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Water requirement of Paddy under Different Land Levelling, Cultivation Practices and Irrigation Methods

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A B S T R A C T

Water saving by innovative techniques is essential to prevent salinity and land degradation in paddy production. Therefore, the field investigations were conducted in the farmer's field under the jurisdiction of the University of Agricultural Sciences (UAS) Raichur during the *kharif 2015* and *kharif* 2016 using randomized complete block design (RCBD) with 7 treatments to determine water requirement of Paddy under different levelling, cultivation practices and irrigation methods for paddy production. The results showed that the dry Direct Seeded Rice (DSR) plot with laser land levelling and subsurface drip irrigation at 60 cm lateral spacing required the lowest quantity of irrigation water of 3872, 2864 and 3368 m^3 ha^{-1}, respectively during 2015, 2016 and in pooled mean. The control plot with conventional land levelling using flood irrigation (farmers' practice) recorded the highest quantity of water usage of 20260, 19112 and 19686 m^3 ha^{-1} during 2015, 2016 and in pooled mean, respectively. The highest per cent water saving was observed in the plot with dry DSR with laser land levelling and sub-surface drip irrigation with 60 cm lateral spacing with 80.89, 85.01 and 82.89 per cent during 2015, 2016 and in pooled mean, respectively when compared with control *i.e.* farmers' practice.

Introduction

Rice (*Oryza sativa* L.) is the staple food of more than half of the population of the world and its production is an important target to provide food security and livelihood for millions. The world's total estimated area under rice production is 159 M ha with a production of 670 M t with an average yield of 3,889 kg per ha (Anon., 2011). India ranks second in rice production, as it is grown in almost all the states of the country. In India, rice is cultivated in a wide range of ecosystems *viz.,* irrigated (21 M ha), rainfed lowlands (14 M ha), rainfed uplands (6 M ha) and flood prone (3 M ha). The most common method that is being followed by the farmers is generally transplanting, while dry seeding or wet seeding method for cultivation of rice is also adopted depending upon the situation. India faces the challenge of meeting the future demand of food grains due to diversion of land and water resources to not only agriculture but also to other sectors of economy. With the current estimates, India would need 37 per cent more rice and wheat by 2025 with 9 to 10 per cent less water available for irrigation compared to the year 2000. The total area under rice in Karnataka is 1.33 M ha with an annual production of 3.54 M t and with a productivity of 2,670 kg per ha (Anon., 2016). It is cultivated in the command areas of Cauvery basin in south, Tungabhadra and Upper Krishna projects in north where transplanting with flood irrigation is the major method of cultivation. The traditional irrigation method like flooding water in paddy fields consumes more water leading to wastage of precious water resources and the least water productivity. Imminent water crisis due to increasing demands from various sectors, water-demanding nature of traditionally cultivated rice and climbing labour costs all call for search of alternative management methods to increase water productivity, system sustainability and profitability in rice. With this in mind the field investigations were conducted on water requirement of paddy with innovative techniques of laser land levelling and drip irrigation methods for paddy production were taken up in the farmer's field.

Materials and Methods

The experiment was carried out in farmer's field located at Govinadoddi village in Manvi taluka of Raichur district under during *kharif 2015* and *kharif* 2016 using randomized complete block design with 7 treatments which were replicated thrice. The treatments included the land levelling methods *viz.,* laser levelling with near table top level or zero per cent slope and conventional levelling, cultivation practices *viz.,* transplanted rice (TPR) and direct seeded rice (DSR) and irrigation methods *viz.,* drip and flood irrigation. The treatments included the land levelling methods *viz.,* laser levelling with near table top level or zero per cent slope and conventional levelling, cultivation practices *viz.,* transplanted rice (TPR) and direct seeded rice (DSR) and irrigation methods *viz.,* drip and flood irrigation. The treatments were *viz*., T_1 - Dry direct seeded rice (DSR) with laser land levelling and surface drip irrigation with 80 cm lateral spacing, T_2 - Dry direct seeded rice with laser land levelling and surface drip irrigation with 60 cm lateral spacing, T_3 - Dry direct seeded rice with laser land levelling and subsurface drip irrigation with 60 cm lateral spacing, T_4 - Dry direct seeded rice with laser land levelling and subsurface drip irrigation with 80 cm lateral spacing, T_5 - Transplanted rice (TPR) with laser land levelling and conventional method of flood irrigation, T_6 - Dry direct seeded rice with conventional land levelling and conventional method of flood irrigation and T_7 - Control (transplanted rice with conventional land levelling using flood irrigation) *i.e.,* farmer's practice. The test crop used was paddy with variety BPT - 5204 (145-150 days duration). The Diagram showing schematic chart of precise laser land levelling concept is given in Fig.1. Fig.2. shows drip irrigation system with treatments installed in farmers field.

The scheduling of drip irrigation was done based on daily PE values during the crop growth period and the duration of irrigation was computed as follows:

$$\text{Irrigation hours (h)} = \frac{ET_c\ \text{(mm)}}{\text{Application rate (mm h}^{-1}\text{)}} \times 100 \quad \text{(Eq. 1)}$$

Whereas,

Actual evaporation or crop evapotranspiration (ET_c) in mm = ET_0 x Crop factor

Reference evaporation or evapotranspiration (ET_0) in mm = Previous day evaporation x Pan factor.

Crop factors for paddy at its initial, crop development, reproductive and maturity stages is used were 1.15, 1.23, 1.14 and 1.02 respectively and constant pan factor of 0.7 was used. Application rate with discharge of 2 Lph @ 1.5 kg cm^{-2} was calculated using Eq.2.

$$\text{Application rate (mm/hr)} = \left[\frac{\text{Discharge(lph) X 100}}{\text{Lateral distance(m) x Dripper distance(m)}}\right] \quad \text{(Eq. 2)}$$

Two lateral spacings of 0.6 m and 0.8 m were used in the study with a constant dripper distance of 0.4 m throughout the experiment.

Results and Discussion

For the field investigations, the data regarding irrigation water used (m^3 ha^{-1}) and per cent water saving as influenced by different land levelling (Laser and Conventional), cultivation practices (DSR and TPR) and irrigation (Drip and Flood) methods for paddy production are presented in Table 1.

It was observed that the treatment T_3 required the lowest quantity of irrigation water of 3872, 2864 and 3368 m^3 ha^{-1} during 2015, 2016 and in pooled mean, respectively followed the treatment T_2 (3918, 2928 and 3423 m^3 ha^{-1}), T_4 (4034, 3061 and 3548 m^3 ha^{-1}) and T_1 which recorded water usage of 4260, 3142 and 3701 m^3 ha^{-1} during 2015, 2016 and in pooled mean, respectively. The control plot with farmers' practice (T_7) recorded the highest quantity of water usage of 20260, 19112 and 19686 m^3 ha^{-1} during 2015, 2016 and in pooled mean, respectively. It was followed by T_5 (17260, 16065 and 16663 m^3 ha^{-1}) and T_6 (11680, 10662 and 11171 m^3 ha^{-1}).

From the pooled mean the highest per cent water saving was observed in the treatment T_3 (82.89 per cent) when compared with control (conventional land levelling with flood irrigation) *i.e.* farmers' practice (T_7). It was followed by T_2 (82.61 per cent), T_4 with 81.98 and T_1 (81.20 per cent). Dry DSR with conventional land levelling and conventional method of flood irrigation (T_6) recorded 43.25 per cent water saving followed by TPR with laser land levelling and conventional method of flood irrigation (T_5) with 15.36 per cent water saving when compared to farmers' practice.

The similar trend was noticed with the depth of irrigation water applied during 2015, 2016 and pooled mean. From Table 1 and Fig. 3 (a) and (b) considering the effective rainfall during crop period, the quantity of irrigation water applied for paddy was the least in T_3 (33.68 cm).

It was followed by T_2 with 34.23 cm, T_4 with 35.48 cm and T_1 with 37.01 cm. The water requirement was the highest in T_7 (196.86 cm). It was followed by T_5 (166.63cm) and T_6 (111.71 cm). Significant difference was observed in depth of water requirement of paddy as influenced by different cultivation practices, land levelling and irrigation methods.

Among sown rice, the pooled effective rainfall during the crop period, the total quantity of water requirement of paddy was lowest in T_3 (66.65 cm) followed by 67.20, 68.44 and 69.98 cm, respectively in T_2, T_4 and T_1. The total water requirement was the highest in T_6 (144.68 cm). In transplanted rice the water requirement in T_5 (199.59 cm) was lesser than T_7 (229.83 cm).

Among sown rice, the pooled depth of irrigation water requirement was higher in T_6 (111.71 cm). It was followed by T_1 (37.01 cm), T_4 (35.48 cm) and T_2 (34.23 cm) respectively. The least was recorded in T_3 (33.68 cm). Treatment T_5 recorded total water requirement of 166.63 cm followed by T_7 (196.86 cm).

Table.1 Quantity of irrigation water applied and per cent saving as influenced by different cultivation practices, land levelling and irrigation methods for paddy production

Treatment	Total depth of irrigation water applied (cm)			Total quantity of irrigation water applied ($m^3\ ha^{-1}$)			Quantity of irrigation water saved over control (T_7) ($m^3\ ha^{-1}$)			Per cent of irrigation water saved over control (T_7)		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
T_1	42.6	31.42	37.01	4260	3142	3701	16000	15970	15985	78.97	83.56	81.20
T_2	39.18	29.28	34.23	3918	2928	3423	16342	16184	16263	80.66	84.68	82.61
T_3	38.72	28.64	33.68	3872	2864	3368	16388	16248	16318	80.89	85.01	82.89
T_4	40.34	30.61	35.48	4034	3061	3548	16226	16051	16139	80.09	83.98	81.98
T_5	172.6	160.65	166.63	17260	16065	16663	3000	3047	3024	14.81	15.94	15.36
T_6	116.8	106.62	111.71	11680	10662	11171	8580	8450	8515	42.35	44.21	43.25
T_7	202.6	191.12	196.86	20260	19112	19686	---	---	---	---	---	---

Legend

T_1 - Dry Direct Seeded Rice (DSR) with Laser land levelling and Surface Drip irrigation (80 cm Lateral spacing)
T_2 - Dry Direct Seeded Rice (DSR) with Laser land levelling and Surface Drip irrigation (60 cm Lateral spacing)
T_3 - Dry Direct Seeded Rice (DSR) with Laser land levelling and Sub-surface Drip irrigation (60 cm Lateral spacing)
T_4 - Dry Direct Seeded Rice (DSR) with Laser land levelling and Sub-surface Drip irrigation (80 cm Lateral spacing)
T_5 - Transplanted Rice (TPR) with Laser land levelling and Conventional method of flood irrigation
T_6 - Dry Direct Seeded Rice (DSR) with Conventional land levelling and Conventional method of flood irrigation
T_7 - Control (Conventional land levelling with Conventional method flood irrigation) *i.e.* Farmers' Practice

Fig.1 Schematic chart of laser land levelling concept

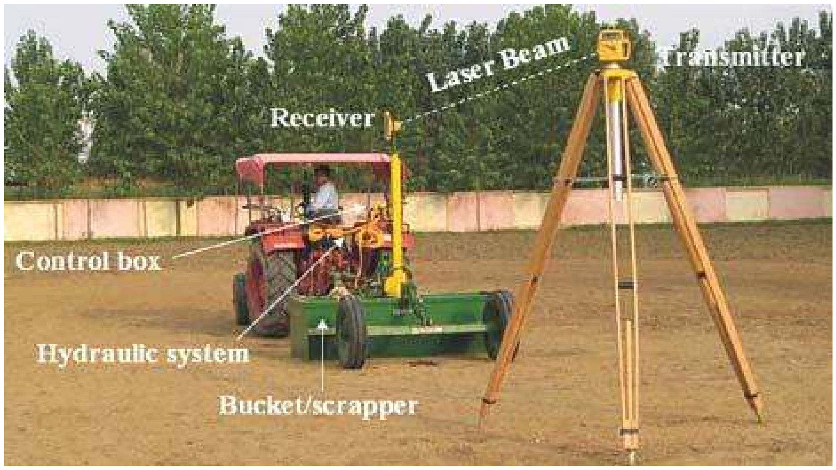


Fig.2 Drip irrigation system installed in farmer's field

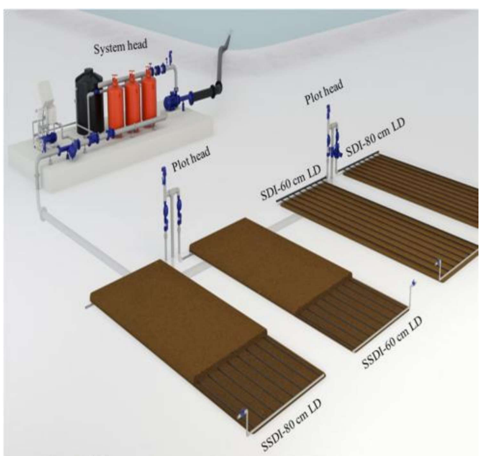


Fig.3 (a) Quantity of water applied as influenced by different cultivation practices, land levelling and irrigation methods for paddy production

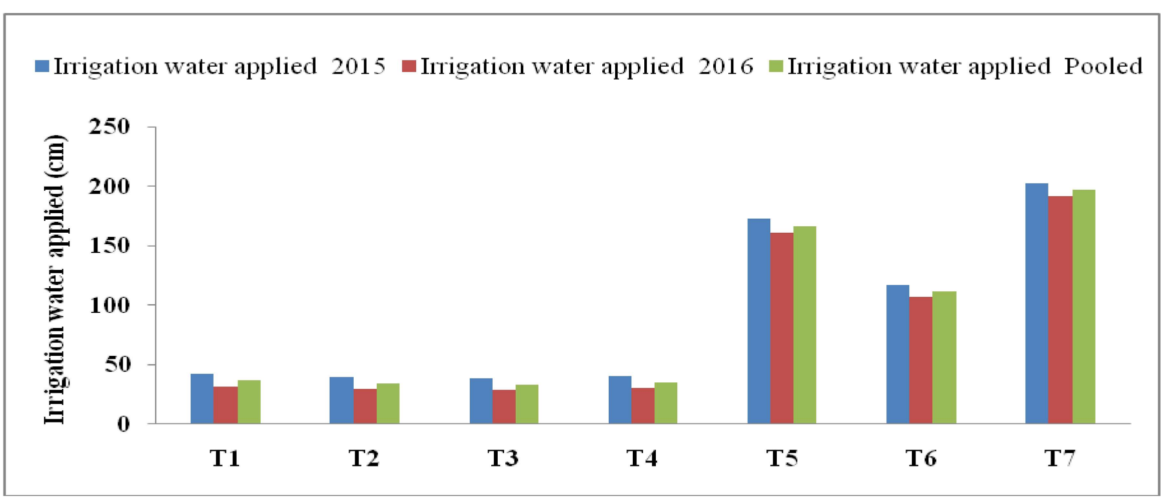
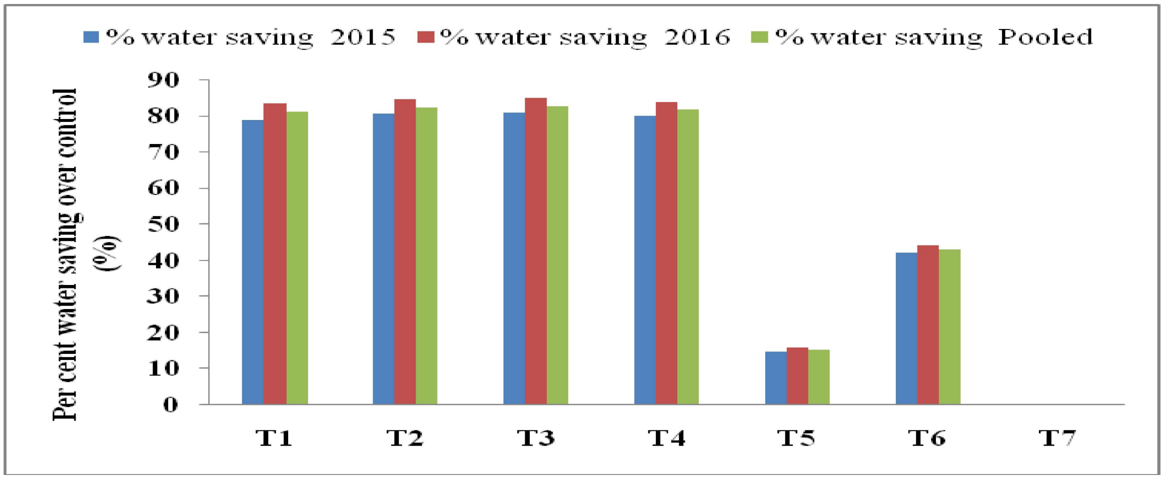


Fig.3 (b) Per cent saving as influenced by different cultivation practices, land levelling and irrigation methods for paddy production



Legend

T_1	Dry Direct Seeded Rice (DSR) with Laser land levelling and Surface Drip irrigation (80 cm Lateral spacing)
T_2	Dry Direct Seeded Rice (DSR) with Laser land levelling and Surface Drip irrigation (60 cm Lateral spacing)
T_3	Dry Direct Seeded Rice (DSR) with Laser land levelling and Sub-surface Drip irrigation (60 cm Lateral spacing)
T_4	Dry Direct Seeded Rice (DSR) with Laser land levelling and Sub-surface Drip irrigation (80 cm Lateral spacing)
T_5	Transplanted Rice (TPR) with Laser land levelling and Conventional method of flood irrigation
T_6	Dry Direct Seeded Rice (DSR) with Conventional land levelling and Conventional method of flood irrigation
T_7	Control (Conventional land levelling with Conventional method flood irrigation) *i.e.* Farmers' Practice

Among sown rice the highest per cent water saving was observed T_3 (82.86 %). It was followed by T_2 (82.61 %), T_4 (81.98 %) and T_1 (81.20 %) when compared with control *i.e.* farmers' practice (T_7). The water saving was mainly due to precise levelling in laser levelled plots leading to smooth and faster movement of water thereby quick uniform distribution of water. Moreover, application of water to the root zone of crops by drip irrigation. But in control plot it was not so smooth. Whereas, water has to be applied so that the water reaches the high spots. The uniform distribution and reduced losses (Rajput and Patel, 2004, Abdullaev *et al.,* 2007) in laser levelling plots also led to reduced depth of application and more saving of water. The irrigation time reduced considerably in laser levelled drip plots. The similar results on irrigation water requirement, depth and saving were obtained by Ahmad *et al.,* (2001), Rickman (2002), Aggarwal *et al.,* (2010), Shahin *et al.,*(2013) and Abdelraouf *et al.,* (2014). Thus, laser land levelling and drip irrigation methods by saving considerable quantity of water were proved to be a RCTs in paddy production.

Laser land levelling and drip irrigation techniques used for paddy cultivation were observed to save huge quantity of irrigation water in paddy cultivation. The dry DSR plot with laser land levelling and subsurface drip irrigation at 60 cm lateral spacing required the lowest quantity of irrigation water whereas farmers' practice of growing paddy recorded the highest quantity of water usage of 19686 $m^3 ha^{-1}$ in pooled mean. This was followed by plot with TPR with laser land levelling and conventional method of flood irrigation. The highest water saving (82.89 per cent) was observed in the plot with dry DSR with laser land levelling and sub-surface drip irrigation with 60 cm lateral spacing when compared with control *i.e.* farmers' practice.

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