International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; SP6: 438-442

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(Special Issue -6)
3rd National Conference
On
PROMOTING & REINVIGORATING AGRI-HORTI, TECHNOLOGICAL INNOVATIONS [PRAGATI-2019]
(14-15 December, 2019)

Influence of integrated nutrient management on brinjal (*Solanum melogena* L.) cv. Kashi Sandesh

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Abstract
The present investigation was conducted under field conditions at Horticultural Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221 005 (Uttar Pradesh) during *kharif* season 2016. The investigation was laid out in randomized block design with three replications. The data on different parameters recorded from seven randomly selected plants for each treatment in each replication**.** The investigation comprised ten *viz.,* 100% NPK (180:80:80), 75% NPK (135:60:60) + VC (25 t per ha), 75% NPK (135:60:60) + FYM (25 t per ha), 75% NPK (135:60:60) + Azotobacter 2 kg per ha, 75% NPK (135:60:60) + PSB 2 kg per ha, 50% NPK (90:40:40) + VC (25 t per ha) + FYM (25 t per ha), 50% NPK (90:40:40) +VC (25 t per ha) + Azotobacter 2kg per ha, 50% NPK (90:40:40) + FYM (25 t per ha) + Azotobacter 2kg per ha, 25% NPK (45:20:20) +VC (25t per ha) + FYM (25t per ha) + Azotobacter 2 kg per ha + PSB 2 kg per ha and control (water spray). The sowing of brinjal cv. Kashi Sandesh was done on 25th July 2016, and transplanting was done on 30th August, 2016 *kharif* season in rows of raised beds. Row to Row and plant to plant spacing were maintained 60 × 60 cm respectively. On the basis of finding of the present investigation with different treatment combinations of different level of NPK, organic manure and bio-fertilizers on vegetative growth, yield and yield attributes in brinjal cv. Kashi Sandesh, it can be concluded that application of 25% NPK + VC + FYM + *Azotobacter* + PSB is more conductive for better growth, development and yield of brinjal than other treatments, which gave the maximum number of primary branches (7.14), secondary branches (7.11) per plant, leaf length (18.33 cm), leaf breadth (13.33 cm), stem diameter (1.35 cm), fruit diameter (9.20 cm), fruit set (72.78%), fresh fruit weight (374.56 g), number of fruits per plant (16.14), fruit yield per plant (1.82 kg), yield per ha (172.04 q) and also gave minimum days to 50% flowering (57.0 days), 1st bud appearance (55.67 days) and 1st edible harvesting (73.67 days) whereas, treatment 50% NPK + VC + FYM gave maximum plant height (72.90 cm) and minimum days to 1st flower appearance (36.83 days). The maximum fruit length (10.56 cm), peduncle length (5.68 cm) and number of tertiary branches per plant (3.87) was recorded under treatment 50% NPK + VC + *Azotobacter.*

Keywords: Brinjal, solanaceae, nutrient, fertilizers and *azotobacter*

Introduction
Vegetables occupy the most important place next to cereals and milk. It has been well advocated in solving food and nutritional problem. Our world population is continuously expanding and estimated to be around 9 billion in 2050. An estimated 2 billion people suffer from malnutrition due to lack of vitamins and essential minerals in their food. Vegetables are good source of carbohydrate, vitamins and minerals particularly calcium, iron and magnesium and these are essential for nourishment and help to generate immunity against various diseases. An interesting point to note about vegetables is that one hectare of vegetable crop produces much more calories than cereals (Muthukumar, 2013) [11]. Brinjal, also known as

eggplant or aubergine (*Solanum melongena* L.) is one of the important vegetable crops grown all over the country and throughout the year for its tender fruits. The name eggplant is derived from the shape of the fruit of some varieties, which are white in colour and similar in shape to chicken eggs. It belongs to the family solanaceae with diploid chromosome number 24. Several advanced cultivars and numerous landraces are cultivated in India for their young, unripe fruits, which are consumed fresh, dried or pickled (Swarup, 2010) [17]. In India, it is one of the most common and versatile crops adapted to different agro climatic regions and can be grown throughout the year right from sea level to snowline for its immature, unripe fruits which are used in a variety of ways as cooked vegetable and in curries (Singh *et al.*, 2014) [16]. Many brinjal varieties produce fruits with a wide diversity of shapes, sizes and colours (Kashyap *et al.*, 2003 and Kantharajah and Golegaonkar, 2004) [8, 7]. Brinjal has been a staple vegetable in many tropical countries since ancient times. White brinjal is said to be good for diabetic patients. Taking brinjal fried in til oil can cure tooth ache. It has also been recommended as an excellent remedy for those suffering from liver complaints (Chauhan, DVS, 1981) [3]. Brinjal reduce the risk of cancer, cardiovascular diseases, pre-menstrual syndrome, amenorrhea, antenatal anemia and cholesterol. They also soak injurious chemicals, enable weight loss and manage diabetes. Finally, the leaves, stem, fruit and roots of egg plants are used for food, fuel, rituals, decoration, and to cure diseases.

Chemical fertilizers supply only one or two nutrient elements to the crop. Moreover, the ever increasing prices of these fertilizers have discouraged the poor hill farmers to invest on these costly inputs. The integrated use of chemical fertilizers, FYM and bio-fertilizers and other organic hold great promise in securing high level of crop productivity and also to protect soil health from deterioration and pollution hazards (Meena *et al*., 2017) [10]. Bio-fertilizers are microbial inoculants. The complementary use of chemical fertilizers, organic manures, biofertilizers and other organics is important to maintain and sustain a higher level of soil fertility and crop productivity. Application of biofertilizers help in improving number of biological activities of desired microorganisms in soil and helps to improve plant growth and yield. Certain microbes have the capacity to fix atmospheric N; some other microbes increase availability of some nutrients such as P, S, Mn and Zn. They also stimulate the plant growth by producing bioactive compounds in the soil. Further, bio-fertilizers are the non-bulky and cheap sources of nutrients and may prove cost effective and eco-friendly supplementation in vegetable farming (Chen, 2006) [4].

Use of bio-fertilizer to meet the nutrient requirement of the crop would be inevitable practices in the years to come for sustainable agriculture. Since bio-fertilizers containing live and latent cell of efficient strain of nitrogen fixing, Phosphate solubilizing or cellulolytic microorganism are used to soil or seedling treatment with the objective to augment the availability and access of nutrient to the plant (Sahu *et al.*, 2014) [15]. *Azotobacter* plays an important role in the nitrogen cycle in nature as it possesses a variety of metabolic functions (Sahoo *et al*., 2013) [14]. Phosphate solubilizing bacteria (PSB) were playing a significant role in phosphorous mobilizing in the soil through solubilizing the inorganic phosphates which is not available to the plant. In case of bio-fertilizers, combined inoculation of *Azotobacter* + phosphorus solubilizing bacteria (PSB-*Bacillus polymyxa*) was found most effective over their sole inoculation and control (Khan *et al*., 2008) [9]. Thus, the study on the integrated use of chemical fertilizers, bio-fertilizers and organic materials in the current concern on sustainability seems obvious. Therefore, the present study was undertaken to find out Impact of integrated nutrient management in brinjal (*Solanum melogena* L.) cv. Kashi Sandesh.

Materials and Methods

The investigation entitled "Influence of integrated nutrient management on brinjal (*Solanum melogena* L.) cv. Kashi Sandesh" was conducted under field conditions at Horticultural Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221 005 (Uttar Pradesh) during *kharif* season 2016. Varanasi city is geographically situated at $25^0$15' North latitude and $83^0$03' East longitude. The altitude of the location is about 129.23 meter above mean sea level and it is located in the center of Indo Gangetic plains. The investigation was laid out in randomized block design with three replications. The data on different parameters recorded from seven randomly selected plants for each treatment in each replication. The treatments comprised of four levels of NPK (25%, 50%, 75% and 100% RDF), two organic manure (Farm yard manure and Vermicompost) and also in combination with two bio-fertilizers (*Azotobacter* and Phophorus Solubizing Bacteria) and control. The standard recommended dose of fertilizers was used 180 kg per ha nitrogen, 80 kg per ha phosphorus and 80 kg per ha potassium. The treatment detail are as followed - T_0 – Control, T_1 - 100% NPK (180:80:80), T_2 - 75% NPK (135:60:60) + VC (25 t per ha), T_3 - 75% NPK (135:60:60) + FYM (25 t per ha), T_4 - 75% NPK (135:60:60) + Azotobacter 2 kg per ha, T_5 - 75% NPK (135:60:60) + PSB 2 kg per ha, T_6 - 50% NPK (90:40:40) + VC (25 t per ha) + FYM (25 t per ha), T_7 - 50% NPK (90:40:40) +VC (25 t per ha) + Azotobacter 2kg per ha, T_8 - 50% NPK (90:40:40) + FYM (25 t per ha) + Azotobacter 2kg per ha, T_9 - 25% NPK (45:20:20) +VC (25t per ha) + FYM (25t per ha) + Azotobacter 2 kg per ha + PSB 2 kg per ha. The fertilizers were applied in experimental plots as per requirement of the treatments. The sowing of brinjal cv. Kashi Sandesh was done on 25th July 2016, and transplanting was done on 30th August, 2016 *kharif* season in rows of raised beds. Row to Row and plant to plant spacing were maintained 60 × 60 cm respectively. All the recommended agronomic practices were adopted during the experimental period. Plant height, leaf length, leaf breadth and Peduncle length of selected plants from each plot were measured with the help of a meter scale in centimeter. The diameter, fruit length and fruit width was measured with the help of verneer calipers in centimeter. The weight of randomly selected seven fruits was measured in grams with help of the electronic balance. The data was analysed statistically by analysis of variance for randomized block design model proposed by Panse and Sukhatame (1985) [12].

Results and Discussion

Growth parameters

The data pertaining to the growth parameters recorded have been show in table 1. Plant height in brinjal was found to be significantly increased by use of different level of NPK and VC, FYM, bio-fertilizers. The maximum (72.90 cm) plant height was recorded in treatment 50% NPK + VC + FYM which was statistically at par with treatments 50% NPK + VC + *Azotobacter* (71.86 cm), 25% NPK + VC + FYM + *Azotobacter* + PSB (71.10 cm) and 100% NPK (70.98 cm) whereas, minimum (61.00 cm) plant height was recorded in control. This may due to fact higher dose of N and long duration availability of N from VC and FYM might have enhanced cell division and formation of more tissues resulting in luxuriant vegetative growth and thereby increased plant height. Similar finding was also reported by Anburani and Manivannan (2002) [1]. The maximum (85.73) number of leaves per plant was recorded in treatment 50% NPK + FYM + *Azotobacter* followed by 50% NPK + VC + FYM (83.41) and 25% NPK + VC + FYM + *Azotobacter* + PSB (80.86). The minimum (62.94) number of leaves per plant was recorded in control. The number of leaves increased progressively with increasing dose of NPK and a simultaneous increase in number of leaves in treatments in which *Azotobacter* were used as compared to sole NPK application. It might be due to fact that *Azotobacter* creates favorable environment for nutrient availability and uptake. Similar finding was also reported by Chumei *et al.* (2013) [5]. The maximum (7.14) number of primary branches and secondary branches (7.11) per plant was recorded in treatment 25% NPK + VC + FYM + *Azotobacter* + PSB whereas, maximum (3.87) number of tertiary branches per plant was recorded in treatment 50% NPK + VC + *Azotobacter* which was statistically at par with treatments 50% NPK + VC + FYM (3.61), 50% NPK + FYM + *Azotobacter* (3.18). The minimum number of primary branches, secondary branches and tertiary branches per plant was recorded (4.10), (4.40) and (2.45) respectively in control. This might be due to the better availability and uptake of plant nutrients, more specifically N, P and K, resulting in better photosynthesis and protein synthesis and also it might due to fact of biofertilizers creates favorable environment for nutrient availability and uptake. Similar finding was also reported by Chumei *et al.* (2013) [5], Anburani and Manivannan (2002) [1] and Barman et *al.* (2017) [2]. The longest (18.33 cm) leaf length and highest (13.33 cm) leaf breadth was recorded in treatment 25% NPK + VC + FYM + *Azotobacter* + PSB whereas, the minimum (14.76 cm) leaf length was recorded in treatment 75% NPK + FYM and lowest (10.22 cm) leaf breadth was recorded in control. Similar finding was also reported by Harish and Patil (2012) [6]. Highest (1.35 cm) stem diameter was recorded in treatment 25% NPK + VC + FYM + *Azotobacter* + PSB which was statistically at par with all the treatments 75% NPK + PSB (1.30 cm), 100% NPK (1.29 cm) and 50% NPK + FYM + *Azotobacter* (1.29 cm) whereas, lowest (1.01 cm) stem diameter was recorded in control. Similar finding was also reported by Anburani and Manivannan (2002) [1].

Table 1: Influence of integrated nutrient management on growth parameters of brinjal

Treatments	Plant Height (cm)	Number of leaves per plant	No. of primary branches	No. of secondary branches	No. of tertiary branches	Leaf length (cm)	Leaf breadth (cm)	Stem diameter (cm)
T_0	61.00	62.94	4.10	4.40	2.45	16.08	10.22	1.01
T_1	70.98	73.81	5.52	5.86	2.67	17.02	12.17	1.29
T_2	65.57	71.72	5.62	5.95	2.84	16.48	11.89	1.25
T_3	67.14	79.26	5.90	5.94	2.76	14.76	10.50	1.22
T_4	70.25	75.81	5.43	5.76	2.89	16.85	11.07	1.22
T_5	70.48	70.23	5.48	5.81	2.62	16.50	10.93	1.30
T_6	72.9	83.41	6.71	6.71	3.61	16.33	11.29	1.23
T_7	71.86	77.24	6.81	6.84	3.87	16.64	11.74	1.26
T_8	68.43	85.73	6.57	6.51	3.18	16.71	11.67	1.29
T_9	71.1	80.86	7.14	7.11	3.08	18.33	13.33	1.35
CD 5%	3.67	1.75	1.35	1.31	0.70	1.39	1.55	0.08

Floral characteristics

The data pertaining to the floral characteristics recorded have been show in table 2. The minimum (36.83 days) days to 1st flower appearance was recorded under treatments 75% NPK + *Azotobacter* and 50% NPK + VC + FYM which was statistically at par with treatments 100% NPK (37.83 days), 75% NPK + FYM (38.70 days) and 50% NPK + FYM + *Azotobacter* (38.70 days) whereas, maximum (44.33 days) to 1st flower appearance was recorded under control. The minimum (57.0 days) to 50% flowering was recorded in treatment 25% NPK + VC + FYM + *Azotobacter* + PSB which was statistically at par with treatments 50% NPK + FYM + *Azotobacter* (57.50 days), 75% NPK + PSB and 50% NPK + VC + FYM (58.33 days), whereas, maximum (62.83 days) to 50% flowering appearance was recorded under treatment 100% NPK. This could be due to nitrogen and other inputs like biofertilizers which encouraged the earlier flowering. In control there is no fertilizer was applied probably due to the nutrient stress resulting in late flowering. Similar finding was also reported by Anburani and Manivannan (2002) [1]. Early flowering might also be due to the fact that *Azotobacter* is capable of elaborating small quantities of growth promoting substances like vitamins 'B' and phytohormones like IAA, GA and Cytokinins which along with applied N, P and K and FYM and would have improved the physiology of the plants to shift from vegetative to reproductive stage. The minimum (55.67 days) to 1st bud appearance was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB which was statistically at par with treatments 50% NPK + FYM + *Azotobacter* (56.67 days), 50% NPK + VC + *Azotobacter* (56.78 days) and 100% NPK (57.67 days) whereas, maximum (61.27 days) to 1st bud appearance was recorded under 75% NPK + VC.

Table 2: Influence of integrated nutrient management on floral characteristics of brinjal

Treatments	Days to 1st flower appearance	Days to 50% flowering	Days to 1st bud appearance	Days to 1st edible harvesting	Fruit length (cm)	Fruit diameter (cm)
T_0	44.33	60.83	58.67	82.33	8.11	7.11
T_1	37.83	62.83	57.67	81.33	9.61	8.79
T_2	41.53	60.67	61.27	78.00	9.78	7.46
T_3	38.70	58.50	58.56	81.67	9.24	8.08
T_4	36.83	58.50	62.33	80.67	9.72	7.94
T_5	38.50	58.33	57.44	79.67	9.13	8.78
T_6	36.83	58.33	59.00	79.33	8.28	7.80
T_7	39.33	58.83	56.78	80.00	10.56	5.50
T_8	38.70	57.50	56.67	77.00	9.72	6.41
T_9	40.33	57.00	55.67	73.67	8.83	9.20
CD 5%	4.00	2.68	2.96	4.61	1.33	1.51

Yield parameters

The data pertaining to the yield parameters recorded have been show in table 3. The minimum (73.67 days) to 1st edible harvesting was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB it was statistically at par with treatments 50% NPK + FYM + *Azotobacter* (77.00 days) and 75% NPK + VC (78.00 days) whereas, maximum (82.33) days to first flower appearance was recorded under control. It might be due to fact PSB mobilizes P from deeper layer thus better uptake of P enhances flowering leads to earliest fruiting (Rajagopal and Rao, 1974) [13]. The maximum (10.56 cm) fruit length was recorded in treatment under treatment 50% NPK + VC + *Azotobacter* which was statistically at par with treatments 75% NPK + VC (9.78 cm), 50% NPK + FYM + *Azotobacter* and 75% NPK + *Azotobacter* (9.72 cm) whereas, minimum (8.11 cm) fruit length was recorded in control. The maximum (9.20 cm) fruit diameter was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB it was statistically at par with treatments 100% NPK (8.79), 75% NPK + PSB (8.78 cm) and 75% NPK + FYM (8.08 cm) whereas, minimum (5.50 cm) fruit diameter was recorded under treatment 50% NPK + VC + *Azotobacter*. This might be attributed to the increased availability of NPK and water at the critical stages of the crop growth resulting early establishment, vigorous growth and development of plants leading to longer fruits and higher fruit diameter. Similar finding was also reported by Chumei *et al.* (2013) [5]. The longest (5.68 cm) peduncle length was recorded under treatment 50% NPK + VC + *Azotobacter* which was statistically at par with treatments 75% NPK + VC (5.55 cm), 100% NPK (5.44 cm) and 75% NPK + *Azotobacter* whereas, shortest (4.72 cm) peduncle length was recorded in 75% NPK + FYM. The maximum (72.78%) of fruit set was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB followed by 50% NPK + VC + *Azotobacter* (70.22%) and 50% NPK + FYM + *Azotobacter* (70.00%) whereas, minimum (59.22%) was recorded under control. The maximum (374.56 g) fresh fruit weight was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB which was statistically at par with treatments 50% NPK + FYM + *Azotobacter* (368.78 g), 50% NPK + VC + *Azotobacter* (339.44 g) and 75% NPK + *Azotobacter* (326.33 g) whereas, minimum (275.00 g) fruit width was recorded in treatment 100% NPK. Similar finding was also reported by Chumei *et al.* (2013) [5] and Anburani and Manivannan (2002) [1]. The maximum (16.14) number of fruits per plant was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB followed by 50% NPK + FYM + *Azotobacter* (15.83) and 50% NPK + VC + *Azotobacter* (14.71) whereas, minimum (9.73) number of fruits per plant was recorded under control. This may be due to vigor of plant and more number of fruit by the combined application of organic manure, RDF, and bio fertilizers while less number of fruits per plant might be due to the poor nutritional status of control. Similar results were also revealed by Anburani and Manivannan, (2002) [1]. Among the treatments, maximum (1.82 kg) fruit yield per plant and (172.04 q) yield per ha was recorded under treatment 25% NPK + VC + FYM + *Azotobacter* + PSB whereas, minimum (0.97 kg) fruits yield per plant and lowest (84.07 q) fruit yield per ha was recorded under control. Similar results were also revealed by Vidhate *et al*. (2015) and Anburani and Manivannan (2002) [18, 1].

Table 3: Influence of integrated nutrient management on yield parameters brinjal

Treatments	Peduncle length (cm)	Percentage of fruit set	No. of fruits per plant	Fresh fruit weight (g)	Fruit yield per plant (kg)	Fruit yield per ha (q)
T_0	5.06	59.22	9.73	318.89	0.97	84.07
T_1	5.44	65.56	12.58	275.00	1.27	112.04
T_2	5.55	68.11	12.18	311.29	1.26	106.48
T_3	4.72	69.11	12.85	308.00	1.30	112.96
T_4	5.33	68.11	13.18	326.33	1.79	117.52
T_5	5.33	68.56	14.04	304.67	1.65	131.48
T_6	5.00	69.78	14.33	297.78	1.68	140.37
T_7	5.68	70.22	14.71	339.44	1.70	124.00
T_8	5.06	70.00	15.85	368.78	1.81	166.26
T_9	5.06	72.78	16.14	374.56	1.82	172.04
CD 5%	0.38	1.28	1.22	54.53	0.15	13.18

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