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Babita Mishra
Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

GS Sahu
Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

P Tripathy
Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

S Mohanty
Department of soil Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

B Pradhan
Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Correspondence
Babita Mishra
Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Effect of integrated nutrient management (INM) on growth, yield, nutrient uptake and soil fertility in okra (*Abelmoschus esculentus* (L.) Moench) cv. Pusa A-4

Babita Mishra, GS Sahu, P Tripathy, S Mohanty and B Pradhan

Abstract
A field experiment was conducted at the instructional farm of Krishi Vigyan Kendra Jajpur, Odisha during 2015 to study the "effect of integrated nutrient management on growth, yield, nutrient uptake and soil fertility in okra" variety-Pusa A-4. It was observed that application of RDF (75%) + (25%) N through neem oil cake (T_7) produced maximum plant height (131.40 cm), number of leaves/plant (19.68), leaf area (324.68cm^2), minimum days to first flowering (32.1), minimum days to 50% flowering (41.8), minimum days to first harvest (37.6), maximum number of fruits/ plant (14.42) and maximum yield (9.49 t/ha) and followed by T_5 where RDF (75%) + (25%) N through vermicompost was applied. RDF was 110:50:80 NPK kg/ha. Highest uptake of nitrogen (64.52 kg/ha), phosphorus (19.58 kg/ha) and potassium (57.50 kg/ha) were recorded in T_7 where RDF (75%) + (25%) N through neem oil cake was applied. Highest post-harvest available nitrogen (328 kg/ha), phosphorus (27.3kg/ha) and potassium (268 kg/ha) were found in T_{11} where 25% N through FYM + 25% N through vermicompost+25% N through poultry manure+25% N through neem oil cake were applied. Whereas, lowest post harvest available nitrogen (292kg/ha), phosphorus (12.7kg/ha) and potassium (218kg/ha) were found in T_7.

Keywords: INM, growth, yield, neem oil cake, vermi compost, poultry manure, FYM, nutrient uptake

Introduction
Okra, (*Abelmoschus esculentus* (L). Moench) belonging to family Malvaceae (2n= 130) commonly known as Lady's finger is grown in all the thirty districts of Odisha 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. The 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
A field experiment was conducted at the instructional farm of Krishi Vigyan Kendra Jajpur, Odisha during 2015 to study the effect of integrated nutrient management on growth, yield and quality of okra, variety-Pusa A-4. The experiment was laid out in randomized block

design (RBD) with three replications and twelve treatments. Treatments involved were T_1 (100% RDF), T_2 (100% RDF + FYM 1.5 t / ha), T_3 (RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2kg/ha each), T_4 (RDF (75%) + (25%) N through FYM), T_5 (RDF (75%) + (25%) N through vermi compost), T_6 (RDF (75%) + (25%) N through poultry manure), T_7 (RDF (75%) + (25%) N through neem oil cake), T_8 (RDF (50%) + (25%) N through FYM + (25%) N through vermicompost), T_9 (RDF (50%) + (25%) N through FYM + (25%) N through poultry manure), T_{10} (RDF (50%) + (25%) N through FYM + (25%) N through neem oil cake), T_{11} (25% N through FYM + 25% N through vermicompost + 25% N through poultry manure + 25% N through neem oil cake), T_{12} (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 fine tilth through ploughing and tillage. Irrigation channels and bonds 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 and 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. The data on these parameters were subjected to statistical analysis to draw logical conclusions.

Results and Discussion

Growth and yield parameters

The growth and yield parameters like plant height, number of leaves per plant, leaf area, days to first flowering, days to 50% flowering, days to first harvest, number of fruits per plant and Yield differed significantly due to various treatments.(Table-1) From the experiment it was observed that application of RDF (75%) + (25%) N through neem oil cake (T_7) produced maximum plant height (131.40 cm), number of leaves per plant (19.68), leaf area (324.68cm^2), minimum days to first flowering (32.1), minimum days to 50% flowering (41.8), minimum days to first harvest (37.6), maximum number of fruits/ plant (14.42) followed by T_5 where RDF (75%) + (25%) N through vermicompost was applied. Due to application of 75 % RDF through chemical fertilizer and 25 % RDF through neem oil cake less incidence of sucking pest and disease occurrence were observed for which the source- sink relation and photosynthesis was somewhat normal resulting in increase in plant height. Initial requirement of N was met from the inorganic source and subsequent requirement of N from organic source assuring continuous N supply throughout growing period favored consistent N uptake by plant at different growth stage favoring increase in height, number of leaves per plant, leaf area. The present findings coroborate with the findings of Shelar (2011), Ghuge *et al*. (2015), Anand *et al*. (2016) [13, 7, 3]. Combined effect of chemical fertilizers along with neem oil cake helped to absorb nutrients which was utilized for early initiation of the flowering bud and ultimately developed more flower within a shortest possible period. The present findings are in conformity with the reports of Kumar *et al*. (2017) [9]. 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. Similar result was obtained by Bairwa *et al*. (2009) [4].

Fruit yield was found to be maximum with T_7 (9.49 t/ha) receiving 75 % RDF + 25 % N through neem oil cake which was at par with (T_5) 75 % RDF + 25 % N through vermicompost (9.02 t/ha) and was found minimum in T_{11} (6.62 t/ha) where only organic fertilizers were applied. Application of neem oil cake along with chemical fertilizer significantly increased the number of fruits per plant and fruit weight which resulted in increasing yield due to better availability and uptake of plant nutrients for a longer time of crop growth. The application of neem cake not only increased the N status of soil but also improved the rate of multiplication of beneficial microorganism, which in turn helped the decomposition of applied manures. Similar findings were obtained by Adilakshmi *et al*. (2008) Tripathy *et al*. (2008), Sachan *et al*. (2017) and singh *et al*. (2018) [1, 15, 10, 10].

Soil parameters

Nutrient uptake by okra plant as well as post harvest availability of N, P_2O_5, K_2O significantly influenced by different treatments is shown in Table 2. Highest uptake of nitrogen (64.52 kg/ha), Phosphorus (19.58 kg/ha), Potassium (57.50 kg/ha) were recorded in T_7 where RDF (75%) + (25%) N through neem oil cake were applied. This might be due to the solubilization of organic acids produced during decomposition of organic manures (neem oil cake), improved aeration and root proliferation which helped in increased uptake. Moreover better nutritional atmosphere of rhizosphere with respect to nutrients might have increased nutrient uptake (Khankhana and Yadav, 2003) [8]. Similar findings were obtained by Barani and Anburani (2004), Sharma *et al*. (2009), Wagh *et al*. (2014) and Amiry *et al*. (2018) [5, 12, 16, 2]. Highest post harvest availability of N (328 kg/ha), P_2O_5 (27.3kg/ha), K_2O (268 kg/ha) were found in T_{11} where 25% N through FYM + 25% N through vermicompost+25% N through poultry manure + 25% N through neem oil cake were applied. Whereas, lowest post-harvest availability of N (292kg/ha), P_2O_5 (12.7kg/ha), K_2O (218kg/ha) were found in T_7. The lower content of available nitrogen in soil might be due to higher uptake of nutrients by the plants. The use of neem oil cake and vermicompost might have supplied an addition dose of N besides causing an improvement in microbial activity, stabilization of soil structure and associated benefits. It was also observed that the available nitrogen content after harvest of crop due to its high uptake, decreased but, had maintained the available nitrogen in soil sufficiently at higher level indicating slow and steady release of nitrogen which is essential for sustainable soil fertility and productivity. The present findings corroborate with Salvi *et al*. (2015) [11]. The increase in available P might be due to the mineralization of insoluble compounds through action of organic acids released during the decomposition of organic manure. The present findings is in accordance with same type of result which were reported by Sharma *et al*. (2009) [12]. The increase in the availability of K through addition of organic manure was also reported by Choudhary *et al*. (2015) [6], Kumar *et al*. (2017) [9] and Amiry *et al*., (2018) [2].

Table 1: Effect of integrated nutrient management on growth and yield in okra

Treatment	Plant height (cm)	No. of leaves/plant	Leaf area (cm^2)	Days to first flowering	Days to 50% flowering	Days to first harvest	No. of fruits/plant	Yield (t /ha)
T_1	114.25	16.82	269.03	34.0	44.2	39.2	12.84	8.48
T_2	118.00	16.24	311.82	33.5	42.3	38.7	13.10	8.86
T_3	102.53	14.28	249.28	35.9	46.2	41.1	11.03	7.50
T_4	110.95	15.24	238.62	35.0	45.7	41.0	12.21	8.03
T_5	128.84	19.24	298.86	34.1	43.9	39.8	13.64	9.02
T_6	115.4	16.29	238.32	35.2	45.1	40.4	13.02	8.57
T_7	131.40	19.68	324.68	32.1	41.8	37.6	14.42	9.49
T_8	113.45	16.65	238.43	34.1	44.8	39.9	12.66	8.27
T_9	106.42	16.50	298.84	33.7	43.7	38.9	11.93	7.91
T_{10}	119.82	17.70	296.86	33.9	43.5	38.9	13.15	8.93
T_{11}	94.86	14.18	211.42	36.2	46.3	41.4	10.42	6.62
T_{12}	97.49	14.52	269.32	36.4	46.7	41.8	10.98	6.76
SEm (±)	4.76	0.77	9.19	0.68	0.95	0.59	0.39	0.28
CD (0.05)	13.96	2.26	26.95	2.00	2.78	1.70	1.13	0.84

Table 2: Effect of integrated nutrient management on nutrient uptake and soil fertility in okra

Treatment	Nutrient uptake (kg/ha)			Post-harvest soil availability of nutrients (kg/ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	47.68	11.70	40.96	310	18.3	251
T_2	52.58	13.55	46.89	306	15.1	232
T_3	39.02	7.74	31.32	324	23.4	264
T_4	43.66	9.93	36.78	319	21.4	258
T_5	62.43	17.84	53.19	298	13.3	221
T_6	49.48	12.59	42.24	308	17.4	248
T_7	64.52	19.58	57.50	292	12.7	218
T_8	45.97	10.44	38.03	312	20.2	254
T_9	41.49	8.89	34.11	321	22.2	263
T_{10}	61.53	15.58	49.31	303	14.2	229
T_{11}	32.27	6.89	26.42	328	27.3	268
T_{12}	35.77	7.74	28.60	326	25.3	266
SEm (±)	1.37	0.49	1.26	3.08	0.83	4.92
CD (0.05)	4.03	1.44	3.71	9.03	2.43	14.42

Conclusion

From the experimental result it was observed that integrated application of 75% RDF in the form of chemical fertilizers and 25 % N through neem oil cake was found best in producing more plant height, more number of leaves, maximum leaf area, minimum days to first flowering, 50% flowering, minimum days to first harvest, maximum number of fruits per plant, with higher yield (9.49 t/ha) followed by T_5 (9.02 t/ha) where 75% RDF in the form of chemical fertilizers and 25 % N through vermi compost were applied. It also improved the soil health. Therefore, T_7 has been considered as best treatment for higher production and more profit and can be adopted under field condition.

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