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Influence of Site-specific Nutrient Management and Nutrient Omission on Yield Augmentation of Maize (*Zea mays*) in an Acid Soil

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A field experiment was carried out during the *Kharif* seasons of 2016 and 2017 on a strongly acidic sandy soil (pH- 5.01 and organic carbon - 4.8 g kg^{-1}) of Sambalpur district in Odisha, India to study the influence of site-specific nutrient management (SSNM) and nutrient omission technique on the productivity of 'Mahyco-Hybrid 3845 S' maize under eight treatment combinations consisting of SSNM, three nutrient omissions, one organic, another organic and inorganic amelioration and absolute control. SSNM treated plot showed the highest biomass production (10.9 t ha^{-1}) whereas omission of all NPK resulted in 50.4 % less biomass production. All the major nutrient concentrations *i.e.*, N, P and K were found lowest in their respective omission treatment. It was observed that lime treatment showed the highest Ca content in biomass whereas the lowest in N omitted treatment. Integration of organic alone, with inorganic amelioration and organic-inorganic combination with deficient nutrient resulted in the highest uptake of N, P and K as compared to 100% NPK. SSNM practices improved the soil fertility status and raised the net income and B: C ratio.

(***Key words:*** *Maize, Nutrient omission, Productivity, Site specific nutrient management*)

There is a need to produce more food under the condition of diminishing per capita arable land, irrigation, water resources, agro-inputs and expanding biotic and abiotic stress across the world. Each input used in agriculture production needs to be utilized effectively and efficiently to make agriculture system cost-effective, remunerative and acceptable.

Maize is the second most important cereal crop in Asia, not only as a staple food but also as a major component of feeds for the animal industry. Being an exhaustive crop, maize requires large amounts of nutrients, particularly N and K, for obtaining higher yields. Imbalanced and inadequate nutrient application in maize is one of the factors responsible for the lower yield. Further, the productivity of maize is low due to poor inherent soil fertility, imbalanced fertilizer use, and non-recycling of organics (Shahi *et al*., 2020). Under these circumstances, integrated use of organics and chemical fertilizer-management strategies might augment the sustainable high productivity along with improved nutrient use efficiency in maize. Different crop-based concepts for nutrient management have been proposed for maize. Some include measurement of indigenous supply in omission plots for making field-specific pre-plant decisions on amounts of N, P and K to apply (Dobermann *et al*., 2002), whereas others are restricted to post-emergence management of N using leaf N diagnosis. In recent years, the site-specific nutrient management (SSNM) approach which is based on soil nutrient supply and nutrient uptake demand for targeted yield has shown potential to improve farm profit through optimal nutrient supply in several crops (Singh *et al*., 2015a, b). The SSNM approach not only aims to reduce fertilizer use but is also an effective tool for supplying crop nutrients to achieve higher yields. SSNM has successfully been tried in India using different approaches and demonstrated a potential not only to increase crop yields and farmer profits but also has shown increasing evidence of environmental friendliness owing to its balances and crop-need nutrient application (Satyanarayana *et al*., 2011). Recommendations for managing nutrient inputs are consequently adapted to, local conditions and vary among fields and locations (Buresh *et al*., 2005). Depending on the local conditions and the nutrient interest, SSNM can be of field-specific nature (*e.g*., N) or include domain-specific fertilizer recommendations (*e.g*., P and K) (Dobermann *et al*., 2003).

The maize crop is sensitive to soil acidity and soil acidity problems are encountered mostly in uplands and

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to some extent in medium lands where mostly maize crop is cultivated. This emphasizes the role of acidic soil amelioration for crop production. From the results of the long-term experiments conducted worldwide, the importance of integrated nutrient management (INM) with organic and inorganic is well documented.

In addition to INM, there is also a need for balanced fertilizers application because the availability of plant nutrients and their utilization by crops are inter-dependable. Emphasizing these facts, the present study was undertaken during the *Kharif* season of 2016 and 2017 in the Sambalpur district of Odisha, India.

MATERIALS AND METHODS

A field experiment was conducted at a farmer's field in Sambalpur district (22°33′ N latitude and 81°21′ E longitude and an altitude of 178.8 m above mean sea level) during the *Kharif* season of 2016 and 2017 on a strongly acidic (pH - 5.01) sandy soil with low organic carbon content (4.8 g kg^{-1}). The KM_nO_4 extractable N, Bray's 1 P, neutral normal NH_4-OAc extractable K and 0.15% $CaCl_2$ extractable S in soil were 252, 7.9, 121 and 8.4 kg ha^{-1} soil, respectively. Sulphur was the limiting nutrient in the soil. The lime requirement (LR) of the soil by the Woodruff buffer method was 3.1 t $CaCO_3$ ha^{-1} to raise the pH to 6.5. However, lime was applied as paper mill sludge (PMS) @ 0.1 LR. The $CaCO_3$ equivalent of PMS was 62%. The PMS was applied in the *rhizosphere* below the seed zone behind the plough after drawing furrows and applied on the day of sowing of seeds with proper soil moisture. The test crop maize (cv. Mahyco Hybrid-3845 S) was grown under eight different fertilization treatments with each treatment being replicated three times. The eight treatments were, (i) absolute control (no nutrients added), (ii) 100 % PK (-N), (iii) 100 % NK (-P), (iv) 100 % NP (-K), (v) 100 % NPK, (vi) 100 % NPK + FYM (F), (vii) 100 % NPK + F + Lime (L) and (viii) 100 % NPK + F + L + Sulphur (S)-SSNM. The last treatment was considered SSNM because the nutrients applied as per the soil test values of that specific location. Each treatment was imposed randomly over the statistically laid out field following an RBD design. The recommended dose of NPK and S for maize is 100:50:50:45 kg ha^{-1} of N:P:K:S and the nutrients were supplied through urea, diammonium phosphate, muriate of potash, KH_2PO_4 and Navaratna (N:P:K:S::20:20:0:13) after working out their quantities required as per the specific treatments. Full doses of phosphorous and sulphur, 25 % N and K were applied as basal while 50 % N and K at the knee height stage of the crop (30 days after sowing) and the rest of N and K at 50^{th} day of the crop were side dressed. The boron as borax @ 0.2% and Zn as Zn EDTA @ 0.1 % were sprayed on the 40th day of crop growth and were common to all the treatments, except the absolute control. The farm yard manure (FYM) was applied @ 5 t ha^{-1} as basal. The crop was protected from pests by application of phorate mixed with sand in 1:1 ratio in the neck zone of the crop and once sprayed with Sheathmar (Validamycin 3% L) against sheath blight disease.

The crop was harvested on the 90^{th} day at the green cob stage as green cob is the preferred food item in the local area. The green stover is used as fodder for animals during the stress periods generally occur during the late *kharif* season. The grain yield was expressed in kg ha^{-1}. For uptake studies, the concentration of individual nutrients was multiplied by the oven-dry weights of grain and stover weights. The plant and soil samples from each treatment were collected, dried and processed for analysis following standard procedure for estimation of nutrients concentration (Jackson, 1973) and soil properties (Page *et al*., 1982). In the plant samples, nitrogen in the processed sample was determined by the Kjeldahl digestion method. For other elements like P and K, the samples were digested in diacid mixture [HNO_3 : $HClO_4$ (3:2)]. Phosphorus was estimated spectrophotometrically and K flame photometrically, (Jackson, 1973). The biometric data, nutrient uptake, cob and stover yield were recorded, compiled in appropriate tables and individual character data sets were statistically analyzed and mean comparison between treatments was established at the 5% level of significance by using the SPSS statistical software package. The B:C ratio was calculated considering the present rate of inputs and the market value of the produce. Nutrient recovery was calculated by adopting the formula given by Dobermann (2007) as shown below.

Nutrient Recovery (%) =

$$\frac{(\text{Uptake of nutrient in desired treatment}) - (\text{Uptake in absolute control})}{\text{Amount of nutrient added}\left(\text{kg ha}^{-1}\right)} \times 100$$

RESULTS AND DISCUSSION

Effect of SSNM and nutrient omission on yield and total biomass of maize

The cob length, grains per cob, green cob yield and the total dry matter production of maize crop receiving one SSNM, three nutrient omissions, one organic, another organic and inorganic amelioration and one absolute control treatment have been presented in Table 1.

The length of the cob was maximum under the SSNM treatment (18.5 cm) which was significantly superior over the absolute control. The length of the cob varied from 10.5 to 18.5 cm, with minimum length in absolute control. The enhanced nutrient availability gave higher crop growth parameters and translated into producing more cobs. This subsequently enhanced the number of cobs per hectare along with enhancement in cob length (Manjunath *et al*., 2021). It is clear from the data that the number of grains per cob was influenced by different treatments. The number of grains per cob was maximum (576) and minimum (356) under the SSNM treatment and absolute control, respectively. However, there was no significant difference found in the integration of organic with inorganic or lime addition with it and SSNM treatments. The omission of any single nutrient significantly decreased the number of grains per cob. The increase in growth and cob parameters led to a better source-sink relationship, which might enhance the grains per cob (Manjunath *et al*., 2021)

The green cob yield of maize due to different nutritional treatments varied between 6.4 and 17.1 t ha^{-1}, with the lowest in absolute control and the highest under SSNM treatment. The yield of maize was recorded as 12.0 t ha^{-1} when NPK were applied as the full recommended dose. However, the yield loss recorded was 46, 30, 27.5 and 8% in absolute control, and the treatment with the omission of N, P and K, respectively. Application of major mineral fertilizer alone had a noticeable increase in grain yield over control or nutrient omitted plots, this might be due to the relatively higher response of maize to N and its role in protein formation, a constituent of chlorophyll and involvement in carbohydrate utilization which resulted in higher grain and straw yield (Ghosh *et al*., 2021). The yield of maize has also been found to be increased by 20, 39.8 and 42.5% in treatments with integration of NPK with organic manure (FYM), inorganic ameliorant (PMS) and application of the limiting nutrient sulphur, respectively. This might be due to more availability of nutrients from organic manure which acts as a source for growth and multiplication of microorganisms which would have helped to mineralize the nutrients from organic form to inorganic form which would have ultimately increased the grain yield. Lime addition created a better chemical and biological environment in the soil (Ghosh *et al*., 2019a). Chandrakar *et al*. (2018) also reported that proper decomposition of FYM supplied available plant nutrients directly to plants and created favourable soil environment which ultimately increased the grain yield.

The total dry biomass of maize varied from 3.6 and 10.9 t ha^{-1}, being lowest in absolute control and highest with SSNM. Omission of all major nutrients (NPK) resulted in 50.4% less biomass production. The present

Table 1. *Effect of SSNM and nutrient omission treatment on cob length, grains per cob and yield of maize (pooled data over two years)*

Treatment	Cob Length (cm)	Grains cob^{-1}	Green cob yield (t ha^{-1})	Total dry biomass (t ha^{-1})
Absolute control	10.5	356	6.4 (-46)	3.6 (-50.4)
100% PK (-N)	11.9	390	8.4 (-30)	3.8 (-48.9)
100% NK (-P)	12.5	423	8.7 (-27.5)	5.2 (-29.8)
100% NP (-K)	12.9	439	11.0 (-8.0)	6.7 (-9.5)
100% NPK	14.3	480	12.0	7.4
100% NPK +F	16.4	510	14.4(+20)	9.0 (+22)
100% NPK+F+L	18.3	560	16.7 (+39.8)	10.5 (+42)
100% NPK+F+L+S	18.5	576	17.1 (+42.5)	10.9 (+47)
CD (P=0.05)	2.61	72.69	4.09	3.92

Data in the parenthesis indicate per cent increase or decrease compared to 100% NPK study also finds support from the results of Rodriguez and Nga (2012) who reported that SSNM only increased the yield by 0.6 t ha^{-1}. The results also showed that the omission of N, P and K individually decreased the biomass production to the tune of 48.9, 29.8 and 9.5 %, respectively compared to the full recommended NPK. Prusty *et al*. (2020) also reported a similar decrease in grain yield of maize due to N, P and K omissions while application of NPK with FYM, PMS and limited nutrient S resulted in 22, 42 and 47% increase in biomass production. Such increased biomass production due to the integrated application might be due to the increased availability of soluble nutrients in the soil. These results also corroborated with the findings of Ghosh *et al*. (2019b).

Effect of SSNM and nutrient omission on nutrient uptake by maize

The quantity uptake of added major nutrients through maize crop have been presented in Table 2. The N uptake varied between 40.5 and 137.4 kg ha^{-1}, lowest due to N omitted crop and highest with SSNM treated crop. Similar results were also reported by Khuong *et al*., (2011). Its uptake varied significantly with nutrient management practices. More of N was removed through the crop grown with absolute control than that with N omission. Omission of other nutrients (P by 38% and K by 14.7%) considerably influenced N uptake by the crop but not to the extent of N omission (56% loss). Such variation in uptake of major nutrients by maize might be explained by varying increased biomass production. Organic (23.8%) and inorganic (42.9%) amelioration significantly influenced N uptake. Supplementation of the deficient nutrient with organic and inorganic ameliorants increased N uptake by 48.8 % which might be ascribed to prevailing favourable conditions causing the release of nutrients in the soil solution.

The uptake P by maize crop varied between 8.8 and 25.9 kg ha^{-1}, lowest in absolute control and highest with SSNM treatment. Omission of P did not influence P uptake to the extent that of N omission which might be due to decreased vegetative growth. Omission of NPK from fertilizer schedule reduced P uptake by 50.6%, N omission by 44%, P omission by 35.4% and K omission by 13.5% compared to recommended NPK application. Organic integration increased P uptake by 27.5%, organic with inorganic by 42.1%, and organic + inorganic with correction of different nutrients by 45.5% over the recommended NPK levels.

The amount of K uptake by maize crop was next to that of N, ranging from 48.2 to 131.2 kg ha^{-1}. Omission of N resulted in K uptake less than the absolute control which might be explained by less biomass production caused by less vegetative growth. Omission of NPK resulted in 46% less K uptake, and omission of N only resulted in 51.8% less K compared to 100% NPK. Similarly, the omission of P and K from the NPK schedule removed 33.3 and 18.6% less K compared to the amount due to 100% NPK. Integration of organic alone, with inorganic amelioration and organic-inorganic soil amelioration with the deficient nutrient, resulted in 26.0, 44.2 and 46.9% increase in K uptake compared to recommended NPK and such increased uptake in maize might be attributed to greater biomass production as well as more K concentration in maize.

Table 2. *Effect of SSNM and nutrient omission treatment on uptake of nutrients through maize biomass (pooled data of two years)*

Treatment	N	P	K	Ca	S
	(kg ha^{-1})				
Absolute control	48.0	8.8	48.2	14.8	7.4
100% PK (-N)	40.5	9.9	43.0	14.4	6.9
100% NK (-P)	57.4	11.5	59.5	20.4	9.9
100% NP (-K)	78.7	15.4	72.7	29.0	14.2
100% NPK	92.3	17.8	89.3	33.5	16.9
100% NPK +F	114.3	22.7	112.5	42.5	20.4
100% NPK+F+L	131.9	25.3	128.8	50.7	22.2
100% NPK+F+L+S	137.4	25.9	131.2	51.3	26.2
CD (P=0.05)	3.35	1.18	4.69	1.27	0.88

With regards to the uptake of Ca by maize, it was found next to N and K which varied between 14.4 and 51.3 kg ha^{-1}, being lowest due to N omission and highest due to SSNM treatments. Omission of major nutrients had considerable influence on Ca uptake by the crop which might be due to less biomass production as well as very little amount of Ca mobilization within the plant. Omission of NPK, N, P and K individually from the schedule resulted in 55.8, 57, 39.1, 13.4% less Ca uptake compared to 100% NPK. However, integration of FYM, FYM + lime and lime + FYM with deficient nutrient S increased Ca uptake by 26.8, 51.3 and 53.1% compared to 100% NPK, respectively which might be attributed to the development of favourable conditions resulting in the release of more amount of soluble nutrients in soil solution (Das, 2007).

The uptake of S was lowest among the nutrients studied, which varied between 7.4 and 26.2 kg ha^{-1}. It was less than the amount of P uptake by the crop. Deletion of major nutrients from fertilizers schedule resulted in uptake of S significantly less than that due to 100% NPK and such effect might be due to the very little or no positive interaction among S and NPK fertilizers (Das, 2007). Among the nutrients, N omission had a greater effect than P than K. Integration of organic ameliorant improved S uptake by 20.7%, FYM with inorganic ameliorant (PMS) by 31.3%, further supplementing deficient nutrient S by 55% compared to S uptake amount of 16.9 kg ha^{-1} due to 100% NPK.

Effect of SSNM and nutrient omission on recovery of added nutrients of maize

The recovery of added nutrients through maize crop production varied widely from nutrient to nutrient (Table 3). The recovery of N ranged from 9.4 to 89.4%, lowest through P omitted crop and highest with SSNM treatment. Deleting K from the schedule resulted in a recovery of 30.7% of applied N, whereas with 100% NPK it was 44.3%. When full amount of the inorganic fertilizer dose was integrated with FYM, the recovery increased to 66.3% which might be explained by more solubilisation of nutrients as well as balanced nutrition (Maiti *et al*., 2006). Ameliorating acid soil with PMS along with other practices increased the recovery by 83.9%. Correcting the deficient nutrient along with soil amelioration and proper fertilization raised the recovery level to as high as 89.4%. Results of several studies in Asia revealed that the SSNM model increased average grain yield and nitrogen fertilizer use efficiency by 30-40% (Dobermann *et al*., 2002; Pampolino *et al*., 2007).

Generally, P use efficiency under normal condition does not exceed 25%. In this present investigation, apparent P recovery varied between 5 and 53.8%. Deleting N from the fertilizer schedule resulted in the poorest recovery of N by the crop due to restricted crop growth. Deleting K addition from fertilizer schedule recorded P recovery of 30%. With the application of full dose of inorganic fertilizers, P recovery increased to 41.2%. Integrating FYM with NPK raised it to 22.5%. Liming of soil with PMS improved the P recovery by 8%, with all supplements it attained a maximum of 53.8%. The present study also finds support from the results reported by Ghosh *et al*. (2021). This might be due to increased concentration in plant tissues correspondingly resulting in greater uptake, which ultimately yielded higher fertilizer use efficiency.

The apparent recovery of K presented a different picture. Crop with N omission nutrition did not recover any added K, however without P addition in presence of N and K, its recovery was 39%. With the application of full dose of N, P and K, the crop could utilize 98.7%

Table 3. *Effect of SSNM and nutrient omission treatment on nutrient recovery by maize (pooled data of two years)*

Treatment	Recovery of nutrients			
	N	P	K	S
100% PK (-N)	-	5.0	-	-
100% NK (-P)	9.4	-	39.0	-
100% NP (-K)	30.7	30.0	-	-
100% NPK	44.3	41.2	98.7	-
100% NPK + F	66.3	43.7	113.7	-
100% NPK + F + L	83.9	51.8	142.4	--
100% NPK + F + L + S	89.4	53.8	146.7	57.8

of added K as the K requirement of the crop was high, soil was just medium in status and it was applied in three splits matching the crop requirement period. Organic integration with inorganic fertilizers raised K recovery further to 113.7%. Organics improve the soil structure, favour root growth, water retention in soil and increase available soil water, prevent loss of water-soluble nutrients, provide more nutrients for plant availability, and thereby increase recovery. Liming of acid soil increase availability of K in soil, as a result crop utilize more K, increasing recovery. The crop received inorganic S nutrition through gypsum. As the soil was deficient in S, its supplementation made the nutrient programme balanced which resulted in higher crop yield with better recovery (50%) by the crop.

Effect of SSNM and nutrient omission on post-harvest soil properties

Influence of SSNM and nutrient omission practices on soil pH, and organic carbon and available nutrients status are depicted in Table 4. The soil reaction was acidic (pH 5.01). After the harvest of the maize, the pH of the soil varied from 4.84 to 5.08. As compared to initial status, soil pH decreased among all the treatments, except the treatments that received soil ameliorant. Regarding pH of the soil, there was no significant variation except in lime applied plots. Cropping with maize removed considerable number of basic cations like Ca, Mg even K, which resulted in acidification of soil. Limed soil maintained higher pH than initial, because of supplementation of lost basic cations through liming (Table 4).

The organic carbon in post harvest soil compared to initial status decreased in nutrient omitted plots, even in 100% NPK treated plots but its level was maintained or slightly increased in plots receiving inorganic and organic soil amelioration measures. The SOC ranged from 4.4 to 4.9 g kg^{-1} lowest in absolute control and highest in SSNM treatments. The extent of biological turnover to increase organic carbon status was less/no/negligible compared to organically and inorganically ameliorated soil, leading to variation in organic carbon status in post-harvest soil (Table 4).

Appraisal of results of the present study (Table 4) demonstrated that all the treatments except INM treatments and SSNM treatments failed to maintain the available N status of soil after harvest of maize as compared to initial status of soil (252 kg ha^{-1}). Maximum available N (259 kg ha^{-1}) was attained in the treatment receiving SSNM practice. Addition of lime and FYM promoted appreciable amount of total N which may be ascribed to vast and diversified microbial population developed in the congenial soil environment for more N mineralization (Bhardwaj, 2021). Soils receiving imbalanced and single input had depleted N status. Continuous removal by crops without external addition of fertilizers and FYM/VC over a period of time resulted decline in soil available nitrogen (Ghosh *et al*., 2019b).

The available P status before initiation was 7.9 kg ha^{-1}. Except in P omission and absolute control treatment, the available P status increased in all other treatments. The extent of P build up in soil differed from treatment to treatment at the same dose of P application.

Table 4. *Effect of SSNM and nutrient omission treatment on post-harvest soil properties (pooled data of two years)*

Treat.	pH	OC (g kg^{-1})	Av. N	Av. P	Av. K	Av. S
			(kg ha^{-1})			
Absolute control	4.97	4.4	206	6.6	70	6.1
100% PK (-N)	4.98	4.5	211	9.0	80	6.7
100% NK (-P)	4.87	4.6	244	6.9	83	6.2
100% NP (-K)	4.85	4.7	240	8.3	73	6.7
100% NPK	4.84	4.7	216	10.7	88	7.4
100% NPK +F	4.99	4.8	254	13.9	92	8.2
100% NPK+F+L	5.08	4.9	257	15.2	93	8.0
100% NPK+F+L+S	5.06	4.9	259	16.0	97	12.4
CD(P=0.05)	0.27	0.03	15.1	1.98	5.68	0.98
Initial	5.01	4.8	252	7.9	121	8.4

Maximum P (16 kg ha^{-1}) build up was recorded in the treatment where SSNM practices were followed. Higher availability might be due to solubilisation of P by organic acids released from the organic manures, reduction of P fixation in soil due to chelation of P fixing cations. However, control recorded lowest available P (6.6 kg ha^{-1}). In N omitted plot higher P status was recorded than that of K omission treatment, the reason being the extent of removal of P is less in (–) N plot compared to (–) K treatment. Moreover, except crop P uptake, P is not lost from the system by any other means, which helped in P build up in the soil (Maiti *et al*., 2006).

The available K status decreased in all the treatments from its initial value of 121 kg ha^{-1}. Initial available K status was medium, the crop had received uniform dose of K as fertilizer and to some extent through FYM, except in absolute control treatment. The quantity of K removal by maize crop is high, comparable to that of N, but the extent of K addition is 2.4 times less than that of N. Potassium is also subjected to leaching loss under coarse textured soil conditions. All these facts resulted in heavily K depletion post-harvest soil irrespective of the treatments (Table 4). Similar findings were obtained by Purohit *et al*. (2020). Cultivation practices decreased the sulphur content in soil as compared to its initial status (8.4 kg ha^{-1}) except SSNM which resulted in a buildup of the status (12.4 kg ha^{-1}) in spite of crop uptake. In rest of the treatments, the status had decreased because of no application.

Effect of SSNM and nutrient omission on economics of maize production

The cost of cultivation of maize crop varied widely between ₹ 24520 to ₹ 32700 (Table 5). The gross income also varied widely between ₹ 26,900 and ₹ 1,06 020 and the lowest income was incurred from absolute control treatment and the highest with SSNM treatment. The net income registered between ₹ 2,380 and ₹ 73,320 ha^{-1}. Dawe *et al*. (2004) found in their study in China, Southern India and the Philippines that the profitability in SSNM ranged from $ 57 to $ 82 ha^{-1}. Khurana *et al*. (2007) in North-Western India reported similar results. The B:C ratio varied widely between 1.09 and 3.24 which indicates that for every rupee investment the return incurred between 1.09 and 3.24. Crop production with native or inherent soil fertility or with unbalanced nutrient management were not remunerative. Soil test-based nutrient management with the integration of organic and inorganic ameliorants raised the net income and B:C ratio where the grower could almost triple their returns.

From this experiment, it can be concluded that site-specific integrated nutrient management based on soil test not only yielded more produce with comfortable income but also created a better growing environment for future crop production. The results also emphasize the impact of omission of individual major nutrients, managing problem soils with proper amelioration measure with appropriate organic integration and correction of deficient nutrients in crop production.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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Table 5. *Effect of SSNM and nutrient omission treatment on economics of maize production (pooled of two years)*

Treatment	Cost of cultivation (₹)	Gross income (₹)	Net profit (₹)	B:C ratio
Absolute control	24520	26900*	2380	1.09
100% PK (-N)	26500	37980	11480	1.43
100% NK (-P)	26572	50200	23628	1.88
100% NP (-K)	27100	65240	38140	2.40
100% NPK	29000	73200	44200	2.52
100% NPK +F	31800	87840	56040	2.76
100% NPK+F+L	32500	103194	70697	3.17
100% NPK+F+L+S	32700	106020	73320	3.24

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