RESEARCH PAPER

ADVANCE RESEARCH JOURNAL OF CROP IMPROVEMENT
Volume 8 | Issue 1 | June, 2017 | 24-30
e ISSN-2231-640X

DOI : 10.15740/HAS/ARJCI/8.1/24-30
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Effect of integrated nutrient management on nutrient uptake and yield of okra [*Abelmoschus esculentus* (L.) Moench] under islands conditions

■ R.BHU BHARTHY, M. SANKARAN[1] AND T. SUBRAMANI[2]

AUTHORS' INFO

Associated Co-author :
[1]Indian Institute of Horticulture Research, BENGALURU (KARNATAKA) INDIA
Email: kmsankaran@gmail.com

[2]ICAR-Central Island Agricultural Research Institute, PORT BLAIR (ANDAMAN AND NICOBAR ISLANDS) INDIA
Email:tsubbu10@gmail.com

Author for correspondence:
R.BHU BHARTHY
Ponnaiyah Ramajayam Institute of Science and Technology University, THANJAVUR (T.N.) INDIA
Email: bhartinovesh@gmail.com

ABSTRACT : The experiment was carried out to find out the effect of integrated nutrient management on dry matter production, nutrient uptake and yield of okra var. Arka Anamika during 2015 and 2016 at Multipurpose Farm, Diglipur, North Andaman. There were 14 treatment combinations replicated thrice in RBD. The results indicated that the application of 75 per cent recommended dose of NPK + FYM @ 2.5 t ha^{-1} + NC @ 0.5 t ha^{-1}+ VC @ 1.25 t ha^{-1} recorded higher dry matter production of plant and pod which in turn resulted in higher total dry matter production (3054 and 2955 kg ha^{-1}), which was at par with 50 per cent of recommended dose of NPK + VC @ 5.0 t ha^{-1}, 50 per cent of recommended dose of NPK + FYM @ 3.75 t ha^{-1} + VC @ 2.5 t ha^{-1} + NC @ 1.25 t ha^{-1} and 100 % recommended dose of NPK during both the years of study. Similarly, uptake of N, P and K was maximum with 75 per cent of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1}+ NC @ 0.5 t ha^{-1}) recorded higher pod yield (12.57 and 11.00 t ha^{-1}) and net return (Rs. 2,98,289 and Rs. 2,69,474), respectively. However, higher B: C was registered in T_6 (4.79 and 4.42) followed by T_2. From the results of the experiments, it can be concluded that application of 75 per cent of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} +NC @ 0.5 t ha^{-1} is highly profitable and economically viable for the cultivation of okra in Andaman and Nicobar Islands.

KEY **W**ORDS : Okra, INM, Nutrient uptake, Yield, Island ecosystem

How to cite this paper : Bharthy, R.Bhu, Sankaran, M. and Subramani, T. (2017). Effect of integrated nutrient management on nutrient uptake and yield of okra [*Abelmoschus esculentus* (L.) Moench] under islands conditions. *Adv. Res. J. Crop Improv.,* **8** (1) : 24-30, **DOI : 10.15740/HAS/ARJCI/8.1/24-30**.

Paper **H**istory : **Received :** 08.02.2017; **Revised :** 27.04.2017; **Accepted :** 07.05.2017

Okra [*Abelmoschus esculentus* (L). Moench] commonly known as okra or lady's finger belongs to the family Malvaceae is one of the most important warm season annual vegetable crops grown in tropical and sub-tropical regions of the world. In India, okra occupies an area of about 0.50 m ha with production of 5.8 m t and productivity of 11.5 t/ha (Horticultural Statistics at a glance, 2015). In Andaman and Nicobar islands, it is grown in area of 850 ha with production of 4600 tonnes. Though the weather prevailing in Andaman and Nicobar islands are conducive for okra, its productivity is very low (5.41 t/ha) as compared to national average (11.5 t/ha) due to imbalanced use of fertilizers with more nitrogen and less phosphorus and potassium and virtual absence of micronutrients. Optimum crop performance is usually limited due to inadequate

availability of essential nutrients. Fertilizer is one of the important inputs contributing to crop production because it enhances yield and quality (Shiyab *et al*., 2014). However, continuous and imbalance use of fertilizers caused deterioration of soil health. Integrated nutrient management is in fact most important component of the production technology to sustain soil fertility and crop productivity in the future. The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai, 2007). Organic manures improve soil physical, chemical and biological properties and thus enhance crop productivity *vis-à-vis* maintain soil health. Organic manures contain plant nutrients in small quantities, as compared to the chemical fertilizers, the presence of growth hormones and enzymes make them essential for improvement of soil fertility and productivity. In addition to this, the organic manures help in improving the use efficiency of inorganic fertilizers (Singh and Biswas, 2000). The organic sources available presently in the country could meet nearly 1/3rd of total nutrients required to achieve the target of agricultural production. Though many workers at mainland have reported effect of integrated nutrient management on the performance of okra, very few information is available on the use of farm yard manure, vermicompost, neem cake integrated with inorganic fertilizers for cultivation of okra under island condition, where the level of fertilizer use in agriculture is minimal. The climatic condition favours luxuriant vegetations and provide scope for organic waste recycling. The total availability of organic wastes in Andaman and Nicobar Islands accounts to 5,77,672 MT per annum (Velmurgan *et al*., 2014). Regular application of organic manure in amounts sufficient to meet the nutrient requirements of crops not only increase the crop yield but also improve the soil fertility and organic matter content (Ramesh *et al*., 2009) and availability of plant nutrients as compared to chemical fertilizer (Brar *et al*., 2004). It is essential to develop a cost effective and eco-friendly integrated nutrient management package for Andaman and Nicobar Islands by using locally available organic manures. Therefore, the experiment was conducted to study to the effect of various organic sources along with different levels of inorganic fertilizers on dry matter production, nutrient uptake and yield of okra under island conditions.

RESEARCH PROCEDURE

The experiment was carried out at multipurpose Farm, Diglipur, North Andaman to study the effect of various organic and inorganic sources of nutrients on dry matter production, nutrient uptake and yield of okra var. Arka Anamika, during 2015 and 2016. The experimental site is situated at 13.26° N latitude and 92.98° E longitude, where the average temperature ranges from 23°C to 34° C with the average annual rainfall of 3180 mm. The mechanical analysis was determined by Bouyousous hydrometer method (Bouyousous, 1951) and the textural classes were estimated by using textural triangle (Kanwar and Chopra, 1978). The physico- chemical properties *i.e.* Soil pH and electrical conductivity was determined by glass electrode pH meter and EC meter, respectively using 1:2.5 soil:water: suspension (Jackson, 1973), organic carbon content by wet digestion method using Walkly and and Black's rapid titration method (Black, 1965). The available Nitrogen was estimated by alkaline $KMnO_4$ method (Subbiah and Asija,1956), available phosphorus was estimated by spectrophotometer method (Bray and Kurtz, 1945) and available potassium was estimated through neutral normal ammonium acetate method by flame photometer (Tandon, 1993). The soil of the experimental plot was clay loam in texture, slightly acid in reaction, medium in organic carbon, low in available nitrogen and phosphorus and medium in available potassium. The experiment was laid out in Randomised Block Design (RBD) with three replications, each replication comprised of 14 treatments which include T_1- Control (no manure), T_2- 100 % of recommended dose of NPK, T_3- 75% of recommended dose of NPK + FYM @ 5.0 t ha^{-1}, T_4- 75% of recommended dose of NPK+VC @2.5 t ha^{-1}, T_5- 75% of recommended dose of NPK +NC @1.25 t ha^{-1}, T_6- 75% of recommended dose of NPK + FYM @2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} +NC @ 0.5 t ha^{-1}, T_7- 50% of recommended dose of NPK +FYM @7.5 t ha^{-1}, T_8-50% of recommended dose of NPK + VC @ 5.0 t ha^{-1}, T_9-50% of recommended dose of NPK+NC@ 2.5 t ha^{-1}, T_{10}-50% of recommended dose of NPK + FYM @3.75 t ha^{-1}+VC @ 2.5 t ha^{-1}+ NC @ 1.25 t ha^{-1} ,T_{11} -25% of recommended dose of NPK + FYM @10 t ha^{-1}, T_{12} - 25% of recommended dose of NPK +VC @7.5 t ha^{-1}, T_{13}-25% of recommended dose of NPK +NC @5.0 t ha^{-1} and T_{14}- 25% of recommended dose of NPK + FYM @ 5.0 t ha^{-1} + VC @ 3.75 t ha^{-1}+ NC @ 2.5 t ha^{-1}. The

recommended dose of fertilizer adopted for okra was 80, 50, 50 kg NPK ha^{-1}. The seeds of okra cv. ARKA ANAMIKA were sown in the last week of April at spacing of 60 x 30 cm during both the years. Full dose of phosphorus, potash and ½ dose nitrogen was applied as basal, while remaining ½ dose nitrogen was applied as split dose at 30 and 60 days after sowing. The inorganic source of N, P and K were urea, diammonium phosphate and muriate of potash, respectively. Well decomposed farm yard manure, vermicompost and *Neem* cake were applied one week before sowing. All the cultural practices were followed as per recommendations. Need based plant protection measures were also followed. The observations related to dry matter production, nutrient uptake and yield attributes were recorded and subjected to statistical analysis as per method suggested by Gomez and Gomez (1984). The total N, P and K uptake by plants at harvest was calculated by multiplying per cent nutrient content with their respective dry matter production.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Dry matter production :

The data in respect of total dry matter production of okra pod and plant (kg/ha) as influenced by various treatments are furnished in Table 1. It is clear from the data that dry matter production of okra pod and plant were significantly affected by different treatments in both the years of study. The results revealed that application of 75 per cent recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1}+ NC @ 0.5 t ha^{-1} (T_6) recorded higher dry matter production of plant and pod which in turn resulted in higher total dry matter production (3054 and 2955 kg ha^{-1}), which was at par with T_8 (50% of recommended dose of NPK + VC @ 5.0 t ha^{-1}), T_{10} and T_2 during both the years. This is in line with the findings of Sanjeev Kumar and James Pitchai (2010) who have recorded highest dry matter production in bhindi treated with 50 per cent RDF in combination with goat manure @ 6.5 t ha^{-1} and Kuppuswamy *et al*. (2013) who obtained the highest dry matter production with the application of 50 per cent nitrogen through urea and 50 per cent through FYM. The probable cause may be due increased availability of nitrogen with the integration of organic and inorganic sources.

Nutrient uptake :

The data pertaining to nutrient uptake in respect of plant, pod and total uptake under various treatments are given in Table 2. It is evident from the data that application of inorganic fertilizers at higher levels alone or in

Table 1 : Dry matter production (kg/ha) as influenced by integrated nutrient management in okra

Treatments	Plant		Pod		Total DMP	
	2015	2016	2015	2016	2015	2016
T_1	1124	1094	651	643	1775	1737
T_2	1804	1783	945	918	2749	2701
T_3	1612	1596	849	827	2461	2423
T_4	1733	1697	920	873	2653	2570
T_5	1658	1627	870	864	2528	2491
T_6	2029	1991	1025	964	3054	2955
T_7	1729	1632	919	874	2648	2505
T_8	1967	1912	987	956	2954	2867
T_9	1616	1576	850	866	2466	2443
T_{10}	1829	1756	968	943	2797	2699
T_{11}	1436	1450	764	743	2200	2194
T_{12}	1459	1514	776	797	2235	2310
T_{13}	1365	1342	726	717	2092	2058
T_{14}	1328	1281	804	712	2132	1993
S.E.±	123	88	64	63	187	135
C.D.(P=0.05)	252	180	132	131	383	277

combination with organic fertilizers had significant effect on uptake of N, P and K in okra.

The nitrogen uptake by the okra plants was significantly influenced by synergistic effect of organic and inorganic sources of nutrients.Among the various treatments, the total N uptake of okra plant was maximum (84.20 and 83.49 kg ha^{-1}) with 75 per cent recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} + NC @ 0.5 t ha^{-1} (T_6) during both the years and was found comparable to T_8, T_{10} and T_2. Similar results were also reported by Sharma *et al*. (2009) who reported that application of 100 % NPK +10 t vermicompost to okra increased the N uptake over 100 per cent NPK alone. Gowda *et al*. (2002) has also reported that in okra with increased level of fertilizers, accumulation of nitrogen also increased significantly in various plant parts. These data indicate the need for integrated nutrient supply system for okra. The significant interaction between organic manures and inorganic fertilizers at different levels might have increased the plant nutrient uptake. Yadav *et al*. (2000) reported that efficiency of inorganic fertilizer is improved when used in conjunction with organic manures.

Among the various treatments, the maximum total P uptake (14.87 and 14.82 kg ha^{-1}) of okra was recorded with 75% recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} + NC @ 0.5 t ha^{-1} (T_6) and at par with T_8 during both the years. The increased uptake in plants might be attributed to the fact that at higher levels of RDF the prolific root system might have developed resulting in better absorption of water and nutrients along with improved physical environment. Wagh *et al*. (2014) also recorded higher nutrient uptake with 75 % RDF + 12.5 % RDN through vermicompost + 12.5 % RDN through *Neem* cake. Similar results were also reported by Majeeduddin *et al*. (2015). The P uptake of okra plant was lower with reduced fertilizer level in combination with organic fertilizers.

Total K uptake was also higher at 75 per cent recommended dose of NPK + FYM @2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} + NC @ 0.5 t ha^{-1} (T_6) and at par with T_2 and T_4. The beneficial effect of nutrients on nutrient uptake may be due to increased supply of nutrients to the crop. Dademal and Dongale (2004) also reported that the concentration of N and K in various parts of okra plant were increased significantly with increased level of fertilizer than control. Bairawa *et al*. (2009) has obtained highest nitrogen phosphorus and potassium contents of leaves with application of neem cake 6q ha^{-1}+ vermicompost 10q ha^{-1} + *Azotobacter* + PSB + 60% recommended dose of NPK through inorganic fertilizers over the nutrient management through both sole inorganic

Table 2 : Effect of integrated nutrient management on nutrient uptake (kg/ha) of okra

Treatmens	Nutrient uptake in plants						Nutrient uptake in pod						Total Nutrient uptake					
	N		P		K		N		P		K		N		P		K	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
T_1	20.86	20.14	2.54	2.47	13.77	13.33	18.59	18.40	4.90	4.90	19.48	17.44	39.45	38.54	7.44	7.37	33.25	30.77
T_2	39.82	38.82	4.34	4.17	23.49	22.97	36.16	34.31	8.29	7.94	32.47	30.33	75.98	73.14	12.63	12.11	55.96	53.30
T_3	36.16	35.61	3.97	3.88	19.71	19.36	32.89	32.15	7.53	7.24	27.84	26.51	69.04	67.76	11.50	11.12	47.55	45.87
T_4	39.71	37.28	4.27	4.31	22.54	21.94	36.20	35.37	8.09	7.91	31.24	30.88	75.91	72.64	12.37	12.22	53.78	52.82
T_5	37.03	35.65	4.11	3.89	20.50	20.23	33.64	32.66	7.76	7.83	28.78	27.92	70.68	68.31	11.88	11.72	49.28	48.16
T_6	44.15	43.33	5.19	4.96	25.23	24.47	40.04	40.17	9.68	9.86	35.57	35.64	84.20	83.49	14.87	14.82	60.08	60.11
T_7	38.24	35.93	3.85	3.54	21.13	19.86	34.74	34.23	7.64	7.31	29.73	28.30	72.98	70.15	11.49	10.85	50.86	48.16
T_8	42.51	42.54	4.78	4.54	25.16	23.98	38.47	38.34	9.13	9.00	35.01	34.05	80.98	80.88	13.91	13.54	60.17	58.03
T_9	37.11	35.92	3.49	3.41	19.62	19.08	33.81	32.69	7.06	7.01	27.77	26.85	70.92	68.61	10.56	10.42	47.39	45.93
T_{10}	40.69	40.03	4.34	3.98	22.49	21.49	36.96	37.45	8.37	8.01	31.66	30.19	77.65	77.48	12.71	11.99	54.15	51.68
T_{11}	31.93	30.39	3.62	3.28	17.86	17.75	29.00	28.14	6.77	6.73	24.98	24.71	60.74	58.53	10.39	10.01	42.84	42.46
T_{12}	31.09	31.71	2.97	3.33	18.44	18.88	28.08	27.12	6.20	6.06	25.79	26.01	57.17	58.84	9.17	9.38	44.23	44.89
T_{13}	26.63	26.63	2.87	3.00	16.85	16.55	23.85	24.91	5.86	6.03	23.61	23.48	50.48	51.53	8.73	9.03	40.46	40.04
T_{14}	26.43	25.64	2.89	2.66	16.06	15.60	23.65	24.08	5.03	5.07	22.54	21.80	49.99	49.72	7.92	7.73	38.60	37.41
S.E.±	4.07	2.64	0.42	0.32	1.53	1.67	3.88	3.20	0.53	0.50	3.48	2.65	7.96	5.61	0.88	0.75	3.74	3.55
C.D. (P=0.05)	8.38	5.42	0.87	0.65	3.15	2.40	7.98	6.59	1.08	1.03	7.15	5.45	16.36	11.52	1.82	1.54	7.68	7.29

and organic sources.

Yield :

Integration of individual organic sources with inorganic fertilizer exhibited higher yield in okra during both the years (Table 3). The treatment T_6 (75% of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} +NC @ 0.5 t ha^{-1}) has registered higher yield per plant (278.76 and 244.11 g) and yield per hectare (12.57 and 11.00 t) during both the years which was at par with yield obtained in the treatment T_8, as compared to other treatments. Integrated management of nutrients on growth and yield attributes has brought significant improvement in yield over other treatments. This is in conformity with the findings of Tripathi *et al.* (2004) who reported that combined application of 75% NPK + vermicompost @ 5 t ha^{-1} produced significantly higher yield of okra. Similar results were also reported by Vennila and Jayanthi (2008). Premsekhar and Rajshree (2002) have reported that the yield attributes as well as the yield of okra were significantly enhanced by the application of 2 0 t ha^{-1} of FY M. Soil fertility build up in terms of available nitrogen, phosphorus and potash was also observed improved in soil under combination of crop residues (5 tonnes /ha), FYM (5 tonnes/ha) and biofertiliser (*Azospirillum*, PSB) from paddy-okra cropping system. Shelar *et al*. (2011) stated that the yield (154.47 q/hectare) and yield parameters such as fruit weight (10.47 g), fruit breadth (1.5cm) and fruit length (9.5 cm) were highest in the treatment T_9 (50% N through urea + 50 % N through *Neem* cake). Kuppuswamy *et al*. (2013) reported that the supply of 50 per cent of nitrogen through urea and the remaining either through FYM or vermicompost has recorded the better growth and yield in okra.

Economics :

The economics of the okra worked out in the present study (Table 3) revealed that maximum net return (Rs. 2,98,289 and Rs. 2,69,474) was registered by the treatment T_6 (75% of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1}+ NC @ 0.5 t ha^{-1}) during both the years followed by T_8 (50% of recommended dose of NPK + VC @ 5.0 t ha^{-1}) out of other treatments tried, indicating that these treatment combinations are profitable. Similarly, treatment T_6 (75% of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1}+ NC @ 0.5 t ha^{-1}) recorded higher B: C (4.79 and 4.42) followed by T_2 (100 % RDF through NPK) during both the years.Though the treatment T_8 (50% of recommended dose of NPK + VC @ 5.0 t ha^{-1}) recorded higher yield attributes and yield as compared to T_2, recorded lower B: C (3.25 and 3.03) due to higher cost of vermicompost. Similar observations have also been made by Bairwa *et*

Table 3 : Effect of integrated nutrient management on yield and economics of okra

Treatments	Yield/plant (g)		Yield/ ha (t/ha)		Net return (Rs./ha)		BCR	
	2015	2016	2015	2016	2015	2016	2015	2016
T_1	107.78	98.12	4.86	4.36	96021	87597	2.93	2.76
T_2	189.13	172.66	8.53	7.86	199772	182910	4.57	4.27
T_3	182.93	171.68	8.25	7.74	178401	157240	3.59	3.28
T_4	211.12	191.43	9.52	8.63	204026	173647	3.50	3.13
T_5	194.03	189.72	8.75	8.00	197269	152534	4.03	3.34
T_6	278.76	244.11	12.57	11.00	298289	269474	4.79	4.42
T_7	210.83	185.92	9.50	8.98	210763	196644	3.83	3.64
T_8	254.15	225.10	11.46	10.62	238093	214732	3.25	3.03
T_9	176.74	165.42	7.97	7.46	166110	156995	3.28	3.15
T_{10}	223.69	207.62	10.08	9.36	203886	190978	3.07	2.94
T_{11}	154.76	138.54	6.98	6.25	129561	97391	2.62	2.22
T_{12}	166.44	139.34	7.50	6.28	95367	59218	1.74	1.46
T_{13}	137.25	134.05	6.19	5.87	96285	80177	2.08	1.90
T_{14}	157.68	151.97	7.11	6.48	91219	64018	1.75	1.52
S.E.±	26.78	16.8	1.21	0.7	-	-	-	-
C.D.(P=0.05)	55.06	34.55	2.48	1.56	-	-	-	-

al. (2009). Kumar *et al.* (2013) in a study has obtained highest B:C (1.77) with the application of 75 kg N + 40 kg P_2O_5 +40 kg K_2O +5 t ha^{-1} VC + 20 kg $ZnSO_4$ ha^{-1}.

Conclusion :

Application of 75% of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} + NC @ 0.5 t ha^{-1} was highly favourable for dry matter production, nutrient uptake and yield of okra. Increased net return and B: C were also associated the integrated nutrient management *i.e.*, 75% of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} + NC @ 0.5 t ha^{-1}. Hence, from the results of this experiment it can be concluded that 75% of recommended dose of NPK + FYM @ 2.5 t ha^{-1} + VC @ 1.25 t ha^{-1} + NC @ 0.5 t ha^{-1} is the highly profitable and economically viable for the cultivation of okra under Island conditions.

Acknowledgement :

The authors are thankful to Dr. S. Dam Roy, Director, ICAR-CIARI, Port Blair for the help rendered during the research period. We sincerely acknowledge the support of officers and staff of Department of Agriculture, Diglipur, scientists and technical staffs of CIARI, Port Blair.

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