The Bioscan 13(1): 267-271, 2018 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

INTEGRATED NUTRIENT MANAGEMENT EFFECT ON YIELD AND QUALITY OF BRINJAL (*Solanum melongenal* L.)

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KEYWORDS
Biofertilizers
Organic manures
Growth
Yield Brinjal

Received on :
22.01.2018

Accepted on :
18.03.2018

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ABSTRACT
An experiment with the effect of integrated nutrient management on the yield of brinjal was conducted. Among different levels of fertilizers in combination with organic manures and biofertilizers the maximum plant height (95.17 cm), plant spread (83.49 cm), days to 50 per cent flowering (41.78), days to first picking (61.22), fruit diameter (81.57 mm), number of fruits per plant (11.49), fruit yield per plant (2.31 kg), fruit yield per hectare(54.55 t ha^{-1}), shelf life (8.67 days), TSS (5.17°Brix), average fruit weight (196.20 g) and fruit length (102.30 mm) were recorded with the combined application of 75 per cent RDF + biofertilizers + farm yard manure.These results suggested that the optimum production of brinjal can be obtained with integrated application of 75 per cent RDF + farm yard manure + biofertilizers. The use of biofertilizers along with organic manures (FYM) with the reduced quantity of chemical fertilizers is therefore recommended for better yield of brinjal

INTRODUCTION

Brinjal (*Solanum melongena* L.) popularly known as egg plant belongs to family Solanaceae and India is its center of origin and diversity (Vavilov, 1931 and Bahaduri, 1951). Brinjal fruit contains high amount of carbohydrates (6.4%), protein (1.3%), fat (0.3%), calcium (0.02%), phosphorus (0.02%), iron (0.0013%) and other mineral matters. Apart from these, it also contains β-carotene (34 mg), riboflavin (0.05 mg), thiamine (0.05 mg), niacine (0.5 mg) and ascorbic acid (0.9 mg) per 100 g of fruit (Choudhary, 1976). The brinjal plant contains an alkaloid called "solanine" found in roots and leaves.

Now-a-days demand for brinjal as a fruit vegetable is increasing rapidly among the vegetable consumers in view of its better fruit colour, size and taste. Average productivity of brinjal crop is quite low and there exists a good scope to improve its average productivity in India and Karnataka in particular to fulfill both domestic and national needs. The productivity of brinjal can be increased by using several techniques *viz*., Organic farming, Integrated Nutrient Management, good hybrid seeds and biofertilizers. Biofertilizers are inputs containing micro-organisms capable of mobilizing native elements from nonusable form to usable form through biological processes. However, the use of expensive commercial fertilizers as per a requirement of the crop is not much affordable to the average farmers. Therefore, the application of plant nutrients through organic sources likes compost, farm yard manure and bio fertilizers remain the alternative choice of the growers for maintaining its sustainable production (Choudhary *et al*., 2015). Vermicompost also plays an important role in increasing soil fertility level in diverse manner. There are abundant evidences to show that the exchangeable calcium, magnesium and available N, P is higher in earthworm casts (vermicompost) (Chaterjee *et al*., 2013).

Vermicompost applied at 5t/ha either individual or in combination with FYM enhanced the growth, yield and food quality of eggplants (Vijaya and Seethalakshmi, 2011). According to Graff (1970), the earthworm castings enrich the plant nutrients in soil. Nielson (1985) has reported the presence of plant growth promoting compounds, synthesized by the earthworms and secreted by them into their cast and thus into soil (Salroo *et al*., 2002 and Yasari, 2006). So from the above facts we can conclude that crops grown with integrated nutrient management techniques are nutritionally and environmentally superior to those fertilized with inorganic forms of nutrients. Therefore, the objectives of the study was to assess the effect of FYM, RDF, vermicompost, biofertilizers on brinjal in terms of growth and yield, soil health parameters and the economies of different treatments.

MATERIALS AND METHODS

The investigation was carried out at experimental farm of Department of Agriculture, Mata Gujri College, Fatehgarh Sahib Punjab during Kharif season of 2015 to evaluate the performance of brinjal under different nutrient management practices. The experiment was laid out with Navkiran variety in a Randomized Block Design (RBD) with 3 replications and 9 treatment combinations given in table 1.

Soil characteristics

Soil samples were collected randomly from different spots from a depth of 0-15 cm from unmanured field to judge the

fertility status of the soil before laying out the experiment. Then composited sample was prepared which was analyzed for various soil characteristics in order to get information about the nutrient status of the soil. The different determined parameters are given in the table 2

Dose of fertilizers

The recommended doses of nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) are 125, 63 and 30 kg ha^{-1}, respectively as recommended by Punjab Agriculture University, Ludhiana for brinjal (Anonymous, 2015).

OBSERVATIONS RECORDED

Parameters as per brinjal descriptor

Growth Parameters

Days to 50% flowering
Days to first fruit picking
Plant height (cm)
Plant Spread (cm)
Harvest duration (days)

Yield Parameters

Average fruit weight (g)
Fruit length (mm)
Fruit diameter (mm)
Number of fruits $plant^{-1}$
Fruit yield (kg $plant^{-1}$)
Fruit yield (kg $plot^{-1}$)
Fruit yield (t ha^{-1})

Quality Parameters

Shelf life (days)
Total soluble solids (ºBrix)
Ascorbic acid (mg 100 g^{-1})

Soil Chemical Properties

Available nitrogen (kg ha^{-1})
Available phosphorus (kg ha^{-1})
Available potassium (kg ha^{-1})
pH
Organic carbon (%)

Statistical analysis

The statistical analysis was done as per design of the experiment as suggested by Panse and Sukhatme (1967). The interpretation of result is based on 'F' test. The critical difference (CD) was worked out for significant treatments. Total variance was portioned into different sources of variation as shown in analysis of variance mentioned in table

RESULTS AND DISCUSSION

Effect on Growth Attributes

The growth attributes like days to 50% flowering, days to first fruit picking, plant height (cm), plant spread (cm) evident from the data presented in table 3 was found statistically at par with T_9 *i.e.* 75% RDF + vermicompost + biofertilizers. An application of T_8 recorded significantly minimum number of days to 50 per cent flowering (41.78). The reason behind the earliness in flowering might be due to accelerated photosynthesis and rapid translocation of photosynthesis towards initiating flower buds in early flowering (Ademola and Agele, 2015), minimum days (61.22) to first picking was again recorded with T_8 (75% RDF + FYM + biofertilizers) followed by T_9 (61.55) i.e. 75 per cent RDF + vermicompost + biofertilizers and further followed by T_6 *i.e.* 75 per cent RDF + FYM with value of 61.89 days. This increase in temperature and the higher amounts of potassium may be responsible for acceleration of the onset of flowering and hence resulted in early picking (Zahra, 2014). These findings are in accordance with Naidu *et al.* (2009) and Ademola and Agele (2015).

Maximum plant height (95.17 cm) was recorded with T_8 followed by T_9 with the value of 94.39 cm. The findings are in line with Kumar *et al.* (2013) and Tekasangla *et al.* (2015) who reported that maximum plant height in broccoli and cauliflower respectively with the application of integrated nutrient sources. Kumar *et al.* (2014) and Fawzy *et al.* (2012) recorded increase in the plant height with combined application of organic and inorganic manures.

Maximum plant spread (83.49 cm) was found for treatment T_8 which was statistically at par with T_9 (82.96 cm) and are in line with Hadwani *et al.* (2013) who reported that this might be due to better nutrient uptake, photosynthesis, besides excellent physiological and biochemical activities due to presence of *Azotobacter* and PSB. Anitha *et al.* (2016) recorded significant increase in plant spread with the application of nutrients in integrated manner in fenugreek. Minimum plant spread was recorded in the plots which were given no treatment.

Effect on Yield Attributes

Average fruit weight (g), fruit length (mm), fruit diameter (mm), number of fruits $plant^{-1}$, fruit yield (kg $plant^{-1}$), fruit yield (kg $plot^{-1}$), fruit yield (t ha^{-1}) were progressively enhanced by the T_8 (75% RDF + FYM + biofertilizers) which was statistically at par with T_9 *i.e.* 75% RDF + vermicompost + biofertilizers and is tabulated in table 3. The maximum fruit weight (196.20 g)

Table 1: Details of treatments

Treatment	Treatment Combination
T_1	Control
T_2	Vermicompost (5 t ha^{-1})
T_3	FYM (20 t ha^{-1})
T_4	100% RDF
T_5	75% RDF + Biofertilizers (5 kg ha^{-1})
T_6	75% RDF + FYM
T_7	75% RDF + Vermicompost
T_8	75% RDF + FYM + Biofertilizers (5 kg ha^{-1})
T_9	75% RDF + Vermicompost + Biofertilizers (5 kg ha^{-1})

Table 2 : Initial fertility status of soil

Particulars	Values obtained	Method employed
Soil texture	Sandy loam	International pipette method (Piper, 1966)
Soil pH	7.9	1:2 soil: water suspension, with the help of digital pH meter (Jackson, 1973).
Soil organic carbon	0.81	Walkey and Black method (1934).
Available nitrogen (kg ha^{-1})	224.15	Alkaline potassium permanganate method of Subbiah and Asija (1956).
Available phosphorus (kg ha^{-1})	23.67	Olsen *et al.* (1954).
Available potassium (kg ha^{-1})	123.18	Ammonium acetate method of Merwin and Peach (1951).

Table 3 : Effect of Integrated Nutrient Management on growth and fruit characters of Brinjal

Treatments	Days taken to 50% flowering	Days taken to first picking	Plant height (cm)	Plant spread (cm)	Average fruit weight (g)	Fruit Length (mm)	Fruit width (mm)	Number of fruits plant^{-1}	Fruit yield plant^{-1} (kg)	Fruit yield plot^{-1} (kg)	Fruit yield hectare^{-1} (t)	Shelf life (Days)	TSS (°Brix)	Ascorbic acid (mg 100 g^{-1})
T_1: Control	42.77	64.22	78.36	73.14	145.07	80.53	77.93	6.78	0.98	14.75	23.21	5.33	4.10	4.20
T_2: Vermicompost	42.66	63.77	81.28	74.18	166.09	85.20	76.30	8.55	1.42	21.31	33.55	6.00	4.17	6.40
T_3: FYM	42.55	63.33	80.73	75.32	169.68	82.70	80.70	8.22	1.39	20.92	32.92	6.33	4.20	6.11
T_4: 100 % RDF	42.33	63.00	87.88	79.89	178.57	84.17	80.47	9.44	1.69	25.29	39.81	8.00	4.77	7.39
T_5: 75 % RDF + Vermicompost	42.22	62.11	91.10	77.70	185.69	91.37	78.40	10.11	1.88	28.14	44.29	7.33	4.53	7.06
T_6: 75 % RDF + FYM	42.11	61.89	85.21	81.17	188.96	97.00	77.50	10.22	1.93	28.96	45.59	8.33	4.87	7.53
T_7: 75 % RDF + Biofertilizers	42.22	62.44	83.92	78.40	173.43	83.53	80.40	9.77	1.69	25.42	40.02	6.67	4.37	7.93
T_8: 75% RDF + FYM + Biofertilizer	41.78	61.22	95.17	83.49	196.20	102.30	81.57	10.89	2.12	31.74	49.96	8.67	5.17	9.04
T_9: 75% RDF + Vermicompost + Biofertilizers	41.89	61.55	94.39	82.96	194.32	92.13	76.50	10.33	2.03	30.41	47.86	8.33	5.07	8.60
SE(m)	0.16	0.13	0.49	0.40	0.98	0.73	0.60	0.27	0.05	0.78	1.23	0.38	0.04	0.15
$CD_{(0.05)}$	0.47	0.40	1.36	1.19	2.94	2.19	1.80	0.80	0.16	2.34	3.68	1.15	0.13	0.44

was observed in T_8 followed by T_9 (194.32 g) and T_6 (188.96 g) and are supported by (Lal and Kanaujia (2013) and Kumar *et al.(*2015).

The mean performance of different treatments showed that maximum fruit length 102.30 mm was found with T_8 followed by T_6 and T_9 with respective values 97.00 mm and 92.13 mm. On the other hand, minimum value of fruit length (80.53 mm) was recorded in T_1 (control). Maximum fruit diameter (81.57 mm) was recorded in T_8 which was statistically at par with T_3 (80.70 mm) and T_4 (80.47 mm). However, minimum fruit diameter (76.30 mm) was recorded in T_2 (Vermicompost) which are in line with the studies of (Chumei *et al.,* 2013). Thirunavukkarasu and Balaji (2015) also observed increase in fruit size of okra with combined application of nutrient sources.

Maximum number of fruits plant^{-1} (10.89) was observed in T_8 and was statistically at par with having 10.33 number of fruits plant^{-1} with the mean performance of different treatments. Increased number of fruits per plant may be obtained due to the plants receiving the integrated nutrient input could be attributed to synergistic effect of organic and inorganic resources Sileshi *et al.* (2011) and Anjanappa *et al.* (2012). More number of fruits per plant and fruit weight per plant ultimately results in more fruit yield. Chattoo *et al.* (2011), Tandel *et al.* (2010) and Fawzy *et al.* (2012) recorded higher yields with the application of combined nutrients. The same trend was found with maximum fruit yield and was recorded (2.12 kg) in T_8 found statistically at par with T_9 having fruit yield 2.03 kg and the minimum fruit yield plant^{-1} (0.98 kg) with T_1 (control). This could be due to the influence of biofertilizers in combination with NPK and FYM which enhanced the synthesis of photosynthates by increasing the synthesis of growth regulators like IAA, GA, amino acids and vitamins (Anjanappa *et al.,* 2012).

Maximum shelf life (8.67 days) was recorded in T_8 was at par with T_9 (8.33 days), T_6 (8.33 days) and T_4 (8.00 days).The possible reason for better shelf life may be due to low respiration and transpiration rates, resulting in a reduced level of shrinkage and reduced ethylene metabolism (Chatterjee *et al*., 2013). Mittal *et al*. (2010) recorded a significant increase in shelf life of African marigold with the application of RDF with vermicompost and biofertilizers. The findings of Chaurasia *et al*. (2001) and Hadwani *et al*. (2013) are in line with the present results whereas maximum total soluble solids (5.17 °Brix) was obtained in T_8 at par with T_9 and T_6 having values 5.07 and 4.87 °Brix, respectively. Results obtained by Patel *et al*. (2011), Lal and Kanaujia (2013) and Kumar *et al*. (2014) are in conformity with the present findings.

Maximum ascorbic acid content (9.04 mg) was recorded in T_8 whereas minimum (4.20 mg 100 g^{-1}) was recorded in T_1 (Control). This may be due to the slow but continuous supply of all major and micro nutrients, which might have helped in the assimilation of carbohydrates and in turn synthesis of ascorbic acid (Jaipaul *et al*., 2011). Chumei *et al*. (2013) and Kumar *et al*. (2014) also recorded higher content of ascorbic acid in the brinjal fruits which were cultivated through integrated nutrient management techniques.

Effect on Soil characters

In context with pH and organic carbon, results were found

Table 4: Effect of Integrated Nutrient Management on Soil Characters and Yield of Brinjal

Treatments	Organic Carbon(%)	pH	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Yield (t ha^{-1})
T_1: Control	0.8	7.9	213.65	19.18	115.44	23.21
T_2: Vermicompost	0.8	7.8	233.6	23.03	128.65	33.55
T_3: FYM	0.8	7.9	232.34	21.87	130.44	32.92
T_4: 100 % RDF	0.81	8.03	229.69	26.03	126.73	39.81
T_5: 75 % RDF +Vermicompost	0.81	7.7	235.15	28.47	132.61	44.29
T_6: 75 % RDF + FYM	0.8	7.8	237.17	28.89	134.08	45.59
T_7: 75 % RDF + Biofertilizers	0.81	7.9	240.36	27.41	131.57	40.02
T_8: 75% RDF + FYM + Biofertilizer	0.82	7.8	244.58	29.73	136.94	49.96
T_9: 75% RDF + Vermicompost + Biofertilizers	0.82	7.8	248.26	30.9	135.68	47.86
SE(m)	0.02	0.16	1.36	0.65	0.76	
$CD_{(0.05)}$	NS	NS	4.06	1.94	2.29	

non significant. pH also slightly moved towards the neutrality in the plots treated with combination of organic and inorganic nutrients which indicated that use of organic amendments have positive influence on soil health. The net increase in organic carbon might be due to the combined application of organic manures, inorganic fertilizers and biofertilizers (Lal and Kanaujia, 2013). The present results are in accordance with Jaipaul *et al*. (2011), Vijaya and Seethalakshmi (2011) and Thingujam *et al*. (2016).

Influence of difference on N and P content of the soil indicated that treatment combination T_9 (75% RDF + biofertilizers + vermicompost) registered maximum N (248.26 kg ha^{-1}) as well as P (30.90 kg ha^{-1}) content. These findings are found relevant by Sheikh and Dwivedi (2017) for nitrogen studies and Chetri *et al*. (2012) expressed their similar views for the increase in nitrogen and phosphorus in soil after harvesting of brinjal crop. In terms of K, maximum available K (136.94 kg ha^{-1}) was observed in T_8 (75% RDF + FYM + biofertilizer) which was statistically at par with T_9 (75% RDF + vermicompost + biofertilizer) having 135.68 kg potassium hactare^{-1}. FYM application might have reduced the solubility of aluminium & iron and improved the cation exchange capacity (CEC) of the soil and thus increased the retention of K in exchangeable form by a mass action effect (Chumei *et al.,* 2013). Similar views were expressed by Lal and Kanaujia (2013). Results of Prativa and Bhattarai (2011) are in accordance with our present findings. The studies of soil characters are plotted in table 4.

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