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Verification of integrated plant nutrient system based fertilizer adjustment equations of maize and wheat in wet temperate zone of Himachal Pradesh

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Abstract

Forty field verification trials were conducted on maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.) during 2000-2006 at farmers' fields to ascertain the validity of IPNS based fertilizer adjustment equations for achieving specific yield targets in wet temperate zone of Himachal Pradesh. Different fertilizer recommendation methods along with fertilizer doses calculated through IPNS based fertilizer adjustment equations for varying levels of targeted yields of maize and wheat were evaluated. Results indicated that fertilizer recommendations based on targeted yield concept were more precise and dependable up to the yield targets of 4000 kg ha^{-1} each for maize and for wheat, respectively.

Key words: IPNS, fertilizer adjustment equations, targeted yields, maize, wheat.

Introduction

Maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.) are the major cereal crops grown in Himachal Pradesh having average productivity of 2000 and 1600 kg ha^{-1}, respectively. The low productivity of cereals in the State provides immense scope for increasing the production by 2-10 times through soil fertility management alone. In state, almost every farmer has domestic animals for ploughing and milk production. Therefore, they always have FYM with them which they apply to crops. In this case, applied FYM contributes substantial amount of nutrients to the crops. The soil testing is more commonly used for quick characterization of the soil fertility status and making fertilizer recommendations with the objective to increase the soil productivity and efficiency of different nutrients. The general fertilizer recommendations (kg ha^{-1}) in terms of N, P_2O_5 and K_2O such as 120:60:40 for maize and 120:60:30 for wheat, respectively are made for soils of medium fertility. However, if a soil tests *low* in a particular nutrient, the generalized fertilizer recommendation for that nutrient will be increased by 25 per cent and if, fertility status is high, the generalized fertilizer dose is decreased by 25 per cent. Among many methods and approaches for fertilizer recommendations, target yield approach based on nutrient requirements of crops, efficiency of soil available nutrients and efficiency of nutrients added through manure and fertilizer which, are worked out by conducting standard test crop experiments. Simple workable Integrated Plant Nutrient System based fertilizer adjustment equations are developed from soil test crop response data (Ramamoorthy *et al.* 1967). Target yield approach provides a scientific basis for balanced fertilization not only between the soil and fertilizer nutrients but also amongst the soil available nutrients themselves, compared to general soil test recommendations. The fertilizer adjustment equations so developed for different agro-climatic zones are verified for their usefulness on farmers' fields by conducting multi-locational verification trials. Present experiments were also conducted on farmer's fields with the objective of evaluating said IPNS based equations developed for maize and wheat crops grown in wet temperate zone of Himachal Pradesh for their further recommendations to farmers either as such or after modifications based on results obtained

Material and Methods

Field experiments were conducted in wet temperate zone with maize and wheat at Research Farm of the University, Palampur. The soil of Palampur farm was thermic Typic Hapludalf with a pH value of 5.7. The soil was silty clay loam in texture and contained average contents of organic

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carbon (0.80 %), cations exchange capacity (11.8 c mol (p^+) kg^{-1}) , available N (509 kg ha^{-1}) , P(12 kg ha^{-1}) and K (206 kg ha^{-1}) , respectively. The field lay out for each crop comprised of four strips in which soil fertility gradients were artificially created by applying graded doses of N, P and K fertilizers resulting in wide range of soil fertility. An exhaust crop was raised on these four strips to stabilize the soil system. For the test crop of maize, wheat was used as an exhaust crop whereas for wheat, maize was used as an exhaust crop. After the harvest of exhaust crops, the experiments on maize (cv early composite), and wheat(cv HS-240) as test crops were conducted in the subsequent seasons by dividing each of the four fertility strips into 16 plots which received 13 selected treatments combinations from four levels of N , three levels of P and K and two levels of FYM. The remaining three plots in each strip were kept as controls (Ramamoorthy and Velayuthan 1971).

Representative soil samples (0-0.15 m) were taken from each of the 64 plots for each crop before the application of fertilizers at sowing of test crops. The FYM was applied @ 5000 kg ha^{-1} (on dry weight basis). The fertilizer materials used were urea, single super phosphate and muriate of potash for all the crops. Full doses of P and K and half dose of N were applied at the time of sowing. The remaining half dose of N was top dressed at maximum tillering stages of wheat and at knee high stage of maize. The yield data for grain and straw/stover for all the plots were recorded at the harvest of each crop. Grain and straw samples were analyzed for N, P and K contents for computation of total uptake. Similarly, available N (alkaline $KMnO_4$), P (Olsen-P) and K(ammonium acetate- K) were determined in all the soil samples taken before sowing of each crop.

From the nutrient uptake data and soil test values, the basic data i.e. nutrient requirement in kg per quintal of grain, per cent contribution of a particular nutrient from soil and applied FYM and fertilizers were calculated and the basic data was transformed into IPNS based fertilizer adjustment equations (Table 1) for targeted yields of maize and wheat (Ramamoorthy *et al.*, 1967). The step-wise methodology for development of Integrated Plant Nutrient system based fertilizer adjustment equations are given as:

a) Nutrient Requirement (NR) of N,P and K for grain production

$$\text{Nutrient Requirement (NR)} = \frac{\text{Total uptake of a particular nutrient (kg ha}^{-1}\text{)}}{\text{Grain yield (q ha}^{-1}\text{)}}$$

b) Contribution of Nutrient from soil (CS)

$$\text{\% Contribution from soil (CS)} = \frac{\text{Total uptake in control plots (kg ha}^{-1}\text{)}}{\text{Soil test values of nutrient in control plots (kg ha}^{-1}\text{)}} \times 100$$

c) Contribution of Nutrient from Fertilizer

$$\text{\% Contribution from Fertilizer (CF)} = \frac{\text{(Total uptake of a particular nutrient in fertilizer treated plots)} - \text{(Soil test values of that nutrient in fertilizer treated plot x CS)}}{\text{Fertilizer doses (kg ha}^{-1}\text{)}} \times 100$$

d) Contribution of Nutrient from FYM (CFYM)

$$\text{\% Contribution from FYM} = \frac{\text{(Total uptake of a particular nutrient in FYM treated plots)} - \text{(Soil test values of that nutrient in FYM treated plot x CS)}}{\text{Quantity of that particular nutrients through FYM (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Fertilizer Doses} = \left(\frac{NR}{CF} \times 100 \times T\right) - \left(\frac{CS}{CF} \times STV\right) - \left(\frac{CS}{\text{Nutrients in FYM}} \times CFYM\right)$$

$$= a \text{ constant} \times \text{Yield Target (q ha}^{-1}\text{)} - b \text{ constant} \times \text{soil test value (kg ha}^{-1}\text{)} - c \text{ constant} \times \text{quantity of nutrients through FYM (kg ha}^{-1}\text{)}$$

To validate the developed fertilizer adjustment equations at farmers' fields, 40 multi locational verification field trials, replicated two times at each location, were conducted in wet temperate zone of Himachal Pradesh with maize and wheat during *kharif* 2002 to 2005 , and *rabi* 2000-01 to 2005-06, respectively. Out of 40 experiments, 16 and 24 were conducted with maize and wheat, respectively. Each experiment comprised of seven sets of treatments namely, control, farmers' practice, state level fertilizer recommendations (SLD), and four sets of IPNS based yield targets of 2000 , 3000, 4000 and 5000 kg ha^{-1} for maize and 2500, 3500, 4000 and 5000 kg $ha^{-1}$for wheat, respectively using the equations given in table 1. At the harvest, the yield of each crop at each location was recorded. The benefit cost ratio was determined for each treatment from the cost of produce and cost of fertilizers applied. The average data from different locations for each crop are presented in the paper.

Table 1. Basic parameters and IPNS based fertilizer adjustment equations for wet temperate zone of Himachal Pradesh for maize and wheat

Crop	Basic Parameters											
	Nutrient contribution (kg q^{-1} grain)			Contribution from soil (%)			Contribution from fertilizer (%)			Contribution from FYM (%)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Maize	3.08	1.58	3.13	12	39	42	42	32	86	49	26	43
Wheat	2.40	0.94	2.26	10	9	12	46	23	81	48	22	45
	IPNS based Fertilizer Adjustment Equations*											
Maize	FN=5.88T-0.23SN-0.93ON			F P_2O_5 =4.87 T-1.22 SP-0.81OP			F K_2O=3.66T-0.49 SK – 0.51OK					
Wheat	FN=5.27T-0.25 SN-1.06ON			F P_2O_5 = 4.13 T-0.38 SP-0.98OP			F K_2O=2.87 T-0.15 SK – 0.55OK					

* In these equations FN, FP_2O_5 and FK_2O are the fertilizer doses of N, P_2O_5 and K_2O, respectively in kg ha^{-1}; T is the yield target in q ha^{-1}; SN,SP and SK are the soil test values for N,P and K, respectively, in kg $ha^{-1}$and ON,OP and OK are amount of N,P and K in kg added through farm yard manure.

Results and Discussion

The fertilizer doses applied in each treatment, grain yields with Benefit Cost ratio and per cent deviation from pre-fixed yield targets averaged over all sites and study years for maize and wheat are given in Tables 2 and 3, respectively.

Fertilizer Doses: In maize, nitrogen doses up to 3000 kg ha^{-1}yield target were less than SLD, phosphorous doses except for 2000 kg ha^{-1}yield target were more than SLD and potassium doses in all yield targets were less than SLD. In wheat, nitrogen and phosphorus doses up to 3500 kg ha^{-1} were less than SLD, whereas, potassium doses

Table 2. Verification of IPNS based fertilizer adjustment equations of maize on farmers' fields (Average of 16 experiments) in wet temperate zone of Himachal Pradesh (2002 to 2005)

Treatments	FYM (t ha^{-1})	Fertilizer Doses (kg ha^{-1})			Grain yields (kg ha^{-1})	Per cent Deviation	B:C ratio
		N	P_2O_5	K_2O			
Control	-	0	0	0	1753	-	-
Farmer's Practice	5	40	0	0	2000	-	-
State Level Dose	5	120	90	40	2203	-	3.5
2000 kg ha^{-1}	5	45	57	2	2393	+19.7	7.7
3000 kg ha^{-1}	5	102	115	10	3003	0.0	4.7
4000 kg ha^{-1}	5	162	153	26	3577	-10.6	3.7
5000 kg ha^{-1}	5	220	207	36	4207	-15.9	3.2

Soil test value range: 264-511 kg $ha^{-1}$for N, 21-34 kg $ha^{-1}$for P and 189-236 kg $ha^{-1}$for K

Table 3. Verification of IPNS based fertilizer adjustment equations of wheat on farmers' fields (Average of 24 experiments) in wet temperate zone of Himachal Pradesh (2000-01 to 2005-06)

Treatments	FYM (t ha^{-1})	Fertilizer Doses (kg ha^{-1})			Grain yields (kg ha^{-1})	Per cent Deviation	B.C ratio
		N	P_2O_5	K_2O			
Control	-	0	0	0	1306	-	-
Farmer's Practice	5	30	0	0	1639	-	-
State Level Dose	5	120	90	30	1913	-	3.9
2500 kg ha^{-1}	5	42	36	17	2530	+1.2	14.9
3500 kg ha^{-1}	5	90	77	33	3246	-7.3	7.4
4000 kg ha^{-1}	5	146	126	51	3549	-11.3	6.0
5000 kg ha^{-1}	5	197	178	89	4147	-17.1	4.7

Soil test value range: 322-578 kg ha^{-1} for N, 16-35 kg ha^{-1} for P and 257-272 kg ha^{-1} for K

except for 2500 kg ha^{-1} yield target were higher than SLD. Application of FYM @ 5000 kg ha^{-1} reduced fertilizer doses as 20-26 kg N ha^{-1}, 10-15 kg P $ha^{-1}$and 15-21 kg K ha^{-1}. The difference in nutrient doses among treatments affected the crop growth and grain yields.

Grain yields: Maize and wheat grain yields obtained at harvest were highest under 5000 kg ha^{-1}yield target and lowest under FP. increasing the pre-fixed yield targets increased the nutrient doses which ultimately resulted in increase in grain yields in similar pattern. State level dose obtained lower grain yields as compared to all targeted yield plots for maize as well as wheat. The lower yields under SLD might be due to imbalanced fertilization (higher N and lower P) as compared to soil test based fertilizer doses (N and P in proportionate) which resulted in succulent plant stand thereby promoting the attack of insect-pests and diseases. Reproductive phase of crop under sld was also affected.

Per cent deviation calculated from pre-fixed yield target indicated that yield targets up to 4000 kg $ha^{-1}$for maize and wheat was within permissible limits (+10 %) hence, the target concept is applicable up to 4000 kg ha^{-1}. The lower nutrient doses for 2000 and 2500 kg ha^{-1}yield target for maize and wheat compared to other yield targets resulted in higher B:C ratio. Verma *et al.*(1987) on the basis of 13 multilocational experiment's in wet temperate zone observed that yield of wheat can be predicted up to 4 t/ha using target yield concept. Target yield approach was superior to both state level and soil test based approach (suri and verma, 1999). Further, Verma *et al.* (2002) found that integration of prescription based fertilizer recommendations with additional 5 t fym /ha not only increased wheat yield by 5 q ha^{-1} but also built up the soil available N,P and K and DTPA extractable micronutrients.

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