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Effect of continuous use of Fertilizers and amendments on micronutrient cations uptake by wheat (*Triticum aestivum* L.) in an acid Alfisol

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ABSTRACT

The effect of continuous application of fertilizers and amendments on micronutrients cations uptake in an acid Alfisol during rabi (2016-17) was evaluated in field experiment at the research farm of the Department of Soil Science, CSKHPKV Palampur. This experiment was initiated during 1972 in randomized block design with eleven treatments which were replicated three times. The soil of the experimental area was silt loam and classified taxonomically as "Typic Hapludalf". The highest uptake of micronutrient cations by wheat grain and straw was recorded in the treatment comprising 100 per cent NPK + FYM followed by 100 per cent NPK + lime for Fe, Mn and Cu. 100% NPK +Zn recorded higher uptake of Zn as compared lime amended treatment. Continuous application of N alone (T_7) resulted in zero yield thus uptake could not be recorded. Omission of K and S from the fertilization schedule also resulted in drastic reduction in the uptake of micronutrient cations. Combined use of FYM with optimal dose of NPK (T_8) recorded the highest total uptake of Zn, Fe, Cu and Mn (323.2, 880.4, 364.1 and 510.0 g ha^{-1}, respectively). The lowest total uptake value (27.6, 74.7, 35.5 and 45.4 g ha^{-1}) of Zn, Fe, Cu and Mn, respectively, was recorded in control plot apart from zero uptake in 100% N treatment.

Keywords: *Alfisol, amendments, fertilizers, micronutrients, uptake*

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INTRODUCTION

In the era of green revolution, use of fertilizers and other inputs had resulted in achieving self sufficiency in food grain production. Though fertilizers have contributed in increasing the food production but the imbalanced and continuous use of high analysis fertilizers, have resulted in micronutrient deficiency in soils as the native reserves of micronutrients are not being replenished with these fertilizers. Micronutrient cations are the growth regulators and activator of many enzymes in the plant system. Thus this necessitates the need of balanced fertilization of organic and inorganic sources of nutrients to maintain the organic matter content, sustain the productivity and health of soil. Farmyard manure is a reservoir of macro and micro nutrients thus adds to fertility build up of soil. Organic manures improve soil physical, chemical and biological properties and thus enhance crop productivity vis-à-vis maintain soil health. In addition to this, the organic manures help in improving the use efficiency of inorganic fertilizers [10].

The importance of long-term fertilizer experiments in studying the effects of continuous cropping and fertilizers application on sustenance of crop production has been widely recognized. Long-term fertilizer experiments play very important role in understanding the various interactions involving soils, plants and management practices and their effects on crop productivity and soil health. Also, it is well recognized that long-term fertilizer experiments are repositories of valuable information regarding the sustainability of intensive agriculture. Thus, long-term fertilizer experiments serve as an important tool to understand the changes in nutrient uptake due to intensive cropping and continuous fertilization. Keeping in view the above facts, the present investigation was undertaken to access the effect of continuous use of fertilizers and amendments on micronutrient cations uptake in an acid Alfisol.

MATERIAL AND METHODS

The present investigation was carried out in an ongoing long-term fertilizer experiment started during 1972-73 (*rabi*) at the Research Farm of the Department of Soil Science, College of Agriculture, CSKHPKV Palampur. The experimental farm is situated at $32^0 6^/$ N latitude and $76^0 3^/$ E longitude at an altitude of about 1290 meters above mean sea level. The site is situated in the Palam valley of Kangra district under mid hills sub humid zone of Himachal Pradesh. Soil of the study area was silt loam in texture and was classified as "*Typic Hapludalf*". The 11 treatments were as follows: T_1 –50% NPK; T_2 –100% NPK; T_3 –150% NPK; T_4 –100% NPK + Hand Weeding (HW); T_5 –100% NPK + Zinc (Zn); T_6 –100% NP; T_7 –100% N; T_8 –100% NPK + FYM; T_9 –100% NPK (-S); T_{10} –100% NPK + lime; T_{11} – control. The experiment was conducted in randomized block design (RBD) with three replications and the plot size was 15 m^2 (5m × 3m). Due to the marked build-up of available P, the original treatment structure was slightly modified from *kharif* 2011, optimal and super optimal doses of P were reduced by 50 per cent and in case of 50 per cent NPK, the addition of farmyard manure (FYM) @ 5 t ha^{-1} on dry weight basis to maize crop only was also included. The wheat crop (variety HPW-155) was shown on 15th November, 2016 and harvested on 16th May, 2017. Irrigations were given at critical growth stages of wheat. Chemical weed control measures with Isoproturon @ 1.125 kg ha^{-1} (as post-emergence) was adopted except in T_4 (100 % NPK + hand weeding), where weeds were removed manually and incorporated in the plot itself. Micronutrient concentration in plant and grain sample was estimated by digestion and further analyzed on atomic absorption spectrophotometry [3]. The nutrient uptake was calculated by multiplying per cent concentration of a particular nutrient with grain and straw yields. The uptake of the nutrients obtained in respect of grain and straw yield was summed up in order to compute the amount of total nutrients removed by the crop.

RESULTS AND DISCUSSION

Zinc uptake

Zn uptake by wheat grain varied from 7.1 to 88.1 g ha^{-1}. Maximum uptake of Zn by wheat grains (88.1 g ha^{-1}) was recorded in 100 per cent NPK + FYM followed by 100 per cent NPK + Zn (77.0 g ha^{-1}) and minimum uptake (7.1 g ha^{-1}) was recorded in control, apart from zero uptake in 100 per cent N (T_7). Zinc uptake by wheat grains in 100 per cent NPK was found to be at par with 150 per cent NPK with values of 45.2 and 41.9 g ha^{-1}, respectively. Whereas, control (T_{11}), 100 per cent NP (T_6) and 100 per cent NPK (-S) (T_9) showed a decline of 84.3, 57.7 and 54.6 per cent, respectively, over 100 per cent NPK.

Zinc uptake by wheat straw was also influenced significantly by different treatments. It was the highest (235.1 g ha^{-1}) under 100 per cent NPK + FYM (T_8), followed by 100 per cent NPK + Zn with Zn uptake of 216.9 g ha^{-1} and the lowest (20.5 g ha^{-1}) was recorded in control. Omission of K (T_6) and S (T_9) led to 63 and 59.2 per cent reduction in Zn uptake by wheat straw, respectively, over the balanced fertilization (T_2). The data also revealed that the maximum values of Zn uptake were recorded in wheat straw as compared to grain. The total Zn uptake was also the highest (323.2 g ha^{-1}) in 100 per cent NPK + FYM followed by 100 per cent NPK + Zn (293.9 g ha^{-1}). The total Zn uptake in 100 per cent NPK (T_2), 100 per cent NPK + HW (T_4) and 100 per cent NPK + lime (T_{10}) was 185.2, 209.9 and 272.2 g ha^{-1}, respectively.

Continuous application of 100 and 150 per cent NPK (T_1 and T_3) resulted in lower Zn uptake as compared to 100 per cent NPK + FYM (T_8) and 100 per cent NPK + Zn (T_5). According to Rattan *et al.* [6] this could be due to the continuous use of chemical fertilizers alone that might have depleted the organic carbon of soil which is a sink of micronutrients. According to Singh *et al.* [11], incorporation of organics might have increased the Zn uptake on decomposition. The lowest Zn uptake in control plot might be due to nutrient deficiencies and low yield obtained in this plot.

Iron uptake

Iron uptake by both grain and straw of wheat was significantly influenced by various treatments. The iron uptake by wheat grains varied from 15.7 to 209.0 g ha^{-1}. The maximum iron uptake by wheat grains (209.0 g ha^{-1}) was recorded in the 100 per cent NPK + FYM followed by 100 per cent NPK + lime (145.4 g ha^{-1}). Lime and FYM amended plots had significantly higher iron uptake over rest of the treatments. Plots receiving 100 per cent NPK + HW were statistically at par with 100 per cent NPK with Fe uptake of 119.7 and 126.2 g ha^{-1}, respectively. A reduction of 78.5 g ha^{-1} in Fe uptake by wheat grains was noted in 100 per cent NP treated plots as compared to 100 per cent NPK treated plots.

Iron uptake by wheat straw was also significantly influenced by different treatment and it was the highest (671.5 g ha^{-1}) in 100 per cent NPK + FYM (T_8) followed by 100 per cent NPK + lime (T_{10}) with Fe uptake of 566.9 g ha^{-1}. Increasing dose of fertilizers from 50 to 100 per cent NPK resulted in significantly higher Fe uptake by wheat straw. Treatments where K and S were excluded (T_6 and T_9) recorded Fe uptake values of 198.5 and 181.1 g ha^{-1} by wheat straw, respectively, and these were significantly lower than 100 per cent NPK. With the increasing dose of fertilizers from sub optimal to optimal level, Fe uptake by wheat straw also increased but super optimal dose of NPK decreased the Fe uptake as compared to the optimal dose (100% NPK).

Total uptake of Fe varied from 74.7 g ha^{-1} in control to 880.4 g ha^{-1} in 100 per cent NPK + FYM. All the plots receiving chemical fertilizer alone or in combination with manure significantly increased the total Fe uptake over control. Control (T_{11}), 100 per cent NP (T_6), 100 per cent NPK (-S) and sub optimal dose of NPK recorded significantly lower Fe uptake values as compared to 100 per cent NPK.

The increase in the uptake of Fe in FYM amended plot might be ascribed to more availability of the nutrients particularly Fe from the added fertilizers and also due to the solubilizing action of organic acids produced during the decomposition of FYM, thus more release of nutrients from the soil as reported by Arulmozhiselvan *et al.* [1]. Addition of FYM increased the availability of nutrients which in turn might have increased the uptake. Uptake of nutrients was lower in plots receiving neither fertilizer nor manure (control) which may be due to absence of external source of essential major nutrients to the plants. Hence, the lower nutrient uptake might be due to lower grain and straw yield of wheat in control plot. Sub optimal dose of fertilizers recorded lower Fe uptake than optimal dose of fertilizers which resulted in lower wheat yield and ultimately lower uptake. Control plots resulted in lower Fe uptake and this could be attributed to low yields and continuous cropping without any external inputs. The lower Fe uptake in the treatments where K and S were excluded (T_6 and T_9) could be due to depletion of nutrient reserve in the soil under intensive cropping.

Copper uptake

The copper uptake by both grain and straw of wheat was significantly influenced due to various treatments. A perusal of the data revealed that apart from no uptake in 100 per cent N, copper uptake by wheat grains varied from 9.2 g ha^{-1} in control to 114.4 g ha^{-1} in 100 per cent NPK + FYM followed by 100 per cent NPK + lime with Cu uptake of 93.2 g ha^{-1}.

Copper uptake in recommended dose of fertilizers (100% NPK) was at par with 100 per cent NPK + Zn (T_5) and 150 per cent NPK (T_3) with uptake values of 56.2, 56.8 and 54.9 g ha^{-1}, respectively. Whereas, 100 per cent NP (T_6) and 100 per cent NPK (-S) (T_9) showed a decline of 52.1 and 52.3 per cent, respectively, over 100 per cent NPK (T_2). A decrease of 17.8 per cent was recorded in 50 per cent NPK as compared to 100 per cent NPK fertilization (T_2). Whereas, 100 per cent NPK + HW registered an increase of 27.6 per cent over 100 per cent NPK.

Copper uptake by wheat straw varied from 26.2 to 249.7 g ha^{-1} under different treatment combinations. Maximum uptake of copper by wheat straw (249.7 g ha^{-1}) was registered when 100 per cent NPK was integrated with FYM followed by 100 per cent NPK + lime with uptake value of 229.1 g ha^{-1} and the lowest uptake (26.2 g ha^{-1}) was recorded in control, apart from zero uptake in 100 per cent N (T_7). A reduction of 51.1 and 51.4 per cent in Cu uptake by wheat straw was noted in 100 per cent NP (T_6) and 100 per cent NPK (-S) (T_9) treated plots, respectively, in comparison to 100 per cent NPK (T_2). Higher values of Cu uptake were recorded in wheat straw as compared to the grain.

Further, it may also be conjectured from the data (Table 1) that the total Cu uptake by wheat varied from a minimum value of 35.5 g ha^{-1} in control to a maximum value of 364.1 g ha^{-1} in 100 per cent NPK + FYM. Application of FYM and lime along with 100 per cent NPK recorded significantly higher Cu uptake over rest of the treatments. Plots receiving 150 per cent NPK (T_3) and 100 per cent NPK + Zn (T_5) with total Cu uptake values of 186.9 and 184.4 g ha^{-1}, respectively, were statistically at par with each other and with 100 per cent NPK (193.0 g ha^{-1}).

Beneficial effects of integrated use of nutrients in association with FYM on the uptake of nutrients have been reported by Singh and Pathak [13], Kadam *et al.* [4] and Sawarkar *et al.* [7]. The lower Cu uptake in the treatments where K and S were excluded (T_6 and T_9) could be due to depletion of nutrient reserve in the soil under intensive cropping. Comparatively, higher Cu uptake under 100 per cent NPK + HW was probably due to improved physical condition of soil due to the incorporation of weed biomass. Zero Cu uptake in 100 per cent N (T_7) treated plot can be ascribed to zero yield obtained in the plot due to complete degradation of soil. The treatments in which yield was low the Cu uptake was also low. Similar was the case with application of sub optimal dose of fertilizers in which lower Cu uptake was recorded than optimal dose which may be due to the lower crop yield in this treatment.

Manganese uptake

The highest Mn uptake by wheat grain (144.4 g ha^{-1}) was recorded in 100 per cent NPK + FYM (T_8) while the lowest (12.5 g ha^{-1}) was recorded in control plot (T_{11}), apart from zero uptake in 100 per cent N (T_7). Integrated use of fertilizers and manure (T_8) resulted in significantly higher Mn uptake to a tune of 72.3 per cent over 100 per cent NPK (T_2).

Application of 100 per cent NPK along with lime (T_{10}) and Zn (T_5) recorded Mn uptake values of 129.3 and 78.1 g ha^{-1}, respectively. Graded doses of fertilizers (T_1 to T_3) were statistically at par among themselves and with 100 per cent NPK + Zn (T_5). Regarding wheat straw, Mn uptake varied from 32.9 g ha^{-1} in control to 365.6 g ha^{-1} in 100 per cent NPK + FYM. Uptake of Mn increased significantly with the addition of FYM and lime along with NPK fertilizers. Sub optimal, optimal and super optimal doses of NPK resulted in Mn uptake of 181.0, 198.4 and 199.8 g ha^{-1}, respectively, and these uptake values were statistically alike with each other.

A significant decrease in Mn uptake by wheat straw was recorded in the treatments where K and S were excluded from the fertilization schedule and the decline was 85.9 and 96.5 g ha^{-1} in T_6 and T_9 treatments, respectively, as compared to 100 per cent NPK. The data also revealed that higher values of Mn uptake were recorded in wheat straw as compared to grain.

Total Mn uptake by wheat varied from 45.4 g ha^{-1}in control to 510.0 g ha^{-1} in 100 per cent NPK + FYM. With the addition of FYM and lime along with 100 per cent NPK, increase in uptake of Mn by wheat was to the tune of 80.7 and 68.6 per cent, respectively, over 100 per cent NPK (T_2). Total Mn uptake in 100 per cent NP and 100 per cent NPK (-S) was 151.6 and 138.9 g ha^{-1}, respectively.

Application of FYM along with fertilizers increased manganese uptake as compared to the application of fertilizers alone. The improved uptake of manganese with applied fertilizer nutrients and organics could be due to better soil microenvironment with available mineral nutrients as reported by Patel and Anurag [5]. Similar results have been reported by Sharma and Bapat [9], Sawarkar *et al.* [7] and Soliman *et al.* [14]. Higher Mn uptake in lime amended plots might be due to higher yield obtained in this plot due to ameliorating effect of lime on soil pH, thus, higher nutrient availability and increased yields [12]. Zero Mn uptake in 100 per cent N fertilized plots can be ascribed to no biomass production due to declining soil pH thus, might have aggravated the problem of soil acidity and toxicity of Al^{3+} and Fe^{2+}. Lower Mn uptake in control plot might be due to low yield obtained in the plot due to poor inherent capacity of soil to supply the essential nutrients for crop growth and could also be due to decrease in soil organic carbon content. These findings are in conformity with *Bhatt et al.* [2] and Shambhavi *et al.* [8].

Table 1 Effect of long-term use of fertilizers and amendments on micronutrient cations uptake (g ha^{-1}).

Treatment	Zinc			Iron			Copper			Manganese		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1: 50% NPK	36.3	111.4	147.7	108.9	313.6	422.5	46.2	111.4	157.6	72.4	181.0	253.5
T_2: 100% NPK	45.2	140.0	185.2	126.2	384.0	510.2	56.2	136.8	193.0	83.8	198.4	282.2
T_3: 150% NPK	41.9	136.6	178.5	107.0	380.7	487.7	54.9	132.1	186.9	78.6	199.8	278.5
T_4:100%NPK + HW	58.6	151.4	209.9	119.7	404.7	524.4	71.7	150.0	221.7	104.1	239.3	343.4
T_5: 100% NPK + Zn	77.0	216.9	293.9	98.4	384.3	482.8	56.8	127.6	184.4	78.1	212.6	290.7
T_6: 100% NP	19.1	51.8	70.9	47.7	198.5	246.3	26.9	66.9	93.8	39.1	112.5	151.6
T_7: 100% N	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
T_8:100%NPK+ FYM	88.1	235.1	323.2	209.0	671.5	880.4	114.4	249.7	364.1	144.4	365.6	510.0
T_9: 100% NPK (-S)	20.5	57.1	77.6	44.9	181.1	226.0	26.8	66.5	93.3	37.0	101.9	138.9
T_{10}:100%NPK +lime	61.1	211.1	272.2	145.4	566.9	712.3	93.2	229.1	322.3	129.3	346.7	476.0
T_{11}: Control	7.1	20.5	27.6	15.7	59.0	74.7	9.2	26.2	35.5	12.5	32.9	45.4
CD (P= 0.05)	10.3	17.6	26.2	20.3	46.6	63.7	8.6	22.7	29.3	15.8	30.2	38.9

CONCLUSION

Integrated use of optimal dose of NPK along with amendments (FYM/Lime) enhanced the uptake of micronutrient cations by wheat. The lowest nutrient uptake by grain and straw was recorded in control followed by treatments receiving imbalanced dose of fertilizers [100% NP, 100% NPK(-S)].

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