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Research Article

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND 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 total (seed + straw), which were significantly higher over control as well as other treatments except T_6. The uptake of micronutrient (Zn, Fe, Mn and Cu) were also recorded significantly higher with the application of 100% RDF+ FYM 2.5t/ha + *Azotobacter* + PSB over other treatments except T_6 and T_9. The application of 100% recommended dose + FYM @ 2.5 t/ha + *Azotobactor* + PSB augmented highest B: C ratio up to 3.24 and 150% RDF (3.07) was the second best INM treatment.

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

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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 in India, 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 [3]. 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 [5-6] reported that bio-fertilizer technology minimize the 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 [10]. Integrated nutrient management reduced the need for chemical fertilizers by taking advantages of non chemical sources of nutrients such as the manures, composts and bio-fertilizers [8]. Bio-ferttilizers application not only increases plants growth and yield but increase soil microbial population and activity, resulting in improved soil fertility [2]. 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 to encourage the nutrient uptake by wheat in alluvial soils of Madhya Pradesh.

MaterialsandMethods

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 7.5 and 7.6) with low in organic carbon (0.40 and 0.44%) and available N (168 and 160 kg/ha) and medium in available P (14.2 and 15.2 kg/ha) and K (240 and 230 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 (T1 Control, T2 FYM @ 10 t/ha, T3 FYM @ 5 t/ha + Azotobactor + PSB,T4 FYM @10 t/ha + Azotobactor + PSB, T5 NPK (100% recommended dose) 120:60:40 kg/ha, T6 NPK (150% recommended dose), T7 NPK (100% recommended dose) + Azotobactor + PSB, T8 NPK (100% recommended dose) + FYM @ 2.5 t/ha + Azotobactor + PSB, T9 NPK (100% recommended dose) + FYM @ 2.5 t/ha, T10 NPK (75% recommended dose) + Azotobactor + PSB, T11 NPK (75% recommended dose) + FYM @ 2.5 t/ha and T12 NPK (75% recommended dose) + FYM @ 2.5 t/ha + Azotobactor + PSB). Thus, 12 treatments were laid out in randomized completely block design with three replications. The seed was sown @ 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 [7].

Results and Discussions

Results indicated [Table-1] that the maximum grain yield (4960 kg/ha in 2013-14 and 4952 kg/ha in 2014-15) was obtained under application of 100% RDF + FYM 2.5 t/ha + Azotobactor + PSB (T8), but at par with T6 and both of these treatments resulted in 44.47 to 47.53 (2013-14) and 49.77 to 53.65 (2014-15) per cent increased grain yield over control. An examination of the pooled data on grain yield (kg/ha) revealed that, all nutrient management treatments significantly enhanced grain yield over control. The significantly higher grain yield of 4956 kg/ha was obtained with application of 100% RDF + FYM 2.5 t/ha + Azotobactor + PSB but at par with T6 (4842 kg/ha).

Table-1 *Effect of integrated nutrient management practices on yield and economics of wheat*

Treatments	Sy.	Grain yield (kg/ha)			Straw yield (kg/ha)			Cost of cultivation	Net income	B:C ratio
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled			
Control	T_1	3362	3223	26750	5314	5204	5259	21750	38655	2.78
FYM 10 t/ha	T_2	3664	3604	24450	5727	5693	5710	26750	39699	2.48
FYM 5 t/ha + *Azotobactor* + PSB	T_3	3647	3597	26950	5683	5650	5667	24450	41725	2.71
FYM 10 t/ha + *Azotobactor* + PSB	T_4	3868	3817	26317	6010	6010	6010	26950	43257	2.61
100% RDF	T_5	4288	4233	28601	6580	6580	6580	26317	51338	2.95
150% RDF	T_6	4857	4827	26517	7357	7323	7340	28601	59334	3.07
100% RDF + *Azotobactor* + PSB	T_7	4437	4420	27767	6760	6747	6753	26517	53990	3.04
100% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB	T_8	4960	4952	27567	7507	7500	7504	27767	62218	3.24
100% RDF + FYM 2.5 t/ha	T_9	4640	4620	25375	7057	7057	7057	27567	56604	3.05
75% RDF + *Azotobactor* + PSB	T_{10}	4160	4127	26425	6423	6423	6423	25375	50186	2.98
75% RDF + FYM 2.5 t/ha	T_{11}	4295	4206	4250	6580	6513	6547	26425	50993	2.93
75% RDF + FYM 2.5 t/ha + *Azotobactor* + PSB	T_{12}	4460	4433	4447	6810	6783	6797	26625	54262	3.04
S.E.(m)±		**67**	**70**	**49**	**95**	**103**	**70**	-	-	-
C.D. (at 5%)		**198**	**205**	**139**	**277**	**301**	**200**	-	-	-

Table-2 *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.Em ±		**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**

The treatment T8 and T6 were resulted in 47.04 to 50.51 and 13.64 to 16.31 per cent increased grain yield as compared to control and 100% RDF, respectively. All the nutrient management practices significantly increased straw yield over control during both the years as well as on pooled basis. The maximum straw yield 7507 kg/ha (2013-14), 7500 kg/ha (2014-15) and 7504 kg /ha (pooled basis) was obtained with treatment T8 (100% RDF + FYM 2.5 t/ha + Azotobactor + PSB), which was found significantly higher over rest of the other INM treatments except T6 [Table-2].

Application of 10 t FYM ha-1 significantly improved the wheat production over control during both the years of study. The improved total biomass production with FYM may be attributed to the increased availability of nutrients to the wheat crop from the soil and improvement in physico-chemical and biological properties of soil which is very much in agreement with the findings of [9,11], who showed a general increase in yield with organic matter application. Inoculation of seeds with Azotobacter + PSB along with 10 t FYM ha-1 further improved the yield over 10 t FYM ha-1 alone in both crop seasons. This might be attributed to increased activity of Azotobacter + PSB in the presence of organic matter. [1] also observed that Azotobacter increased the yield of wheat significantly over control. The data pertaining to [Table-1] revealed that the application of 100% RDF + FYM 2.5 t/ha + Azotobactor + PSB recorded the highest net monitory return (Rs. 62218/ha) followed by 150% RDF (Rs. 59334/ha) and 100% RDF + FYM 2.5 t/ha (Rs. 56604/ha). The minimum net monetary return was obtained by control plot (Rs 38655 /ha). The maximum benefit: cost ratio was found with 100% RDF + FYM 2.5 t/ha + Azotobactor + PSB (3.24) followed by 150% RDF (3.07) and 100% RDF + FYM 2.5 t/ha (3.05). The minimum benefit: cost ratio was recorded in FYM 10 t/ha (2.48).

The results indicated [Table-2] 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 treatments. Application of 100% RDF + FYM 2.5 t/ha + Azotobactor + PSB (T8) showed maximum uptake of N by wheat grain, straw and as pooled analysis and it was significantly higher over all the treatments except T6 during both the years.

Moreover, addition of 10 t FYM ha-1 (T2) increased significantly the N uptake by the crop over control (T1). 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 [4]. 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. Application of 100% RDF + FYM 2.5 t/ha + Azotobactor + PSB (T8) recorded significantly higher P uptake by grain, straw as well as total uptake by crop over other treatments during both the years as well as on pooled basis except T6 in 2013-14. The minimum values of P uptake by crop were noted in control, which was comparable to T2 and T3 in 2013-14. Application of 10 t FYM significantly increased the P uptake over T1. 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. 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. The application of NPK (75 and 100%) levels along with FYM also improved the uptake of phosphorus by wheat crop in both crop seasons. The uptake of phosphorus was further increased significantly with NPK (75 and 100%) fertilizers, FYM (2.5 t ha-1) and Azotobacter + PSB inoculation.

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 treatments.

Table-3 *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. Em ±		**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**

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 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 [4]. 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 which creats a negative K balance. The maximum values of K uptake by wheat crop were recorded under T8 (100% NPK + 2.5 t FYM ha-1 + Azotobacter + PSB) treatment.

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 T12 and T9 treatments. The Pooled data indicated 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 T8 (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 T9, T6 and T12 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 T1 (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 T9 and T6. The minimum values of micronutrients were noted under control plot.

The increase in uptake of NPK and micronutrients by wheat crop with integrated 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 surface area and soil depth. Moreover, organic manures after decomposition release nutrients, which became available to the plants and thus increase NPK and micronutrients uptake. 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.

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 yield, economics and 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 other treatments.

Conflict of Interest: None declared

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