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Effect of Integrated Nutrient Management On Yield And Availability of Micronutrients In Soil

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ABSTRACT
A field experiment was conducted during Rabi season 2013-14 and 2014-15 on sandy loam soil to study on crop research Centre Chirori of Sardar Vallabhbhai Patel University of Agriculture and Technology; Meerut (U.P.). Application of 125% RDF recorded significantly highest grain yield 49.73 to 47.75 q ha^{-1} during 2013-14 & 2014-15, respectively. Among the various treatments where 125% NPK was applied proved to be superior and it statistically at par with T_2 and T_{11} in terms of growth, yield attributes and yields during first & second years. The results revealed that application if micronutrient at different stages during both the years. The effects of mineral and organic fertilization on the contents of Fe, Cu, Zn, Mn and Mo the highest available was found in T_{11} where 75% NPK with vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter was applied. While minimum during both the years respectively was found under control. In soil and in the soil solution as well as on the availability of these elements for crops were investigated in the long-term field trial. The highest contents of Zn, Fe, Mn and Cu in soil and soil solution were observed in the treatment with the lowest pH (NPK).
Keywords: *Fe, Mn, Zn and Cu on available micronutrient in soil at various stages*

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important food crops of the world in terms of area, production and nutrition which contribute 20 percent of total food requirement of the world population. It provides more than 19 % calories and 21 % of the protein [6], besides is a major source of dietary fibre in human nutrition since decades. The area under wheat increased from 12.8 M ha in 1966-67 to 29.65 M ha^{-1} in 2013-14. While, production has also increased from 11.4 to 93.50 Mt and the productivity increased from 0.887 to 3.153 t ha^{-1} of the [3, 6]. Moreover, Productivity of wheat is very low in India in comparison to major wheat-producing country viz., UK (7.9 t ha^{-1}), Germany (7.8 t ha^{-1}), France (7.5 t ha^{-1}) China (4.7 t ha^{-1}) etc. The fertilizers are necessary for enhancing productivity in crops especially in wheat, rising use macronutrients and low use micronutrients leading to an imbalance of soil chemical. A staple fertilization program with macronutrients and micronutrients in plant nutrition is essential in the high production of yield with good quality products, so there is a need balance use of fertilizers and agronomic procedures are needed to increase the yield of this crop. The function of macronutrients and micronutrients is vital in crop nutrition for improved yield and quality .

Obtaining high yields with good quality relies upon appropriate provision of macro- and microelements into plants. Even though plant requirements for microelements are considerably lower when compared to those for macro elements, microelements are essential nutrients needed for proper plant growth and development. Deficiency of microelements in plants results firstly in decreasing plant resistance to harmful environmental factors, followed by declining yields and their quality [1-9]. Long-term mineral and organic fertilization can significantly modify soil properties such as pH, organic matter contents or else soil richness in available forms of macronutrients, which determine the availability of micronutrients to plants [10]. Mineral fertilization, and especially nitrogen fertilization contributes to a decrease of soil pH and this enhances the mobility of Cu, Fe, Mn and Zn [5]. Several studies showed that phosphorus fertilization limits Zn availability for plants [10, 5]. Systematic, long-term application of farmyard manure results in an increase of organic matter content in the soil. Together with the increased organic matter, an increase of Zn availability is observed, whereas Cu and Mn availability to plants is decreased [5]. The aim of this study was (1) to determine the effect of long-term fertilization on microelement contents in soil and in the soil solution as well as (2) to track relationships between plant nutritional requirements and microelement amounts in soil and the soil solution when observed under the conditions of long-term fertilization.

MATERIALS AND METHODS

Field experiments were conducted during winter season 2013-14 and 2014-15 at CRC Farm Chirrori, Sardar Vallabhbhai Patel Agriculture University Meerut. The soil was sandy loam having organic carbon 0.56 and 0.54% with pH 8.25and 8.10, available N 241 kg ha^{-1} and 240 kg ha^{-1}, available $P_20_5$13.60 and 13.33 kg ha^{-1} and available K_20 208.6 kg ha^{-1} and 206.25 kg ha^{-1} at the start of the experiment in 0 to 30 cm soil layer during 2013-14 and 2014-15 respectively. The experiment consists of thirteen treatments *viz*., T_1 (Control), T_2 (100 % NPK) , T_3 (75% NPK + FYM @ 7.5 t ha^{-1}) , T_4 (75 % NPK + vermicompost @ 2.5 t ha^{-1}), T_5 (75 % NPK + Press mud 3.0 t ha^{-1}), T_6 (75 % NPK + Press mud @ 1.5 t ha^{-1} + FYM @ 3.75 t ha^{-1}), T_7 (75 % NPK + vermicompost @ 1.25 t ha^{-1} + Press mud @1.50 t ha^{-1}), T_8 (75 % NPK + vermicompost @ 1.25 t ha^{-1} + FYM @3.75 t ha^{-1}), T_9 (75 % NPK+ *Azotobacter* + PSB), T_{10} (75 % NPK+ FYM @ 7.5 t ha^{-1} + PSB+ *Azotobacter*) ,T 11(75 % NPK +vermicompost @ 2.5 t ha^{-1} + PSB + *Azotobacter*),T_{12} (75 % NPK + press mud @ 3.0 t ha^{-1}+PSB+ *Azotobacter*) ,T_{13} (125% NPK),. The experiment was laid out in Randomized Block Design with three replications. Farmyard manure was applied 15 days before sowing as per treatment. Wheat cultivar PBW-550 was sown in rows 20 cm apart on 12 Nov. in 2013-14 and 14 Nov. in 2014-15 and harvested on 15 March in 2013-14 and 12 March in 2014-15 respectively. Half of the nitrogen and a full dose of phosphorus and potash were applied at the time of sowing as per treatment combination. The remaining nitrogen as per treatment was top-dressed after first irrigation. N, P, and K were applied through urea, Diammonium phosphate (DAP) and muriate of potash respectively. The seeds were inoculated with phosphate solubilizing bacteria (PSB) i.e. *Pseudomonas strata* before sowing as per treatments. The crop received three uniform irrigations (at Crown Root Initiation, flowering and milking stages). Postharvest soil samples were drawn and analyzed for organic carbon by wet digestion method [16], available N by alkaline permanganate method [14], available phosphorus (P) by 0.5 M $NaHCO_3$ Extractable Olsen's Colorimetric method [13] and available potassium (K) by neutral normal ammonium acetate method [9]. The treatment comparisons were made using t-test at 5% level of significance. The economics was calculated on the basis of prevailing local market price of wheat grains and cost of inputs.

RESULTS AND DISCUSSION

Available iron in soil

Iron content mg kg^{-1} in the soil as affected by different treatments at different day's interval, sampling is presented in Table 1.The highest available iron was found in T_{11} where 75% NPK with vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter was applied. While minimum iron was found under control. Available iron in soil at harvesting was significantly higher in the treatments consisting application of 75% NPK with organics.This effect may be supposed due to more availability of iron by chelates of iron with organic compound released by decomposition of organic sources during growth period..Similar results were also reported by Uyanoz *et al*. [15] reported that treating sandy clay loam with the organic materials increased plant total and grain yields, protein content, number of grains in spike, and accumulation of nitrogen (N), phosphorus (P), potassium (K), iron (Fe), zinc (Zn), manganese (Mn).It might be due to that iron played crucial role in plant metabolism particularly in chlorophyll synthesis which is vital for plant photosynthesis and it is also necessary for the biosynthesis of chlorophyll and cytochrome because it is a structural component of porphyrin molecules like cytochrome, hemes, ferrichrome which are involved in photosynthesis

Available zinc in soil

Zinc content mgkg^{-1} in the soil as affected by different treatments at different days interval sampling in wheat are presented in Table 2. The highest and non-significantly more available soil zinc than the rest of the treatments mg kg^{-1} was found in T_{11} where 75% NPK with vermicompost @ 2.5 tha^{-1} + PSB + Azotobacter was applied during both the years. The lowest zinc content was found under control both the years. Similar results were also reported by.This might be attributed to the zinc has a crucial role to play in various physiological aspects of the plant such as carbohydrates and photosynthetic metabolisms, phytohormone activity and the proper functioning of a number of enzymes which help in more dry matter accumulation [2].

Available manganese in soil

Manganese mg kg^{-1} in the soil as affected by different treatments at different days interval sampling is given in Table 3. Maximum and non-significantly higher manganese content than the rest of the treatments was found in T_{11} where 75% NPK with vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter was applied, during both the years. A similar result was also recorded by Zaid *et al*. [17] reported that the residual effect of organic manures on the uptake of N, P and K by wheat plants was more pronounced in the clay soil than in the other soils. The residual effect of applied organic manures caused a marked increase in concentration and uptake of Fe, Mn, Zn and Cu by wheat plants (2^{nd} crop) grown on the tested soils. This increase seemed dependent on the manure type. The organic matter, total N, total count of bacteria and dehydrogenates activity, were increased by manure application with greater values recorded following the preceding (1^{st}) crop (i.e., the maize crop) than following the wheat (2^{nd}) crop.

Available copper in soil

Copper content mg kg^{-1} in the soil as affected by different treatments at different days interval sampling is presented in Table 4.Maximum and non-significantly higher copper than the rest of the treatments copper was found in T_{11} where 75% NPK with vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter was applied. Copper content estimated at harvesting was found to be affected by the organic application during both the years. Higher doses of vermicompost, FYM, Pressmud application at similar NPK level increased available copper in soil no significantly. Minimum significantly lower than the rest of the treatments was found in T_1 control during both the years.Available copper in soil was non-significantly higher in the treatments consisting application of 75% NPK with vermicompost @ 2.5 tha^{-1} + PSB + Azotobacter.This effect may be supposed due to more availability of Cu during later stage chelating effect of Cu with organic compound resulting low availability of Cu due to complexation treatment. A similar result was also recorded by. Increase in dry matter yields due to Cu application occurred because the soil was deficient in Cu. Similar increases in wheat yields due to Cu applications have also been reported by [4, 7, 8, 11].

Yield (q ha^{-1})

The grain yield of wheat which ranged from 26.52 to 49.73 and 24.57 to 47.75 q ha^{-1} during 2013-14 and 2014-15, respectively was influenced significantly by different treatments (Table 2). The maximum grain yield 47.75 to 49.73 q ha^{-1} during the first and second year, respectively recorded with the application was 125% NPK was found statistically at par with treatment T_2, T_{11} during both the years. The minimum yield of wheat 24.57 to 26.52 q ha^{-1} was recorded from the treatment under control. The effect of FYM, vermicompost and presumed application with 75% NPK was not similar and the grain yield in 75% NPK + vermicompost 2.5 t ha^{-1} was significantly higher than 75% NPK+FYM or pressmud. Grain yield was statistically similar to the treatments receiving 100% NPK and 75% NPK + vermicompost. The effect of biofertilizers inclusion with 75 % NPK was not appreciable but when biofertilizers were applied with vermicompost it yielded statistically at par to T_{13} during both the years. This might be due to the immediate and quick supply of plant nutrients through chemicals for crop growth and a steady supply of plant nutrient by organics throughout growing period.

Table: 1Effect of integrated nutrient management on yield attributes and yield of wheat crop

Treatment	Grain Yield (q ha^{-1})		Spike length (cm)		No of spikelets/spike		No. of grains/spike		Test weight (g)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	26.52	24.57	6.65	6.43	8.33	8.23	28.80	27.65	31.18	30.85
100 % RDF of NPK	47.12	46.02	10.75	10.65	13.85	13.52	45.97	45.58	45.84	45.62
75% NPK + FYM @ 7.5 t ha^{-1}	40.54	38.60	10.32	10.30	13.50	13.28	42.97	42.50	45.18	44.56
75 % NPK + VC @ 2.5 t ha^{-1}	44.40	42.61	10.19	9.88	12.45	12.20	40.40	39.75	43.58	42.84
75 % NPK + PM 3.0 t ha^{-1}	37.47	36.73	8.93	8.85	11.25	10.78	38.00	37.56	40.77	40.60
75 % NPK + PM @ 1.5 t ha^{-1} +FYM @ 3.75 t ha^{-1}	39.32	37.73	9.73	9.68	11.56	11.20	39.23	38.10	42.94	42.75
75 % NPK + VC @ 1.25 t ha^{-1}+ PM @1.50t ha^{-1}	41.62	39.70	10.00	9.90	12.51	12.30	41.30	40.85	43.89	43.50
75 % NPK + VC @ 1.25 t ha^{-1} + FYM @3.75 t ha^{-1}	45.08	43.68	10.58	10.48	13.68	13.45	45.60	45.12	45.28	44.26
75 % NPK+ *Azotobacter* + PSB	36.63	35.73	8.67	8.47	10.85	10.50	37.90	36.83	40.65	40.28
75 % NPK+ FYM @ 7.5 t ha^{-1} + PSB+ *Azotobacter*	42.34	40.55	9.94	10.12	12.58	11.95	42.07	41.21	45.10	44.37
75 % NPK + VC @ 2.5 t ha^{-1} + PSB + *Azotobacter*	47.82	45.68	11.12	11.10	14.23	13.80	46.43	45.30	45.99	45.65
75 % NPK + PM @ 3.0 t ha^{-1}+PSB+ *Azotobacter*	38.80	37.08	9.53	9.48	11.43	11.10	38.30	37.10	42.33	41.64
125% RDF of NPK	49.73	47.75	11.38	11.27	14.56	13.86	49.27	47.42	48.47	47.78
SEm(±)	0.99	0.78	0.44	0.43	0.53	0.52	0.61	0.58	1.67	1.65
C.D. (P=0.05)	2.92	2.30	1.29	1.28	1.57	1.53	4.73	4.65	4.91	4.85

The FYM released nutrients following decomposition and mineralization that would have increased the availability of plant nutrients at a later stage and brought improvement in physical, chemical and biological properties of soil. As a result, the fertility status of soil might have increased and thus increasing the absorption of plant nutrients.

Table:2Effect of integrated nutrient management on available iron (mg kg^{-1}) in soil at various stages.

Treatment	30		60		90		At harvest	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	16.28	17.56	15.81	16.65	15.23	16.57	15.19	14.71
100 % Recommended dose of NPK	16.84	17.88	16.13	17.63	16.21	17.48	16.1	15.27
75% NPK + FYM @ 7.5 t ha^{-1}	18.03	19.38	17.63	19.10	17.68	18.81	17.43	16.46
75 % NPK + Vermicompost @ 2.5 t ha^{-1}	17.35	18.65	16.90	18.1	16.68	17.84	16.46	15.78
75 % NPK + Press mud 3.0 t ha^{-1}	17.98	19.30	17.55	18.74	17.32	18.71	17.33	16.41
75 % NPK + Press mud @ 1.5 t ha^{-1} +FYM @ 3.75 t ha^{-1}	17.75	19.10	17.35	18.41	16.99	18.58	17.20	16.18
75 % NPK + Vermicompost @ 1.25 t ha^{-1}+ Press mud @1.50t ha^{-1}	17.05	18.21	16.46	17.85	16.43	17.72	16.34	15.48
75 % NPK + Vermicompost @ 1.25 t ha^{-1} + FYM @3.75 t ha^{-1}	17.95	19.15	17.40	18.65	17.23	18.65	17.27	16.38
75 % NPK+ Azotobacter + PSB	18.11	19.48	17.73	19.23	17.81	19.10	17.72	16.54
75 % NPK+ FYM @ 7.5 t ha^{-1} + PSB+ Azotobacter	17.42	18.78	17.03	18.18	16.76	18.48	17.10	15.85
75 % NPK +vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter	18.25	19.58	17.83	19.41	17.99	19.22	17.84	16.68
75 % NPK + press mud @ 3.0t ha^{-1}+PSB+ Azotobacter	16.90	18.29	16.54	17.73	16.31	17.62	16.24	15.33
125% Recommended dose of NPK	16.71	17.74	15.99	17.45	16.03	17.24	15.86	15.14
SEm(±)	0.87	0.82	0.38	0.32	0.87	0.82	0.53	0.47
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table: 3-Effect of integrated nutrient management on available zinc (mg kg^{-1}) in soil at various stages

Treatment	30		60		90		At harvest	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	1.07	1.03	1.08	1.05	1.00	0.98	0.96	0.91
100 % Recommended dose of NPK	1.33	1.29	1.28	1.25	1.26	1.24	1.20	1.15
75% NPK + FYM @ 7.5 t ha^{-1}	2.28	2.24	2.25	2.22	2.18	2.16	2.10	2.05
75 % NPK + Vermicompost @ 2.5 t ha^{-1}	1.78	1.74	1.71	1.68	1.68	1.66	1.60	1.55
75 % NPK + Press mud 3.0 t ha^{-1}	2.18	2.14	2.15	2.12	2.13	2.11	2.08	2.03
75 % NPK + Press mud @ 1.5 t ha^{-1} +FYM @ 3.75 t ha^{-1}	1.90	1.86	1.87	1.84	1.84	1.82	1.78	1.73
75 % NPK + Vermicompost @ 1.25 t ha^{-1}+ Press mud @1.50t ha^{-1}	1.60	1.56	1.37	1.34	1.31	1.29	1.28	1.23
75 % NPK + Vermicompost @ 1.25 t ha^{-1} + FYM @3.75 t ha^{-1}	1.97	1.93	1.92	1.89	1.88	1.86	1.81	1.76
75 % NPK+ Azotobacter + PSB	2.31	2.27	2.30	2.27	2.23	2.21	2.13	2.08
75 % NPK+ FYM @ 7.5 t ha^{-1} + PSB+ Azotobacter	1.86	1.82	1.81	1.78	1.77	1.75	1.71	1.66
75 % NPK +vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter	2.37	2.33	2.31	2.28	2.27	2.25	2.20	2.15
75 % NPK + press mud @ 3.0t ha^{-1}+PSB+ Azotobacter	1.54	1.50	1.33	1.30	1.28	1.26	1.23	1.18
125% Recommended dose of NPK	1.21	1.17	1.18	1.15	1.21	1.19	1.16	1.11
SEm(±)	0.29	0.24	0.98	0.93	0.84	0.81	0.68	0.62
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table: 4Effect of different treatments on available manganese mg kg^{-1} in soil at various stages

Treatment	30		60		90		At harvest	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	2.21	2.31	2.19	2.30	2.17	2.30	2.14	2.24
100 % Recommended dose of NPK	2.65	2.75	2.61	2.72	2.58	2.71	2.51	2.61
75% NPK + FYM @ 7.5 t ha^{-1}	3.65	3.75	3.61	3.72	3.58	3.71	3.53	3.63
75 % NPK + Vermicompost @ 2.5 t ha^{-1}	3.18	3.28	3.15	3.26	3.11	3.24	3.03	3.13
75 % NPK + Press mud 3.0 t ha^{-1}	3.58	3.68	3.51	3.62	3.48	3.61	3.38	3.48
75 % NPK + Press mud @ 1.5 t ha^{-1} +FYM @ 3.75 t ha^{-1}	3.37	3.47	3.33	3.44	3.30	3.43	3.22	3.32
75 % NPK + Vermicompost @ 1.25 t ha^{-1}+ Press mud @1.50t ha^{-1}	3.10	3.20	2.98	3.09	2.94	3.07	2.90	3.00
75 % NPK + Vermicompost @ 1.25 t ha^{-1} + FYM @3.75 t ha^{-1}	3.41	3.51	3.38	3.49	3.35	3.48	3.31	3.41
75 % NPK+ Azotobacter + PSB	3.85	3.95	3.81	3.92	3.78	3.91	3.73	3.83
75 % NPK+ FYM @ 7.5 t ha^{-1} + PSB+ Azotobacter	3.28	3.38	3.24	3.35	3.21	3.34	3.18	3.28
75 % NPK +vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter	3.88	3.98	3.86	3.97	3.83	3.96	3.78	3.88
75 % NPK + press mud @ 3.0t ha^{-1}+PSB+ Azotobacter	2.87	2.97	2.81	2.92	2.78	2.91	2.73	2.83
125% Recommended dose of NPK	2.38	2.48	2.35	2.46	2.31	2.44	2.28	2.38
SEm(±)	0.38	0.36	0.33	0.31	0.30	0.29	0.28	0.27
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table: 5 Effect of integrated nutrient management on available copper (mg kg^{-1}) in Soil at various stages

Treatment	30		60		90		At harvest	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	0.28	0.23	0.26	0.23	0.25	0.21	0.21	0.18
100 % Recommended dose of NPK	0.34	0.29	0.33	0.30	0.31	0.27	0.29	0.26
75% NPK + FYM @ 7.5 t ha^{-1}	0.47	0.42	0.45	0.42	0.43	0.39	0.38	0.35
75 % NPK + Vermicompost @ 2.5 t ha^{-1}	0.39	0.34	0.38	0.35	0.36	0.32	0.32	0.29
75 % NPK + Press mud 3.0 t ha^{-1}	0.46	0.41	0.42	0.39	0.38	0.34	0.35	0.32
75 % NPK + Press mud @ 1.5 t ha^{-1} +FYM @ 3.75 t ha^{-1}	0.42	0.37	0.40	0.37	0.38	0.34	0.35	0.32
75 % NPK + Vermicompost @ 1.25 t ha^{-1}+ Press mud @1.50t ha^{-1}	0.38	0.33	0.36	0.33	0.33	0.29	0.29	0.26
75 % NPK + Vermicompost @ 1.25 t ha^{-1} + FYM @3.75 t ha^{-1}	0.44	0.39	0.42	0.39	0.41	0.37	0.37	0.34
75 % NPK+ Azotobacter + PSB	0.41	0.36	0.39	0.36	0.37	0.33	0.35	0.32
75 % NPK+ FYM @ 7.5 t ha^{-1} + PSB+ Azotobacter	0.49	0.44	0.47	0.44	0.45	0.41	0.41	0.38
75 % NPK +vermicompost @ 2.5 t ha^{-1} + PSB + Azotobacter	0.51	0.46	0.48	0.45	0.45	0.41	0.41	0.38
75 % NPK + press mud @ 3.0t ha^{-1}+PSB+ Azotobacter	0.36	0.31	0.35	0.32	0.33	0.29	0.29	0.26
125% Recommended dose of NPK	0.31	0.26	0.30	0.27	0.28	0.24	0.26	0.23
SEm(±)	0.24	0.22	0.20	0.19	0.18	0.16	0.17	0.15
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

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