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BROCCOLI CULTIVATION WITH ORGANIC AND INORGANIC SOURCES OF NITROGEN AND ITS EFFECTS ON THE NUTRIENTS BALANCE

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Abstract

The experiment was conducted on broccoli var. Premium Crop at Bangabandhu Sheikh Mujibur Rahman Agricultural University during the period from November, 2014 to March, 2015 with 24 treatment combinations (IPNS based) comprised with 4 inorganic sources of nitrogen as 140, 160 and 180 kg USG N ha^{-1} and 180 kg PU N ha^{-1} and 6 levels of organic nitrogen sources as i) 1 ton mustard oil cake ha^{-1}; ii) 2 ton mustard oil cake ha^{-1}; iii) 2 ton poultry manure ha^{-1}; iv) 3 ton poultry manure ha^{-1}; v) 3 ton cow dung $ha^{-1}$and vi) 5 ton cow dung ha^{-1} were considered. Results revealed that integration of organic and inorganic N sources have a little influence on soil physical and chemical properties of soil and its affects on soil nutrient balance. Post harvest soil organic carbon content was significantly influenced by the organic-inorganic N management approach, but no influence on soil pH, bulk density and partical density. However, a significant effect was found on post harvest soil nutrient balance where K showed a (-) ve balance but N with a little exception, P, S and B showed (+) ve balance which was affected by the organic-inorganic integrated N management approach. But better soil physical and chemical properties as well as higher (+) ve nutrient balance was found with higher rate of USG-organic manure as compared to that of PU-organic manure integration.

Keywords: Broccoli, Soil Nutrient Status, Nutrient Balance, Organic and Inorganic Nitrogen.

Introduction

Integrated N management approach has a good positive response on improvement of soil fertility as well as soil physical and chemical properties. According to Mishra *et al.* (2014), integrated nutrient management aims to cultivate a land where the soil should remain sustainable with maximum production of quality crop. Soil organic matter is a key factor for sustainable soil

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fertility and crop productivity. Reganold *et al.* (1990) showed that a suitable combination of organic and inorganic source of nutrients is necessary for sustainable agriculture that can ensure high quality food production. Ali *et al.* (2009) reported that organic matter undergoes mineralization with the release of substantial quantities of N, P, and S and smaller amount of micronutrients. Soil nutrient status was influenced by the application of both organic and inorganic sources of N. Bhandari *et al.* (1992) reported that a combined use of organic manure with chemical fertilizer increased organic carbon status of the soil. The 100% NPK fertilizers and their combined use with organic N sources also increased the available N and P by 5.22 and 0.8-3.8 kg

ha^{-1}, respectively from their initial values. Basel *et al*. (2008) observed that electrical conductivity of soil and organic matter were increased by increasing levels of organic fertilizer except soil pH. Priyanka *et al.* (2017) revealed that the integration of organic and inorganic fertilizers had a marked effect in enhancing yield as well as productivity of broccoli with maximum net returns. Nahar *et al.* (2021) reported that among different organic and inorganic sources of nutrients, application of litter showed the best performances regarding all the growth and yield contributing characters of Chinese broccoli. Sarker and Singh (1997) observed that alone or combined application of organic with inorganic fertilizers increased the level of soil organic carbon as well as the total N, P and K content. Hoque *et al.* (2007) reported that various organic manures influenced post-harvest soil pH, organic matter, total N, available P, exchangeable K and available S contents. As soil organic matter were increased by increasing organic fertilizer, efficient management through integrated plant nutrition system (IPNS) is a prerequisite to improve soil productivity for achieving higher yield of broccoli. Therefore, the experiment was undertaken to assess the effect of different levels of organic and inorganic sources of nitrogen on the post harvest soil nutrient status and nutrient balance in broccoli field.

Materials and Methods

Location and soil

The experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Bangladesh during November, 2014 to March, 2015. Soil texture of the experimental field is silty clay loam having a poor physical property(Table 1), that belongs to the agro-ecological zone Madhupur Tract (AEZ 28). Initial soil samples were collected from the experimental plots; analyzed to different physical and chemical properties in the laboratory of the Department of Soil Science, BSMRAU and the analytical results are presented in Table 1.

Table 1. Physico-chemical properties of soil of the experimental field

Physical properties of soil		Chemical properties of soil	
Soil properties	Analytical value	Soil properties	Analytical value
Particle size distribution	Sand (%) : 17.8	Soil pH	5.97
	Silt (%) : 45.6	Organic carbon (%)	0.96
	Clay (%) : 36.6	Total N (%)	0.083
Soil texture	Silty clay loam	Available P (µg g^{-1})	15.14
Bulk density (g cm^{-3})	1.34	Exchangeable K (meq $100g^{-1}$ soil)	0.298
Particle density (g cm^{-3})	2.61	Available S (µg g^{-1})	11.878
Porosity (%)	48.7	Available B (µg g^{-1})	0.182
Field capacity (%)	28.67	CEC (meq $100g^{-1}$ soil)	12.67

Fully decomposed mustard oil cake, poultry manure and cow dung were used as organic sources of nitrogen and samples from these organic sources were collected and analyzed. Analytical values of these materials are presented in Table 2

Table 2. Nutrient status and moisture content of cow dung, poultry manure and mustard oil cake

Sample	Nutrient content (oven dry basis)				
	Moisture (%)	N (%)	P (%)	K (%)	S (%)
Mustard oil cake (OC)	18.88	5.32	0.83	0.71	0.66
Poultry litter (PM)	48.57	1.72	1.29	0.82	0.38
Cow dung (CD)	41.53	1.35	1.01	0.68	0.24

The experiment was designed in factorial randomized complete block (RCB) with three replications having 24 treatment combinations. Three doses of USG (@ 140, 160 and 180 kg N ha^{-1}) and one dose of PU (@ 180 kg N ha^{-1}) as inorganic sources of nitrogen combined with 2 levels of 3 organics as i) 1 ton OC ha^{-1}; ii) 2 ton OC ha^{-1}; iii) 2 ton PM ha^{-1}; iv) 3 ton PM ha^{-1}; v) 3 ton CD ha^{-1} and vi) 5 ton CD ha^{-1} were considered. From these levels 24 (IPNS based) treatment combinations were comprised as- T_1: USG-$N_{140}OC_1$; T_2: USG-$N_{140}OC_2$; T_3: USG-$N_{140}PM_2$; T_4: USG-$N_{140}PM_3$; T_5: USG-$N_{140}CD_3$; T_6: USG-$N_{140}CD_5$; T_7: USG-$N_{160}OC_1$; T_8: USG-$N_{160}OC_2$; T_9: USG-$N_{160}PM_2$; T_{10}: USG-$N_{160}PM_3$; T_{11}: USG-$N_{160}CD_3$; T_{12}: USG-$N_{160}CD_5$; T_{13}: USG-$N_{180}OC_1$; T_{14}: USG-$N_{180}OC_2$; T_{15}: USG-$N_{180}PM_2$; T_{16}: USG-$N_{180}PM_3$; T_{17}: USG-$N_{180}CD_3$; T_{18}: USG-$N_{180}CD_5$; T_{19}: PU-$N_{180}OC_1$; T_{20}: PU-$N_{180}OC_2$; T_{21}: PU-$N_{180}PM_2$; T_{22}: PU-$N_{180}PM_3$; T_{23}: PU-$N_{180}CD_3$ and T_{24}: PU-$N_{180}CD_5$. A blanket dose of other fertilizers were used as per recommendation of the crop @ 53, 83, 20, 2.0, 1 and 0.8 kg P, K, S, Zn, B and Mo ha^{-1}, respectively in the form of TSP, MoP, gypsum, zinc oxide, boric acid and sodium molybdate.

Additional nutrients were supplied from inorganic sources adjusting per IPNS based recommendation after getting these from organic sources. Broccoli variety "Premium Crop" a hybrid variety of broccoli by TAKI Seed Company, Japan was used as a test crop. After proper land preparation, 25 day old seedlings were transplanted in lines with a distance from row to row and plant to plant 60 and 45 cm, respectively.

Soil sample collection and analytical procedure

At the beginning of the experiment, soil samples were collected from each unit plots for analysis of both physical and chemical properties. For each plot 5 samples from 0-15 cm depth were randomly collected, mixed well, air-dried, ground and sieved through a 2 mm (10 mesh) sieve. At the same time, undisturbed soil samples from 0-15 cm depth were collected for determination of soil bulk density. Samples were analyzed for particle size distribution, particle density, bulk density, pH, organic C, total N, available P, exchangeable K, available S and B (Table 2). Similarly, post harvest soil samples of 0-15 cm depth were also collected from each plot and samples were air-dried, ground, sieved through a 2 mm (10 mesh) sieve and were analyzed for particle density, bulk density pH, organic matter, total N, available P, exchangeable K, available S and B. Particle size analyses of soil was done by Hydrometer Method (Black, 1965) and the textural class was determined by plotting the values of % sand, % silt and % clay to the Marshall's triangular coordinate following the USDA system

Particle density of soil was determined by Pycnometer Method (Black, 1965) following the formula:

$$\text{Particle density } (\rho_s) = \frac{\text{Weight of oven dry soil}}{\text{Volume of soil (solid)}} \text{ g/cc}$$

Bulk density of soil was determined by Core Sampler Method following the formula

$$\text{Bulk density } (\rho_b) = \frac{\text{Weight of oven dry soil}}{\text{Total volume of soil}} \text{ g/cc}$$

Porosity of soil was calculated from the following formula:

$$\text{Total porosity (\%)} = 1 - \frac{\rho_b}{\rho_s} \times 100$$

Where, ρ_b=Bulk density (g/cc)

ρ_s=Particle density (g/cc)

Analytical procedures of soil chemical properties

Glass electrode pH meter was used to measure soil pH using soil-water suspension of 1: 2.5 as described by Jackson (1962). Soil organic carbon was determined following the wet oxidation method according to Page *et al.* (1982) and the organic matter content was calculated by multiplying the % organic carbon with the Van Bemmelen factor 1.73(Piper, 1950).Flame-photometer (Atomic absorption spectrophotometer, model No. Hitachi, Japan) was used to determine cation exchange capacity (CEC) followed by ammonium acetate extraction method. Total N of soil was estimated following the micro-Kjeldahl method (Jackson, 1973). Available P was determined colorimetrically followed by sodium bicarbonate extraction method (Olsen *et al.*, 1954). Exchangeable potassium of soil was determined from ammonium acetate (1N NH_4OAC) extract as described by Jackson (1973) using flame-photometer (Atomic absorption spectrophotometer, model No. Hitachi, Japan). Available sulphur was determined by extracting the samples with $CaCl_2$ (0.15%) solution tubidimetrically **(**Page *et al.*, 1982). For determination of total B content dried plant materials were digested with concentrated HNO_3 and $HClO_4$ (Par-chloric acid) mixture followed by adding curcumin, H_2SO_4 plus methanol solution (Hunter, 1980) and concentration was measured using double beam spectrophotometer (Model no. 200-20, Hitachi, Japan) at 555 nm wave length.

To calculate apparent or partial N, P, K and S balance a simplified method was used based on major inputs like fertilizer, manures etc and outputs (above ground plant uptake. Calculation of apparent or partial net nutrient balance was done using the following formula:

Apparent/partial nutrient balance (kg ha^{-1}) = Nutrient input (kg ha^{-1}) -Nutrient output (kg ha^{-1})

According to experimental design treatmentwise data on different soil and plant parameters were recorded time to time throughout the cropping season. Collected data were tabulated with the help of Microsoft Office Excel (2010) and analyzed statistically using statistical program MSTATC. Variations among the treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% levels of probability.

Results and Discussion

Effect of organic and inorganic sources of nitrogen on head yield andpost harvest soil physico-chemical properties in broccoli field

Head yield

The head yield was published earlier by Hussain *et al.* (2021). According to them the maximum head yield (14.75 tonha^{-1}) was recorded with USG-N_{160}× OC_2 followed by USG-N_{180}×OC_2 (14.48 ton ha^{-1}), USGN_{160}×PM_3 (13.84 ton ha^{-1}) and PU-N_{180}×PM_3 (13.72 ton ha^{-1}) and the lowest yield (11.87 ton ha^{-1}) from USG-N_{140}×CD_3.

Table 3. Effect of different forms and levels of organic and inorganic sources of nitrogen on soil pH and organic carbon

Treatment	Soil pH		Organic carbon (%)	
	Initial	Post harvest	Initial	Post harvest
USG-N_{140}×OC_1	5.86	5.75	0.95i	1.01c
USG-N_{140}×OC_2	5.91	5.78	0.97fgh	1.05bc
USG-N_{140}×PM_2	5.85	5.76	1.00bc	1.03c
USG-N_{140}×PM_3	5.84	5.81	1.01a	1.04bc
USG-N_{140}×CD_3	5.83	5.86	1.01ab	1.04bc
USG-N_{140}×CD_5	5.84	5.80	0.99c	1.09ab
USG-N_{160}×OC_1	5.83	5.80	0.96fgh	1.04bc
USG-N_{160}×OC_2	5.85	5.82	0.96hi	1.05bc
USG-N_{160}×PM_2	5.86	5.80	0.97fgh	1.03c
USG-N_{160}×PM_3	5.93	5.90	0.98cde	1.13a
USG-N_{160}×CD_3	5.96	5.87	1.00bc	1.01c
USG-N_{160}×CD_5	5.81	5.78	0.98def	1.11a
USG-N_{180}×OC_1	5.78	5.77	0.96ghi	1.01c
USG-N_{180}×OC_2	5.82	5.80	0.97efg	1.05bc
USG-N_{180}×PM_2	5.81	5.78	1.00bc	1.09ab
USG-N_{180}×PM_3	5.82	5.81	1.01ab	1.13a
USG-N_{180}×CD_3	5.85	5.82	1.00bc	1.04bc
USG-N_{180}×CD_5	5.84	5.77	0.97efg	1.11a
PU-N_{180}×OC_1	5.85	5.76	0.97efg	1.05bc
PU-N_{180}×OC_2	5.86	5.78	0.97fgh	1.04bc
PU-N_{180}×PM_2	5.86	5.79	0.94i	1.03c
PU-N_{180}×PM_3	5.95	5.89	0.98cde	1.04bc
PU-N_{180}×CD_3	6.04	5.85	0.99cd	1.01c
PU-N_{180}×CD_5	5.92	5.79	0.98def	1.03c
CV (%)	1.22	1.12	1.29	2.23
SE ± 0.05	0.041	0.037	0.005	0.016

Means followed by common letters are statistically similar to each other at 5% level of provability by DMRT

Soil pH

Soil pH value at the beginning and after harvest are presented in Table 3. The post harvest soil pH showed a little variation among the treatments and it varied within the range of 5.75 to 5.90. The highest post harvest soil pH value (5.90) was recorded from the treatment USG-N_{160}× PM_3 whereas the lowest value (5.75) in treatment USG-N_{140}×OC_1. The result revealed that the lower pH value was noticed where inorganic nutrient was applied with mustard oil cake but with PM its pH increased slightly, whereas cow dung showed the intermediate pH value. The higher values of pH with PM may be due to more base cation (Ca^{+2}). Sanwal *et al.* (2007) also reported that the application of farm yard, poultry and pig manure considerably reduced the soil acidity.This finding also supported by Pathak *et al*. (2005) who found the higher soil pH in organic plots as compared to combine dose of NPK with farm yard manure. Organic sources help in addition of basic cations on its decomposition and production of bi-carbonate ion due to root respiration. This might be due to relatively higher buffering capacity of soil based on its high carbonate contents that can fix any change in soil pH during organic matter decomposition (Wong *et al*., 1999).

Organic carbon

Data on organic carbon content of the initial and post harvest soil presented in Table 3. Effect of organic manures (CD, PM and OC) along with chemical fertilizers was found significant. The maximum organic carbon content (1.13%) in post harvest soil was found in the treatment USG-N_{180}×PM_3 and USG-N_{160}×PM_3 followed by USG-N_{160}×CD_5 (1.11), but lowest (1.01 %) in USG-N_{140}×OC_1 and USG-N_{180}×OC_1. It was seen from the result that among the treatments receiving CD, PM and OC, poultry manure contributed for higher organic matter. Initial soil organic carbon status was ranged from 0.94 to 1.01 %, which increased due to the addition of organic manures. Application of different amounts of organic manure with or without inorganic fertilizer were significantly increased organic matter content in the soil. Similar informations were reported by (Al-Tarawneh, 2005).

Bulk density of soil

Among the physical properties of soil, bulk density is slightly influenced by the applied organic manures. Bulk densities after harvesting of broccoli showed a little difference among the treatments of OC, PM and CD but it was insignificant (Table 4). Initial bulk density varied within the range of 1.33 to 1.36 g cm^{-3}. At 0-15 cm soil depth bulk density of post harvest soil ranged from 1.35 to 1.38 g cm^{-3}. The highest bulk density (1.38 g cm^{-3}) was recorded with USG_{140}×OC_1 and the lowest bulk density (1.35 g cm^{-3}) was noted in treatment $PU_{180}PM_3$ followed by USG_{160}×PM_3 (1.35 g cm^{-3}). It was observed that bulk density of soil reduced under higher rate of application of organic manures. This might be due to impact of addition of large amount of CD, PM and OC, which made the soil loose and friable, increased porosity resulting in decreased bulk density and improved soil physical environment. Swarup (2000) reported that long-term application of organic manures decreased soil bulk density, which was in agreement with this finding.

Particle density of soil

Variations in particle densities of post harvest soils were observed under different treatments of organic manures (Table 4), but it was insignificant and ranged from 2.55 to 2.61 g cm^{-3}. The highest particle density (2.61 g cm^{-3}) was recorded in the treatment $USG_{140} \times OC_1$ followed by $USG_{160} \times OC_1$ and $USG_{180} \times CD_3$ (2.60 g cm^{-3}). The lowest particle density of soil (2.55 g cm^{-3}) was found in the treatment of $USG_{160} \times PM_3$. The treatment receiving higher amount of organic manures always exhibited lower particle density value in each form of organic manures. This result is in agreement with the findings of Anwar (2008).

Table 4. Effect of different forms and levels of organic and inorganic sources of nitrogen on bulk density and particle density of soil

Treatment	Soil bulk density (g cm^{-3})		Soil particle density (g cm^{-3})	
	Initial	Post harvest	Initial	Post harvest
USG-N_{140}×OC1	1.35	1.38	2.62	2.61
USG-N_{140}×OC_2	1.34	1.37	2.63	2.56
USG-N_{140}×PM_2	1.35	1.38	2.62	2.59
USG-N_{140}×PM_3	1.35	1.36	2.61	2.56
USG-N_{140}×CD_3	1.35	1.38	2.60	2.59
USG-N_{140}×CD_5	1.35	1.35	2.62	2.56
USG-N_{160}×OC_1	1.34	1.38	2.60	2.60
USG-N_{160}×OC_2	1.34	1.36	2.61	2.58
USG-N_{160}×PM_2	1.34	1.38	2.59	2.59
USG-N_{160}×PM_3	1.35	1.35	2.62	2.55
USG-N_{160}×CD_3	1.34	1.37	2.61	2.59
USG-N_{160}×CD_5	1.35	1.36	2.61	2.56
USG-N_{180}×OC_1	1.36	1.37	2.60	2.59
USG-N_{180}×OC_2	1.35	1.36	2.61	2.56
USG-N_{180}×PM_2	1.35	1.37	2.59	2.57
USG-N_{180}×PM_3	1.34	1.36	2.59	2.56
USG-N_{180}×CD_3	1.35	1.38	2.63	2.60
USG-N_{180}×CD_5	1.34	1.36	2.63	2.57
PU-N_{180}×OC_1	1.35	1.38	2.62	2.60
PU-N_{180}×OC_2	1.33	1.36	2.59	2.57
PU-N_{180}×PM_2	1.35	1.37	2.61	2.60
PU-N_{180}×PM_3	1.35	1.35	2.58	2.57
PU-N_{180}×CD_3	1.34	1.37	2.61	2.58
PU-N_{180}×CD_5	1.35	1.36	2.60	2.56
CV (%)	1.03	1.77	0.92	0.76
SE ± 0.05	0.005	0.006	0.018	0.006

Means followed by common letters are statistically similar to each other at 5% level of provability by DMRT

Effect of organic and inorganic sources of nitrogen on post harvest soil nutrient status in broccoli field

Soil N content

Variations among the initial soil N content were insignificant (0.073 to 0.09 %). The post harvest soil N was significantly affected by the treatment combinations (Table 5). The maximum N content (0.097 %) was recorded with the treatment combinations USG_{180}×CD_3, USG_{180}×CD_5, PU_{180}×OC_1, PU_{180}×OC_2, USG_{140}×PM_3, USG_{140}×CD_5, USG_{160}×OC_2, USG_{160}×PM_3, USG_{160}×CD_5 and USG_{180}×OC_2. For all the cases USG with 2 ton OC, 3 ton PM and 5 ton CD showed higher residual effect on post harvest soil. This indicated that the residual effect of N application in the form of USG combining with organic manure was higher than that of PU. This result was similar to the findings of Evaraats *et al.* (1999) who reported that the post harvest soil N content was increased with increasing amounts of N application. Nambiar (1991) observed that integrated use of organic manure with N, P and K fertilizers was quite promising providing greater stability in production as well as maintaining higher soil fertility status. Ali *et al.* (2009) reported that application of 3 t ha^{-1} PM once in a year with 70% NPKS can reduce 30% of NPKS fertilizers.

Table 5. Effect of different forms and levels of organic and inorganic sources of nitrogen on soil nitrogen, phosphorus and potassium status in broccoli field

Treatment	Initial soil N (%)	Post harvest soil N (%)	Initial soil P (µg g^{-1})	Post harvest soil P (µg g^{-1})	Initial soil K (meq $100g^{-1}$)	Post harvest soil K (meq $100g^{-1}$)
USG-N_{140}×OC1	0.073	0.095b	19.5	20.8k	0.303	0.231e
USG-N_{140}×OC_2	0.080	0.095b	12.6	26.6b	0.298	0.298a-d
USG-N_{140}×PM_2	0.080	0.084bc	17.2	19.3l	0.303	0.270d
USG-N_{140}×PM_3	0.080	0.097a	14.7	22.7hi	0.303	0.287a-d
USG-N_{140}×CD_3	0.080	0.095b	13.2	23.2ghi	0.298	0.275cd
USG-N_{140}×CD_5	0.080	0.097a	13.7	25.3cd	0.287	0.312ab
USG-N_{160}×OC_1	0.087	0.095b	19.5	20.5k	0.298	0.287a-d
USG-N_{160}×OC_2	0.090	0.097a	12.6	24.1fg	0.296	0.278bcd
USG-N_{160}×PM_2	0.090	0.095b	17.2	24.6cde	0.303	0.287a-d
USG-N_{160}×PM_3	0.083	0.097a	14.7	21.3jk	0.303	0.292a-d
USG-N_{160}×CD_3	0.090	0.095b	13.2	22.2ij	0.298	0.298a-d
USG-N_{160}×CD_5	0.090	0.097a	13.7	26.7b	0.287	0.312ab
USG-N_{180}×OC_1	0.080	0.095b	19.5	21.1jk	0.298	0.278bcd
USG-N_{180}×OC_2	0.090	0.097a	12.6	24.1de	0.298	0.298a-d
USG-N_{180}×PM_2	0.087	0.095b	17.2	22.6i	0.303	0.289a-d
USG-N_{180}×PM_3	0.080	0.095b	14.7	23.4ghi	0.303	0.287a-d
USG-N_{180}×CD_3	0.083	0.097a	13.2	20.3kl	0.298	0.284a-d
USG-N_{180}×CD_5	0.080	0.097a	13.7	27.6a	0.289	0.315a

Treatment	Initial soil N (%)	Post harvest soil N (%)	Initial soil P (µg g^{-1})	Post harvest soil P (µg g^{-1})	Initial soil K (meq $100g^{-1}$)	Post harvest soil K (meq $100g^{-1}$)
PU-N_{180}×OC_1	0.077	0.093b	19.5	25.1cd	0.298	0.298a-d
PU-N_{180}×OC_2	0.080	0.097a	12.6	23.9f-h	0.298	0.289a-d
PU-N_{180}×PM_2	0.080	0.084bc	17.2	26.3cd	0.301	0.270d
PU-N_{180}×PM_3	0.080	0.095b	14.7	24.0ef	0.303	0.303a-d
PU-N_{180}×CD_3	0.080	0.084bc	13.2	22.2ij	0.298	0.298a-d
PU-N_{180}×CD_5	0.080	0.095b	13.7	25.5c	0.287	0.306abc
CV (%)	0.69	6.42	2.53	5.05	4.25	3.50
SE ± 0.05	-	0.005	-	0.402	-	0.010

Means followed by common letters are statistically similar to each other at 5% level of probability by DMRT

Soil P content

Initial soil available P content varied insignificantly within the range of 12.6 to 19.5 µg g^{-1} (Table 5). However, post harvest soil P content was significantly affected by the different organic and inorganic treatment combinations (Table 5). Maximum P content (27.6 µg g^{-1}) was found with the treatment USG_{180} × CD_5 which was significantly higher than all other treatments. The lowest P content (19.3 µg g^{-1}) was recorded with USG_{140} × PM_2. Organic manures might have increased the microbial population and their solubilizing activities of insoluble phosphate. Sharma and Saxena (1985) explained that incorporation of poultry manure or FYM in to the soil increased maize yields through improving soil P indices which is also in accordance with the present study. Ali *et al*, (2009) reported that application of 3 t ha^{-1} PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers.

Soil K content

Initial soil exchangeable K content was varied within the range of 0.287 to 0.303 meq $100g^{-1}$ soil (Table 5). The post harvest soil exchangeable K was significantly affected by the treatment combinations and the maximum K content (0.315 meq $100g^{-1}$ soil) was found from the treatment USG_{180} × CD_5 which was statistically identical with all other treatment combinations except USG_{140}×OC_1, USG_{140}×PM_2, USG_{140}×CD_3, USG_{160}×OC_2, USG_{180}×OC_1 and PU_{180}×PM_2. The lowest K content (0.231 meq $100g^{-1}$) was recorded in USG_{140} × OC_1 treatment. This indicated that the effect of N on K uptake varied irrespectively with treatment combination. This result was supported by the findings of Zhang *et al.* (1996) where they showed that the contents of soil organic matter and total N, P and K were raised, soil nutrients were activated and soil fertility level was enhanced by the combined application of organic and inorganic fertilizers. Ali *et al.*, (2009) reported that application of 3 t ha^{-1} PM once in a year with 70% NPKS can reduce the 30% use of NPKS as fertilizers.

Table 6. Effect of different forms and levels of organic and inorganic sources of nitrogen on soil sulphur and boron status in broccoli field

Treatment	Initial soil S (µg g^{-1})	Post harvest soil S (µg g^{-1})	Initial soil B (µg g^{-1})	Post harvest soil B (µg g^{-1})
USG-N_{140}×OC1	11.4	12.6e-h	0.228	0.171c
USG-N_{140}×OC_2	11.6	13.0d-g	0.124	0.171c
USG-N_{140}×PM_2	13.9	11.3h	0.228	0.285a
USG-N_{140}×PM_3	10.5	15.3a	0.124	0.228b
USG-N_{140}×CD_3	14.0	12.0gh	0.241	0.285a
USG-N_{140}×CD_5	10.6	15.3a	0.124	0.229b
USG-N_{160}×OC_1	10.8	13.1c-g	0.228	0.281a
USG-N_{160}×OC_2	10.8	13.1c-g	0.124	0.228b
USG-N_{160}×PM_2	13.5	12.0f-h	0.228	0.285a
USG-N_{160}×PM_3	10.8	14.7ab	0.124	0.285a
USG-N_{160}×CD_3	14.0	14.3a-d	0.241	0.228b
USG-N_{160}×CD_5	10.5	15.4a	0.124	0.171c
USG-N_{180}×OC_1	11.0	12.6e-h	0.228	0.171c
USG-N_{180}×OC_2	11.5	14.5abc	0.124	0.164d
USG-N_{180}×PM_2	13.9	12.7e-h	0.228	0.228b
USG-N_{180}×PM_3	10.8	15.1a	0.124	0.169c
USG-N_{180}×CD_3	14.0	11.4h	0.241	0.164d
USG-N_{180}×CD_5	10.5	15.0ab	0.124	0.164d
PU-N_{180}×OC_1	11.1	13.5b-f	0.228	0.285a
PU-N_{180}×OC_2	11.1	15.1a	0.124	0.229b
PU-N_{180}×PM_2	13.5	12.7e-h	0.228	0.285a
PU-N_{180}×PM_3	11.0	14.7ab	0.124	0.266a
PU-N_{180}×CD_3	13.6	13.9a-e	0.241	0.285a
PU-N_{180}×CD_5	10.6	14.8ab	0.124	0.228b
CV (%)	8.00	5.81	6.65	6.45
SE ±0.05	-	0.459	-	0.01

Means followed by common letters are statistically similar to each other at 5% level of provability by DMRT

Soil S content

Initial soil available S content ranged from 10.5 to 14.0 µg g^{-1} (Table 6). But post harvest soil S was significantly affected by the treatment combinations (Table 6).

Maximum S content (15.4 µg g^{-1}) was recorded in the treatment combination of USG_{140} × CD_5 followed by USG_{140} × PM_3 (15.3 µg g^{-1}), $USG_{180}PM_3$, PU_{180}×OC_2, PU_{180}×CD_5, USG_{160}×CD_3, USG_{180}×OC_2, USG_{180}×CD_5, PU_{180}×PM_2, PU_{180}×CD_3 and USG_{160}×PM_3, respectively This indicated that the effect of N on the S uptake was irrespective to different treatment combination. This result was an accordance with the findings of Hoque *et al.* (2007) also found that the application of various organic manures significantly influenced the S uptake, soil pH, organic matter content, and the available S contents of the post-harvest soil.

Soil B content

Initial soil B content of the experimental units ranged from 0.124 to 0.241 µg g^{-1} (Table 6). The post harvest soil B content was significantly affected by the treatment combinations. Maximum B content (0.285 µg g^{-1}) was noted in the treatments USG_{140}×PM_2, USG_{140}×CD_3, USG_{160}×PM_2, USG_{160}×PM_3, PU_{180}×OC_1, PU_{180}×PM_2, PU_{180}×PM_3 and PU_{180}×CD_3 followed by PU_{180}×PM_3 and USG_{160}×OC_1. The lowest B content (0.164 µg g^{-1}) was noted in USG_{180}×OC_2, USG_{180}×CD_3 and USG_{180}×CD_5. This result is in agreement with the findings of Gaur and Verma (1991) and Rani Perumal *et al.* (1991) who depicted that combined application of organic manures and mineral fertilizers were promising in maintaining of lateral micronutrient like B for crop production stability and providing favorable physical, biological and soil ecological conditions.

Effect of organic and inorganic sources of nitrogen on nutrient uptake by the broccoli plant

Nitrogen uptake

The nitrogen uptake by the broccoli plants was significantly affected by different organic and inorganic sources of N (Table 7). Maximum N uptake was found with the treatment USG-N_{180}×OC_2 (208.3 kg N ha^{-1}) followed by USG-N_{160}×OC_2 (204.3 kg N ha^{-1}). However, USG-N_{180}×PM_3 (202.8 kg N ha^{-1}), PU-N_{180}×OC_2 (199.8 kg N ha^{-1}), USG-N_{180}×CD_5 (198.1 kg N ha^{-1}) and PU-N_{180}×PM_3 (193.3 kg N ha^{-1}) had higher levels of N uptake. Nitrogen uptake was increased with increasing levels of N applied and this amount was higher in the USG-applied plots with OC. This might be due to the high availability and uninterrupted supply of N with deep-placed USG in combination with OC. Here, organic manure might have acted as a slow-releasing N source which can supply N for a long period of time to the plant resulting higher N uptake. This finding was supported by Rickard (2008) as the plant N uptake was synergistically influenced by N application. Tremblay *et al*. (2001) also showed that the N uptake was approximately 260 kg ha^{-1} for an average yield of field vegetables.

Table 7. Effect of different forms and levels of organic and inorganic sources of nitrogen on nutrient uptake by broccoli plant

Treatment	N uptake (kg ha^{-1}±SE)	P uptake (kg ha^{-1}±SE)	K uptake (kg ha^{-1}±SE)	S uptake (kg ha^{-1}±SE)
$USG_{140}OC_1$	167.6±7.06hij	23.9±0.83cd	212.6±4.44a-e	2.38±0.10ef
$USG_{140}OC_2$	191.8±4.63b-e	30.8±1.45ab	238.3±6.82ab	3.02±0.14bcd
$USG_{140}PM_2$	139.4±2.36k	22.2±0.57d	187.2±3.91e	2.17±0.04f
$USG_{140}PM_3$	173.7±6.21f-i	25.1±1.09bcd	205.9±6.27b-e	2.68±0.19c-f
$USG_{140}CD_3$	143.3±7.33k	23.1±1.15d	206.1±3.25b-e	2.37±0.17ef
$USG_{140}CD_5$	173.7±4.79f-i	25.1±1.16bcd	216.0±2.76a-e	2.61±0.09c-f
$USG_{160}OC_1$	171.0±2.12g-j	25.7±0.90bc	215.5±3.38a-e	2.43±0.05ef
$USG_{160}OC_2$	204.3±4.17ab	33.0±2.15a	247.0±6.78a	3.24±0.21ab
$USG_{160}PM_2$	159.9±8.49ij	25.1±0.21bcd	193.9±5.63de	2.38±0.15ef
$USG_{160}PM_3$	188.8±8.59b-f	28.0±0.33ab	226.8±5.05a-d	2.73±0.13cde
$USG_{160}CD_3$	158.1±3.06j	24.8±0.23cd	200.5±6.04cde	2.45±0.11ef
$USG_{160}CD_5$	178.0±1.92d-h	26.4±1.70bc	212.9±3.87a-e	2.56±0.08def
$USG_{180}OC_1$	194.6±1.54abc	25.0±1.83bc	228.6±4.87a-d	3.00±0.15bcd
$USG_{180}OC_2$	208.3±7.39a	33.0±1.13a	247.3±8.05a	3.45±0.15a
$USG_{180}PM_2$	185.9±5.67c-g	28.3±0.82ab	214.9±5.52a-e	2.54±0.19def
$USG_{180}PM_3$	202.8±2.25ab	32.8±1.18a	238.3±7.36ab	3.10±0.16bcd
$USG_{180}CD_3$	185.2±6.86c-g	26.5±1.00bc	209.5±5.78b-e	2.45±0.15ef
$USG_{180}CD_5$	198.1±6.97abc	27.8±1.12bc	220.3±3.05a-e	2.60±0.09def
$PU_{180}OC_1$	168.6±6.12hij	24.3±1.30cd	202.5±5.65b-e	2.22±0.12ef
$PU_{180}OC_2$	199.8±4.56abc	28.5±0.87ab	234.9±5.90abc	2.66±0.12c-f
$PU_{180}PM_2$	172.7±2.31.g-j	22.7±0.79d	195.8±6.99de	2.30±0.17ef
$PU_{180}PM_3$	193.3±6.68a-d	26.1±1.29bc	211.1±4.07a-e	2.52±0.11def
$PU_{180}CD_3$	176.9±3.09-h	24.9±1.22cd	206.6±3.18b-e	2.46±0.09ef
$PU_{180}CD_5$	190.9±6.85b-e	26.5±1.03bc	219.1±4.58a-e	2.59±0.07def
CV (%)	5.33	7.61	3.95	9.31

Means followed by common letters are statistically similar to each other at 5% level of provability by DMRT

Phosphorus uptake

Application of nitrogenous fertilizer at higher rates significantly increased the P uptake and the highest value (33.0 kg ha^{-1}) was recorded with USG-N_{180}×OC_2 and USG-N_{160}×OC_2 being at par to USG-N_{180}×PM_3, PU-N_{180}×OC_2 and USG-N_{140}×OC_2. The lowest P uptake (22.2 kg ha^{-1}) was recorded with USG-N_{140}×PM_2. However, P uptake was found higher in the treatment where USG was applied with organic manure (Table 7). The major cause of variation in P uptake is due to the variation in yield of broccoli (Hussain *et al.* (2021). Similar result was found by Yoldas *et al*. (2008) as they reported that P concentration in broccoli heads were increased with increasing rates of N application. This higher P uptake might be the effect of N conversion to nitrate and subsequently this nitrate was absorbed by the root system creating a negative charge in root cells with charge equilibrium caused by cation absorption and consequently, P absorption by the plant increased (Moniruzzaman *et al*. (2007).

Potassium uptake

Potassium uptake increased with the increasing rates of nitrogenous fertilizer but similar K uptake (247.3 kg ha^{-1}) was recorded with USG-N_{180}×OC_2 followed by USG-N_{160}×OC_2 (247.0 kg).. The lowest K uptake (187.2 kg) was noted with USG-N_{140}×PM_2 treatment (Table 7). This was also due to the continuous supply and greater recovery percent of K fertilizer with USG-organic manure integration over PU. This result was supported by Yoldas *et al*. (2008) who reported that nitrogen application increased the K concentrations in broccoli heads. Similar results were also reported by Abdelrazzag (2002) and Magnusson (2002) with several vegetable crops. The possible reason for the higher K uptake was the conversion of N to nitrate in the soil solution and its absorption by the roots resulting a negative charge in root cells maintaining a charge equilibrium through cation absorption and consequently, K absorption by the plant increased (Moniruzzaman *et al*. (2007).

Sulfur uptake

It was observed that increasing levels of nitrogenous fertilizer significantly increased S uptake and the maximum S uptake (3.45 kg ha^{-1}) was recorded with USG-N_{180}× OC_2 followed by USG-N_{160}× OC_2 (3.24 kg). Here, the higher S uptake was found in the USG-treated plots rather than PU (Table 7) and S uptake was found greater with higher amount of organic manure. This might be due to the random supply and the greater recovery percent of S with the integrated application of USG-organic manure than PU. The higher N supply from USG synergistically induced a higher S uptake by the broccoli plant. Ali *et al.* (2009) reported that the total uptake of S ranged from 6 to 21 kg ha^{-1} with the application of dhaincha, mungbean residues, cowdung and poultry manure with 70% NPKS where higher uptake of nutrients by the crops was recorded compared to 70% NPKS application as fertilizer only.

Effect of organic and inorganic sources of nitrogen on **soil nutrient balance**

Nutrient balance has an important implication to maintain the total soil nutrients status for long-time and sustainable soil fertility (BARC, FRG'2005). The apparent nutrient balance in all the treated plots was found negative for N and K but a positive balance was observed in P and S. Zaman *et al.* (2008) found that the negative apparent NPKS balance in all the treatments composed of both organic and inorganic combination in rice.

Nitrogen balance

Nitrogen replenishment through chemical fertilizer and addition of organic manures either singly or in combination was not enough to balance N removal by crops because much of the applied N was lost from the soil. The N balance thus was very small but positive almost in all the treatment except treatment USG-N_{140} × OC_2 and USG-N_{160} × OC_2 which showed a little negative balance (Table 8). Nitrogen is subjected to loss through volatilization, denitrification, leaching and surface run-off during heavy rain; therefore, the theoretical balance of N in tropical soil may not be so useful, unless the subsequent crop utilizes the residual N of the previous crop. Non-symbiotic biological N fixation (BNF) was not taken under consideration. Without considering non-symbiotic BNF by the crop all treatments had more or less positive N balances except treatment USG-N_{140}×OC_2 and USG-N_{160} × OC_2 which showed a little negative balance. The negative N balances ranged between -3.8 to -11.8 kg ha^{-1} $season^{-1}$ (Table 8). The highest negative balance (-11.8 kg ha^{-1} $season^{-1}$) was obtained from USG-N_{140}×OC_2 with the higher initial crop growth followed by USG-N_{160} × OC_2 (-3.8 kg ha^{-1} $season^{-1}$). The results are also well accordance with Saha *et al.* (2003). Ali *et al.* (2009) reported a negative balance for N and K with the highest mining of K, while the balances for P and S were positive.

Table 8. Integrated effect of different forms and levels of organic and inorganic sources of nitrogen on apparent nitrogen balance on broccoli field (Nutrient input-output system)

Treatments	Input (N kg ha^{-1})			Output (N kg ha^{-1})			Apparent N balance (N kg ha^{-1})
	Inorganic source	Organic source	Total	Crop uptake	Loss	Total	
USG-N_{140}×OC1	114.5	25.5	180.0	167.6	-	167.6	12.4
USG-N_{140}×OC_2	89.0	51.0	180.0	191.8	-	191.8	-11.8
USG-N_{140}×PM_2	117.0	23.0	180.0	139.4	-	139.4	40.6
USG-N_{140}×PM_3	105.5	34.5	180.0	173.7	-	173.7	6.3
USG-N_{140}×CD_3	126.5	13.5	180.0	143.3	-	143.3	36.7
USG-N_{140}×CD_5	117.5	22.5	180.0	173.7	-	173.7	6.3
USG-N_{160}×OC_1	134.5	25.5	200.0	171.0	-	171.0	29.0
USG-N_{160}×OC_2	109.5	51.0	200.5	204.3	-	204.3	-3.8
USG-N_{160}×PM_2	137.0	23.0	200.0	159.9	-	159.9	40.1
USG-N_{160}×PM_3	125.5	34.5	200.0	188.8	-	188.8	11.2
USG-N_{160}×CD_3	146.5	13.5	200.0	158.1	-	158.1	41.9
USG-N_{160}×CD_5	137.5	22.5	200.0	178.0	-	178.0	22.0
USG-N_{180}×OC_1	154.5	25.5	220.0	194.2	-	194.2	25.9
USG-N_{180}×OC_2	129.0	51.0	220.0	208.3	-	208.3	11.7
USG-N_{180}×PM_2	157.0	23.0	220.0	185.9	-	185.9	34.1
USG-N_{180}×PM_3	145.5	34.5	220.0	202.8	-	202.8	17.2
USG-N_{180}×CD_3	166.5	13.5	220.0	185.9	-	185.2	34.8

Treatments	Input (N kg ha^{-1})			Output (N kg ha^{-1})			Apparent N balance (N kg ha^{-1})
	Inorganic source	Organic source	Total	Crop uptake	Loss	Total	
USG-N_{180}×CD_5	157.5	22.5	220.0	198.1	-	198.1	21.9
PU-N_{180}×OC_1	154.5	25.5	220.0	168.6	-	168.6	51.4
PU-N_{180}×OC_2	129.0	51.0	220.0	199.8	-	199.8	20.2
PU-N_{180}×PM_2	157.0	23.0	220.0	172.7	-	172.7	47.3
PU-N_{180}×PM_3	145.5	34.5	220.0	193.3	-	193.3	26.7
PU-N_{180}×CD_3	166.5	13.5	220.0	176.9	-	176.9	43.1
PU-N_{180}×CD_5	157.5	22.5	220.0	190.9	-	190.9	29.1

Note: Other sources of inputs (Biological N fixation, rain and irrigation water etc.) and output (Leaching loss, run-off, volatilization and denitrification loss etc.) were not considered here.

Phosphorus balance

The apparent P balance in soil resulting from different fertilizer management practices ranged from 20.0 to 30.8 kg ha^{-1} season^{-1} in different treatments (Table 9). The apparent P balance was found positive in all treatments. The highest apparent P balance (30.8 kg ha^{-1} season^{-1}) was recorded in the treatment USG_{140}× PM_2 due to lower uptake of nutrients as compared to other treatments. Basak (2002) also observed similar trend of nutrient balance in the groundnut - rice cropping pattern under irrigated nutrient management system. Ali *et al*. (2009) reported a negative balance for N and K with the highest mining of K, while the balances for P and S were positive with anapplication of 3 t ha^{-1} PM once in a year.

Table 9. Integrated effect of different forms and levels of organic and inorganic sources of nitrogen on apparent phosphorus balance on broccoli (Nutrient input-output system)

Treatments	Inputs (P kg ha^{-1})			Outputs (P kg ha^{-1})		Apparent P balance (P kg ha^{-1})
	Inorganic source	Organic source	Total	Crop uptake	Total	
USG-N_{140}×OC1	49.0	4.0	53.0	23.9	23.9	29.1
USG-N_{140}×OC_2	45.0	8.0	53.0	30.8	30.8	22.2
USG-N_{140}×PM_2	32.0	21.0	53.0	22.2	22.2	30.8
USG-N_{140}×PM_3	21.5	31.5	53.0	25.1	25.1	27.9
USG-N_{140}×CD_3	48.5	4.5	53.0	23.1	23.1	29.9
USG-N_{140}×CD_5	45.5	7.5	53.0	25.1	25.1	27.9
USG-N_{160}×OC_1	49.0	4.0	53.0	25.7	25.7	27.3
USG-N_{160}×OC_2	45.0	8.0	53.0	33.0	33.0	20.0
USG-N_{160}×PM_2	32.0	21.0	53.0	25.1	25.1	27.9
USG-N_{160}×PM_3	21.5	31.5	53.0	28.0	28.0	25.0
USG-N_{160}×CD_3	48.5	4.5	53.0	24.8	24.8	28.2
USG-N_{160}×CD_5	45.5	7.5	53.0	26.4	26.4	26.6

Treatments	Inputs (P kg ha^{-1})			Outputs (P kg ha^{-1})		Apparent P balance (P kg ha^{-1})
	Inorganic source	Organic source	Total	Crop uptake	Total	
USG-N_{180}×OC_1	49.0	4.0	53.0	26.0	26.0	27.0
USG-N_{180}×OC_2	45.0	8.0	53.0	33.0	33.0	20.0
USG-N_{180}×PM_2	32.0	21.0	53.0	28.3	28.3	24.7
USG-N_{180}×PM_3	21.5	31.5	53.0	32.8	32.8	20.2
USG-N_{180}×CD_3	48.5	4.5	53.0	26.5	26.5	26.5
USG-N_{180}×CD_5	45.5	7.5	53.0	27.8	27.8	25.2
PU-N_{180}×OC_1	49.0	4.0	53.0	24.3	24.3	28.7
PU-N_{180}×OC_2	45.0	8.0	53.0	28.5	28.5	24.5
PU-N_{180}×PM_2	32.0	21.0	53.0	22.7	22.7	30.3
PU-N_{180}×PM_3	21.5	31.5	53.0	26.1	26.1	26.9
PU-N_{180}×CD_3	48.5	4.5	53.0	24.9	24.9	28.1
PU-N_{180}×CD_5	45.5	7.5	53.0	26.5	26.5	26.5

Potassium balance

Unlike P, the apparent balance of K in soil was highly negative as influenced by the treatment combinations. The magnitude of the negative K balance ranged from -104.2 to -164.3 kg ha^{-1} season^{-1} (Table 10). Potassium replenishment through application of inorganic fertilizer and organic manures either singly or in combination was not enough to balance K removal by crops since the crops used much of the applied K and some of the K leached from the soil. This may lead to K depletion in the long run. These results confirmed the reports by Hunag Li. and Xie (1990), Prasad (1993) and Saha *et al.* (2003) indicating negative K balances and ongoing K depletion in many irrigated rice systems. Ali *et al*. (2009) reported that application of 3 t ha^{-1} PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers. There were negative balances for N and K with the highest mining of K, while the balances for P and S were positive. Ali *et al*. (2009) reported a negative balance for K with the highest mining of K with an application of 3 t ha^{-1} PM.

Table 10. Integrated effect of different forms and levels of organic and inorganic sources of nitrogen on apparent potassium balance on broccoli (Nutrient input-output system)

Treatments	Inputs (K kg ha^{-1})			Outputs (K kg ha^{-1})		Apparent K balance (K kg ha^{-1})
	Inorganic source	Organic source	Total	Crop uptake	Total	
USG-N_{140}×OC1	78.0	5.0	83.0	212.6	212.6	-129.6
USG-N_{140}×OC_2	73.0	10.0	83.0	238.3	238.3	-155.3
USG-N_{140}×PM_2	69.0	14.0	83.0	187.2	187.2	-104.2
USG-N_{140}×PM_3	62.0	21.0	83.0	205.9	205.9	-122.9
USG-N_{140}×CD_3	68.0	15.0	83.0	206.1	206.1	-123.1

Treatments	Inputs (K kg ha^{-1})			Outputs (K kg ha^{-1})		Apparent K balance (K kg ha^{-1})
	Inorganic source	Organic source	Total	Crop uptake	Total	
USG-N_{140}×CD_5	58.0	25.0	83.0	216.0	216.0	-133.0
USG-N_{160}×OC_1	78.0	5.0	83.0	215.5	215.5	-132.5
USG-N_{160}×OC_2	73.0	10.0	83.0	247.0	247.0	-164.0
USG-N_{160}×PM_2	69.0	14.0	83.0	193.9	193.9	-110.9
USG-N_{160}×PM_3	62.0	21.0	83.0	226.8	226.8	-143.8
USG-N_{160}×CD_3	68.0	15.0	83.0	200.5	200.5	-117.5
USG-N_{160}×CD_5	58.0	25.0	83.0	212.9	212.9	-129.9
USG-N_{180}×OC_1	78.0	5.0	83.0	228.6	228.6	-145.6
USG-N_{180}×OC_2	73.0	10.0	83.0	247.3	247.3	-164.3
USG-N_{180}×PM_2	69.0	14.0	83.0	214.9	214.9	-131.9
USG-N_{180}×PM_3	62.0	21.0	83.0	238.3	238.3	-155.3
USG-N_{180}×CD_3	68.0	15.0	83.0	209.5	209.5	-126.5
USG-N_{180}×CD_5	58.0	25.0	83.0	220.3	220.3	-137.3
PU-N_{180}×OC_1	78.0	5.0	83.0	202.5	202.5	-119.5
PU-N_{180}×OC_2	73.0	10.0	83.0	234.9	234.9	-151.9
PU-N_{180}×PM_2	69.0	14.0	83.0	195.8	195.8	-112.8
PU-N_{180}×PM_3	62.0	21.0	83.0	211.1	211.1	-128.1
PU-N_{180}×CD_3	68.0	15.0	83.0	206.6	206.6	-123.6
PU-N_{180}×CD_5	58.0	25.0	83.0	219.1	219.1	-136.1

Sulphur balance

The S balance was favorable as expected and considerable quantities of S were accumulated in the fertilized plots. The apparent positive S balance among the different treatments ranged from 16.5 to 17.8 kg ha^{-1} season^{-1} (Table 11). Treatments receiving both higher dose of organic manures and inorganic fertilizers showed higher nutrient uptake than that received lower organic and inorganic fertilizer. The highest positive S balance (17.83 kg ha^{-1} season^{-1}) was noted in treatment USG_{140}× PM_2. Basak *et al.* (2008) reported that S balance increased significantly in IPNS based treatment under Mustard - Boro rice - T. Aman rice cropping pattern. Ali *et al.* (2009) reported a positive balance for P and S with anapplication of 3 t ha^{-1} PM once in a year.

Table 11. Integrated effect of different forms and levels of organic and inorganic sources of nitrogen on apparent sulphur balance on broccoli field (Nutrient input-output system)

Treatments	Inputs (S kg ha^{-1})		Outputs (S kg ha^{-1})		Apparent S balance (S kg ha^{-1})
	Inorganic + organic source	Total	Crop uptake	Total	
USG-N_{140}×OC1	20.0	20.0	2.38	2.38	17.6
USG-N_{140}×OC_2	20.0	20.0	3.02	3.02	17.0

Treatments	Inputs (S kg ha^{-1})		Outputs (S kg ha^{-1})		Apparent S balance (S kg ha^{-1})
	Inorganic + organic source	Total	Crop uptake	Total	
USG-N_{140}×PM_2	20.0	20.0	2.17	2.17	17.8
USG-N_{140}×PM_3	20.0	20.0	2.68	2.68	17.3
USG-N_{140}×CD_3	20.0	20.0	2.37	2.37	17.6
USG-N_{140}×CD_5	20.0	20.0	2.61	2.61	17.4
USG-N_{160}×OC_1	20.0	20.0	2.43	2.43	17.6
USG-N_{160}×OC_2	20.0	20.0	3.24	3.24	16.8
USG-N_{160}×PM_2	20.0	20.0	2.38	2.38	17.6
USG-N_{160}×PM_3	20.0	20.0	2.73	2.73	17.3
USG-N_{160}×CD_3	20.0	20.0	2.45	2.45	17.6
USG-N_{160}×CD_5	20.0	20.0	2.56	2.56	17.4
USG-N_{180}×OC_1	20.0	20.0	3.00	3.00	17.0
USG-N_{180}×OC_2	20.0	20.0	3.45	3.45	16.6
USG-N_{180}×PM_2	20.0	20.0	2.54	2.54	17.5
USG-N_{180}×PM_3	20.0	20.0	3.10	3.10	16.9
USG-N_{180}×CD_3	20.0	20.0	2.45	2.45	17.6
USG-N_{180}×CD_5	20.0	20.0	2.60	2.60	17.4
PU-N_{180}×OC_1	20.0	20.0	2.22	2.22	17.8
PU-N_{180}×OC_2	20.0	20.0	2.66	2.66	17.3
PU-N_{180}×PM_2	20.0	20.0	2.30	2.30	17.7
PU-N_{180}×PM_3	20.0	20.0	2.52	2.52	17.5
PU-N_{180}×CD_3	20.0	20.0	2.46	2.46	17.5
PU-N_{180}×CD_5	20.0	20.0	2.59	2.59	17.4

Conclusion

From the above discussion it could be concluded that integration of organic and inorganic N sources have a little influence on soil physical and chemical properties of soil and its effects on soil nutrient balance. Post harvest soil organic carbon content was significantly influenced by the integration of organic-inorganic N management approach, but soil pH, bulk density and particle density were influenced a little. However, a significant influence was found on post harvest soil nutrient balance where K balance showed (-) ve but N (except a little), P, S and B showed (+) ve balance as affected by the integrated nitrogen management through organic-inorganic sources of N. Soil physical and chemical properties were slightly increased under higher rate of USG-organic manure as compared to PU-organic manure integration.

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