Indian Journal of Agronomy **61** (2): 204–209 (June 2016)

Research Paper

Nutrient omission effects on yield, water productivity and profitability of maize (*Zea mays*)

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Received : March 2015; Revised accepted : March 2016

ABSTRACT

A 2-year field experiment was conducted during the rainy seasons (July–October) of 2012 and 2013 on a non-calcareous alkaline sandy clay loam soil, to (i) assess the effect of omitted nutrients on growth, yield, water productivity (WP) and profitability of maize (*Zea mays* L.) crop, and (ii) develop guidelines for the use of soil test crop response (STCR) approach and omission plots, in site-specific nutrient management (SSNM) for targeted and sustained yield of maize in the maize (*Zea mays* L.)–wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] cropping system. The experiment comprised 15 treatments, involving application of N (-PKZn), NP (-KZn), NPK (-Zn) and NPZn (-K) to both maize and wheat crops, to maize and to wheat crop only, absolute control (no nutrient applied), recommended rate of nutrients (120, 60, 40, 5.5 kg/ha N, P, K, Zn) and STCR-based application of nutrients (200, 100, 55, 4 kg/ha N, P, K, Zn). The experiment was set in a randomized complete-block design with 3 replications, in fixed plots. Growth and yield attributes were significantly influenced by nutrient-omission treatments and their values were higher when nutrients were applied according to STCR approach. The STCR-based nutrient application increased dry-matter production and grain yield by 5.9 and 5.7%, respectively over balanced fertilization (recommended doses of NPKZn). Omission of P and K resulted in 9 and 9.7% reduction, respectively, in grain yield of maize. The yield reduction caused by Zn omission was about 3% only. On an average, STCR-based fertilization enhanced water productivity (WP) by over 6.2% compared to balanced fertilization with recommended doses of nutrients. Omission of K in both maize and wheat crops reduced WP by 9.3% compared to recommended doses of NPKZn-applied plot. The highest gross profit of ₹70,425/ha was also realized from STCR-based nutrient application.

Key words : Maize, Nutrient omission, Productivity, Profitability, Site-specific nutrient management, Water productivity

India produces 24.19 million tonnes (mt) maize grain from an area of 8.40 million ha (mha), with an average productivity of 2.55 t/ha, and shares 5.25% of area and 2.41% of world maize production (DES–DAC, 2013–14). Maize is such an important crop that each part of it is used for one or the other purpose and nothing goes as waste. Its hybrids being nutrient-exhaustive, draws plenty of soil nutrients, and thus, under continuous maize based cereal-cereal cropping system, nutrient management assumes utmost importance. Among different maize-based cropping systems, maize–wheat ranks first occupying 1.8 m ha area mainly concentrated in rainfed ecologies and contributes about 3% in the national food basket. The productivity of this cropping system is limited by low fertilizer efficiency, inadequacy of current fertilizer recommendations, and the ignorance of nutrients other than N, P, and K and continuously deteriorating soil quality.

The use of chemical fertilizers has played a crucial role in increasing crop yields, and will continue to be the important input in achieving the food production targets in the country. Since soil reserves alone are not sufficient to meet the nutrient uptake needs of these crops, a balanced nutrient supply has to be ensured keeping in view the soil's inherent nutrient supplying capacity to achieve desired crop yield levels (Dass *et al.,* 2014). The suitable match and balance between applied nutrients, soil sources and plant needs contribute considerably towards the

Based on a part of Ph.D. thesis of the first author submitted to ICAR-Indian Agricultural Research Institute, New Delhi 110 012 (unpublished)

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higher use efficiencies of applied inputs, and higher productivity and profitability of crops or cropping systems. Current average yield of maize and wheat indicate immense opportunities to further enhance their productivity, using site-specific, integrated nutrient and crop management taking into account the crop requirements, soil-test values and yield targets (Xu *et al*., 2009). Hence, the current study was designed to determine the effect of omitted nutrients on growth, productivity and profitability of maize crop, in maize-wheat cropping system.

MATERIALS AND METHODS

A field experiment was carried out at the research farm of Division of Agronomy, ICAR-Indian Agricultural Research institute, New Delhi, during rainy seasons (July–October) of 2012 and 2013. The site of the experimental field belongs to Order Inceptisol, Mehruli series, having non-calcareous alkaline sandy clay loam texture (sand 64.5%, silt 13.4% and clay 18.5%) with the *p*H of 7.9, cation-exchange capacity 10.7 cmol/kg and electrical conductivity 0.32 dS/m in the top 15 cm of soil. Soil had low initial N (124 kg/ha), medium P (17.37 kg/ha) and K (224 kg/ha), and high Zn (0.8 ppm) contents. The recommended dose of NPK and Zn for maize was 120:60:40:5.5 kg/ha. The experiment had 15 treatments, set in a rendomized complete-block design with 3 replications in fixed plots. Treatments comprised application of N (-PKZn), NP (-KZn), NPK (-Zn) and NPZn (-K) to both maize and wheat crops, to maize and to wheat crop only, absolute control (no nutrient applied), recommended rate of nutrients (120, 60, 40 and 5.5 kg/ha N, P, K and Zn) and STCR-based application of nutrients (200, 100, 55 and 4 kg/ha N, P, K and Zn). Based on initial soil-test value of N, P and K, the fertilizer recommendation for maize variety 'PEEHM 5' for a targeted yield of 5 t/ha was calculated using STCR equation at the beginning of the experiment and computed values were 200, 100, 55 and 4 kg/ha of NPK and Zn.

The STCR equations for computation of N, P and K dose are given below:

$F_N = 6.61\ T – 0.52\ SN$

$F\ P_2O_5 = 4.77\ T – 5.13\ SP$

$F\ K_2O = 2.75\ T – 0.24\ SK$

Same nutrient-omission treatments were tested on wheat crop also. The fertilizers used for applying N, P, K and Zn were urea, diammonium phosphate (adjusted for its N content) and muriate of potash and zinc sulphate ($ZnSO_4.7H_2O$), respectively. One-third dose of N and full dose of all other nutrients were applied basal to maize. Remaining N was top-dressed at 30 and 60 days after sowing (DAS) in 2 equal splits. The gross plot size was 4.2 m × 4.5 m, accommodating 7 rows of maize, planted at a spacing of 60 cm × 20 cm. Maize was sown in the second week of July and harvested in the second week of October. The total rainfall during the crop period was 470 mm and 1037.6 mm in 2012 and 2013, respectively. The distribution of rainfall during 2013 was uneven and resulted in water-logging in maize plots. The average monthly air temperature, relative humidity and bright sunshine hours were almost similar during both the years. Three irrigations were provided to maize during 2012 and 2 during 2013. Three hand-weedings were done at 10, 45 and 60 DAS to control the weeds. Carbofuran 0.6-0.75 kg a.i./ha was applied to control stem-borer infestation at 30 DAS. Five plants in each plot were selected randomly and tagged for taking various biometric observations. For dry-matter accumulation at different growth stages, the selected plants were cut close to the ground and kept in paper bags for sun-drying. Sun-dried samples were dried in an hot-air oven at 65°C temperature for 36 to 48 hours to obtain a constant dry weight. Leaf-area index (LAI) was worked out for maize crop as per standard method. Cobs of harvested plants of net plot area, after proper sun-drying, were separated from plants, dehusked and shelled with the help of cob sheller. The produce was cleaned, weighed separately and expressed in terms of grain and stover yield (t/ha). Statistical analysis of the data was carried out using analysis of variance technique as applicable to RCBD (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth and yield attributes

The STCR-based application of N, P, K and Zn resulted in the significantly higher dry-matter accumulation compared to all the other treatments in both study years. The treatment NPK (–Zn) applied to maize resulted in significantly higher dry-matter accumulation than the plots fertilized with N alone, NP and NPZn. The similar trend was also observed under cumulative effect of NPK application to both crops of cropping system. The residual effect of all nutrient-omission treatments was significantly superior to the absolute control. Omission of K and Zn in both maize and wheat crops resulted in 10 and 1.2, 12.9 and 2.1% reduction in dry-matter accumulation of maize at harvesting during *kharif* 2012 and 2013, respectively, compared to application of recommended doses of NPKZn. Similarly, omission of P in both maize and wheat also caused 1.3% reduction in dry-matter production during 2012 and 2.6% reduction during 2013 compared to application of N alone with exclusion of all the other nutrients. The effect of Zn omission on dry-matter accumulation of maize was not as pronounced as that of macro- nutrients probably due to high Zn content in soil.

Similarly, the tallest plants at harvesting and the highest values of LAI both at 30 and 60 DAS were observed in the plots receiving STCR-based NPKZn and in the absolute control plots the shortest plants were observed besides the lowest values of LAI (Table 1). The improvement in LAI under this treatment was 6.8% and 8% at 30 and 60 DAS, respectively, over recommended doses of NPKZn. Application of STCR-based N resulted in higher growth of maize crop compared to recommended dose of N (Dass *et al*., 2015). The residual effect of application of NP, NPK, NPZn on maize LAI at 30 and 60 DAS was significantly superior to the absolute control. Likewise, the plots fertilized with NPK to preceding wheat crop resulted in significantly taller plants at harvesting compared to the plots fertilized with NP, NPZn and N alone to preceding wheat during the second year *kharif* season. With omission of K in both maize and wheat crops and in *kharif* maize only, significant reduction in the plant height was observed at harvesting, but Zn omission had no significant effect. Application of only N and exclusion of PKZn to both the crops and to only maize crop resulted in significant reduction in plant height at harvesting and LAI at both growth stages during both the years. Omission of P, K and Zn resulted in reduced values of LAI during both the years, but the reduction was more severe during 2013 (Table 1).

The highest values of growth parameters with the application of NPKZn using STCR approach got translated into better yield attributes of maize as reflected by the highest values of cob length, cobs/plant, grains/cob, grain weight/cob, total weight of cobs and 1,000-grain weight under this treatment. Nutrient omissions significantly influenced the yield components of maize during both the years (Table 2). These results are similar to those of Trinh *et al*. (2010), who reported the highest values of yield attributes like number of ears/ha, kernels/ear and 100-seed weight under SSNM treatment compared to farmer's practice. Although omission of P and Zn resulted in numerically lower values of all yield traits, P omission had significantly influenced and lowered the cob weight compared to treatment where only N was applied and the other nutrients were omitted. The lowest values of all yield traits were recorded in the control followed by K and P-omission plots. Similar trend was also noticed during the second year in the respective omission treatments. The direct as well as cumulative effects of NPK applied directly to maize and to both crops on cobs/plant, cob weight, grain weight/cob were significantly superior to the application of N alone and in either year of study. The residual effect of NPK applied to preceding wheat on maize cobs/plant, cob length and cob weight was significantly higher compared to the application of N alone and absolute control plots.

Table 1. Effect of nutrient omission treatments on growth characteristics of maize crop

Treatment	Plant height (cm)		Dry-matter accumulation (g/plant)		Leaf-area index			
					30 DAS		60 DAS	
	2012	2013	2012	2013	2012	2013	2012	2013
NPKZn (based on STCR)	229.4	225.8	130.5	128.8	4.2	4.1	4.8	4.7
NPKZn (based on RDF)	225.4	216.0	123.6	121.4	4.0	3.8	4.5	4.3
N (-PKZn) in both maize and wheat	199.6	195.9	106.5	102.9	3.6	3.4	4.2	3.9
NP (-KZn) in both maize and wheat	219.3	209.2	107.9	105.6	3.6	3.5	4.3	4.0
NPK (-Zn) in both maize and wheat	222.7	212.5	122.1	118.9	3.9	3.7	4.5	4.2
NPZn (-K) in both maize and wheat	220.1	210.0	112.4	107.5	3.7	3.5	4.3	4.0
N (-PKZn) only in maize	198.0	194.4	105.3	102.8	3.6	3.4	4.2	3.9
NP (-KZn) only in maize	216.6	208.3	108.3	105.5	3.6	3.4	4.3	3.9
NPK (-Zn) only in maize	218.8	210.6	116.9	113.1	3.8	3.6	4.4	4.1
NPZn (-K) only in maize	216.7	205.8	110.2	106.3	3.7	3.5	4.3	4.0
N (-PKZn) only in wheat	170.8	163.0	83.2	82.3	2.0	2.0	3.4	3.4
NP (-KZn) only in wheat	171.5	163.9	85.7	84.7	2.0	2.1	3.4	3.5
NPK (-Zn) only in wheat	172.9	168.8	89.5	88.7	2.1	2.1	3.4	3.5
NPZn (-K) only in wheat	172.5	165.8	88.4	86.7	2.0	2.1	3.4	3.5
Absolute control (no fertilizer)	170.1	159.6	81.8	79.7	1.9	1.8	3.4	3.3
SEm±	1.90	1.79	1.00	1.38	0.11	0.11	0.14	0.13
CD (P=0.05)	3.83	3.67	2.04	2.77	0.23	0.22	0.29	0.25
Control v/s others								
SEm±	1.39	1.15	0.64	1.01	0.07	0.08	0.09	0.09
CD (P=0.05)	2.80	2.35	1.31	2.03	0.15	0.16	0.18	0.18

STCR, Soil-test-crop response; RDF, recommended dose of fertilizer

Table 2. Effect of nutrient omission treatments on yield attributes of maize crop

Treatment	Cobs/plant		Cob length (cm)		Cob weight (g)		Grains/cob		Grain weight/ cob (g)		1,000-grain weight (g)		Shelling (%)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
NPKZn (based on STCR)	1.8	1.5	18.9	17.3	132.7	123.3	475	454	97.9	86.7	265	251	73.7	70.3
NPKZn (based on RDF)	1.4	1.3	16.3	15.2	124.9	115.5	458	432	90.0	79.9	261	237	72.1	69.1
N (-PKZn) in both maize and wheat	1.0	0.8	14.2	13.8	103.5	97.1	438	409	65.1	57.0	243	217	62.9	59.0
NP (-KZn) in both maize and wheat	1.1	1.1	14.7	14.1	112.8	103.4	442	411	71.8	62.3	245	221	63.6	60.2
NPK (-Zn) in both maize and wheat	1.3	1.3	15.6	15.0	121.7	112.3	451	420	81.0	71.5	253	230	66.6	63.7
NPZn (-K) in both maize and wheat	1.2	1.2	14.7	14.7	119.6	110.2	445	413	73.2	67.3	247	223	61.2	61.0
N (-PKZn) only in maize	0.9	0.8	14.1	12.8	102.3	96.2	428	403	51.1	52.3	236	214	50.2	54.3
NP (-KZn) only in maize	1.1	1.0	14.6	14.3	112.8	103.4	433	407	60.9	57.5	238	217	54.0	55.6
NPK (-Zn) only in maize	1.2	1.2	15.2	15.0	121.7	112.3	442	415	72.2	64.9	248	226	59.4	57.9
NPZn (-K) only in maize	1.1	1.1	14.7	14.7	119.2	109.8	436	410	64.8	59.7	240	219	54.3	54.3
N (-PKZn) only in wheat	0.8	0.7	10.3	9.3	71.8	82.4	328	301	38.4	36.8	184	184	53.6	44.6
NP (-KZn) only in wheat	0.8	0.8	10.5	9.7	75.0	85.6	332	306	40.6	36.9	186	185	54.1	43.1
NPK (-Zn) only in wheat	0.9	0.9	10.7	10.9	77.1	87.7	334	315	44.3	39.2	198	188	57.4	44.7
NPZn (-K) only in wheat	0.8	0.7	10.6	9.9	78.8	89.4	331	309	43.3	37.2	188	186	55.0	41.6
Absolute control (no fertilizer)	0.7	0.6	9.9	9.5	69.7	80.3	328	289	37.3	34.2	180	182	53.5	42.6
SEm±	0.11	0.09	0.38	0.66	3.05	2.04	11.9	14.0	4.43	2.74	7.3	6.8	3.55	2.92
CD (P=0.05)	0.23	0.19	0.77	1.32	6.25	4.11	24.3	28.5	9.07	5.52	15.0	13.6	7.27	5.87
Control v/s others														
SEm±	0.07	0.07	0.24	0.48	1.96	1.49	7.6	10.2	2.84	2.01	4.7	4.9	2.28	2.14
CD (P=0.05)	0.15	0.14	0.49	0.97	4.01	3.00	15.6	20.6	5.82	4.04	9.6	9.9	4.66	4.29

STCR, Soil-test-crop response; RDF, recommended dose of fertilizer

Grain and stover yields

Omission of nutrients, such as P, K and Zn showed significant effects on the growth and yield attributes which were also directly reflected in the grain and stover yields of maize. It is well established that, N is the most limiting plant nutrient; thus was not omitted in any of the treatments, and applied uniformly in all treatments. However, the results of current study revealed K to be the second most limiting in the maize–wheat production system (Table 3). Grain yield under STCR approach was significantly superior to that obtained from all the other treatments and improved by 5.8% in 2012 and 5.7% in 2013 compared to optimally fertilized plot with recommended fertilizer doses. The direct and cumulative effects of treatment where NPK was applied directly to maize and to both crops on grain yield was significantly superior to the application of N alone, NP and NPZn. Similarly, the residual effect of same treatment applied to preceding wheat on maize grain yield was also significantly superior to the absolute control, application of N, NP and NPZn. Sreelatha *et al*. (2012) and Umesh *et al*. (2014) also indicated that the grain yield and fertilizer NPK use were significantly greater under SSNM treatment over farmers' practice or state recommendation. Phosphorus and potassium omission resulted in similar reduction in yield during both the years, showing the slow depletion of soil P and K reserves in maize *kharif* crop. Omission of P resulted in 8.9 and 10.4% reduction in grain yield during 2012 and 2013, respectively, compared to the treatment where only N was applied. The reduction in yield due to K-omission in both the crops and directly in maize ranged from 8.1 to 13.3%, signifying the importance of K nutrition in maize crop (Table 3). Omission of K to both maize–wheat crop resulted in 8.1% reduction in grain yield during 2012 and 11.2% reduction in 2013. The yield reduction was slightly lower in Zn-omission treatments. The continuous and sustained application of N alone, NP, NPK and NPZn to both the crops of maize–wheat cropping system resulted in 2.8, 3.9, 1.6 and 1.5% respectively, higher grain yield of maize over direct effect of similar treatments on maize crop.

The stover yield ranged from 4.05 to 7.59 t/ha in 2012 and 3.77 to 7.33 t/ha in 2013. Stover yield is strongly correlated with K supply, omission of which resulted in 3–5% reduction in above-ground biomass production during both the years. The reduction was higher during 2013 than to preceding year. Omission of P and Zn caused comparatively lower reduction in stover yield. Application of N alone (-PKZn), NP (-KZn), NPK (-Zn) and NPZn (-K) to both the crops of maize–wheat cropping system resulted in 1.2, 1.3, 1.0 and 1.2% higher stover yield of maize compared to direct effect of the same treatments on maize crop. The direct and cumulative effects of NPK applied to maize and to both crops of maize–wheat cropping system on maize stover yield were significantly superior to the application of N alone and NP. The residual effect of treatments where NP, NPK and NPZn were applied to preceding wheat crop on maize grain yield was significantly higher to the absolute control, but statistically at par with the same for maize stover yield. Omission of P and K resulted in the reduced partitioning of dry-matter in favour of grain yield (Table 3). Application of various nutrient omission treatments to supply nutrients to maize crop failed to exhibit significant variation in harvest index during both the years.

Economics

Omitted nutrients showed considerable effect on gross and net profit from maize cultivation. Consistently higher gross returns were realized during 2012 and 2013, respectively, in balanced application of NPKZn based on STCR approach to both maize and wheat crops, which was significantly superior to recommended doses of nutrients (Table 3). The highest benefit: cost ratio (net returns per rupee invested) was realized from the treatment involving the application of N only, exclusion of P, K and Zn to both the crops in a maize–wheat cropping system. The cumulative effect of treatments where N alone, NP, NPK and NPZn were applied resulted in numerically higher gross and net returns of maize than direct effect of similar treatments

Table 3. Effect of different nutrient-omission treatments on yield, economics and water productivity of maize crop

Treatment	Yield (t/ha)				Harvest index (%)		Economics						Water productivity (kg/m³)	
	Grain yield		Stover yield				Gross returns (×10³ ₹/ha)		Net returns (× 10³ ₹/ha)		Benefit: cost ratio			
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
NPKZn (based on STCR)	5.11	5.03	7.59	7.33	40	41	67.6	73.2	38.6	42.6	1.33	1.39	1.24	0.68
NPKZn (baesd on RDF)	4.83	4.76	7.50	7.25	39	40	64.3	69.6	39.0	42.8	1.55	1.60	1.17	0.64
N (-PKZn) in both maize and wheat	3.94	3.85	6.78	6.53	37	37	53.1	57.0	33.0	35.3	1.64	1.63	0.96	0.52
NP (-KZn) in both maize and wheat	4.29	4.25	6.82	6.55	39	39	57.2	62.2	33.6	37.0	1.42	1.47	1.04	0.57
NPK (-Zn) in both maize and wheat	4.69	4.61	7.48	7.21	39	39	62.6	67.6	38.0	41.4	1.54	1.58	1.14	0.62
NPZn (-K) in both maize and wheat	4.47	4.28	7.24	6.96	38	38	59.8	63.0	35.5	37.2	1.46	1.44	1.08	0.58
N (-PKZn) only in maize	3.87	3.71	6.74	6.42	36	37	52.2	55.0	32.1	33.4	1.60	1.54	0.94	0.50
NP (-KZn) only in maize	4.24	3.99	6.76	6.45	39	38	56.6	58.7	32.9	33.5	1.39	1.33	1.03	0.54
NPK (-Zn) only in maize	4.64	4.53	7.41	7.14	39	39	61.9	66.5	37.3	40.3	1.52	1.54	1.13	0.61
NPZn (-K) only in maize	4.42	4.20	7.18	6.86	38	38	59.1	61.9	34.9	36.0	1.44	1.39	1.07	0.57
N (-PKZn) only in wheat	2.12	2.05	4.07	3.82	34	35	29.0	30.7	10.8	10.9	0.59	0.55	0.51	0.28
NP (-KZn) only in wheat	2.17	2.14	4.05	3.86	35	36	29.5	31.9	11.3	12.1	0.62	0.61	0.53	0.29
NPK (-Zn) only in wheat	2.21	2.35	4.17	3.96	35	37	30.1	34.7	11.9	15.0	0.66	0.76	0.54	0.32
NPZn (-K) only in wheat	2.19	2.19	4.14	3.95	35	36	29.9	32.6	11.7	12.9	0.64	0.65	0.53	0.30
Absolute control (no fertilizer)	2.08	1.96	4.05	3.77	34	34	28.5	29.4	10.3	9.7	0.57	0.49	0.50	0.26
SEm±	0.115	0.117	0.179	0.178	1.2	1.6	1.36	1.49	1.36	1.49	0.065	0.074	0.028	0.016
CD (P=0.05)	0.235	0.236	0.366	0.357	2.4	3.2	2.80	3.00	2.80	3.00	0.133	0.148	0.057	0.032
Control v/s others														
SEm±	0.074	0.086	0.115	0.130	0.8	1.2	0.88	1.09	0.88	1.09	0.042	0.054	0.018	0.012
CD (P=0.05)	0.151	0.172	0.235	0.261	1.6	2.3	1.79	2.20	1.79	2.20	0.085	0.108	0.037	0.023

STCR, Soil-test-crop response; RDF, recommended dose of fertilizer applied to maize. Application of NPK directly to maize crop and to both crops was significantly superior to the application of N and NP, but was at par with treatment where NPZn was applied during 2012 and also significantly superior to NPZn during 2013. Omission of P reduced the gross and net returns by 8.1 and 3.3%, respectively, compared to the plots fertilized with N only and excluding all other nutrients. Omitting K to both maize and wheat crop resulted in 9% reduction in gross returns and 12.7% reduction in net returns from maize. Omission of Zn decreased gross and net returns by 2 – 3% which was at par with recommended doses of NPKZn. The NPK applied to preceding wheat crop resulted in significant increase in gross returns and net returns of maize compared to application of N alone and absolute control plot during 2013.

Water productivity

Water productivity of maize was higher during 2012 than during 2013 owing to higher yield and lower but uniform distribution of rainfall in 2012. However, higher rainfall during 2013 increased the water-use but did not increase grain yield proportionately; rather some heavy storms created water-logging and reduced grain yield finally resulting in the lower water productivity of maize. Application of nutrients on the basis of STCR resulted in significantly higher water productivity over all the other treatments. Application of NPK only to *rabi* crop resulted in significantly higher water productivity over application of N alone and absolute control during 2013 (Table 3). Omission of K resulted in greatest reduction in water productivity (9.3%) followed by P (8.9%) and Zn (2.9%). The direct and cumulative effect of NPK applied on maize water productivity was significantly higher than N and NP application during 2012 and was significantly higher to NPZn too during 2013.

It could be concluded from the 2-year study on maize–wheat cropping system that STCR-based nutrient application proved to be the best approach and resulted in highest yield and water productivity of maize crop under maize–wheat cropping system. But, the net returns were similar to conventionally recommended doses of NPKZn. The maximum reduction in growth, productivity and profitability of maize was due to omission of K followed by P and Zn. The reduction due to P and K omission was more severe during second year cropping of the experiment. So there is need of applying P and K to at least second year maize crop under input-constrained condition in maize–wheat cropping system to get higher and sustainable yields. Thus in spite of getting higher grain yield in STCR approach involving relatively higher amounts of nutrients, need lies to rationalize it to make maize–wheat cropping system remunerative and sustainable.

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