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LASER LAND LEVELING SCRAPER AND BLADE MOVING STRUCTURE

El-Sheikha, M. A.[1]; H.E. Osman[2]; M. A. Moustafa[1] and M. F. Zayed[2]
1 Agric. Eng. Dept., Fac. of Agric., Mansoura Univ.
2 Agric. Eng. Res. Inst., A.R.C., Dokki. Giza

ABSTRACT

A study was carried out to test and evaluate a LASER land leveling scraper. A scraper structure including a leveling blade supported by heavy duty wheels trailing. Also, adding (6) solid shanks on the main frame of the scraper at equal distances along the whole width of the scraper. A LASER receiver is carried by the leveling scraper for raising and lowering the land leveling scraper blade as the receiver falls and rises in traveling across a field. The leveling scraper blade and receiver are sufficiently closely spaced longitudinally so as to cause the receiver to detect a change in the surface of the terrain substantially coincident with the arrival of the blade at the detected change. Results indicate that, the draft increased with the increase of measuring depth at zero level and 0.03% slope.

The recorded draft of scraper for measuring depths 10, 15, 18, and 21cm were 11.57, 13.14, 13.93 and 15.2kN at zero level and 12.95, 13.64, 14.62 and 15.79kN at 0.03% slope with operating speed of 3.45km/h. While the draft was 9.86, 9.81, 9.89 and 10.00kN at zero level and 9.81, 9.88, 11.18 and 13.44kN at 0.03% slope with operating speed of 5.53km/h respectively. Corresponding pull decreased with increasing of operation speed of the tractor under different measuring depth at zero level and 0.03% slope. Draw bar power increased with the increase of operating speed under different measuring depth at 0.03% slope. At low operating speed the obtained high draft but consumed drawbar power was low while at high operating speed the obtained low draft but consumed draw bar power was high.

INTRODUCTION

As the LASER controlled leveling as well as the manual controlled leveling the chiseled layer of the soil was transported from the higher areas to the lower areas of the land . This process leads to a well leveled blocked surface layer in the higher area. This phenomenon must hinder the leveling production .After irrigation the thick pulverized layer will sediment and leave its surface lower than its equalize in the un-chiseled Land. Egypt's Agricultural Mechanization Project (EAMP) in its Land Improvement Sub-Project (LISP) has set the standard of 80 percent or more of field rod reading on a 20 meter by 20 meter grid must fall within± 20 mm. Surface roughness is a major factor in setting these standards (El-Haddad *et al.* 1984). Land leveling results in economic profit and represents a necessary condition for applying modern agriculture techniques. However, inaccuracy and misapplication of land leveling has led to destruction of soil properties and removal of the topsoil. Therefore, land leveling requires practical experience as well as scientific knowledge (Abou El-Enine *et al.*, 1988). The leveling of land is done precisely with the automatic functioning of the laser-operated scraper. With the laser system, the reference plane is generated above the ground with the help of a rotating transmitter in the form of a beam, which is intercepted by a receiver fitted on the scraper. The hydraulic system of the scraper is controlled by the laser beam, through a control panel and a solenoid valve, to maintain a desired level by raising or lowering the cutting edge of the blade automatically depending upon the field grades. The tractor operator constantly receives the signals regarding high or low spots, on the grade information on the control box located in the driven cabin, and on the light display fitted in front of operator (Maheshwari, 2004). An automatic land leveling control system (ALLCS) consists of different sections such as electronic circuitry, laser and hydraulic devices to adjust the height of scraper. A laser beam strikes a photocell array and then the electronic circuit detects the level of the laser beam. If the level of laser beam is not the same as set point, a control signal is transmitted to adjust the height of the scraper. (Mohtasebi *et al.*, 2007).

A new lower-cost laser controlled leveling system, integrated with medium-sized and small-sized tractors, for farm land leveling. The system consisted of a laser transmitter for creating a laser beam scanned altitude level reference, a laser signal receiver, an intelligent hydraulic controller, a hydraulic control unit and a leveling bucket (Lin *et al.*, 2007). El-Raie (1982) monitored that when drawbar pull increased slip percentage increases. He advised that slip must be kept less than 15%. If the amount exceeded it will cause a loss in power. He also added that, the effectiveness of different land leveling method on the performance of the working seed drill were related to among precision leveling index. Nasr (1985) reported that, the percent of wheel slip when tractor is executing the 2^{nd} pass with a chisel plough is higher than the slip percent with the farm tractors and plough when executing the 1^{st} ploughing pass. This is due to fact that the soil is looser and less compaction prior to the 2^{nd} ploughing thus allowing more wheel slip. Also, all operations carried by different tractors power the percentage slip, fuel consumption ,actual field capacity and estimated needed brake horse power increase by increasing the forward speed of operation. The power requirement for laser land leveling operation was 60.15 hp. While for manual land leveling was 58.39 hp under the same conditions, also actual field capacity in laser was 17.3 m^3/h but in manual leveling was 14.5 m^3/h. The increase in the field capacity was 19.3 % for laser leveler. In general, it can be concluded that the use of laser leveling requires lower power for unit earth work volume than in using manually controlled leveling by 13.4% under the same conditions (Mostafa *et al.*, 1993). Abd El-Wahab (1994) showed that the increase in the travel speed results in an increase in bulk density, soil penetration resistance, slip, draft and consumed energy. On the other hand, fuel consumption decreased as the travel speed increased, due to increasing the field capacity related to the increase in forward speed. Zayed (2005) found that, energy requirements for tractor at forward speed 4.91 and 5.62 km/h were 39.09 and 34.81kW with modified laser scraper comparing with the laser scraper 38.03 and 34.18kW at forward speed of 5.62 and 4.91km/h, respectively. Although the modified laser scraper required more power, operational costs decreased by about 32% in comparison with the unmodified scraper for 0% and 0.03%slopes. The objective of the modification is to eliminate firm, un-chiseled, spots that normally appear during leveling with the unmodified laser scraper. In such cases, a chisel plow has to be used to loosen the soil in-between scraper runs to level these spots, which increases the operational costs. Michael(1990) showed that Land leveling resulted in increasing coefficient of useful time, field capacity and germination capacity as compared with unleveled land. Also, land leveling resulted in increasing the harvesting machine performance as, coefficient of useful time, field capacity, and harvesting efficiency.

MATERIALS AND METHODS

Materials:

Field experiments were carried out during the agricultural season 2009 at Nasser El Noba, Kom Ombo, Aswan Governorate. The soil has been classified as a clay soil (59.1%clay,30.7%silt and10.2%sand) to evaluate the performance of developed motion for LASER land leveling scraper . The draw bar power needed for operating LASER land leveling scraper was identified.

Equipment:

LASER system equipment:

Specifications of laser system equipment used in the present investigation are as follows:

Transmitter:

The Rugby 320 SG transmitter generates a long-range, rotating LASER beam that can be accurately and easily positioned to provide a control plane in X axis(single grade).

Beam:	Visible red laser diode, 635 nm.
BRH classification:	Class III laser product.
Operating range, (m):	900m- (450m) radius.
Power requirements:	Removable battery pack.
Rotating head speed, rps:	5 to 20, variable speeds.
Self leveling accuracy:	±1.6mm per30m.
Self-leveling range, (deg)	± 5
Grade capability:	-5 to 25%.

LASER Receiver:

Receiver is usually omni-directional and sensitive to the transmitted LASER beam. Other light being received is usually filtered out mechanically or electrically. Receiver is mounted on mast above scraper. The receiver has at least three different vertical sensing areas. 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 usually has two modes of operation, which are "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.

Control box:

The control box accepts and processes signals from the machine mounted receiver. It displays these signals to indicate the drag bucket's position relative to the finished grade. When the control box is set to automatic, it provides 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 are on/off, auto/manual, and manual raise/lower.

Level eye: The alignment level eye was used with LASER transmitter to survey an area for elevation reading or for direct cut or fills reading.

The hydraulic solenoid valve:

The solenoid control valve controls the flow of oil to the hydraulic ram, which raises and lowers the bucket. The hydraulic ram can be connected as a single or double acting ram. When connected as a single acting ram only one oil line is connected to the ram. An air breather is placed in the other connection of the ram to avoid dust contamination on the non-working side of the ram. In this configuration, the scraper can be lowered using its weight. The desired rate at which the scraper raises and lowers will depend on the operating speed. The ground speed the faster the bucket will need to adjust. The rate at which the bucket will raise and lower is dependent on the amount of oil that is supplied to the delivery line. Where a remote relief valve is used before the control valve, the pressure setting on this valve will change the raise/lower speed. The control valves, supplied by the manufacturer, have pressure control adjustments on both the bypass relief valve and the raise and lower valves.

Laser Scrapers:

The scrapers bucket have a height of 53 cm and a longitudinal depth of 82 cm it is mounted types with hydraulic depth control and a capacity of 1.3 m3. Utilizing implement a group of solid shanks ended with a set of blades in front of the scraper. This group of blade shanks is fixed on a steel rectangle cross-section bar(10x10cm), which in turn fitted on the both sides fig (1and2a,b). The working depth of this blades group is 21 cm deeper than the scraper blade to ensure soil disturbance before leveling. In general a land leveling scraper of the type adapted to be drawn by a tractor or other towing means has been provided employing a scraper structure characterized by a leveling blade. Heavy duty wheels disposed in trailing relation to the scraper structure are supported in relation by a trailing connection formed between the heavy duty wheels and the scraper structure. The trailing connection serves to maintain the swivel axles of the heavy duty in fixed lateral relation relative to the ends of the blade. A fixed towing connection is formed and carried at the leading portion of the scraper structure so as to be adapted to be coupled to the towing assembly of a tractor. The towing connection serves to support the scraper structure in terrain following movement. As thus arranged the land leveling scraper is substantially frameless whereby the angle of the leveling blade can be adjusted by adjusting a hydraulic ram interposed between the back panel of the scraper structure and the trailing connection.

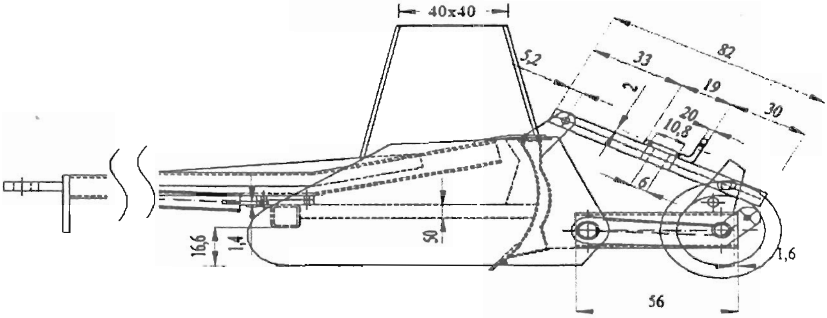
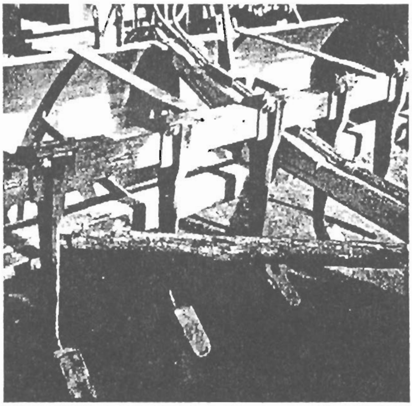


Fig.(1): Side view diagram of LASER land leveling scraper(Dim in cm)



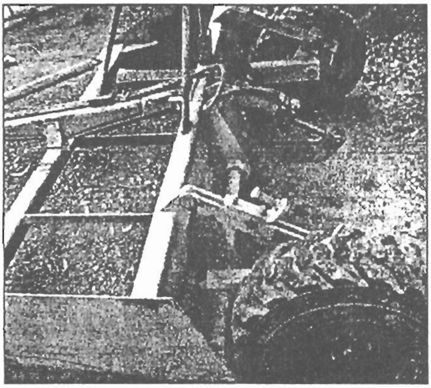


Fig. (2): (a) A photo shows (6) solid chisel shanks mounted of the scraper (b) LASER land leveling scraper .

METHODS:

The main experiment was carried out in clay soil. The experimental area,8-feddans ,was divided into 4 plots,2-feddans each. The first plot without any slope (zero level) while the second plot leveled at 0.03% slope The plots were plowed twice before performing the land leveling. The tractor (Massy Ferguson, 99.36 kW) was operated in the experimental plots.

Experimental treatments

Four measuring depths (d) under blade scraper (10, 15, 18, and 21 cm), four tractor operating speeds (s) (3.45, 4.19, 4.86 and 5.53 km/h) and tow slopes zero and 0.03% slope level(3cm per 100m lengthy) were used for the experimental work.

Test procedure and measurements:

The hydraulic drawbar dynamometer are used as shown in Fig. (3). The pressure set up in the fluid contained in a hydraulic link is transmitted to a small recording cylinder, in which a plunger acts against the force of a spring. The movement of the plunger may be read directly. The hydraulic drawbar dynamometer can measure load from zero to 8000 kg. Its indicator was analog but it had liquid in his indicator box to reduce the movement of the indicator when value to read.

Calibration of the hydraulic dynamometer

The calibration of hydraulic dynamometer was conducted in the lab of testing of material in faculty of Engineering, Alexandria University.

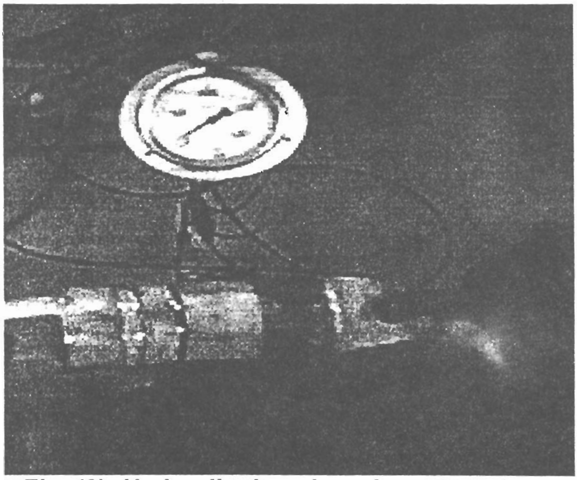


Fig. (3): Hydraulic draw bar dynamometer.

Experimental Measurements:

Drawbar power

Drawbar power was calculated using the following equation:

$$\text{Drawbar power (kW)} = \frac{\text{(Drawbar pull (N) X traveling speed (km/hr))}}{1000 \times 3.6}$$

RESULTS AND DISCUSSION

Effect of measuring depth and operating speed on draft:

Figure (4) shows that effect of measuring depth and operating speed at zero level on draft. As shown in the figure, draft increased with the increase of measuring depth. The recorded draft of scraper for measuring depths 10, 15, 18, and 21cm were 11.57, 13.14, 13.93 and 15.20kN at operating speed 3.45 km/h, respectively. While at operating speed 4.19km/h and depths 10, 15, 18, and 21cm the draft were 10.39, 12.02, 14.72 and 17.17kN respectively. Also, at operating speed 4.86km/h and depths 10, 15, 18, and 21m the draft were 10.30, 10.00, 12.95 and 14.27kN respectively. Consequently, at operating speed 5.53 km/h and depths 10, 15, 18, and 21 cm the draft were 9.86, 9.81, 9.89 and 10.00kN respectively.

On the same time Fig. (5) shows that effect of measuring depth and operating speed at 0.03% slope level on draft. As shown in the figure, draft increased with the increase of measuring depth. The recorded draft of scraper for measuring depths 10, 15, 18, and 21cm were 12.95, 13.64, 14.62 and 15.79kN respectively at operating speed 3.45km/h. While at operating speed 4.19km/h and depths 10, 15, 18, and 21m the draft were 11.97, 12.46, 13.15 and 15.11kN respectively. Therefore, at operating speed 4.86km/h and depths 10, 15, 18, and 21m the draft were 11.82, 10.99, 12.56 and 14.52kN respectively. Hence, at operating speed 5.53km/h and depths 10, 15, 18, and 21m the draft were 9.81, 9.88, 11.18 and 13.44kN respectively.

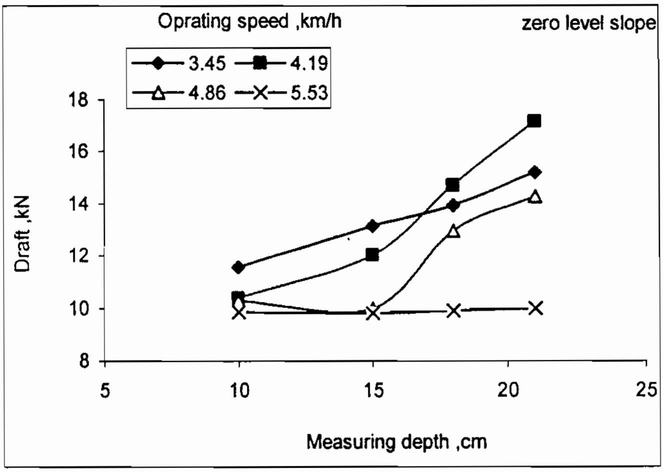


Fig. (4): Effect of measuring depth and operating speed at zero level on draft.

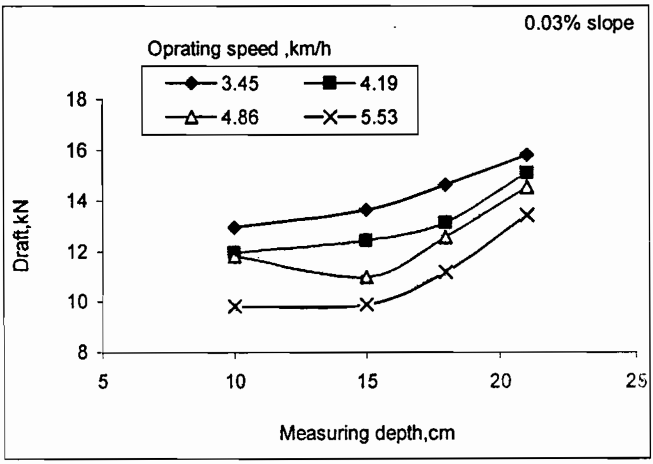


Fig. (5): Effect of measuring depth and operating speed at 0.03% slope level on draft.

Effect of operating speed on corresponding pull:

Figure (6) shows that effect of operating speed at zero level on corresponding pull. As shown in the figure, corresponding pull decreased with the increase of operating speed under different measuring depth. The recorded of corresponding pull for operating speeds 3.45, 4.19, 4.86, and 5.53km/h were 11.57, 10.39, 10.30 and 9.86kN respectively at measuring depth 10cm. Therefore at measuring depth 15cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the corresponding pull were 13.14, 12.02, 10.00 and 9.81 kN respectively. While at measuring depth 18cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the corresponding pull were 13.93, 14.72, 12.95 and 9.89kN respectively. Also, at measuring depth 21cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the corresponding pull were 15.2, 17.17, 14.27 and 10.00kN respectively.

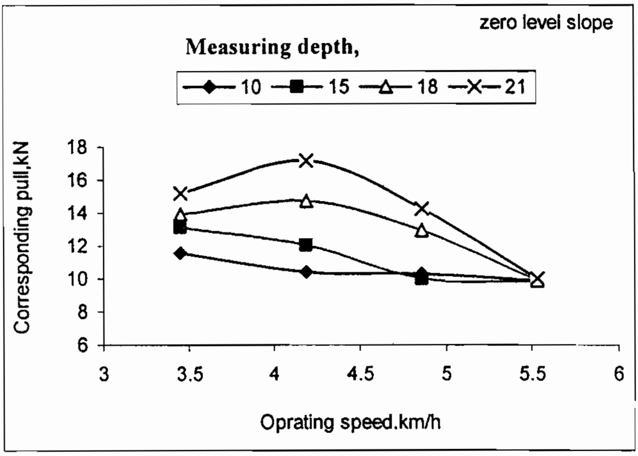


Fig.(6): Effect of operating speeds and measuring depths at zero level on corresponding pull.

On the other hand, Fig. (7) shows that effect of operating speed at 0.03% slope level on corresponding pull. As shown in the figure, corresponding pull decreased with the increase of operating speed under different measuring depths. The recorded of corresponding pull for operating speeds 3.45, 4.19, 4.86, and 5.53km/h were 12.95, 11.97, 11.82 and 9.81kN respectively at measuring depth 10cm. Therefore at measuring depth 15cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the corresponding pull were 13.64, 12.46, 10.99 and 9.88kN respectively. Also, at measuring depth 18cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the corresponding pull were 14.62, 13.15, 12.56 and 11.18kN respectively. While at measuring depth 21cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the corresponding pull were 15.79, 15.11, 14.52 and 13.44kN respectively.

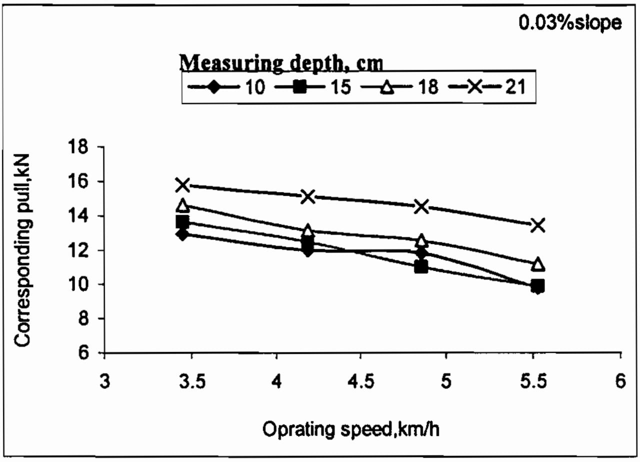


Fig.(7): Effect of operating speeds and measuring depths 0.03% slope level on corresponding pull.

In general, draft increased with the increase of measuring depths. However, it has greatly increased on zero level during LASER land leveling To relate the changes of soil topography. While corresponding pull decreased with the increase of operating speed under different measuring depth.

Effect of operating speed on draw bar power

Figure (8) shows that effect of operating speed under different measuring depths on draw bar power at zero level.

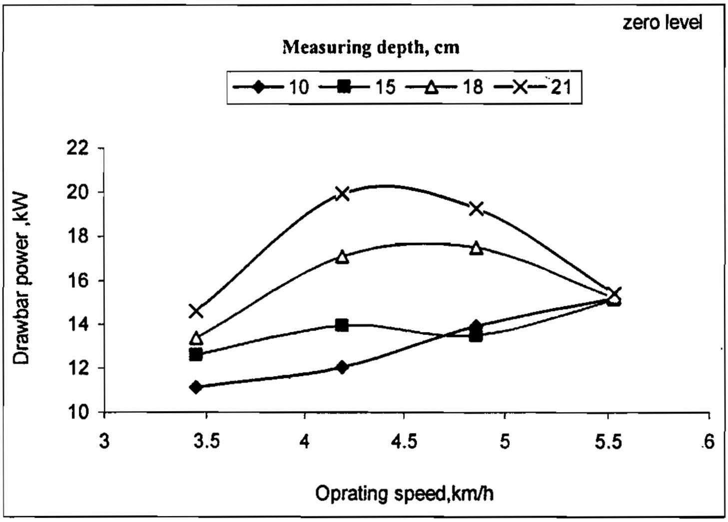


Fig. (8): Effect of operating speeds under different measuring depths on drawbar power at zero level.

As shown in the figure, drawbar power increased with the increase of operating speed under different measuring depth . The recorded of draw bar power for operating speeds 3.45, 4.19, 4.86, and 5.53km/h were 11.11, 12.05, 13.91 and 15.18kw at measuring depths 10cm, respectively. While at measuring depth 15cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h drawbar power were 12.61, 13.94, 13.50 and 15.10kW respectively. Consequently, at measuring depth 18cm, values increased until operating speed 4.86km/h and decreased at speed 5.53km/h this resulted different because recorded lowest value for draft at this speed were 13.37, 17.07, 12.95 and 15.23kw respectively. While at measuring depth 21cm, values increased until operating speed 4.86km/h and decreased at speed 5.53km/h this resulted different because recorded lowest value for drawbar power at this speed were 14.59, 19.91, 19.26 and 15.4kW respectively. On the same time Figure. (9) shows that the effect of measuring depth and operating speed at 0.03% slope level on drawbar power. As shown in the figure, drawbar power increased with the increase of operating speed under different measuring depths. The recorded of drawbar power for operating speeds 3.45, 4.19, 4.86, and 5.53km/h were 12.43, 13.89, 15.96 and 15.10kW respectively at measuring depth 10cm. While at measuring depth 15cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the drawbar power were 13.09, 14.45, 14.84and15.22 kW respectively. Hence at measuring depth 18cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the drawbar power were14.04, 15.25, 16.96 and 17.22 kW respectively. Therefore, at measuring depth 21cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h the drawbar power were 15.16, 17.53, 19.60 and 20.69 kW respectively.

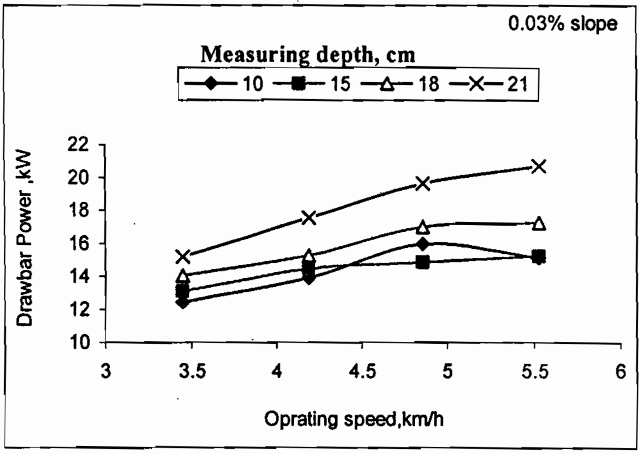


Fig.(9): Effect of operating speeds under different measuring depths on draw bar power at 0.03% slope.

CONCLUSION

1- The draft increased with the increase of measuring depth at zero level and 0.03% slope. The recorded draft of scraper for measuring depths 10, 15, 18, and 21cm were 11.57, 13.14, 13.93 and 15.2 kN and were 12.95, 13.64, 14.62 and 15.79 kN at 0.03% slope for operating speed 3.45km/h. While at the corresponding measuring depths the draft were 9.86, 9.81, 9.89 and 10.00kN (zero level) and 9.81, 9.88, 11.18 and 13.44kN at operating speed 5.53km/h respectively.

2- Corresponding pull decreased with the increase of operating speed under different measuring depth at zero level and 0.03% slope.

3- Drawbar power increased with the increase of operating speed. While at measuring depths 18 and 21cm, values increased until operating speed 4.86km/h and decreased at speed 5.53 km/h this resulted different because recorded lowest value for draft at zero level.

4- Drawbar power increased with the increase of operating speed under different measuring depth at 0.03% slope. The recorded of drawbar power for operating speeds 3.45, 4.19, 4.86, and 5.53km/h were 12.43, 13.89, 15.96 and 15.10kW respectively at measuring depth 10cm. While at measuring depth 21cm and operating speeds 3.45, 4.19, 4.86, and 5.53km/h drawbar power were 15.16, 17.53, 19.6and20.69 kW respectively.

5- At low operating speed the obtained high draft but consumed drawbar power was low while at high operating speed the obtained low draft but consumed draw bar power was high.

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تعديل حركة قصابية التسوية بالليزر

محمد أحمد الشيخة[1]، حسن البنا عثمان[2]، محمد عبد الفتاح مصطفي[1]و مؤمن فرحات السيد زايد[2]
١ قسم الهندسة الزراعية– كلية الزراعة– جامعة المنصورة
٢ معهد بحوث الهندسة الزراعية – مركزالبحوث الزراعية – الدقى – جيزة

أجريت تلك الدراسة بهدف تقييم حركة قصابية التسوية بالليزر بعد تعديل النظام الخاص برفع وخفض القصابية أثناء التشغيل الحقلى لتناسب إمكانية إضافة عدد ستة أسلحة صلبة أمام القصابية لتفكيك التربة الغير مثارة مما يسهل من إجراء عملية التسوية وبالتالي الحصول علي عمق تربة مثارة أسفل سطح التسوية مما يزيد من كفاءة التسوية.

ويمكن تلخيص النتائج المتحصل عليها فيما يلى :

١- زادت قوة الشد بزيادة عمق التشغيل أسفل سلاح قطع القصابية عند التسوية بدون ميل وبميل ٣سم لكل ١٠٠متر طولي حيث زادت علي سبيل المثال من ١١,٥٧ إلي ١٥,٢٠ كيلو نيوتن (بدون ميل) ومن ١٢,٩٥ الي ١٥,٧٩ كيلو نيوتن (ميل ٠,٠٣%) عند سرعة تشغيل ٣,٤٥ كم/س

٢- يتناقص الشد المطلوب بزيادة سرعة التشغيل وذلك في حالتي التسوية بدون ميل وبميل ٣سم لكل ١٠٠متر طولي.

٣- القدرة علي قضيب الجر تزداد بزيادة السرعة وذلك عند عمق ٢٠،١٨م حتى سرعة تشغيل ٤,٨٦كم/ساعة وتتناقص بعد ذلك عند سرعة تشغيل ٥,٥٣كم/ساعة ويرجع هذا الاختلاف نتيجة إنخفاض قيم الشد عند تلك المستويات عند التسوية بدون ميل.

٤- تزداد القدرة علي قضيب الجر بزيادة سرعة التشغيل عند مختلف الأعماق موضع الدراسة عند التسوية بميل ٠,٠٣%.

٥- من خلال التجربة يلاحظ عند التسوية بسرعات تشغيل منخفضة فإن قوة الشد تكون كبيرة ولكن القدرة المستغلة قليلة بعكس التسوية بسرعات تشغيل عالية فان القدرة تكون كبيرة ولكن قوي الشد صغيرة لذا ينصح باستخدام السرعات المنخفضة في بدايات التسوية.