IMPACT OF PRECISION LEVELING ON SPATIAL VARIABILITY OF MOISTURE CONSERVATION IN ARID ZONES OF KARNATAKA

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ABSTRACT

Precision farming is the need of the hour for increasing the food production by providing innovative techniques to address spatial variability prevalent in agricultural fields. Laser leveling is such a technique that can assist in reducing spatial variability in soil moisture content across a field. This approach is particularly helpful in arid regions such as Raichur. A study was conducted in research farms of UAS, Raichur to find the feasibility of using a tractor operated laser guided land leveler to control spatial variation in moisture content distribution. A comparative evaluation of the laser guided land leveler with the existing system of leveling with respect to leveling index, moisture distribution was undertaken. The results showed that the standard deviation of reduced levels before leveling was 11.42 cm and after using the laser leveler was 1.43 cm. The standard deviation of reduced levels before leveling was 14.43 cm and 8.63 cm after leveling using the conventional leveler for leveling. This accounted for a reduction of 47.42 per cent for laser leveling. From contours analysis higher accuracy of grading was observed when the fields were graded with the laser leveler which led to uniform distribution of moisture storage in the field. After rainfall of 19mm and 70mm at different durations, the average uniformity coefficients of moisture content distribution and standard deviation in case of precision leveled fields were found to be 93.63 per cent and 3.53 per cent respectively. The same were 74.41 per cent and 10.73 per cent respectively in case of traditional leveling. The leveling indices after leveling were 1.22 cm and 6.69 cm**,** respectively, for precision leveled and traditionally leveled fields. The spatial variability of moisture conservation was observed to be very less in case of precision leveled plots as compared to traditionally leveled plots. However, the cost of operation was 23.14 per cent higher in case of Laser guided precision leveler. The practice of precision leveling reduces the spatial variability by reducing leveling index and also enhancing better conservation of moisture and its utilization in arid zones of Northern Karnataka where water resources are very limited.

Key words: Precision leveler, Laser leveler, Moisture conservation, Spatial Variability, Moisture Contours

INTRODUCTION

In agriculture land and water are playing important roles. Precision farming is the need of the hour for increasing the food production for the growing population in our country. For this precise land development and scientific irrigation methods are important. Unevenness of the soil surface has a major impact on the germination, spatial variability of water saving and crop yield. Traditional methods of leveling lands are more cumbersome and time-consuming. Studies have indicated that a significant (20-25%) amount of irrigation water is lost during its application at the farm due to poor farm design and unevenness of the field (Cook and Peikert, 1960). Land leveling saves irrigation water and facilitates field operation and increases yield (Rickman, 2002). Leveled land also helps in mechanization of various field operations. Several types of land levelers such as bucket scrapers, drag scrapers, land smoothers and bull dozers are used for leveling both to obtain a perfectly level field (0% slope) and to obtain a field with the desired slope. At present most of the fields are small and undulating, which results in waste of irrigation water and inefficient use of farm machinery. For an efficient conservation and uniform distribution of rain water in dry lands, the level difference between high and low spots of a field should not exceed 20 mm whereas under actual field conditions, a difference of 50 to 100 mm is very common. The laser leveling is state of the art of technique. It is being used in civil engineering projects but very rare usage is found in farmers' field. To bridge a gap in usage of this technology in agriculture research was felt necessary. Also in this part of arid agro climatic zone conservation and of rain water is very much essential. This is possible only through precise levelers using laser technology. No study was available for this technology in this part. Hence, the present study to find the advantages of a tractor operated laser guided land leveler with respect to spatial variability of moisture conservation of rain water was carried out in the research farms of University of Agricultural Sciences (UAS), Raichur, Karnataka

MATERIALS AND METHODS

In this study comparative evaluation of the laser guided land leveler with the existing system of leveling was made in respect of spatial variability of moisture conservation under clayey soils, during 2010-11. The experimental plots of UAS Raichur lie between the latitudes and longitudes of 16^{0}12'10.2" N, 77^{0}19'33.1"E and 16^{0}12'16.8" N, 77^{0}19'30.7"E. The area falls under North Eastern Dry zone of Karnataka with an annual average rainfall of 621 mm, maximum and minimum temperatures of 41.3^{0}C and of 13.3^{0}C and maximum and minimum relative humidity of 93 per cent and 60 per cent. In order to eliminate differences in leveler performance due to design of the drag scraper, the same leveler was used for both traditional and laser leveling studies. The laser leveler, model "AG 401"was used for the study (Make: Spectra Precision Pvt. (Ltd) New Delhi, India). For evaluating traditional leveling the laser system was not used and the hydraulic system was actuated manually.

Description of laser guided land leveler

A commercial unit of laser guided land leveler was used for the study. The laser-controlled system consisted of (i) Laser transmitter with a tripod, (ii) Laser eye-receiver, (iii) Laser plane receiver,(iv) Control box (v) Twin solenoid hydraulic control valve, (vi) Drag scrapper.

The laser transmitter transmits a laser beam, which is intercepted by the laser receiver mounted on the leveling bucket. The control box mounted on the tractor intercepts the signals from receiver and opens or closes the hydraulic control valve, which will raise or lower the bucket in order to achieve the desired level. The laser transmitter mounts on a tripod stand which allows the laser beam to sweep above the tractor unobstructed. With the plane of laser beam (light) above the field, several tractors can work from one transmitter.

Methodology

In order to evaluate accuracy of the laser system, two treatments were taken *viz.*, (a) leveling with laser guided leveler and (b) leveling with same leveler and prime mover without using the laser transmitter and laser plane receiver, *i.e.* conventional land leveling method. The reduced levels of grid points (10 x10 m) were taken prior to and after the leveling operation, following standard surveying and leveling procedures. No grade (slope) was given to the land. The standard deviations of reduced levels of the grid points were calculated. The field was ploughed using a disk plow in order to increase the topsoil volume. Further a cultivator was used, followed by rotavator to achieve the fine tilth of the soil to ensure smooth flow of soil in the leveler scraper (bucket). After the field preparation, a topographic survey was conducted with an auto level to record the high and low spots in the field. From the surveyed readings, the mean reduced levels of the field were then established. Fig.1. shows the operational view of leveling with laser technology. Fig.2. shows the flow chart of methodology followed in this study.

Fig. 1.Operational View of Laser leveler and final view of laser leveled field

Contour survey of unleveled fields

⇩

Ploughing and pulverizing the fields

⇩

Leveling the fields with laser and without laser transmitter

⇩

Contour survey of leveled fields and Surfer analysis

⇩

Moisture content determination at center of grid points after rain and Calculation of moisture distribution uniformity

Fig. 2. Flow chart of methodology adopted in the study.

Procedure

The plots were divided into two portions. In one portion, the leveling operation was carried out using the laser guided land leveler, whereas, in the second portion, the control box switch was set to MANUAL and leveling carried out by using judgment and skill of the tractor driver *i.e.* traditional leveling. In the latter case, for lowering and lifting of the leveler blade, the RAISE and LOWER switches of the control box were used. The reduced levels were taken at all grid points with the help of auto level and leveling staff using survey procedures at a spacing of 10 x 10 m. To determine reduced level of each grid point “height of instrument method” of surveying was used. The average reduced levels and standard deviation of reduced levels of the grid points were calculated. 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). Further, the mast was moved up or down till the green light was displayed in the control box. The setting was changed to AUTO in control box. The land leveling was started until all portions of the field showed green light. The tractor was then driven in a circular direction from the high areas to the lower areas in the field. When the whole field has been covered in the circular manner, a final leveling pass was made in long runs from the high end of the field to the lower end. After the operation, contour or grid survey of field was again carried out using the auto level. As before, the average reduced levels and standard deviation of reduced level of the grid points were again calculated. For a subjective assessment of accuracy of leveling, contour maps were plotted before and after leveling. The contour maps were plotted against a level field as the base. The costs of leveling per ha, for both the system were also calculated using standard procedures (Jagdishwar Sahay, 2006)

Moisture distribution Uniformity: After rainfall the moisture contents at grid points were measured and its distribution uniformity or Uniformity co-efficient was calculated in both the fields using Christiansen formula

$$Cu = 100\left[1 - \frac{\sum X}{mn}\right]$$

Where,

Cu = Uniformity Coefficient or Moisture distribution Uniformity, %

m = Average value of all moisture contents, %

n = Total number of grid points

X = Numerical deviations of individual observations or grid moisture content from the average moisture content.

The leveling Index of the fields before and after leveling was calculated using equation given by Agarwal and Goel (1981).

$$\text{Leveling index} = \frac{\sum \text{Numerical difference between the designed and existing grid levels}}{\text{Number of grid points}}$$

The slope of the plane best fit in X and Y directions before and after leveling was determined by the least squares method. In a rectangular area this can be represented by the following equation**.**

$$S=\frac{\sum(D\times H)-\frac{\left(\sum D\times\sum H\right)}{n}}{\sum(D^2)-\frac{\left(\sum D\right)^2}{n}}$$

where,

S = slope of the line in a plane in % (dimensionless)
D = distance from the reference line in m
H = elevation of the grid point in m
n = number of grid points

RESULTS AND DISCUSSION

From Table.1, it was observed that the standard deviation of reduced levels corresponding to a plane before leveling was 11.41 cm and 14.43 cm for laser and traditional leveling respectively. The high value of standard deviation was mainly due to presence of a grade or slope in the field. To assess the accuracy of leveling, the standard deviation of reduced levels was calculated for each field after leveling. The standard deviation of reduced levels after leveling was 1.43 cm (field No. 2) and 8.63 cm (field No.1) for laser and traditional leveling respectively. The field capacity of the laser leveler was observed as 0.078 ha h^{-1}, whereas, without using the laser system, the field capacity of the leveler was 0.086 ha h^{-1}. The findings by Mathankar *et al.*, 2005, on comparison of the performance of the laser guided land leveler with conventional methods were that the standard deviation of reduced levels varied from 1.9 to 4.4 mm as compared to values of 25.0 to 30.2 mm for leveling without using laser system.

Table1. Observations from selected fields before and after leveling.

Parameters	**Values**	
	Field 1(Traditional leveling)	**Field 2 (Laser leveling)**
Length of field, m	80	90
Width of field, m	70	70
Area of field, m^2	5600	6300
Range of elevation height, cm	30.4 to -56	21 to -24
Standard deviation before leveling, cm	14.43	11.41
Standard deviation after leveling, cm	8.63	1.43
Leveling index before leveling, cm	11.69	9.67
Leveling index after leveling, cm	6.69	1.22

Field Capacity, ha h^{-1}	0.086 ha h^{-1}	0.078 ha h^{-1}/h

The 87.47 % standard deviation was reduced in the case of laser leveling, whereas, for the conventional method it 40.05 %, which was 45.78 % lower than the laser leveling. (Chaudhuri *et al.*, 2005). Since the standard deviation was only 1.43 cm, the accuracy of leveling using laser leveler was more precise than the traditional method. The contours of the field before conventional leveling and laser leveling, namely for field no. 1 and field no. 2 were shown in Fig.3 and Fig.4 respectively.

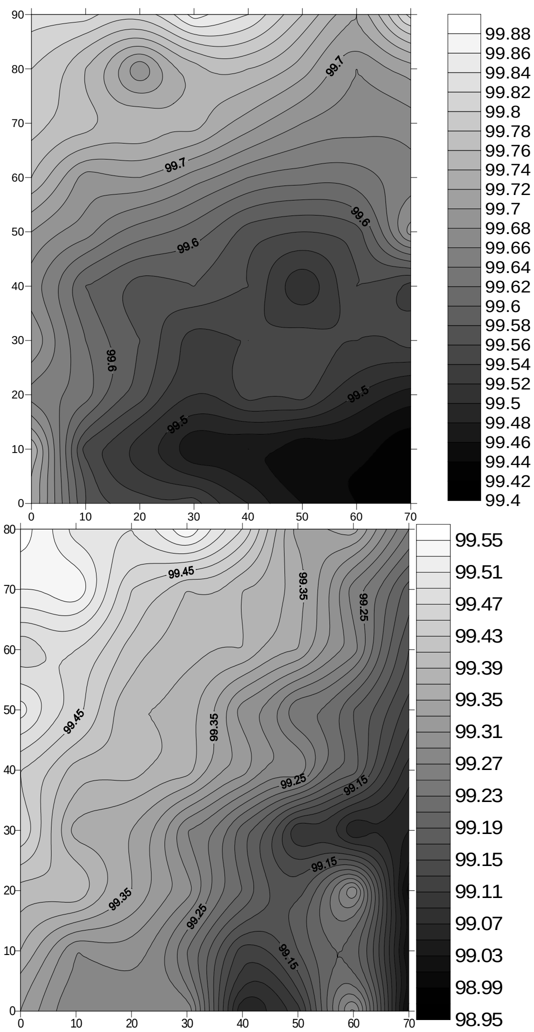

Fig. 3 and 4. The contour maps for before leveling the field using laser leveler and traditional method.

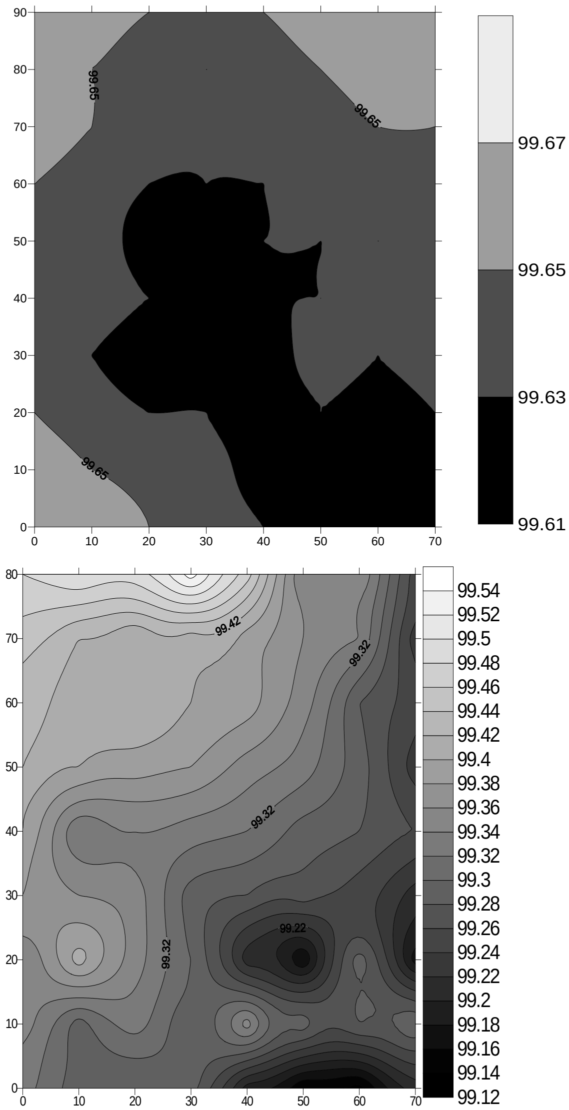

Fig. 5 and Fig. 6: The contour maps for after leveling the field using Laser leveler and traditional method.

For a subjective assessment of accuracy of leveling contour maps were plotted before and after leveling for both the fields using the SURFER 8.0 package. The contour maps for fields after leveling with laser leveler and conventional leveler were shown in Fig. 5 and Fig. 6.

From contour maps it was observed 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 in effectively reaching the corners of the field due to large turning radius of the tractor. From Fig. 4 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. However, the undulations on the field were relatively more in traditional method. This was further confirmed the results obtained from standard deviation of the surveyed readings.

Increased value of leveling index, indicating non-uniform topography reduced the moisture distribution uniformity. From Table 1 and Table 2, the laser leveled field having the leveling index value was almost nearer to zero grade level *i.e.*, 1.22 cm and recorded 93.63 per cent average moisture uniformity after rainfall. In case of traditional leveling index was 6.69 cm and recorded average moisture uniformity of 74.41 per cent after rainfall. With increase of leveling index resulted in lower uniformity of moisture conservation or moisture distribution efficiency. Results were confirmed with the findings of Raj Vir Singh et al. (1988).

From Table 2, after rainfall of 19 mm and 70 mm at different durations, the average uniformity coefficients of moisture content distribution and standard deviation in case of precision leveled fields were found to be 93.63 per cent and 3.53 per cent respectively. The same were 74.41 per cent and 10.73 per cent respectively in case of traditional leveling. This was mainly due to accuracy of grading, lower leveling index and highest slope reduction in case of Laser leveled fields. It showed that uniform topography resulted in uniform moisture distribution and non-uniform topography led to higher spatial variability of moisture retention and distribution.

Table 2. Moisture content readings for traditional and laser leveled fields

Particulars	**Traditional leveled field**			**Laser leveled field**		
	After 1st rainfall of 19 mm	After 2nd rainfall of 70 mm	Average	After 1st rainfall of 19 mm	After 2nd rainfall of 70 mm	Average
Average moisture content	30.38	36.60	-	30.64	38.26	-
Standard deviation	9.11	12.35	10.73	3.73	3.32	3.53
Uniformity coefficient, %	75.9	72.93	74.41	92.9	94.36	93.63

The cost of operation of the tractor and leveler combination was calculated both for laser guided land leveler and conventional leveler as per the standard procedures. The cost of operation of the laser guided land leveler was \$ 14 h^{-1} (INR Rs. 709 h^{-1}) as compared to \$11 h^{-1} (INR Rs. 545 h^{-1}) for the traditional leveler. The cost of the operation was 23.14% higher for the laser guided land leveler as compared to the traditional leveler as the sub surface conditions were hard.

The cost of leveling was considerably higher when the laser guided land leveler was used. The cost of leveling per hectare using the laser leveler was \$ 180 ha^{-1} (INR Rs. 8997 ha^{-1}) and \$ 127 ha^{-1} (INR Rs. 6333 ha^{-1}) traditional leveling. The cost of operation in terms of per unit area was considerably higher when the laser systems of the leveler were in the operation in contrast to grading without use of laser system. This was due to high initial cost of the laser guided land leveler.

Table 3**.** shows slopes of traditional and laser leveled fields before and after leveling. From

Table 3. Per cent slope reductions in X-direction and Y-directions were 31.03 and 51.06 respectively in fields leveled by traditional method. On the other hand per cent slope reductions in X-direction and Y-directions were 93.43 and 91.05 respectively in

fields leveled with laser leveler. This showed the more uniform topography in laser leveled fields.

Table 3. Slopes of the traditional and laser leveled fields before and after leveling

Particulars		Traditional leveled(field#1)	Laser leveled(field #2)
Slope In X direction (%)	Before leveling	0.29	0.32
	After leveling	0.20	0.021
	% reduction of slope	31.03	93.43
Slope In Y direction (%)	Before leveling	0.47	0.19
	After leveling	0.23	0.017
	% reduction of slope	51.06	91.05

CONCLUSIONS

1. It was observed from contour charts and from values of standard deviation of reduced levels that considerably higher accuracy in grading were observed when the fields were graded by laser guided land leveler in comparison to using the leveler without laser systems.
2. The field capacity of the laser leveler was observed as 0.078 ha h^{-1} whereas, without using the laser system, the field capacity of the leveler was 0.086 ha h^{-1}. The cost of leveling per hectare using laser leveler is $ 180 ha^{-1} (INR Rs. 8997 ha^{-1}) whereas it was $ 127 ha^{-1} (INR Rs. 6333 ha^{-1}) for tradintional leveling.
3.The slope reduction was more and leveling index was very less in case of laser leveled fields resulting to more uniform distribution of rain water and less spatial variability of moisture distribution.
4. Cost of grading was considerably higher when the laser-guided land leveler was used for grading in comparison to using the leveler without laser system. The cost of operation of the laser guided land leveler was $ 14 h^{-1} (INR Rs.709 h^{-1}) as compared to $11 h^{-1} (INR Rs.545 h^{-1}) for the conventional leveler. The cost of operation was 23.14 % costlier in case of laser guided land leveler as compared to the traditional leveling.
5. The moisture conservation was more uniform in laser leveled fields as compared to traditional leveled fields. Hence the spatial variability was least in precise leveled fields.

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