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Maximization of crop yield and sustaining soil health through site specific nutrient management

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Abstract

Field experiments were conducted at Student Instructional Farm of the university, to achieve the maximum economic yield of maize and potato through site specific nutrient management during two consecutive years 2006 and 2007. Result indicated that imbalance and inadequate use of fertilizer by farmers fetched lower yield of maize 3027 kg^{-1} and potato each in state recommendation treatment 19.4 t ha^{-1}. Maximum yield was observed with complete SSNM treatments of maize 5819 kg ha^{-1} potato 32.85 t ha^{-1}. From the above account concluded that the site specific nutrient management provide a complete plant nutrient umbrella for high yield target and maintenance of soil fertility at sustainable. Raising STR level to 125% for resource constraints farmers and 150% for resourceful farmers was a gainful venture. Balancing the STR with S+Zn and FYM was helpful in yield maximization above STR level. The nutrients like phosphorus, potash, sulphur exhibited an increase in soil after two crop cycles. Indicating nutrient mining might not be a yield limiting factor. Although the cost benefit ratio tended to decline at higher nutrient level the net profit was maximum at SSNM treatment.

Key words: SSNM, Soil health, MEY

Introduction

Sustainability of Indian agriculture to maintain self-sufficiency will depend on high input high-output. The low input high concept is not practical (Ttiwari, 2002). Based on soil and other conditions, location specific fertilizer recommendation should be made available for individual farmer based on soil test on major, secondary and micro nutrients for efficient nutrients management and soil health. Soil test-based fertilizer recommendations n the state are proving to be suboptimum for desired maximum economic yield (MEY) of crop.

The present-day soil test recommendations are suboptimal and inadequate for high yield targets. In view of dwindling cultivated land on one hand and increasing of population on other, it has become imperative to harvest maximum from minimum per capita land. Imbalanced use of nutrients is also a major constraint in crop production resulting in multi-nutrients deficiencies in our soils. Beside there is large heterogeneity in every patch of land and in order to have uniformly higher yield from every patch of land, site specific nutrients management is only effective measure. Site specific nutrients management should also take care of deficiencies of major, secondary and micro-nutrients. The missing nutrients techniques reveal the magnitude of deficiencies and yield loses thereof in this technique. It ensures the optimized maxima of nutrient and takes care of local practices, availability of organic manures, farmer resources, and prevalent cropping system.

The present experiment was planned at upgraded nutrients levels combined with organic manure to achieve high yield targets harnessing the sustainable practices under specific nitches of the system. The study also seeks the justification of raising the nutrients level in balanced manner, on rice-wheat system.

Materials and methods

The Field experiments were conducted at Student Instructional Farm of the university, to achieve the maximum economic yield of maize and potato

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Treatments	Corresponding dose kgha^{-1}	
	Maize	Potato
T_1 Control	N 0 + P2O$_5$ 0 +k$_2$O 0	N 0 + P2O$_5$ 0 +k$_2$O 0
T_2 Farmers Fertilizers practice (FFP)	N 60 + P$_2$O$_5$ 20 + K$_2$O 0	N 200 + P2O$_5$ 200 +k$_2$O 80
T3 State Recommendation (SR)	N 120 + P2O5 60 + K2O 60	N 180 + P2O$_5$ 80 +k$_2$O 100
T_4 Soil Test Recommendation 100% (STR)	N 119 + P2O5 40 + K2O 36 + FYM 8 t ha^{-1}	N 180 + P2O5 56 + K2O 57+FYM 6.0 t ha^{1}
T_5 STR 100% + S+ Zn	N119+P2O5 40+K2O 36+S40+ZnSO$_4$ 25 +FYM 8 t ha^{-1}	N 180 + P2O5 56 + K2O 57+ S 40 + ZnSO$_4$ 25 + FYM 6.0 t ha^{-1}
T6 STR 125%	N 149 + P2O5 50 + K2O 45 + FYM 10 t ha^{-1}	N 225 + P2O5 70 + K2O 72+ FYM 7.5 t ha^{-1}
T7 STR 125% + S+ Zn	N 149 + P2O5 50 + K2O 45 + S 40 + ZnSO$_4$ 25 + FYM 10 t ha^{-1}	N 225 + P2O5 70+ K2O 7 2+ S 40+ ZnSO$_4$ 25 + FYM 7.5 t ha^{-1}
T8 STR 150%	N 178+P2O5 60 + K2O 54 + FYM 12 t ha^{-1}	N 270 + P2O584 +K2 O86 + FYM 9.0 tha^{1}
T9 STR 150% +S + Zn	N 178 + P2O5 60 + K2O 54 + S 40 + ZnSO4 25 + FYM+ 12 t ha^{-1}	N 270 + P2O5 84 + K2O 86+ S 40 + ZnSO$_4$ 25 + FYM 9.0 t ha^{-1}
T10 STR 150% +S +Zn + 5t FYM	N 178 +P2O5 50 + K2O 54+ S 40 + ZnSO4 25 + FYM+ 17 t ha^{-1}	N 270 + P2O5 84 + K2O 86 + S 40 + ZnSO$_4$ 25 + FYM 14 t ha^{-1}

through site specific nutrient management during two consecutive years 2006 and 2007 with the following treatments. The analysis of Experimental soil was pH 7.21, EC 0.175 dsm$^{-1,}$ OC0.421 %, available N 210 kgha^{-1}, available P 13.5 kgha^{-1}, available K 175 Kgha^{-1}, available S 11mgkg^{-1} and available Zn 1.13 mgkg^{-1}.

Treatments were kept in randomized block design with five replications with plot size of 20 m^2. Crop varieties were maize Azad Uttam and Potato Kufari Bahar-3797.

Results and discussion

Maize

There was significant increase in plant height due to addition of nutrients both over control and over farmer's practices (Table 1). The response was more pronounced probably because the initial fertility of soil was low. The plant height increased almost linearly with the increase in the status of the nutrients and the maximum height was obtained in T_9 and T_{10}.The result corroborates the study of (Latif *et al*. 1983 Gukova *et al*. 1985).

Significant increase in the cob length was observed in all the treatments over control and STR 125% was the best treatment addition of S+Zn with 125% and 150% STR did not show any increasing effect on cob length. It has also been reported by other workers (Latif *et al.* 1983 Kumar *et al*. 1993).Test weight of maize varies from 18.91 (T1) to 25.15 (T_8) based on mean of two years.

Grain yield of maize varied significantly according to different treatments the farmer's fertilizer practices consisting of N 60 P 20 kg ha^{-1} was better than no fertilizer but SR of 120:60:60 NPK was much higher than STR in respect of grain yield. Addition of 40 kg S and 25 kg $ZnSo_4$ to 100% STR surpassed in its yield performance over both SR and STR indicating the high response of balancing 100% NPK +S +Zn. The yield increases were highly significant from 100% STR to increase to 125% STR. The yield of grain was further increased due to sequential addition of S+ Zn and FYM. It was also observed that the prevailing soil test recommendation are yearly sub optimal in obtaining the high sustainable yield targets. There is a justification of increasing STR by 150% and balancing the NPK with S+Zn organic matter proved to be further rewarding.

The fertilizer management is also governed by the farmer's recourse. It is therefore important to suggest that 125% STR balanced with S and Zn might be suitable for the farmers of limited resources. On the other hand, the resource rich farmers should adopt full SSNM dose. The present study is agreement with several workers. Biswas and Benbi 1997, Bhandri 1999).

The total uptake of nutrients in maize crop increased linearly with increasing level of fertility (Table 2). The maximum being in case of full SSNM treatments. N uptake increased from 60.41 kg ha^{-1} to 185.58 kg ha$^{-1.}$ The total N uptake indicates nearly three times increased in total uptake from control to full SSNM treatment. The significant increase in N uptake with increasing fertility levels has been reported by other workers. Our results are in agreements with their finding (Sakel *et al.* 2000, Dixit and Patra 1999, Lozok

Table 1: Effect of treatments on plant height, cob length, Test weight and Grain yield of maize

Treatments	Mean of two years			
	Plant Height (cm)	Cob Length (cm)	Test Weight (gm)	Grain Yield (kg ha$^{-1)}$
T_1 Control	184.5	14.80	18.91	2480.00
T_2 Farmers fertilizers practices (FFP)	214.4	18.65	20.74	3026.95
T_3 State Recommendation 100% (SR)	248.0	21.55	22.17	4028.75
T_4 Soil Test Recommendation 100% (STR)	246.65	20.70	21.49	3888.12
T_5 STR 100% + S+ Zn	247.40	20.65	24.45	4223.12
T_6 STR 125%	252.30	22.40	22.49	4573.75
T_7 STR 125% +S + Zn	247.80	21.10	21.51	4788.52
T_8 STR 150%	249.10	21.45	25.15	5113.75
T_9 STR 150% + S + Zn	254.25	21.95	23.85	5552.25
T_{10} STR 150% + S + Zn +5t FYM	252.7	22.05	24.95	5819.37
SEm ±	5.38	0.25	0.48	169.25
CD at 5%	11.03	0.52	0.99	347.40

Table 2: Effect of treatments on N, P, K and S uptake (kg ha^{-1}) in maize on dry basis

Treatments	Mean of two years			
	N	P	K	S
T_1 Control	60.41	12.13	111.25	6.25
T_2 Farmers fertilizers practices (FFP)	83.22	18.27	159.09	8.75
T_3 State Recommendation 100% (SR)	104.97	26.94	244.17	11.44
T_4 Soil Test Recommendation 100% (STR)	102.51	25.17	206.46	10.75
T_5 STR 100% + S+ Zn	124.89	32.40	275.59	16.90
T_6 STR 125%	139.72	39.10	305.07	15.04
T_7 STR 125% +S + Zn	147.47	40.92	325.78	20.54
T_8 STR 150%	160.47	47.49	348.29	18.48
T_9 STR 150% + S + Zn	177.33	50.69	380.12	23.21
T_{10} STR 150% + S + Zn +5t FYM	185.58	55.12	390.93	25.39
SEm ±	5.33	1.78	13.78	0.79
CD at 5%	10.96	3.67	28.28	1.61

Table 3: Effect of treatments on potato tuber, haulms yield, dry matter and moisture content

Treatments	Mean of two years			
	Tuber Yield (t ha^{-1})	Haulms Yield (t ha^{-1})	Dry Matter (t ha^{-1})	Moisture Content (%)
T_1 Control	9.30	0.38	1.89	79.88
T_2 Farmers fertilizers practices (FFP)	21.15	1.00	4.52	78.39
T_3 State Recommendation 100% (SR)	19.3	0.8	3.87	79.9
T_4 Soil Test Recommendation 100% (STR)	19.4	1.05	3.85	80.19
T_5 STR 100% + S+ Zn	22.15	1.33	4.94	77.46
T_6 STR 125%	26.00	1.22	5.27	80.65
T_7 STR 125% +S + Zn	28.35	1.3	5.60	80.49
T_8 STR 150%	30.85	1.22	6.2	82.04
T_9 STR 150% + S + Zn	31.95	1.41	6.22	81.00
T_{10} STR 150% + S + Zn +5t FYM	32.85	1.58	6.24	82.04
SEm ±	1.07	0.81	0.21	-
CD at 5%	2.19	0.17	0.44	-

Table 4: Effect of treatments on total N, P, K and S uptake (kg ha^{-1}) in potato crop on dry weight basis

Treatments	Mean of two years			
	N	P	K	S
T_1 Control	44.03	6.11	71.11	6.15
T_2 Farmers fertilizers practices (FFP)	99.98	17.47	156.76	10.43
T_3 State Recommendation 100% (SR)	82.88	13.41	134.06	8.63
T_4 Soil Test Recommendation 100% (STR)	90.13	13.37	140.20	10.68
T_5 STR 100% + S+ Zn	114.59	17.86	182.32	18.26
T_6 STR 125%	121.81	18.94	188.48	12.87
T_7 STR 125% +S + Zn	127.44	20.38	200.64	19.16
T_8 STR 150%	145.85	20.91	217.42	13.43
T_9 STR 150% + S + Zn	151.36	23.14	224.61	21.65
T_{10} STR 150% + S + Zn +5t FYM	155.44	24.20	230.29	23.45
SE ±		5.77	0.82	8.50
0.93				
CD at 5%	11.87	1.69	17.46	1.91

Table 5: Change in macro nutrients status of soil due to different treatments in two crop cycles

Treatments	After 1st cycle				After 2nd cycle			
	Kg ha^{-1}			mg kg^{-1}	Kg ha^{-1}			mg kg-^{1}
	N	P	K	S	N	P	K	S
T_1 Control	210	13.0	173	11.0	200	12.8	172.0	11.0
T_2 Farmers fertilizers practices (FFP)	210	14.0	173	11.0	205	14.2	172.0	11.2
T_3 State Recommendation 100% (SR)	210	14.3	176	11.2	205	14.5	177.5	11.2
T_4 Soil Test Recommendation 100% (STR)	215	14.5	176	11.8	220	14.8	178.0	12.0
T_5 STR 100% + S+ Zn	215	14.5	176.5	15.5	220	15.0	178.5	16.0
T_6 STR 125%	215	14.9	177.2	12.5	225	15.4	182.0	13.0
T_7 STR 125% +S + Zn	220	14.8	177.8	16.0	225	15.4	182.0	16.8
T_8 STR 150%	230	16.8	180.0	13.2	230	17.5	183.0	13.5
T_9 STR 150% + S + Zn	230	16.6	181.0	16.2	235	17.5	183.0	16.8
T_{10} STR 150% + S + Zn +5 t FYM	240	17.9	185.0	16.5	250	19.0	186.0	17.2
Initial Value	210	13.5	175.0	11.0	-	-	-	-

1998).

The results related to uptake of phosphorus are more or less similar to Nitrogen. Increase in uptake of phosphorus was more pronounced in case higher STR levels of NPK but S and Z application to had STR also synergistic effects. Organic matter responsible for higher uptake, due to double role organics is supply and enhanced availability of P due to regulation of pH. Similar results have been reported by other workers (Modgal, 2001 and Reichubuch *et al.* 1989).

K uptake increase with the increasing fertility levels varies from 111.25 kg ha^{-1} to 390.93 kg ha^{-1} from control to full SSNM treatments these finding are agreements with other invigilator (Iswari *et al* 1987, Ray and Kumar 1993).

S uptake maize crop increases about four times from control to full SSNM treatments. The treatments giving maximum yield (T_{10}) had the maximum S uptake. Increase in S uptake with increasing fertility has been reported by several workers (Iswari et al 1987, Barson *et.al.* 1996 Sarkel *et al*.2000)

Potato

The result indicated that the increasing effects of nutrients were significant for both tuber and haulms yield (Table 3). The average tuber yield increased from 9.3 t ha^{-1} to 32.85 t ha^{-1} from control to full SSNM dose (T_{10}). It was clear that balanced fertilizer based on STR had greater yield and economy then framer's practices at continuously low but balanced level of fertilizer. The results of the study are in agreements

with other workers (Imas and Bansal 2006).

Dry matter yield of tuber increased significantly due to treatments and increases with increasing fertility. The dry matter varies from 1.89 t ha^{-1} control to 6.24 t ha^{-1} SSNM treatments. Perhaps due to tuber bulking moisture content was also increased from 79.88% to 82.04%. These results are corroborating with (Kate *et al.*2005, Imas and Bansal 2006.)

The total uptake of nutrient is as a function of biomass and concentration. The treatment effect was significant it was evident that the total N uptake could be increased from 44.03 kg ha^{-1} to 155.40 kg ha^{-1} from control to SSNM treatments (Table 4). The increase in concentration and uptake of N in potato as observed in this study has been reported by other workers. (Gupta *et al.* 2007).

The uptake of Phosphorus increased almost four times due to treatments over control it varies from 6.11 kg ha^{-1} to 24.20 kg ha^{-1} The FFP was statistically superior over SR and 100% STR. These results are in agreements with other workers (Sharma *et al*. 1990, Gupta *et al*.2007). Similarly, the results indicate K uptake from 7.11 kg ha^{-1} to 230.29 kg ha^{-1}. The uptake of K was much higher than any other nutrients justifying the need of K fertilization in potato for yield maximization similar result have been reported by other workers (Gupta *et al*. 2007).

Uptake of S due to S application along with STR increased with S uptake almost two times as compared to STR in potato tubers. The application of NPK and organic manure also played a synergetic role in the total uptake of S finding are supported by the other invigilator (Tiwari and Gupta 2006).

The result showed that the change in chemical property of soil due two crop cycles. Available N increased from 210 kg ha^{-1} to 240 kg ha^{-1} and 200 kg ha^{-1} to 250 kg ha^{-1} during 1^{st} and 2^{nd} crop cycles. Similarly trends in available P K and S are observed from control to SSNM treatments (Table 5). From the results it is clear that with the application of high fertilizer in each crop a part of nutrient added to the soil left over as residue after the crop, which may be utilize by the next crop and his residue might provide sustainability but in term of soil nutrients and crop yields.

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