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Influence of Integrated Nutrient Management in Rice (*Oryza sativa*) on Performance of Wheat (*Triticum aestivum*) under Long Term Rice-Wheat Cropping System

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ABSTRACT

The concern to increase the production along with maintenance of environmental sustainability is increasing day by day. A long-term field experiment (since 1984) comprising of eleven treatments with different combinations of inorganic and organic fertilizers such as farm yard manure (FYM), wheat straw and *Sesbania aculeata* as green manure (GM) was conducted during the *rabi* season of 2020-21 at research farm of Bihar Agricultural University, Sabour, Bhagalpur to assess the impact of variable integrated nutrient management (INM) in rice (*Oryza sativa*) and inorganic nutrient management in wheat on leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) and dry biomass of wheat (*Triticum aestivum*). The results revealed that maximum LAI (0.54, 2.34, 3.05 and 2.43), dry biomass (104.4, 312.5, 663.1, 858.5 and 967.2 g m^{-2}) and CGR (6.94, 11.68 and 6.51 g m^{-2} day^{-1})at different intervals were found with application of 50% recommended dose through fertilizers (RDF) in rice and 50% inorganic N (nitrogen) by FYM followed by 100% RDF in wheat. In case of NAR, during 30-60 DAS it was found highest (6.80 g m^{-2} day^{-1}) with 50% RDF in rice and 100% RDF in wheat but at 60-90 DAS (4.36 g m^{-2} day^{-1}) and 90-120 DAS (3.06 g m^{-2} day^{-1}) it was maximum with application of 50% RDF and 50% N through FYM in rice and 100% RDF in wheat. Therefore, application of 50% RDF in rice and substitution of 50% inorganic N by FYM followed by 100% RDF in wheat can improve growth of wheat in long term rice-wheat cropping system with reduced environmental hazard.

Key words : *Environmental sustainability, Farm yard manure, Integrated nutrient management*

Introduction

Wheat (*Triticum aestivum* L.) is a long day plant and mainly grown in tropical climatic areas during winter season. In India, it is the second most important cereal crop after rice. Maintenance of soil health is essential for sustaining crop productivity. The indiscriminate use of chemical fertilizers to increase the production of food is causing concern as continuous use of suboptimal doses of nutrients in intensive cropping system has resulted in severe depletion of nutrient reserves in soil, leading to multiple nutrient deficiencies. The use of high-analysis fertilizers devoid of micronutrients has led to micronutrient deficiencies causing significant decline in crop productivity. After the success of green revolution, a decline in the growth rate of food production is observed during recent past in terms of crop produc-

tivity and fertilizer input response. To curb this trend of declining yield, there is a need to adopt the concept of integrated nutrient management. The combined use of organic manures and inorganic fertilizers significantly enhanced crop yield over recommended dose of chemical fertilizers alone (Ali *et al.,* 2018). The application of chemical fertilizers alone at higher rate has lead to environmental pollution along with decrease in crop production. Adoption of integrated plant nutrient supply and management strategies for enhancing soil quality, input use efficiency and crop productivity is important for ensuring food as well as nutritional security. Thus, a study was conducted to assess the impact of long-term integrated nutrient management in rice on growth of succeeding wheat.

Materials and Methods

The experiment was conducted during *rabi* season of the year 2020-2021 in the research farm of Bihar Agricultural University, Sabour, Bhagalpur. The geographical location of Bhagalpur comes under middle gangetic plains of India at latitude of 25°15' 4" N and longitude 78°2' 45" E with an elevation of 37.19 meter above the mean sea level. Since a long term experiment was carried out in the plot since 1984, only rice and wheat were grown in *kharif* and *rabi* seasons, respectively over the years followed by fallow in *zaid*. The research was carried out using wheat variety 'HD-2967'. The design used in this experiment was randomized block design and there were eleven treatments and three replications. The treatments were, T_1: Control (No fertilizer, no organic manure) in both rice and wheat, T_2: 50% RDF in both rice and wheat, T_3: 50% RDF in rice and 100% RDF in wheat, T_4: 75% RDF in both rice and wheat, T_5: 100% RDF in both rice and wheat, T_6: 50% RDF and 50% N through FYM in rice and 100% RDF in wheat, T_7: 75% RDF and 25% N through FYM in rice and 75% RDF in wheat, T_8: 50% RDF and 50% N through wheat straw in rice and 100% RDF in wheat, T_9: 75% RDF and 25% N through wheat straw in rice and 75% RDF in wheat, T_{10}: 50% RDF and 50% N through GM (*Sesbania aculeata*) in rice and 100% RDF in wheat and T_{11}: 75% RDF and 25% N through GM (*Sesbania aculeata*) in rice and 75% RDF in wheat.

Results

The observations related to growth parameters such as LAI, CGR, NAR and dry biomass were recorded and estimated as per the standard procedures.

Integrated nutrient management practices exerted significant effect on LAI, the results showed that the LAI increased steadily from its low value at 30 DAS up to the highest value at 90 DAS and thereafter, it decreased drastically. The treatment T_6 (50% RDF and 50% N through FYM in rice and 100% RDF in wheat) recorded maximum value of LAI at 90 DAS (Fig. 1). Dry matter accumulation at 30, 60, 90, 120 DAS and at maturity was recorded maximum with 50% RDF and 50% N through FYM in rice and

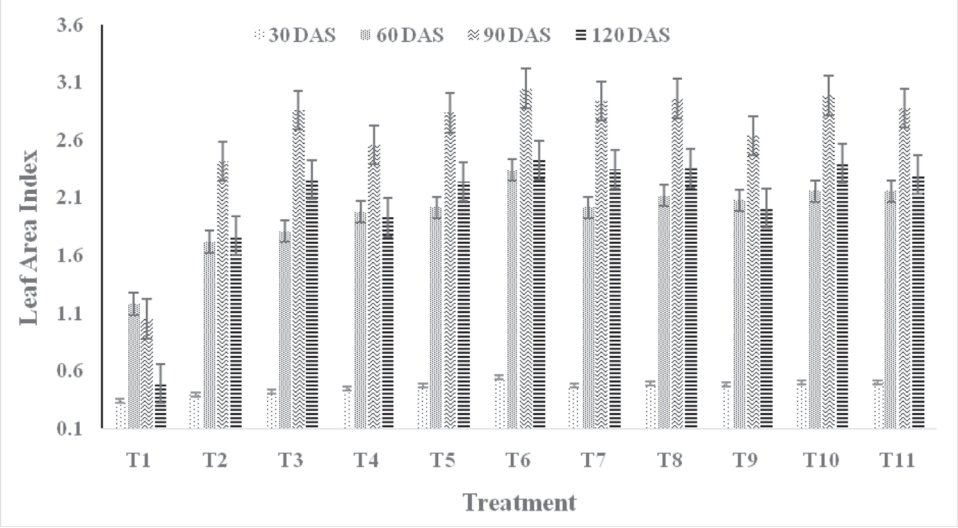

Fig. 1. Effect of integrated nutrient management practices on leaf area index of wheat at different days after sowing

Table 1. Effect of integrated nutrient management practices on dry biomass (g m^{-2}) of wheat at different days after sowing

Treatment	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
T_1	24.2	53.7	120.4	150.5	177.1
T_2	51.5	171.3	365.0	467.3	513.6
T_3	82.5	275.4	560.7	727.8	815.9
T_4	65.8	226.0	460.2	583.0	662.5
T_5	79.3	272.8	555.9	710.8	788.7
T_6	104.4	312.5	663.1	858.5	967.2
T_7	93.4	292.0	588.8	753.8	829.5
T_8	95.8	296.6	614.5	786.4	872.6
T_9	76.1	265.5	540.0	687.2	755.8
T_{10}	100.4	305.5	632.9	814.5	926.2
T_{11}	91.8	289.6	577.1	740.0	821.1
SEm(±)	2.1	4.2	15.3	19.9	25.2
CD at 5%	6.2	12.5	45.0	58.6	74.3

100% RDF in wheat (Table 1). Similarly, CGR was calculated using dry biomass at different intervals and it was observed that during 30-60 DAS, 60-90 DAS and 90-120 DAS highest CGR was found with application of 50% RDF and 50% N through FYM in rice and 100% RDF in wheat (Table 2). In case of NAR, during 30-60 DAS, it was found maximum in T_3 (50% RDF in rice and 100% RDF in wheat) whereas at 60-90 DAS and 90-120 DAS it was highest with 50% RDF and 50% N through FYM in rice and 100% RDF in wheat (Table 3).

Table 2. Effect of integrated nutrient management practices on CGR (g m^{-2} day^{-1}) of wheat at different days after sowing

Treatment	30-60 DAS	60-90 DAS	90-120 DAS
T_1	0.98	2.23	1.00
T_2	3.99	6.46	3.41
T_3	6.43	9.51	5.57
T_4	5.34	7.81	4.09
T_5	6.45	9.44	5.16
T_6	6.94	11.68	6.51
T_7	6.62	9.89	5.50
T_8	6.69	10.60	5.73
T_9	6.31	9.15	4.91
T_{10}	6.84	10.92	6.05
T_{11}	6.59	9.58	5.43
SEm(±)	0.12	0.56	0.15
CD at 5%	0.37	1.64	0.46

Discussion

The treatments involving organic and inorganic combinations performed better in comparison to inorganic treatment alone. This is a clear indication that application of only inorganic fertilizers cannot fulfil nutrient requirement of crops. Decomposition of organic matter results in formation of humus which is involved in improving the soil physical and chemical properties leading to proper growth and development of crops. Besides making major nutrients available, organic matter also release almost all the essential elements required for growth and development, which leads to superiority to organic sources over inorganic fertilizers. Researchers have found that some of the nutrients applied in organic form were available to the plants after 30 to 40 years of application (Prakash and Mahajan, 2016). Hence, it might be possible that the incorporation of organic source in all the previous years is responsible for providing a part of its nutrients in the coming year.

Table 3. Effect of integrated nutrient management practices on NAR (g m^{-2} day^{-1}) of wheat at different days after sowing

Treatment	30-60 DAS	60-90 DAS	90-120 DAS
T_1	1.44	2.02	1.71
T_2	4.47	3.15	2.12
T_3	6.80	4.15	2.79
T_4	5.18	3.46	2.38
T_5	6.08	3.92	2.61
T_6	5.69	4.36	3.06
T_7	6.29	4.05	2.67
T_8	6.03	4.22	2.77
T_9	5.82	3.91	2.71
T_{10}	6.07	4.29	2.88
T_{11}	5.85	3.83	2.69
SEm(±)	0.24	0.25	0.10
CD at 5%	0.70	0.72	0.31

Table 4. Relationship between CGR and NAR on time series under long term INM in rice-wheat cropping system

Time series	Relationship (CGR and NAR)	R^2 value
30-60 DAS	Y= 0.7787X + 0.9565	0.926
60-90 DAS	Y= 0.2576X + 1.4818	0.981
90-120 DAS	Y= 0.2426X + 1.4818	0.968

The reason behind best expression of growth characters in wheat with application 50% RDF and 50% N through FYM in rice and 100% RDF in wheat can be residual effect of substitution of 50% inorganic N by FYM in rice. Other organic sources such as wheat straw and green manure were also productive and was found more superior over application of 100% RDF in inorganic forms to both the crops. The higher effectiveness of FYM is due to its rapid rate of mineralization (Singh *et al.,* 2019). It also produces plant growth promoting substances like auxins, heteroauxin, gibberellins etc. which stimulates root and shoot development. Wheat straw requires more time for decomposition than FYM and green manure crops as it contains more amount of cellulose, waxes and silica. *Sesbania aculeata* was used as a green manure crop in this experiment, it is easily decomposed but its total organic matter content on per unit nutrient basis is less in comparison to FYM. Hence, application of FYM enhanced the growth of wheat more over wheat straw and green manuring with *Sesbania aculeata*.

There is a direct relationship of CGR and NAR with dry biomass. The data pertaining to correlation between CGR and NAR on time series was presented in Table 4. Regression studies revealed a close linear relationship at 30-60 DAS (R^2 = 0.926), 60-90 DAS (R^2 = 0.981), 90-120 DAS (R^2 = 0968) between CGR and NAR (Table 4). It suggests that combined application of inorganic fertilizer and organic source of nutrients can enhance growth and dry biomass in wheat (Kakraliya *et al.,* 2017).

Conclusion

Therefore, from long term experiment of 36 years it may be concluded that farmers may adopt substitution of 50% inorganic N by FYM and application of 50% RDF in rice followed by 100% RDF in wheat for proper growth and development of wheat in rice-wheat cropping system.

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