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Impact of FYM and Micronutrients on Nutrient Content, Uptake, Yield and Economic Attributes of Direct Seeded Basmati Rice

Priyanka Sanwal, R.S. Garhwal*, Sekhar Kumar, Sunil Kumar and Satender Kumar
Department of Soil Science, CCSHAU, Hisar, Haryana-125 001, India
E-mail: sanwalpriyanka2015@gmail.com

Abstract: A field experiment was carried out at CCS HAU, College of Agriculture, Kaul research farm during *kharif*, 2020 to study the effect of FYM and micronutrients on nutrient content, uptake, yield and economic attributes of direct seeded basmati rice. The experiment was laid out in randomized block design with 7 treatments including each with a different combination of chemical fertilizer (RDF), farmyard manure (FYM), and micronutrients ($ZnSO_4$ and $FeSO_4$). Amongst the all treatments, 75% RDF along with FYM @ 15 t/ha resulted in the highest yield attributes (like plant height, number of effective tillers per m^2, grain yield, straw yield and harvesting index) and economic parameters (like cost of cultivation, gross return, net return and benefit-cost ratio) which was at par with 50% RDF with FYM @ 15 t/ha but statistically superior then control. Amongst micronutrient treatments, combined foliar application of zinc and iron along with RDF resulted in higher yield and highest Benefit and Cost ratio (B:C) was observed as compared to other treatments resulting in higher returns with low cost of cultivation.

Keywords: Basmati rice, Micronutrients, FYM

Rice (*Oryza sativa* L.) is one of the world's most important cereal food crops in India. It is responsible for about 45% of total food grain production in India. The rice sowing area is roughly 44 million hectares (Mha), with approximately 112.9 Million tonne (Mt) and 24.32 quantal per hectare (q/ha) production and productivity, respectively (Anonymous 2020a). Rice inhabited nearly 1.42 Mha in Haryana, with a production of 4.88 M t and a productivity of roughly 34.32 q/ha (Anonymous 2020b). Punjab and Haryana are the major basmati rice-producing states in India, accounting for roughly 80% of total basmati paddy cultivation (APEDA 2014). The standard method of rice cultivation is by transplanting, which necessitates a significant amount of water, labour, and energy. Water availability has dropped in recent years, and the water table level is rapidly dropping, limiting the extent of rice cultivation through transplanting methods in the coming years. As a result, it is extremely crucial to focus on finding out the best suitable rice cultivation practice. Direct seeding of rice (DSR) is one of the reasonable options because it can save water, reduces labour requirements, and lessens greenhouse gas (GHG) emissions, and there is no need to prepare nurseries in DSR (Kumar et al 2022).One of the prime causes of the decrease in rice production is a scarcity of micronutrients (Somaratne et al 2021). Iron (Fe) deficiency is among the most widespread micronutrient deficiencies worldwide, occurring in approximately 60% of the world's population (Vijayakumar et al 2020). It kills nearly 0.8 million people worldwide annually. Zinc (Zn) deficiency is yet another serious concern that affects approximately one-third of the worldwide people (Singh and Singh 2018). Foliar micronutrient application is the easiest and fastest method to address nutrient deficiency symptoms in plants and generate a rapid response (Fernández and Brown 2013).

Consistent use of inorganic fertilizers degrades soil conditions and lessens yield over time, whereas FYM strengthens soil Physico-chemical properties including porosity, aggregate stability, water holding capacity, nutrient recycling, organic carbon, cation exchange capacity (CEC), and so on. Organic manure inclusion into soil has been found to improve crop yield and soil fertility (Bhavani et al 2017). The use of organic manure associated with inorganic fertilizers is effective in relieving nutrient deficiency. Thus, the present investigation was carried out to investigate the impact of FYM and foliar application of micronutrients along with RDF on nutrient (N, P, and K) content, uptake, yield, and yield parameters of direct seeded basmati rice.

MATERIAL AND METHODS

The field experiment to study the impact of FYM and micronutrients on nutrient content, uptake, yield and economic attributes of direct seeded basmati rice in clay loam soil at Kaithal district of Haryana at CCS HAU, College of Agriculture, Kaul, during *Kharif* 2020. The initial soil properties are presented in Table 1. The experiment was set up in a randomised block design with seven treatments, each with a different combination of chemical fertiliser (RDF), farmyard manure (FYM), and micronutrients ($ZnSO_4$ and $FeSO_4$) with three replications (Table 2). On June 22nd, 2020, the Basmati variety CSR-30 was directly sown at a seed rate of 20 kg/ha. Nitrogen was applied in three split doses using urea, with half of the total nitrogen applied as a basal dose and the remaining half applied in two equal split doses at active tillering and panicle initiation. The full dose of phosphorus and potassium doses were applied during sowing using diammonium phosphate (DAP) and murate of potash (MOP), respectively. Two weeks prior sowing, well-decomposed FYM @ 15 t/ha was incorporated as per recommended in Haryana condition (Kavinder et al 2019). However, the average chemical compositions of NPK in FYM (0.58, 0.26 and 0.60%) and micronutrient Fe and Zn (184 and 4.67ppm). At the tillering and panicle initiation stages, two foliar sprays of iron sulphate (0.5%) and zinc sulphate (0.5%) were applied by dissolving the required amount of iron and zinc sulphate in water with urea. The crop was harvested manually at physiological maturity and then threshing was also done manually. Plant height and the number of effective tillers per m^2 were measured manually by selecting five plants at random from each plot. Plant height was measured from ground surface to the top of the ear at physiological maturity.

Table 1. Initial soil chemical properties

Soil property	Value
Bulk density (Mg/m^3)	1.34
pH	8.66
EC (dS/m)	0.11
Organic carbon (%)	0.54
Available nitrogen (kg/ha)	105
Available phosphorus (kg/ha)	21.47
Available potassium (kg/ha)	360
DTPA-Zn (ppm)	1.8
DTPA-Fe (ppm)	14.75
DTPA-Cu (ppm)	1.34
DTPA-Mn (ppm)	2.95

Table 2. Treatment details

Treatments	Nutrients levels
T_1	Control
T_2	RDF (NPK)
T_3	75% RDF + FYM @ 15 t/ha
T_4	50% RDF + FYM @ 15 t/ha
T_5	RDF + two sprays of 0.5% $ZnSO_4$
T_6	RDF + two sprays of 0.5% $FeSO_4$
T_7	RDF + two sprays of 0.5% $FeSO_4$ + two sprays of 0.5% $ZnSO_4$

*RDF- recommended dose of fertilizers

The harvest index was calculated by dividing the grain yield by the biological yield (grain yield + straw yield) and then multiplied by 100:

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

Plant analysis: At harvest of crop, grain and straw samples from each plots were collected, initially the samples were dried in air, and finally in oven at 60 **±** 2^{0}C for 24 hours. After that samples were ground in mini willey with stainless steel blades and stored in different polyethylene bags for the analysis of nitrogen, phosphorus, potassium, zinc, iron, manganese and copper. The determination of nitrogen, phosphorus and potassium in plant samples was done by colorimetric method using Nessler's reagent (Lindner 1944), vanado-molybdate phosphoric yellow colour method, and flame photometer respectively (Jackson 1973). The uptake of nitrogen, phosphorus, potassium, iron, zinc, manganese and copper by rice grain and straw were computed from the data on nutrients content, grain and straw yield.

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{\% nutrient content} \times \text{Yield (Grain or straw)}}{100}$$

The, net return was calculated by using gross returns and cost of cultivation:

Net returns = Gross returns − cost of cultivation

Treatment wise benefit cost (B: C) ratio was calculated using the following formula:

$$\text{B: C ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

Data analysis: The crop data subjected to statistically analysis using the OPSTAT statistical software package.

RESULTS AND DISCUSSION

Yield attributes: Combining FYM or micronutrients with RDF has resulted in significant increase yield attributes as compared to control (Table 3). Rice plots fertilized with 75% RDF and FYM at 15 t/ha had the highest plant height (126.47 cm), number of effective tillers per m^2 (270.33), grain yield (34.66 q/ha) and straw yield (45.88 q/ha); at par with 50% RDF and FYM at 15 t/ha. T_5 treatment had the highest harvest index (43.33%). The plot with no fertilizer applied (T_1) had the lowest value followed by RDF (T_2). This could be due to the synergistic effect of inorganic fertilizer and FYM on plant vegetative growth, which resulted in taller plants, higher grain and straw yield, and a greater number of effective tillers per m^2 (Kumar et al 2022). In the crop, there was a positive relationship between yield attributes (plant height and number of effective tillers) and yield (grain and straw yield)

(Fig. 1). Earlier researchers also observed that applying 50% RDN through inorganic fertilizer and 50% N through FYM increased plant growth and development over RDF alone (Singh et al 2019, Meena et al 2019 and Ashwini et al 2015). Similarly, Garai et al (2014) concluded that 100% RDF along with vermicompost at 2.5 t/ha, PSB, and Azotobacter, which was at par with 75% RDF along with vermicompost at 2.5 t/ha and PSB and Azotobacter. Upinder et al (2016) found that continuous substitution of 50% NPK by green manure produced maximum rice grain and straw yields that were 16.8 and 14.8% higher than 100% NPK alone in a rice-wheat cropping system in CSK Himachal Pradesh. However, Apon et al (2018) observed that 100% RDF + 5 t/ha FYM produced the most, followed by 75% RDF + 5 t/ha FYM, and then 50% RDF + 5 t/ha FYM.

Foliar application of micronutrients (Fe and Zn) in conjunction with RDF increased yield over control and/or RDF alone (Table 3). It could be due to an increase in the availability and uptake of essential nutrients caused by Zn supply, which improves plant metabolic processes and, ultimately, crop growth. Zayed et al (2011) observed that applying micronutrients (Zn^{2+}, Fe^{2+}, and Mn^{2+}) as soil single treatments or combined treatments (Zn^{2+} + Mn^{2+}, Zn^{2+} + Fe^{2+}, Mn^{2+} + Fe^{2+}, and Zn^{2+} + Mn^{2+} + Fe^{2+}) through soil as well as foliar spray resulted in higher yield attributes over the control, especially in saline conditions. Sultana et al (2001), Ali et al (2003), and Naik and Das (2007) also found similar trend.

Nutrient content in both grain and straw- Nutrient content in terms of N, P and K in both grain and straw was significantly increased on the combined application of FYM or micronutrients with RDF over the control and/ or RDF alone (Table 4). Amongst the treatments, N, P and K content in rice grain varied from 1.08 to 1.35% with the variation of 25%, 0.46 to 0.57% with the variation of 86.81% and 0.46 to 0.58% with the variation of 26.08% respectively. The combined application of RDF with FYM @ 15 t/ha found to give the highest N, P and K content in rice grain and the least was found in plot with no fertilized treatment. In straw, N content ranged from 0.45 to 0.54%, P content ranged from 0.21 to 0.27% and K content ranged from 1.43 to 1.75% with increment of 20, 28.57 and 22.37% respectively. This might be due to synergic effect of FYM and RDF which not only results in direct supply of nutrients on their application but also helps in mineralization of native immobilized nutrients present in the soil. Because of this, nutrients are more available for plant uptake and thus increase nutrient content

Table 3. Effect of micronutrients (Zn and Fe) and FYM on yield attributes of direct seeded basmati rice

Treatments	Plant height (cm)	No. of effective tillers per m^2	Grain Yield (q/ha)	Straw Yield (q/ha)	Harvest index (%)
T_1	105.02	210.67	21.56	32.91	39.58
T_2	111.36	246.67	31.15	42.49	42.30
T_3	126.47	270.33	34.66	45.88	43.04
T_4	121.55	265.33	33.55	44.68	42.89
T_5	121.4	256.33	31.98	41.82	43.33
T_6	118.58	248.13	31.78	41.84	43.17
T_7	121.6	262.33	32.79	42.89	43.33
CD (p= 0.05)	5.40	7.82	1.38	1.45	1.81

Table 4. Effect of micronutrients (Zn and Fe) and FYM on NPK content in rice grain and straw of direct seeded basmati

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1	1.08	0.45	0.46	0.21	0.46	1.43
T_2	1.26	0.49	0.48	0.26	0.52	1.67
T_3	1.35	0.54	0.57	0.27	0.58	1.75
T_4	1.30	0.52	0.50	0.26	0.54	1.71
T_5	1.24	0.5	0.48	0.25	0.50	1.68
T_6	1.26	0.49	0.47	0.25	0.49	1.66
T_7	1.27	0.51	0.49	0.25	0.51	1.68
CD (p= 0.05)	0.06	0.04	0.02	0.01	0.06	0.07

in plant grain and straw. These results were supported by findings of Islam et al (2018) and Sultana et al (2021).

Nutrient uptake in both rice grain and straw-The uptake of N, P, and K nutrients in grain and straw varied significantly (Table 5). In rice grain, nutrient uptake ranged from 23.21 to 43.36 kg/ha for N, 9.88 to 15.24 kg/ha for P, and 10.13 to 17.87 kg/ha for K, with a variation of 86.81%, 54.25%, and 76.40%, respectively, when compared to control. The plot with RDF and FYM @ 15 t/hahad the highest value of N and K uptake in rice grain, while the T_6 had the highest value of P uptake. The plot with no fertiliser applied (T_1) had the lowest N, P, and K uptake in rice grain. Nutrient uptake in rice straw

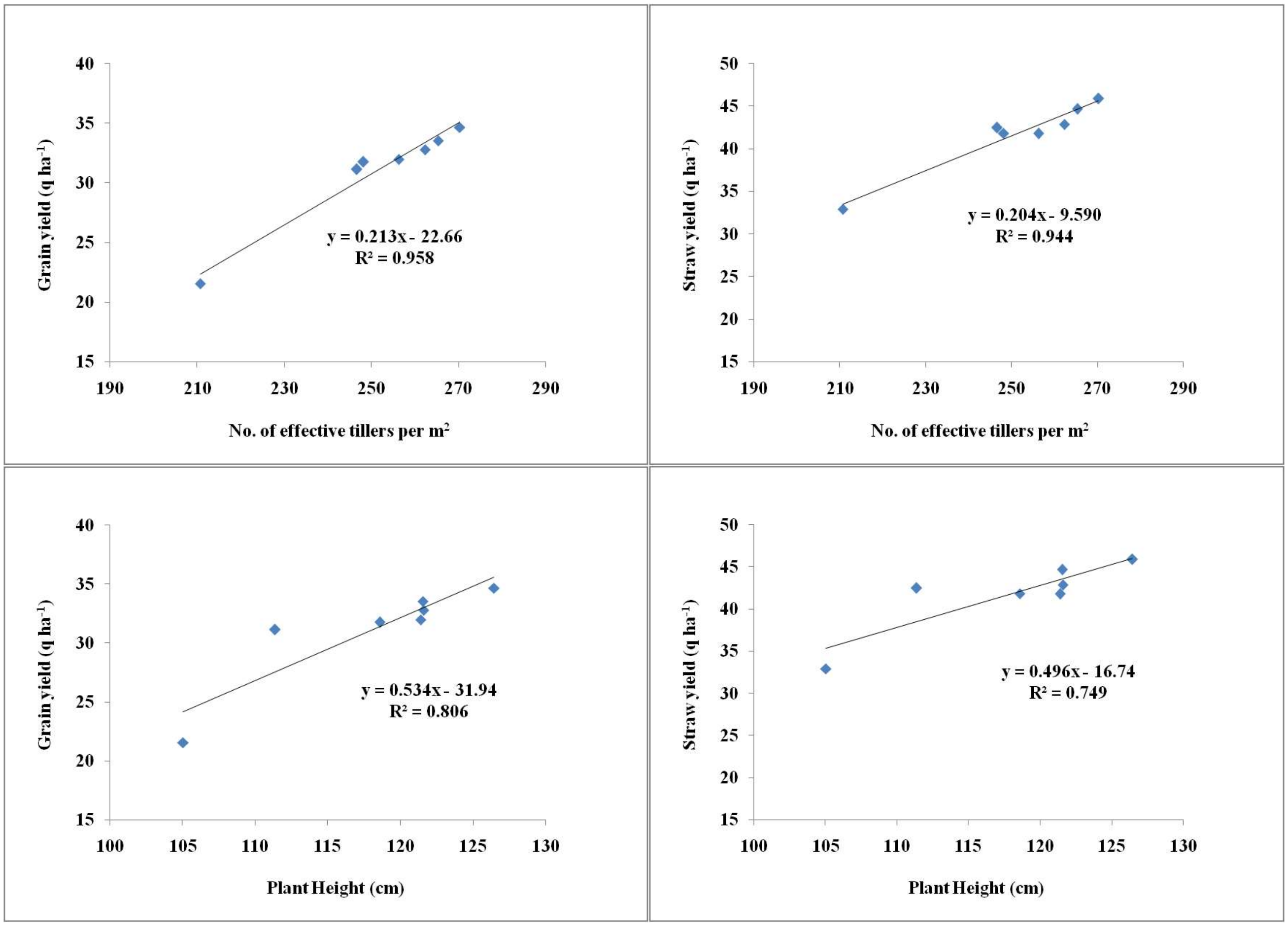

Fig. 1. Relationship between yield attributes and yield in direct seeded basmati rice

Table 5. Effect of micronutrients (Zn and Fe) and FYM on NPK uptake in rice grain and straw of direct seeded basmati rice

Treatments	N Uptake (kg/ha)		P Uptake (kg/ha)		K Uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1	23.21	15.07	9.88	7.03	10.13	46.29
T_2	29.81	17.92	15.03	10.05	12.22	61.09
T_3	43.36	23.65	13.41	10.95	17.87	76.65
T_4	40.82	22.18	12.96	10.19	16.60	72.95
T_5	32.45	19.36	14.21	9.84	13.05	65.16
T_6	32.70	18.96	15.24	10.91	12.84	64.24
T_7	37.45	19.95	12.75	9.7	15.00	66.24
CD (p= 0.05)	1.43	1.60	0.51	0.34	1.83	2.02

Table 6. Effect of micronutrients (Zn and Fe) and FYM on economics of direct seeded basmati rice

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	C:B
T_1	29330	63670	34340	1: 2.17
T_2	32656	91465	58809	1: 2.14
T_3	36623	101648	65023	1: 2.58
T_4	35793	98420	62627	1: 2.57
T_5	33184	93729	60547	1: 2.31
T_6	33169	93172	60002	1: 2.31
T_7	33696	96091	62394	1: 2.56

ranged from 15.07 to 23.65 kg/ha for N, 7.03 to 10.95 kg/ha for P, and 46.29 to 76.65 kg/ha for K. The application of 75% RDF with FYM @ 15 t/ha resulted in the highest nutrient uptake in both grain and straw, followed by 50% RDF with FYM @ 15 t/ha, and the lowest in T_1. Gill and Aulakh (2018) also observed that using nitrogen from two sources, one through recommended nitrogen (RN) at 50% and the other through FYM, resulted in the highest N, P, and K uptake in both grain and straw. Pandey et al (2015) concluded that judicious use of organic fertilizer with a lower amount of recommended nitrogen (RN) significantly improved N uptake in rice (32.0 kg/ha). Srinivas et al (2010) mentioned that the combined application of FYM and chemical fertilizers significantly influenced k uptake in rice grain. The application of FYM + 50% RN and FYM + GM (Green Manure) improved crop P and K uptake, which could be due to organic acids released by the decomposition of organic materials, which increase the availability of phosphorus and potassium in the soil by the release of native P and K. Ranjitha et al (2013) also revealed that treatments receiving 50% inorganic nitrogen source (root dipping) and 50% organic nitrogen source through vermicompost (root dipping) had significantly higher NPK uptake by rice (157.9-30.7-166.0 kg/ha) when compared to 100% inorganic N source alone (136.5-23.2-125.6 kg/ha) and control (58.7-6.9-61.6 kg/ha). Furthermore, Kumar et al (2014) demonstrated that combining organic and inorganic nutrient sources significantly increased N uptake in grain and straw (36.81% and 42.81%, respectively), P uptake in grain and straw (32.62% and 31.56%, respectively), and K uptake in grain and straw (35.46% and 25.39%, respectively) over control. Wolie and Admassu (2016) also observed the same trend.

Economics: The application of FYM @ 15 t/ha or spray of micronutrients along with RDF resulted increase in economic attributes (Table 6). The range of various economic attributes like cost of cultivation varied from 29,330 to 36,623 Rs/ha, gross return varied from 63,670 to 1,10,648 Rs/ha, net return varied from 34,340 to 65,023 Rs/ha and cost-benefit ratio varied from 1:2.17 to 1:2.58. Amongst all treatments, T_3 (75% RDF + FYM @ 15 t/ha) and T_4 (50% RDF + FYM @ 15 t/ha)resulted in the higher cost of cultivation, gross return, net return and Benefit-Cost ratio. More monetary returns were observed on combined application of the organic manure and inorganic fertilizers. Meena et al (2019) and Pandey et al (2015) found that 50% RDN through inorganic fertiliser plus 50% N through FYM (T_4) produced significantly higher net returns than T_3 (75% RDN through inorganic fertiliser + 25% N through FYM). However, Koushal et al (2011) reported that during the wheat season, 100% RDF produced significantly higher yields, gross return net returns, and B : C ratios that were comparable to 75% of the recommended dose of fertilizer applied and replacing fertilizer with organic sources like vermicompost and FYM by 50% of RDN would be a better proposition for reducing chemical fertilizer use in rice and 25% in wheat.

CONCLUSION

Application of either FYM or micronutrients along with RDF resulted in significantly higher nutrient content and uptake in both grain and straw. The 75% RDF along with FYM @15 t/ha resulted in the highest yield and economic attributes, which is followed by 50% RDF along with FYM. The 50% RDF along with FYM @ 15 t/ha was a more economically feasible treatment because of reducing in the amount of inorganic fertilizer used which in turn reduces the cost of cultivation. The spray of micronutrients (either $ZnSO_4$ or $FeSO_4$ or in combination) along with RDF also enhanced yield attributes.

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