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Research Article

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT (INM) ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L. Moench) *cv*. GAO 5 UNDER NORTH GUJARAT CONDITION

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Abstract: The present experiment was carried out during the Kharif 2017 at experimental farm College of Horticulture, SDAU, Jagudan (Gujarat). The experiment was laid out in randomized block design with thirteen treatments *viz*., RDF- 100:50:50 kg NPK/ha + FYM 20t/ha (T_1), 75 % T_1 + Pressmud 1.25 t/ha (T_2), 50 % T_1 + Pressmud 2.5 t/ha (T_3), 75 % T_1 + Vermicompost 2.5 t/ha (T_4), 50 % T_1 + Vermicompost 5.0 t/ha (T_5), T_2 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T_6), T_3 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T_7), T_4 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T_8), T_5 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T_9), T6 + $ZnSO_4$ 20 kg/ha (T_{10}), T_7 + $ZnSO_4$ 20 kg/ha (T_{11}), T8 + ZnSO4 20 kg/ha (T_{12}), T_9 + $ZnSO_4$ 20 kg/ha (T_{13}).The results revealed that the significantly maximum stem thickness at 45 DAS (11.04 mm) and at 90 DAS (19.09 mm), highest plant height at 45 DAS (32.61 cm) and at 90 DAS (116.50 cm), maximum number of leaves per plant at 45 DAS (8.89) and at 90 DAS (17.30), maximum leaf area per plant at 60 DAS (1819.12 cm^2), maximum days taken to last picking (107.91), number of pod per plant (13.13), pod yield per plant (217.54 g), pod yield per plot (6.97 kg) and pod yield per hectare (120.86 q) were recorded with treatment T_{13}. Significantly maximum was recorded with treatment T_{13}).

Keywords: INM, Nutrients, Okra

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Introduction

Okra (*Abelmoschus esculentus* L. Moench) belongs to the family Malvaceae. It is widely adopted vegetable in Indian kitchens and can be grown round the year. Besides the utility of its tender green pods as a vegetable, it is used in soups and curries. Green Fingers are canned or dried for off-season use by army at high altitudes and are being exported for earning of foreign exchange. Okra pods are excellent source of minerals which imparts resistance against many diseases. It is also good for patients suffering from cardiac disorders. Ripped seeds are used as substitute of coffee. The roots, stems and plant fibre are used as a sugarcane juice clearing agent during the preparation of jaggary. Paper industries also demand this plant's fibre and widely grown in Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Karnataka, Maharashtra and Gujarat. India produces about 5.86 MT of okra from 0.51 M ha. In Gujarat, it is grown either as inter or sole crop. The area of okra is 76,029 ha with total production of 908676.75 MT and especially Mehsana district having an area is 2,055 ha with total production 28461.75 MT with an average productivity of 10 t/ha [1]. The excessive use of fertilizer and less use of organic matter, the green revaluation of previous decades and the intensive agriculture has depleted the soil and indicated wide spread deficiency of micro-nutrients. The gap in NPK fertilizers and the increasing deficiency of secondary and micronutrients which alert the scientists to concentrate more for partly meeting the crop requirements on mining the existing soil resources through use of organic and biofertilizers known as the Integrated Nutrient Management (INM). In other words, the INM has the basic philosophy of utilizing the (i) organic on and off-farm residues (cakes, pressmud, biocompost, farm residues, green manures) and use of (ii) symbiotic (species. of Rhizobium) and (iii) nonsymbiotic N fixing microbes (species of Azotobactor, Blue green algae, Azolla and Mycorrhizae). Since most of the sources are organic in nature, the physical and the biological soil fertility would also be sustained with the use of organics. Keeping in view these facts, present study was conducted to study the influence of different source of nutrient on growth parameters and efficacy on yield and yield contributing attributes

Materials and Methods:

The present investigation was carried out during *Kharif*-2017 at experimental farm College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Dist. Mehsana (Gujarat). The experiment consists thirteen treatments namely recommended dose of fertilizer (RDF) (100: 50: 50 kg NPK/ha)+ FYM 20t/ha (T_1), 75 % T_1 + Pressmud (PM) @ 1.25 t/ha (T_2), 50 % T_1 + Pressmud (PM) @ 2.5 t/ha (T_3), 75 % T_1 + Vermicompost (VC) @ 2.5 t/ha (T_4), 50 % T_1 + Vermicompost (VC) @ 5.0 t/ha (T_5),T_2 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T6), T_3 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T_7), T_4 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T8), T5 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha (T_9), T_6 + $ZnSO_4$ 20 kg/ha (T_{10}), T_7 + $ZnSO_4$ 20 kg/ha (T_{11}), T_8 + $ZnSO_4$ 20 kg/ha (T_{12}) and T_9 + $ZnSO_4$ 20 kg/ha (T_{13}) were laid out in a randomized block design replicated thrice. Observations were recorded on growth and yield traits and data were subjected for statistical analysis.

Results and Discussions:

Data presented in [Table-1] revealed that the effect of integrated nutrient management on stem thickness at 45 and 90 DAS was found significant. The maximum stem thickness (11.04 mm) at 45 days after sowing and (19.09 mm) after 90 DAS were recorded with treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + $ZnSO_4$ 20 kg/ha) which was statistically at par with treatment T_{11}, T_{12}, T_{10}, T_9, T_7, T_8, T_6, T_5 and T_3. The minimum stem thickness (8.73 mm) and (15.23 mm) were recorded 45 and 90 DAS respectively with treatment T_1 (100% RDF + FYM 20 t/ha). Increase in stem thickness might be due to the enhanced availability of nutrients and growth promoting substances that might have caused cell enlargement and cell multiplication which is directly correlated to the plant height and number of leaves. These results are in line with the finding of Singh *et al*. (2012) [2] and Gayathri and Reddy (2013) in okra. [3] The effect of integrated nutrient management on plant height [Table-1] at 45 and 90 DAS were found significant.

Table-1 Effect of integrated nutrient management on Stem thickness(mm), plant height (cm) and number of leaves

No.	Treatments detail	Stem thickness at 45 DAS (mm)	Stem thickness at 90 DAS (mm)	Plant height at 45 DAS (cm)	Plant height at 90 DAS (cm)	Number of leaves /plant at 45 DAS	Number of leaves /plant at 90 DAS
T_1	100% RDF (100:50:50 kg NPK/ha + 20 tonne FYM/ha)	8.73	15.23	24.59	93.25	7.28	13.87
T_2	75 % T_1 + Pressmud (PM) @ 1.25 t/ha	9.14	15.36	28.07	96.28	7.53	14.09
T_3	50 % T_1 + Pressmud (PM) @ 2.5 t/ha	9.99	16.59	29.52	97.22	7.97	15.05
T_4	75 % T_1 + Vermicompost (VC) @ 2.5 t/ha	9.64	16.25	28.86	97.14	7.79	14.51
T_5	50 % T_1 + Vermicompost (VC) @ 5.0 t/ha	10.10	16.50	30.43	100.40	8.08	15.19
T_6	T_2 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	10.21	16.51	30.47	101.49	8.25	15.35
T_7	T_3 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	10.53	17.69	30.74	103.16	8.60	15.73
T_8	T_4 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	10.31	17.33	30.52	101.90	8.40	15.49
T_9	T_5 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	10.56	17.61	30.76	104.23	8.70	15.76
T_{10}	T_6 + $ZnSO_4$ 20 kg/ha	10.58	17.81	31.75	104.80	8.86	16.39
T_{11}	T_7 + $ZnSO_4$ 20 kg/ha	10.88	18.67	32.06	114.16	8.60	17.07
T_{12}	T_8 + $ZnSO_4$ 20 kg/ha	10.71	18.44	31.84	107.97	8.85	16.60
T_{13}	T_9 + $ZnSO_4$ 20 kg/ha	11.04	19.09	32.61	116.50	8.89	17.30
	S.Em. ±	0.46	0.82	1.42	4.45	0.36	0.71
	C.D. (P = 0.05)	1.33	2.38	4.15	12.98	1.04	2.06
	C.V. %	7.75	8.24	8.17	7.48	7.48	7.86

Table-2 Effect of integrated nutrient management on Leaf area per plant (cm^2), days taken for initiation of first flower after sowing, days taken for maturity from first flower initiation, days taken to first picking and days taken to last picking

No.	Treatments detail	Leaf Area per plant at 60 DAS (cm^2)	Days taken for initiation of first flower after sowing	Days taken for maturity from first flower initiation	Days taken to first picking	Days taken to last picking
T1	100% RDF (100:50:50 kg NPK/ha + 20 tonne FYM/ha)	1504.15	43.33	7.70	50.38	98.96
T_2	75 % T_1 + Pressmud (PM) @ 1.25 t/ha	1568.15	42.90	7.58	49.81	100.48
T_3	50 % T_1 + Pressmud (PM) @ 2.5 t/ha	1583.74	42.59	7.30	49.65	101.50
T_4	75 % T_1 + Vermicompost (VC) @ 2.5 t/ha	1572.79	42.83	7.34	49.68	101.48
T_5	50 % T_1 + Vermicompost (VC) @ 5.0 t/ha	1586.83	42.00	7.09	49.37	102.42
T_6	T_2 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	1625.68	41.67	6.96	48.55	103.03
T_7	T_3 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	1715.41	41.43	6.86	48.23	104.05
T_8	T_4 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	1628.40	41.45	6.91	48.41	103.52
T_9	T_5 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	1762.01	41.33	6.85	48.22	104.62
T_{10}	T_6 + $ZnSO_4$ 20 kg/ha	1792.92	41.30	6.69	48.13	106.77
T_{11}	T_7 + $ZnSO_4$ 20 kg/ha	1812.61	40.66	6.61	47.90	107.35
T_{12}	T_8 + $ZnSO_4$ 20 kg/ha	1798.18	40.97	6.68	48.03	106.79
T_{13}	T_9 + $ZnSO_4$ 20 kg/ha	1819.12	39.88	6.04	47.88	107.91
	S.Em. (±)	75.62	1.69	0.30	1.39	1.90
	C.D. (P = 0.05)	NS	NS	NS	NS	5.56
	C.V. (%)	7.82	7.02	7.49	4.95	3.18

Table-3 Effect of integrated nutrient management on number of pod per plant, number of picking, pod yield per plant (g) per plot (kg) and per hectare (q).

No.	Treatments detail	Number of pod per plant	Number of picking	Pod Yield per plant (g)	Pod Yield per plots (kg)	Pod Yield per hectare (q)
T_1	100% RDF (100:50:50 kg NPK/ha + 20 tonne FYM/ha)	10.72	14.78	168.26	5.22	90.64
T_2	75 % T_1 + Pressmud (PM) @ 1.25 t/ha	11.26	15.80	174.87	5.54	96.18
T_3	50 % T_1 + Pressmud (PM) @ 2.5 t/ha	11.25	16.86	183.82	5.88	102.08
T_4	75 % T_1 + Vermicompost (VC) @ 2.5 t/ha	11.43	15.80	183.75	5.87	101.86
T_5	50 % T_1 + Vermicompost (VC) @ 5.0 t/ha	11.47	16.87	186.74	5.89	102.22
T_6	T_2 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	11.57	16.88	188.74	6.02	104.85
T_7	T_3 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	11.56	16.92	191.91	6.14	106.62
T_8	T_4 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	11.74	16.88	188.94	6.04	104.97
T_9	T_5 + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha	11.77	16.92	192.36	6.16	106.86
T_{10}	T_6 + $ZnSO_4$ 20 kg/ha	13.10	17.18	192.98	6.18	107.21
T_{11}	T_7 + $ZnSO_4$ 20 kg/ha	12.71	17.61	214.09	6.85	118.94
T_{12}	T_8 + $ZnSO_4$ 20 kg/ha	13.13	17.48	207.38	6.63	115.21
	S.Em. ±	0.55	17.66	217.54	6.97	120.86
	C.D. (P = 0.05)	1.59	0.70	8.64	0.30	5.13
	C.V. %	8.07	NS	25.22	0.86	14.98
			7.27	7.81	8.38	8.38

The highest plant height (32.61 cm) &(116.50 cm) were observed at 45 and 90 DAS respectively with treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + $ZnSO_4$ 20 kg/ha) which was statistically at par with treatment T_{11} ,T_{12}, T_{10}, T_9, T_7, T_8, T_6, T_5, T_3, and T_4 Whereas, the lowest plant height (24.59 cm) at 45 DAS and (93.25 cm) 90 DAS were recorded with the treatment T_1 (100% RDF + FYM 20 t/ha). An increase in plant height might be due to enhanced availability of nutrients and production of growth promoting substances that might have caused cell elongation and cell multiplication. These results are in conformity with the finding of Medhi and Kakati (1994) [4], Ray *et al*. (2005) [5], Singh *et al*. (2008) [6] and Mal *et al*. (2013) in okra [7]. [Table-1] showed that effect of integrated nutrient management on number of leaves at was found significant. Maximum number of leaves (8.89) and (17.30) were recorded 45 and 90 DAS respectively with treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + $ZnSO_4$ 20 kg/ha) which was statistically at par with treatment T_{10}, T_{12},T_9, T_{11}, T_7, T_8, T_6, T_5 andT_3.

However, the minimum number of leaves (7.28) at 45 DAS and (13.87) at 90 DAS was recorded with treatment T_1 (100% RDF + FYM 20 t/ha).Increase in number of leaves might be due to higher metabolic activity because of the higher N supply resulting in higher production of carbohydrates and phytohormones which were manifested in the form of enhanced growth. Vermicompost is reported to be a very good source of macro and micro elements, growth hormones, vitamins and micro flora. Production of growth promoting substances and vitamins by the combine application of chemical fertilizer *i.e*. RDF and vermicompost and their favourable influences in increasing the leaf number and height Solabannavar (2012) [8]. These results are in conformity with the finding of Nuruzzaman *et al*. (2003) [9] and Kanzariya *et al*. (2010) in okra [10]. Leaf area per plant (cm^2), days taken for initiation of first flower after sowing, Days taken for flower initiation to edible maturity and days to first picking of okra was not influenced by the any of the treatments and their combinations [Table-2]. Data [Table-2] clearly indicated the significant different among the treatments on days taken for last picking. The maximum days to last picking (107.91) was obtained in treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + $ZnSO_4$ 20 kg/ha) which is statistically at par with T_{11}, T_{12}, T_{10}, T_9, T_7, T_8, T_6 and T_5. While, the minimum days taken to last picking (98.96) was recorded with treatment T_1 (100% RDF + FYM 20 t/ha). The beneficial effect of application of organic manures along with inorganic manures reflected in enhanced vegetative growth of plant. This may be attributed to the synergistic effect of organic manures in making available more plant nutrient by improving the soil physical and chemical condition and solubilizing the nutrients. Findings of Kanzariya *et al*. (2010) [10] and Gayathri and Reddy (2013) [3] have supported the present results. It was observed from the data [Table-3] that numbers of pod per plant were influenced by different treatments. Among thirteen treatments, maximum number of pod per plant (13.13) was recorded with T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.50 l/ha + $ZnSO_4$ 20 kg/ha) which was statistically at par with treatment T_{11},T_{12}, T_{10},T_9, T_7 and T_8. Whereas, the minimum number of pod per plant (10.55) has been observed under treatment T_1 (100% RDF + FYM 20 t/ha).The number of pod per plant, the most important factor of fruit yield in okra were also significantly influenced due to the combined application of chemical fertilizer, vermicompost and biofertilizer. This might be due to the better availability and uptack of nutrient by plants for a longer duration of crop growth. These results are in conformity with the finding of Mal *et al*. (2013) [7], Mishra *et al*. (2009) [11] and Gayathri and Reddy (2013) [3]. Data pertaining to periodical observations on number of picking of okra are not influenced by different organic source of nutrients and biofertilizers which are presented in [Table-3]. The analysis of [Table-3] showed that yield per plant (g) was significantly influenced by the application of different treatments. Significantly maximum pod yield per plant (217.54 g) was obtained with treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + $ZnSO_4$ 20 kg/ha) which was statistically at par with T_{11}, T_{12}, T_{10} and T_9. While, the lowest yield per plant (168.26 g) was recorded with treatment T_1 (100% RDF + FYM 20 t/ha).

The significantly maximum yield per plot (6.97 kg) was obtained with treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.50 l/ha + $ZnSO_4$ 20 kg/ha) Which statistically at par with T_{11}, T_{12}, T_{10}, T_9 and T_7. while the lowest yield per plot (5.22 kg) was recorded with treatment T_1 (100% RDF + FYM 20 t/ha). The significantly maximum yield per hectare (120.86 q) was obtained with treatment T_{13} (50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha +*Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + $ZnSO_4$ 20 kg/ha) which, was statistically at par with T_{11}, T_{12}, T_{10}, T_9 and T_{17}. while, the lowest yield per hectare *i.e*., (90.64 q) was recorded with treatment T_1 (100% RDF + FYM 20 t/ha).The increased in yield may be due to better root proliferation, more photosynthesis efficiency, enhanced food accumulation, increased availability of atmospheric nitrogen and soil phosphorus by microbial inoculants and synthesis of plant growth hormones at all the essential stage of growth and development by the combined application of inorganic fertilizer and organic manure as well as biofertilizer. These results are conformity with the findings of Krishna (2000) [12], Mishra *et al*. (2009) [11] and Choudhary *et al*. (2015) [13].

Conclusion

It can be concluded that the application of 50% RDF + FYM 10 t/ha + Vermicompost 5.0 t/ha + *Azospirillum* 2.5 l/ha + PSB 2.5 l/ha + ZnSO4 20 kg/ha (T13) give higher yield of okra but the application of 50% RDF + FYM 10 t/ha + pressmud 2.5 t/ha + *Azospirillum* 2.5 l/ha + PSB 2.50 l/ha + ZnSO4 20 kg/ha (T11) recommended for getting higher return of okra.

Application of research: Study shows the maintaining the sustainability and enhancement of the production of okra.

Research Category: Vegetable Science

Abbreviations:
RDF- Recommended Dose of Fertilizers
FYM- Farm Yard Manures
PSB- Phosphate Solubilizing Bacteria
$ZnSO_4$- Zinc Sulphate

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