The Pharma Innovation Journal 2022; 11(5): 2142-2145

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(5): 2142-2145
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www.thepharmajournal.com
Received: 06-02-2022
Accepted: 29-04-2022

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Effect of irrigation, nutrients levels and weed management practices on economics of aromatic rice (*Oryza sativa* L.)

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Abstract
The experiment was conducted at Student's Instructional Farm, Chandra Shekhar Azad University of Agriculture & technology, Kanpur during *Kharif* 2019 and 2020 on silty clay loam soils. The soil of the experimental field was neutral in reaction, testing medium in available P and K and low in available N with medium organic carbon content of 0.80. The treatments comprising of two irrigations methods: alternative wetting and drying (AWD), and flooding irrigation assigned to main plots, four nutrients levels (RDF+ $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 10 kg ha^{-1}, RDF+ $ZnSO_4$ @ 25 kg ha^{-1} and RDF+ $FeSO_4$ @ 10 kg ha^{-1}) in sub plots and four weed management practices including two herbicidal treatments (Chlorimuron ethyl and Fenoxaprop-p-ethyl), hand weeding along with weedy check to sub-sub-plots replicated were tested in Split-split plot design. On the basis of pooled data of two years revealed that highest economic returns in terms of total cost of cultivation, gross income, net return and benefit cost ratio was recorded during both the years of experimentation by irrigation methods, nutrients levels and weed management practices. Significant increase in total cost of cultivation, gross income, net return and benefit cost ratio was recorded due to the effect of irrigation methods. Highest total cost of cultivation, gross income, net return and benefit cost ratio was recorded with alternative wetting and drying (AWD) which was superior to flooded irrigation methods during both the years of experimentation. Among the nutrients RDF + $ZnSO_4$+ $FeSO_4$ at par with RDF + $ZnSO_4$ proved excellent resulted in higher economic returns comparable to RDF treatment. The data on weed management practices manifest that all the herbicides used for control of weeds including hand weeding found to be highest economic return compared to weedy check. The highest net realization of Rs.70924 ha^{-1}. With highest B: C ratio of 1.49 was ensured under treatments hand weeding during both the year.

Keywords: Irrigation, nutrients, management, economics, aromatic, *Oryza sativa* L.

Introduction
Rice (*Oryza sativa* L.) a member of Poaceae, formerly called Gramineae family is one of the most important food crops in the world forms the staple diet of 2.7 billion people. It is grown in all the continents except Antarctica, occupying 150 million ha, the production of 622 million tons of paddy with an average productivity of 3.83 tones ha^{-1}. Cultivation of rice is of immense importance to food security of Asia, where more than 90% of the global rice is produced and consumed). Rice is one of the major contributors to the food grain production contributing approximately 43 per cent of the total food grain production in India (Upendra *et al.*, 2013) [1]. India is the second largest consumer and producer of rice in world after China. The area, production and productivity of India is 43.78 m ha, 118.4 mt. and 27.05 qha^{-1}, respectively. (Anonymous, 2020-21). Uttar Pradesh is the 2nd largest rice growing state only after West Bengal in the country, with an area of 58.30 lakh hectares, production 141.18 lakh tones and the productivity of 2421 kg ha^{-1}. Demand for rice is growing every year and it is estimated that by 2025 AD the requirement would be 140 million tones to sustain present food self-sufficiency and to meet future food requirements, India has to increase its rice productivity by 3 per cent per annum.

The FAO estimates that rice crop consumes about 4000- 5000 liters' water per kg of grain produced. Since water for rice production has become increasingly scarce water saving strategies has become a priority in rice research (Raju and Sreenivas, 2008 and Borker *et al.*, 2000) [5]. The scarcity of water for agriculture production is becoming a major problem in many countries, particularly in word's leading rice-producing countries like China and India.

Rice cultivation in India is predominantly practiced under transplanting method that involves raising, uprooting and transplanting of seedlings. This technique requires continuous ponding of water. Now a day, water scarcity is a major concern in many regions of the world, as competition between agricultural and industrial consumption of water resources intensifies and climatic unpredictability increases (Hanjar, Quer; leshi, 2010; and Mahajan *et al*., 2011 & 2012).

The long term fertilizer experiment showed that continuous application of imbalance dose of chemical fertilizers alone or in combination to rice crop resulted in the deterioration of soil health. Recommended dose with proper balance of nutrients improve the nutrient status and soil health as well as proved to be a boon in stabilizing the crop yield over a period of time. Since the nitrogen, utilization varies from less than 30% in flooded (low land) crop to about 50-60% phosphorus in utilized by the first crop, with some residual phosphorus available for succeeding crops. Although utilization efficiency of applied potassium is fairly high about 80%, it needs proper and balance application along with over all crop management practices.

Materials and Methods

The experiment was conducted at the Student's Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during *Kharif* season 2019 and 2020. Geographically located at 26^0 29' 35''N latitude and 80^0 18' 35'' E longitudes at an altitude of 125.9 meters above from mean sea level. It lies in the alluvial belt of gangetic plain and is located in the central part of Uttar Pradesh. The experimental field had fairly leveled topography and good drainage system.

the soil of experimental field was alkaline in reaction (7.50 pH), low in organic carbon (0.30%) available nitrogen (211.5 kg ha^{-1}) and available phosphorus (15.68 kg ha^{-1}) while medium in potassium (232.3 kg ha^{-1}), respectively. The treatments comprising of two irrigations methods: alternative wetting and drying (AWD), and flooding irrigation assigned to main plots, four nutrients levels (RDF+ $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 10 kg ha^{-1}, RDF+ $ZnSO_4$ @ 25 kg ha^{-1} and RDF+ $FeSO_4$ @ 10 kg ha^{-1}) in sub plots and four weed management practices including two herbicidal treatments (Chlorimuron ethyl and Fenoxaprop-p-ethyl), hand weeding along with weedy check to sub-sub-plots replicated were tested in Split-split plot design.

Climate and weather condition:

Uttar Pradesh enjoys a sub-tropical region of the country. The climate is semi dry type with hot summer and cold winter. The mean annual rainfall is about 926 mm, most of which is received between Junes to October. During course of investigation since 28th June - 28th October, 2019, and 20th June - 19th October 2020. The total rainfall received was 901.7 mm in the year 2019 received growth period 26-46 (Standard meteorological week) and 945 mm in the second year 2020 received growth period 25-44 (Standard meteorological week) at the growth period of rice after emergence during the growing season. The data regarding weather conditions prevailing during the experiment period was obtained from the meteorological observatory of the university.

Application of fertilizers

After making individual experimental units. The recommended dose of fertilizers was applied as per treatments. Urea, Di-ammonium phosphate, Murate of potash, Zinc sulfate and Ferrus sulphate were used to supply N 120 kg ha^{-1}, P 60 kg ha^{-1}, K 40 kg ha^{-1}, $ZnSO_4$ 25 kg ha^{-1} and $FeSO_4$ 10 kg ha^{-1} respectively. One third dose of nitrogen and total phosphorus, potash and zinc were applied as basal application before puddling and incorporated in the top 15 cm soil. Remaining dose of nitrogen was applied as top dressing in two equal doses, each at tillering and panicle initiation stage respectively.

Economics

Cost of cultivation (Rs ha^{-1})

The cost of cultivation was worked out treatment wise. The common cost of cultivation to all treatments was added to the respective additional cost involved in each treatment.

Gross income (Rs. ha^{-1})

The gross income was calculated plot wise. For this purpose, grain yield was converted into rupees per hectare at prevailing market price of wheat grains and straw. The sum was used for statistical analysis.

Net income (Rs. ha^{-1})

For obtaining the net income, the cost of cultivation was deducted from the gross income of each treatment.

Net return = Gross return- cost of total inputs

Return per rupee (Benefit: cost ratio):

For the calculation of return per rupee, the gross income was divided by the value of cost of cultivation. The value obtained was considered as cost benefit ratio or return per rupee.

$$\text{Return per rupee} = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

Result and Discussion

Cost of cultivation

The data regarding cost of cultivation presented in table 1: showed that there is difference was noted regarding the methods of sowing. Total cost is under alternating wetting and drying method (45314 Rs. ha^{-1}) on the basis of pooled data.

In case of nutrient management practices, numerically maximum cost was calculated in RDF + $ZnSO_4$ + $FeSO_4$ (47180 Rs. ha^{-1}) while the minimum was noted in RDF (45012 Rs. ha^{-1}) alone.

Amongst weed management treatments, maximum cost cultivation (Rs 47954 ha^{-1}) on the basis of pooled data, respectively, was associated with weedy check. Whereas, minimum cost of cultivation Rs 44265 ha $^{-1}$ was recorded under weedy check

Gross income (Rs. ha^{-1})

The data regarding to gross income ha^{-1}summarized and presented in table 1. Gross income varied from Rs. 109154 ha^{-1} for crop raised with flooded irrigation method to highest of Rs. 115067 ha^{-1} from the crop raised with alternating wetting and drying method. Supported by Parameswari and Srinivas (2017) [4], Kumar *et al*., (2018) [3].

The highest gross income (117785 Rs. ha^{-1}) calculated in RDF + $ZnSO_4$ + $FeSO_4$which was significantly superior than RDF + $ZnSO_4$ (114110Rs. ha-1) and RDF + $FeSO_4$ (110299 Rs. ha-1). It is also clear from the data RDF + $ZnSO_4$ + $FeSO_4$ was also significantly superior than RDF during both the year and pooled basis.

In case of weed management practices, significantly highest gross income (118896 Rs. ha^{-1}) was found in hand weeding as compared to weedy check alone (103357 Rs. ha^{-1}) during both years and pooled basis. These results are in close conformity with the results showed by the.

Table 1: Effect of different methods of irrigation and weed management practices on total cost (Rs. ha^{-1}), gross income (Rs. ha^{-1}), net income (Rs. ha^{-1}) and benefit cost ratio.

Treatments	Total cost	Gross income (Rs.ha^{-1})			Net income (Rs. ha^{-1})			B:C ratio		
	(Rs ha^{-1})	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
		(Irrigation management)								
I_1	46615	106567	111742	109154	59590	65709	62650	1.27	1.43	1.35
I_2	45314	112279	117855	115067	66535	73013	69774	1.46	1.63	1.54
SE (d) +	158.0	144.3	161.3	108.3	223.8	229.6	160.3	0.11	.02	0.09
CD (P= 0.05)	438.7	621.0	694.3	300.6	963.2	988.1	445.0	0.48	.07	0.25
		(Nutrients levels)								
F_1	45012	103483	109014	106249	58162	64758	61460	1.28	1.46	1.37
F_2	45545	111267	116953	114110	65309	71823	68566	1.42	1.59	1.51
F_3	46121	107729	112870	110299	61112	67174	64143	1.32	1.47	1.39
F_4	47180	115213	120335	117785	67666	73688	70677	1.43	1.58	1.50
SE (d) +	213.5	343.6	290.1	224.9	432.5	493.4	328.0	0.20	.03	0.02
CD (P= 0.05)	440.6	748.7	632.1	464.1	942.3	1075.1	677.0	0.44	.06	0.03
		(Weed management)								
W_1	45552	111425	116952	114189	65293	72024	68659	1.42	1.60	1.51
W_2	46088	109363	114638	112000	62721	69092	65907	1.35	1.52	1.43
W_3	47954	116048	121745	118896	67835	74013	70924	1.43	1.55	1.49
W_4	44264	100857	105858	103357	56401	62314	59358	1.26	1.43	1.35
SE (d) +	246.9	435.2	373.2	286.7	558.8	637.3	423.8	0.26	0.35	0.02
CD (P= 0.05)	288.9	922.5	791.2	567.6	1124.4	1282.3	839.2	0.52	0.07	0.04

Net income (Rs. ha^{-1})

The data regarding for net income (Rs. ha^{-1}) given in table 1: clearly showed that significantly highest net income (73013 Rs. ha^{-1}) was recorded in alternating wetting and drying method which was significantly superior than flooded irrigation (47578Rs. ha^{-1}) method. The net income increased in alternating wetting and drying method by (7000 Rs. ha^{-1}) or 11.2% as compared to flooded irrigation method.

Persusal of data presented in Table 1: revealed that higher net returns were fetched with different nutrient management practices in comparison to RDF. The crop grown with RDF + $ZnSO_4$ + $FeSO_4$ fetched highest net returns of (Rs. 70677ha^{-1}) followed by RDF + $ZnSO_4$ (Rs. 68566 ha^{-1}). Crop receiving RDF along with $ZnSO_4$ + $FeSO_4$ gave net return higher by Rs. 9217 ha^{-1} than RDF and Rs. 6534 ha^{-1} than RDF + $FeSO_4$ during both the years and pooled basis.

Regarding weed management influenced significantly and highest recorded in hand weeding (70924 Rs. ha^{-1}) which was significantly superior than Chlorimuron ethyl 25% WP (68659 Rs. ha^{-1}) and Fenoxaprop-p- ethyl (65907 Rs. ha^{-1}). The net income increased in hand

Weeding by (11566 Rs. ha^{-1}) or 19.5% as compared to weedy check and (5017 Rs. ha^{-1}) or 7.6% as compared to Fenoxaprop-p- ethyl. It is also clear from the data that hand weeding was also significantly superior to weedy check and Fenoxaprop-p- ethyl during both the year and pooled basis. Shan *et al*. (2012), Bhat *et al.* (2013) and Ganai *et al.* (2014).

Benefit: Cost ratio

The data regarding for benefit cost ratio given in table 1 clearly showed that no significantly highest benefit cost ratio (1.54) found in alternating wetting and drying method which was superior than flooded (1.35) during both the year and pooled basis. The B: C ratio under the treatments was in the in the descending AWD>Flooded irrigation method.

Under nutrient management practices, significantly highest benefit cost ratio (1.51) was found in RDF + $ZnSO_4$ as compared to RDF alone (1.37) during both the year and pooled basis. The B: C ratio under the treatments was in the in the descending F_2>F_4>F_3>F_1. Similar findings were found by Sidhu *et al*. (2014), Tomar *et al*. (2018) and Fu Li Cheng *et al*. (2010) [6, 7].

In case of weed management significantly highest benefit cost ratio (1.51) was calculated in W_1 - Chlorimuron ethyl (1.51) as compared to weedy check and Fenoxaprop-p- ethyl (1.43) during both the year and pooled basis. The B: C ratio under the treatments was in the in the ascending W_4<W_2<W_3<W_1.

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