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Response of brinjal to integrated nutrient management in lateritic soils of Konkan region

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Abstract
A field experiment conducted during Summer 2016 entitled, "Response of brinjal to integrated nutrient management in lateritic soils of konkan region" at Dapoli. The experiment was laid out in Randomized Block Design (RBD) comprising eleven treatment combinations replicated thrice and observations were recorded at 60, 90 days after transplanting (DAT) and after harvest. The effect of different inorganic fertilizers and organic manures viz., FYM and vermicompost either alone or in combinations on growth attributing characters and yield of brinjal (cv., Bandhtivare local) were studied. The growth attributing characters and yield of brinjal increased gradually from transplanting to harvest of the brinjal crop. The combined application of 25 % RDF through inorganics and 75% RDN through vermicompost (T_9) was found to be responsible for producing beneficial effect on growth attributing characters (viz., plant height, number of leaves, fresh weight of brinjal plant, dry weight of brinjal plant, number of branches, and root length) and yield of brinjal plant. It was closely followed by the treatment (T_6) 25 % RDF through inorganic fertilizers and 75 % RDN through FYM indicating integration is a need of future for growth and maximising yield of brinjal.

Keywords: brinjal, integrated nutrient management, lateritic soil, konkan

1. Introduction
Brinjal (*Solanum melongena* Linn.) belongs to the family Solanaceae. Plant is herbaceous, annual, erect or semi-spreading in habit. The brinjal also known as 'eggplant' or 'guinea squash'. It is one of the most popular and commercial crop grown in India and other parts of the world and rightly called as vegetable of masses. Brinjal fruits have medicinal properties. Some medicinal use of brinjal tissues and extract include treatment of diabetes, asthama, cholera, bronchitis and diarrhoea. The juice of brinjal significantly reduces weight and lowers certain levels of blood cholesterol.

Brinjal has been known in India from ancient times. India is its center of origin and diversity (Saravaiya *et al,* 2010) [9]. Apart from India, the other major brinjal growing countries are China, Turkey, Japan, Italy, Indonesia, Iraq, Syria, Spain and Phillippines. China is the largest producer of brinjal and contributes about 57.9% of the world's production while India occupies second position in production with a share of 27.2%.The global area has been estimated at 1864.3 '000 hectares contributing 49782.11 MT '000 production with 26.7 MT per ha as productivity (Anonymous, 2014) [1].

Plants need certain mineral nutrients to grow and to produce yield, with nitrogen, phosphorus, and potassium being required in the largest quantities and usually become deficient first in the soil. Nutrient availability has been reported to be directly related to yield. The deficiency of plant nutrients causes different changes in the physiological and biochemical processes within the plant cell resulting in a reduction of growth, delay of development and qualitative and quantitative decrease of yield (Varalakshmi *et al.*, 2005) [11].

For achieving high level of production, it should be supplied with adequate quantities of manures and fertilizers. Now-a-days chemical fertilizers are quite expensive input and their usage over a long period may deplete the soil fertility it is also considered that their indiscriminate usage may also cause environmental pollution problems, soil sickness, reduce the microbial activities and availability of essential nutrients and deteriorate the product quality. Therefore, use of chemical fertilizers cannot be avoided but their consumption can be lowered down by using alternative sources of nutrients *i.e.* organic manures like farm yard manure, poultry manure and vermicompost. Low use efficiencies of inorganic fertilizers

coupled with their rising costs and the need for organically produced food has directed the attention of farmers towards organic sources.

Only one source of nutrients like chemical fertilizers, organic manures and biofertilizers cannot improve the production or maintain the production sustainability and soil health. In recent times the concept of Integrated Nutrient Management system has been receiving increasing attention worldwide obviously for reasons of economization of fertilizer usage, safeguarding and ensuring scientific management of soil health for optimum growth, yield and quality of crops in an integrated manner in a specific agro-ecological situation, through balanced use of organic and inorganic plant nutrients; so that one can harvest good yield without deteriorating soil health.

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 to fulfil both domestic and national needs. Keeping the above facts in view, a study entitled, "Response of Brinjal to Integrated Nutrient Management in Lateritic Soils of Konkan Region" was undertaken.

2. Material and Methods

The field experiment was laid out in Randomized Block Design (RBD) comprising of eleven treatment combinations replicated thrice at Research Farm of Agronomy Department, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri during the month of February to June, 2016.

The soil of the experimental plot at the initial stage *i.e.* before the commencement of the experiment, was sandy loam in texture, moderately acidic in reaction and having low electrical conductivity, moderately high in organic carbon, medium in available nitrogen and available phosphorus and very high in available potassium.

Brinjal (Local cultivar Bandhtivare) was taken as a test crop during *summer* season 2016. Bandhtivare, the local cultivar of brinjal is grown successfully in all three seasons i.e. *Kharif*, *Rabi* and *Summer* season under Konkan conditions with the yield variation from 250 to 350 q ha^{-1} with a spacing of 60cm X 60cm.

3. Results and Discussions

3.1 Growth attributing characters of the brinjal

3.1.1 Plant height of the brinjal

The data on effect of integrated nutrient management on plant height of brinjal at 60, 90 DAT and after harvest are presented in Table 1.

At 60 Days after transplanting (DAT)

The plant height of brinjal at 60 DAT varied from 37.53 to 61.53 cm with a mean value of 51.95 cm (Table 1). At 60 DAT, the treatment receiving integration of 25 % RDF through inorganics and 75 % RDN through vermicompost (T_9) also recorded the highest plant height (61.53 cm), however, it was at par with (T_6) and (T_{10}). The treatment (T_1) i.e. control recorded the lowest plant height (37.53 cm) at 60 DAT. Further, effect of all the treatment combinations were found to be statistically significant over treatments (T_1) and (T_2). While these treatments (T_1) and (T_2) were remained statistically at par with each other. Average height of brinjal at 60 DAT showed a slight but definite increase as compared to the average height reported at 30 DAT.

At 90 Days after transplanting (DAT)

The plant height of brinjal at 90 DAT varied from 57.33 to 85.40 cm and average plant height of brinjal 74.15 cm. It was maximum (85.40 cm) in the treatment receiving application of 25 % inorganic fertilizers along with 75% RDN through vermicompost (T_9), while the lowest plant height of brinjal (57.33 cm) was observed in the control treatment (T_1). A critical look on data on plant height of brinjal further revealed that the treatment (T_9) was found to produce significant effect on plant height of brinjal over almost all the treatments with exception of the treatments (T_6), (T_7) and (T_{10}). Further, it was noticed that there was a slight increase in the average plant height of brinjal as compared to the average plant height of brinjal at 30 and 60 DAT.

After harvest

The data on plant height after harvest of brinjal crop (Table 4.7) when studied revealed that plant height after harvest ranged from 77.45 to 104.19 cm with an average value of 93.43 cm. Treatment receiving application of 25% RDF through inorganics and 75% RDN through vermicompost (T_9) produced the highest plant height (104.19 cm). However, it was at par with T_6 (102.12 cm), T_7 (97.45 cm), T_{10} (99.39 cm) and T_{11} (96.72 cm). The treatment (T_1) i.e. control recorded the lowest plant height (77.45 cm) after harvest of the brinjal crop. Further, it was observed that all the treatment combinations were found to be statistically significant over control (T_1), (T_2) and (T_5).

It might be due to the slow release of nutrients through the vermicompost for longer period. The increase in plant height of brinjal might be attributed to quick release, increased absorption and utilization of nitrogen. Beside, the better efficiency of organic manures in combination with inorganic fertilizers might be due to the fact that the organic manures would have provided the micro nutrients in an optimum level, which involved in synthesis of most important phytohormones, chlorophyll synthesis and respiratory reactions. Application of organic manures might have helped in for better plant metabolic activity as a result of release of micronutrients in the early growth phase which inturn encouraged vigorous growth (Kantaiah, 2008) [3].

Table 1: Effect of integrated nutrient management on plant height (cm) and number of leaves of brinjal

Tr. No.	Treatment	Plant height (cm)			Number of leaves		
		60 DAT	90 DAT	After harvest	60 DAT	90 DAT	After harvest
T_1	Control (No NPK)	37.53	57.33	77.45	26.7	41.6	73.9
T_2	100% RDN through FYM	45.07	69.33	88.12	33.7	49.3	84.2
T_3	100% RDN through VC	49.33	70.53	91.65	36.9	52.2	87.7
T_4	100% RDF through inorganic fertilizers	53.00	70.07	93.19	43.7	57.4	95.3
T_5	80% RDF through inorganic fertilizers	52.67	67.83	87.62	33.5	48.4	92.3
T_6	25%RDF + 75% RDN through FYM	58.33	84.67	102.12	49.3	72.7	100.2
T_7	50% RDF + 50% RDN through FYM	53.60	80.00	97.45	43.9	64.9	95.9

T_8	75% RDF + 25% RDN through FYM	51.73	71.00	89.79	37.8	57.5	92.3
T_9	25% RDF+ 75% RDN through VC	61.53	85.40	104.19	51.0	73.9	103.9
T_{10}	50% RDF + 50% RDN through VC	58.33	83.27	99.39	44.9	67.9	99.2
T_{11}	75% RDF + 25% RDN through VC	50.93	76.27	96.72	39.6	61.1	92.9
Mean		51.95	74.15	93.43	40.09	58.82	92.52
S.E. (±)		2.622	2.803	3.715	2.057	5.469	3.754
CD (P=0.05)		7.73	8.27	10.96	6.07	16.13	11.07

3.1.2 Number of leaves of the brinjal

The data pertaining to the number of leaves of brinjal plant as affected by different organics and inorganic fertilizers at 60, 90 DAT and after harvest are presented in Table 1.

At 60 days after transplanting (DAT)

The data presented in Table 1indicated that the number of leaves at 60 DAT ranged from 26.7 to 51.0 with an average value of 40.09. Data further indicated that the application of 75% RDN through vermicompost and 25% RDF through inorganics (T_9) recorded maximum number of leaves (51.0), whereas minimum number of leaves (26.7) were seen in the treatment (T_1) without fertilizer application. Data further indicated that treatment (T_9) was statistically significant over almost all the treatments with exception of treatments (T_6) and (T_{10}).

At 90 days after transplanting (DAT)

Maximum number of leaves (73.90) were seen in the treatment receiving application of 25 % RDF through inorganics and 75% RDN through vermicompost (T_9) while, minimum number of leaves (41.60) were seen in the control treatment (T_1). Further, it was seen from the data treatment (T_9) produced significant effect on number of leaves of brinjal crop over almost all the treatment combinations except treatments (T_6), (T_7), (T_{10}) and (T_{11}). However, treatments (T_6), (T_7), (T_{10}) and (T_{11}) were remained statistically at par.

After harvest

The number of leaves of brinjal crop after harvest ranged between 73.90 and 103.90 with mean value of 92.52. When data examined critically, revealed that the integration of 25 % RDF through inorganics and 75% RDN through vermicompost (T_9) recorded maximum number of leaves (103.9) and minimum (73.9) were seen in the control treatment (T_1). It is also observed from the data that the treatment (T_9) producing significant effect on the number of leaves of brinjal over the treatments (T_1), (T_2), (T_3), (T_5) and (T_8). In general, the number of leaves of brinjal crop was found to be increased with advancement of growth period. This might be attributed to the readily available nitrogen from fertilizers and it's supply from organic source throughout the crop growth period along with the improvement in soil physical properties which might have resulted in increasing the production of more number of leaves (Ravi *et al.*, 2006).

3.1.3 Fresh weight of the brinjal

The data pertaining to the fresh weight as affected by different organic and inorganic fertilizers at 60, 90 DAT and after harvest are presented in Table 2.

At 60 days after transplanting (DAT)

Data when studied revealed that the fresh weight of brinjal plant showed variation from 108.67 to 184.67 g with an average value of 147.33 g. Data further, indicated that minimum fresh weight of brinjal plant (108.67 g) was observed in the control treatment (T_1) not receiving any fertilizers. Whereas, maximum fresh weight of brinjal plant (184.67 g) was seen in the treatment (T_9) receiving combined application of 25 % RDF through inorganic and 75 % RDN through vermicompost. A critical look on data indicated that all treatment combinations showed statistically significant effect over the treatments (T_1), (T_2), (T_3) and (T_5). It was further observed that the treatments (T_4), (T_6), (T_9) and (T_{10}) were found to be statistically at par with each other.

At 90 Days After Transplanting (DAT)

The fresh weight at 90 DAT was found to be varied from 136.00 to 236.00 g with a mean value of 198.21 g (Table 2). The treatment (T_9) receiving application of 25% RDF through chemical fertilizers along with 75% RDF through vermicompost was found to produce significant effect on fresh weight of brinjal and recorded the highest fresh weight (236.00 g) over almost all the treatments, except T_6 (234.00 g), T_{10} (221.67 g) and T_{11} (217.33 g). The treatment (T_1) i.e. control recorded the lowest fresh weight (136.00 g). Further, all the treatments showed statistically significant variation in fresh weight of the brinjal over the control treatment.

After harvest

The data on fresh weight of brinjal after harvest when examined revealed that the fresh weight of brinjal ranged from 190.10 to 329.05 g with an average value of 275.45 g. Further, it was observed that the application of 25% RDF through inorganics along with 75% RDN through vermicompost (T_9) produced statistically significant effect on fresh weight over the treatments (T_1), (T_2), (T_3), (T_4), (T_5), (T_7), (T_8) and (T_{11}). However, it was statistically at par with the treatments T_6 (323.23 g) and T_{10} (315.73 g). The treatment (T_1) i.e. control recorded the lowest fresh weight (190.10 g).

The integration of 25% RDF through inorganics along with 75% RDN through vermicompost (T_9) caused significant increase in the fresh weight of brinjal and recorded the highest fresh weight of brinjal at all growth stages of brinjal. The significant increase in the fresh weight of plant due to combined application of chemical fertilizers and organic manures was also reported by Kantaiah (2008) [3] and Suge *et al.* (2011).

Table 2: Effect of integrated nutrient management on fresh weight (g) and dry weight (g) of brinjal plant

Tr. No.	Treatment	Fresh weight (g)			Dry weight (g)		
		60 DAT	90 DAT	After harvest	60 DAT	90 DAT	After harvest
T_1	Control (No NPK)	108.67	136.00	190.10	15.17	34.31	45.29
T_2	100% RDN through FYM	132.00	176.00	222.20	22.99	38.27	52.27
T_3	100% RDN through VC	134.00	186.67	237.03	24.81	40.53	54.49
T_4	100% RDF through inorganic fertilizers	159.33	183.33	266.13	28.05	41.71	52.41

T_5	80% RDF through inorganic fertilizers	130.67	169.33	239.17	26.39	40.60	48.61
T_6	25%RDF + 75% RDN through FYM	172.67	234.00	323.23	32.17	59.15	73.02
T_7	50% RDF + 50% RDN through FYM	143.33	215.33	310.77	26.96	44.97	60.13
T_8	75% RDF + 25% RDN through FYM	135.33	204.67	286.87	23.55	38.56	50.07
T_9	25% RDF+ 75% RDN through VC	184.67	236.00	329.05	33.25	60.32	75.25
T_{10}	50% RDF + 50% RDN through VC	169.33	221.67	315.73	29.99	56.53	64.39
T_{11}	75% RDF + 25% RDN through VC	150.67	217.33	309.60	24.74	47.76	57.36
Mean		147.33	198.21	275.45	26.19	45.70	57.57
S.E. (±)		8.892	6.740	4.970	0.974	1.479	2.928
CD (P=0.05)		26.23	19.88	14.66	2.87	4.36	8.64

3.1.4 Dry Weight of the brinjal plant

The data pertaining to the Dry Weight of the brinjal plant as affected by different organics and inorganic fertilizers at 60, 90 DAT and after harvest are presented in Table 2.

At 60 days after transplanting (DAT)

As seen from the Table 2 the data indicated that the maximum dry weight of brinjal plant (33.25 g) was registered in the treatment (T_9) where conjunctive use of 25 % RDF through inorganics + 75 % RDF through vermicompost was done. Whereas, minimum (15.17 g) dry weight of plant was observed in the treatment where no fertilizer application was done i.e. control treatment (T_1). An average yield of brinjal crop was 26.19 g. However, treatment combinations 25 % RDF + 75 % RDN through FYM (T_6) and integration of 25 % RDF through chemical fertilizers along with 75 % RDN through vermicompost (T_9) were found to be statistically beneficial for increasing dry weight of brinjal plant over the rest of the treatments (T_1), (T_2), (T_3), (T_4), (T_5), (T_7), (T_8) (T_{10}) and (T_{11}).

At 90 days after transplanting (DAT)

An examination of data on dry weight of brinjal plant (Table 2) revealed that the dry weight of crop varied from 34.31 to 60.32 g with a mean value of 45.70 g. Further, it was observed that the lowest dry weight of crop (34.31g) was observed in the control treatment (T_1) whereas the highest (60.32 g) dry weight of brinjal crop was seen in the treatment (T_9) where application of 25% RDF along with 75% RDN through VC was done. Different treatment combinations were found to be beneficial for producing higher dry weight of brinjal over the treatments (T_1), (T_2) and (T_8). It was further noticed that the treatment (T_9) receiving combined application of 25 % RDF through inorganics and 75 % RDN through vermicompost was found to produce statistically significant effect on dry weight of brinjal and recorded the highest dry weight (60.32 g) over almost all the treatment combinations, except T_6 (59.15 g) and T_{10} (56.53 g).

After harvest

The data on dry weight of brinjal after harvest when examined revealed that the dry weight of brinjal ranged from 45.29 to 75.25 g with an average value of 57.57 g. Further, it was observed that the application of 25% RDF through inorganics along with 75% RDN through vermicompost (T_9) produced statistically significant effect on dry weight over rest of the treatments with exception of treatment (T_6). The treatment (T_1) i.e. control recorded the lowest dry weight of brinjal (45.29 g). The control treatment was found to be statistically at par with (T_2), (T_4), (T_5) and (T_8).

In general, average dry weight of brinjal showed a slight but definite increase with advancement in growth stages of brinjal crop. The integration of 25% RDF and 75 % RDN through vermicompost (T_9) was found to be responsible for producing maximum dry weight of brinjal at all growth stages of observation of brinjal crop. It was closely followed by the application of 25% RDF through inorganics along with 75% RDN through (T_6). Also this is in accordance with the findings of Kantaiah (2008) [3] and Kumar (2016) [5]. The nitrogen might have enhanced the vegetative growth with more number of branches and the phosphorous might have increased root production. This might be attributed to the increase in the accumulation of dry matter and increase in the production of photosynthesis might have produced higher biomass (Kantaiah, 2008) [3].

3.3.5 Number of branches of the brinjal

The perusal of data pertaining to number of branches at different growth stages i.e. 60, 90 DAT and after harvest of brinjal presented in the Table 3.

At 60 Days after transplanting (DAT)

The number of branches at 60 DAT ranged from 1.80 to 4.87 with an average value of 3.66 (Table 3). The treatment receiving application of 25% RDF through inorganic plus 75 % RDF through vermicompost (T_9) was found to be statistically significant (4.87) over the treatments (T_1), (T_2), (T_3), (T_5), (T_7), (T_8) and (T_{11}). However, it was statistically at par with T_4 (4.67), T_6 (4.27) and T_{10} (4.33). The lowest number of branches (1.80) were observed in the treatments (T_1).

At 90 Days after transplanting (DAT)

The number of branches showed variation from 3.00 to 6.40 with a mean value of 5.29. The treatment receiving application of 25% RDF through inorganic plus 75% RDN through vermicompost (T_9) was found to be statistically significant (6.40) over the treatments (T_1), (T_2), (T_4), (T_5), (T_8) and (T_{11}). However, it was statistically at par with T_3 (5.60), T_6 (6.13), T_7 (5.73) and T_{10} (5.87). The lowest number of branches (3.00) were recorded in the control treatment (T_1).

After harvest

The number of branches varied from 6.07 to 10.73 with a mean value of 8.83. A critical look on data further revealed that treatment (T_9) receiving conjunction of 25 % RDF through inorganic + 75 % RDF through vermicompost was found to be statistically significant (10.73) over almost all the treatments except (T_6), (T_7) and (T_{10}). The treatment (T_1) i.e. control recorded the lowest number of branches (6.07). Further, it was noticed that all treatments combination were statistically significant over the control treatment (T_1).

It might have resulted in the higher absorption of nutrients especially nitrogen which enhanced cell division and cell elongation and concomitant increase in metabolic activity (Kantaiah, 2008) [3]. The results of the present investigation are in the conformity with Mujawar (2012) [7] and Chumei *et al.* (2013) [2].

Table 3: Effect of integrated nutrient management on Number of branches, Root length (cm) and Yield (t ha^{-1}) of brinjal plant

Tr. No.	Treatment	Number of branches			Root length	Yield (t ha^{-1})
		60 DAT	90 DAT	After harvest		
T_1	Control (No NPK)	1.80	3.00	6.07	22.33	13.34
T_2	100% RDN through FYM	3.40	5.13	8.27	27.00	19.05
T_3	100% RDN through VC	3.47	5.60	9.20	27.44	21.43
T_4	100% RDF through inorganic fertilizers	4.67	5.33	7.67	37.22	17.29
T_5	80% RDF through inorganic fertilizers	3.13	4.67	7.53	33.22	15.24
T_6	25%RDF + 75% RDN through FYM	4.27	6.13	10.17	40.44	24.68
T_7	50% RDF + 50% RDN through FYM	3.53	5.73	9.67	36.88	23.46
T_8	75% RDF + 25% RDN through FYM	3.20	5.27	9.00	35.22	20.92
T_9	25% RDF+ 75% RDN through VC	4.87	6.40	10.73	48.78	26.83
T_{10}	50% RDF + 50% RDN through VC	4.33	5.87	9.73	40.11	24.66
T_{11}	75% RDF + 25% RDN through VC	3.60	5.03	9.13	39.99	22.58
Mean		3.66	5.29	8.83	35.33	20.86
S.E. (±)		0.394	0.338	0.476	1.609	0.727
CD (P=0.05)		1.1	1.00	1.40	4.75	2.14

3.1.6 Root Length of brinjal

The data on root length of brinjal presented in Table 3. Data when studied revealed that the root length varied from 22.33 to 48.78 cm with an average value of 35.33 cm. A critical look on data further revealed that treatment (T_9) receiving conjunctive application of 25 % RDF through chemical fertilizer and 75 % RDN through vermicompost recorded the longest root length (48.78 cm), which was found to be statistically superior over all the remaining treatments. The treatment (T_1) i.e. control recorded the shortest root length (22.33 cm). The control treatment was found to be statistically at par with (T_2). These findings are in conformity with Latha *et al.* (2014) and Kumar (2016) [5].

3.2 Effect of integrated nutrient management on the Yield of brinjal (t ha^{-1})

The data (Table 3) indicated that the maximum yield (26.83 t ha^{-1}) was registered in the treatment where conjunctive use of 75 % RDN through organic (vermicompost) and 25 % RDF through inorganic fertilizer (T_9) was done whereas minimum yield (13.34 t ha^{-1}) was observed in the treatment where no fertilizer application was done i.e. control treatment (T_1). An average yield of brinjal crop was 20.86 t ha^{-1}.

Treatment combinations receiving no fertilizer application (T_1) and 80 % RDF through inorganic fertilizers (T_5) showed their influence on yield but did not reach up to the level of significance. Further these treatments were found to be statistically at par. However, treatment combinations 25 % RDF + 75 % RDN through FYM (T_6) and integration of 25 % RDF through chemical fertilizers along with 75 % RDN through vermicompost (T_9) where found to be statistically beneficial for increasing yield over the treatments (T_1), (T_2), (T_3), (T_4), (T_5), (T_7), (T_8), (T_{10}) and (T_{11}).

The possible reasons for increased yield per plant could be attributed to the increase in the vegetative growth, better performance of yield attributes which might have promoted greater yield (Mujawar, 2012) [7]. These observations are in close conformity with the findings of Kashyap *et al.* (2014) [4].

4. Conclusion

The results of the present investigation revealed that the application of 25 % RDF through inorganic fertilizers and 75 % RDN through vermicompost had shown it's influence on the growth attributing characters and maximising yield of brinjal.

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