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RESEARCH PAPER

Laser guided land levelling: A precision technique for enhancing water productivity

R. H. RAJKUMAR, A. T. DANDEKAR, J. VISHWANATHA, A. V. KAREGOUDAR AND YOGESH KUMAR SINGH

Department of Soil and Water Engineering, Directorate of Research
University of Agricultural Sciences, Raichur - 584 104, Karnataka, India
E-mail: halidoddiraju@gmail.com

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Abstract: Paddy-paddy is a traditional cropping system in the Tungabhadra Project (TBP) Command area. Though paddy fields are nearly leveled, unevenness of growth and yield variability are observed quite often in a given piece of land. This may be attributed to non-uniform spread of irrigation water and hence nutrients applied over the field. Conventional methods of land leveling followed traditionally are good enough to meet only the partial requirement of land leveling and leaves scope of improvement. The use of laser technology in the precision land leveling is of recent origin in India. It not only minimizes the cost of leveling but also ensures the desired degree of precision in land leveling. Live field demonstration of the laser leveling technology by the Saline Water Scheme centre, Gangavathi attracted many farmers especially of the tail end command who get canal water for irrigation once in 20 days rotation basis. Over the past four years, about 105 farmers got benefitted through laser leveling technology in about 350 ha. Once such good example is Sri. Ramakrishna S/o N. Suri Narayana R/o Devicamp, Karatagi, Gangavathi, District Koppal of Karnataka, a successful farmer who leveled 4 ha land with the laser leveler, who taken this equipment on rent basis from Saline Water Scheme, Gangavathi. In comparison with paddy yields under laser leveled field and the field leveled through conventional methods, higher water saving and yield was observed. The farmer could enhance paddy yields by 12 % (` 6000/ ha) and saved irrigation water to a tune of 20-25% as compared to traditionally leveled land. A field day was also organized on laser guided land.

Keywords: Land levelling, Laser levelling, Paddy, Precision agriculture, Water productivity

Introduction

Agriculture resources management such as land, water and vegetation is a tough and tedious task. However, better management of these resources will give an assured increase in the income of the farmer and also save these precious resources to a great extent. The saving of the resources will pay the way for expanding or increasing the area to be cultivated to certain extent. The land which needs to be put for cultivation after a long fallow or the land which is already under cultivation with lots of undulation in field condition will lead to loss of resources. The reason being is that, the land which is uneven in the field will lead to channelizing of applied water in the field causing rill and sheet erosion leading to loss of productive top soil (Kaur *et al.*, 2012). On the other hand a field which is uneven will create problem of non uniform supply of water to the plants and over growth, undergrowth and other issues. The maturity of crop will take different days, somewhere in the field where water is not supplied properly will start drying and grain filling with little quantum, but in those areas where the water supply is better, the plant is still growing. This leads to uneven growth as well as problem in scheduling the different agronomical operations in the field.

Manual land leveling with experienced/inexperienced tractor driver is generally used by many people in the field to avoid the depression and water ponding in different places and achieve the needed level of leveling. However, the leveling by manual has its own positives and negatives, positives like it can be done locally, with cheap available farm implements, when rough leveling is required and do not want to invest little bit higher amount as compared with the recent techniques. The negatives being that, even though a very good experienced person available, the manual leveling goes with sight observation by sitting on the tractor, this generally does not give proper observation, the driver lowers or rises the hydraulic lever abruptly and this leads to sudden removal of soil in the field which gives rough leveling feel. If the driver is inexperienced, than it better not to level rather than making an expenditures in leveling, since it will lead to more rough and depression than the proper field leveling. Paddy crop as we know consumes the higher amount of water as compared to other cereals and needs to ponded water for its entire growing period; hence it is required to save the water loss which is lost in the cultivation of paddy. Rice is the important crop of Tungabhadra Project (TBP) command area, though only 8.6% (29,032 ha) of the TBP command was earmarked for paddy cultivation, now it has been increased to more than 70% (2,55,366 ha) (Anonymous, 2013) and in all these cases, rice is traditionally grown by transplanting under puddle fields. For this puddling operation, farmers in this area are going for intensive tillage under continuous ponded water nearly 10 cm throughout the season, which serves to break down soil aggregates, reduced macro-porosity, disperse the clay fraction and farming dense zone of compaction at depth. In this method, the farmers are using excessive irrigation water and fertilizers with unscientific method, which leading to wastage of precious natural resource i.e. water and land becoming degraded by waterlogging and salinity and it was estimated that around 96,125 ha land has been affected in TBP command. In this command area, around 20-30% of the total water required for the rice culture is being dedicated by the farmers to nursery rising, puddling and transplanting. Paddy-paddy is a traditional cropping system in the TBP command area. Unevenness of growth and yield variability are observed. This may be attributed to non-uniform spread of irrigation water and hence nutrients applied over the field. Laser guided equipment automatically level the land with very precisely. Where ever there is a rise, it cuts the soil and fills in the depression. It not only minimizes the cost of leveling but also ensures the desired degree of precision in land leveling which intern saves 20-25% irrigation water. Best water saving technology for both head reach and tail end farmers.

Laser Land leveling is one such important technology for using water efficiently as it reduces irrigation time and enhances productivity not only of water but also of other non-water farm inputs. The use of laser technology in the precision land leveling is of recent origin in India. It does not only minimize the cost of leveling but also ensures the desired degree of precision. It enables efficient utilization of scarce water resources through elimination of unnecessary depression and elevated contours (Naresh *et al.,* 2011). It has been noted that poor farm design and uneven fields are responsible for 30% water losses (Asif *et al.,* 2003). Precision land leveling (PLL) facilitated application efficiency through even distribution of water and increased water-use efficiency that resulted in uniform seed germination, better crop growth and higher crop yield (Jat *et al.,* 2006).

Material and methods

Site location

The field experiment was carried out during *Kharif* 2014-15 and 2015-16 at Agricultural Research Station, Gangavathi, Karnataka, India; situated in the north-eastern dry zone of the state with latitude of 15^0 15' 41'' N and longitude of 76^0 31' 40'' E and at an altitude of 419 m above mean sea level.

Soil characteristics

The soil of the site was medium deep black soil which was determined by international pipette method (clay, silt and sand 47.6, 29.5 and 22.9%, respectively). The infiltration rate of the experimental site was 14 mm h^{-1} and it was determined by double ring infiltrometer (Manjunatha *et al.,* 2002). Average annual rainfall of the station is 537.7 mm. During *Kharif* 2014-15 and 2015-16 the rainfall during the growing season of paddy was 228.3 and 240.8 mm, respectively. The soil of the experimental site were analyzed using conductivity bridge in 1:2.5 soil water extract method to determine soil ECe and it was ranges between 1.25 to 1.45 dS m^{-1} and pH less than 8.3. The mean bulk density of the experimental site was ranged between 1.44 to 1.56 g cm^{-3} which was measured by collecting a known volume of soil using a metal ring pressed into the soil (intact core), and determined the weight after drying (McKenzie *et al.,* 2004). The soil porosity was ranged from 42.2% to 47.5% which was

T_1 - Puddled transplanting (PTR) in traditionally leveled land (control)

T_2 - Direct Seeded Rice (DSR) in traditionally leveled land

T_3 - Puddled transplanting in laser leveled land

T_4 - DSR in laser leveled land

determined by % solid space (bulk density /particle density x 100) and % porosity was then calculated by 100 - (% solid space).

Field layout and treatments

The experiment was consisted of four treatments *viz.,* T_1 - puddled transplanting (PTR) in traditionally leveled land (control), T_2 - Direct Seeded Rice (DSR) in traditionally leveled land, T_3 - Puddled transplanting in laser leveled land and T_4 - DSR in laser leveled land. Each treatment was implemented with an area of 0.40 ha. The available laser leveler (Spectra Pvt. Ltd.) was used for leveling the plots. DSR was sown with the available multi-crop seed drill with row to row distance of 22.5 cm and transplanting was done by traditional method. Before implementation of the experiments, the slopes of the four plots was measured which were approximately 0.2 to 0.25% and land was well prepared with two times tillering and one time rotovator.

Water quantification

The quantum of irrigation water applied at each time for all the four treatments were measured with cut throat flume water measuring instrument. The discharge available at outlet was measured every time. The time of irrigation application for different treatment was noted during each irrigation. The applied irrigation depth was calculated from measured discharge applied to known area for recorded time by the following equation:

$$QT=AD$$

Where Q = Discharge ($m^3 s^{-1}$); T = Time (s); A = Area (ha), and D = Depth (m).

The amount of water (m^3) applied to each treatment was determined by multiplying the discharge at field outlet with the time of application. The total amount of water applied was computed for the entire crop season for all the four treatments. Water use efficiency (WUE) was computed by the formula WUE ($kg\ m^{-3}$) = Yield ($kg\ ha^{-1}$) / Total water applied (mm). Growth and yield observations were recorded at harvest.

Results and discussion

The results obtained from the field experiments are given below. From Fig.1and 2, it can be seen that, there was a decreasing trend of water applied from traditional to laser leveled land for the year 2014-15 as well as 2015-16. Among the T_1 and T_3 and T_2 and T_4, we can see a considerable change in the total amount of water applied after deduction of the rainfall for both the years.

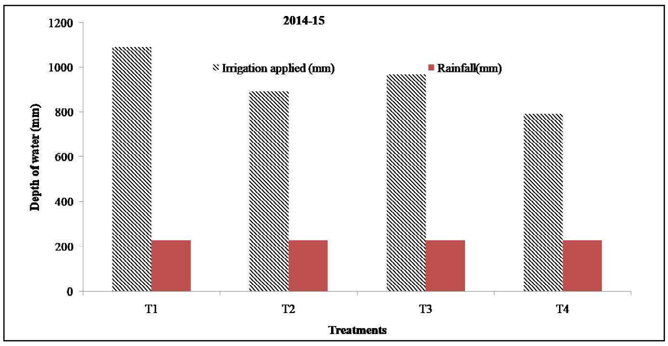

Fig.1. Analysis of irrigation water application and rainfall between PTR and DSR in traditionally leveled and laser leveled land for the year 2014-15

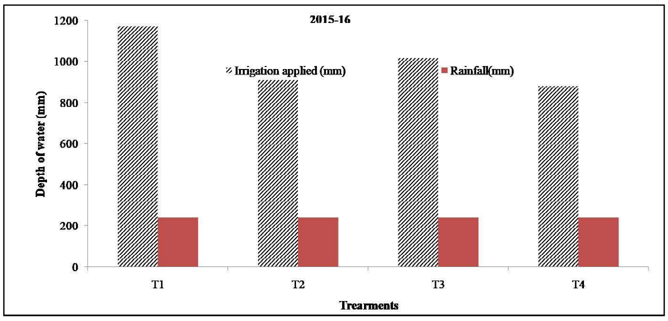

Fig.2. Analysis of irrigation water application and rainfall between PTR and DSR in traditionally leveled and laser leveled land for the year 2015-16

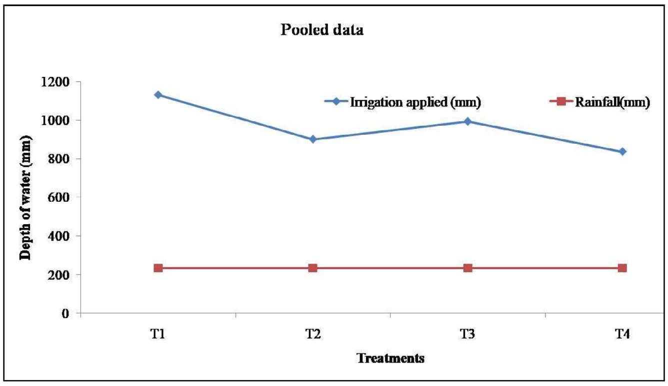

Fig.3. Pooled data of analysis of irrigation water application and rainfall between PTR and DSR in traditionally leveled and laser leveled land

Pooled data analysis of the experiment showed that total water applied for different treatments and especially T_4 has the least water applied (Fig. 3).

The irrigation applied and total irrigation applied (which includes the effective rainfall of 140.7 mm during growing season) was significantly higher with PTR in traditionally leveled land (1132.0 and 1272.2 mm) followed by PTR in laser leveled land (993.0 and 1133.2 mm), DSR in traditionally leveled land (901.0 and 1041.7 mm) and least in case of DSR in laser leveled land (837.0 and 977.2 mm). This was due to even land surface which intern leads to less time taken for to irrigate to laser leveled treatments. However, as compared to DSR and PTR in traditionally leveled lands, less irrigation was applied with DSR. This was mainly because of continuous ponding of water in PTR which leads to more irrigation application and in case of DSR, the irrigation was given only when there was hair cracks (Fig. 4 to 6).

Water use and water production efficiency

The total irrigation water applied was 10.9% less in case of PTR in laser leveled land as compared to control. However, the

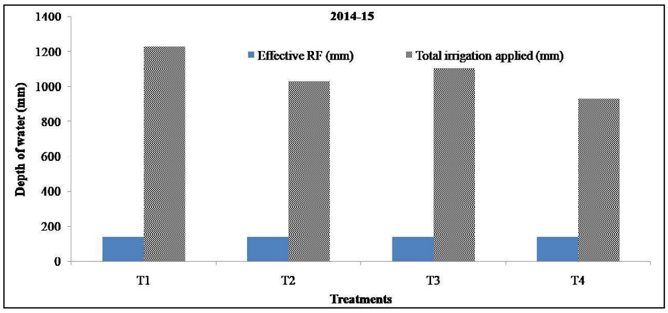

Fig.4. Total irrigation water applied for PTR and DSR in traditionally leveled and laser leveled land for the year 2014-15

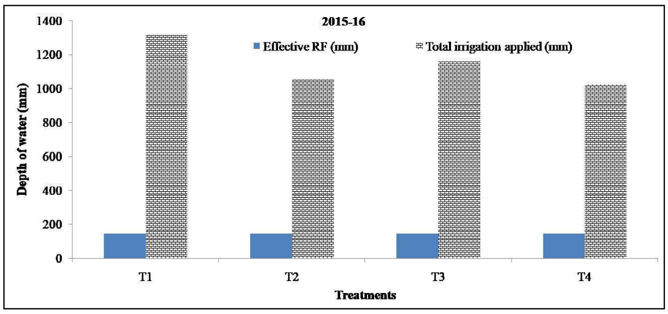

Fig. 5. Total irrigation water applied for PTR and DSR in traditionally leveled and laser leveled land for the year 2015-16

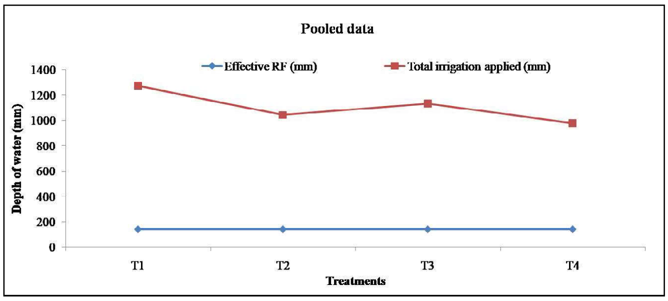

Fig. 6. Pooled data of total irrigation water applied for PTR and DSR in traditionally leveled and laser leveled land

total irrigation water applied was 23.2 and 18.1% less in case of DSR in laser leveled land and DSR in traditionally leveled land treatment respectively as compared to control treatment (Table 1). Water production efficiency was recorded significantly higher with DSR in laser leveled land treatment (0.58 kg m^{-3}) followed by PTR in laser leveled land (0.51 kg m^{-3}), DSR in

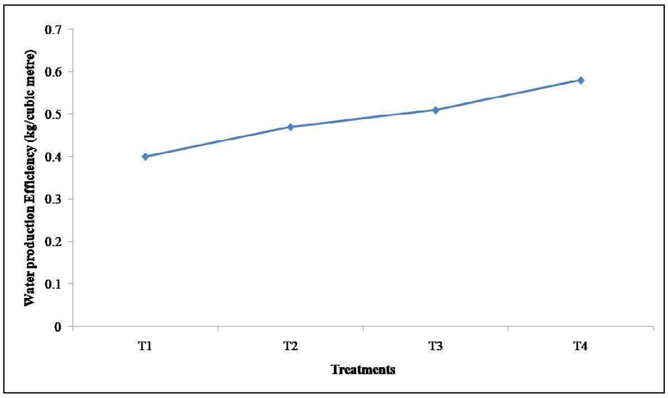

Fig. 7. Water Production Efficiency of different treatments

traditionally leveled land (0.47 kg m^{-3}) and least in case of PTR in traditionally leveled land (0.4 kg m^{-3}) i.e. control treatment (Fig. 7).

This huge difference in water use efficiency was because of reduced grain yield and higher amount of water applied to unlevel and traditional leveled fields. The decrease in water use efficiency in unleveled fields also reflected the sensitivity of the crop to water excess/deficit, a characteristic of undulating fields' surface of unleveled fields. However, the reason for lower WUE in traditionally leveled and unleveled fields was the inefficient use of the water applied. The precisely leveled and smooth field showed a positive impact on the total water use resulting in a tangible reduction. The only reason for excessive water application in control treatments was uneven surface to the unleveled treatment. The greater variation in surface level on unleveled and traditional leveled field resulted not only in wastage of water but also reduced crop yield. The above results are in line with the findings of Jat *et al.* (2009) and Abdullaev *et al.* (2007)

Conclusions

This could be concluded that before going for the direct seeding in TBP command, the land should be leveled with laser leveling and then DSR must be sown with seed drill. This intern helps in attaining uniform seeding depth and smooth operation of the seed drill. This technology could help the farmers of the region by reducing the waterlogged problem and in-time availability of canal water for the tail ender's of command area. The result suggests that laser land leveling is more water use efficient, more cost effective and give higher crop yield through efficient utilization of scarce land and water resources. Thus in

Table 1. Percent of total less water applied in different treatment than control

Sl. No	Treatments	Irrigation applied: Change from PTR in normal leveled land (mm) %			Water Saving: Change over PTR in normal leveled land		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled
1	T_1 - Puddled transplanting in normal leveled land	_	_	_	_	_	_
2	T_2 - Direct seeded rice in normal leveled land	199	262	230.5	16.2	19.9	18.1
3	T_3 - Puddled transplanting in laser leveled land	124	154	139	10.1	11.7	10.9
4	T_4 - Direct seeded rice in laser leveled land	298	292	295	24.3	22.2	23.2

the light of this study, it is imperative to recommend that laser land leveling should be popularized among the farmers at it not only increase water use efficiency and yield but also ensure better germination, better utilization of water and non water inputs towards increased yield. Although, laser land leveling is beneficial, there are certain limitations associated with it such as high cost of the equipment/laser instrument and need for a skilled operator. It may be less efficient in irregular and small sized fields.

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