Pakistan Journal of Applied Sciences 3 (7): 481-487, 2003
ISSN 1607-8926

A Research on Unit Costs and Factors Effective on Performance of Laserplane Grade Control System in Turkey

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Abstract: In this research, 0 and 3% slopes were given to laserplane grade control system for two different soil conditions. Effect of different soil conditions on landlevelling was investigated. Unit operating cost and accuracy of machine were found. For this aim soil resistance, volume weight and specific gravity were found for two different soil conditions. Human factor wasn't considered because operator wasn't changed. Accuracy of landlevelling for sellected two grade angles was tested using with nodal network system. Excavation-filling amount was determined for two field and two grade during landlevelling. Operating costs for unit time and unit area were calculated at the end of operations. Based on the experiment results, it has been found that a variation for first field is more than second field to excavation-filling amount. Desired grades for two field were obtained. These trials were performed at Trakya University Tekirdag Agricultural Faculty Research and Application Fields that have 40x20 m dimensions. In these trials Fiat Mara model laserplane grade control machine that has got 3 m work with and New Holland M 95 traktor was used for pulling of laserplane grade control machine.

Key words: Landlevelling, grade control, penetration resistance, machine operating costs

Introduction

Fields should carefully be prepared prior to production to achieve expected succes from the irrigated agriculture. For this aim, landlevelling is one of the most important activities. By this way either a straight surface without grade or graded field may be provided (Kadayifcilar and Erdogan, 1988).

Laser landlevelling is performed with earth-moving equipment automaticlly controlled by a laser grade control system. In conventional landlevelling, the grade can only be checked at the grade stake, which are usually spaced in a 30 m grid. With laser control systems, grade is checked and controlled continuously as the tractor and scrapers move across the field. Constant checking forms the basis for the precision of laser landlevelling (Anonymous, 1987). Field measurement and survey data included (Soedjatmika and Esmay, 1983)

- Age and experience of operators
- Operator experience in land preparation
- Hours worked per day
- Depth of tillage
- Plot size and percent untilled land
- Traveling speeds
- Actual field capacity
- Fuel and oil consumption
- Equipment price and operator wage
- Land holding
- Labor imputs

Three factors affect landlevelling, machine, soil and operator. The straightnes of landlevelling is provided using an appropriate combination of these three factors. As other agricultural operation, economy is an important aspect beside the accuracy of the produced work because fuel consumption is much during landlevelling.

Materials and Methods

Experiments were conducted on two different research field having different soil properties. Same laserplane machine with same operator and 95 HP 4 WD tractor were used during landlevelling for fields. Soil properties of the research fields are as shown in Table 1 (Bouyoucos, 1951).

A laser system consists of a laser transmitter, a 360 degrees receiver, a control box and cable kit and a hydraulic interface was used during the experiments (Table 2).

Laserplane (Spectra Physics) mark, 1145-S model transmitter was used as laser transmitter. Laser transmitter emits a thin 360 degress rotating beam of red laser light detectable to 10 mm accuracy at 300 metres. It provides a constant grade reference at any point over the work site. Its plane of light can be dead level, or tilted on one grade or tilted on two grades. The instrument electronically self-levels over the grade settings. It is powered by a 12 V battery and is mounted on a heavy tripod to set the beam height above the tractor cabin height.

Laserplane (Spectra Physics) mark receiver was used as laser receiver. Receiving system detects this beam at any point over the work area. It constantly sends grade information of the cutting edge depth in relation to this beam, "high", "low" or "on grade" to the control box mounted in the tractor cabin. Signals or grade on the control box allow the operator to adjust cutting edge to "on grade" manually by this his hydraulic levers or automaticlly if a hydraulic interface kit has been installed with the laser. Zeiss mark Ni 4 model nivelman was used to obtain the heights on field after landlevelling.

Table 1: Results of soil analysis for the research fields

	Profile depth (cm)	Clay (%)	Silt (%)	Sand (%)	Texture class	Bulk density (g.cm^{-3})
Field A	0-30	40.73	23.85	35.42	Clay loam	1.49
	30-60	43.64	24.30	32.06	Clay loam	1.60
Field B	0-30	25.45	15.93	58.62	Sandy clay loam	1.83
	30-60	21.18	11.73	67.09	Sandy clay loam	1.69

Table 2: Laserplane machine

Working width (m)	3.5
Length (m)	7
Closing manner	Mechanical
Hydraulic control mechanizm	Apart
Control manner of receiving system	Hydraulic
Sloping adjust	Mechanical
Required traction Power (HP)	70
Allowed maximum power (HP)	180

For the measturements, a mechanical penetrometer (Eijelkamp, Stiboka type) was used. The penetration values were determined according to ASAE standard S313.2 (ASAE, 1994; Bayhan ***et al.***, 2002).

Soil resistance has an impotant effects on the performance of the laserplane machine during the landlevelling. Penetrograph measuruments were done in stubble and tillaged field for 3% sloped and 0% sloped field before and after sloping operation. Penetrograph measurements were done three time for filled south area, middle area and excavated north area because fields have a natural grade.

Conic tip of penetrograph was shinked until 30 cm depth and soil resistance was recorded to determine soil penetration resistance. Penetration resistance at every 2.5 cm depth of soil was read as MPa.

Two different fields in the dimension of 20×40 m and having different soil texture (Table 1) were selected. Firstly the fields were tillaged by ploughing (30 cm) and fragmented by diskharrow then landlevelling was performed.

Field A was firstly sloped by 3% and then requirement measurements were taken. After that, it was sloped by 0% and measurements were completed. Slope of field was measured by using nedal network system and excavation-filling volume was determined after every sloping. The same procedure was repeted for field B (Yuksel and Albut, 1998).

Operating costs include the costs of labor, fuel and oil, repair and maintenance (Srivastava, 1993). Unit operating cost of every one landlevelling (Euro.h^{-1} and Euro.ha^{-1}) was determined after operations were done. Labor costs are € 3.182 hour^{-1}. Diesel fuel costs 0.82 €L^{-1}, while motor oil costs 2.87 €.L^{-1}.

Repair and maintenance costs tend to increase with the size and complexity and thus with the purchase price of the machine. The following equation from ASAE EP496 can be used to estimate accumulated repair and maintenance costs (Srivastava, 1993).

$$\frac{C_{rm}}{P_u} = RF_1 \left(\frac{t}{1000}\right)^{Rf_2} \quad (1)$$

Where:

C_{rm} : Accumulated repair and maintenance costs (€)

P_u : Purchase price of machine (€)

RF_1, RF_2 : Repair factors

t : Accumulated use (h)

Purchase price of landlevelling machine is 23500 Euro. Accumulated use of landlevelling machine was found as 8000 h.

Results and Discussion

Results of penetrograph measurument to determine the soil resistance were shown in Fig. 1 and 2.

As shown Fig. 1 and 2 penetration resistance values for field A and B for different depts are very close each other. The reason why the penetration resistances up to 30 cm for both fields after obtaining 0% slope were lower was because this part of the profile was filled. Determined penetration resistance valuses from upper of fields began to rise near surface.

This was because A and B fields have a natural grade. Determined slopes and excavation-filling volumes in the experiments are as Table 3 and 4.

Field A was provided with 2.844% grade angle after landlevelling whileit has 1.87% natural grade angle in the directions of north-south. It was provided with 0.09% grade angle in the direction of north-south and 0.004% grade angle in the direction of east-west after 0% landlevelling.

Table 3: Determined excavation-filling volume for field A (m^3)

Grade angle	Calculated excavation volume (m^3)	Calculated filling volume (m^3)	Excavation volume after levelling (m^3)	Filling volume after levelling (m^3)
3%	46.25	21.125	41.5	21.153
0%	26.412	85.95	23.7	87.825

Table 4: Determined excavation-filling volume for field B (m^3)

Grade angle	Calculated excavation volume (m^3)	Calculated filling volume (m^3)	Excavation volume after levelling (m^3)	Filling volume after levelling (m^3)
3%	73.2	65.475	69.225	58.725
0%	79.8	70.9	77.45	72.875

Table 5: Deviation in the excavation-filling volume for fields A and B

Grade angle		Field A	Field B
3%	Excavation volume	less 10.27%	less 5.43%
	Filling volume	more 0.13%	less 10.3%
0%	Excavation volume	less 10.26%	less 2.9%
	Filling volume	more 2.18%	more 2.8%

Table 6: Fuel consumption values

Grade angle		Fuel consumption (L.h^{-1})	Fuel consumption (€.h^{-1})
Field A	3%	16.767	13.749
	0%	14.909	12.225
Field B	3%	14.01	11.488
	0%	13.48	11.053

Table 7: Calculated operating costs for unit area and unit time

		Grade angle		Operating costs	
		(€.h^{-1})	Total (€.h^{-1})	(€.ha^{-1})	Total(€.ha^{-1})
Field A	3%	27.619		1651.06	
	0%	26.095	53.714	1076.42	2727.48
Field B	3%	25.358		1119.81	
	0%	24.92	50.278	944.72	2064.53

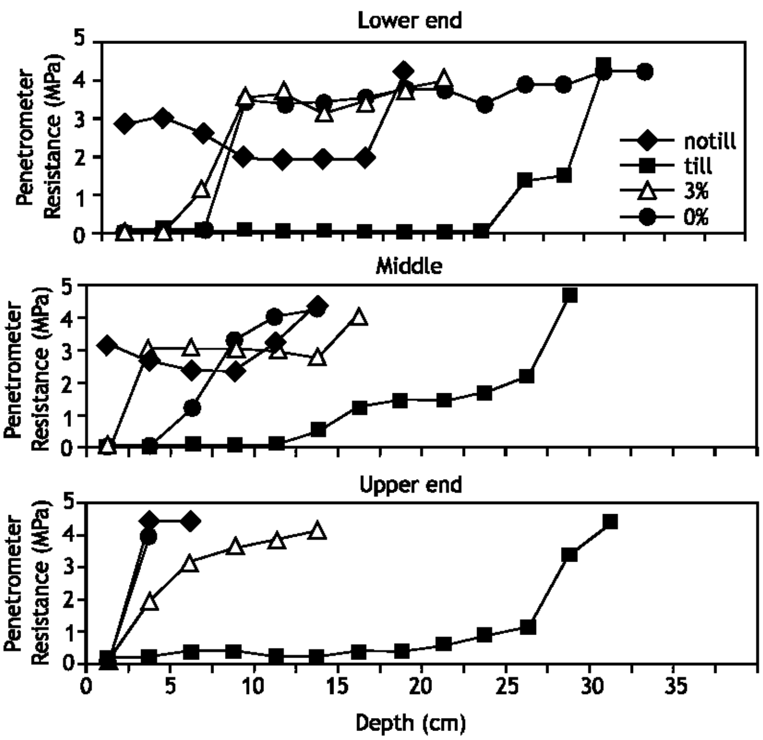

Fig. 1: Determined penetration resistance values for stubble, tillaged, 3 and 0% sloped in lower end, middle and upper end of field A

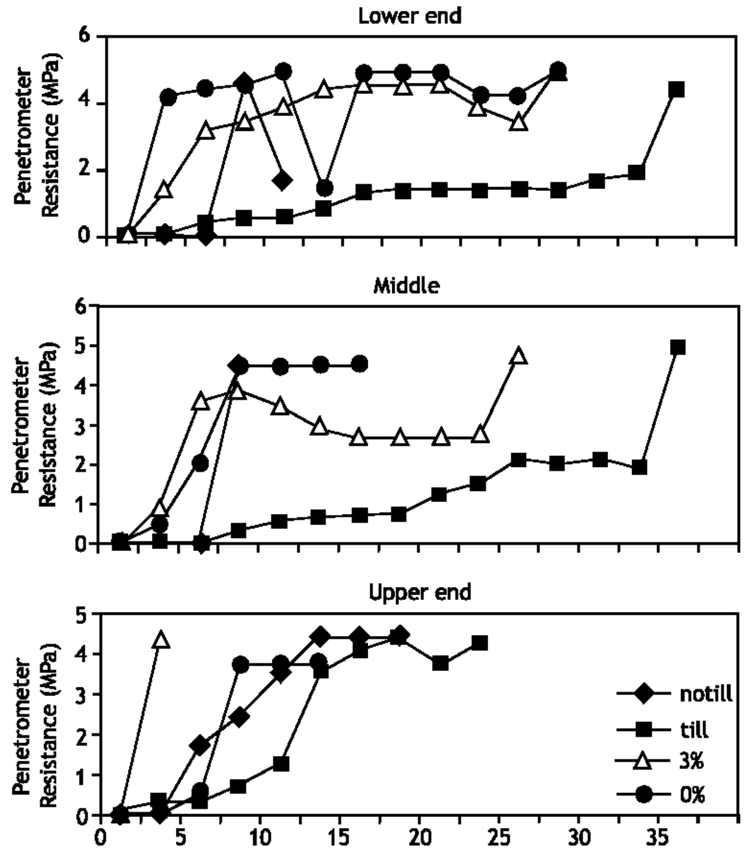

Fig. 2: Determined penetration resistance value for stubble, tillaged, 3 and 0% sloped in lower end, middle and upper end of field B

Error of 0.173% was obtained when achieving 3% slope for field. However errors of 0.1 and 0.0044% were recorded in the direction of north-south and south-west, respectively while creating 0% slope in the same field.

Field B was provided with 2.9% grade angle after landlevelling whileit has 1.98% natural grade angle in the directions of north-south. It was provided with 0.11% grade angle in the direction of north-south and 0.004% grade angle in the direction of east-west after 0% landlevelling.

Error of 0.11% was obtained when achieving 3% slope for field. However errors of 0.12 and 0.0044% were recorded in the direction of north-south and south-west, respectively while creating 0% slope in the same field. Deficiency and excess occured to excavation-filling volumes in the experiments (Table 5).

It occured minimum 0.13 and maximum 10.3% deviation in the calculate of excavation-filling volume.

More deviation was determined in field A for excavation-filling volume. However, this deviation was within the excepted ranges.

Operating cost of four operations made with laserplane machine was calculated at the end of the operations

More fuel was consumed in field A as shown in Table 6. When 0 and 3% were compared in respect to fuel consumption, more fuel was consumed in the latter for both field.

Operating costs for unit time and unit area were obtained at the end of operations and shown in Table 7. Costs for field A is more than field B as shown in Table 7. The factors effecting landlevelling in the experiments were as below.

- Soil properties and moisture content
- Experience of operator
- Correctness land preparation
- Power of tractor
- Actual field working capasity of equipment

Fuel and oil consumption, working hours and uniformity of land change depending on the this factors.

The same tractor landlevelling machine and operator was used for both fields and close penetration resistance values were obtained. The differences was attributed to the refferences in the fuel consumption due to the variation in the soil texture.

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