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Response of integrated nutrient management on growth, yield and quality of okra (*Abelmoschus esculentus* (L.) Moench), variety-Pusa A-4

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Abstract

Field trial was conducted at the instructional farm of Krishi Vigyan Kendra Jajpur, Odisha during summer 2015 and 2016 to study the "Response of integrated nutrient management on growth, yield and quality of okra" variety-Pusa A4. From the two years trials it was observed that application of RDF (75%) + (25%) N through neem oil cake (T₇) produced maximum plant height (133.91 cm), internode length (8.11cm), fruit length (12.04cm), maximum number of fruits per plant (14.72), individual fruit weight (15.00g) and yield per ha. (9.99 ton) where RDF was 110:50:80 NPK kg/ha. Whereas, maximum number of nodes per plant (22.87), maximum fruit girth (5.87cm) were found in (T₅) where RDF (75%) + (25%) N through vermicompost were applied. Application of RDF (75%) + (25%) N through neem oil cake (T₇) recorded high protein content (15.65%). Highest chlorophyll content in leaves (1.47mg/g) was found in T₂ (100% RDF+ FYM 1.5t/ha). High Ascorbic acid content (15.19mg/100g) was found in T₁₂ (25% N through FYM + (25%) N through vermicompost + (25%) N through poultry manure + (25%) N through neem oil cake + sea weed extract (15kg/ha). Low crude fibre content (10.67%) was observed in T₁ (100% RDF) followed by T₇ (10.93%) and T₅ (11.07%). High TSS content (3.69⁰Brix) was found in T₂ receiving RDF (100%) and FYM (1.5kg/ha).

Keywords: INM, growth, yield, quality, neem oil cake, vermicompost and okra

Introduction

Okra, (*Abelmoschus esculentus* (L.) Moench) is one of the most important vegetable crop grown in tropical and subtropical region of the world belongs to family Malvaceae (2n= 130). It is a popular fruit vegetable grown round the year and fetches premium price in the market. Besides the utility of its tender green fruits as vegetable, it is used in soups and curries. Okra fruits are canned green or dried for use by army at high altitudes and are also exported helping in earning foreign exchange. In Odisha okra is grown all the thirty districts as a main crop in summer and rainy season and to some extent also in winter and also fetches premium prices in the market. The production of okra is comparatively low due to injudicious application of inorganic and organic fertilizers and high incidence of disease and pest. Nutritional imbalances in the soil cause instability in productivity and hidden hunger of nutrient besides resulting in poor nutritional quality of vegetable. The maintenance of sustainability in production through integrated use of different sources of nutrients also help to maintain the fertility of soil and avoids depletion of soil organic matter and plant nutrients besides suppression of some insect, pest and diseases. Integrated nutrient management (INM) system envisages use of organic manures, green manures, bio-fertilizers along with chemical fertilizers. From the stand point of crop yield and quality, nutrient supply from both organic and inorganic sources is important. Integrated nutrient management (INM) help to store and sustain soil fertility and crop productivity. It may also help to check the emerging deficiency of nutrient other than N, P and K. In the present Indian Agriculture, keeping in view the inadequate availability of organic sources of nutrients and expected yield decline at least in the initial years, complete substitution of chemical fertilizer is not necessarily warranted. Rather organic sources should be used as partial replacement of the chemical fertilizer. Thus, a strategy for judicious combination of both organic and inorganic sources of nutrient is the most viable option for nutrient management in okra. It will be economically viable and also help in attaining sustainability in production and maintaining soil health and environment. The use of organic amendments applied to soil not only enhances its nutrient status but also reduces the incidence of pest. (Adilakshmi *et al.*, 2008)^[1].

Materials and methods

The experiment was conducted at the instructional farm of Krishi Vigyan Kendra Jajpur, Odisha during 2016 to study the "Response of organic, inorganic fertilizers and integrated nutrient management on growth, yield and quality of okra" variety-Pusa A4. The experiment was laid out in randomized block design (RBD) with three replications and twelve treatments. Treatments involved were T₁ (100% RDF), T₂ (100% RDF + FYM 1.5 t / ha), T₃ (RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2kg/ha each), T₄ (RDF (75%) + (25%) N through FYM), T₅ (RDF (75%) + (25%) N through vermicompost), T₆ (RDF (75%) + (25%) N through poultry manure), T₇ (RDF (75%) + (25%) N through neem oil cake), T₈ (RDF (50%) + (25%) N through FYM + (25%) N through vermicompost), T₉ (RDF (50%) + (25%) N through FYM + (25%) N through poultry manure), T₁₀ (RDF (50%) + (25%) N through FYM + (25%) N through neem oil cake), T₁₁ (25% N through FYM + 25% N through vermicompost + 25% N through poultry manure + 25% N through neem oil cake), T₁₂ (25% N through FYM + 25% N through vermicompost + 25% N through poultry manure + 25% N through neem oil cake + sea weed extract 15kg/ha), where RDF was recommended dose of fertilizers (110:50:80 NPK kg/ha.) The land was brought to a fine tilth through ploughing and tillage. Irrigation channels and bunds were prepared according to layout.

The seeds were soaked overnight and sown in the field directly. Light irrigation was given just after sowing of seeds. Organic manures were applied one week before sowing. Full dose of phosphorus, potassium and half dose of nitrogen as per treatments were applied just before sowing. The remaining half dose of nitrogen was applied twenty-five days after sowing. All cultural practices were followed regularly during crop growth and observations were recorded on yield and yield attributing characters. A comparative data was prepared for each combination of treatments. The collected data were analysed statistically to find the significant difference in parameters studied between various treatments.

Results and discussion

It was observed that yield as well as yield attributing characters like plant height, inter node length, number of nodes per plant, fruit length, girth of fruit, fruit number, fruit weight, yield per plot, yield per ha. were significantly influenced by different treatments. Application of nutrients through combinations of organic and inorganic manures were proved beneficial increasing growth, yield as well as quality of okra.

Growth parameters

Plant height (cm)

Maximum plant height (133.91cm) was recorded in T₇ followed by T₅(131.73cm), T₁₀(126.32cm), respectively. Minimum plant height (98.58 cm) was found in T₁₁. Plant height in T₇ (133.91 cm), T₅(131.73 cm), T₁₀ (126.32 cm) were found to be at par with each other. Increase in plant height observed in T₇ was due to supply of 75% RDF through chemical fertilizer and 25% N through neem oil cake which resulted in less incidence of sucking pest and disease occurrence for which the source- sink relation and photosynthesis was somewhat normal resulting in increase in plant height. Continuous N supply through organic as well as inorganic sources throughout growing period favours consistent N uptake by plant at different growth stage favouring increase in height. The present findings corroborate

with the findings of Anand *et al.* (2016)^[3], Choudhury *et al.* (2015)^[7] and Das *et al.* (2014)^[9].

Internode length (cm)

The pooled data for internode length revealed the same trend in the experiment. Internode length was maximum in T₇ (8.11 cm) and minimum was in T₁₁(6.75 cm). Treatments T₇ (8.11 cm) and T₅ (7.91 cm) were found at par with each other, but differed significantly from all other treatments. This might be attributed due to less incidence of disease and pest, synergetic effect of organic and inorganic fertilizer combinations which could make available different nutrients in the soil to the plant and enhanced steady supply of essential nutrient to the crop. Similar results were obtained by Adilakshmi *et al.* (2008)^[11] and Sharma *et al.* (2014)^[20].

Number of nodes per plant

The number of nodes per plant varied from 15.64 to 22.87. Maximum number of nodes (22.87) were found in T₅ and the minimum number of nodes (15.64) found in T₁₁. T₅ produced significantly higher nodes per plant as compared to other treatments. However, T₇ produced 21.13 nodes per plant followed by T₁₀ (20.23 nodes), T₂ (19.94 nodes) and T₁ (18.41 nodes) respectively. This is due to better availability and uptake of plant nutrients, more specially N, P, K resulting in better photosynthesis and protein synthesis. Thus, these increased amount of NPK nutrients in plants, lead to increase plant metabolites that help to build up plant tissues of okra (Prabhu *et al.*, 2003)^[16]. The present finding is in accordance with same type of results obtained by Barani and Anburani (2004)^[5], Bairwa *et al.* (2009)^[4], Kumar *et al.* (2013)^[11].

Fruit length

Maximum fruit length of 12, 04 cm was recorded in T₇ and minimum 9.01 cm in T₁₁. There was significant difference in fruit length observed during the experiment in different treatments. T₇ (12.04cm) and T₅ (11.58cm) were found to be at par but significantly different in fruit length as compared to other treatments. T₁₀ produced fruit length of 11.37 cm followed by T₂ (11.28cm) and T₆(11.25cm) respectively.. This is in general agreement with report of Santi and Vijaykumari (2005)^[19], Bodamwal *et al.* (2006)^[6] and Bairwa *et al.* (2009)^[4].

Fruit number

The pooled data for number of fruits per plant revealed that maximum number of fruits per plant was observed with T₇ (14.72) followed by T₅ (14.17), T₁₀ (13.80), T₂ (13.36) respectively. Whereas, minimum number of fruits were found with T₁₁ (10.57). T₇ (14.72) and T₅ (14.17) were at par for this character. Integrated use of 75% RDF through chemical fertilizer + 25% N through neem oil cake or vermicompost improved the physical properties of soil and thereby improved the water and nutrient holding capacity of soil as well as soil fertility condition (Subba Rao and Shankar, 2001)^[24]. Availability of nutrients helps the plant to bear more number of flower and reduces the chances of flower drop resulting in more number of fruits per plant. The present findings corroborate with the findings of Bodamwal *et al.*, (2006)^[6], Munikrishnapa and Tirakannanavan, (2009)^[15] and Bairwa *et al.* (2009)^[4].

Girth of fruit (cm)

Girth of fruit varied from 5.45 cm to 5.87 cm. It was maximum in T₅ (5.87 cm) and was minimum in T₁₁ (5.45cm).

For this character T₅(5.87 cm), T₇(5.84 cm), T₁₀ (5.82 cm), T₂ (5.80 cm), T₆ (5.81 cm) and T₁ (5.68 cm) were found at par. This might be attributed to the synergistic effects of organic manures which make more nutrients available to the plants by improving the soil physical condition and solubilising the nutrients in soil. The increased vegetative growth, balanced C/N ratio and increased synthesis of carbohydrates help in increasing the fruit size. Similar findings were reported by Bodamwal *et al.*, (2006)^[6], Bairwa *et al.*, (2009)^[4] and Shelar *et al.* (2011)^[22].

Fruit weight (g)

Pooled data for fruit weight revealed that maximum fruit weight of 15.00 g was with T₇ and minimum of 12.72 g was with T₁₁. T₇ (15.00 g), T₅ (14.80 g), T₁₀ (14.29 g) and T₂ (14.08 g) were at par for this character and significantly differed from all other treatments. Combined application of organic and inorganic fertilizer increase the availability and uptake of more plant nutrients resulting in luxuriant vegetative growth. The increased photosynthetic area and translocation of photosynthetics in plants subsequently accelerated the formulation of more number of large sized fruits with more number of seeds per fruits resulting in increase in fruit weight. Similar results for okra were also

reported by Bairwa *et al.* (2009)^[4], Shelar *et al.* (2011)^[22], Wagh *et al.* (2014)^[26] in okra.

Fruit yield

In the pooled data maximum yield was obtained in T₇ (9.99 t/ha) and minimum in T₁₁(6.96 t/ha). T₇ (9.99t/ha), T₅ (9.44 t/ha) T₁₀ (9.29 t/ha) and T₂ (9.19 t/ha) were at par for this character and was significantly differed from all other treatments. It was evident from the present study that application of neem oil cake proved to be very significant in reducing incidence of disease and pest. The efficacy of neem cake in reducing incidence of pest in okra reported by Godase and Patel, 2001^[10], Mallick and Lal, 1989^[14] and Tripathy *et al.*, 2009^[25].

Application of neem oil cake along with chemical fertilizer significantly increased the number of fruits per plant, fruit weight which result in increasing yield. This is due to the better availability and uptake of plant nutrients for a longer time of crop growth due to neem cake as compared to other combination of fertilizer. Similar type of results were also reported by Bairwa *et al.*, (2009)^[4], Prasad and Naik, (2013)^[17], Mal *et al.*, (2014)^[13], Choudhary *et al.*, (2015)^[7], Das *et al.*, (2014)^[9], Anand *et al.*, (2016)^[3] and Kumar *et al.*, (2017)^[12] in okra.

Table 1: Response of organic, inorganic fertilizers and integrated nutrient management on yield and yield attributing characters of okra

Treatment	Plant height (cm)	Inter node length (cm)	Number of nodes	Fruit length (cm)	Fruit girth (cm)	Fruit number	Fruit weight (g)	Yield/ha. (Ton.)
T ₁	116.52	7.27	18.41	10.91	5.68	12.90	13.45	8.60
T ₂	119.65	7.34	19.94	11.28	5.80	13.36	14.08	9.19
T ₃	104.88	6.88	16.49	10.27	5.49	11.24	13.04	7.89
T ₄	113.60	7.25	17.39	10.60	5.57	12.34	13.24	8.31
T ₅	131.73	7.91	22.87	11.58	5.87	14.17	14.80	9.44
T ₆	117.30	7.28	18.92	11.25	5.81	13.12	13.64	8.78
T ₇	133.91	8.11	21.13	12.04	5.84	14.72	15.00	9.99
T ₈	117.44	7.32	17.55	10.79	5.61	12.76	13.34	8.44
T ₉	109.32	7.19	16.69	10.46	5.54	12.07	13.14	8.13
T ₁₀	126.32	7.54	20.23	11.37	5.82	13.80	14.29	9.29
T ₁₁	98.58	6.75	15.64	9.01	5.45	10.57	12.72	6.96
T ₁₂	101.42	6.96	15.87	9.32	5.47	11.06	12.83	7.13
SE(m)±	3.45	0.13	0.42	0.33	0.08	0.37	0.38	0.29
CD(0.05)	10.13	0.39	1.22	0.96	0.22	1.08	1.10	0.86

Quality parameters

Leaf chlorophyll

Leaf chlorophyll content was influenced by combined application of inorganic fertilizers along with organic manures in the form of neem oil cake, poultry manure, vermicompost, FYM, biofertilizer and sea weed extract. In Pooled data leaf chlorophyll content was maximum in T₂ (1.47 mg/g) and was minimum in T₁₂ (1.26 mg/g). T₂ (1.47 mg/g), T₃ (1.46 mg/g), T₉ (1.46 mg/g), T₅ (1.44 mg/g), T₇ (1.44 mg/g) were at par. Similar result were obtained Bairwa *et al.*, 2009^[4], Shanti and Vijayakumari (2005)^[19] and Sharma and Choudhary (2011)^[11].

Ascorbic acid content

The present investigation revealed that ascorbic acid content in okra varied significantly with treatments. In pooled data maximum ascorbic acid content of (15.19 mg/100 g) was found in T₁₂ and minimum was in T₆ (12.25 mg/100 g). Treatment T₁₂(15.19 mg/100 g), T₈ (14.70 mg/100 g), T₁₁ (14.61 mg/100 g) and T₇ (14.49 mg/100 g) were at par. Similar findings of increased ascorbic acid content of okra fruits with combined application of organic and inorganic

fertilizers were also reported by Tripathy *et al.* (2009)^[25], Ciba *et al.* (2017)^[8] and Singh *et al.*, 2018^[23] in okra.

Crude protein

In pooled data maximum protein content was found in T₇ (15.65%) and minimum in T₁₁ (13.34%). T₇ (15.65%), T₅ (15.35%) were at par. Variation in protein content in okra fruit due to different INM practices were also reported by Raj and Geethakumari (2001)^[18] and Wagh *et al.* (2014)^[26] in okra.

Crude fibre content

Crude fibre content is one of the important criteria to judge the quality of okra pod. In pooled data maximum crude fibre% was recorded with T₂ (12.91%) and minimum in T₁ (10.67%). T₁ (10.67%), T₇ (10.93%), T₅(11.07%) and T₁₀(11.30%) were at par with each other. The crude fibre content increased with the advancement of crop growth. It might be due to reduced succulence resulting from the cell wall thickening and reduced uptake of nitrogen with advancement of crop growth. The present findings corroborate with Wagh *et al.* (2014)^[26], Ciba *et al.* (2017)^[8] and Amiry *et al.* (2018)^[2] in okra.

Total soluble solid (TSS)

Pooled data of data also revealed same trend of results. T₂ (3.69 °Brix) was found to be significantly superior to any other treatments.

TSS content of fruit was maximum in T₂ (3.69 °Brix) whereas, minimum in T₄ (2.50 °Brix). This result was in conformation with Singh *et al.* (2018)^[23] and Amiry *et al.* (2018)^[2] in okra.

Table 2: Effect of inorganic as well as organic manures on quality of okra

Treatment	Chlorophyll (mg/g)	Ascorbic acid (mg/100g)	Crude protein (%)	Crude fibre (%)	TSS (°Brix)
T ₁	1.35	12.44	14.38	10.67	2.89
T ₂	1.47	13.63	14.81	12.91	3.69
T ₃	1.46	13.54	13.57	12.25	3.23
T ₄	1.36	12.73	13.99	11.71	2.50
T ₅	1.44	13.35	15.35	11.07	2.69
T ₆	1.35	12.25	14.68	11.86	3.13
T ₇	1.44	14.49	15.65	10.93	3.15
T ₈	1.35	14.70	14.18	12.80	2.77
T ₉	1.46	13.40	13.71	12.62	2.90
T ₁₀	1.42	13.54	15.00	11.30	3.44
T ₁₁	1.32	14.61	13.34	11.74	3.30
T ₁₂	1.26	15.19	13.47	12.02	3.12
SE(m) _±	0.01	0.25	0.18	0.34	0.06
CD (0.05)	0.03	0.73	0.54	0.99	0.18

Conclusion

From the experimental result it was observed that integrated application of 75% RDF in the form of chemical fertilizers and 25% through neem oil cake was found best in producing more plant height, internode length, number of nodes per plant, fruit length, fruit girth, number of fruits per plant, fruit weight with higher yield and also increased quality of fruit in okra.

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