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Integrated Nutrient Management by Using Target Yield Equation for Maize-Wheat System in Chandauli District (Uttar Pradesh)

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Abstract

Field studies on target yield equation (TYE) based on integrated nutrient management in maize (Zea mays L) and wheat (Triticum aestivum L) were conducted to investigate its value in achieving target yields and soil nutrient status. The study was conducted in 2015-16 under farmer's field. Growing maize variety Jaunpury white in sequence with wheat variety Malviya-234 in kharif and rabi seasons. Requirement of nitrogen (N), phosphorous (P) and potassium (K) for achieving target yield of 3.5 t ha^{-1} for Maize and 4.5 t ha^{-1} for wheat was estimated following a soil test crop response (STCR) - based TYE. Four sets of treatments included only synthetic fertilizers in maize and farm yard manure (FYM) as organic source along with synthetic fertilizers in wheat were applied, compared with an untreated crop (no NPK) usually followed in farmer's practice. Results showed marginal deviation from specified target yield, achieving 98.5% of the target yield in maize and 96.6% in wheat. Integrated nutrient management resulted in significantly higher yield of both maize (3.45 t ha^{-1}) and wheat (4. 35 t ha^{-1}), in treatment T_5. As a result, the system productivity aggregating maize and wheat was also highest (7.88 t ha^{-1}) with treatment T_5. A benefit: cost ratio was also derived, showing a maximum of 4.29 in maize wheat cropping system in treatment T_5, compared with 2.99 with the application of farmer practice. Nutrient uptake was also higher in crops in treatment T_5. In addition, sustained availability of soil N, P, and K (and thereby, improvement in soil), was pronounced more in treatment T_5. Therefore, the one year on-farm study showed that TYE-based INM not only helped achieve near-target yields but also promoted nutrient utilization and sustainable soil NPK status.

Key words: *Integrated nutrient management, target yield, nutrient uptake, soil NPK, maize wheat and B:C ratio*.

Introduction

The chemical fertilization alone has a negative impact on conservation of soil quality. Even a soil nutrient resilience mechanism would be severely affected by disrupting dynamic bio equilibrium in soil-plant continuum and by disintegrating soil strata. The balanced nutrient management by taking into account organic sources in combination with chemical fertilizer, has been reported that integrated use of organic and chemical nutrient sources proved quite promising, not only for attaining greater yield stability but also in enhancing the resilience of soil status[1, 7]. The present experiment was conducted under a farmer's field to evaluate the appropriateness of estimating N, P, and K requirements by using a 'soil test crop response (STCR)'-based 'target yield equation (TYE)' for enhancing crops and nutrient productivity as well as soil nutrient balance[2]. The experiment also studied the impact of applying both organic and fertilizer nutrients in sequentially grown maize and wheat on system productivity under rainfed conditions.

Materials and methods

Field experiments on integrated nutrient management in maize and wheat under rainfed

conditions were conducted during 2015-16, consecutively, in a farmer's field at Majhagawan, Naugarh, Chandauli (U.P.), India. The location's soil profile characteristics at 50 cm depth were analyzed to determine its textural class as well as its fertility status. The texture of the soil was alluvial sandy loam. The soil contained 0.71% organic carbon, 185.00 kg ha^{-1} available N, 12.50 kg ha^{-1} available P, and 178.00 kg ha^{-1} available K with EC 0.30 dSm^{-1} and pH 7.00 this status found in 2015 before sowing of maize. Doses of N, P_2O_5 and K_2O calculated on soil test basis by using the equations:

For maize[5], FN=12.69T-1.27 SN-0.59ON, FP= 3.92T-4.25 SP-0.67OP and FK=6.25T-0.76 SK-0.39OK, and **for wheat[3],** FN=4.28T-0.38 SN-0.12ON, FP=0.93T-0.43 SP-0.02OP and FK=2.60T-0.27 SK-0.14OK

Where, T= Yield target; FN, FP and FK is fertilizer N, P_2O_5 and K_2O (kg ha^{-1}), respectively; SN, SP and SK are available N P and K of soil (kg ha^{-1}) and ON, OP and OK are available N P and K of farm yard manure (%), respectively.

Five nutrient management practices viz. T_1- Control, T_2- Farmer's Practices of maize fertilizer *i.e.* for maize 100 kg N, 35 kg P_2O_5 and 35 kg K_2O ha^{-1} and for wheat 100 kg N, 35 kg P_2O_5 and 35 kg K_2O ha^{-1}, T_3 - GRD (General recommended Dose) N P and K, 120,60, 60, T_4- 100 % NPK with 2 t ha^{-1} FYM on ST-TY (Target for maize – 3.0 t ha^{-1} and for wheat – 4.5 t ha^{-1}), T_5-100 % NPK with 2 t ha^{-1} FYM on ST-TY (Target yield for maize 3.5 t ha^{-1} and for wheat 4.5 t ha^{-1}), FYM were tested in randomized block design with three replications for maize only in T_4 and T_5. Maize variety 'jaunpury white' was sown in the second week of July and wheat variety 'Malviya 234' was sown in second week of November with recommended package and practices. The grain yield in maize and wheat crop was recorded after harvesting of crop. The experiment was laid out in a RBD design with three replications. Each micro plot size was 6 m × 5 m and the net harvested area in each plot was 5.5 m × 4.5 m leaving 0.5 m boarder zone around periphery of each plot. Nutrient uptake was determined by analyzing the entire plant sample collected randomly from each plot at harvest, and soil N, P, and K status were estimated collecting random soil samples from each plot immediately after harvest. Plant nutrient uptake and soil nutrient content were analyzed following the standard methods of N, P, and K analysis. The economics in term of benefit cost ratio was also calculated at price prevailing in nearest market The grain yields of maize, wheat yield, and other parameters of nutrient dynamics were subjected to standard analysis of variance (ANOVA), and treatment differences were tested following tests of least significant difference (LSD).

Results and Discussion

Maize and wheat Yield and Production Economics

Overall results showed that maize grown with TYE-based integrated nutrient management produced a 'near target' grain yield, consistently over the years as compared with other treatments. This was enhanced further by the application of 100% NPK with 2 t ha^{-1} farm yard manure producing 3.45 t ha^{-1} grain yield, significantly higher than that (3.11 t ha^{-1}) under 100% estimated fertilizer NPK, treatment T_3 (Parihar *et al*., 2015). None the less, previous wheat with this 100% NPK with 2 t ha^{-1} farm yard manure also produced significantly higher wheat yield (4.35 t ha^{-1}) (Table 1). Therefore, 100% NPK with 2 t ha^{-1} farm yard manure ensured 98.5 % of the target grain yield achieved, compared with the 89% with the application of 100% fertilizer NPK, T_3.

Table 1 Maize-wheat yield, percent achievement of target yield, system productivity and benefit: cost ratio under maize-wheat crop system at Village- Majhagawan, Naugarh Chandauli (U.P.)

Treatmnets Fertilizer dose N, P_2O_5, K_2O (kg ha^{-1}) & t ha^{-1} FYM	Grain yield of Maize (t ha^{-1})	% achievement of yield	Treatmnets Fertilizer dose N, P_2O_5, K_2O (kg ha^{-1}) & t ha^{-1} FYM	Grain yield of wheat (t ha^{-1})	% achievement of yield	System productivity (t ha^{-1})	B:C
T_1-0-0-0	1.46	42.0	T_1-0-0-0	1.78	47.0	3.24	-
T_2-100-35-35	2.65	50.0	T_2-100-35-35	2.76	61.0	5.41	2.99
T_3-120-60-60	3.11	89.0	T_3-120-60-60	3.41	76.0	6.52	2.97
T_4-97-34-35-2	2.81	80.0	T_4-83-28-48-2	3.59	80.0	6.40	3.99
T_5-160–53-101-2	3.45	98.5	T_5-126–37-74-2	4.35	96.6	7.88	4.29
LSD (P=0.05)	0.11	6.38	-	0.24	9.69	1.17	-

The corresponding values in wheat were 96.6% and 76%, respectively. As a result, system productivity aggregating yield of maize and wheat also remained highest with the application of 100% NPK with 2 t ha^{-1} farm yard manure, estimating 7.88 t ha^{-1} (Singh *et al*., 2014). Subsequently, the production economics of the system also determined 100% NPK with 2 t ha^{-1} farm yard manure more profitable, deriving a maximum benefit: cost ratio of 4.29 compared with the 100% fertilizer NPK application (3.99). Overall performance of maize and wheat grown with INM, which resulted in higher yield, was better than that treated with fertilizer NPK alone[5]. Balanced nutrition due to adequate nutrients uptake following INM promoted maize growth and subsequent development of yield attributes appreciably. The achieving higher system productivity, the benefit: cost ratio was also higher in maize-wheat with INM in either of the proportions used.

Table 2 Nutrient uptake and soil nutrient status in the final year of maize-wheat crop system at Village- Majhagawan, Naugarh Chandauli (U.P.)

Treatmnets	Maize Nutrient Uptake (kg ha^{-1})			Wheat Nutrient Uptake (kg ha^{-1})			Available nutrient Status after One year of cropping system (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1	32.00	11.00	30.50	28.05	11.05	18.05	210.20	20.01	181.02
T_2	42.25	18.01	42.05	81.05	33.20	43.20	218.60	24.05	192.20
T_3	55.66	27.00	59.20	87.05	39.20	50.40	222.60	26.06	200.10
T_4	75.22	32.00	72.00	95.50	42.10	56.42	231.50	29.06	212.50
T_5	91.08	37.00	80.00	105.50	46.00	68.60	250.50	32.60	216.60
LSD (P=0.05)	6.53	4.63	6.96	1.68	1.33	1.03	2.00	0.53	1.72

Nutrient Uptake

INM also promoted nutrient utilization, accounting for better NPK uptake in maize-wheat system. N, P, and K uptake were higher in maize with 100% NPK with 2 t ha^{-1} farm yard manure, estimated at 91.08, 37.00 and 80.00 kg ha^{-1}, compared with 55.66, 27.00 and 59.20 kg ha^{-1} of N, P, and K uptake, respectively, in maize with 100% fertilizer NPK application (Table 2). A similar trend in results was also noticed in wheat with 100% NPK with 2 t ha^{-1} farm yard manure, estimated at 105.5, 46.00 and 68.60 kg ha^{-1}, compared with 87.05, 39.20 and 50.40 kg ha^{-1} of N, P, and K uptake, respectively, in wheat with 100% fertilizer NPK application. The mechanism of nutrient uptake pattern depends on soil and maize-wheat environment, as well as on the method of crop and nutrient management. Use of 100% NPK with 2 t ha^{-1} farm yard manure, significantly promoted higher N, P, and K uptake in maize and wheat. The results accorded with the findings of earlier investigators[3].

Soil NPK Status

INM in the maize-wheat crop system promoted considerable improvement in soil fertility parameters as shown one year cropping system application following the TYE-based precision nutrient management strategy. Soil available N, P, and K after one year of study was estimated 250.50, 32.60 and 216.60 kg ha^{-1}, respectively, in plots treated with 100% NPK with 2 t ha^{-1} farm yard manure as compared with their initial value of 185.0, 1 2.5, and 78.0 kg ha^{-1} at the beginning of the program. Even significant improvement in soil available N, P, and K was also in plots treated with 100% NPK compared with fertilizer alone. TYE-based integrated nutrient management promoted sustainable development in soil quality status[1]. Growing crops sequentially under intensive crop systems with fertilizer alone results in depleting soil nutrients reserve. Balanced nutrition of the soil, through integrated management using both organic and chemical nutrient sources appears to be essential.

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