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Effect of prescription based fertilizer recommendations on micronutrients uptake and maize productivity under acid Alfisol of Himachal Pradesh

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Abstract

This investigation was conducted in maize (*kharif*, 2013) in the ongoing long-term experiment on soil test crop response correlation studies (STCR), initiated during *kharif*, 2007 at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to evaluate different approaches of fertilizer recommendations to maize. The prescription based nutrients application based on STCR approach for realizing yield target of 40 q ha^{-1} with and without FYM proved significantly better as compared to conventional soil test based (STB) approach as well as general recommended dose (GRD) for the productivity as well as uptake of micronutrients. Fertilizers application based on STCR along with FYM for yield target of 40 q ha^{-1} enhanced the grain yield by 35 % and 33% over GRD and STB, respectively. Whereas, in case of STCR based fertilizers application without FYM for same yield target the yield increments over GRD and STB were 32 and 30%, respectively. The uptake of Fe, Mn, Zn and Cu by maize grains increased by about 41, 44, 41 and 63%, respectively following fertilizers application based on STCR along with FYM for yield target of 40 q ha^{-1} in comparison to GRD.

Key words: STCR, prescription, productivity, micronutrient, maize, uptake.

India's fertilizer consumption is increasing day by day as compared to food grain production. Imbalanced use of fertilizers has led to the degradation of soil health. Overall nutrient use ratio (N: P_2O_5: K_2O) of 4:2:1 is considered ideal for Indian soils, whereas the present ratio of 6.7:2.4:1 is far off the mark. Moreover, the nutrients are not being applied as per their status in soil. This imbalanced nutrient use has resulted in wide gap between crop removal and fertilizer application. Thus, balanced NPK fertilization has received considerable attention in India. To ensure balanced fertilizer application soil testing is the key. However to judiciously use nutrients from organic as well as inorganic sources, target yield approach (Ramamoorthy *et al.* 1967) also known as prescription based approach; employing soil testing and crop correlation has evolved as one of the most efficient nutrient management approaches. This approach takes into account the absolute content of available nutrients present in soil for realizing the desired yields of crops. Therefore, this study was undertaken to evaluate the effect of targeted yield approach of fertilizer application with and without FYM on yield and uptake of micronutrient cations by maize in comparison to the conventional approaches of fertilizer recommendations.

Materials and Methods

The study was conducted in an ongoing long-term experiment initiated during Kharif, 2007 with maize-wheat cropping system at the research farm of Himachal Pradesh Krishi Vishvavidyalya, Palampur. The soil of the experimental site was acidic in reaction, silty clay loam in texture and is situated at 32° 6' N and latitude, 76° 3' E longitude and an altitude of 1290 m. The investigation comprised 8 treatments *viz;* T_1- Control, T_2- Farmers' Practice (FP) i.e. 25 % of general recommended dose of N (30 kg N ha^{-1}) + 5 t ha^{-1} FYM on dry weight basis, T_3- General recommended dose (GRD) i.e. 120, 60, 40 kg ha^{-1} N, P_2O_5 and K_2O, respectively, T_4- Soil test based fertilizer application (STB), T_5- chemical fertilizers as per STCR approach for yield target of 30 q ha^{-1}, T_6- 5 t ha^{-1} FYM + chemical fertilizers as per STCR approach for yield target of 30 q ha^{-1}, T_7- chemical fertilizers as per STCR approach for yield target of 40 q ha^{-1} and T_8- 5 t ha^{-1} FYM + Chemical Fertilizers as per STCR approach for yield target of 40 q ha^{-1}.

Various fertilizer doses in case of target yield treatments were worked out using equations given below:

i. $FN = 5.88\,T - 0.23\,SN - 0.93\,ON$ ii. $FP_2O_5 = 4.87\,T - 1.22\,SP - 0.81\,OP$

iii. $FK_2O = 3.66\,T - 0.49\,SK - 0.51\,OK$

In above equations, FN, FP_2O_5, FK_2O are doses of N, P_2O_5 and K_2O, respectively in kg ha_{-1}. T is the yield target (q ha^{-1}), SN, SP and SK are soil available N, P and K contents before sowing of the crop, respectively in kg ha^{-1}. Whereas ON, OP and OK are N, P and K supplied by FYM, respectively in kg ha^{-1}. One third dose of N and full dose of P and K were applied at the time of sowing. The remaining one third N was top dressed at knee high and the other one third applied at pre-tasseling stage in maize. The sources of N, P and K were urea, SSP and MOP, respectively. FYM application was made @ 5 t ha^{-1} on dry weight basis to maize, which corresponds to 12.5 t ha^{-1} on fresh weight bases, with 60 per cent moisture. Average nutrient content in FYM on dry weight basis was 0.51, 0.22 and 0.44 percent of N, P and K, respectively. Thus, 5 t ha^{-1} FYM on fresh weight basis contained 25.5 kg N, 11.5 kg P and 22 kg K ha^{-1}.

The maize crop (var. Kanchan) was sown on 29th June, 2013 and harvested on 24th October, 2013. One pre-sowing irrigation was given to maize crop. Thereafter the crop met its water requirement through rainfall, which was very high during the entire crop growth period. Chemical as well as manual weed control measures were followed during the crop period. After the harvest of maize (kharif, 2013), grain and stover yields were recorded. Grain yield of maize was computed at 13 per cent moisture content, whereas micronutrient concentrations in grain as well as stover were determined using wet digestion method (Jackson, 1973).

Results and Discussion

Yield

Nutrients application based on STCR concept for yield target of 40 q ha^{-1} with and without FYM (T_8 and T_7), proved significantly better as compared to conventional soil test based as well as general recommended doses (table 1). Treatment comprising yield target of 40 q ha^{-1} along with FYM (T_8) significantly enhanced the grain yield by 35 % and 33% over conventional general recommended dose and soil test based, respectively. Whereas, from treatment for same yield target, without FYM (T_7) over conventional GRD and STB increment was 32 and 30%, respectively. Soil test based fertilizer application (T_4) enhanced the grain yield over the farmers' practice (T_2) but it was statistically at par with general recommended dose with respect to yield of maize. The higher grain and stover yield of the crop in targeted yield treatments both with and without FYM over conventional general recommended dose and soil test based treatments may be ascribed to the balanced and judicious use of the NPK fertilizers. The higher grain and stover yield in case of targeted yield treatments with FYM might be due to improved physical properties like bulk density, water retention, better aggregation that might have helped in better development of roots and proper use of native and applied nutrients and enhanced microbial activities on addition of FYM. These results are in the conformity with Verma *et al.* (2002).

Table 1. Effect of prescription based fertilizers and FYM application on yield of maize

Treatment	Nutrient Dose (kg ha^{-1})			Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
	N	P_2O_5	K_2O		
T_1- Control	0	0	0	11.6	28.9
T_2- Farmers' Practice (FP)	30	0	0	20.4	38.9
T_3- General recommended dose (GRD)	120	60	40	27.8	46.7
T_4- Soil test based (STB)	150	45	35	28.2	49.3
T_5- Target yield 30 q ha^{-1} (T_{30})	115	89	0	28.3	56.4
T_6- Target yield 30 q ha^{-1} with FYM @ 5 t ha^{-1} (T_{30} IPNS)	91	74	0	31.6	58.4
T_7-Target yield 40 q ha^{-1} (T_{40})	172	128	7	36.7	60.9
T_8-Target yield 40 q ha^{-1} with FYM @ 5 t ha^{-1} (T_{40} IPNS)	147	113	0	37.6	62.4
CD (P=0.05)				2.93	6.96

Uptake of micronutrients

Iron (Fe): Iron uptake by maize grain in treatment comprising yield target of 40 q ha^{-1} with FYM (T_8) and same yield target without FYM (T_7) was found significantly better as compared to other conventional treatments *viz*; general recommended dose and soil test based. Where T_8 increased the Fe uptake in maize grain by 41% over GRD, while increase in iron uptake by maize grain in T_7 over GRD was observed 27% (Table 2). The STCR (IPNS) treatment for targeted yield of 40 q ha^{-1} (T8) was significantly better as compared to the rest of the treatments except T_7. No significant differences were observed in IPNS and non-IPNS treatments for similar yield targets. Among remaining treatments farmers' practice (T_2) resulted in 87 per cent higher Fe uptake by grains over control, whereas application of general recommended dose of fertilizers (T_3) further enhanced it by about 46 per cent over FP. Like Fe uptake by grain, its uptake by stover was also highest (1112 g ha^{-1}) in STCR (IPNS) treatment for targeted yield of 40 q ha^{-1} (T_8) and increasing it by 35% over treatment based on soil test based approach. Target based applications of nutrients were found to be significantly better than other conventional treatments in enhancing Fe uptake by stover.

Table 2. Effect of prescription based fertilizers and FYM on uptake of micronutrient cations by maize

Treatment	Micronutrients uptake (g ha^{-1})							
	Fe		Mn		Zn		Cu	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1	34.4	448	30.6	210	30.4	95	23.7	57.6
T_2	64.2	622	50.3	297	49.9	137	42.8	78.9
T_3	92.3	767	61.3	342	63.9	171	55.4	101.6
T_4	101.7	826	62.1	365	67.8	174	61.0	113.6
T_5	101.8	960	67.6	429	69.0	194	61.1	126.6
T_6	103.4	1002	79.1	462	75.6	204	69.3	138.1
T_7	117.4	1038	80.8	468	87.8	231	85.4	141.4
T_8	130.6	1112	88.0	500	90.4	250	90.2	150.2
CD (P=0.05)	21.05	122.21	14.58	55.11	12.74	44.1	8.62	12.86

Significantly higher uptake of Fe recorded under GRD (T_3) and soil test based treatment (T_4) over farmers' practice (T_2) was because of balanced application of NPK and high biological yield. The significant increase in Fe uptake in STCR approach based targeted yield treatments as compared to soil test based fertilizer application (T_4) and general recommended dose (T_3) might be due to higher yields owing to balanced application of fertilizers as per soil status and plant requirement. Moreover, FYM after decomposition releases micronutrients which after becoming available are easily taken up by the plants and make improvement in soil environment is also one of the reasons for highest uptake in treatments comprising STCR based approach along with FYM. These results are in conformity with Khan *et al.* (2006), Naidu *et al.* (2008) and Deepak (2011).

Manganese (Mn): Manganese uptake by maize grains as well as stover was recorded higher prescription based fertilizer applications. Application of nutrients based on this approach along with 5 t ha^{-1} FYM for yield target of 40 q ha^{-1} (T8) recorded significantly higher Mn uptake by grains in comparison to non STCR treatments. Where T_8 increased Mn uptake by grain over treatments based on general recommended dose and soil test based approach by 44 and 42

%, respectively. However, no significant differences in Mn uptake by grains were observed among the prescription based treatments. As regards the Mn uptake by maize stover, it was also highest in STCR (IPNS) treatments for yield target of 40 q ha-1 with FYM (T_8). The Mn uptake by maize stover increased significantly by 23% in the treatment comprising soil test based fertilizer application (T_4) over farmers' practice (T_2). The STCR approach based target yield treatments corresponding to yield targets of 30 and 40 q ha^{-1} with and without use of FYM recorded higher Mn uptake by stover in comparison to other fertilizer treatments but among themselves these were statistically at par with each other. Substantial decline in Mn uptake in control plots might be because of their continuous removal in the absence of nutrients addition from any external source resulted in low productivity and hence reduced Mn uptake by crops. However in farmers' practice, Mn uptake was more than control which might be due to addition of FYM @ 5 t ha^{-1}. Positive influence of STCR approach based treatments *viz.*, T_5, T_6, T_7 and T_8 over general recommended dose (T_3) may be due to more grain and stover yield obtained under these treatments and consequently more uptake. Amongst all the treatments STCR approach based targeted yield treatments with and without FYM recorded higher Mn uptake which was due to balanced use of fertilizers, based on soil status and crop needs leading to higher yield. Furthermore, application of chemical fertilizers along with FYM might have the favourable conditions for roots and crop growth as well FYM on decomposition must have supplied Mn for uptake by the crop (Naidu *et al.* 2008) and (Deepak 2011).

Zinc (Zn): Uptake of Zn by maize grains under treatments corresponding to targeted yield of 40 q ha^{-1} with FYM (T_8) was 33 and 41% higher over soil test based (T_4) and general recommended dose (T_3), respectively. Zinc uptake by maize grains in treatment comprising soil test based (T_4) increased Zn uptake by 36 per cent over farmers' practice (T_2). Nutrients applied on STCR (IPNS) approach basis for yield target of 40 q ha^{-1} (T_8) significantly increased Zn uptake over treatments corresponding to yield target of 30 q ha^{-1} with and without FYM, and the extent of increase was 22 and 28 per cent, respectively. Whereas, zinc uptake by maize stover in treatment for target yield of 40 q ha^{-1} with FYM (T_8) was found 46 % higher than GRD and 44 % over STB, while treatment comprising same yield target but without FYM (T_7) resulted in 36 % more Zn uptake in stover as compared to GRD. Like Mn and Fe, significantly higher Zn uptake was found under STCR (IPNS) approach based treatments over soil test based and general recommended dose which might be due to more biomass production as compared to other two treatments and also that FYM during its decomposition releases micronutrient cations, which were easily taken up by plants. Similar results were reported by Jadhav *et al.* (2009) and Deepak (2011).

Copper (Cu): Copper uptake by grains among STCR based treatments, T_5 and T_6 was significantly lesser than that observed in IPNS (T_8) as well as non IPNS (T_7) treatments for yield target of 40 q ha^{-1} (Table 2). Where T_8 enhanced Cu uptake in grains over T_6 by 30%, while T_7 increasing it by 40 % over T_5. Per cent increases in Cu uptake by grains due to application of fertilizers and FYM as per target 40 q ha^{-1} IPNS (T_8) over GRD (T_3) and STB (T_4) worked out to 63 and 47%, respectively. On the other hand copper uptake by maize grains in general recommended dose increased by 29 % over FP. However, general recommended dose was found statistically at par with soil test based. The treatment comprising soil test based significantly improved copper uptake by stover as compared to farmers' practice. IPNS based treatment corresponding to yield target of 40 q ha-1 (T_8) increased Cu uptake in stover by 19 per cent over non IPNS treatment for yield target of 30 q ha^{-1}). The increase in Cu uptake in all the treatments over control was due to increased level of nutrition resulting in increased productivity level of the crops. The STCR (IPNS) approach based treatments (T_6 and T_8) resulted in higher Cu uptake than general recommended dose and soil test based which might be due to release of Cu from FYM, which was added to these plots @ 5 t ha^{-1} along with chemicals. Higher Cu uptake under STCR based non IPNS treatments in comparison to GRD, FP and STB might be due to the balanced as well as precise application of fertilizers under these treatments for specific yield targets based on soil test and crop requirement. Higher uptake under these treatments was due to higher yields. Also, the fact that farm yard manure after decomposition releases micronutrient cations, which become available for plant use might also be responsible for increased uptake in IPNS treatments. These results are in conformity with the findings of Naidu *et al.* (2008) and Deepak (2011).

From the above results, it may be inferred that prescription based nutrients application approach for yield targets of 30 and 40 q ha^{-1} in maize is far superior to conventional soil test based and general fertilizer recommendations approaches in realizing higher yields as well as the uptake of micronutrient cations.

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