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IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, NUTRIENT UPTAKE, PROTEIN CONTENT OF WHEAT (*TRITICUM ASTIVAM*) AND SOIL FERTILITY IN A *TYPIC HAPLUSTERT*

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ABSTRACT

The present investigation were conducted for two *rabi* seasons during 2007 and 2008 in the field of Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh to study the effect of integrated nutrient management on yield, nutrient uptake, protein content and soil fertility of wheat in a Vertisol. The results revealed that the substitution of 25% NPK through farmyard manure in recommended dose of NPK along with 5 kg Zn/ha and PSB + *Azotobacter* recorded significantly higher grain yield (58.23 q/ha) over the 100% NPK treatment (49.79 q/ha). However, the maximum nutrient (N, P, K, S and Zn) uptake by wheat 147.08, 28.44, 174.6, 51.94 kg /ha and 335.6 g/ ha, respectively were observed in the treatment receiving 75% NPK + 5t FYM ha^{-1} + PSB+*Azotobacter* + Zn (T_9). Further, the conjunctive use of inorganic fertilizers and organic manure along with biofertilizers and micronutrients gave highest available N, P, K, S and Zn in soil as compared to other treatment combinations. Thus, integrated resource management improved the crop yields, produces quality grain as well as improved the soil fertility.

INTRODUCTION

In India, during the past three decades, intensive agriculture involving exhaustive high-yielding varieties of rice and wheat has led to heavy withdrawal of nutrients from the soil. Furthermore, imbalanced use of chemical fertilizers by farmers has deteriorated soil health. The widely practiced rice-wheat system in India is one such instance, where sustainability is under threat. Wheat is the premier food grain crops of the India and in particular of Madhya Pradesh. There has been a phenomenal increase in their production after mid sixties with the introduction of high yielding verities. To curb this trend of declining yield, there is a need to adopt the concept of integrated nutrient management. Improving and maintaining soil quality for enhancing and sustaining agricultural production is of utmost importance for India's food and nutritional security. Though India is a food surplus nation at present with about 200 Mt food grain production per annum, it will require about 7-9 Mt additional food grains each year if the trend in rising population persists. This challenge can be met by greater and more efficient use of fertilizers and organic sources. Adoption of integrated plant nutrient supply and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in Indian agriculture (Swarup, 2010).

Integrated plant nutrient system (IPNS) has assumed a great importance and has vital significance for the maintenance of soil productivity. However, organic manures, particularly FYM are important components of integrated nutrient management (Patra *et al.,* 1998) not only supply macronutrients but also meet the requirement of micronutrients, besides improving soil health. Boosting yield, reducing production cost and improving soil health are three inter-linked components of the sustainability triangle (Singh *et al.,* 2008). Verma *et al.,* 2005 was also revealed that the integration of inorganic fertilizers with organic manures will not only sustain the crop production but also will be effective in improving soil health and enhancing the nutrient use efficiency.

Keeping this in view, the present investigation was planned to study the effect of integrated nutrient management on yield, nutrient uptake, grain quality (protein content) and soil fertility of wheat in a Vertisol.

MATERIALS AND METHODS

The field experiment was conducted during rabi 2007 and 2008 in Research Farm of the Department of Soil Science and Agricultural Chemistry at Jawaharlal Nehru Krishi Viswa Vidyalaya, Jabalpur (M.P.) to study the effect of integrated nutrient management on soil fertility as well as yield and mineral nutrition of wheat in a Vertisol. The soil was *Typic Haplustert*, clayey in texture, having pH 7.2, EC 0.14, organic carbon 6.5 g /kg , available N 220 kg/ha, available P 17.3 kg/ha, available K 255 kg/ha, available S 23.1 kg/ha and available Zn 0.46 mg/ kg. The experiment was laid out in a randomized block design with 12 treatments comprising different combinations of inorganic fertilizers, organic manure and biofertilizers were replicated four times. The details of the treatments were T_1 =

100% NPK through chemical fertilizers as per STV, T_2 = 75% NPK through chemical fertilizers as per STV, T_3 = 50% NPK through chemical fertilizers as per STV, T_4 = 75% NPK + 5t FYM/ ha, T_5 = 75% NPK + *Azotobacter* + PSB, T_6 = 75% NPK + 5t FYM + *Azotobacter* + PSB, T_7 = 75% NPK + Zn, T_8 = 75% NPK + 5t FYM/ ha + Zn, T_9 = 75% NPK + 5 t FYM + *Azotobacter* + PSB + Zn, T_{10} = 50% NPK + 5t FYM/ ha, T_{11} = 50% NPK + 5t FYM /ha + PSB + *Azotobacter,* T_{12} = 50% NPK + 5t FYM /ha + PSB + *Azotobacter* + Zn.

Recommended doses of NPK (100% as per soil test value) applied to wheat were N (@ 27.8 kg/ ha), P_2O_5 (@ 61.8 kg/ ha) and K_2O (@ 35.4 kg/ ha). Further, for 75% level the application rate of NPK nutrients were (20.9 N, 46.4 P_2O_5 and 26.6 K_2O kg/ ha). Similarly, for 50% level the application rate of NPK nutrients were (13.9 N, 30.9 P_2O_5 and 17.7 K_2O kg/ ha). The 100% application of P and K was basal at the time of sowing and in case of nitrogen 50% was applied as basal and rest is in two split, 25% N is 21 days of after sowing and rest 25% N is after 15 days of first spilt. In addition to these applications, $ZnSO_4$ was applied as basal @ 25 kg/ha only to the treatment with Zn. The sources of NPK fertilizers were nitrogen through urea (46% N), phosphorus through single super phosphate (16% P_2O_5), potash through muriate of potash (60% K_2O), and zinc through zinc sulphate (21% Zn). FYM @ 5 t /ha was applied prior to sowing in the concerning treatments. The bio fertilizers i.e. *Azotobacter* and phosphate solubilizing bacteria (PSB) as inoculants were applied @ 3 kg/ ha with 150 kg of well decomposed FYM and were applied at 5 cm depth in the furrows, just before the seed sowing.

Wheat (GW-273) was sown during third week of October and harvested in the first week of March. At harvest samples were collected, oven dried, processed. The chemical analysis of the plant sample was carried out by wet digesting with HNO_3:$HClO_4$ (4:1) di-acid mixture as per the procedure outlined by (Jackson 1973) and to determine concentrations of N, P, K, S and Zn at harvest using procedure described by (Jackson 1973). The grain and straw yield of wheat were recorded and soil samples (0–20 cm) were collected from each plot after harvest of wheat. These samples were analyzed for *p*H (1:2.5 soil: water suspension), electrical conductivity by conductivity meter (Jackson, 1973), organic carbon by rapid titration method (Walkley and Black, 1936). Available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available P by Olsen's method (Olsen *et al.* 1954), available K by ammonium acetate extraction method (Jackson, 1967) and available S was estimated by turbidimetric method (Chesnin and Yien, 1950). The Available Zn was extracted with DTPA and determined by atomic absorption spectrophotometer as described by (Lindsay and Norvell, 1978). The analysis of variance was carried out using the randomized complete block design (Gomez and Gomaz, 1984).

RESULTS AND DISCUSSION

Grain yield

The data on grain yield of wheat for two years are presented in table 1 revealed that the highest seed yield was recorded in T_9 (58.65 q/ha during 2007 and 57.82 q/ha in 2008) which was significantly superior to all other treatments. The lowest seed yield was recorded in T_3 (38.05 q/ha during 2007 and 36.57 q/ha in 2008) which was significantly inferior to most of the treatments except T_{10}. Further, T_1, T_6 and T_8 were at par with each other. The grain yields in these treatments ranged from 50.14 to 58.65 q/ha and 48.85 to 57.82 q/ ha during 2007 and 2008, respectively. The grain yield of T_2 treatment was significantly higher than that of T_3. Similar trend was observed in the pooled data. Further, the grain yield of wheat was higher under 100% recommended dose of NPK fertilizer applied through either inorganic source alone or 75% through inorganic and 25% through organic source. Application of NPK at suboptimal dose i.e. 75% and 50% of recommended NPK dose reduced the grain yield significantly. The advantage of organic manures is quite obvious, as these provide a steady supply of nutrients leading better growth of plants. Moreover, the increased availability of P and K in addition to other plant nutrients released by the organic manures might have contributed in enhancing the yield-attributes. The positive impact of availability of individual plant nutrients and humic substances from manure and balanced supplement of nitrogen through inorganic fertilizers might have induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and regulation of water intake into the cells, resulting in the enhancement of yield parameters (Sekar, 2003). Improvement in yield due to combined application of inorganic fertilizer and organic manure might be attributed to

Table 1: Effect of integrated nutrient management on grain yield and protein content (%) of wheat

Treatments	Grain yield of wheat (q/ ha)			Protein content of wheat grain (%)		
	2007	2008	Pooled	2007	2008	Pooled
T_1 : 100% NPK	50.14	48.85	49.49	10.59	10.13	10.36
T_2 : 75% NPK	41.86	40.58	41.22	9.97	9.50	9.73
T_3 : 50% NPK	38.05	36.57	37.31	9.39	8.92	9.16
T_4 : T_2 + FYM	51.28	49.95	50.62	10.19	9.72	9.95
T_5 : 75% NPK+ *Azotobacter* + PSB	50.98	49.65	50.32	10.33	9.86	10.09
T_6 : T_4 + T_5	51.42	50.12	50.77	10.20	9.69	9.95
T_7 : T_2 +Zn	52.32	50.95	51.64	10.08	9.58	9.83
T_8 : T_4 + Zn	57.33	56.76	57.04	10.20	9.66	9.93
T_9 : T_4 + T_5 + Zn	58.65	57.82	58.23	10.61	10.30	10.45
T_{10}: T_3+ FYM	40.19	38.94	39.57	9.53	9.16	9.34
T_{11}: T_{10} + *Azotobacter* + PSB	41.16	39.86	40.51	9.41	9.25	9.33
T_{12}: T_{10} + T_{11} + Zn	44.26	43.44	43.85	9.73	9.45	9.59
CD (p = 0.05)	8.85	6.55	4.95	0.72	1.23	0.64

control release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth (Katkar *et al.,* 2011).

Nutrient uptake

It is evident from the table 2 that integration effect of chemical fertilizer, organic manure and biofertilizers alongwith Zn applied in T_8, T_9 and T_{12} had significant positive impact on uptake of nutrients over the other treatments (75% NPK and 50% NPK). The nitrogen uptake by wheat increased with the increasing levels of fertilizers and integration with organic manure and biofertilizers. The highest nitrogen uptake by wheat was observed in T_9 treatment 149.72 and 144.45 kg /ha during 2006 and 2007, respectively while, the lowest nitrogen uptake was found in treatment T_3. The pooled data of two years revealed that the integrated nutrient management (INM) treatments increased N uptake by wheat and it is ranged between 82.81to 147.08 kg/ ha. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in different plant parts. The results are in agreement with the findings of (Mitra *et al.,* 2010).

Phosphorus uptake by wheat was also influenced by combined application of inorganic fertilizers, organic manure and biofertilizers. Almost all the INM treatments except T_{10} recorded significantly higher P uptake by wheat (14.52 kg/ ha in 2007 and 13.31 kg/ ha in 2008) compared to 50% NPK treatment during first and second year (Table 2). Similar trend was observed in pooled data also and the magnitude of increase was about 72 and 16% over 75 and 100% NPK, respectively. The solubilizing action of organic acids produced during decomposition of farmyard manure might have increased the release of native P, stimulated microbial growth in soil, and favoured root growth which had finally led to increased P uptake by wheat. Incorporation of FYM and PSB along with inorganic P increase the availability of P to crop and mineralization of organic P due to microbial action and enhanced mobility of P. The increase in available P is due to the addition of P through manure/fertilizer in excess of removal by the crop (Singh *et. al.,* 2008). Similar findings were also reported by (Dwivedi *et al.,* 2007 and Bahadur *et al.,* 2012).

Potassium uptake was found significantly higher in almost all the INM treatments as compared to T_{3}-50% NPK (97.50 kg/ha in 2007 and 97.55 kg/ ha in 2008) in both the years. Similar trend was observed in the pooled data also (Table 2). The magnitude of increase in K uptake due to T_8 (170.81 kg/ ha) and T_9 (174.60 kg/ ha) treatments over 75% NPK treatment (T_2) was 63 and 67% respectively. The increased uptake of K by wheat may be ascribed to the release of K from the K-bearing minerals by complexing agents and organic acids

Table 2: Effect of integrated nutrient management on nutrient uptake by wheat

Treatments	Nutrient uptake (kg/ ha)								
	Nitrogen			Phosphorous			Potassium		
	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1 : 100% NPK	131.36	122.51	126.94	25.04	23.13	24.08	160.12	157.77	158.95
T_2 : 75% NPK	98.44	91.02	94.73	17.12	15.40	16.26	105.46	103.95	104.71
T_3 : 50% NPK	85.90	79.72	82.81	12.54	11.37	11.95	97.50	95.55	96.52
T_4 : T_2 + FYM	126.08	117.93	122.00	21.95	20.59	21.27	140.73	139.87	140.30
T_5 : 75% NPK+ *Azotobacter* + PSB	124.76	116.59	120.67	20.62	19.25	19.94	135.80	134.99	135.40
T_6 : T_4 + T_5	126.38	117.36	121.87	22.87	21.60	22.24	143.06	142.43	142.75
T_7 : T_2 +Zn	125.33	116.83	121.08	21.48	19.81	20.64	139.89	139.92	139.91
T_8 : T_4 + Zn	147.47	138.00	142.74	28.24	26.99	27.61	170.93	170.70	170.81
T_9 : T_4 + T_5+ Zn	149.72	144.45	147.08	28.35	28.52	28.44	173.22	175.97	174.60
T_{10}: T_3+ FYM	90.59	84.39	87.49	14.52	13.31	13.91	100.01	98.90	99.45
T_{11}: T_{10} + *Azotobacter* + PSB	92.49	87.18	89.84	14.53	13.28	13.91	106.40	105.72	106.06
T_{12}: T_{10} + T_{11} + Zn	103.42	98.52	100.97	17.59	16.50	17.04	115.77	115.27	115.52
CD (p = 0.05)	19.21	17.86	11.80	3.54	4.97	3.35	16.11	15.39	10.02

Table 3: Effect of integrated nutrient management on sulphur and zinc uptake by wheat

Treatments	Sulphur (kg/ ha)			Zinc (g/ ha)		
	2007	2008	Pooled	2007	2008	Pooled
T_1 : 100% NPK	37.35	37.49	37.42	175.30	163.19	169.24
T_2 : 75% NPK	21.86	22.05	21.96	128.09	117.34	122.72
T_3 : 50% NPK	17.44	17.32	17.38	105.24	95.42	100.33
T_4 : T_2+ FYM	33.28	34.11	33.70	169.32	155.59	162.46
T_5 : 75% NPK+ *Azotobacter* + PSB	29.74	31.43	30.58	168.03	158.50	163.27
T_6 : T_4 + T_5	35.03	36.28	35.66	195.46	178.88	187.17
T_7 : T_2 +Zn	29.58	31.42	30.50	252.42	251.90	252.16
T_8 : T_4 + Zn	41.95	43.54	42.74	314.86	315.60	315.23
T_9 : T_4 + T_5+Zn	50.48	53.40	51.94	332.30	338.91	335.60
T_{10}: T_3+ FYM	21.40	21.66	21.53	120.61	116.12	118.36
T_{11}: T_{10} + *Azotobacter* + PSB	19.94	20.57	20.26	120.34	111.46	115.90
T_{12}: T_{10} + T_{11}+Zn	30.43	30.57	30.50	183.34	186.87	185.10
CD (p = 0.05)	6.70	6.73	4.27	49.17	40.37	28.64

Table 4: Effect of integrated nutrient management on physico-chemical properties and available nutrient contents of soil (2008)

Treatments	Soil pH	EC (dSm^{-1})	OC (%)	Available Nutrients (kg ha^{-1})				Zn(mg/ kg)
				N	P	K	S	
T_1 : 100% NPK	7.5	0.21	6.0	218.5	18.7	262.3	29.8	0.47
T_2 : 75% NPK	7.4	0.18	5.7	213.5	17.1	250.5	23.6	0.44
T_3 : 50% NPK	7.2	0.15	5.2	202.3	17.0	242.3	21.0	0.41
T_4 : T_2+ FYM	7.1	0.15	6.8	226.3	18.1	261.3	28.6	0.47
T_5 : 75% NPK+ *Azotobacter*+PSB	7.0	0.18	7.3	230.0	17.9	261.8	29.5	0.52
T_6 : T_4 + T_5	7.0	0.16	7.3	242.0	18.5	264.0	32.9	0.56
T_7 : T_2 +Zn	7.3	0.21	6.3	227.0	18.4	259.0	31.2	0.69
T_8 : T_4 + Zn	7.4	0.21	7.2	235.8	18.7	266.3	30.6	0.73
T_9 : T_4 + T_5 + Zn	7.3	0.21	8.3	248.0	19.9	277.0	33.9	0.83
T_{10}: T_3+ FYM	7.1	0.16	6.5	217.0	17.6	249.5	24.5	0.48
T_{11}: T_{10} + *Azotobacter* + PSB	7.1	0.15	7.0	223.8	17.4	252.5	28.9	0.55
T_{12}: T_{10} + T_{11}+Zn	7.0	0.17	7.2	230.0	18.3	255.0	31.0	0.62
CD (p = 0.05)	NS	NS	0.21	42.80	2.49	NS	12.7	0.15

produced during decomposition of organic resources. Similar results were also observed by (Mohapatra *et al.,* 2008) in rice–potato (*Solanum tuberosum* L.) cropping system and (Sawarkar *et. al.,* 2013) under soybean-wheat cropping sequence in a Vertisol.

The data related to sulphur uptake of wheat crop grown under different combinations by integrating the input of nutrients including the different levels of P through super phosphate which contains sulphur, presented in Table 3 indicated that the impact was quite apparent in different treatments. Sulphur uptake by wheat decreased with the level of nutrient application. However, there was relatively more decrease when the application rate reduced to 50%. On the other hand a significant increase in S uptake was recorded by inoculation of seeds with Azotobactor and/or PSB application. The pooled S uptake was varied from 17.38 to 51.94 kg/ ha. Similar observations were also reported by (Thakur *et al.,* 2009).

Data on uptake of Zn by wheat in the present study (Table 3) indicated that the behavior of different treatments was similar to that obtained in case of other nutrients. Yet, the values of zinc uptake increased significantly when the Zn was applied through $ZnSO_4$ as the nutrients. The differences were relatively low, yet significant. The highest value of Zn uptake were recorded 332.3, 338.9 and 335.6 g /ha during 2007, 2008 and pooled of both years, respectively in T_9. The lowest values of zinc uptake were found in 50% NPK (T_9).The process of enrichment of organics with Zinc improves the nutrient use efficiency as well as quantity of FYM to a considerable extent (Meena *et. al.,* 2006). Similar findings were also reported by (Rathod *et. al.,* 2012).

Protein content in wheat

The data related to the per cent protein content of wheat grain is presented in table 1 emphasized that the similar trend was noted in per cent protein content to that of nitrogen uptake by wheat. The highest value of pooled protein content in wheat 10.45% was associated with T_9 and the lowest value 9.16% in T_3 treatment. The percent protein content under T_9 nutrient level was significantly higher than most of the other treatments except T_1. Similar findings were also reported by (Saha *et al.,* 2010).

Physico-chemical properties and soil fertility

Soil pH maintained or declined in all the INM treatments as compared to the initial value (Table 4). This decline in soil *p*H may be ascribed to the formation of organic acids due to the decomposition of organic manure and crop residues. The organic C and the available N content of the experimental soil was found to increase over the initial value in all the INM treatments. Maximum increase in the OC and available N were noted in T_9 (0.83% and 265.5 kg/ ha) and was significantly superior over T_1 treatment (0.60% and 218.5 kg/ha). The treatment T_1 was at par with T_5, T_{11} and T_{12} treatments. The lowest value of OC and N was recorded in T_3 (0.63% and 202.3 kg/ ha).This increase may be attributed to higher microbial activity in the INM treatments which favoured the conversion of the organically bound nitrogen to inorganic form (Panwar, 2008). Similar increase in available N in soil due to addition of organics was observed in wheat (Singh *et al.,* 2006). The soil available P was either maintained or slightly improved due to addition of different organic manure and/or PSB over the T_1 (18.7 kg /ha). Incorporation of FYM and PSB along with inorganic P increase the availability of P to crop and mineralization of organic P due to microbial action and enhanced mobility of P. The increase in available P is due to the addition of P through manure/fertilizer in excess of removal by the crop (Singh *et. al.,* 2008). Organic manures, on decomposition, solubilize insoluble organic P fractions through release of various organic acids, thus resulting into a significant improvement in available P status of the soil (Laxminarayana, 2006 and Maitra *et al.,* 2008) also found similar improvement in soil available P status due to integrated nutrient management in sun hemp. The available K and S content of the soil were also found non-significant among all the treatments. The highest value were recorded in T_9 (277.0 & 33.0 kg/ ha) and the lowest in T_3 (242.3 & 21.0 kg/ ha). The data recorded for available Zn of the soil sample collected after the harvest of wheat crop possesses significant differences amongst some of the treatments. The highest available zinc was recorded in T_9 (0.83 mg /kg) and was significantly superior to most of the treatments except, $T_{7,}$ T_8 &T_{12}. The lowest value was recorded in T_3 (0.41 mg/ kg). Similar, results was found by (Thakur *et al.,* 2011).

These results suggested that application of fertilizers on the basis of soil test (100% NPK) was although more effective in comparison to below the recommended level (75% or 50%

NPK), but the integrated use of organic, inorganic and biofertilizers (75% NPK + 5t FYM/ha + Azotobactor + PSB and/or Zn) was more effective in enhancing the yield and quality of wheat. Improvement in soil properties and fertility status was recorded when chemical fertilizers (75% NPK and 50% NPK) were integrated with organic manure and biofertilizers.

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