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Influence of integrated nutrient management in yield and nutrient uptake of wheat crop (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted during the Rabi season of 2021-2022 at Instructional farm AKS University, Satna. The experiment was aimed to study the effect of organic and inorganic treatments in wheat crop. It was conducted in Randomized block design with 12 treatments (Control, 100% RDF, 75% RDF + FYM, 75% RDF + vermicompost, 75% RDF + *Azotobacter*, 75% RDF + PSB, 75% RDF + *Azotobacter* + PSB, 75% RDF +Vermicompost + *Azotobacter*, 50% RDF + FYM + vermicompost, 50% RDF + vermicompost + *Azotobacter* + PSB, 50% RDF + FYM, 50% RDF + Vermicompost + PSB) replicated thrice. Application of 100 % RDF (120:60:40 kg NPK/ha) recorded significant increase in growth, yield and nutrients uptake in both seed and straw followed by application of 75% RDF + vermicompost + *Azotobacter*. Finally results concluded that application of 100 % RDF significantly increases growth, yield and nutrients uptake in wheat crop and INM strategy plays a significant role in plant nutrition.

Keywords: Wheat, nutrients uptake, integrated nutrients management

Introduction
Wheat (*Triticum aestivum* L.) is one of the world's leading cereal crops, which can be grown in broad range of altitudes and latitudes. Wheat is one of the good sources of carbohydrates and unique protein, which is consumed as human as well as animal feed. Wheat is the staple food of nearly 35% of world population. The total area under wheat cultivation in the world during 2018-19 was 218.2 million hectares with an annual production of 765.5 million tons and average productivity of 3.51 tons ha1 (USDA, 2019). Wheat is globally second to rice in terms of total production.

Integrated nutrient management (INM) is a practices where all sources of nutrients namely organic, inorganic(chemical fertilizer), biofertilizer can be combined use for improving and maintenance of soil fertility, supply of plant nutrients, soil health get good quality yield and also maintain ecology and environment. Agriculture remains a soil based industry. A long term imbalance use of fertilizers like N, P, K and some micronutrients is adversely affecting the sustainability of agricultural production eventually causing environmental pollution. INM is better approach for supplying nutrition to the crop by including organic and inorganic sources of nutrients. Also will be effective in improving soil health and hastening the nutrients use efficiency. INM strategy and play significant role in plant nutrition.

To overcome the problem of nutrient deficiency and to increase wheat yield, the farmers are applying chemical fertilizers. However, the chemical fertilizers are expensive and the small farmers cannot afford to use these fertilizers in suitable amount and balanced proportion. Under such condition integrated use of chemical and organic manures with bio- fertilizers like *Azotobacter* and PSB can play an important role to sustain soil fertility and crop productivity. In most of developing countries due to non-availability of sufficient credits and subsidies, small and marginal farmers cannot afford the high prices of chemical fertilizers; even the rich farmers realized the negative impacts of chemical fertilizers through reduced factor productivity. As the organic and biological sources contain nutrients in small proportion and usually, they are not available in adequate quantities to fully support the crop production and maintain soil fertility levels. Therefore, a suitable combination of both inorganic and organic fertilizers integration with bio- fertilizers is the best way to ensure sustainability in crop production.

Materials and Methods

The experiments were conducted during the rabi season of 2021-2022 with wheat variety GW 322. Experiments were conducted at instructional farm, AKS University, Satna (M.P.). Satna district is located in the Kymore Plateau and Satpura Hill Zone of MP-4 (Agro-climatic Zone-VIII). It is located at an elevation of 315 metres above mean sea level in the north-eastern section of Madhya Pradesh with 24.34 ° north latitude and 80.49 ° east longitude east in the Rewa division of M.P. State of India. In Satna, rainfall is moderate and low during the kharif and Rabi seasons, respectively. The soil texture of experimental plot was clay loam with pH of 7.96 which was slightly alkaline in nature, EC was 0.14, organic carbon in the plot was 0.39%, the initial N: P_2O_5: K_2O was 150.4 kg N/ha: 16.8 kg P_2O_5/ha: 285.5 kg K_2O/ha respectively. N was applied in three split doses, P_2O_5 and K_2O was applied in one single dose during sowing as per blanket recommendation that is 120 kg N/ha, 60 kg P_2O_5/ha and 40 kg K_2O/ha.

There were total 10 treatments that were T_1 =control, T_2 = 100% RDF, T_3=75% RDF + FYM, T_4=75% RDF + vermicompost, T_5 =75% RDF + *Azotobacter*, T_6= 75% RDF + PSB, T_7= 75% RDF + *Azotobacter* + PSB, T_8=75% RDF +Vermicompost + *Azotobacter*, T_9=50% RDF + FYM + vermicompost, T_{10}=, 50% RDF + vermicompost + *Azotobacter* + PSB, T_{11}= 50% RDF + FYM , T_{12}= 50% RDF + Vermicompost + PSB, seeds were sown at a spacing of 22.5 cm between rows and 10 cm between plants. Sowing was taken on 1st of November 2021. Plants growth parameters such as plant height and number of tillers were taken. Plant height was measured from base to top at 30, 60 and 90 DAS and number of tillers were counted at 30 and 60 DAS. The average of 5 plants were considered for final plant height and number of tillers. Yield parameters such as spike length, no. of spikelets per spike, 1000 grain weight and yield were taken individually from each plots after harvest. Primary nutrients uptake by wheat was analysed in the lab, nitrogen uptake was estimated using kjeldahl method (Subbiah and Asija, 1956) [1], phosphorus uptake was estimated using spectrophotometer by Olsen's method (Olsen *et al.*, 1954) [3], potassium uptake was estimated using flame photometric method (Jackson, 1974) [2], boron uptake was estimated using DTPA extractable Atomic Absorption Spectrophotometry, (Lindsay and Norvell, 1978) and zinc was estimated using DTPA extractable Atomic Absorption Spectrophotometry, (Lindsay and Norvell, 1978).

Results and Discussion

The result of different integrated nutrients management treatments on growth characteristics such as plant height and number of tillers was found significant and given in table 1 and it was observed that plant height and number of tillers increased significantly with 75% RDF + Vermi+ Azotobacter. The application of the application of 100% RDF resulted in significantly higher growth characteristics such as plant height and number of tillers followed by application of 50% RDF + FYM, as per the research. This increase I n plant height of wheat might be due better availability of nutrient through both chemical and organic sources of the nutrient throughout the crop growth stages, where the chemical fertilizer supplied the nitrogen at initial growth stages of the crop and organic manures at later stages through slow and steady release of nitrogen. . These results are in conformity with the findings of Kumar *et al.* (2017) [5], Rathwa *et al.* (2018) [14] and Hadis *et al.* (2018) [13].

Yield attributes are the major determinants of the final yield of crop. Yield characteristics such as spike length, number of spikeletes per spike, grains per spike, Grain yield and Test weight (1000 seed weight) was found significant and given in table 2, which were found to be increasing with different integrated nutrients management treatments the application of 75% RDF + Vermicompost + Azotobacter resulted in significantly higher numbers of spikes per plant, spike length, grains per spike, grain weight and test weight followed by the application of 50% RDF + FYM. The rise in yield characteristics of wheat could be attributed to better nutrient availability during the crop's development and reproductive stages, which supplied more photosynthates from sink to source and raised the number of spikelets per spike, spike length, grains per spikes, yield and test weight. These findings are consistent with those of Patel *et al.* (2018) [8], Maurya *et al.* (2019) [20], Rathwa *et al.* (2018) [14] and Singh *et al.* (2016) [4].

The maximum nutrients uptake was found to be increasing with different integrated nutrients management treatments and given in table 3 the application of 100% RDF, followed by 75% RDF +Vermicompost + *Azotobacter*, resulted in considerably increased nitrogen, phosphorus, potassium, boron and zinc uptake by grain and straw of wheat among the treatments. The enhanced nitrogen, phosphorus and potassium uptake of wheat with these treatments was due to more nitrogen being available in sufficient amounts, which was supplied through chemical fertilizers and organic fertilizers such as vermicompost, FYM, PSB, *Azotobacter* etc. throughout active growth stages of the crop during development and reproductive stages of the crop. These findings are consistent with those of Singh *et al.* (2016) [4], Singh and Jat (2016) [12], Singh and Sharma (2016) [16], Dahiya *et al.* (2019) [18], Kaushik *et al.* (2007) [15] and Rasul *et al.*, (2015) [17].

Table 1: Effect of different integrated nutrients management treatments on growth parameters such as plant height @30, 60 and 90 DAS and number of tillers per plant@30 and 60 DAS.

Treatments	Plant height (cm)			Number of tillers	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS
Control	7.47	31	45.33	8.20	16.00
100% RDF	14.2	47.58	70.72	26.07	40.13
75% RDF + FYM	11.21	43.66	65.55	16.67	36.00
75% RDF + vermi	11.04	43.23	64.6	12.53	37.73
75% RDF + Abacter	9.36	37.94	58.52	3.33	23.04
75% RDF + PSB	9.65	40.85	59.73	4.87	26.00
75% RDF + Abacter + PSB	9.95	41.24	60.98	6.08	28.13
75% RDF + Vermi+Abacter	13.09	44.59	68.75	21.93	53.13
50% RDF + FYM	12.39	44.89	67.31	19.80	43.00
50% RDF + vermi +Abacter + PSB	12.01	44.74	66.11	17.08	39.00

50% RDF + FYM	10.33	42.81	63.71	10.40	31.93
50% RDF + Vermicompost + PSB	10.16	42.32	62.85	8.93	29.47
S. Em ±	0.20	0.44	0.63	1.02	1.16
CD (p=0.5)	0.59	1.27	1.82	2.95	3.36

RDF = Recommended Dose of Fertilizer, FYM = Farm Yard Manure, Vermi = Vermicompost, Abacter = Azotobacter, PSB = phosphorus Solubilising Bacteria.

Table 2: Effect of different integrated nutrients management treatments on yield attributes such as spike length, number of spikelets per spike, grain yield and test weight.

Treatments	Spike Length (cm)	Number of spikes per plant	Grain yield (q/ha)	Test weight (g)
Control	3.91	6.87	17.69	29.55
100% RDF	12.88	22.53	51.31	41.90
75% RDF + FYM	10.30	16.73	45.47	38.35
75% RDF + vermi	10.01	15.60	45.31	36.72
75% RDF + Abacter	7.18	12.13	34.83	30.92
75% RDF + PSB	8.27	13.00	35.53	31.53
75% RDF + Abacter + PSB	8.78	13.33	36.11	32.58
75% RDF + Vermi+Abacter	11.95	20.27	49.56	41.25
50% RDF + FYM	11.23	17.93	48.14	39.68
50% RDF + vermi +Abacter + PSB	10.71	17.13	46.72	38.83
50% RDF + FYM	9.68	14.80	44.00	36.27
50% RDF + Vermicompost + PSB	9.09	13.87	42.42	35.41
S. Em ±	0.31	0.46	0.72	0.42
CD (p=0.5)	0.90	1.34	2.10	1.22

RDF = Recommended Dose of Fertilizer, FYM = Farm Yard Manure, Vermi= Vermicompost, Abacter= Azotobacter, PSB= phosphorus Solubilising Bacteria.

Table 3: Effect of different integrated nutrients management treatments on primary nutrients uptake in seed and straw i.e., nitrogen uptake, phosphorus uptake and potassium uptake in seed and straw.

Treatments	Nitrogen uptake (kg/ ha)		Phosphorus uptake kg/ha		Potassium uptake (kg/ha)	
	Seed	Straw	Seed	Straw	Seed	Straw
Control	30.67	10.00	5.24	1.40	7.42	42.30
100% RDF	106.33	38.00	21.48	9.53	26.29	144.54
75% RDF + FYM	78.87	29.33	13.37	8.20	21.29	136.14
75% RDF + vermi	78.06	28.06	13.21	8.05	20.35	127.62
75% RDF + Abacter	73.07	23.07	11.12	5.66	15.41	94.94
75% RDF + PSB	74.21	24.21	11.68	6.27	17.52	113.70
75% RDF + Abacter + PSB	75.36	25.36	11.95	7.57	18.20	122.17
75% RDF + Vermi+Abacter	98.13	37.13	19.71	8.76	25.80	141.34
50% RDF + FYM	80.47	32.47	18.16	8.56	22.75	138.57
50% RDF + vermi +Abacter + PSB	79.33	29.87	14.61	8.39	22.61	137.86
50% RDF + FYM	77.21	27.21	13.11	7.66	19.69	126.36
50% RDF + Vermicompost + PSB	76.49	26.49	12.25	7.61	19.03	123.96
S. Em ±	1.03	0.27	0.22	0.30	0.43	0.72
CD (p=0.5)	3.01	0.78	0.64	0.87	1.25	2.10

RDF = Recommended Dose of Fertilizer, FYM = Farm Yard Manure, Vermi= Vermicompost, Abacter= Azotobacter, PSB= phosphorus Solubilising Bacteria.

Conclusions

Application of 100% RDF (120: 60: 40 kg NPK/ha) could able to cause pronounced effect on all the growth characters (plant height and the number of tillers per plant), yield attributes and nutrients uptake in seed and straw of wheat of wheat crop. While, among the integrated nutrient management use of 75% RDF + Vermicompost @ 4 t/ha + Azotobacter (10 ml/kg seed) produced significantly higher growth characters such as plant height and the number of tillers per plant, maximum yield attributes and maximum nutrients uptake by seed and straw of wheat crop. Application of chemical fertilizers may increase crop yield significantly but in long run its will degrade soil quality so implementing INM can help sustain the agricultural lands for future.

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