LASER LEVELING HOLDS A LOT OF PROMISE IN WATER CONSERVATION AND SAVING IN DRY ZONES (DROUGHT PRONE AREAS) OF KARNATAKA.

P. S. Kanannavar, P. Balakrishnan, B. T. Pujari and M.B. Patil

University of Agricultural Sciences, Raichur, India

S. K. Upadhyaya

University of California, Davis, USA

ABSTRACT

Agricultural land leveling is of high importance in modern and intensive agriculture, especially under drought prone conditions where water resources are limited. The technology of laser leveling is very much effective in tackling these issues. A study using the technique of laser leveling was conducted in paddy farms of UAS, Raichur, Karnataka, India to find uniformity of moisture distribution and saving of water in paddy fields in comparison with the conventional leveling. The standard procedures were followed in surveying the fields and determining the moisture contents after leveling the fields and drawing contours. After rainfall of 54 mm, the moisture contents at the center of 10x10 m grids were measured at two depths of 0-30 cm and 30-60 cm. The average uniformity co-efficient of moisture content distribution in case of Laser leveled fields were found to be 93.92 per cent in 0-30 cm and 94.31 per cent in 30-60 cm soil depth. The standard deviations of 2.43 and 2.21 per cent respectively were observed in Laser leveled fields. The lower moisture content uniformity coefficients of 81.27 per cent and 81.12 per cent and higher standard deviations of 6.49 and 6.47 per cent respectively were observed in case of conventional leveling. The first irrigation required for puddling the paddy fields revealed that the time saved per hectare and the per cent quantity of water saved in laser leveled fields were 18.2 percent. This showed that in areas with limited water resources laser leveling provides uniform distribution of water and also considerable savings and better management of water resources over conventional leveling. So the laser leveling technique holds a lot of promise to preserve water, expand area under irrigation, optimize the water use, improved crop growth, reducing irrigation time and ultimately increase in crop yields for agricultural sustainability.

Key words: Laser leveler, water conservation, Irrigation water saving, Moisture contours

INTRODUCTION

Unevenness of the soil surface has a major impact on the germination, stand and yield of crops through nutrient water interaction and salt and soil moisture distribution pattern. Land leveling is a precursor to good agronomic, soil and crop management practices. Resource conserving technologies perform better on well leveled and laid-out fields. Farmers recognize this and therefore devote considerable attention and resources in leveling their fields properly. Very often most rice farmers level their fields under ponded water conditions. The others dry level their fields and check level by ponding water. Thus in the process of a having good leveling in fields, a considerable amount of water is wasted. It is a common knowledge that most of the farmers apply irrigation water until all the parcels are fully wetted and covered with a thin sheet of water. Studies have indicated that a significant (20-25%) amount of irrigation water is lost during its application at the farm fields (Cook and Peikert, 1960). This problem is more pronounced in the case of rice fields. Unevenness of fields leads to inefficient use of irrigation/rain water with more spatial variability of moisture and nutrient conservation. Fields that are not level have uneven crop stands, increased weed burdens and uneven maturing of crops. So Agricultural land leveling is of high importance in modern and intensive agriculture, especially under drought prone conditions where water resources are limited. The technology of laser leveling is very much effective in tackling these issues. Laser land leveling is meant to optimize water-use efficiency, better distribution of soil moisture, improve crop establishment, reduce the irrigation time and save irrigation water and effort required to manage crop and reduce spatial variability (Rickman, 2002). With all these points in view study was taken up to see the effects of precise leveling over conventional methods with objectives of determining moisture storage uniformity and extent of saving of irrigation water for puddling in rice fields of UAS Raichur Research Farm.

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 and water saving for puddling in paddy plots under clayey soil, during 2011-12. The experimental plots of UAS Raichur lie between the latitudes and longitudes of 16^{0}11’32.4” N, 77^{0}18’48.3” E and 16^{0}11’29.2” N, 77^{0}18’46.2” 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. The laser leveler, model “AG 401” (Make: Spectra Precision Pvt. (Ltd) New Delhi, India) was used for the study. In order to eliminate differences in leveler performance due to design of the drag scraper, the same leveler was used for both studies. For evaluating conventional 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 plowed using a disk plow in order to increase the topsoil volume and front dozer was used in the beginning for heavy earthwork removal. 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 and final view of laser leveled field. Fig.2. shows the flow chart of methodology adopted in this study.

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

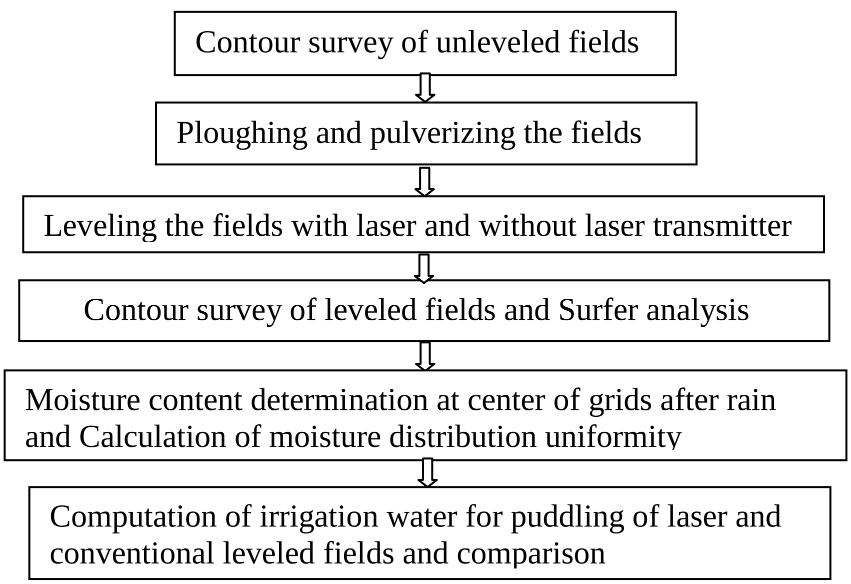

Fig. 2. Flow chart of methodology adopted in the study

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 was carried out by using judgment and skill of the tractor driver. 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 then changed to AUTO in control box. The land leveling was continued 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 leveling 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. After rainfall, the moisture contents at center of grids were measured at depths of 0-30 cm and 30-60 cm from ground surface.

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 in %

m = Average value of all moisture contents in %

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).

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

Slope of the plane best fit: 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 average standard deviation of reduced levels corresponding to a plane were 12.18 to 23.97cm for conventional and laser 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 average standard deviation of reduced levels before leveling was 23.97cm and after leveling is 1.59 cm, for fields leveled with the laser leveler. The findings of the present study agree with the study made by Mathankar *et al.*, 2005 on comparison of the performance of the laser guided land leveler with conventional methods were that standard deviation of reduced levels varied from 1.9 to 4.4 mm as compared to values of 25.0-30.2 mm for leveling without using laser system. In this study the average standard deviation of reduced levels before leveling was 12.18 cm and after leveling was 7.97 cm for the fields leveled with conventional method. Hence the accuracy of leveling using laser leveler was higher with more precision than conventional method since the standard deviation was only 1.59 cm. The reasons for variations in standard deviations are due to the fields in our study were newly formed paddy cultivable land and higher degree of hardness of the soil profile.

Table1. Particulars of selected fields.

Parameters	Conventional leveling		Laser leveling	
	Field-I	Field-II	Field-I	Field-II
Length (m)	60	60	60	60
Width(m)	35	30	35	30
Area (m^2)	2100	1800	2100	1800
Average SD of elevations before leveling, cm	12.18		23.97	
Average SD of elevations before leveling, cm	7.97		1.59	

The contours of the field before laser leveling and conventional leveling were shown in Fig. 3 and Fig. 4 respectively. For a subjective assessment of accuracy of leveling contour maps were plotted before and after leveling for both the conventional and laser leveled fields using the Golden 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.

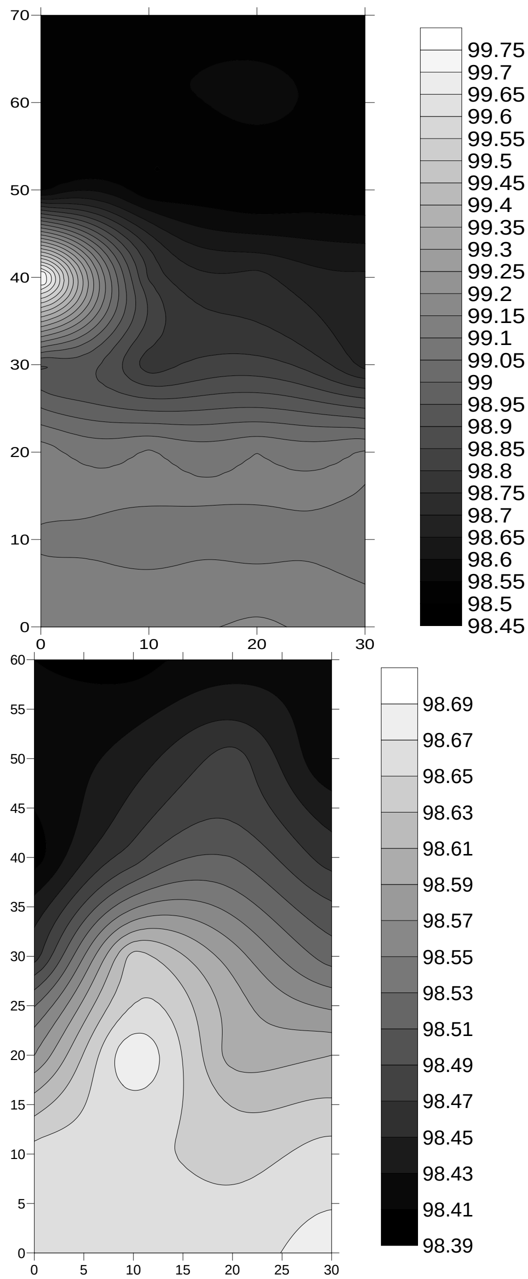

Fig. 3 and Fig. 4 The contour maps for before leveling the field using laser leveler and

Conventional methods.

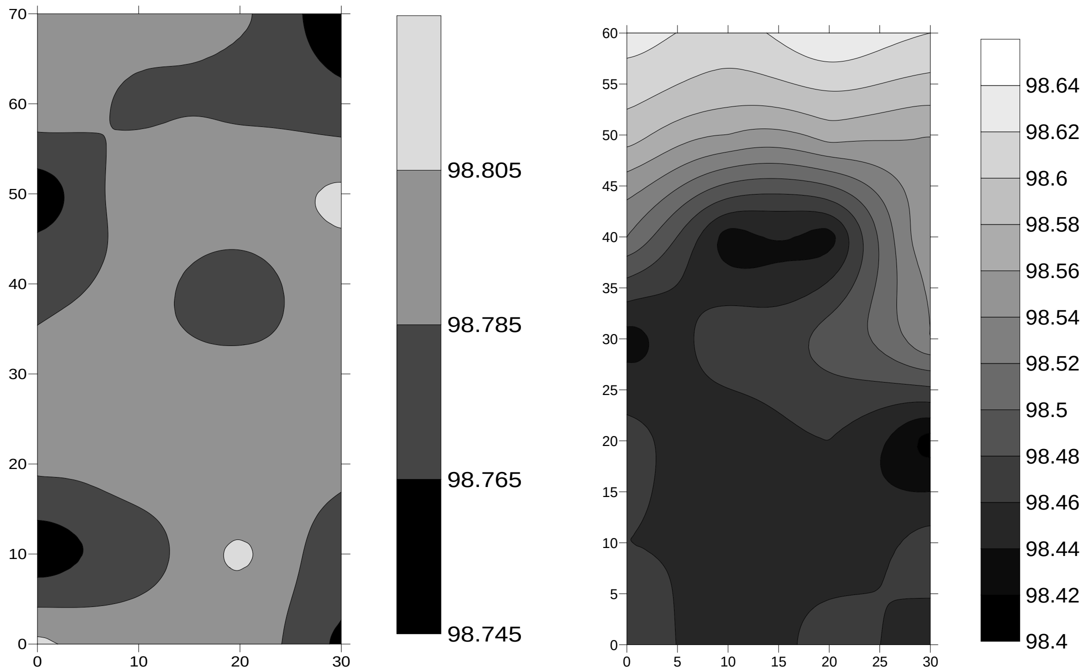

Fig. 5 and Fig.6 The contour maps for after leveling the field using laser leveler and conventional methods.

From 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 conventional method. This further confirmed the results obtained from standard deviation of the surveyed readings.

Table 2. shows slope and leveling index of conventional and laser leveled fields. From Table 2. Per cent slope reductions in X-direction and Y-directions were 56.80 and 38.62 respectively in fields leveled by conventional method. The average leveling indices before and after were 8.95 and 4.27 cm respectively for conventional leveled fields. On the other hand per cent slope reductions in X-direction and Y-directions were 97.95 and 99.64 respectively in fields leveled with laser leveler. The average leveling indices before and after leveling were 15.32 cm and 1.44 cm respectively for laser leveled fields.

Table 2. **Slope and leveling index of conventional and laser leveled fields**

Particulars		Conventional field		Precision field	
		Field-I	Field-II	Field-I	Field-II
Slope in X-direction(%)	Before leveling	1.37	1.36	1.05	0.17
	After leveling	0.67	0.51	0.007	0.006

	% reduction slope	51.10	62.50	99.44	96.47
	Avg. % reduction slope	56.80		97.95	
Slope in Y-direction(%)	Before leveling	1.26	1.08	1.06	0.855
	After leveling	0.85	0.60	0.005	0.002
	% reduction slope	32.8	44.44	99.53	99.76
	Avg. % reduction slope	38.62		99.64	
Average Leveling Index , cm	Before leveling	8.95		15.32	
	After leveling	4.27		1.44	

Table 3. Moisture content readings and Uniformity co-efficient for conventional and laser leveled fields

Particulars		Conventional leveling		Laser leveling	
		Field-I	Field-II	Field-I	Field-II
Avg. moisture content , %	0-30 cm	29.03	29.58	29.05	29.05
	30-60 cm	30.17	27.60	26.72	26.83
Standard deviation , %	0-30 cm	6.36	6.61	1.89	2.97
	30-60 cm	6.34	6.59	1.98	2.44
Uniformity coefficient , %	0-30 cm	80.71	81.84	95.01	92.85
	30-60 cm	82.22	80.03	94.49	94.13

Table 3. shows after rainfall of 54 mm, for measured moisture contents at the center of grids, the average uniformity co-efficient of moisture content distribution in case of laser leveled fields were found to be 93.92 per cent in 0-30 cm and 94.31 per cent in 30-60 cm soil depth. The standard deviations of 2.43 and 2.21 per cent respectively were observed in laser leveled fields. The lower moisture content uniformity coefficients of 81.27 per cent and 81.12 per cent and higher standard deviations of 6.49 and 6.47 per cent respectively, were observed in case of conventional leveling. In laser leveled fields the observed higher slope reduction and lower leveling index showed the uniform topography which resulted into uniform distribution of rain water conservation by reducing the spatial variability. Sattar *et al.*, 2003 also reported 21.7 per cent water saving in paddy fields leveled with laser leveler. Chaudhuri *et al.*, 2007 reported that the water saving was mainly due to precise leveling since, in conventional leveling more water has to be applied so that the water reaches the high spots of the field.

From Table 4. It was observed that the saving of irrigation time and water for puddling was 18.2 per cent in case of laser leveled fields as compared to conventional leveled fields because of improved application efficiency due to uniform topography and reduced spatial variability achieved in laser leveling.

Table 4. Water saving in puddling of conventional leveled and laser leveled fields

Parameters	Area , ha	Time taken for irrigation, h	Total quantity of water in m^3	Time saving for irrigation for puddling, %	Water saving in irrigation for puddling, %
Conventional levelling	0.39	10.83	390	---	---
Laser /Precision levelling	0.385	8.75	315	18.2	18.2

CONCLUSIONS

1. It was observed from contour charts and from values of standard deviation of reduced levels and leveling index that considerably higher accuracy of grading were observed when the fields were graded by use of laser guided land leveler in comparison to using the leveler without laser systems.
2. The reduction in slope of fields in both the directions was the highest in case of laser leveled plots in comparison to fields with conventional leveling.
3. The moisture conservation was more uniform in laser leveled fields as compared to conventional leveled fields. Hence the spatial variability was least in precise leveled fields.
4. In paddy field with laser leveling, 18.2 per cent water saving in irrigation for puddling was observed as compared to conventional leveled field which also reduced time required for irrigation.

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