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Integrated Nutrient Management (INM) in Okra (*Abelmoschus esculentus* (L.) Moench) for Better Growth and Higher Yield

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Abstract
Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. A field experiment was conducted at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, (U.P) India, during the March to June season of 2017, to study the growth, yield and quality of Okra (*Abelmoschus esculentus* L.) as influenced by the Integrated Nutrient Management. The experiment was laid out in randomized block design with three replications. The twelve treatment combinations viz. T_1 (Control), T_2 (FYM @ 20tn/ha), T_3 (Poultry Manure @ 10tn/ha), T_4 (Vermi Compost @ 10tn/ha), T_5 (FYM @ 10tn/ha + PM @ 5tn/ha), T_6 (FYM @ 10tn/ha + VC @ 5tn/ha), T_7 (Poultry manure @ 5tn/ha + Vermi Compost @ 5tn/ha), T_8 (FYM @ 10tn/ha + Poultry manure @ 5tn/ha + Vermi Compost @ 5tn/ha), T_9 (NPK @ 50% + FYM @ 10tn/ha + PM @ 5tn/ha), T_{10} (NPK @ 50% + FYM @ 10tn/ha + VC @ 5tn/ha), T_{11} (NPK @50% + Poultry manure @5tn/ha + Vermi Compost @5tn/ha) and T_{12} (NPK @ 75% + FYM @2.5tn/ha + Poultry manure @2.5tn/ha + Vermi Compost @2.5tn/ha) were allocated randomly in each plot. The results revealed that the treatment T_{12} significantly found best among the all treatments at all successive growth stages in almost all the traits i.e. plant height (154.0 cm), number of Branches per plant (4.91), fresh weight of plant (17.11t/ha) and dry weight of plant (2267.67kg/ha) as growth parameters; whereas no. of pods per plant (12.44), single pod weight (15.17gm), length of pods (11.58 cm), dry weight of pods (1039.33kg/ha), total pod yield (14.29t/ha) as yield related traits and protein content (16.61%) and TSS (2.44˚Brix) as quality parameters while the treatment T_1 (control) showed lowest response in term of growth, yield and quality of okra.

Keywords: Okra, FYM, Vermicompost, Poultry Manure, Growth, Yield and Quality.

Introduction
Okra (*Abelmoschus esculentus* L. Moench.) is a fast growing, erect, herbaceous annual and belongs to the family Malvaceae. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. Centre of origin of okra is Africa.

It is commonly grown through the warmer parts of temperate Asia, Southern Europe, Northern Africa, the United States, and in all parts of the tropics. India ranks first for okra production in the world. In India, Uttar Pradesh covering an area of 11.1 thousand hectares with a production of 128.80 thousand million tonnes and productivity of 11.31 metric tonnes per hectare (Anonymous, 2011).

Okra has good nutritional value as 100g consumable unripe fruit contains moisture 89.6g, carbohydrates 6.4g, protein 1.9g, fat 0.2g, fibre 1.2g, minerals 0.7g, vitamin A 88 IU, thiamine 0.07mg, riboflavin 0.10mg, nicotinic acid 0.60mg and vitamin C 13mg.

Okra requires large quantities of both macro and micro nutrients for required economic yields. Nitrogen, phosphate and potash nutrients are important and play a key role in the production of both quantity and quality level in okra. These nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity. Indiscriminate use of inorganic fertilizers has resulted in decreased nutrient uptake, poor quality of vegetables and deterioration of soil health (Agrawal, 2003) [1]. Integrated nutrient management (INM) system envisages use of organic manures 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 helps to restore and sustain soil fertility and crop productivity. It may also help to check the emerging deficiency of nutrient other than N, P and K. The result of this research was helpful to identify the best organic manure and inorganic fertilizers combination for sustainable cultivation of okra.

Materials and Methods

An experiment was conducted at Horticulture Experimental field, Department of Horticulture, SHUATS, Allahabad during March to June of 2017. The experiment was laid out in randomized block design with 12 treatments and each replicated thrice. The treatments involved were T_1 (Control; RDF), T_2 (FYM @ 20tn/ha), T_3 (Poultry Manure @ 10tn/ha), T_4 (Vermi Compost @ 10tn/ha), T_5 (FYM @ 10tn/ha + PM @ 5tn/ha), T_6 (FYM @ 10tn/ha + VC @ 5tn/ha), T_7 (Poultry manure @ 5tn/ha + Vermi Compost @ 5tn/ha), T_8 (FYM @ 10tn/ha + Poultry manure @ 5tn/ha + Vermi Compost @ 5tn/ha), T_9 (NPK @ 50% + FYM @ 10tn/ha + PM @ 5tn/ha), T_{10} (NPK @ 50% + FYM @ 10tn/ha + VC @ 5tn/ha), T_{11} (NPK @ 50% + Poultry manure @ 5tn/ha + Vermi Compost @ 5tn/ha) and T_{12} (NPK @ 75% + FYM @ 2.5tn/ha + Poultry manure @ 2.5tn/ha + Vermi Compost @ 2.5tn/ha), where is RDF: Recommended Dose of fertilizers. The plot size was 2.0 x 1.5 m and spacing followed was 45 x 30cm. The land was brought to a fine tilth through ploughing and tillage. Irrigation channels and bunds were maintained properly. The seeds were sown directly to the field. Light irrigation was given after sowing. The organic manures were applied one week before sowing, for proper decomposition, full dose of phosphorus and potassium and half dose of nitrogen as per treatment were applied just before the sowing. The remaining half dose of nitrogen was applied 30 days after sowing. All cultural practices were followed regularly during crop growth and observations were recorded on growth characters i.e., plant height, No. of branches, fresh weight of plant and dry weight of plants; yield parameters like single pod weight, dry weight of pods, No. of pods per plant, length of pod, total pod yield and quality parameters like TSS and protein content were recorded. The data on these parameters were subjected to statistical analysis to draw logical conclusions.

Results

The vegetative growth parameters like plant height, number of branches, fresh weight of plant and dry weight of plants were influenced significantly due to different treatments as shown in table 1. Overall vegetative parameters were influenced due to application of Nutrient through combination of organic manure and inorganic fertilizers were proved beneficially for increasing growth of Okra crop. The maximum vegetative growth in terms of plant height at 90 DAS (154.0cm), number branches at 90 DAS (4.91) fresh weight of plant (17.11t/ha) and dry weight of plants (2267.67kg/ha) were recorded in the treatment T_{12} receiving combination of [NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)]. The minimum values for all above vegetative parameters were found in T_1 (control). These results are closely confined with the findings of Obaji (2002) [4]; Patil *et al.* (2003) [5] and Bairwa *et al.* (2009) [2].

The yield parameters like single pod weight, dry weight of pods, No. of pods per plant, length of pod, total pod yield was influenced significantly as presented in table 2, by the combination of organic and inorganic fertilizers in different treatments which were recorded after harvesting of pods. The maximum pod length (11.58cm), single pod weight (15.17gm), No. of pods per plant (12.44), dry weight of pods (1039.33kg/ha), total pod yield (14.29t/ha) were recorded with the treatment T_{12} receiving [NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)]. Similar results were reported by Prabhu *et al.* (2002) [6]; Bodamwal *et al.* (2006) [3] and Tripathy and Maity (2009) [7].

Nutritive value of the pods is determined by the protein content and total soluble solid content in the pods. Significant differences were found in treatments in respect of Protein content and total soluble sugar as quality parameters (depicted in table 3). The highest protein content (16.61%) is noticed in treatment T_{12} [NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)] and also produced highest TSS (2.44^0Brix) which was superior over the other treatments. These results are closely confined with the findings of Vennila and Jayanti (2008) [8].

Conclusion

From the above findings it is concluded that the combination of T_{12} [NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)] resulted in maximum yield, protein content, TSS and found profitable as (1:2.23) benefit cost ratio in Okra under Allahabad Agro climatic condition.

Table 1: Effect of organic manures and inorganic fertilizer on growth parameters.

Treatments No.	Treatments Combination	Plant height (cm)			Number of Branches		Fresh weight of plant (t/ha)	Dry weight of plant (kg/ha)
		30 DAS	60 DAS	90 DAS	60 DAS	90 DAS		
T_1	Control (Recommended dose of NPK 100:50:50 kg/h)	28.67	67.77	117.53	1.93	2.54	12.48	1767.33
T_2	FYM (20tn/ha)	30.52	71.36	126.53	1.97	2.64	12.61	1784.67
T_3	Poultry Manure (10tn/ha)	34.65	74.73	135.53	2.05	3.12	13.23	1801.00
T_4	Vermi Compost (10tn/ha)	32.12	72.37	133.80	2.04	2.92	12.84	1791.67
T_5	FYM (10tn/ha) + PM (5tn/ha)	36.37	76.06	138.53	2.17	3.51	14.16	1847.00
T_6	FYM (10tn/ha) + VC (5tn/ha)	35.07	75.17	136.20	2.07	3.31	13.71	1815.33
T_7	Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	37.95	81.38	146.13	2.35	3.71	14.51	1848.33
T_8	FYM (10tn/ha) + Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	43.14	92.39	151.06	3.20	4.43	16.20	2185.33
T_9	NPK (50%) + FYM (10tn/ha) + PM (5tn/ha)	40.00	85.80	149.06	2.73	3.91	15.31	2061.00
T_{10}	NPK (50%) + FYM (10tn/ha) + VC (5tn/ha)	38.40	82.06	148.60	2.53	3.81	15.03	1932.67
T_{11}	NPK (50%) + Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	41.25	90.87	149.79	3.05	4.30	15.81	2104.00
T_{12}	NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)	45.60	95.09	154.00	3.70	4.91	17.11	2267.67
	F-test	S	S	S	S	S	S	S
	S. Ed	4.54	1.88	3.76	0.31	0.88	0.12	5.82
	C.D. at 0.5%	2.19	0.90	1.58	0.15	0.42	0.06	2.80

Table 2: Effect of organic manures and inorganic fertilizer on yield and fruit parameters.

Treatments No.	Treatments Combination	Length of pods (cm)	Single pod weight (g)	No. of Pods per plant	Dry weight of pods (kg/ha)	Total pod yield (t/ha)
T_1	Control (Recommended dose of NPK 100:50:50 kg/h)	8.37	8.91	9.45	880.33	5.06
T_2	FYM (20tn/ha)	8.69	9.13	9.54	915.33	7.26
T_3	Poultry Manure (10tn/ha)	9.31	9.64	10.14	948.00	9.11
T_4	Vermi Compost (10tn/ha)	9.05	9.33	9.81	927.00	7.61
T_5	FYM (10tn/ha) + PM (5tn/ha)	10.12	10.51	10.60	958.00	8.65
T_6	FYM (10tn/ha) + VC (5tn/ha)	9.32	10.03	10.43	950.33	8.54
T_7	Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	10.44	10.61	10.63	968.67	9.31
T_8	FYM (10tn/ha) + Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	11.23	13.02	11.28	1006.67	12.21
T_9	NPK (50%) + FYM (10tn/ha) + PM (5tn/ha)	10.75	11.47	11.01	976.33	9.99
T_{10}	NPK (50%) + FYM (10tn/ha) + VC (5tn/ha)	10.65	10.95	10.82	971.00	9.73
T_{11}	NPK (50%) + Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	10.75	12.87	11.07	979.33	10.58
T_{12}	NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)	11.58	15.17	12.44	1039.33	14.29
	F-test	S	S	S	S	S
	S.Ed	0.89	0.29	0.31	4.14	0.28
	C.D. at 0.5%	0.43	0.14	0.15	2.00	0.13

Table 3: Effect of organic manures and inorganic fertilizer on quality parameters.

Treatments No.	Treatments Combination	TSS (˚Brix)	Protein (%)
T_1	Control (Recommended dose of NPK 100:50:50 kg/h)	1.43	14.36
T_2	FYM (20tn/ha)	1.48	14.60
T_3	Poultry Manure (10tn/ha)	1.64	15.23
T_4	Vermi Compost (10tn/ha)	1.59	14.91
T_5	FYM (10tn/ha) + PM (5tn/ha)	1.83	15.58
T_6	FYM (10tn/ha) + VC (5tn/ha)	1.79	15.36
T_7	Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	1.95	15.61
T_8	FYM (10tn/ha) + Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	2.19	16.53
T_9	NPK (50%) + FYM (10tn/ha) + PM (5tn/ha)	2.02	15.98
T_{10}	NPK (50%) + FYM (10tn/ha) + VC (5tn/ha)	2.01	15.71
T_{11}	NPK (50%) + Poultry manure (5tn/ha) + Vermi Compost (5tn/ha)	2.12	16.21
T_{12}	NPK (75%) + FYM (2.5tn/ha) + Poultry manure (2.5tn/ha) + Vermi Compost (2.5tn/ha)	2.44	16.61
	F-test	S	S
	S.Ed	0.22	0.17
	C.D. at 0.5%	0.11	0.08

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