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Soil nutrient balance under influence of differential placement of fertilizer doses and potassium splitting in maize (*Zea mays* L.)

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Abstract
Nutrient management of crops influences the nutrient balance of soil. A faulty nutrient management strategy leading to imbalance in soil nutrient status could adversely affect the crop yields in long term. Therefore, the present study was conducted to investigate the effect of different nutrient management strategies on nutrient balance of soil. Nutrient management strategies included K application methods (100% K as basal and 50% K as basal+ 50% split at earthing up), NPK doses (eight doses with each nutrient at 75 and 100% of recommended level) in differential fertilizer placement method (50% fertilizers at 5cm depth in seed furrows and 50% at 10-12 cm depth) along with a farmers' practice (fertilizer application in seed furrows at 5 cm depth with whole K as basal). Apparent loss of N and P was found higher in whole basal K application treatment while net loss was higher in K split application. But split application of K resulted in higher apparent and net nutrient balance in soil. Among the fertilizer doses 100% NPK dose exhibited the highest net balance of N,P and K. Differential placement of fertilizers with and without K split application resulted in higher apparent and net balance of nutrients in soil. Therefore, split application of K and 100% NPK dose at two different depths (50% at 5 cm in seed zone and 50% at 10-12 cm) can minimize nutrient losses from soil.

Keywords: Maize, nutrient balance, differential placement, K split, nutrient dose

Introduction
Maize is a versatile crop and it has numerous domestic and industrial uses. It is being rotated with various crops primarily wheat, making maize-wheat the third most important cropping system of India after rice-wheat and rice-rice (Farmers' portal, GOI). Because of its great production capacity it requires large amount of nutrients than most of the other cereals. Continuous growing of maize crop can deplete soil fertility if nutrient management is not given due attention. Chemical fertilizers are essential inputs for modern crop production to fulfill nutrient demand of crop. With increase in production and productivity of crops the nutrient demand has also increased markedly shifting the nutrient balance towards the negative side in most of the Indian soils (Tandon, 2007) [14]. Crop cultivation without judicious use of nutrients may adversely affect the sustainability of agriculture system. Therefore, a quantitative knowledge of nutrient depletion from soils may be helpful in selecting appropriate nutrient management strategies. Most of the farmers apply heavy dose of nutrients as basal at the time of sowing of crop. But basal application of K fertilizers at sowing causes its fixation and reduces its availability. Split application of K reduces its fixation and increases its availability and use efficiency (Kolar and Grewal, 1994 and Romheld and Kirkby, 2010) [6, 11].
Fertilizers should be applied in such a way that some amount may become available for early growth and remaining in later growth stages of crop. Since P and K are likely to fix into the soil hence their band placement helps to reduce the fixation and increases their availability (Farmaha *et al*., 2013 and Fernández and White, 2012) [1, 3]. Beneficial effect of fertilizer placement at differential depth in soil has been reported by many researchers.
Differential fertilizer application and splitting of potassium can reduce the nutrient fixation into soils, therefore more amount of nutrients may become available which may be used efficiently by crops plants and thus, may result in nutrient economy (Mandal and Thakur, 2010) [8]. A negative nutrient balance in soil can be minimized by adopting such type of nutrient management practices.
Appropriate nutrient management strategies must be adopted in maize for maintaining soil fertility. Therefore, the present study was conducted to evaluate various nutrient management strategies for obtaining a good crop response without disturbing the soil nutrient balance.

Materials and Methods

The present study was carried out during *kharif* 2016 at the Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, situated at 29˚ N latitude, 79.5˚ E longitude and at an altitude of 243.83 m above mean sea level. The soil of the experimental site was medium in organic carbon (0.71%), neutral in reaction (pH 7.2), low in available N (234.9 kg/ha) and medium in available P and K (20.7 and 212.4 kg/ha, respectively). There were 16 treatments consisting of 2 potassium application methods (100% K as basal and 50% basal + 50 % at earthing up) and 8 combinations of N, P and K doses (each nutrient at 100 and 75 % recommended levels). Fertilizers were applied in two depths (50 % fertilizers in seed furrows at 5 cm depth and 50% at 10-12 cm depth). The experiment was conducted in a factorial randomized block design with three replications. The recommended dose of nutrients was 150:60:40 kg N:P_2O_5:K_2O/ha. Along with these treatments a farmers' practice treatment (100% NPK applied into the seed furrows at 5 cm depth and whole K as basal) was also tested for comparison. Differential fertilizer placement was done by opening 10-12 cm deep furrows at 75 cm distance. Half of the calculated fertilizer amount according to treatment was applied into these furrows followed by filling up with soil and leveling. Furrows of 5 cm depth were opened at the same position where deep furrows were opened and the remaining fertilizers and seed was applied into these furrows. K splitting was done at earthing up operation (30-35 DAS). Urea was applied prior to K split application to reduce the fixation of applied K. Maize was sown at spacing of 75 cm × 20 cm in 5 cm deep furrows. 'P3396' variety of maize was sown on June 27 and harvested on October 18, 2016. Plant nutrients were supplied through NPK mixture (12-32-16), urea, di-ammonium phosphate and muriate of potash. Nitrogen was applied in three equal splits at planting, knee high and at tasseling stage. Whole amount of phosphorus was given as basal. Potassium was applied according to the treatment. In farmers' practice, one third basal dose of N along with full P and K was applied at sowing in 5 cm deep seed furrows. Remaining N was applied in two equal splits at knee high and tasseling stage. Three soil samples at 0-15 cm depth from each plot were collected randomly and these soil samples were analyzed for available N, P and K contents after harvesting of maize. Available N, P and K in soil was analyzed using alkaline $KMnO_4$ (Subbiah and Asija, 1956) [13], Olsen's extraction method (Olsen *et al.*, 1954) [9] and flame emission spectrometry method (Jackson, 1973) [5]. Nutrient balance was calculated by using following formula:

Apparent gain or loss of nutrient = Final status of nutrient in soil - (Initial status of nutrient in soil + nutrient applied - nutrient uptake by crop)

Net gain or loss of nutrient = final status of nutrient in soil - Initial status of nutrient in soil

Data on various parameters were analyzed as described by Gomez and Gomez (1984) [4] at 5% level of significance for factorial randomized block design. To compare differential fertilizer placement with and without K split application and farmers practice 'student t' test was used at 5% significance level as per the methods explained by Ragnaswami (2006) [10].

Results and Discussion

Nutrient uptake by crop

Uptake of N, P and K by the crop (105.9, 30.9 and 99.7 kg/ha, respectively) was significantly higher under split application of K than its whole basal application (Table 1, 2 and 3). Split application of K caused 6.2, 8.0 and 6.5 per cent more uptake of N, P and K, respectively than of its basal application. Split K application at earthing up stage improved availability of K throughout the crop growth period which helped in better plant metabolic activities and hence resulted in more uptake of all three nutrients. Yu *et al.* (2007) and Tewari *et al.* (2016) [16, 15] also reported significantly higher uptake of nutrients with split application of K.

Table 1: Balance sheet of N as influenced by K splitting and differential placement of nutrient doses in maize

Treatments	Initial available N status (kg/ha)	Added N (kg/ha)	N uptake (kg/ha)	Expected balance in soil (kg/ha)	Available N in soil after harvest (kg/ha)	Apparent loss or gain (kg/ha)	Net loss or gain (kg/ha)
K application*							
100% basal	234.9	131.2	99.7	266.4	230.8	-35.6	-4.1
50% basal+50% split		131.2	105.9	260.2	227.9	-32.3	-7.0
SEm ±			1.3	1.3	1.9		
CD (p=0.05)			3.7	3.7	NS		
Nutrient doses* (per cent of recommended NPK)							
75-75-75	234.9	112.5	76.1	271.3	222.9	-48.4	-12.0
75-75-100		112.5	86.4	261.0	223.6	-37.5	-11.3
75-100-75		112.5	90.5	256.9	225.5	-31.5	-9.4
75-100-100		112.5	99.1	248.3	226.9	-21.3	-8.0
100-75-75		150.0	112.0	272.9	231.2	-41.7	-3.7
100-75-100		150.0	118.0	266.9	234.2	-32.7	-0.7
100-100-75		150.0	118.9	266.0	234.8	-31.2	-0.1
100-100-100		150.0	121.6	263.3	235.9	-27.4	1.0
SEm ±			2.6	2.6	3.9		
CD (p=0.05)			7.5	7.5	NS		
Farmers' practice (FP) vs differential fertilizer placement (DFP) under 100% NPK with K splitting							
FP	234.9	150.0	106.5	278.4	230.5	-47.9	-4.4
DFP+ K splitting		150.0	124.9	260.0	234.1	-25.9	-0.8
t- value			4.39	4.39	0.53		
Significance			S	S	NS		
Farmers' practice (FP) vs differential fertilizer placement (DFP) under 100% NPK without K splitting							
FP	234.9	150.0	106.5	278.4	230.5	-47.91	-4.4

DFP only		150.0	118.3	266.6	237.6	-25.9	2.7
t- value			1.95	1.95	1.00	-28.9	
Significance			NS	NS	NS		

*treatments were laid out under differential fertilizer placement

Table 2: Effect of K splitting and differential placement of nutrient doses in balance sheet of P

Treatments	Initial available P status (kg/ha)	Added P (kg/ha)	P uptake (kg/ha)	Expected balance in soil (kg/ha)	Available P in soil after harvest (kg/ha)	Apparent loss or gain (kg/ha)	Net loss or gain (kg/ha)
K application*							
100% basal	20.7	22.9	28.6	15.1	20.4	5.4	-0.29
50% basal+50% split		22.9	30.9	12.8	20.2	7.4	-0.51
SEm ±			0.4	0.4	0.3		
CD (p=0.05)			1.2	1.2	NS		
Nutrient doses* (per cent of recommended NPK)							
75-75-75	20.7	19.7	22.0	18.3	19.7	1.4	-0.97
75-75-100		19.7	24.7	15.7	19.9	4.2	-0.82
75-100-75		26.2	26.2	20.7	20.2	-0.5	-0.54
75-100-100		26.2	29.3	17.6	20.9	3.3	0.21
100-75-75		19.7	31.7	8.7	20.0	11.3	-0.75
100-75-100		19.7	33.7	6.7	19.9	13.2	-0.83
100-100-75		26.2	34.4	12.5	20.7	8.2	0.04
100-100-100		26.2	35.8	11.1	21.2	10.1	0.46
SEm ±			0.9	0.9	0.6		
CD (p=0.05)			2.5	2.5	NS		
Farmers' practice (FP) vs differential fertilizer placement (DFP) under 100% NPK with K splitting							
FP	20.7	26.2	31.0	15.9	20.3	4.39	-0.41
DFP+ K splitting		26.2	36.8	10.1	21.1	10.9	0.37
t- value			7.19	7.19	0.7		
Significance			S	S	NS		
Farmers' practice (FP) vs differential fertilizer placement (DFP) under 100% NPK without K splitting							
FP	20.7	26.2	31.0	15.9	20.3	4.39	-0.41
DFP only		26.2	34.8	12.1	21.3	9.2	0.55
t- value			2.85	2.85	1.9		
Significance			S	S	NS		

*treatments were laid out under differential fertilizer placement

Table 3: Balance sheet of K as influenced by K splitting and differential placement of nutrient doses in maize

Treatments	Initial available K status (kg/ha)	Added K (kg/ha)	K uptake (kg/ha)	Expected balance in soil (kg/ha)	Available K in soil after harvest (kg/ha)	Apparent loss or gain (kg/ha)	Net loss or gain (kg/ha)
K application*							
100% basal	212.4	29.2	93.6	147.9	208.2	60.2	-4.24
50% basal+50% split		29.2	99.7	141.9	211.3	69.4	-1.11
SEm ±			1.4	1.4	2.2		
CD (p=0.05)			4.0	4.0	NS		
Nutrient doses* (per cent of recommended NPK)							
75-75-75	212.4	25.0	74.1	163.3	206.4	43.1	-5.98
75-75-100		33.3	84.2	161.5	210.3	48.7	-2.13
75-100-75		25.0	87.4	150.0	207.4	57.3	-5.03
75-100-100		33.3	93.2	152.5	211.0	58.5	-1.36
100-75-75		25.0	102.7	134.7	208.9	74.2	-3.52
100-75-100		33.3	109.7	136.0	212.1	76.1	-0.26
100-100-75		25.0	110.1	127.3	208.5	81.2	-3.91
100-100-100		33.3	111.9	133.9	213.2	79.3	0.78
SEm ±			2.8	2.8	4.4		
CD (p=0.05)			8.1	8.1	NS		
Farmers' practice (FP) vs differential fertilizer placement (DFP) under 100% NPK with K splitting							
FP	212.4	33.3	99.0	146.8	209.9	63.0	-2.53
DFP+ K splitting		33.3	114.0	131.7	214.7	83.0	2.3
t- value			2.49	2.77	0.51		
Significance			NS	NS	NS		
Farmers' practice (FP) vs differential fertilizer placement (DFP) under 100% NPK without K splitting							
FP	212.4	33.3	99.0	146.8	209.9	63.0	-2.53
DFP only		33.3	109.7	136.0	211.7	75.6	-0.7
t- value			3.24	5.24	0.17		
Significance			S	S	NS		

*treatments were laid out under differential fertilizer placement

Different nutrient doses also exerted significant variation in uptake of nutrients by crop. Nutrient uptake increased with increase in nutrient dose. Significantly higher uptake of nutrients was observed with 100% recommended N, P and K. Crop fertilized with 75% recommended nutrient level had significantly the lowest uptake of NPK. Increase in uptake of N, P and K by the crop under 100% recommended nutrient level was to the tune of 59.8, 62.7 and 51.0 per cent, respectively over the 75% recommended level. These findings are in line with Sarnaik (2010) [12].

Nutrient uptake in furrow practice was inferior to differential placement of fertilizers. Differential fertilizer placement with K split application had significantly higher uptake of N (124.9 kg/ha) and P (36.8 kg/ha) as compared to farmers' practice. Similarly, differential fertilizer placement without K split application resulted in significantly higher uptake of P (34.8 kg/ha) and K (109.7 kg/ha). Findings of Fernández and White (2012) [3] also revealed that deep fertilizer placement enhanced uptake of nutrient.

Nutrient status of soil after harvesting

Available N, P and K in soil after harvest of maize crop did not vary significantly between both K application treatments. Different level of nutrients also failed to bring significant variation in available soil nutrient amount though higher values were attained with higher NPK doses. Although differential fertilizer placement with and without K split resulted into higher soil available N, P and K values compared to farmers' practice but differences were not significant.

Nutrient balance in soil

N balance

The results showed that the apparent and net N balance in soil remained negative in both K application treatments (Table 1). Though, the net N balance in soil was higher under treatment in which whole K was applied as basal but the apparent balance was higher under split application of K. Significantly higher N uptake from soil with equal amount of N addition under K splitting treatment and lower available N status of soil under split application of K resulting into more negative net N balance in this treatment.

Among the nutrient levels, 75% N+ 100% PK had minimum apparent N loss from soil (-21.3 kg/ha) whereas, 75% recommended NPK dose recorded the maximum N loss (-48.4 kg/ha). Increase in nutrient dose from 75 to 100% recommended level reduced net N loss in soil. The difference in net N gain between 75 and 100% NPK dose was 13.4 kg/ha. More N under higher nutrient doses increased available N in soil which ultimately helped in increasing net N balance of soil. The findings of Kumar (2009) [7] also confirm these results.

Apparent and net balance of nitrogen was negative both in differential placement of fertilizers and farmers' practice. Differential fertilizer placement with and without K split application had lower apparent and net loss of N compared to farmers' practice. The apparent and net balance was higher by 22.0 and 3.6 kg/ha, respectively under differential fertilizer placement with K split application over farmers' practice. Differential fertilizer placement without K split application recorded 19 kg/ha apparent balance and 7.1 kg/ha more balance than farmers' practice.

P balance in soil

Apparent gain of P was found higher with split K application treatment compared to whole basal application treatment but reverse trend was found for net P loss (Table 2).

The apparent P balance in soil was positive in all nutrient doses except 75% NK+ 100% P. The maximum apparent gain of P (13.2 kg/ha) was observed in 100% NK+ 75% P treatment while the minimum (-0.5 kg/ha) was in 100% P+ 75% NK treatment. Nutrient doses which have 100% P exhibited less apparent loss than that of 75% P due to relatively less increase uptake of P as a result of more biomass production. All nutrient doses except 100% NPK, 100% NP+ 75% K and 100% PK+ 75%N exhibited net loss of P with the maximum loss in 75% NPK (0.97 kg/ha). 100% NPK dose showed the maximum net gain in P (0.46 kg/ha).

Differential fertilizer placement with and without K split application increased the apparent and net gain of P compared to farmers' practice. Farmers' practice resulted in net loss of P from soil.

K balance in soil

Positive balance for apparent K was observed in soil under all the treatments. Split application of K had more apparent K gain by 9.2 kg/ha than whole basal application. The net balance was negative in both K application methods with maximum loss in whole basal treatment.

In all the nutrient doses there was a positive apparent balance of K in soil ranged from 43.1 kg/ha in 75% NPK to 81.2 kg/ha in 100% NP+ 75% K treatment. The net K balance in soil was found negative in all nutrient doses except 100% recommended NPK suggesting less soil fertility exhaustion under this treatment.

Differential placement of nutrients with and without K split application had more apparent and net gains of K than farmers' practice. Farmers' practice exhibited net loss of K from soil.

Conclusion

Farmers' practice of fertilizer application along with seeds in furrows leaves the soil in poor fertility status. Application of K in splits and 100% NPK dose at two different depths (50% at 5 cm in seed zone and 50% at 10-12 cm) can minimize reduction in nutrient losses from soil.

References

1. Farmaha BS, Fernández FG, Nafziger ED. Distribution of soybean roots, soil water, phosphorus and potassium concentrations with broadcast and subsurface-band fertilization. Soil Sci. Soc. Am. J. 2013; 76:1079-1089
2. Farmers' portal, Government of India. Web link: https://farmer.gov.in/imagedefault/pestanddiseasescrops/normalmaizeproductiontechnologies.pdf
3. Fernández FG, White C. No-till and strip-till corn production with broadcast and subsurface-band phosphorus and potassium. Agron. J. 2012; 104(4):996-1005.
4. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2 edition). John wiley and sons, New York, 1984.
5. Jackson ML. Soil chemical analysis. Prentice Hall pvt. Ltd., New Delhi, 1973.
6. Kolar JS, Grewal HS. Effect of split application of potassium on growth, yield and potassium accumulation by soybean. Fertilizer Res. 1994; 39:217-222.
7. Kumar A. Influence of varying plant population and nitrogen levels on growth, yield, economics and nitrogen

use efficiency of popcorn *(Zea mays* everta sturt). Crop Res. 2009; 37(1, 2 & 3):19-23.
8. Mandal S, Thakur TC. Effect of subsoiling, deep and differential rate placement of fertilizer on sugarcane crop response. J Agric. Engg. 2010; 47(1):9-13.
9. Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S.D.A Circ. No. 939, 1954.
10. Rangaswamy R. A Text Book of Agricultural Statistics. New Age Int. Ltd., New Delhi, 2006.
11. Romheld V, Kirkby EA. Research on potassium in agriculture: Needs and prospects. Plant Soil. 2010; 335:155-180.
12. Sarnaik PH. Nitrogen management in hybrid maize (*Zea mays* L.) through leaf colour chart. Thesis (M.Sc.). University of Agricultural Sciences, Dharwad, India, 2010.
13. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in rice soil. Curr. Sci. 1956; 25:259-260.
14. Tandon HLS. Soil nutrient balance sheets in India: importance, status, issues, and concerns. Better Crops – India. 2007; 1(1):15-19.
15. Tewari NK, Zaidi SFA, Singh CK, Singh RK. Effect of split application of NPK fertility on nutrient uptake by hybrid rice (*Oryza sativa* L.) and soil health. Agric. Update. 2016; 11(1):75-78.
16. Yu ZW, Liang XF, Li YQ, Wang X. Effects of potassium application rate and time on the uptake and utilization of nitrogen and potassium by winter wheat. Chinese J Applied Ecol. 2007; 18(1):69-74.