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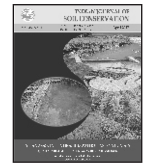

Resources conservation through laser guided land leveller for paddy cultivation in Raichur, Karnataka

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ABSTRACT

The present study was conducted to evaluate resources conservation using laser guided land leveller at research farms of University of Agricultural Sciences (UAS), Raichur, Karnataka. The study evaluated the volume of earthwork and cost economics in comparison with traditional levelling method for paddy crop. In paddy cultivation the precision of levelling depends on volume of earthwork in the cut or fill with respect to the desired plane in an area. The results indicated that the standard deviation of reduced levels of grid points of 10x10 m before levelling was 23.97 cm and after using the laser leveller was 1.59 cm. The standard deviation of reduced levels before and after levelling was 12.18 and 7.97 cm in traditional levelling. In case of traditional levelling the average volume of earthwork (cut and fill) was reduced from 69.1 to 41.91 m^3 and in laser levelling, it was reduced from 74.51 to 7.55 m^3. The reduction in volume of earthwork was 39.35% and 89.83% in traditional and laser levelling methods, respectively. The field capacity of the levelling operations for paddy cultivation was 0.071 ha h^{-1} and 0.081 ha h^{-1} in case of in laser levelling and traditional levelling, respectively. The cost of levelling for paddy cultivation was ₹11138 ha^{-1} in laser levelling and ₹ 7491 ha^{-1} for traditional levelling. 30.31% higher cost/ha in case of laser levelling was due to more volume of earthwork turned out during levelling.

1. INTRODUCTION

In agriculture production system precision agriculture plays an important role in augmenting food security especially with the changing scenario of climate change (Rajput and Patel, 2003). Precision agriculture is essentially a more precise farm management practice which can be made possible application of modern farm technology in farming (Playan *et al.,* 1996). It is a new paradigm shift from traditional management practices of the soil and crop with spatial variability to suit variation in resource condition. Land development is an important operation for good agronomic, soil and crop management practices (Rajput *et al.,* 2004 and Rajput and Patel, 2004). Traditional methods of levelling land are not accurate as they depend purely on driver's judgement (Rickman, 2002) which leads to more variability. A significant 20-25% amount of irrigation water was lost during its application at the farm due to poor farm designing and unevenness of the fields (Cook, 1960 and Kahlown *et al.,* 2000). The mechanisation of most agricultural work has required land levelling and land consolidation before planting, which alters the natural drainage and soil hydrology as well as the soil properties (Ramos and Casasnovas, 2007).

In irrigated and rainfed environments, precision land levelling improves uniform application of water, betters the crop stands and helps to reduce abiotic stress intensities, enhancing survival of young seedlings and robustness of the crop to withstand stress and stabilize yields through improved nutrient-water interactions. Laser-assisted precision land levelling saves irrigation water, nutrients and agro-chemicals (Kahlown *et al.,* 2000). It also enhances environmental quality and crop yields. In spite of the known benefits of precision land levelling, Indian farmers are unable to take full advantage of it and have to rely on traditional methods of land levelling which are labour intensive and crude, and do not achieve a high level of smoothness of land surface (Aggarwal *et al.,* 2010).

Land development and scientific irrigation assume key role in precision farming. A comparative evaluation of the laser guided land leveller with the existing system of levelling showed that the percentage reduction in standard deviation of reduced level, before and after levelling was 85.7% for laser levelling and 46.79% for conventional method, which was 38.91% lower than the laser levelling (Anuraja *et al.,* 2013). From the results of contours analysis, it was observed that considerably higher accuracy of grading was obtained when the fields were graded by use of the laser leveller.

Research conducted by Punjab agricultural University, Ludhiana has shown a large increase in rice yield due to proper field levelling (Aggarwal *et al.,* 2010). For the same rice varieties and the same fertilizer input, the average increase in crop yield was found to be 24%. Improved water coverage from better land levelling reduces weeds by up to 40%, irrigation time by 47-69 hr ha^{-1} season^{-1} and improved yield by approximately 7% compared with traditionally levelled fields (Aggarwal *et al.,* 2010).

Conservation agriculture practices coupled with precision land levelling facilitate uniform water application and reduce deep percolation losses of water (Corey and Clyma, 1973 and Sattar *et al.,* 2003). Precision land levelling helps even distribution of soluble salts in salt-affected soils (Khan, 1986), increases cultivable land area up to 3-5% (Choudhary *et al.,* 2002 and Jat and Chandana, 2004), improves crop establishment, reduces weed intensity (Rickman, 2002) and results in saving in irrigation water (Ali *et al.,* 1975; Khattak *et al.,* 1981; Jat *et al.,* 2003 and Panigrahi, 2009).

Paddy is a major crop in Tungabhadra Command area of Karnataka which needs precise land development to reduce the wastage of water. This leads to precise levelling techniques to conserve more valuable resources *viz.,* soil and water. Social and economic constraints have led to the introduction of new intensive management systems in agriculture (Kanannavar *et al.,* 2009). So, the precision in relation to earthwork needs to be studied and compared with the traditional method of levelling. The present study was conducted to evaluate the feasibility of tractor operated laser guided land leveller in respect of earthwork, its precision and cost economics in comparison with traditional levelling method in the research farms of UAS, Raichur.

2. MATERIALS AND METHODS

The present study was conducted at research farms of University of Agricultural Sciences (UAS), Raichur, Karnataka in paddy field. In this study comparative evaluation, the laser leveller (levelling with a Laser guided land leveller) with the traditional system of levelling was carried out in paddy fields. The details of selected fields have area 2100 m^2 (60 x 35 m). In order to eliminate differences in leveller performance due to design of the drag scraper, the same capacity bucket was used for both levellers study.

Laser Guided Land Leveller

A commercial unit of laser guided land leveller was used. The laser controlled system consisted of (i) Laser transmitter, (ii) Laser receiver (iii) Laser plane receiver (iv) Control box (v) Twin solenoid hydraulic control valve (vi) Drag scrapper. The view of the field before and after laser levelling is shown in Fig. 1.

The laser transmitter transmits the laser beam, which is intercepted by the laser receiver mounted on the levelling bucket. Receiver sends the signals through cable to control box mounted with tractor which is also operated by the operator (driver). This control box operates the valves to raise or lower the levelling bucket. The transmitter mounts on the tripod stand which allows the laser beams to sweep above the tractor unobstructed. The reduced level of grid

Fig. 1. View of the field before and after laser levelling

points (10 x 10 m) were taken prior to levelling operation in both the fields which is shown in the Table 1 and Table 2.

Standard surveying and levelling procedures were followed. No grade (slope) was given to the land. All surface residues were cut and removed to aid soil flow from the bucket to achieve the field for mean value. The laser controlled bucket was positioned at a point that represents the mean height of the field and the cutting blade was set slightly above ground level (1-2 cm). For evaluating traditional levelling the manually hydraulic system was used (Suthakar *et al.*, 2008). After the field preparation, a topographic survey was conducted to record high and low spots in the field.

Earthwork Quantity

The land levelling earth work was estimated using four point method (eq.1 and eq. 2) (Michael 2010).

$$V_f = \frac{L^2}{4}\frac{(\sum F)^2}{(\sum C + \sum F)} \quad ...(1)$$

$$V_c = \frac{L^2}{4}\frac{(\sum C)^2}{(\sum C + \sum F)} \quad ...(2)$$

Which, V_f = volume of fill, m^3, V_c = volume of cut, m^3, L = grid spacing, m, $\sum C$ = sum of cuts on four corners of grid square, m, $\sum F$ = sum of fills on four corners of grid square, m.

The cost of the operation of the laser guided land leveller and traditional leveller including tractor were estimated by straight line method. The estimated total cost per hour including fixed and variable cost was calculated (Sahay, 2006) using standard method.

3. RESULTS AND DISCUSSION

The present study was conducted to evaluate the performance of laser guided land leveller for Paddy cultivation. The study includes to determine volume of earthwork and cost involved in relation to precision of levelling in different levelling methods *viz.,* traditional and laser levelling and field capacity levels. The details of field before and after levelling is illustrated in Table 3. It is evident from Table 3 that variation in standard deviation of reduced levels corresponding to a plane was 12.18 to7.97 and 23.97 to 1.59 cm for traditional and laser levelling, respectively. The high value of standard deviation was mainly due to presence of a grade or slope in the field. The standard deviation value of reduced levels represents the accuracy of levelling, which was calculated for each field after levelling. The standard deviation of reduced levels before levelling was 12.18 cm and after levelling was 7.97 cm using the traditional leveller. The standard deviation of reduced levels before levelling was 23.97 cm and after levelling was 1.59 cm using the laser leveller. The 93.36% standard deviation was reduced in the case of laser levelling, whereas, for the traditional method it was 34.56%, which was 58.80% lower than the laser levelling. Hence the accuracy of levelling using laser leveller is higher with more precision than traditional methods since the standard deviation was only 1.59 cm. The result also supported by study conducted Mathankar *et al.* (2005).

The volume of the earthwork was calculated for both the fields before and after levelling. The results of earthwork are shown in Table 4. It is evident from the Table 4 that the volume of earthwork before and after levelling was 69.101 m^3 and 41.90 m^3 in case of traditional levelling. In case of laser levelling method the volume of earthwork before and after levelling was found, 74.51 m^3 and 7.55 m^3, respectively. The volume of earthwork turned out was 89.83% in laser levelling and 39.35% in case of traditional levelling.

The Field capacity and levelling cost/ha for traditional and laser levelled fieldhas also determined. The field capacity using laser leveller field was observed as 0.071 ha h^{-1}, whereas, without using the laser system, the field capacity was 0.081

Table: 1
Reduced levels of field before traditional levelling

Grid Point	1	2	3	4	5	6	7
A	98.65	98.66	98.57	98.46	98.40	98.42	98.41
B	98.67	98.65	98.69	98.64	98.48	98.44	98.40
C	98.66	98.64	98.60	98.58	98.51	98.48	98.42
D	98.68	98.66	98.61	98.52	98.46	98.41	98.42

Table: 2
Reduced levels of field before precision levelling

Grid Point	1	2	3	4	5	6	7	8
A	99.15	99.09	99.13	98.89	99.79	98.53	98.55	98.51
B	99.14	99.08	99.11	98.77	98.79	98.51	98.55	98.53
C	99.16	99.08	99.10	98.82	98.72	98.50	98.58	98.52
D	99.13	99.07	99.11	98.68	98.66	98.51	98.53	98.50

Table: 3
Details of selected field

Parameters	Traditional levelled field	Laser levelled field
Length (m)	60	70
Width (m)	35	25
Area (m²)	2100	1750
Standard deviation before levelling, cm	12.18	23.97
Standard deviation after levelling, cm	7.97	1.59

Table: 4
The volume of earthwork before and after levelling using traditional and laser levelling

Particulars		Before levelling (m^3)	After levelling (m^3)	Per cent earthwork turned out (%)
Laser levelling field	Volume of cut	79.53	7.82	90.15
	Volume of fill	69.49	7.27	89.52
	Average	74.51	7.55	89.83
Traditional levelling field	Volume of cut	69.1	42.3	38.77
	Volume of fill	69.1	41.5	39.93
	Average	69.1	41.9	39.35

ha h^{-1}. The reasons for variations in standard deviations and field capacities are due to newly formed cultivable land and higher degree of hardness of the soil profile. The cost of operation of the tractor and leveller combination was calculated both for laser guided land leveller and traditional leveller using standard method. The cost of operation of the laser guided land leveller was ₹ 791 h^{-1} as compared to ₹ 607 h^{-1} for the traditional leveller. The cost of the operation was 30.31% costlier for the laser guided land leveller as compared to the traditional leveller. The field capacity of the laser leveller was observed as 0.071 ha h^{-1}, whereas, without using the laser system, the field capacity of the leveller was 0.081 ha h^{-1}. The reduced levels of both the fields are given in Table 5 and Table 6. The earthwork volume was calculated using four point method for both fields (Michael, 2010). The field capacity and costs of levelling per hectare for both the levelling methods (system) were calculated.

The contour maps of two dimensions (2D) and three dimensions (3D) for traditional method before and after levelling are shown in Fig. 3 and Fig. 4. Simultaneously the contour maps of two dimensions (2D) and three dimensions (3D) for precision block before and after levelling are shown in Fig. 5 and Fig. 6. All contour maps are presented with a contour maps interval of 5 cm. These maps have been developed with respect to a level plane.

It is evident from Fig. 5 and Fig. 6, that accurate grading was possible using the laser guided land leveler as seen from parallel lines or evenness in the contour map. The grading was not so accurate at end of field, since there was difficulty ineffectively reaching the corners of the field due to large

Table: 5
Reduced levels of field after traditional levelling

Grid Point	1	2	3	4	5	6	7
A	98.48	98.46	98.47	98.43	98.52	98.59	98.63
B	98.44	98.46	98.44	98.48	98.43	98.56	98.61
C	98.47	98.45	98.46	98.49	98.43	98.57	98.64
D	98.45	98.47	98.41	98.54	98.56	98.56	98.62

Table: 6
Reduced levels of field after precision levelling

Grid Point	1	2	3	4	5	6	7	8
A	98.81	98.75	98.79	98.79	98.78	98.75	98.80	98.79
B	98.80	98.77	98.80	98.79	98.79	98.80	98.78	98.79
C	98.80	98.81	98.79	98.79	98.77	98.80	98.78	98.79
D	98.76	98.77	98.79	98.79	98.80	98.81	98.77	98.75

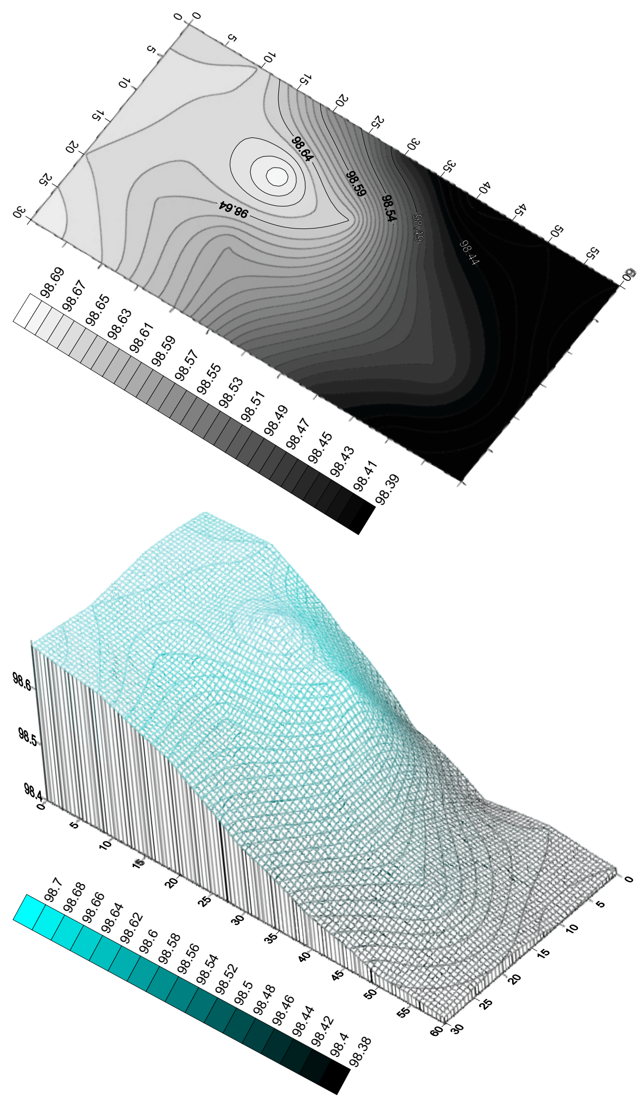

Fig. 3. The contour maps (2D and 3D) for traditional block 1 before levelling

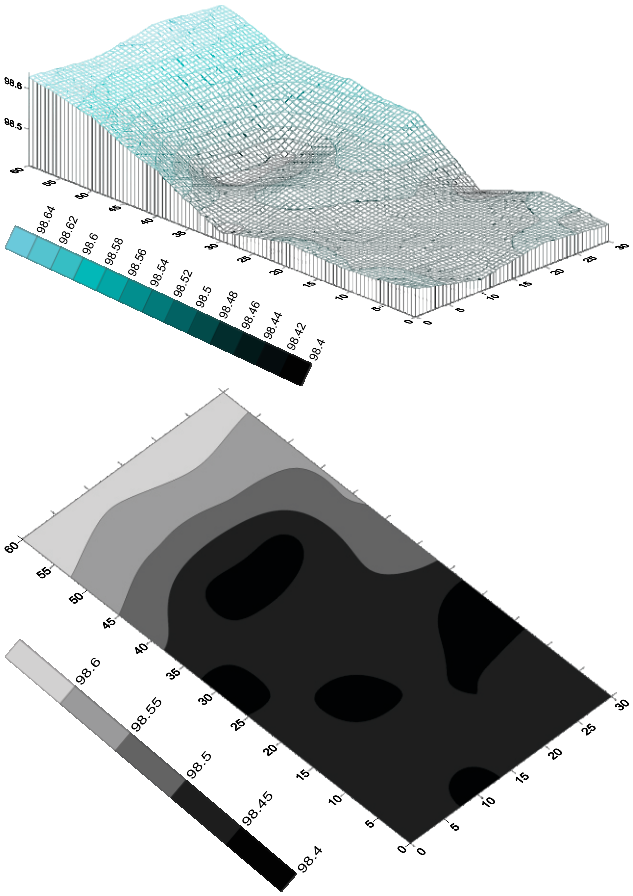

Fig. 4. The contour map (2D and 3D) for Traditional block 1 after levelling

turning radius. From the Fig. 4 and Fig. 5, it was observed that grading of the field without laser components was less accurate as compared to the laser system. From the contour maps it was also clear that similar trend of unevenness in grading was obtained in the field corners as observed in the case of laser leveled portion of the fields. The trend of the results are in agreement with the findings of Sudhakar *et al.* (2008). However, the undulations on the field are relatively more in conventional method.

4. CONCLUSIONS

It was observed from contour maps and standard deviation of reduced levels that higher accuracy of grading was observed when the fields were graded by use of laser guided land leveller in comparison to using the leveller without laser systems. The field capacity of using laser leveller was observed as 0.071 ha h^{-1} whereas, without using the laser system, the field capacity was 0.081 ha h^{-1}. The cost of operation /h was 30.31% costlier in case of laser guided land leveller as compared to the traditional leveller but water and fertilizer use efficiency is higher. The volume of earthwork turned

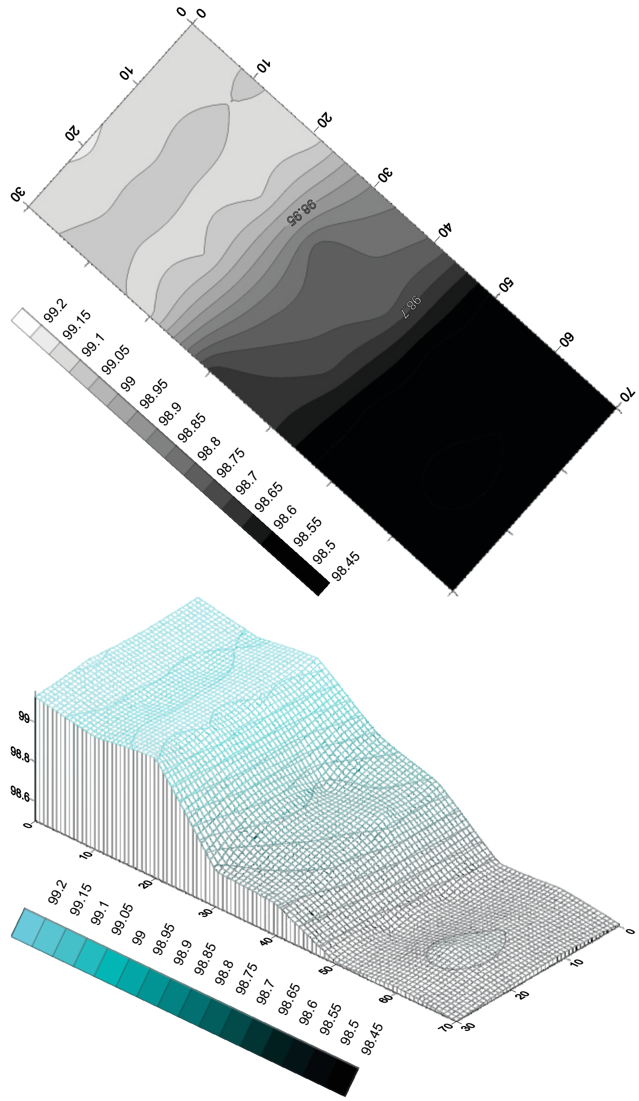

Fig. 5. The contour map (2D and 3D) for precision block before levelling

out was very high (89.83%) in laser levelling compared to traditional levelling (39.35 %).

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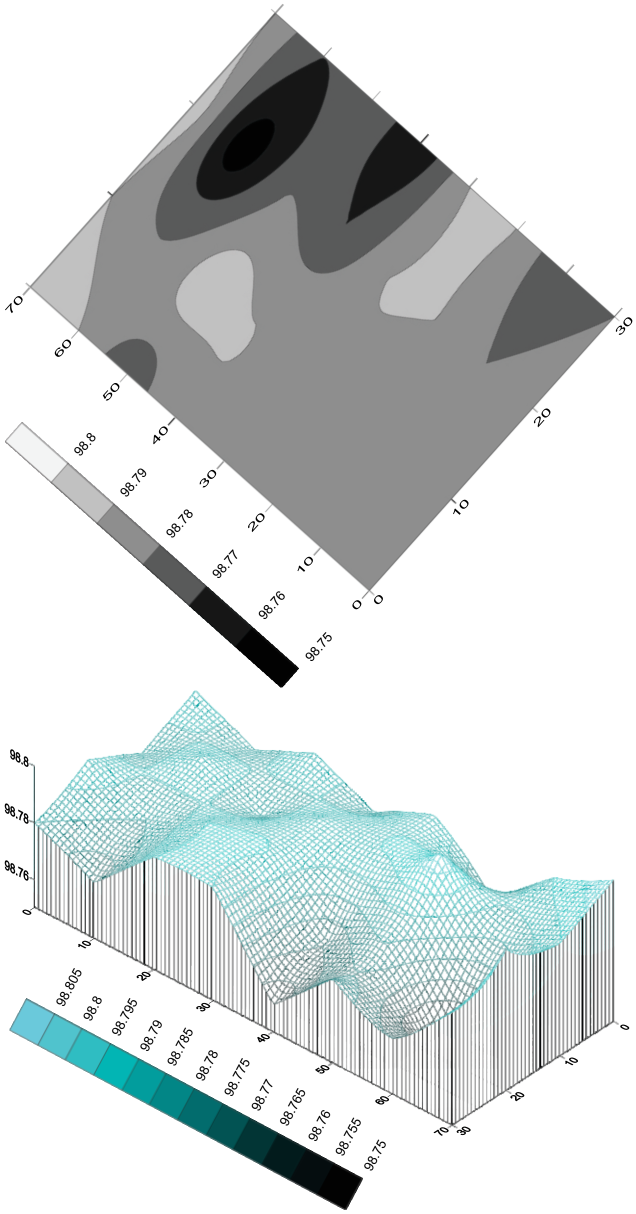

Fig. 6. The contour map (2D and3D) for precision block after levelling

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