



Original Research Article

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Productivity and Water Expense Efficiency of Rice (*Oryza sativa* L.) under Different Irrigation Scheduling in South-West Punjab

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ABSTRACT

Keywords

Rice, Grain yield, Irrigation scheduling and water expense efficiency

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A field experiment entitled “Effect of irrigation scheduling on performance and water expense efficiency in rice (*Oryza sativa* L.) in South-west Punjab” was conducted during the *rabi* season of 2017 at Research Farm of Guru Kashi University, Talwandi Sabo, Bathinda (Punjab). The experiment was laid out in RCBD (Randomized complete block design) with 4 treatments viz., T₁: Continuous standing of irrigation water, T₂: Irrigation one day after infiltration of ponded water, T₃: Irrigation two days after infiltration of ponded water, T₄: Irrigation four days after infiltration of ponded water. The results showed that the application of irrigation one day after infiltration of ponded water recorded significantly higher no. of tillers/hill (16.12), plant height (129.9 cm), no. of effective tillers/hill (14.9), panicle length (29.1 cm), number of grains/panicle (204.5), grain yield (77.1 q/ha), straw yield (187.3 q/ha), biological yield (294.9 q/ha) and water expense efficiency (42.2 kg/ha/cm) than other treatments. Application of irrigation one day after infiltration of ponded water do not produced only higher grain yield but also helped to save 27% irrigation water compared to continuous flooding. The findings can be useful for improving rice productivity with less water consumption in Punjab state.

Introduction

Rice (*Oryza sativa* L.) is an important cereal crop in Asia and contains 74.8% carbohydrate, 8.4% protein, 2.6% fat, amino acids and minerals. In India, rice occupying 43.95 million ha and production of 106.54 million tones rice with average productivity 24.24 q/ha. In Punjab, rice was grown on 2.85 million hectares with a production of 11.27 million tonnes and average yield of 40 q/ha during 2018 (Anonymous 2018). Rice crop grows well in high humidity, temperature

ranging between 20-37°C in loamy soil. Rice requires lot of water throughout its life cycle. The current rice production system about 5000 liters of water is needed for production of 1kg grain and short period of water deficit may affect the rice productivity (O’ Toole, 2004).

Paddy is generally grown in low land area under continuous flooded conditions which is an inefficient method and accounts for 50-80 wastage of total water input (Sharma, 1989). High emission of methane (Wassmann *et al.*,

2009), leaching of soluble nutrients, blocking of soil microbial activities reduced mineralization have also been reported under continuous flooding of rice (Uphoff and Randriamiharisoa, 2002). Water saving is the main issue in maintaining the sustainability of rice production under scarce water conditions (Arif *et al.*, 2012).

Number of alternatives to continuous flooding of rice has been developed by the researches and intermittent irrigation approach can be an applicable strategy that can be used for water saving without any loss in yield of rice. The earlier studies showed 21%, 50% and 21% decrease in plant growth, flowering and grain yield of rice, respectively due to water deficit (Pirdashti *et al.*, 2004). The intermittent irrigation resulted decrease in water consumption and increased water productivity without any loss of yield (Rezaei and Nahvi 2007 and Rezaei *et al.*, 2010). Sheela and Alexander (1996) reported that water stress affects the chlorophyll content in leaves which lead to inactivation of photosynthesis (Kura-Hotta *et al.*, 1987).

Low availability of nutrients to plant (Wopereis *et al.*, 1999) under water stress conditions decreased in number of tillers, leaf area, dry matter, number of panicles, kernel weight and yield of rice (Beldar *et al.*, 2004). The use of vague irrigation practices by the farmers has resulted in either under irrigation or over irrigation of rice crops leading to low production per unit of applied water. Keeping in view, in adequate canal water availability and poor quality of underground water in south- western districts of Punjab, the present investigation was undertaken to provide information on low water use in rice cultivation. The objectives of the study were: To study the effect of irrigation scheduling on growth and yield of rice. To study the effect of irrigation scheduling on water saving and water expense efficiency in rice.

Materials and Methods

The present investigation “Effect of irrigation scheduling on performance and water expense efficiency in rice (*Oryza sativa* L.)” was conducted at experimental farm of University College of Agriculture, Guru Kashi University Talwandi Sabo, Bathinda during *rabi* season 2017. Talwandi Sabo is located at 29°57 N latitude and 75°7 E longitudes and altitude (213 m above sea levels). The tract is characterized by semi-arid climate. Maximum temperature is about 45-47°C is not uncommon during summer, while freezing temperature accompanied by frost occurrence may be witnessed in the month of December and January. The mean annual rainfall fluctuates around 150 mm, major part of which is during the month of July to November with a few shower of cyclonic rains during winter and spring month. The soil of experimental field was slightly alkaline (pH 7.6) with normal electrical conductivity (0.25 dSm⁻¹), low in organic carbon content (0.30%) and available nitrogen (234.3 kg/ha), medium in available phosphorus (15.1 kg/ha) and available potassium (217.6 kg/ha). The experiment was laid out in randomized block design with five replications. The treatments comprised of continuous standing of irrigation water, irrigation one day after infiltration of pounded water, irrigation two days after infiltration of pounded water, irrigation four days after infiltration of pounded water.

During the crop growth period, the following observations were recorded from time to time. The height of five randomly selected plants was measured at maturity. Number of tillers was counted manually from randomly selected five plants at maturity in each plot. Tillers bearing panicles were counted and recorded as productive tillers. The length of the panicle from neck node to the apex tip of panicle from the five randomly selected plants in each plot was measured and average value

was expressed in centimeters. The weight of total produce/plot was recorded after harvest of the crop with help of spring balance. Then the weight of grains per plot was recorded after threshing of the harvested produce from each bundle and mean converted into the grain yield kg/ha. The bundle weight was taken before threshing and plot wise straw yield was obtained after deducting the grain weight from the whole bundle weight. The straw yield was expressed in kg/ha. The weight of randomly 1000-grains was recorded from each plot and expressed in g. Harvest index (HI) was calculated by using following formula;

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Results and Discussion

Growth parameters of rice

Significantly highest plant height was recorded with irrigation was applied one day after infiltration of pounded water (129.9 cm) which was followed by continuous irrigation (125.9 cm) and was significantly higher than other treatments i.e. irrigation two and four days after infiltration of pounded water (Table 1).

The significantly higher number of tillers/hill (16.12) were recorded in plots receiving irrigation one day after infiltration of pounded water followed by continuous standing of water (14.7). The minimum number of tillers/hill (11.9) was recorded in plots where irrigation was applied four days after infiltration of pounded water.

Yield attributes of rice

Application of irrigation one day after infiltration of pounded water resulted in maximum number of effective tillers (14.8)

per plant and followed by continuous standing of water (13.4) and was significantly higher than other treatments (Table 2). The lowest number of effective tillers (10.9) per plant was recorded in treatment receiving irrigation four days after infiltration of pounded water. Similar results were also reported by Islam (1999), Pal *et al.*, (2013), Thakur *et al.*, (2010), Gani *et al.*, (2002) and Parihar (2004).

Application of irrigation one day after infiltration of pounded water significantly increased rice panicle length (29.1 cm) as compared to other treatments and followed by continuous standing of water (28.9 cm) (Table 3). The lowest panicle length (26.8 cm) was observed in plots receiving irrigation four days after infiltration of pounded water and was at par with irrigation applied two days (27.2) after infiltration of pounded water. The variation in the above mentioned growth parameters have also been reported by many research workers Belder *et al.*, (2004), Rezaei and Nahvi (2007)

The different irrigation treatments showed the significant effect on number of grains per panicle. The maximum number of grains per panicle (204.5) was recorded in plots where irrigation was applied one day after infiltration of pounded water followed by continuous flooding (198.8). The minimum number of grains per panicle (183.5) was recorded in plots receiving irrigation four days after infiltration of pounded water. Similar results were also reported by Uppal and Bali (1994), Sarwar *et al.*, (2004).

The data showed a significant effect of different irrigation treatments. Application of irrigation one day after infiltration of pounded water resulted in significantly higher the 1000-grain weight (29.3 g) as compared to other treatments except in continuous flooding which was at par (28.7). The minimum 1000-grain weight (26.9 g) was

recorded in plots receiving irrigation four days after infiltration of pounded water and was at par with irrigation four days after infiltration of pounded water (27.50). Parihar (2004) suggested that irrigation applied one day after infiltration of pounded water can be considered as standard irrigation schedule.

Yield of rice

The data revealed that irrigation one day after infiltration of pounded water gave significantly higher grain yield (77.1 q/ha) as compared to other treatments and was 11.2, 25.2 and 35.1% higher over continuous flooding, irrigation applied two days and four days after infiltration of pounded water, respectively (Table 3). The increase in grain yield may be due to increased number of effective tillers/hill, number of grains/panicle and test weight. Similar results were also reported by Dung *et al.*, (2009) and Hao *et al.*, (2007).

The maximum straw yield (187.3 q/ha) was recorded in plots receiving irrigation one day after infiltration of pounded water followed by continuous flooding (179.2 q/ha). The

lowest straw yield (163.9 q/ha) was recorded when irrigation was applied four days after infiltration of pounded water but was at par with irrigation applied two days after infiltration of pounded water (167.1 q/ha). Water stress prevented transfer nutrients to plants which decreased dry matter, leaf area, number of panicle, resulting low straw yield. Similar results were also reported by Parihar (2004).

The data revealed that irrigation applied one day after infiltration of ponded water produced significantly higher biological yield of rice (294.7 q/ha) and was 10, 20.4 and 38.8% higher over continuous flooded, irrigation applied two days and four days after infiltration of pounded water respectively. Similarly, irrigation applied four days after drainage of infiltration water produced lowest biological yield of rice (212.3 q/ha). The increased in biological yield of rice may be attributes to increase in plant height, better nutrient availability which resulted in more biomass. The variation in the above mentioned growth parameters have also been reported by Gani *et al.*, (2002).

Table.1 Effect of irrigation scheduling on plant height, number of tillers and number of effective tillers in rice

Treatments	Plant height (cm)	No. of tillers/hill	Number of effective tillers/hill
T₁: Continuous standing of irrigation water	125.9	14.7	13.4
T₂: Irrigation one day after infiltration of pounded water	129.9	16.1	14.9
T₃: Irrigation two days after infiltration of pounded water	122.2	13.6	12.4
T₄: Irrigation four days after infiltration of pounded water	117.9	11.9	10.9
LSD (P=0.05)	1.4	0.70	0.7

Table.2 Effect of irrigation scheduling on yield parameters of rice

Treatments	Panicle length (cm)	Number of grains/panicle	Test weight (g)
T ₁ : Continuous standing of irrigation water	28.2	198.8	28.7
T ₂ : Irrigation one day after infiltration of pounded water	29.1	204.5	29.3
T ₃ : Irrigation two days after infiltration of pounded water	27.2	188.7	27.5
T ₄ : Irrigation four days after infiltration of pounded water	26.8	183.5	26.9
LSD (P=0.05)	0.5	1.8	0.6

Table.3 Effect of irrigation scheduling on productivity of rice

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest Index (%)
T ₁ : Continuous standing of irrigation water	69.3	179.3	267.9	27.9
T ₂ : Irrigation one day after infiltration of pounded water	77.1	187.3	294.7	29.1
T ₃ : Irrigation two days after infiltration of pounded water	61.6	167.1	244.7	26.9
T ₄ : Irrigation four days after infiltration of pounded water	57.0	163.9	212.3	25.8
LSD (P=0.05)	2.2	3.8	14.8	0.4

Table.4 Irrigation water applied and water expense efficiency under different irrigation treatments in rice

Treatment	Irrigation water applied (cm)	Water expense efficiency (kg/ha/cm)
T ₁ : Continuous standing of irrigation water	302.4	22.9
T ₂ : Irrigation one day after infiltration of pounded water	182.4	42.2
T ₃ : Irrigation two days after infiltration of pounded water	152.5	40.4
T ₄ : Irrigation four days after infiltration of pounded water	137.5	41.7
LSD (P=0.05)	0.1	1.2

The maximum percent harvest index (29.1) was recorded in plots receiving irrigation one day after infiltration of ponded water followed by continuous flooding (27.9). The minimum percent harvest index (25.79) observed in plots receiving irrigation four days after infiltration of ponded water.

Irrigation water applied and water expense efficiency

The maximum quantity of water (302.5 cm) applied under continuous irrigation and was significantly higher than other treatments (Table 4). The minimum quantity of water was (137.5 cm) when irrigation was applied four days after infiltration of ponded water. The maximum water expense efficiency (42.2 kg/ha/cm) was recorded when irrigation was applied one day after infiltration of ponded water and was at par i.e. 41.7 kg/ha/cm in case of irrigation applied four days after infiltration of ponded water. The minimum water expense efficiency (22.9 kg/ha/cm) was recorded under continuous irrigation.

In conclusion, Irrigation applied one day after infiltration of ponded water in rice gave maximum grain yield (77.1 q/ha) as well as straw yield (187.3 q/ha). Application of irrigation water one day after infiltration of ponded water significantly increased plant height, number of effective tillers/hill, number of grains/panicle and biological yield as compared to other treatments. Irrigation applied one day after infiltration of ponded water saved 27% irrigation water over continuous flooding. Application of irrigation water one day after infiltration of ponded water resulted in maximum water expense efficiency (42.2 kg/cm).

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