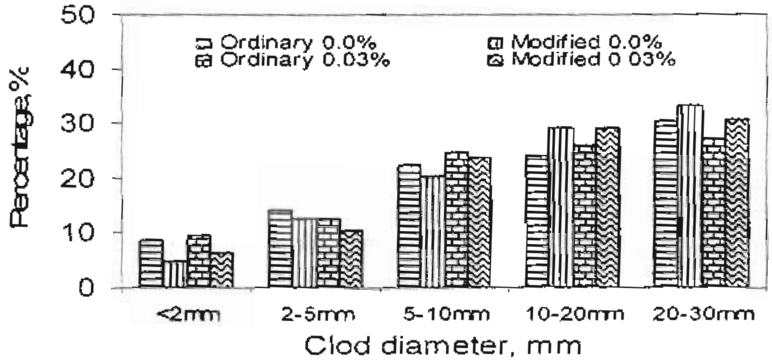


Figure 8: Clod diameter as affected by LASER land leveling using the modified and ordinary scrapers at 0 and 0.03% slopes.

Power requirement:

Power required for operating the hydraulic scraper was significantly affected by its blade size and the used tractor. The power requirements for the used tractor at the minimum and maximum forward speeds, 4.91 and 5.62 km/h, were shown in figure 9. Results demonstrated that higher power values were required (39.09 and 34.81kW) with modified LASER scraper compared to 38.03 and 34.18 kW with the ordinary one at forward speeds of 5.62 and 4.191 km/h, respectively. It was noticeable that the power needed for the modified LASER scraper was higher than that required for the ordinary one. This difference in power needs was due to the addition of extra chisel shanks which required more power. Another observation was the higher power requirement with increasing the forward speed which agreed with the common sense since the power is a function of the forward speed.

The consequent field capacities of 0.33, 0.35, 0.46 and 0.52 fed./h for the ordinary (0%), modified (0%), ordinary (0.03%) and modified (0.03%), correspondingly, resulted in energy requirements of 109.82, 105.57, 78.5 and 70.71 kW.h/fed., respectively. Accordingly, the modification resulted in decreasing the energy requirements per feddan. The saved energy due to the modification constituted 4% and 9% for the leveling at 0% and 0.03%, respectively.

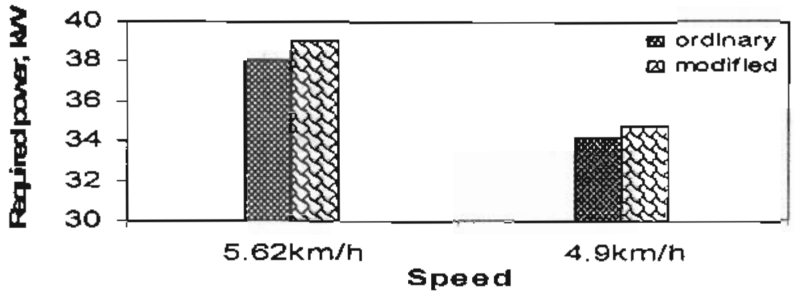


Figure 9: Power requirements as affected by forward speed of LASER land leveling using the modified and ordinary scrapers.

Operational cost:

Operational cost for modified and ordinary scrapers under investigation was illustrated in figure 10. Cost of field leveling was affected by the scraper and the power unit used, tractor. Results indicated that lower cost values of 74.87L.E. /h and 89.84 L.E./h were achieved with the modified scraper for the 0.03% and 0.0% slopes, respectively. However, higher cost values of 111.28 L.E./h and 133.58 L.E./h were achieved with the ordinary scraper for the 0.03% and 0.0% slopes, respectively. In summary the modified scraper had lower operational cost by about 32% than the ordinary scraper for both slopes.

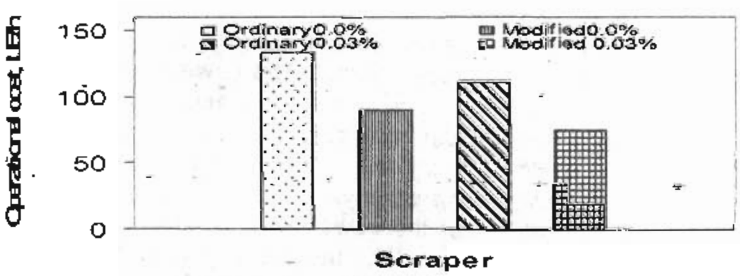


Figure 10: Operational cost of LASER land leveling using the modified and ordinary scrapers at 0 and 0.03% slopes.

CONCLUSION

The surveying grid of the experimental land after leveling with ordinary LASER scraper at zero level showed that an average level of 2.502 m and a standard deviation of ±0.0074 m were recorded. An un-chiseled soil was observed after the leveling was achieved. It was obvious that the majority, ≈90% of the leveled land, had a level range of 2.49-2.51 m, while, the rest of the filed, ≈10%, had a level of less than 2.49 m. The surveying grid after land leveling with modified LASER scraper at zero level indicated that an average level of 2.499 m and a standard deviation of ± 0.0049 were achieved and no firm, un–chiseled, soil was detected. The modification resulted in a more homogeneous field with level values from 2.49 to 2.51 m. Only a small spot, ≈2% of the field, showed up at a lower land level, more than 2.51-m.

The surveying grid of experimental field after land leveling with the ordinary LASER scraper at a slope of 0.03% indicated that the average level of 2.401 m and the standard deviation of ± 0.0049 were attained. An un-chiseled soil was observed too. Only two spots with an area of about 4% of the experimental field had less than the average level. It was clear that the leveled field was more homogenous than that leveled with the same scraper at zero level. The surveying grid after land leveling with modified LASER scraper at a slope 0.03% showed that the difference between the highest and the lowest spots was 2.48-m to 2.51-m with an average level of 2.49-m and a standard deviation of ± 0.0037. The field was well leveled with the desired slope except two spots with an area of about 8.3% of the whole field, which were higher than the surrounding land by about 2-cm. Therefore it is recommended to increase the chisel shank depth than the suggested depth in the present study to avoid any future heterogeneity.

The soil bulk density had a decreasing trend with the forward speed. Lower values were attained with the modified, at all forward speeds, compared to the ordinary LASER scraper. Soil porosity was having an inverse behavior to the soil bulk density. In other words, porosity increased with increasing forward speed. Also, modified LASER scraper resulted in higher porosity than the ordinary one

Modified scraper resulted in better soil pulverization than the ordinary one. However, it was noticeable that the power needed for the modified LASER scraper was higher than the ordinary LASER scraper, which was due to the addition of extra chisel shanks that needed more power. Even so, the required energy per feddan was lower for the modified scraper. On the other hand, from the economical point of view, operational costs of the modified LASER scraper were lower by about 32% than that of the ordinary one.

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تحسين آداء قصابية الليزر

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لقد أجريت هذه التجربة سنة ٢٠٠٤ في حقول مصنع السكر دات تربة طينية بكوممبو، محافظة اسوان لتقييم أداء منظومة التسوية بالليزر المعدلة بالمقارنة بأداء المنظومة الغير معدلة. و لقد شمل التعديل إضافة ٨ قصبات محراث حفار في مقدمة الإطار الرئيسي للمنظومة. و كان الهدف الرئيسي من هذه الإضافة هو التغلب علي مشكلة ظهور الأرض البلاط عند التسوية بمنظومة الليزر مما يستلزم إستخدام محراث حفار لفك الأرض البلاط ثم إعادة التسوية مما يزيد من تكاليف التسوية دون الوصول إلي التسوية المثلي. أيضا تم مقارنة أداء المنظومتين عند التسوية علي ميول مختلفة (٠,٠ % و ٠,٠٣%).

و لقد أوضحت النتائج أن التسوية بالمنظومة المعدلة عند ميول ٠,٠% و ٠,٠٣%، قد أعطت سطح تربة متجانس مع عدم ظهور الأرض البلاط في حالة الميل ٠,٠%. بينما بينت النتائج أن المنظومة الغير معدلة قد أعطت سطح تربة متجانس أكثر عند ميل ٠,٠٣% ، بالمقارنة بالتسوية عند ميل ٠,٠%.

أعطت التسوية بمنظومة الليزر المعدلة خصائص فيزيائية أفضل للتربة (كثافة ظاهرية أقل و مسامية أعلي و تحبب أفضل) من التسوية بالمنظومة الغير معدلة.

علي الرغم من تطلب منظومة الليزر المعدلة لقدرة أعلي، فإن تكاليف التسوية بصفة عامة كانت أقل من مثيلتها الغير معدلة بمقدار ٣٢% . و بالتالي فإن التعديل المقترح قد حسن من أداء منظومة التسوية الليزر و قلل من تكاليف التشغيل.