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STUDIES ON IRRIGATION AND WEED MANAGEMENT FOR ENHANCING RICE YIELD AND WATER PRODUCTIVITY UNDER SYSTEM OF RICE INTENSIFICATION

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ABSTRACT

Plant height (113.68 cm),LAI (3.04),crop growth rate(11.96 g/day/m^2) number of panicles/m^2, (249.23) grain weight/panicle, (3.62 gm) grain and straw yield (64.07 q/ha) (86.85q/ha) respectively were found to be maximum under the treatment continuous submergence to 2.5 cm and were showed significantly superior over submergence to 2.5 cm 5 DAD but statisticallyat par with 1 DAD and 3 DAD.Higher water use efficiency (82.99kg/ha-cm) and water productivity (6.87 Rs/m^3) were found with submergence to 2.5 cm 3 DAD. Similarly levels of mechanical weedings has significant influenced on growth and yield attributes,grainand straw yield (64.18q/ha) (85.83q/ha) respectively. These were found maximum with the rotary weeding at 10, 20, 30 and 40 DAT which was significantly superior over rotary weeding at 20 and 40 DAT but statistically were at par with rotary weeding at 20, 30 and 40 DAT. Test weight was not affected significantly due to irrigation and mechanical weeding treatments. Thus Irrigation of 2.5 cm water at 3 DAD and rotary weeding at 20, 30 and 40 days after transplanting should be practiced for getting higher grain yield, water use efficiency and water productivity of rice under SRI in agro-climatic zone 1 of Bihar.

INTRODUCTION

Rice (*Oryza sativa*) is the most important staple food for a large portion of the world's human population (about 3 billions) and supplies as much as half of the daily calories of the world population (Abbas *et al.*, 2011). Almost 90% area and production of the world's rice accounted and consumed in Asia. The world's total area is 168 million ha and production is about 722 million tonne with the productivity of 4.29 tonne/ha (FAOSTAT-2012). In India, rice is being cultivated in 42.75 million ha area with an annual production of 105.23 million tonne and average productivity is 2.46 tonne /ha. In Bihar, rice is cultivated on 3.29 million ha area with the production of 7.5 million tonne and the productivity is 2.28 tonne/ha. (Agricultural statistics at a glance, 2012-2013)

The importance of rice production is increasing day by day because of rising population. To ensure food security in the rice consuming countries like India will have to meet consumers demand by enhancing about 125 million tones rice by 2020 (Mishra, 2005). This additional rice will have to be produced on less land with less water, less labour and reduced inputs. The task becomes even more difficult when the sustainability of rice production threatended by increasing scarcity of irrigation water. There is challenge to develop novel technologies and production system that allow rice production to be maintained or increased in the face of declining water availability.

Weeds are major constraints in rice production; it has to be tackled timely and efficiently for successful rice production. An uncontrolled weed may reduce the rice production up to 40-96% hence a weed free period for the first 30-45 days after sowing is required to avoid any loss in yield (Maity and Mukherjee, 2008). Therefore to remove the weeds timely, proper weed management practices are necessary. Use of a rotary weeder has been found to permit greater root growth, better tillering and provides other favorable conditions for better growth especially the soil aeration (Kumar,2004). System of Rice Intensification (SRI) is emerging as a low-input technology for increasing rice productivity with less use of water, seed and fertilizer, SRI has attracted attention because of its apparent success in increasing rice yields with less water-use (Uphoff *et al.*2011).Therefore the present experiment was entitled "Studies on Irrigation and Weed management for enhancing rice yield and water productivity under System of Rice Intensification".

MATERIALS AND METHODS

The field experiment was conducted under AICRP on water management during the *kharif* season of 2008 and 2010 at Agronomy (water management Research) farm of Rajendra Agricultural University, Bihar, Pusa, Samastipur situated at 43" N latitude, 78" E longitude and 52.92 m above mean sea level. The main plottreatmentswere Continuous submergence to 2.5 cm (I_1), submergence to 2.5cm 1 DAD(I_2), submergence to 2.5cm 3 DAD (I_3) and submergence to 2.5cm 5 DAD (I_4). The Sub plot treatments were Rotary weeding at 20 and 40

DAT(W_1), Rotary weeding at 20, 30 and 40 DAT(W_2) and Rotary weeding at 10, 20, 30 and 40 DAT(W_3). The experiment was laid out in Split Plot Design (SPD) with three replications.The plot had fairly uniform topography and the soil was deep and well drained. The soil of the experimental plot was calcareous, sandy loam in texture, low in available nitrogen 150 kg/ha and phosphorous(18.33kg/ha) and medium in potassium content(158.2 kg/ha) with pH of 8.2. Crop was irrigated as per treatment with measured amount water using 7.5 throat parshall flume, installed at the head of experimental plot. Based on the principle of SRI, 10 days old seedlings were uprooted carefully and transplanted single seedling per hill at wider spacing of 25 cm × 25 cm. Transplanted field was well puddled with no water stagnation and the date of transplanting were 29/07/2008 and 23/07/2010. Standard procedures were used for chemical analysis of soil and plant sample. The economics were worked on the basis of prevailing market prices of inputs and outputs.The data collected from the experiment were subjected to statistical analysis by using the Analysis of variance technique as suggested by (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

Growth attributes

Both irrigation and weed management significantly affected the growth parameters.Plant height showed significant variation due to irrigation levels. The maximum plant height was recorded with continuous submergence to 2.5 cm (I_1) which was statistically at par with irrigation levels of submergence to 2.5 cm 1 DAD (I_2) and 3 DAD (I_3) but was significantly superior over submergence to 2.5 cm 5 DAD (I_4) during all the stages of crop growth. This might be due to presence of sufficient moisture with irrigation treatment of submergence to 2.5 cm 5 DAD. Significant increase in plant height due to irrigation has also been reported by various workers Kumar (2006) and Ramakrishna *et al.* (2007). Continuous and sufficient availability of moisture with I_1, I_2 and I_3 stimulate more in cell division causing more stem elongation which is the cause of increased plant height (Kimsangsu *et al.,* 1999). Number of rotary weeding also significantly influenced the plant height. Four (W_3) and three (W_2) rotary weeding recorded significantly higher plant height as compared to less number of weeding (2 times). Increased number of rotary weeding led the suppression of weeds at each and every stage of growth and at the same time more supporting of diverse population of beneficial soil biota (Anas *et al.,* 2011). Maximum leaf area index (LAI) was recorded with continuous submergence of water to 2.5 cm which was at par with submergence to 2.5 cm 1 DAD and 3 DAD as compared to 5 DAD. This was due to adequate moisture supply which influenced the growth of leaves and more number of larger sized leaves. It was also observed that LAI increased upto 60 DAT thereafter it decreased due to aging, senescence, mortality and leaf drying. Mechanical weeding significantly affected the LAI, the maximum LAI was recorded with rotary weeding at 10, 20, 30 and 40 DAT. Under SRI 3-4 mechanical weeding suppress the weed activities and chrun the soil which resulted better aeration and causes more vegetative growth due to higher accumulation of photosynthates. All these physiological phenomenon leads to higher LAI (Haden *et al.* 2007).Crop growth rate is a complex interaction between the plant growth and its environment. The rotary weeding at 10, 20, 30 and 40 DAT influenced the optimum eco-physiological condition of other growth factors and hence attained higher CGR. The higher CGR value contributed to vigorous plant growth and more tillering resulting in higher biomass yield. This was possible due to better nutrient availability and absence of crop weed competition for other growth factors which prevented the mortality of tillers and premature senescence of leaves. The findings of the present investigation in respect of growth parameter are in conformity with Rao *et al.* (2006).

Yield attributes

Yield attributes were significantly influenced by both irrigation and weed management.Maximum value of all the yield attributing characters were recorded with continuous submergence 2.5 cm (I_1) which was statistically at par with submergence to 2.5 cm 1 DAD (I_2) and 3 DAD (I_3) but was significantly superior to 5 DAD (I_4) This might be due to increasing the number of irrigation levels and moisture availability at all the time of reproductive stage. At optimum moisture level, all the physiological activities of plant worked properly which resulted in better translocation of photosynthates form source into sink. Similar observations have also been reported by (Kumar, 2006) and (Thakur *et al.*, 2014). Mechanical weeding significantly influenced the yield attributing characters of rice. The maximum value of almost all the yield attributing characters (number of panicles, number of spikelets, number of grains/panicle, grain weight/panicle, length of panicle, 1000 grain weight and grain: straw ratio were found with rotary weeding at 10, 20, 30 and 40 DAT and was significantly superior over rotary weeding at 20 and 40 DAT but was statistically at par with rotary weeding at 20, 30 and 40 DAT. This might be due to the maximum suppression of weed and less competition for light, nutrient, space etc. Chauhan *et al.* (1999) also agreed with this opinion. Higher translocation and conversion rates of stored photosynthates from vegetative organ was of significant importance for enhanced yield attributes (number of grains, grain weight, number of panicles, and number of spikelets). These treatments offer better assimilation of photosynthate. Better utilization of incident solar radiation, space and nutrition might have increased the size of sink and effective translocation of assimilates lead to improve the length of panicles, number of panicles, number of spikelets/panicle and number of grains/panicle. Similar observation was also reported by Parihar (2004) and Kumar (2006).

Grain and straw yield

The crop raised by the application of continuous submergence under SRI gave significantly higher grain yield of 64.06 q/ha. Which was statistically at par with I_2 and I_3 and was significantly superior over I_4.There was 8.01 percent higher yield with I_1 as compared to I_4. Alternate wetting and drying improve the growth of roots and their activity, favoring water and nutrient uptake, which resulted into a delayed senescence of leaves and a higher photosynthetic rate (Thakur *et al.,* 2010 and 2011). Almost all the growth and yield attributing characters seems to be influenced by the increasing levels of irrigation

Table 1: Effect of irrigation and weed management on growth and yield attribute of rice under system of rice intensification. (Pooled data of two year)

Treatments	Plant height (cm)	LAI	CGR (g/day/m²)	Number of panicles/m²	Number of grains/panicle	Grain weight (g)/panicle
I_1-Continuous submergence to 2.5 cm	113.68	3.04	11.96	249.23	164.99	3.62
I_2- Submergence to 2.5 cm 1 DAD	111.77	2.96	11.75	239.33	161.50	3.54
I_3- Submergence to 2.5 cm 3 DAD	109.89	2.84	11.32	228.37	157.99	3.45
I_4- Submergence to 2.5 cm 5 DAD	105.02	2.67	10.58	215.95	151.81	3.30
S.Em. (±)	1.61	0.07	0.28	6.30	2.36	0.06
CD (P=0.05)	5.58	0.24	0.97	21.78	8.15	0.20
W_1-Rotary weeding at 20 and 40 DAT	106.05	2.71	10.78	219.27	153.86	3.33
W_2- Rotary weeding at 20, 30 and 40 DAT	110.80	2.90	11.47	234.91	159.71	3.49
W_3- Rotary weeding at 10, 20, 30 and 40 DAT	113.42	3.02	11.96	245.48	163.64	3.60
S.Em. (±)	1.30	0.06	0.22	3.77	1.89	0.05
CD (p=0.05)	3.89	0.17	0.67	11.44	5.63	0.15

DAD - Days after disappearance of ponded water

Table 2: Effect of irrigation and weed management on yield, WUE, and water productivity of rice under system of rice intensification. (Pooled data of two year)

Treatments	Grain Yield (q/ha)	Straw Yield (q/ha)	Test Weight (gm)	Water use efficiency kg/ha-cm	Water productivity Rs/m³
I_1-Continuous submergence to 2.5 cm	64.07	86.85	42.46	54.44	4.22
I_2- Submergence to 2.5 cm 1 DAD	62.62	84.66	42.53	63.25	5.05
I_3- Submergence to 2.5 cm 3 DAD	61.61	81.52	43.05	75.60	6.21
I_4- Submergence to 2.5 cm 5 DAD	59.47	78.90	42.93	82.99	6.87
S. Em. (±)	0.84	1.56	0.51	1.01	0.11
CD (P=0.05)	2.89	5.38	NS	3.51	0.39
W_1-Rotary weeding at 20 and 40 DAT	59.26	79.51	42.73	66.13	5.31
W_2-Rotary weeding at 20, 30 and 40 DAT	62.27	83.60	42.70	69.48	5.63
W_3-Rotary weeding at 10, 20, 30 and 40 DAT	64.18	85.83	42.80	71.60	5.82
S. Em. (±)	0.92	1.19	0.51	1.08	0.12
CD (p=0.05)	2.75	3.57	NS	3.22	0.36

DAD- Days after disappearance of ponded water

while at the moisture stress condition for long period, the photosynthetic activity was reduced owing the closure of stomata which resulted low intake of CO_2. Reduced translocation might have hindered further accumulation of the end product while it was just reversed in the case of the treatment receiving sufficient water throughout the growing period (Sarath and Thilak, 2004). Similarly straw yield was 10.08 percent higher with continuous submergence (I_1) as compared to submergence to 2.5 cm 5 DAD (I_4), which was statistically at par with submergence to 2.5 cm 1 DAD (I_2) and 3 DAD (I_3). Satyanarayna *et al.* (2006) also reported that alternate wetting and drying throughout the crop cycle with no continuous flooding was as good as maintaining 1-3 cm of standing water on the field after panicle initiation. Potential of crop to give yield is the sum total of the yield attributing characters as well as whole of the plant growth. The increase in the number of rotary weeding increased all yield attributing characters which was due to the fact that the crop remain free from weeds and had favorable condition for proper growth by utilization of plant nutrient, moisture, and solar radiation facilitating better photosynthetic efficiency. In the present experiment the performance of rotary weeding at 10, 20, 30 and 40 DAT was better than rotary weeding at 20 and 40 DAT but performed equally with rotary weeding at 20, 30 and 40 DAT. The highest mean grain yield of rice (64.18 q/ha) was obtained in the treatment applied with four rotary weedings at 10, 20, 30 and 40 DAT (W_3) followed by W_2 (62.26 q/ha) and W_1 (59.26 q/ha). The increases in grain yield were 8.30 percent under W_3 and 5.07 per cent under W_2 over W_1. This pronounced effect of increasing number of rotary weeding indicates that weed control is the key factor and it also increases the aeration in the field (Fernandes and Uphoff, 2002). Thus, four and three times rotary weeding diminished crop weed competition at the most critical period of weed interference and thus the weed free environment prevailing in ecosystem ensured vigorous plant growth resulting in higher yield. The highest grain yield with increase in rotary weeding under SRI was also observed by (Ravishankar *et al.,* 2008). The least rotary weeding condition create an ecologically harassed environment for the crop plant due to stiff competition with weeds for nutrient supply, water, light and CO_2. Hence, the minimum yields were recorded under two rotary treatments. The result of the present investigation was also favoured by (Sarath and Thilak 2004).Treatments recording higher grain yield also recorded higher yield of straw. Four times rotary weeding (W_3) recorded higher straw yield (85.83 q/ha). Three times rotary weeding (W_2) was the next one producing (83.60 q/ha). The lowest straw yield of (79.25 q/ha) was observed in plot where two times rotary weeding was applied at 20 and 40 DAT (W_1). This might be due to reduced crop growth and dry matter production of rice plant under higher weed infestation with W_1 as compared to W_2 and W_3. As a result the photosynthetic efficiency of the crop plant got reduced drastically and the dry matter production was adversely affected. However, better growing condition under mechanical weeding treatments W_3 and W_2 might have been responsible for higher straw yield than W_1, wherein a lot of nutrient, space, sun light have been shared by weeds bringing out the level of economic yield. This result was in agreement with the result of (Sarath and Thilak, 2004) and (Singh and Singh, 2006). Singh and Paikra, 2014 also reported that suppression of weed competition by weed control treatments offering efficient and prolonged weed control leading to higher grain yield.

Water productivity

Water use efficiency and water productivity (Table 2) were significantly affected due to different levels of irrigation and mechanical weeding.The maximum value of water use efficiency and water productivity were recorded with I_4 and was decreased with increase in number of irrigation.Similar result was depicted by (Chowdhury *et al.,* 2014).

The maximum water use efficiency and water productivity were recorded with W_3 which was significantly superior over W_1 but was statistically at par with W_2. Similar result was also observed by (Thakur *et al.,* 2010 and 2011).

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