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Growth, yield and economics of direct seeded non-scented rice (*Oryza sativa* L.) influenced by integrated nutrient management

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Abstract
A field experiment was conducted during the *kharif* season 2022 at Agriculture research farm, Maharishi Markandeshwar (Deemed to be University), Mullana, Haryana. The experiment conducted in a factorial randomized block design with five treatments and three replications. Three non-scented rice varieties V_1: HKR-47, V_2: HKR-48 and V_3: PR-126 were taken with 5 treatments T_1: Control, T_2: 100% RDN through urea, T_3: 75% RDN through urea + 25% N through vermicompost, T_4: 50% RDN through urea + 50% RDN through vermicompost, T_5: 25% RDN through urea and 75% RDN through vermicompost. Early duration variety PR-126 responded well to INM approach and recorded significantly higher grain yield (52.87 q ha^{-1}), straw yield (66.27 q ha^{-1}) and Harvest index (44.07%). Among the treatments, T3: (75% RDN through urea + 25% RDN through vermicompost) gave higher values in all parameters. Thus, fertilizing the crop with 75% RDN through urea + 25% through vermicompost have been found beneficial. Among varieties V_3: PR-126 gave the highest net return (Rs 64,634/ha) and B: C ratio (2.22) as compared to other two varieties.

Keywords: Rice, INM, vermicompost, urea, PR-126

Introduction

For 40% of the world's population, rice (*Oryza sativa* L.) is the main source of calories from cereals. 44 million hectares of rice are planted in India., providing 2.37 t/ha of productivity to the country's 104.32 million tonnes of grain production. The natural fertility of the soil has been depleted by the cultivation of dwarf plants with high yields that respond to fertilizer and by the excessive use of inorganic fertilizers. Nutrient mining and decreased use of organics have been blamed for the decline or stagnation in yield (John *et al*., 2001) [6]. Since demand for rice is growing, supply will eventually run out if production does not increase at a rate that is faster than the current rate. In order to ensure food security, this indicates that rice production must increase. enhanced soil health and fertility that could support the growth of crops in a sustainable manner. The management of soil fertility and the sustainable production of crops in various agro ecosystems have greatly benefited from long-term fertility experiments (Rawal *et al*., 2017) [14]. In the current situation many farmers use excessive amounts of chemicals in their paddy fields, raising overall costs and decreasing profit. Although inorganic fertilizers increase yield but improper fertilizer use has other negative effects as well like soil and water contamination, micronutrient deficiency and changes in the chemical characteristics of the soil (Selim, 2018) [16].

High fertilizer use in intensive cropping systems can result in a lack of primary, secondary, and micronutrients. Currently, farmers only use NPK, and they do so in an unbalanced ratio, with no consideration given to secondary or micronutrients. (Paul *et al*., 2013) [13]. Use of chemical fertilisers over an extended period of time degrades the soil's physical state. It additionally makes the issue of inadequate fertiliser nitrogen usage efficiency (NUE) worse (Joy *et al*., 2018) [7]. The combined use of organic manures and inorganic fertilisers helps to maintain production stability by addressing minor secondary and micronutrient deficiency, improving the efficacy of given nutrients, and producing suitable soil physical conditions (Gill and Walia, 2014) [4]. By using both organic and inorganic fertilizers together, integrated nutrient management lowers the amount of chemicals used in farming. Between the crop's nutrient needs and fertilizer inputs, it bridges the gap. Improving soil fertility is another

Important function of INM. The improvement of physicochemical biological characteristics of soil characteristics is achieved by adding organic matter through the use of organic manures.Utilizing INM techniques increases farmer income and yield. It also lessens environmental contamination in addition to this (Zhang *et al.*, 2014) [19].

Materials and Methods

The research was carried out at the Department of Agriculture research farm at Mullana-Ambala, Haryana's Maharishi Markandeshwar (Deemed to be University) on a sandy loam texture soil which alkaline in reaction having pH 7.9, low in organic carbon 0.31, electrical conductivity 0.89 dSm^{-1}, medium in available nitrogen 260.23 kg N ha^{-1}, low in phosphorous 5.46 kg P ha^{-1} and high in available potassium 469.73 kg K ha^{-1}. The three non-scented varieties *viz*. HKR-47 (Mid-early duration), HKR-48 (early duration) and PR-126 (early duration) with five treatments *viz*. T_1: Control, T_2: 100% RDN through urea, T_3: 75% RDN through urea + 25% N through vermicompost, T_4: 50% RDN through urea + 50% RDN through vermicompost, T_5: 25% RDN through urea and 75% RDN through vermicompost were investigated under DSR method. The randomised block design used to carry out the research, keeping three non-scented varieties in 3 main plots and 5 treatments in sub-plots with three replications. The paddy seeds were directly sown in the field with the help of tractor-drawn seed drill with the spacing of 20 × 10 cm. The weather was favourable in relation to the growth or vegetative phase of rice crop.

Results and Discussion

Growth studies

The results showed that the treatments comprising combinations of inorganic and organic source of nutrients influenced the height of DSR plants at 60 and 90 DAS, and it grew with increasing levels of nitrogen by application through urea and vermicompost after 90 DAS it slowed down. The maximum plant height was recorded in crop receiving 75% RDN through urea and 25% N through vermicompost (T_3) followed by 50% RDN through urea and 50% N through vermicompost (T_4). Lowest was recorded in control (T_1). All the treatments showed their significant superiority to control (T_1). But proportion of organic manure and chemical fertilizer cause difference in increasing plant height at 60 to 90 DAS. Similar observations on the effect of different proportion of organic manures and chemical fertilizer mixture on influencing height of the rice plants were also noted by (Nayak *et al*., 2023) [11], (Hussainy *et al*., 2019) [5] and (Ruan *et al*., 2021) [15].

Nutrient management practises had a positive and significant effect on the dry matter accumulation (DMA) of non-scented DSR. The maximum DMA was recorded in crop receiving 75% RDN through urea + 25% RDN through vermicompost (T_3) and was closely followed by the treatment 50% RDN through urea + 25% RDN through vermicompost (T_4). The lowest DMA was recorded in control (where no fertilizer was applied). The results clearly demonstrated the importance of using both organic and inorganic fertilisers to promote better crop growth in terms of dry matter accumulation, which ultimately aided in enhancing the productivity of non-scented rice under direct seeded conditions. The results are in conformity with the findings of (Yadav *et al*., 2014) [18] and (Paramesh *et al*., 2014) [12].

Similar results were recorded in expression of leaf area index (LAI). The maximum LAI was recorded with 75% RDN through urea + 25% N through vermicompost (T_3) and it was closely followed by T4 (50% RDN through urea + 50% N through vermicompost). The results corroborate the findings of (Nayak *et al*., 2023) [11].

The results showed that the combination of inorganic and organic sources had a significant effect on the count of tillers. When large amount of organic and small quantity of inorganic sources of nutrients applied, the number of tillers m-2 reduced. On the other hand, when large amount of inorganic and small or almost equal amount of organic source of nutrients applied to the crop field, the tillers per meter square increased due to the ready availability of nutrients in chemical fertilizer thus the treatment T3 (75% RDN through urea + 25% N through vermicompost) have been found best and superior in increasing number of tillers of non-scented rice under direct seeded condition. Similar observations on the effect of different proportion of organic manure and chemical fertilizer mixture on influencing tiller production of rice were also made by (Yadav *et al*., 2014) [18].

Table 1: Impact of combinations of both organic and inorganic source of nutrients on plant height (cm) and dry matter accumulation (g m^{-2}).

Factor A Varieties	Plant height (cm)				Dry matter accumulation (g m^{-2})			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
V_1	33	46.7	65	91.3	53.93	657.80	1045.20	1143.87
V_2	33.8	47.2	67.1	97.6	54.40	663.73	1059.07	1177.40
V_3	35.3	48.8	72.9	102.5	58.13	705.87	1087.93	1205.20
SE(m) ±	0.3	0.3	0.4	0.6	0.31	0.95	0.54	3.83
CD (P=0.05)	0.8	1.0	1.3	1.6	0.91	2.77	1.57	11.14
Factor B Treatments								
T_1	31.7	41.6	59.9	88.1	49.89	574.33	1030.00	1088.89
T_2	33.9	45.2	66.3	93.0	52.78	646.33	1055.78	1176.67
T_3	36.9	54.6	78.8	110.7	65.67	786.11	1099.67	1256.00
T_4	34.8	52.8	75.1	103.8	57.56	743.89	1092.89	1240.67
T_5	32.8	43.6	61.6	90.1	51.56	628.33	1042.00	1115.22
SE(m) ±	0.3	0.5	0.6	0.7	0.4	1.23	0.69	4.94
CD (P=0.05)	1.0	1.3	1.6	2.1	1.18	3.58	2.02	14.38

Table 2: Impact of combinations of both organic and inorganic source of nutrients on tillers (m^{-2}) and Leaf area index.

Factor A Varieties	No. of tillers (m^{-2})				Leaf Area Index		
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS
V_1	184.7	372.2	385.4	379.5	1.35	3.33	4.38
V_2	191.6	382.3	393.2	386.2	1.36	3.56	4.47
V_3	207.9	390.4	400.9	395.7	1.39	3.58	4.62
SE(m) ±	0.6	0.7	0.6	0.6	N/S	0.01	0.01
CD (P=0.05)	1.9	2.1	1.8	1.9	0.01	0.01	0.02
Factor B Treatments							
T_1	168.8	354.8	367.9	360.1	1.32	3.44	4.4
T_2	188.9	375.3	379.8	380.2	1.35	3.49	4.46
T_3	222.9	411.8	424.8	418.6	1.43	3.58	4.61
T_4	214	401.8	415.1	407.4	1.4	3.54	4.55
T_5	179.1	364.6	378.3	369.4	1.34	3.39	4.43
SE(m) ±	0.8	0.9	0.8	0.8	N/S	0.01	0.01
CD (P=0.05)	2.4	2.7	2.3	2.4	0.01	0.02	0.03

Yield studies

The yield attributes and yield of rice was significantly influenced by various integrated nutrient management practices. Among the various nutrient management practices 75% RDN + 25% N through vermicompost recorded better yield attributes number of panicle/m^2 (288.00), number of grains/panicle (118.89) and test weight (24.771 gm) than other treatments same findings have also been reported by (Lakshmi *et al.*, 2012) [10].

The data of grain yield clearly showed that the treatment with 75% RDN through urea + 25% N through vermicompost resulted in more grain yield (59.44 q ha^{-1}) and it was closely followed by the treatment having 50% RDN+50% N through vermicompost. The lowest grain yield was obtained in control (24.67 q ha^{-1}) and it remained significantly inferior to all other treatments in production of grain yield. The results corroborate with the findings of (Balasubramanian 2019) [1] and (Bhagat *et al.*, 2014) [2].

In case of straw yield, 75% RDN through urea + 25% N through vermicompost expressed maximum value among all other treatments. control was significantly inferior to all other treatments. In the study, 75% RDN through urea + 25% N through vermicompost provided availability of N which enhanced steady biomass production, but where higher concentration of organic nutrient is supplied in expressed comparatively less biomass because of slow-release nature of organic manures which could not improve straw yield as obtained with only 75% RDN through urea along with 25% vermicompost. Similar results were also reported by (Borah *et al.*, 2015) [3] and (Kulkarni *et al.*, 2015) [9].

Table 3: Impact of combining inorganic and organic source of nutrients on yield attributes and yield.

Factor A Varieties	yield attributes			yield			
	panicles/m^2	Grains/Panicle	Test weight	grain yield	straw yield	biological yield	Harvest index
V_1	251.07	87.73	24.307	42.53	57.60	100.13	42.00
V_2	256.33	95.53	24.315	45.60	59.80	105.40	42.80
V_3	261.73	105.87	25.304	52.87	66.27	119.13	44.07
SE(m) ±	0.83	0.71	0.005	0.28	0.36	0.61	0.10
CD (P=0.05)	2.41	2.07	0.015	0.81	1.06	1.76	0.28
Factor B Treatment							
T_1	230.78	77.11	24.55	24.67	36.89	61.56	40.11
T_2	245.44	95.00	24.64	49.89	65.56	115.44	43.11
T_3	288.00	118.89	24.77	59.44	71.44	130.89	45.22
T_4	275.56	105.22	24.68	55.00	69.11	124.11	44.11
T_5	242.11	85.67	24.57	46.00	63.11	109.11	42.22
SE(m) ±	1.07	0.92	0.01	0.36	0.47	0.78	0.13
CD (P=0.05)	3.11	2.68	0.02	1.05	1.37	2.28	0.37

Economics

Analysis of economics factors like cost of cultivation, gross return, net return, and B:C ratio are important to evaluate the effect of the treatment from practical point of view to the farming community as well as to the planner. Grain yield was major factor which caused differences in net income and net return per rupees invested. Among varieties, the early duration PR-126 has been found superior in terms of gross return (Rs. 1,17,507/ha), net return (Rs. 64,634/ha) and B: C ratio (2.22) over other varieties. Among treatments maximum Gross return (Rs. 1,26,144/ha) and net return (Rs. 74,012/ha) was recorded in treatment (T_3) which includes application of 75% RDN through urea and 25% N through vermicompost. This is due to higher production of grain and straw yield and higher increased in output in comparison to input. Whereas, the lowest was found in (T_1) control. Because no fertilizer or any kind of nutrient source was applied thus, poor grain production and straw yield influenced the economics which resulted in minimum gross and net return. The benefit cost ratio has been found maximum (2.66) in (T_2) which includes 100% RDN through urea. This is because the low price of urea and other fertilizers as compared to vermicompost. The second highest B: C ratio (2.41) was observed in (T_3) which includes 75% RDN through urea and 25% N through vermicompost. These results corroborated with the findings of Tomar *et al.*, (2018) [17] and Koushal *et al.*, (2011) [8].

Table 4: Effect of combining different sources of nutrients on economics of non-scented DSR.

Factor A Varieties	Economics			
	cost of cultivation	Gross return	Net return	B: C ratio
V_1	52,673	86,567	33,894	1.64
V_2	52,683	97,180	44,497	1.84
V_3	52,873	1,17,507	64,634	2.22
Factor B Treatments				
T_1	31,170	53,256	22,086	1.7
T_2	40,120	1,06,734	66,614	2.66
T_3	52,132	1,26,144	74,012	2.41
T_4	64,143	1,17,311	53,168	1.82
T_5	76,150	98,644	22,494	1.29

Conclusion

From the present study, it may be concluded that integrated nutrient management in non-scented rice under direct seeded condition showed positive and favourable influence on improving the growth and yield. The application of 75% RDN through urea + 25% N through vermicompost improved its growth, yield, economics and quality studies. The results clearly indicated the need of integrated use of organic manures in addition to chemical fertilizers to meet the nutrient need of rice under direct seeded condition.

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