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Effect of integrated nutrient management on nutrient uptake by wheat in alluvial soils of Madhya Pradesh

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Abstract
A field experiment was conducted during the *rabi* season of 2013-14 and 2014-15 on sandy clay loam soil to evaluate the effect of integrated nutrient management on nutrient uptake of wheat *(Triticum aestivum* L.) at Research Farm, College of Agriculture, Gwalior. The experiment consisted of twelve integrated nutrient management treatments. The results revealed that the application of 100% RDF+ FYM 2.5t/ha + *Azotobacter* + PSB recorded maximum uptake of N, P and K by wheat grain, straw and its total, which were significantly higher over control as well as most of the treatments. The uptake of micronutrient ei. Zn, Fe, Mn and Cu were also recorded significantly higher with application of 100% RDF+ FYM 2.5t/ha + *Azotobacter* + PSB over most of the INM treatments.

Keywords: Wheat, Nutrient uptake, Integrated nutrient management, FYM, *Azotobacter*, PSB

1. Introduction
Wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally and is a staple food for about one third of the world's population. It occupies second position both in terms of area and production in the world. It is cultivated over an area of 29.86 million hectares with an annual production of 94.88 million tonnes and productivity of 3.18 Mt/ha, whereas in Madhya Pradesh, it is cultivated in 4.89 thousand hectares of land with an annual production of 12.69 million tonnes and productivity of 2.36 Mt/ha (CLRS, 2014) [2].

On account of counting world energy crisis and spiraling price of chemical fertilizer, the use of organic manure as a renewable source of plant nutrients is assuming importance. In this endeavor proper blend of organic manure and inorganic fertilizer is important not only for increasing yield, but also for sustaining soil health (Kumari *et al.*, 2013) [15]. Golal *et al.* (2001) [9] reported that bio-fertilizer technology minimize production costs and at the same time avoid the environmental hazards.

Nitrogen, phosphorus and potassium as major nutrients, sulphur, calcium and magnesium as the secondary, zinc and boron are the micronutrients play an important role in the yield and quality of wheat. The ability of the plants to produce more yields is dependent on the availability of adequate plant nutrients because cultivation of high yielding varieties of crop coupled with intensive cropping system has depleted the soil fertility, resulting in multi nutrient deficiencies in soil-plant system. Under such situation, use of only one or two primary nutrients will not be sufficient for maintaining the long term sustainability of crop production.

According to soil test findings use of high analysis fertilizer, limited recycling of plant residues and gap between the removal and supplementation of secondary and micronutrients have resulted in widespread multi nutrient deficiencies, especially of N, P, K, S and Zn along with other nutrients.

On the other hand, worlds population explosion in recent decades has caused excessive application of chemical fertilizers in agricultural system, resulting in severe environmental and health problems (Garnier *et al.*, 2010) [8]. However, it is not possible to stop the application of chemical fertilizers to agricultural systems. A logical way to reduce the application rate by adopting integrated nutrient management method. Integrated nutrient management tries to reduce the need for chemical fertilizers by taking advantages of non chemical sources of nutrients such as the manures, composts and bio-fertilizers (Gopalasundaram *et al.*, 2012) [10].

Bio-ferttilizers application not only increases plants growth and yield but increase soil microbial population and activity, resulting in improved soil fertility (Biyari *et al*., 2008) [1].

An integrated approach recognizes that soils are the storehouse of most of the plant nutrients essential for plant growth and that the way in which nutrients are managed will have a major impact on plant growth, soil INM, and agricultural sustainability. The agricultural products are not only concerned with quantity, but it also need appropriate quality is also required, which is directly responsible for human health. Integration of chemical and organic sources and their management have shown promising results not only in sustaining the productivity but also proved to be effective in maintaining soil health and enhancing nutrient use efficiency (Laxminarayana *et al.* 2011 and Kumar *et al.* 2012) [16, 13]. Hence, the present investigation was conducted to identify the best combination of inorganic fertilizer with organic manure as well as bio-fertilizer which is appropriate for encourage the nutrient uptake by wheat in alluvial soils of Madhya Pradesh.

2. Materials and method

The experiment was conducted during two consecutive *rabi* seasons of 2013-14 and 2014-15 at Research Farm, College of Agriculture, Gwalior. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (pH 7.50 and 7.64) with low in organic content (0.40 and 0.44) and available N (168.5 and 160.5 kg/ha) and medium in available P (14.2 and 15.2 kg/ha) and K (240.5 and 230.6 kg/ha) contents. The rainfall during the crop season was 144 and 196.8 mm and was received in 15 and 18 rainy days. Minimum temperature ranged between 6.1 to 23.4 and 4.0 to 22.7 °C and maximum 15.7 to 41.9 and 16.0 to 41.1°C in 2013-14 and 2014-15, respectively. The treatments comprised of twelve INM levels (T_1 Control, T_2 FYM @ 10 t/ha, T_3 FYM @ 5 t/ha + *Azotobactor* + PSB,T_4 FYM @10 t/ha + *Azotobactor* + PSB, T_5 NPK (100% recommended dose) 120:60:40 kg/ha, T_6 NPK (150% recommended dose), T_7 NPK (100% recommended dose) + *Azotobactor* + PSB, T_8 NPK (100% recommended dose) + FYM @ 2.5 t/ha + *Azotobactor* + PSB, T_9 NPK (100% recommended dose) + FYM @ 2.5 t/ha, T_{10} NPK (75% recommended dose) + *Azotobactor* + PSB, T_{11} NPK (75% recommended dose) + FYM @ 2.5 t/ha and T_{12} NPK (75% recommended dose) + FYM @ 2.5 t/ha + *Azotobactor* + PSB). Thus, 12 integrated nutrient management treatments were laid out in Randomized completely block design with three replications. The crop was sown with keeping a seed rate of 120 kg/ha. The wheat variety MP 4010 was used for experimentation and four irrigations were provided. The collected sample were analysed for physical and chemical properties following standard procedure. The data collected from field and laboratory analysis were subjected to statistical analysis by using standard method.

3. Result and discussion

The results revealed that the uptake of N by wheat grain, straw and its total were observed in the range of 58.84 to 101.84, 17.31 to 36.22 and 76.15 to 138.07 kg/ha, respectively under different INM treatments. Application of 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB showed maximum uptake of N by wheat grain, straw and its total, which was significantly higher over remaining INM treatments except T_6 during both the years. Significantly lower N uptake by wheat grain, straw and total by crop was recorded with treatment T_1 (control) over all other INM treatments during both the years as well as in pooled data.

Moreover, addition of 10 t FYM ha^{-1} increased significantly the N uptake by the crop. Higher values of N uptake with FYM addition are apparently the result of favourable effect of FYM on N absorption coupled with greater yields. This increased uptake of N by wheat crop may be ascribed to more availability of N from added FYM. Higher uptake of N under the treatments with FYM indicates that mineralized N from FYM could sufficiently meet the nutritional requirement of the crop. Similar results were also reported by Dahiya *et al.* (1987) [4] and Singh *et al.* (1994) [21]. Application of 10 t FYM ha^{-1} + *Azotobacter* + PSB tended to increase the uptake of nitrogen by the crop. This increase in N uptake may be due to the fixation of nitrogen and better assimilation. The higher values of N uptake were also recorded with all the levels of NPK (100 and 150%). These results are in close conformity with the findings of Mallanagouda *et al*. (1995) [17]. A combined application of NPK (75 and 100%) with 2.5 t FYM ha^{-1} improved significantly the uptake N by wheat crop in both crop seasons. This increased uptake of N in wheat crop may be ascribed to more availability of N from added fertilizer and FYM. Similar results were also reported by Sharma (1983) [18], Jana and Ghoash (1996) [11] and Singh *et al.* (1996) [19]. The uptake of nitrogen by wheat crop was also enhanced when NPK (75 and 100%) fertilizers were applied together with *Azotobacter* + PSB but the magnitude of increase in N uptake was lower than NPK (75 and 100%) fertilizer plus 2.5t FYM ha^{-1}. The integrated use of 75 and 100% NPK through in conjunction with 2.5 t FYM ha^{-1} with *Azotobacter* + PSB seems more advantageous in increasing the N uptake by wheat crop. Kumar *et al.* (2001) [14] also reported that N uptake increased by combined application of FYM, N and *Azospirillum* inoculation. Treatment T_8 (100% NPK + 2.5 t FYM ha^{-1} + *Azotobacter* + PSB) proved significantly superior to other treatments in respect of N uptake by the crop during both the crop seasons except T_6.

Application of 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB recorded significantly higher P uptake by grain, straw as well as total uptake by crop over other INM levels during both the years as well as on pooled basis except T_6 in 2013-14 in respect of P uptake by grain and straw. The minimum values of P uptake by crop were noted in unfertilized plot (control), which was comparable to T_3 and T_2 in 2013-14 in case of P uptake by straw and significantly lower compared to remaining treatments during both the years and pooled basis in respect of P uptake by grain and total by crop.

This may be due to more availability of P from applied FYM and to the solubility action of organic acids produced during degradation of organic material thus, resulting in more release of the native and added P in soil. Dahiya *et al.* (1980) [5] reported that the addition of organic manures increased the P uptake in grain. The greater amount of phosphorus was further utilized under 10 t FYM ha^{-1} + *Azotobacter* + PSB inoculation which may be attributed to higher grain and straw production. Kumar (1995) [12] reported that the uptake of P by wheat crop improved with *Azotobacter* inoculation. The uptake of phosphorus by wheat crop increased with the application of NPK (100 and 150%) levels which may be ascribed to an increased grain and straw production and improvement in P content of the crop. The application of NPK (75 and 100%) levels along with FYM also improved the uptake of phosphorus by wheat crop in both crop seasons. Similar results were also reported by Jana and Ghosh (1996) [11] and Singh *et al*. (1996) [19]. The utilization of phosphorus

by wheat crop also enhanced with increasing levels of NPK (75 and 100%) coupled with *Azotobacter* + PSB in both the years of study. The uptake of phosphorus was further increased significantly with NPK (75 and 100%) fertilizers, FYM (2.5 t ha^{-1}) and *Azotobacter* + PSB inoculation. The maximum amount of P was utilized by wheat crop with T_8 treatment in both the crop seasons.

On the basis of two years pooled data, K uptake by wheat grain, straw and its total were observed in the range of 21.96 to 40.64, 79.13 to 151.27 and 101.09 to 191.91 kg /ha, respectively under different INM treatments. Crop fertilized with 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB showed maximum uptake of K by wheat grain, straw and its total over rest of the INM treatments. Potassium uptake was significantly increased with 10 t FYM ha^{-1} addition over control. This increase in K uptake by wheat crop might be due to higher yields of crop in FYM treated plots which is very much in agreement with the findings of Tekchand and Tomar (1992) [22] and Dahiya *et al.* (1987) [6]. The uptake of potassium by the crop was further improved significantly over T_2 (10 t FYM ha^{-1}) treatment with 10 t FYM ha^{-1}+ *Azotobacter* + PSB inoculation. Kumar (1995) [12] also reported that K uptake increased by *Azotobacter* inoculation over uninoculated control. Addition of all the three levels of NPK to the soil proved beneficial for increasing K uptake by wheat crop. This may be due to higher availability of the nutrients of the soil. The higher yields of grain yield and straw under NPK (75 and 100%) levels coupled with 2.5 t FYM ha^{-1} absorbed large quantities of K from the soil thus depleting the soil more potassium consequently showing its higher uptake in plants. These results are in close conformity with the findings of Jana and Ghosh (1996) [11] and Singh *et al.* (1996) [19]. Application of both the levels of NPK (75 and 100%) along with *Azotobacter* + PSB inoculation also enhanced the K uptake. The uptake to potassium was increased significantly with the inoculation of *Azotobacter* + PSB, both the levels of NPK (75 and 100%) fertilizers and 2.5 t FYM ha^{-1}. The maximum values of K uptake by wheat crop were recorded under T_8 (100% NPK + 2.5 t FYM ha^{-1} + *Azotobacter* + PSB) treatment. Moreover, higher amount of K was received in straw than grain, it was merely because of higher content of K in straw of the wheat crop.

Among all INM treatments, significantly higher Zn uptake by grain, straw and total by crop was recorded with 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB during both the years as well as on pooled basis. However, it was followed by T_{12} and T_9 treatments. The Pooled data revealed that the maximum Zn uptake by grain (91.38 g/ha), straw (99.88 g/ha) as well as total uptake by crop (191.26 g/ha) was noted with 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB and it was significantly higher over other INM treatments during both the years. The pooled data of two years showed that the maximum Fe uptake by grain (296.31 g/ha), straw (299.65 g/ha) as well as total uptake by crop (595.96 g/ha) was noted with 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB and it was significantly higher over other INM treatments.

The maximum Mn uptake by grain (294.25 g/ha) and straw (478.47 g/ha) was recorded with treatment T_8 (100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB), which was significantly superior over all other INM treatments on pooled data basis. However, it was followed by T_9, T_6 and T_{12} treatments. Minimum Mn uptake by grain and straw was noted with control plot. Similarly, highest total Mn uptake by crop (772.72 g/ha) was also registered with application of 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB) and it was found significantly superior over other treatments.

The pooled data of 2013-14 & 2014-15 on Cu uptake by grain and straw as well as its total uptake by wheat crop exhibit that the Cu uptake increased significantly under all the nutrient management treatments over the treatment T_1 (control). Based on pooled data the maximum uptake values of Cu uptake by grain and straw of wheat and its total uptake by crop (28.41, 34.01 and 62.43 g/ha) were recorded with application of 100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB, respectively. However, it was followed by T_9 and T_6. The minimum values of micronutrients were noted under control plot.

The increase in uptake of NPK and micronutrients by wheat crop with integrate application of nutrients in combination of bio-fertilizer may be due to improvement of the soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrients from larger area and depth. Moreover, organic manures after decomposition release nutrients which became available to the plants and thus increase NPK and micronutrients concentration. The higher uptake of nutrients with application of organic manure and bio-fertilizer in combination with inorganic fertilizer 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 similar findings are also reported by Chesti *et al.* (2015) [3] and Deshpande *et al.* (2015) [7].

Table 1: Effect of integrated nutrient management practices on N, P and K uptake by grain and straw of wheat (two years pooled data)

Treatments	Sy.	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Control	T_1	58.84	17.31	76.15	8.35	1.21	9.56	21.96	79.13	101.09
FYM 10 t/ha	T_2	66.46	20.82	87.28	10.71	1.48	12.19	25.49	98.77	124.26
FYM 5 t/ha + *Azotobactor* + PSB	T_3	66.12	20.41	86.52	10.38	1.44	11.83	25.05	96.53	121.58
FYM 10 t/ha + *Azotobactor* + PSB	T_4	71.08	23.21	94.28	11.99	1.78	13.77	27.36	107.76	135.12
100% RDF	T_5	84.73	28.77	113.50	15.66	3.59	19.26	32.62	125.23	157.85
150% RDF	T_6	99.34	35.08	134.42	20.30	5.45	25.75	39.24	144.96	184.20
100% RDF + *Azotobactor* + PSB	T_7	89.32	30.84	120.15	17.35	3.96	21.31	34.99	132.16	167.15
100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB	T_8	101.84	36.22	138.07	21.51	5.68	27.19	40.64	151.27	191.91
100% RDF + FYM 2.5 t/ha	T_9	94.03	33.05	127.08	18.60	4.27	22.87	37.04	139.27	176.31
75% RDF + *Azotobactor* + PSB	T_{10}	81.29	27.32	108.61	15.27	3.50	18.77	31.91	124.28	156.19
75% RDF + FYM 2.5 t/ha	T_{11}	85.47	28.37	113.84	16.15	3.70	19.85	32.76	126.89	159.65
75% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB	T_{12}	89.83	31.28	121.10	17.89	4.45	22.34	35.43	134.89	170.32
S.E.(m)±		0.91	0.49	1.33	0.26	0.05	0.29	0.45	1.52	1.84
C.D. (at 5%)		2.60	1.41	3.81	0.74	0.16	0.83	1.29	4.37	5.28

Table 2: Effect of integrated nutrient management practices on Zn, Fe, Mn and Cu content in grain and straw of wheat (two years pooled data)

Treatments	Sy.	Zn (g/ha)			Fe (g/ha)			Mn (g/ha)			Cu (g/ha)		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Control	T_1	48.96	37.66	86.62	162.51	114.83	277.34	121.49	197.93	319.42	13.12	17.01	30.13
FYM 10 t/ha	T_2	59.35	64.24	123.59	204.71	192.71	397.42	171.18	277.55	448.72	17.02	22.93	39.95
FYM 5 t/ha + *Azotobactor* + PSB	T_3	56.09	58.42	114.50	200.98	175.25	376.23	157.71	256.46	414.17	15.99	23.14	39.13
FYM 10 t/ha + *Azotobactor* + PSB	T_4	63.31	68.77	132.08	217.02	206.31	423.33	185.45	302.84	488.29	18.57	25.09	43.66
100% RDF	T_5	65.42	68.20	133.62	235.71	204.59	440.29	204.03	316.70	520.72	20.18	26.91	47.08
150% RDF	T_6	75.26	77.26	152.52	268.76	231.79	500.55	240.71	378.69	619.41	23.97	31.01	54.98
100% RDF + *Azotobactor* + PSB	T_7	68.95	71.04	139.99	246.08	213.12	459.20	223.49	341.86	565.35	21.67	28.81	50.48
100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB	T_8	91.38	99.88	191.26	296.31	299.65	595.96	294.25	478.47	772.72	28.41	34.02	62.43
100% RDF + FYM 2.5 t/ha	T_9	76.75	81.69	158.44	262.26	245.07	507.33	255.45	398.96	654.41	25.31	30.75	56.06
75% RDF + *Azotobactor* + PSB	T_{10}	63.88	66.69	130.57	229.61	200.07	429.69	196.03	311.54	507.57	19.55	27.72	47.27
75% RDF + FYM 2.5 t/ha	T_{11}	69.92	74.96	144.88	239.92	224.89	464.82	214.46	341.78	556.23	22.03	28.00	50.03
75% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB	T_{12}	76.53	83.00	159.52	254.40	248.99	503.38	231.44	363.00	594.44	23.94	29.24	53.19
S.E.(m)±		0.88	0.93	1.77	2.84	2.78	5.45	2.94	4.73	7.20	0.33	0.36	0.62
C.D. (at 5%)		2.53	2.66	5.07	8.14	7.96	15.61	8.41	13.55	20.61	0.95	1.02	1.78

4. Conclusion

It was concluded that the balanced use of plant nutrients from both organic and inorganic sources with bio-fertilizers enhance the nutrient availability and finally it improves the uptake of nutrient by crop, which are responsible for maintaining quantity and quality of the produce. The uptake of nutrients by grain, straw and its total were found significantly higher with application of 100% recommended dose + FYM @ 2.5 t/ha + *Azotobactor* + PSB over most of the INM treatments.

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