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Assessment of Irrigation Methods on Water Productivity, Growth and Yield of Paddy Crop

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ABSTRACT

Introduction of precise irrigation water application methods in paddy could increase the water productivity by minimizing the seepage and percolation water losses. A field experiment through on farm testing (OFT) was conducted to assess alternate wetting and drying method in paddy farmer's field of cluster villages of ICAR-KVK, Yadgir (Karnataka). The technology options such as alternate wetting and drying (TO_1) and saturation method (TO_2) were compared with traditional practice (TO_3) for water productivity, water saving and crop yield during kharif 2017 and 2018. The results of the study reported that, use of AWD and saturation irrigation methods in paddy could able to save 44 % and 41 % of irrigation water as compared to farmers traditional practices and also possible to achieve water productivity of 7.27 (kg ha^{-1} mm^{-1}) over continuous submergence method without reduction in crop yield. Better aeration and root growth under AWD practice provided sufficient nutrients for vegetative and reproductive growth which enhanced the 10 % (6.55 t ha^{-1}) increase in crop yieldover traditional irrigation method (5.92 t ha^{-1}). The highest B:C of 2.60 was in (TO_1) as compared to 2.12 in traditional practices (TO_3). Therefore, paddy growing farmers should adopt AWD irrigation application method instead of continuous submergence to minimize water losses and solve water scarcity problems in UKP command area.

Keywords: AWD method, Paddy, Irrigation , Water productivity.

INTRODUCTION

Paddy is the traditional crop growing around 30 % of irrigated area in Upper Krishna Project (UKP) command area. The upper end farmers in command area has growing paddy in both kharif and rabi seasons but for tail end farmers they could not able to get sufficient water in kharif seasons. The uneven rainfall and water scarcity in canal irrigation have restricted major crop yield in the season. The judicious use of irrigation water and nutrient management decides the crop yield. Farmers are applying 2 to 2.5 % more fertilizer than the remanded dose that will lead to soil salinization and acidity problems. There is a need in

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adaptation of judicious irrigation water application methods in UKP command areas to minimize excess irrigation and water losses. In paddy cultivation, sufficient soil moisture should be maintained during planting to panicle initiation (PI), panicle initiation to flowering and flowering to crop maturity. In transplanted paddy cultivation, it is suggested to maintain 2.5 cm for first 10 days and thereafter 5.0 cm is to be maintained up 10 days before the crop harvest. However, farmers are maintaining 15 cm depth of water throughout the crop growing period which leads to bring ground water table (GWT) near to soil surface which causes the poor crop productivity.

University of Agricultural Science,Raichur (Karnataka) has developed and modified many irrigation water management methods for paddy cultivation in TungaBandra Project (TBP) and Upper Krishna Project command areas. The Alternate Wetting and Drying (AWD) in paddy for precise water application have been tested by UAS, Raichur and created awareness among paddy growing farmers. The Alternate Wetting and Drying (AWD) were developed by International Institute for Rice Research (IIRR), Philiphines and Indian Institute of Rice Research, Hyderabad. This method has been tested and adopted in TungaBandra Project (TBP) command area by Agricultural Research Station, Gangavati. The Alternate Wetting and Drying (AWD) is an irrigation management practicethat shown to reduce water use in paddy systems (Linquist et al. 2014, Lampayan et al. 2015). In this method, fields are subjected to intermittent flooding(alternate cycles of saturated and unsaturated conditions) whereirrigation is interrupted and water is allowed to subside untilthe soil reaches a certain moisture level, after which the field isreflooded.AWD has been reported to reduce water inputs by 23% (Shantappa et al. 2014) compared to continuously flooded rice systems.

The alternate wetting and drying (AWD) not only saves the irrigation water, it also recorded significantly higher growth and yield parameters over the other traditional irrigation methods due to profuse root growth and aerated condition (Duttarganvi et al. 2016). Increasing water scarcity is becoming real threat to rice cultivation in UKP command area now days due to acute rainfall and water scarcity in UKP project. Hence, water-saving technology which also maintains soil health and sustainability as well as economically beneficial, needs to be developed (Subramaniam et al. 2013). The water stagnation or saturation irrigation with certain depth of irrigation in paddy throughout growth period results in water saving up to 30 % over traditional method of irrigation due to the restriction of seepage and deep percolationlosses by maintaining water level up to saturation attributing to lesser water use under saturation (Shantappaet al. 2014). Many water saving irrigation methods are available, farmers under UKP command area are still practicing traditional irrigation methods which increases the soil salinity problem and reduction in crop yield. Therefore, this study was conducted to assess AWD method along with traditional and saturation irrigation methods on water productivity and paddy growth parameters in UKP command area.

MATERIALS AND METHODS

The study on assessment of alternate wetting and drying irrigation method in UKP was conducted through implementation of On Farm Testing (OFT) in ICAR-KrishiVigyanKendra, Yadgir (Karnataka) at farmer's fields ofcluster villages during kharif 2017 and 2018. RNR 15048 rice variety was used as test crop and three irrigation water application methods were selected for field assessment and details of selected technology options are presented in Table 1.

Alternate wetting and drying method

The 5 cm irrigation water depth was maintained at each alternate wetting and drying by installing filed water tube (Pani Pipe) in all selected farmers field. A

Table 1. Details of selected irrigation water application methods.

Sl. No.	Tech options	Irrigation methods	Source techlogy	Dath of irrigation lied of each irrigation
O_1	TO_1	Allter wetting and Drying irrigation Method	URR	05 cm
O_2	TO_2	Saturation irrigation Method	PJTSAU	02 cm
O_3	TO_3	Traditional irrigation Method	Farmer Practice	05 cm

30 cm length plastic pipe with a diameter of 15 cm was installed with 3 feet away from the bund in field for water measurement. Perforated holes were made up to 15 cm and that portion was inserted below the soil surface. The soil in pani pipe has removed to ensure both water levels in pipe and soil surface in equal level. When the water level has dropped to about 15 cm below the surface of the soil, irrigation has applied to re-flood the field to a depth of 5 cm. From one week before to a week after flowering, the field was kept flooded, topping up to a depth of 5 cm as needed. After flowering, during grain filling and ripening, the water level was allowed to drop again to 15 cm below the soil surface before re-irrigation. AWD was started a few weeks (1−2 weeks) after transplanting. When many weeds are present, AWD was postponed for 2−3 weeks to assist suppression of the weeds by the ponded water and to improve the efficacy of herbicide.

Saturation irrigation method

The irrigation water depth of 2 cm was maintained throughout the crop growth period from transplanting to just 10 days before harvesting. A measuring scale was provided to farmers to maintain 2 cm depth in the field at each irrigation. The cut throat flume was also installed in the field to quantify the irrigation water during each irrigation and observations were recorded.

Traditional irrigation method

The farmers were followed their traditional practice for water application with a 5 cm irrigation water depth at each irrigation during growth period. Irrigation was stopped just 10 days before harvesting the crop.

Irrigation scheduling

The details of irrigation schedule followed and quantity of irrigation water applied in each treatment is presented in Table 2. Cut throat flume was installed to apply required depth of irrigation water in selected irrigation method as per irrigation scheduling.

Water productivity (WUE)

The water productivity of each treatment was calculated which is the ratio of crop yield (kg) to the total quantity of irrigation water applied i. e.

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{(Crop yield (kg)}}{\text{(Total quantity of irrigation water applied (ha mm)}}$$

Data collection

Field observation data during *kharif* 2018 and 2019 were collected on growth parameters such as plant height, tillers m^{-1}, and panicle m^{-1} were collected at maturity stage and pooled data was used for comparing the selected irrigation methods. Weight of 1000 grain and crop yield per hectare was calculated during crop harvest.

Cost economics

The benefit cost ratio was calculated using total expenditure which includes crop inputs incurred during crop production and their net profit with respect to crop yield. The results are presented in Table 3.

Table 2. Irrigation scheduling and quantity of water irrigated in treatments.

Days	No. of irrigation	Quantity water applied ha mm^{-1}	Days	No. of irrigation	Quantity water applied ha mm^{-1}	Days	No. of irrigation	Quantity water applied ha mm^{-1}
1—30	4	200	1—30	5	100	1—30	5	250
31—60	2	100	31—60	5	100	31—60	2	100
61—90	5	250	61—90	14	280	61—90	6	300
91—120	5	250	91—120	15	300	91—120	7	350
121—135	2	100	121—135	7	140	135	6	300
		900			920			1300

RESULTS AND DISCUSSION

The results of plant growth parameters, water use efficiency and water productivity under different irrigation methods are presented and discussed in this section.

Growth parameters

The highest grain yield (6.55 t ha^{-1}) was recorded in TO_1 method followed by TO_2 (6.32 t ha^{-1}) and least was in TO_3 (5.92 t ha^{-1}). The increased yield in AWD (TO_1) was attributed by higher 1,000-seed weight (18.18) and panicle per square meter (368.91). Similarly, AWD resulted in significantlyhigher growth parameters like plant height and tillers which paved the way for formation of requiredyield-contributing parameters over TO_3 and TO_2 (Table 3).There was increase in crop yield of 10.64 % and 6.75 % in TO_1 and TO_2 respectively over TO_1 due to the effect of plant growth parameters due to better aeration and better root growth. Increased crop yield and growth parameters in TO_1 due to better aeration and better root growth in AWD practice which has provided sufficient nutrients for vegetative and reproductive growth and same kind of results were reported by Chandrapalaet al. (2010),Duttarganvi et al. 2016.

Water saving and water productivity

The results of water saving and water productivity under each technology option is presented in Table 4. The maximum irrigation water was consumed in TO_3 (1300 mm ha^{-1}) followed by TO_2 (920 mm ha^{-1}) and least was in TO_1 (900 mm ha^{-1}). However, it was reported that, 44.40 % and 41.30 % of irrigation water was saved by TO_1 and TO_2 over traditional practices of irrigation (TO_3). The highest water productivity was reported in TO_1 (7.27 kg ha^{-1} mm^{-1}) followed by TO_2 (6.86 kg ha^{-1} mm^{-1}) and least was in TO_3 (4.55 kg ha^{-1} mm^{-1}).Application of irrigation water, after formation of hairline cracks showed considerable water saving besides providing a better root-growing environment and microbial environment in AWD and the restriction of seepage and deep percolation losses by maintaining water level up to saturation attributing to lesser water use under saturation which enhance the highest water saving and water productivity in TO_1 and TO_2. These results were in correlation with Shantappaet al. (2014) reported more quantity of water saved (34%) in AWD than farmers traditional practices without reduction in paddy yield.

Benefit cost ratio

The results on expenditure of crop inputs and economic feasibility of selected irrigation methods are presented in Table 5. The maximum benefit cost ratio was recorded in TO_1 (2.60) followed by TO_2 (2.46) and least was in TO_3 (2.12). It is observed that, the intermittent application of water through AWD method reduced application of fertilizer and pesticide which incurred in minimum expenditure and increase in yield due to good management practices. The cost of irrigation was also less in AWD and saturation due to less quantity of irrigation water applied. The less expenditure in irrigation and fertilizer application under AWD and saturation methods enhances the B: C ration in TO_1 and TO_2 and this results are confirmed with Singh et al.(2013),Duttarganvi et al. (2016).

Table 3. Effect of alternate wetting and drying method on growth and yield parameters of rice (Pooled data *kharif* 2017 and 2018).

Sl. No.	Parameters	TO_1	TO_2	TO_3
0_1	Plant height (cm)	91.30	87.10	87.91
0_2	Tillers m^2	404.90	372.43	370.10
0_3	Panicles m^2	368.91	353.52	324.72
0_4	Days to 50% flowering	73.00	80.00	78.00
0_5	Days to maturity	124	132	134
0_6	Panicle weight (g)	6.32	5.53	5.50
0_7	1,000 grain weight	18.18	17.02	16.52
0_8	Crop yield (ha)	6.53	6.32	5.92
0_9	% Increase in yield	10.64	6.75	—

Table 4. Effect of alternate wetting and drying method on water saving and water productivity of rice crop (Pooled data of two season).

Sl. No.	Parameter	TO_1	TO_2	TO_3
0_1	Crop yield (kg ha^{-1})	6550	63.20	57.20
0_2	Quantity of water applied (mm ha^{-1})	900	920	1300
0_3	% Water saving	44.40	41.30	—
0_4	Water Productivity (kg ha^{-1} mm^{-1})	7.27	6.86	4.55

Table 5. Details on expenditure of crop inputs (Rs ha-1) and benefit cost ratio of selected irrigation methods.

Sl. No.	Details	TO_1	TO_2	TO_3
1	Seed	1500	1500	1500
3	Fertilizer cost	7375	7800	8450
4	Weedicideand pesticide applied	4500	5250	6025
6	land paration and puddlity	6250	6250	6250
8	Nurrising planting and transplanting	6250	6250	6250
9	Irrigation	750	1000	2500

CONCLUSION

There is a high time to introduce precise water application methods in paddy cultivation to minimize water losses and soil health related problems in UKP command area and solve water scarcity problem among tail end farmers. The alternative wetting and drying irrigation method is the solution water scarcity problem in command areas. The use of AWD irrigation method in paddy could able to save 44 % of irrigation water as compared to farmers traditional practices and also possible to achieve water productivity of 7.27 (kg ha^{-1} mm^{-1}) over continuous submergence method without reduction in crop yield. The irrigation with 2 cm saturation of water has ability to save 41 % of irrigation water as compared to traditional method. Better aeration and root growth under AWD practice provided sufficient nutrients for vegetative and reproductive growth which enhance the 10 % increase in crop yieldover traditional irrigation method. The intermittent application of irrigation water reduces quantity of fertilizer application and irrigation which enhanced the increase in B:C ration in AWD method. Therefore, paddy growing farmers should adopt AWD irrigation application method instead of continuous submergence to minimize water losses and solve water scarcity problems in UKP command area.

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