Effects of Organic and Inorganic Nutrient Sources on the Growth and Yield of Bottle Gourd

Abstract: Producing nutritious food is the ultimate objective of organic farming, since it helps in improving soil formation, nitrogen fixation, nutrient recycling, erosion mitigation, and carbon sequestration. An experiment was conducted at Nalanda College of Horticulture, Noorsarai, Nalanda during summer season of 2017 and 2018 to assess the effect of integrated and sole applications of organic and inorganic fertilizers on the growth and yield of bottle gourd under onion-onion-bottle gourd crop sequence. The experiment consists of seven treatments*viz.*,T_1-100%NPK through inorganic fertilizers (IFs) 120:60 and 40 Kg N:P_2O_5 and K_2O); T_2-50%NPK through IFs+50%N through farm yard manure (FYM); T_3-50% N through FYM+50% N through vermicompost (VC); T_4-1/3 of N each through FYM + VC + Neemcake (NC); T_5-50% N through FYM + PSB + Azotobactor; T_6-50% N through FYM+50% N through VC+PSB + azotobactor and T_7-1/3 of N each through FYM + VC + NC +PSB + azotobactor. These seven treatments were replicated thrice in Randomized Block Design. Results revealed that T_1-100%NPK through inorganic fertilizers recorded 222.3 q ha^{-1} fruit yield, which was statistically at par with T_2(192.3 q ha^{-1}). T_1 recorded maximum vine length followed by T_2 T_7 and T_6. After completion of the cropping system; onion-onion-bottle gourd, soils were subjected to analysis. EC, pH and soil organic carbon (SOC) didn't differ significantly.AvailableN, P and K also found non-significant due to different fertilizer and organic manure sources, but maximum available N was observed in 100% inorganic plots (T_1) followed by integrated (T_2) and 100 % organics (T_6) .Maximum P and K were observed in T_6. T_1-100% IFs sources recorded highest gross return (1.56 Lakh), net return (1.16 Lakh) and B: C ratio (2.87) followed by T_2. On the basis of result it has been concluded that T_2 having 50 % NPK through inorganic fertilizer + 50 % N through FYM may found suitable for sustainable bottle gourd production as it performed at par with T_1 in respect to crop growth and yield.

Keywords: Bottle gourd, FYM,Vermicompost, Neemcake, Inorganic fertilizer

Introduction

Organic farming methods now offer numerous benefits to the environment, community, and public health. Additionally, carbon sequestration, nutrient recycling, nitrogen fixation, erosion control, and soil formation are all enhanced by organic agriculture. Additionally, it provides more jobs in rural areas and food that is higher quality in terms of safety and nutritional value. To boost crop productivity, insecticides are employed as plant protection measures and fertilizers as a source of plant nutrients. However, excessive and unbalanced usage of these agrochemicals has severely contaminated the ecosystem.There is rising concern that vegetables grown under such conditions may not be high-quality or safe. Although bottle gourd (*Lagenariasiceraria* (Molina) Standl.) is a summer vegetable of great importance, they grow all year round in various parts of the India. It is extensively and widely grown in the Indian states of Bihar, Uttar Pradesh, Haryana, Madhya Pradesh, Chhattishgarh, Odisha, and Punjab. With a productivity of 25.4 tonnes ha^{-1}, Bihar is the most productive state in terms of both area (44.5 thousand hectares) and production (652.80 thousand tones) (DAFW, 2022-23). Regarding the enhancement of soil fertility and sustainable agriculture, the effects of organic and inorganic fertilizers are complimentary. Studies on several facets of its production techniques have been conducted all over the world, but few studies have been conducted on various organic nutrient sources.

"Nutrient availability is one of the many aspects of bottle gourd production that must be considered in order to get a higher crop yield. The bottle gourd exhibits a high response to nitrogen application and a moderate response to phosphorus application, as demonstrated by the experimental findings" (Meena and Bhati, 2017). "Farmers have been using a lot of synthetic fertilizers and pesticides to boost crop yields, which has led to a change in soil management approaches. Nonetheless, a balanced supply of plant nutrients is necessary for crop cultivation. The majority of bodily reactions involve vegetables, which are crucial parts of a human diet. "In high-input intensive agricultural production systems, the widespread use of pesticides has emerged as a dominant feature" (Tilman et al., 2002). "Like fertilizers, pesticides are considered an essential part of modern farming, and they can cause nutrient imbalance, increased soil acidity, degradation of the physical properties of the soil, and loss of organic matter" (Obi and Ofonduro, 1997 and Moyin-Jesu, 2007). As a result, the practice of providing all plant nutrients using chemical fertilizers needs to be reexamined due to its detrimental long-term effects on soil productivity. "It is essential to prioritize research into organic sources in light of the growing demand for organic products in the market. The residual effects of chemical compounds used in crop fields pose health risks and degrade the environment. Inorganic fertilizers and organic

manure are crucial for improving soil sustainability and productivity" (Chaudhary *et al.*, 2018). Since the amount of organic matter in a given soil determines its fertility, organic matter must be replenished in the soil through residue management or the provision of nutrients from organic sources.Considering the aforementioned variables, the current experiment was conducted to identify the best source and dosage of organic fertilizer for improved and sustainable bottle gourd production.

Materials and methods

Experimental Site and Soil

This experiment was conducted at Research Farm of Nalanda College of Horticulture Noorsarai (25.269606 °N, 85.457869°E)Nalanda Bihar during summer season of 2017- 2018. Nalanda College of Horticulture Noorsarai and fall under Zone III (b) of Bihar (Middle Gangetic Plain of India). The soil of the experimental plot was clay loam having 7.47 pH, 0.21 EC (dSm^{-1}) and 0.62 % soil organic carbon, 262 kg, 14.60 kg and 142 kg ha^{-1} available N, P and K, respectively. Soil pH (1:2.5 soil: water) was measured by glass electrode pH meter method **[Jackson, 1973],** and organic matter was determined by Walkley and Black method **[Walkley and Black 1934].** The content of total N was measured by semi-micro Kjeldahl method **[Bremner and Mulvaney 1982]** and available P was determined by Olsen method **[Olsen *et al.*, 1954].** The exchangeable K was determined by flame photometer after extraction with 1 N NH_4OAc at pH 7 **[Knudsen et al., 1982],** and available S was measured by extracting soil samples with $CaCl_2$ solution (0.15%) followed by measuring the turbidity by spectrophotometer **[Williams and Steinbergs, 1959].**

Experimental Details

The experiment consists of seven treatments *viz.*,T_1-100%NPK through inorganic fertilizers (IFs) 120:60 and 40 Kg N: P_2O_5 and K_2Oha^{-1}); T_2-50%NPK through IFs+50%N through farm yard manure (FYM); T_3-50% N through FYM+50% N through vermicompost (VC); T_4-1/3 of N each through FYM + VC + Neemcake (NC); T_5-50% N through FYM + PSB + azotobactor; T_6-50% N through FYM+50% N through VC;+PSB + azotobactor and T_7-1/3 of N each through FYM + VC + NC+PSB + azotobactor. Vermicompost (having 1.21%N, 0.61**%** P_2O_5 and 0.91**%** K_2O) and farm yard manure (having 0.45%N0.23**%** P_2O_5 0.42**%** K_2O) were produced at college farm and neem cake were purchased from the market (having 4.91%N, 1.0**%** P_2O_5 and 1.21**%** K_2O). These seven treatments were replicated thrice in Randomized Block Design

(RBD)having 15 square meters plot size.Among inorganic sources, urea, diamonium phosphate (DAP) and muriate of potash (MOP) were used while, well rotten farm yard manure (FYM), vermicompost (VC), neem cake (NC) and biofertilizers (15 ml per plot of 15 m^2) namely azotobactor and PSB were applied as per treatments.

Agronomic practices

"Recommended agronomical package of practices were followed excluding fertilizers and manures. Organic fertilizers were applied infield 10 days before sowing. It was uniformly spread in the plots and incorporated into the soil manually. Irrigation was given as per crop demand. Weeding was done manually at 25 days after sowing.Harvesting of matured fruit started as they attain maturity in each experimental plot on treatment basis, andobservations such as vine length, number of branches and number of fruits, fruit length and circumference, fruit weight per plot and yield per hectare were measured. After harvesting, soil samples were taken from each plot for routine laboratory analysis. Soil pH and EC" (Chopra and Kanwar, 1982), organic carbon determined by Walkley and Black's rapid titration method (Jackson, 1973). "The determination of available nitrogen was done by alkaline permanganate method" (Subbiah and Asija, 1956), available phosphorus by Olsen's (1954) method (Houba*et al.*,1988), and potassium by flame photometer described by Jackson(1973). The data collected on different aspect of experimentation, were analyzed with the analysis of variance technique given by Gomez and Gomez (1984). Economics of the treatments had been calculated on the local market price of the crop produce and the materials used.

Result and Discussion

Plant growth

Length of the vine and the number of branches are the key factors in bottle gourds that determine the fruit yield performance. Results (Table 1) revealed that, there were significant variations in vine length at 30, 60, and 90 DAS. The maximum vine length measured by T_1 at 30, 60 and 90 days after sowing (DAS) was 38.5, 378.0, and 498.8 cm respectively, which was statistically at par with T_2(34.7 cm, 353.0 cm and 477.2 cm) at all the crop growth stages. Number of branches didn't differs significantly at any crop growth stages, although maximum number of branches (2.3) was noticed in T_6 followed by T_7 , T_3, T_4 and T_1 at 30 DAS. Likewise, similar to 30 DAS T_6again recorded maximum number of branches (4.1)at 60 DAS also.Plants using organic

fertilizers showed significantly increased nutrient content and plant growth compared to control (Selvakumar*et al.,* 2022). Here in this experiment also, it isclearly observed from the Table 1 that, as the plant growth progressed, the number of branches found increased in organic treatments (T_6 and T_7) up to 60 DAS. During later growth stage (90 days after sowing) T_1 recorded maximum number of branches (5.4).

Yield attributes and yield

Fruit length differed significantly due to inorganic, integrated and organic fertilizer sources of nutrients. Results revealed that T_1-100%NPK through inorganic fertilizers (IFs), recorded maximum fruit length (34.1 cm). Although, T_2, T_3, T_6, and T_7, recorded statistically identical fruit length (32.3, 30.2, 31.7 and 31.2 cm) respectively. Maximum fruit length in $T_1$is observed due to quick supply of essential macro nutrients (NP and K) through inorganic fertilizers. Fruit circumference didn't differ significantly due to different treatments but were found maximum in T_1 (22.8 cm) followed by, T_2 (22.0 cm) and T_6 (21.5 cm). Fruit yield differed significantly due to inorganic, integrated and organic fertilizer sources. Results revealed that T_1-100%NPK through inorganic fertilizers (IFs), recorded maximum (222.3 q ha^{-1}) fruit yield, followed by T_2(integrated nutrient management) (192.3 q ha^{-1}). Integrated nutrient management ultimately contributes to continuous plant growth and fruiting (Ghimire *et al.,* 2023). Among organic fertilizer sources T_6 (184.7 q ha^{-1}) recordedhighest over rest of the organic sources. Singh *et al*. (2012) also"reported that application of VC with 50 % recommended dose of chemical fertilizer had a significant effect on growth and yield parameters of bottle gourd". Natsheh and Mousa (2014)"also found that compost application is the best management for increasing soil fertility yield and decrease the use of mineral nitrogenous fertilizers in cucumber".

Effects on soil properties

Soil chemical properties

"The effect of different treatments on soil chemical properties like pH, EC, SOC, available N, P and K after harvesting of bottle gourd shown in the Table-2. The maximum reduction in pH was noticed over initial value (7.47) in the plots receiving organic manures, although maximum pH was found in the plot receiving 100% inorganic fertilizers (T_1)" [29]. The maximum reduction in pH of soil in the plots receiving organic manures may be due to production of organic acids, during decomposition of organic manures which neutralize the sodium salts present in the soil

and increase the hydrogen ions concentration. Maurya and Ghosh, (1972); Swarup and Singh (1989) also reported "decrease in the soil pH by 0.3 to 0.9 unit after continuous application of chemical fertilizer along with green manure and FYM. EC did not differ significantly due to different treatments.T_1recorded highest value of EC (0.12 dS/m) which was found maximum over all the organically treated plots".Similar finding was also observed by (Chaudhary *et al.*,1992; Chaudhary *et al.,* 2018). Kumar and Yadav (1995) also reported that organic plus chemical fertilizer treatments decrease EC at faster rate than inorganic fertilizers alone. The maximum soil organic carbon (SOC) was found (0.64%) in T_6followed by T_7 and other organically treated plots, while the lowest SOC (0.61%) was found in T_1."Variations noticed in pH, EC and SOC due to different treatments didn't differ significantly because changing of soil chemical properties is a long-term process. Though, the improved organic matter content of soil in the treatment having organic manure is attributed to direct incorporation of the organic matter in the soil. Soil organic carbon reported" (Swarup and Yaduvanshi, 2000), significantly lower in inorganic fertilizer treatments as compared to the treatments involving fertilizer with organic sources.

Change in Available Nitrogen, Phosphorus and Potassium

"Manure contains many nutrients needed for crop production. Of these, nitrogen is one of the most important and is the most commonly added to soil for higher yield. Nitrogen undergoes many transformations in soil as it is used, re-used, and made available by soil microbes. Available N content in the soil didn't differ significantly due to different treatments but was recorded maximum (247.6 kg ha^{-1}) in the treatment T_1receiving 100% inorganic fertilizers. Although treatments (T_6) receiving 100% organic sources of nutrients estimated statistically identical N (245.8 kg ha^{-1}) content toT_1 followed by integrated sources of nutrients (T_2-50 % NPK through inorganic fertilizer sources + 50 % N through FYM (245.0 kg ha^{-1}).It may be due to application of FYM and Vermicompost. Since, organic manures are rich in organic matter that increased N content in those treatments where FYM and vermicompost were added. Similar finding were also observed by Sharma and Ghosh (2000). Lowest available phosphorus (Table 2) was noticed in T_5-50 % N through FYM + PSB + Azotobactor(31.78 kg ha^{-1}) while highest P was observed in all those treatment where biofertilizers were applied along with organic manure such as FYM, VC and NC. The maximum build-up of available phosphorus (36.91 kg ha^{-1}) was observed under the treatment T_6 followed by T_7. Increased availability of phosphorus in soil

under treatments may be by increased solubility due to production of organic acids. Similar finding was also observed" by Bhandari *etal.*, (1992); Kumar*et al.*, (2001). The available k content in the soil didn't differ significantly but observed maximum in T6 (181.6) followed by T_1(100% inorganic sources) and T_2(50% inorganicfertilizers+ 50% N through FYM). "The beneficial effects of FYM, Vermicompost and neemcakeonavailable K may be ascribed to the reduction of fixation and release of K due to the interaction of organic matter with clay, besides the direct K addition to the available K pool of the soil. Increase in available potassium due to green manure and FYM was reported by many workers"(Bharadwaj and Omanwar, 1994); Tolanur and Badanur, 2003).

Economics

Economic studies have also been performed (Table 1) which was found highly variable due to different fertilizers and manure sources. Cost of organic manures estimated more as compared to inorganic sources of fertilizers, consequently cost of cultivation in organically treated plots observed relatively high. Results revealed that highest gross return (lakh ha^{-1}), net return (lakh ha^{-1}) and B:C ratio was recorded in T_1-100 % inorganic fertilizer sources (Rs. 1.56, Rs. 1.16 and 2.87 respectively, followed by T_2-50%NPK through inorganic fertilizer +50%N through FYM (Rs. 1.34, Rs. 0.89 and 1.97). Among 100% organics, T_6-50% N through FYM and 50% N through VC +biofertilizers (PSB and azotobactor) recorded highest gross return (Rs 1.29 lakh ha^{-1}), net return (0.73 lakh ha^{-1}) and benefit: cost ratio (1.29) followed by T_7. Since all of the manures utilized in this experiment were bought from the local market, the lowest cost of inorganic fertilizers relative to organic manures may have contributed to the highest net return, which was seen in T_1 and T_2. The reason for the low B:C ratio in organically treated plots is the higher cost of organic manures bought from the nearby market and the similar selling price of products produced organically compared to those produced in inorganically treated plots.

Conclusion

On the basis of result it has been concluded that T_2 having 50 % NPK through inorganic fertilizer + 50 % N through FYM may found suitable for sustainable bottle gourd production as it performed at par with T_1 in respect to crop growth and yield.

Table 1 Vine length, number of branches, yield and economics (Rs. Lakh ha^{-1}) of bottle gourd as influenced by the application of organic and inorganic fertilizer sources in onion-onion-bottle gourd crop sequence (pooled mean of two years).

Treatments	Wine length (cm)			No. of Branches			Fruit length (cm)	Fruit circumference (cm)	Yield (q ha^{-1})	Gross return (Rs.)	Net return (Rs.)	Benefit : Cost Ratio
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS						
T_1	38.5	378.0	498.8	1.6	3.5	5.4	34.1	22.0	222.3	1.56	1.16	2.87
T_2	34.7	353.0	477.2	1.4	3.2	4.4	32.3	22.8	192.3	1.34	0.89	1.97
T_3	32.7	303.4	430.6	1.7	3.6	4.7	30.2	20.4	164.2	1.15	0.62	1.15
T_4	32.1	309.6	466.9	1.7	3.6	4.6	29.2	21.4	146.5	1.03	0.50	0.97
T_5	30.5	240.9	393.7	1.5	3.1	4.2	29.1	21.2	103.4	0.72	0.27	0.58
T_6	33.9	325.2	452.3	2.3	4.1	4.6	31.7	21.5	184.7	1.29	0.73	1.29
T_7	33.4	335.7	459.3	2.0	3.8	4.8	31.2	21.3	167.9	1.18	0.63	1.13
SEm±	3.6	31.3	45.7	0.8	0.6	0.7	2.2	2.1	15.1	-	-	-
C D at 5%	7.8	68.2	99.6	NS	NS	NS	4.7	NS	32.9		-	-

NS-Non significant, DAS- days after sowing

Table 2. pH, EC, OC, available N, P and K as influenced by the application of different organic and inorganic fertilizer sources in bottle gourd after crop harvest in onion-onion-bottle gourd crop sequence(pooled mean of two years).

Treatments	pH (1:2)	EC (dS/m)	SOC (%	Available N (Kg ha^{-1})	Available P (Kg ha^{-1})	Available K (Kg ha^{-1})
T_1	7.53	0.21	0.61	247.6	35.94	180.5
T_2	7.39	0.19	0.62	245.0	33.105	175.8
T_3	7.29	0.18	0.63	238.4	34.91	174.4
T_4	7.38	0.19	0.63	255.7	33.68	165.6
T_5	7.34	0.17	0.63	235.4	31.78	157.2
T_6	7.36	0.19	0.64	245.8	36.915	181.6
T_7-	7.38	0.18	0.63	238.7	36.345	166.9
SEm±	0.13	0.03	0.04	10.5	4.395	11.1
C D at 5%	NS	NS	NS	28.6	NS	NS

T_1-100%NPK through inorganic fertilizers (IFs) 120:60 and 40 Kg N: P_2O_5 and K_2O); T_2-50%NPK through IFs+50%N through Farm yard manure (FYM); T_3-50% N through FYM+50% N through VC; T_4-1/3 of N each through FYM + VC + neemcake; T_5-50% N through FYM + PSB + azotobactor; T_6-50% N through FYM+50% N through VC;+PSB + azotobactor and T_7-1/3 of N each through FYM + VC +

NC+PSB + azotobactor.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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