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Irrigation Water productivity in Rice Crop through Alternate Wetting and Drying method

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ABSTRACT

The demonstrations on alternate wetting and drying (AWD) in rice crops were conducted by KVK Ferozepur, Punjab during Kharif 2019-21 at 25 locations in 5 villages of the district. The selected study locale was characterized by well-drained sandy loam with medium soil fertility status. The three plots of 0.4 ha size each were selected for the three treatments i.e. continuous submergence (farmer practice), after 2-3 days of percolation (AWD), and after 5-6 days of percolation at each of 25 locations. The rice grain yields increased by 1.18 percent under AWD compared to the continuous submergence (71.4 q/ha). The irrigation water productivity (IWP) was higher by 18.36 percent under AWD compared to that in continuous submergence. Rice crops under AWD required 30 cm smaller amount of irrigation water during the whole growing season compared to the continuous submergence. The AWD technique holds great promise as water-saving technology that can help to address water scarcity in the rice growing areas of the food basket bowl of India. Therefore, the AWD method could enhance yield and save irrigation water by 18-20 percent in rice crops.

Keywords: *Rice crop, Water saving, wetting, drying, alternate, yield*

INTRODUCTION

Water is an important natural resource and its increasing scarcity has resulted in the emergence of various issues for its efficient use, management and sustainability. Only 2.7 percent of the global water is available as freshwater, out of which only 30 percent can be used to meet the demand for humans and livestock. While the demand for rice is rising in Asia, many Asian countries are experiencing a decline in the total quantity of freshwater available for agriculture [18,20]. The demand for water (of appropriate quality) is expected to rise manifold owing to ever-increasing population, rising demand for food, urbanization, and industrialization and may even exceed its supply [6].

Among water-saving methods, alternate wetting and drying (AWD) and direct seeded rice (DSR) are appealing options that are being used globally. [15, 21]. However, in light textured soils, using DSR and AWD options has not been successful due to less water holding capacity of soil, more water requirement, and variation in nutrient availability[12]. The adoption of water-saving methods in rice crop not only increases the yield but also increases carbon sequestration, helps in resource (water, labor, energy, and time) saving, and reduce the emission of greenhouse gases (GHGs) [13,22].

Irrigating rice field two days after percolation of ponded water at the vegetative phase was found to be the best irrigation practice for conserving precious water and getting higher grain yield [24]. Alternate wetting and drying can lower water use for irrigated rice by around 35 per cent [11], and increase paddy yield upto 10 percent relative to permanent flooding [11].

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The puddled transplanted rice is traditionally cultivated in flooded fields. Rice crop is an extremely water-intensive crop; on average 3400 liters of water are needed to grow one kilogram (kg) of rice [7]. It has been demonstrated that this amount of water is not always required for rice that is irrigated. A kilogram of rough rice needs 1,432 liters of evapo-transpired water. Therefore, there is scope for water conservation in rice irrigation [8]. On contrary to the actual field requirement, farmers actually use plenty of water for land preparation and crop growth.In comparison to other cereal crops, the water requirement in transplanted paddy is four to five times more. In order to promote or disseminate any technology, demonstrations play a crucial role in raising farmers' awareness. The main purposes of demonstrations are to showcase technological outcomes and provide farmers with an opportunity to try out innovative methods. The design of a new farming invention that precisely uses water is aided by demonstrations. In order to achieve this goal, district Ferozepur, Punjab, conducted demonstrations on the conservation of water in fields of rice.

MATERIALS AND METHODS

To achieve the objectives, demonstrations on AWD in rice were conducted by KVK Ferozepur during Kharif 2019-2021 at 25 locations in 5 villages of Ferozepur. The area is characterized by Semi-arid, arid type of climate with hot and dry early summers from April-June followed by hot and humid period from July September and cold winters from December-January. The annual rainfall of the area is 430.7 mm, most of which is received during July to September [1, 2]. The study sites were characterized by well-drained sandy loam textured soil and the fertility status of study area was medium in category (Table 1). The plot size for the demonstrations were 0.4 ha in size and was selected for the three treatments i.e T1: continuous submergence (farmer practice), T2: After 2-3 days of percolation (alternate wetting and drying)[3], and T3: After

5-6 days of percolation at each of 25 locations. Continuous submergence is common practice which is commonly adopted to irrigate the paddy fields. The source of irrigation was the electric motor at all the locations and the number of irrigations applied in each plot was recorded. The first irrigation for puddling during transplanting of paddy in each treatment was considered to be 12 cm and the subsequent irrigations after transplanting of paddy were assumed to be 6 cm each in order to determine the water productivity. In the demonstration plots, full package of recommended agronomic practices was adopted for using N, P, K, and Zn in paddy crop with special emphasis on the scheduling of irrigation on the basis of AWD (irrigation after 2-3 days of percolation of ponded water). The performance of the demonstrated technology in terms of the observations on a number of tillers, plant height, panicle length, grain yield, and water productivity was compared with the farmers' practice i.e continuous submergence (check). The primary data on grain yield in demonstration plots and farmers' practice was recorded and the yield increase in demonstrations over farmers' practice was calculated using the following formula [5].

$$\%\text{yield increase over farmer's practice (\%YIOFP)} = \frac{(\text{Average demonstration plot yield} - \text{Farmer's average plot yield})}{\text{Farmer's average plot yield}} \times 100$$

Similarly the irrigation water productivity was calculated by the formula [10]

$$\text{IWP} = \frac{\text{Y}}{\text{IW}} \times 100$$

Where, IWP = Irrigation water productivity (kg m^{-3}) Y = Grain yield (kg ha^{-1}) IW = Total irrigation water applied (cm) to the crop

On the contrary, in farmers' practice, continuous irrigation was given to paddy crop up to the harvest stage. The motive behind the conduct of these demonstrations was to create awareness among farmers regarding the efficient use of water in paddy, which is generally held responsible for depleting groundwater. The sites for conducting demonstrations were selected in such a way that these were easily accessible to the neighboring farmers extension workers and visiting team. Orientation training, farmer scientist interactions and campaigns were organized so that all the participating farmers would be attentive toward the aims and objectives of the demonstrations (Table 2).

Table 1: Description of mean values of soil properties from the demonstration sites.

Soil Properties	Sandy Loam	Method
Soil Chemical properties		
Clay %	11.4	[19]
Silt %	17.4	
Sand %	71.2	
Soil pH	7.88	[14]
Soil EC (dS/m)	0.25	[14]
SOC (%)	0.48	[23]
Available P (kg/ha.)	20.5	[4]
Available K (kg/ha.)	146	Neutral NH4OAc [17]
Available Zn (mg/kg)	2.11	DTPA extraction [16]
Available Fe (mg/kg)	22.2	
Available Mn (mg/kg)	8.7	
Available Cu (mg/kg)	1.01	

Table 2: Details of awareness activities conducted in the aspirational area of the district during the three years of study

S. No.	Activity	Number	Participants
1	Training Program	5	116
2	Farmer Scientist Interaction	9	204
3	Awareness Campaigns	14	546

RESULTS

The numbers of total irrigations were significantly less in after 2-3 days of percolation (alternate wetting and drying method) compared to the flooding method. The paddy grain yields (Table 3) increased by 1.18 per cent under AWD compared to the continuous submergence (71.4 q/ha) because significantly better yield attributes in AWD in comparison to submergence but after 5-6 days of percolation decreased the grain yield 69.51 q/ha (Table 3). In the same way the irrigation water productivity (IWP) was higher by 28.57 percent in after 5-6 days of percolation 18.36 percent and after 2-3 days of percolation (AWD) compared to that in continuous submergence. Paddy crop in AWD required 30 cm less amount of irrigation water during the complete growing season compared to the continuous flooding in puddled transplanted rice. The increase in grain yield under AWD system was attributed to an improved proportion of productive tillers, more light on canopy penetration due to reduced angle of the topmost leaves, modifying shoot and root activity i.e. altered root-to-shoot signaling of phytohormones viz., Abscisic Acid and cytokinins as earlier reported by [22]. Similarly, [22] reported that the remobilization of carbohydrates from stems to the grain could be another important mechanism of improving grain filling under AWD treatments. [9] reported that soil drying during the grain-filling phase of rice can increase yield by promoting faster remobilization of carbon and root enlargement for maximum nutrient uptake.

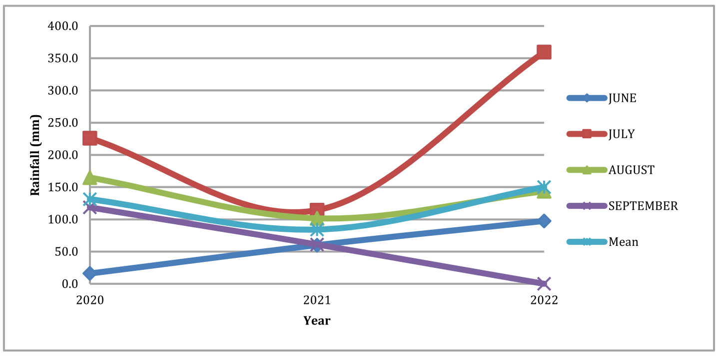

Figure 1: yearly rainfall data of experimental months

The comparative less percent saving in number of irrigations during the year 2022 may be attributed to the more rainfall (359.5 mm in 2022) occurred during the cropping period as compared to the year 2021 (84.2 mm) as depicted in the figure1.

Table 3: Effect of irrigation scheduling on grain yield and water productivity in paddy

Technology	No. of irrigation	No. of tiller/m²	Plant height (cm)	Panicle length (cm)	Yield (q ha^{-1})	Water productivity (kgm^{-3})	% Increase in yield	% Increase in water productivity
Continuous submergence	27.48[c]	442.86[b]	104.85[a]	26.38[a]	71.4[b]	0.40	-	-
After 2-3 days of percolation	22.4[b]	445.32[c]	105.71[b]	26.64[a]	72.25[c]	0.49	1.18	18.36
After 5-6 days of percolation	18.6[a]	438.48[a]	103.07[a]	25.86[b]	69.51[a]	0.56	-2.64	28.57
Sig. ($p<0.05$)	0.00	0.069	0.004	0.537	0.031	-	-	-

CONCLUSION

Results showed that the AWD technique holds great promise as a water-saving technology that can help to address water scarcity in rice growing areas because irrigation water use can potentially be reduced without the adverse effect on paddy yield. Alternate wetting and drying reduced the amount of irrigation water required for rice by around 30 cm during the growing season (18.36 per cent) apart from providing an increase in the yield by 1.18 per cent. So, farmers can irrigate their rice fields by adopting alternate wetting drying methods for sustainable agriculture and can achieve maximum benefit.

Conflict of interest: The authors declare no conflict of interest.

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