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Effect of integrated nutrient management on soil fertility and organic carbon in cabbage (*Brassica oleracea* var. *capitata*) growing soils

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ABSTRACT

Field experiments were conducted in a Haplaquept soil (*p*H 7.70 and organic carbon 0.58%) to study the effect of integrated nutrient management on the availability of N, P, K and cationic micronutrients in soils in relation to 'Green Express' cabbage (*Brassica oleracea* var. *capitata* L.) under different treatment combinations. In general, the adoption of integrated nutrient management practices helped to build up soil nutrient status with respect to N, P, K, Fe, Mn, Cu and Zn contents. The treatment receiving recommended levels of N, P and K 4 tonnes/ha organic manures and 0.5 kg/ha Zn as Zn-EDTA proved superior in augmenting soil fertility. However, the highest organic carbon content (0.88%) was observed in the treatment where 4 tonnes/ha organic manure was applied along with recommended levels of NPK and zinc at 0.5 kg/ha. The amount of cationic micronutrients (Fe, Mn, Cu and Zn) in soil increased in the treatments receiving organic manure @ 4 tonnes/ha + zn at 0.5kg/ ha as Zn-EDTA and organic manure at 10 tonnes/ha + Zn at 0.5kg/ha+ NPK as basal application.

Key words: Availability, Cabbage, Integrated nutrient management, Nutrients

The integrated nutrient management practices which include the use of organic resource materials (on-farm inputs) and inorganic fertilizers (off-farm inputs), are known to modify the fertility status of the soil as well as soil quality. The modern agricultural technology emphazes wide spread use of chemical fertilizers (off-farm inputs) as a source of nutrients. In fact, fertilizer use is considered as barometer of agricultural production. Fertilizers no doubt played a key role in agricultural production and changed Asia from a region of food scarcity to food sufficiency. But the fertilizer production is largely dependent on non-renewable energy sources. Till now, very little attention was paid to maintain soil productivity while reducing dependence on fertilizers. Consequently, the use of organic manures and green manures (on-farm inputs) to supplement fertilizer N declined substantially. The practice of continuous cropping with cereal–cereal rotation raises a question of sustainability of the system highly dependent on chemical fertilizer input and the crops have started giving signals of decline in yield (Meelu 1996). However, integrated approach of plant nutrient management improves soil fertility and maintains soil health without affecting the yield of crops (Badanur *et al*. 1990). Combined application of Zn and organic matter along with recommended levels of N, P and K fertilizers have been reported to increase the status of major and micronutrients along with enhancement of organic carbon and other physical properties of soils (Vyas *et al*. 2003). Hence, the present study was planned and executed accordingly.

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MATERIALS AND METHODS

Field experiments were conducted in a new alluvial soil of West Bengal using 'Green Express' cabbage (*Brassica oleracea* var. *capitata* L.) during 2003-05 at Uttar Chabbis Pargana Krishi Samabay Himghar Ltd, Bagna, Gaighata, West Bengal. The characteristics, viz *p*H, organic C, sand, silt, clay, available N, P_2O_5, K_2O and cationic micronutrients were determined by following the methods described by Jackson (1973) and Lindsay and Norvell (1978). The field experiment was laid out in a randomized block design with 3 replications. The treatments are: $T_{1,}$ control, only organic manure at 10 tonnes/ha; $T_{2,}$ NPK only as basal; $T_{3,}$ NPK as basal + organic manure at 4 tonnes/ha; $T_{4,}$ NPK as basal + organic manure at 8 tonnes/ha; $T_{5,}$ N in 2 splits + PK as basal + organic manure at 4 tonnes/ha; $T_{6,}$ N in 2 splits + PK as basal + organic manure at 8 tonnes/ha; $T_{7,}$ organic manure at 10 tonnes/ha + Zn at 0.5kg /ha as Zn-EDTA; $T_{8,}$ organic manure at 4 tonnes/ha + Zn at 0.5kg/ha + NPK as basal; and $T_{9,}$ organic manure at 10 tonnes/ha + N in 2 splits + PK as basal.

The *p*H, organic carbon, available N, P and K contents of soil under investigation were 7.70, 0.58, 270.12, 4.35 and 231.90 kg/ha, respectively. The DTPA extractable Fe, Mn, Cu and Zn of the soil were 21.86, 4.09, 1.84 and 0.21 mg/kg, respectively.

The size of each plot was 5 m × 2 m surrounded by bunds of sufficient height. Irrigation channels 0.5 m wide were in between the replications to ensure independent easy and uninterrupted flow of irrigation water to an individual plot. The recommended fertilizer dose was 150 : 26 : 66 kg/ha (N: P: K) where, 1/2 N and full P and K were applied as basal. The next 1/4 of total N was applied 21 days after transplanting and the rest 1/4 of total N was applied at 42 days after transplanting. The source of NPK nutrients were urea, single super phosphate and muriate of potash, respectively. All Zn treatments in the form of Zn-EDTA were given through soil application at the time of planting. The different levels of organic manure (containing 0.70, 0.25 and 0.35% N, P and K respectively) were applied at the time of land preparation.

Soil samples (0–10 cm depth) were collected at different intervals from 5 to 6 randomly marked locations in each plot. Soil samples were analyzed for pH, organic C, available N, P and K as per standard methods mentioned earlier and cationic micronutrients like Fe, Mn, Cu and Zn were analyzed by using 0.005 M DTPA as an extractant (Lindsay and Norvell 1978) with the help of Atomic Absorption Spectrophotometer (model Perkin Elmer Analyst 100).

All the data were analyzed statistically as per Panse and Sukhatme (1989), using the statistical computer programme MSTAT, version 5.0 (New Delhi). Non-linear correlations were also calculated using Microsoft Excel computer programme.

RESULTS AND DISCUSSION

Changes in pH and organic carbon content in soil

The mean changes in soil *p*H showed a significant variation among different treatments (Table 1). The changes in *p*H varied from 7.38 to 7.74 at 90 days of crop growth, being significantly lower *p*H (7.38) over the initial value (7.70) in the treatment receiving 10 tonnes/ha organic manures plus zinc at 0.5 kg/ha in the form of Zn-EDTA (T_7), followed by 7.50 in the treatment where recommended levels of NPK along with 8 tonnes/ha organic manures(T_4) were applied. Such decrease might be explained by the production of H^+ ions and subsequently release of H^+ ions in the soil solution resulting from the heavy application of organic manures to the soil. More (1994) had also reported that the

Table 1 Effect of integrated nutrient management on the changes in *p*H, organic carbon, available N,P and K contents during 2003–05 at 90 days of crop growth

Treatment	*p*H		Organic carbon (%)		Available N (kg/ha)		Available phosphorous (kg/ha)		Available potassium (kg/ha)	
	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05
T_1: control, only organic manure at 10 tonnes/ha	7.50	7.66	0.75	0.81	286.90	290.50	11.90	12.30	300.78	303.68
T_2: NPK only	7.70	7.78	0.70	0.68	295.3	284.90	11.53	11.51	312.43	308.49
T_3: NPK + organic manure at 4 tonnes/ha	7.65	7.71	0.75	0.81	310.8	314.60	12.98	13.52	312.78	312.34
T_4: NPK + organic manure at 8 tonnes/ha	7.59	7.41	0.68	0.66	398.90	384.68	15.10	15.18	348.65	341.63
T_5: N in 2 splits + PK + organic manure at 4 tonnes/ha	7.64	7.60	0.60	0.64	357.97	348.49	13.98	13.62	318.38	318.10
T_6: N in 2 splits + PK + organic manure at 8 tonnes/ha	7.55	7.61	0.66	0.64	390.76	398.90	17.23	15.21	346.34	349.06
T_7: organic manure at 10 tonnes/ha + Zn at 0.5 kg /ha as Zn-EDTA	7.30	7.46	0.73	0.77	284.87	294.25	14.13	14.07	299.80	298.68
T_8: organic manure at 4 tonnes/ha + Zn at 0.5 kg/ha + NPK as basal	7.56	7.60	0.80	0.96	398.70	400.86	15.43	15.39	354.98	358.22
T_9: organic manure at 10 tonnes/ha + N in 2 splits + PK as basal	7.51	7.59	0.86	0.82	395.90	397.50	17.90	16.50	348.01	349.41
SEm (±)	0.007	0.007	0.006	0.005	12.32	12.66	0.78	0.84	55.53	56.12
CD (*P*=0.05)	0.02	0.02	0.02	0.02	31.45	32.56	1.58	1.74	166.51	169.32

Table 2 Effect of integrated nutrient management on the changes in cationic micronutrient contents during 2003–05 at 90 days of crop growth

Treatment	Fe(mg/kg)		Mn(mg/kg)		Cu(mg/kg)		Zn(mg/kg)	
	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05	2003–04	2004–05
T_1: control, only organic manure at 10 tonnes/ha	29.54	29.58	4.79	4.65	1.94	1.86	0.60	0.64
T_2: NPK only	26.90	28.84	4.56	4.66	1.83	1.89	0.78	0.74
T_3: NPK + organic manure at 4tonnes/ha	30.34	32.16	4.72	4.74	1.90	1.94	1.08	1.00
T_4: NPK + organic manure at 8tonnes/ha	37.65	32.97	4.80	4.96	1.99	1.91	0.77	0.75
T_5: N in 2 splits + PK + organic manure at 4tonnes/ha	32.68	33.08	4.72	4.68	1.92	1.90	0.54	0.46
T_6: N in 2 splits + PK + organic manure at 8tonnes/ha	33.01	34.01	4.89	4.69	1.96	1.94	0.75	0.81
T_7: organic manure at 10 tonnes/ha+ Zn at 0.5kg /ha as Zn-EDTA	38.98	36.14	5.00	4.96	2.02	1.96	1.36	1.40
T_8: organic manure at 4 tonnes/ha + Zn at 0.5kg/ ha + NPK as basal	40.99	39.03	5.14	5.10	2.03	2.07	1.19	1.13
T_9: organic manure at 10 tonnes/ha + N in 2 splits + PK as basal	34.20	36.32	5.06	5.08	1.95	2.01	0.59	0.57
SEm (±)	0.01	0.02	0.008	0.009	0.009	0.010	0.009	0.008
CD (*P*=0.05)	0.03	0.05	0.02	0.03	0.03	0.03	0.03	0.02

application of farm wastes and organic manures reduced the *p*H of the soil from 9.0 to 8.4 which support the results of the present investigation.

The amount of organic carbon content significantly increased with the crop growth period, irrespective of treatments (Table 2). The highest amount of organic carbon content (0.88%) was recorded at 90 days of crop growth in the treatment where recommended levels of NPK along with 4 tonnes/ha organic manures and zinc at 0.5 kg/ha as Zn-EDTA (T_8) were applied which was followed by 0.84% in the treatment where recommended levels of N as 2 splits and the entire P and K as basal along with organic manure at 10 tonnes/ha (T_9) were applied. Such increase in the organic carbon content might be attributed to the application of organic manures to the soil as also reported by Mathew and Nair (1997) and Rajinder *et al.* (2000). The decrease in soil organic carbon content with the application of larger quantity of organic manure might be explained by the suppression of the rate of mineralization of applied organic manure resulting from the less activity of the soil microorganisms compared to the optimum amount of organic manure application (Maiti *et al.* 2003)

Changes in N, P and K content in soil

The amount of average N content in soil gradually increased over the initial amount(270.12 kg/ha) with the progress of crop growth irrespective of treatments (Table 1). The highest amount (399.78 kg/ha) of N was recorded in the treatment where recommended levels of NPK along with 4 tonnes/ha organic manures and 0.5 kg/ha Zn in the form of Zn-EDTA (T_8) was applied which might be partly due to application of organic matter releasing nitrogen from mineralization (Maiti *et al.* 2003) and partly due to positive interaction effect between applied Zn and N (Das 1996). It was also observed that the amount of N content was higher over that of initial amount in those treatments where only 10 tonnes/ha organic manure has been applied. Vyas *et al.* (2003) reported that the combined application of 5 kg Zn and 10 tonnes farmyard manure/ha increased the yield of soybean (*Glycine max* L. Merr) with the simultaneous increase in N status of the soil which was similar to that of the present investigation. Sukhmal Chand *et al.* (2002) reported 8–10% enhancement of available N status of the soil due to application of organic manure and inorganic chemical fertilizers in mint–mustard cropping system.

The amount of average P and K in soil was also recorded a gradual increase with the progress of crop growth, from 11.52 to 17.20 and 302.23 to 356.60 kg/ha, respectively. The amount of both P (17.20 kg/ ha) and K (356.60 kg/ha) were the highest in the treatments getting recommended levels of NPK along with 4 tonnes/ha organic manures and 0.5 kg/ ha Zn; and nitrogen in 2 splits with P K as basal along with 10 tonnes/ha organic manures (T_8), respectively were applied at 90 days of crop growth. Such increase in P and K in soil might be explained by the release of P from the applied organic matter after mineralization and K due to positive interaction with Zn. The present study also find support from the results reported by More (1994) and Tiwari *et al.* (2002) who also observed improved P and K content of soils with the application of N, P and K along with manure at 15 tonnes/ha.

Changes in cationic micronutrient contents in soil

The amount of average Fe, Mn, Cu and Zn content (Table 2) in soil also followed trend changes similar to that of P content in soil. But the absolute amount were much lower than that of NPK contents. The amount of all cationic micronutrient (Fe, Mn, Cu and Zn) were progressively higher with the crop growth period suggesting a build up of these micronutrient in soil resulting from the adoption of integrated nutrient management systems (INM). Such build up of cationic micronutrients in soil might be partly owing to release of native soil micronutrients resulting from the dissolution action of organic manures and also partly due to release from applied organic manures. The results of the present study are similar to that of Singh *et al.* (1999).

The *p*H of the soil showed a significant negative correlation with N (r = –0.122) and K (r = –0.036) and Fe (r = –0.682) (Table 3) content in soil at 90 days after transplanting while organic carbon content showed a significant positive correlation with P (r = 0.211), Fe (r = 0.404), Cu (r = 0.586) and Mn (r = 0.665) at 90 days after transplanting.

The results of the investigation showed that the *p*H of the soil decreased significantly over the initial values due to the application of organic manures in combination with chemical fertilizers. The lowering of soil *p*H toward the neutral range favours the availability of different major and micronutrients, viz N, P, K, Fe, Cu, Mn, Zn etc. which helps in optimum growth of plants. The organic carbon content increased significantly with different treatments over control. The highest organic carbon content (0.88%) was observed in the treatment where 4 tonnes/ha organic manure along with recommended dose of NPK and Zinc at 0.5 kg/ha were applied. The available N, P and K content in soil gradually increased over the initial amount, irrespective of treatments. The overall results suggested that there was a great role of INM in augmenting the soil fertility build up with respect to both major and micronutrients as well as in maintaining soil quality.

Table 3 Correlation coefficient (r) between different nutrients and properties of soil

Soil properties	N	P	K	Fe	Cu	Mn	Zn
*p*H	–0.122	–0.437	–0.036	–0.682*	–0.603	–0.624	–0.430
Organic carbon	0.076	0.211	0.204	0.404	0.586	0.665*	0.383

**P*=0.05

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