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INFLUENCE OF SPACING AND INTEGRATED NUTRIENT MANAGEMENT (INM) ON YIELD AND QUALITY ATTRIBUTES OF OKRA CV. ANAND KOMAL

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ABSTRACT

An experiment was carried out to study the influence of spacing and INM on yield and quality of Okra cv. Anand Komal at Horticultural Research Farm, B. A. College of Agriculture, AAU, Anand during the two consecutive years 2022 and 2023. The experiment was laid out in Randomized Block Design with factorial concept with three replications and two levels of spacing (S_1: 60 × 30 cm and S_2: 45 × 30 cm) and seven level of integrated nutrient management *viz.*, T_1: 10 t/ ha + 100:50:50 kg/ ha (RDF control), T_2: 75% RDF + 25% RDN through FYM, T_3: 75% RDF + 25% RDN through Vermicompost, T_4: 50% RDF + 50% RDN through FYM, T_5: 50% RDF + 50% RDN through Vermicompost, T_6: 25% RDF + 50% RDN through FYM + NPK consortium 1L/ ha and T_7: 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha. Spacing 60 × 30 cm recorded significantly maximum number of pods per plant (22.48), pod length (11.72 cm), pod diameter (16.62 mm), yield per plant (275.87 g), total numbers of picking (16.02), total soluble sugar (2.19%) and total chlorophyll (0.446 mg/g) in podcontent in pod while, maximum yield (14.19 t/ha), phenol content in pod (0.143%) was recorded in spacing 45 × 30 cm. Among INM treatments, application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha observed higher number of pods per plant (21.67), pod length (13.62 cm), pod diameter (17.58 mm), yield per plant (291.13 g) and yield (15.33 t/ha), total numbers of picking (19.52), total soluble sugar (2.39%), phenol content (0.163%), mucilage (2.47%) and total chlorophyll (0.485 mg/g) content in pod. Sowing at 60 × 30 cm spacing with application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha recorded higher yield per plant (323.77 g) while, maximum yield (16.13 t/ ha) was found in 45 × 30 cm spacing with application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha. Whereas all quality parameters remain non- significant.

Key words: Integrated Nutrient Management, Spacing, Mucilage, Phenol

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the major cultivated vegetable crop in our country belongs to Malvaceae family. It is originated in Africa region and its chromosome number is 2n=130. It is a traditional vegetable crop commercially cultivated in West Africa, India, South East Asia, Southern United States, Brazil, Turkey and Northern Australia. In India, it is widely grown in West Bengal, Gujarat, Madhya Pradesh, Bihar, Odisha, Uttar Pradesh, Punjab and Maharashtra. India is the largest producer of okra covering an area of 5,48,950 ha with an annual production of 71,57,640 MT with an average productivity of 13.04 (MT/ha) (Anon., 2022-23).

Cultivation of okra required some special care for the higher production. There are several factors which are responsible for the lower production like use of low yielder varieties, poor plant density, improper planting date, soil fertility, fertilizer used, attack of numerous insect pests, weeds, *etc.* Among them, plant nutrients and appropriate spacing, determine the production of the okra (Khanal *et al.*, 2020). Improper spacing of okra plants can lead to overcrowded or overly sparse populations that reduces pod yield. Optimal plant density allows for uniform and proper growth by efficiently utilizing moisture, nutrients and light, ultimately leading to maximum okra production. According to Thavaprakash *et al.*, (2005), optimum plant spacing is responsible for higher yield due to efficient utilization of soil resources and solar radiation.

The excessive use of chemical fertilizers that result gave to serious threat to the soil health, environment and on the health of millions of people. On the other hand, reliance on organic fertilizer and biofertilizers alone is also not feasible because they are comparatively low in nutrient and can better serve as a supplement rather than substitute. In other words, using only one source of nutrients such as, chemical fertilizers, organic manures and biofertilizer cannot improve the production, productivity and soil health so, an integrated nutrient management is best way to maximize returns and ensure production sustainability. It synchronizes the supply of nutrients from natural and applied sources with the demand of nutrients for crops. There are several organic resources which can be used as an integrated nutrient management with chemical fertilizers *viz.*, organic manures such as farm yard manure, vermicompost *etc.* and biofertilizers like *Azotobacter*, *Azospirillum*, NPK consortium *etc.*

Material and Methods

The present investigation was carried out at Horticultural Research Farm (22°35' N and 72°56' E), Anand Agricultural University, Anand, India during the two consecutive year 2022 and 2023 during the *Kharif* season. The experiment was laid out in Randomized Block Design (Factorial) with three replications and fourteen treatment combinations comprising of two levels of spacing (S_1: 60 × 30 cm and S_2: 45 × 30 cm) and seven level of integrated nutrient management *viz.*,T_1: 10 t/ha + 100:50:50 kg/ha (RDF control), T_2: 75% RDF + 25% RDN through FYM, T_3: 75% RDF + 25% RDN through Vermicompost, T_4: 50% RDF + 50% RDN through FYM, T_5: 50% RDF + 50% RDN through Vermicompost, T_6: 25% RDF + 50% RDN through FYM + NPK consortium 1L/ ha and T_7: 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha. The experimental site was sandy loam and neutral in reaction with pH 7.26. The available N, P and K of the field soil were 180.03, 28.24 and 191.83 kg ha^{-1}, respectively with 0.31% organic carbon. The recommended dose of fertilizers *i.e.*, 10t/ha FYM + 100:50:50 kg/ha given as a control. For that, FYM was given at the time of land preparation, while full dose of phosphorous, potassium and half dose of nitrogen as a source of single super phosphate, muriate of potash and urea, respectively was applied as a basal dose and remaining half dose of nitrogen in the form of urea was applied at 30 DAS. The organic manures *viz.*, FYM and Vermicompost were applied at the time of field preparation as well as NPK Consortium @1 L ha^{-1} were applied in seed treatment and at 45 DAS. Okra cv. Anand Komal were planted at 15th July in 2022 and 5th July in 2023.

Observations of yield and quality attributes were recorded from the five tagged plants. Total number of green pods harvested from five tagged plants were counted during each picking. The number of fruits per plant were obtained by summing the number of pods in all pickings and average was worked out. Length of the randomly selected five pods from each tagged plant were measured in centimetres from the base of calyx to the tip of the pod by using measuring scale and average value was worked out. Diameter of the randomly selected five pods from each tagged plant were measured in the middle portion of pod with the help of digital vernier calliper and average value was worked out. The weight of pods was recorded during each picking from five tagged plants from each plot. The weight of all the harvested pods during each picking from individual net plot was summed for yield per plot and converted into tonne per hectare. All the quality parameters *viz.*, total soluble sugar, total phenol, total chlorophyll and mucilage content in pods were measured at 4th picking, for that five pod per treatment were randomly selected and all biochemical parameters of pod were recorded. The pooled analysis was conducted in accordance with Panse and Sukhatme (1985) to examine the average effect of various treatments over time.

Result and Discussion

Influence of spacing and INM on yield

Spacing S_1 (60 × 30 cm) recorded maximum number of pods per plant (22.33, 22.62 and 22.48), pod length (11.88, 11.57 and 11.72 cm), pod diameter (16.83, 16.42 and 16.62 mm), yield per plant (273.90, 277.83 and 275.87 g) and total numbers of picking (16.62, 15.43 and 16.02) in year 2022, 2023 and pooled data. It might be due to wider spacing recorded more number of inter nodes per plant and plant get more sunlight, water as well as nutrients than closer spacing that directly increased the number of pods per plant. The less number of plants per unit area under wider spacing received more resources *viz.*, light, water and nutrients, *etc.*, through less inter and intra plant competition that's resulted to increased pod length and diameter that ultimately increased yield per plant. Similar result was also found by Firoz *et al.*, (2007), Maurya *et al.*, (2013) and Bulo *et al.*, (2019) in okra. While,

Table 1a: Influence of spacing and INM on yield attributes.

Treat-ments	Number of pods per plant			Pod length (cm)			Pod diameter (mm)			Yield per plant (g)			Yield (t/ ha)			Total numbers of picking		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Spacing (S)																		
S_1	22.33	22.62	22.48	11.88	11.57	11.72	16.83	16.42	16.62	273.9	277.83	275.87	13.24	13.2	13.22	16.62	15.43	16.02
S_2	18.24	17.8	18.02	11.23	10.95	11.09	15.96	15.56	15.76	221.2	214.63	217.91	14.27	14.12	14.19	15.43	14.33	14.88
S.Em±	0.31	0.34	0.23	0.2	0.19	0.14	0.3	0.3	0.21	5.78	5.65	4.04	0.34	0.31	0.23	0.35	0.38	0.26
CD at 5%	0.91	0.98	0.65	0.58	0.56	0.4	0.86	0.86	0.6	16.81	16.43	11.48	0.99	0.9	0.65	1.03	1.09	0.73
Integrated Nutrient Management (T)																		
T_1	20.9	20.7	20.8	12.4	12.23	12.32	16.85	16.48	16.66	255.27	255.14	255.2	14.23	14.42	14.33	16.5	15.17	15.83
T_2	19.73	19.77	19.75	10.87	10.56	10.72	15.95	15.49	15.72	227.6	227.37	227.48	12.53	12.56	12.54	15.67	14.5	15.08
T_3	20.4	20.3	20.35	11.58	11.4	11.49	16.5	16.09	16.29	242.63	239.24	240.94	13.46	13.22	13.34	16	15	15.5
T_4	18.47	18.8	18.63	9.29	8.84	9.06	14.95	14.38	14.66	214.03	209.53	211.79	12.28	12.34	12.31	14.67	13.83	14.25
T_5	19.07	19.23	19.15	9.91	9.47	9.69	15.48	14.96	15.22	234	230.74	232.37	13.17	13.1	13.14	15.33	14.17	14.75
T_6	21.6	21.17	21.38	13.15	12.78	12.97	17.35	17.08	17.21	267.97	270.72	269.34	15.06	14.88	14.97	16.83	15.67	16.25
T_7	21.83	21.5	21.67	13.7	13.54	13.62	17.71	17.44	17.58	291.37	290.89	291.13	15.57	15.1	15.33	17.17	15.83	16.5
S.Em±	0.58	0.63	0.43	0.38	0.36	0.26	0.56	0.55	0.39	10.81	10.57	7.56	0.63	0.58	0.43	0.66	0.7	0.48
CD at 5%	1.69	1.82	1.22	1.09	1.05	0.74	1.62	1.61	1.11	31.44	30.73	30.6	1.84	1.67	1.22	NS	NS	1.37
Interaction effect (S×T)																		
S.Em±	0.82	0.89	0.61	0.53	0.51	0.37	0.79	0.78	0.55	15.29	14.95	10.69	0.9	0.81	0.61	0.93	0.99	0.68
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	30.6	NS	NS	1.72	NS	NS	NS

maximum yield (14.27, 14.12 and 14.19 t/ha) was noticed with spacing S_2 (45 × 30 cm) in year 2022, 2023 and pooled data. It might be due to maximum plant population per unit area in closer spacing which resulted into maximum yield. Similar results were also found by Padhiyar *et al.,* (2023) and Vashi *et al.,* (2023) in okra.

Treatment T_7 (25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ha) recorded maximum number of pods per plant (21.83, 21.50 and 21.67), pod length (13.70, 13.54 and 13.62 cm), pod diameter (17.71, 17.44 and 17.58 mm), yield per plant (291.37, 290.89 and 291.13 g), yield (15.57, 15.10 and 15.33 t/ha) and total numbers of picking (16.50) in year 2022, 2023 and pooled data, respectively. It might be due to application of both inorganic and organic fertilizers supply adequate amount of nutrients for longer period which increased flower production and pod formation that resulted into more number of pods and that also enhanced the photosynthetic activity which leads accumulation of more food material resulted, increased pod formation and development ultimately higher number of pods per plant. According to Magar *et al.,* (2023) and Narwariya *et al.,* (2023), INM application increase availability of sufficient amount of nutrients present in soil and favour uptake of nutrient to increase metabolism, synthesis of carbohydrates and greater vegetative growth and pod development that ultimately increase yield. Similar results found by Dutta *et al.,* (2020), Gurjar *et al.,* (2022) and Tendulkar *et al.,* (2023) in okra.

Interaction effect of spacing and integrated nutrient management on yield per plant and yield was found non-

Table 1b: Interaction effect of Influence of spacing and INM on yield attributes.

Treatment combi-nations	Yield per plant (g)			Yield (t/ha)		
	2022	2023	Pooled	2022	2023	Pooled
S_1T_1	285.13	283.87	284.50	13.86	14.16	14.01
S_1T_2	274.73	268.53	271.63	13.36	13.05	13.20
S_1T_3	280.20	291.33	285.77	13.62	13.65	13.64
S_1T_4	217.40	219.93	218.67	10.74	10.98	10.86
S_1T_5	257.27	256.01	256.64	12.51	12.44	12.48
S_1T_6	284.20	296.02	290.11	13.81	13.85	13.83
S_1T_7	318.40	329.14	323.77	14.79	14.29	14.54
S_2T_1	225.40	226.42	225.91	14.61	14.68	14.64
S_2T_2	180.47	186.20	183.33	11.70	12.07	11.88
S_2T_3	205.07	187.14	196.10	13.29	12.79	13.04
S_2T_4	210.67	199.12	204.90	13.81	13.70	13.76
S_2T_5	210.73	205.47	208.10	13.84	13.76	13.80
S_2T_6	251.73	245.42	248.58	16.31	15.91	16.11
S_2T_6	264.33	252.64	258.49	16.34	15.92	16.13
S.Em.±	15.29	14.95	10.69	0.90	0.81	0.61
CD at 5%	NS	NS	30.60	NS	NS	1.72

Table 2: Influence of spacing and INM on quality attributes.

Treat-ments	Total Soluble Sugar (%)			Total phenol (%)			Mucilage (%)			Chlorophyll content (mg/g)			Ascorbic acid (mg/ 100 g)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Spacing (S)															
S_1	2.22	2.16	2.19	0.136	0.127	0.132	2.40	2.30	2.35	0.458	0.434	0.446	17.98	17.79	17.89
S_2	2.10	2.03	2.07	0.146	0.140	0.143	2.36	2.28	2.32	0.436	0.408	0.422	17.00	16.76	16.88
S.Em.±	0.02	0.02	0.01	0.001	0.001	0.001	0.02	0.01	0.01	0.003	0.003	0.002	0.15	0.14	0.10
CD at 5%	0.05	0.05	0.04	0.004	0.003	0.003	NS	NS	NS	0.009	0.010	0.007	0.44	0.39	0.29
Integrated Nutrient Management (T)															
T_1	2.26	2.18	2.22	0.150	0.144	0.147	2.43	2.33	2.38	0.463	0.440	0.452	18.19	18.08	18.14
T_2	2.07	2.02	2.04	0.132	0.125	0.129	2.34	2.25	2.29	0.428	0.403	0.416	16.77	16.54	16.65
T_3	2.17	2.10	2.14	0.143	0.134	0.138	2.39	2.29	2.34	0.450	0.422	0.436	17.61	17.39	17.50
T_4	1.88	1.80	1.84	0.115	0.103	0.109	2.22	2.15	2.18	0.392	0.362	0.377	15.10	14.90	15.00
T_5	1.98	1.91	1.94	0.124	0.114	0.119	2.28	2.19	2.24	0.413	0.383	0.398	15.92	15.74	15.83
T_6	2.37	2.31	2.34	0.159	0.155	0.157	2.50	2.40	2.45	0.485	0.462	0.473	19.15	18.97	19.06
T_7	2.42	2.37	2.39	0.166	0.161	0.163	2.53	2.41	2.47	0.495	0.475	0.485	19.72	19.32	19.52
S.Em.±	0.03	0.03	0.02	0.003	0.002	0.002	0.03	0.02	0.02	0.007	0.006	0.005	0.28	0.25	0.19
CD at 5%	0.10	0.10	0.07	0.007	0.006	0.005	0.09	0.06	0.05	0.019	0.018	0.013	0.82	0.73	0.54
Interaction effect (S×T)															
S.Em.±	0.05	0.05	0.03	0.004	0.003	0.002	0.04	0.03	0.03	0.010	0.009	0.007	0.40	0.36	0.27
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

significant in the year 2022 and 2023, but it was found significant in pooled result. Maximum yield per plant (318.40, 329.14 and 323.77 g) was observed with 60 × 30 cm spacing with application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ha whereas, maximum yield (16.34, 15.92 and 16.13 t/ha) was recorded in combination of 45 × 30 cm spacing with application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ha in year 2022, 2023 and pooled data. It might be due to the combined effect of closer spacing that increased plant population as well as INM treatments supply all macro and micro nutrients to plants which ultimately enhanced the yield. These types of results were also found by Vashi *et al.*, (2023), Magar *et al.*, (2023) and Narwariya *et al.*, (2023) in okra.

Influence of spacing and INM on quality

There was no any significant difference observed between spacing for mucilage content in okra pod in both year and pooled data. Maximum total soluble sugar (2.22, 2.16 and 2.19%) and totalchlorophyll (0.458, 0.434 and 0.446 mg/g) contentin pod was observed with spacing S_1 (60 × 30 cm) in year 2022, 2023 and pooled data. Adequate spacing fosters healthier plants with improved photosynthesis, potentially leading to higher sugar accumulation in pods. Similar result was found by Bharai and Leua (2022) in brinjal. This might be due to less shading effect on plants due to wider spacing that causing good transmission of the photosynthetically active radiation (PAR) as well as more micro nutrient available (*viz.*, zinc, magnesium and iron etc.,) with the wider spacing that increase synthesis of total chlorophyll content in pod. Similar results were reported by Padhiyar *et al.*, (2023), Jyothi and Tambe (2019) in okra. Whereas, maximum phenol content (0.143%) in pod was observed with spacing S_2 (45 × 30 cm) in year 2022, 2023 and pooled data. Closer spacing in okra increases phenol content in pods due to competition for resources, inducing plant stress. This stress prompts the plant to produce more phenolic compounds as a defence mechanism, resulting in higher phenol content in pod. Similar results were obtained by Ndereyimana *et al.*, (2013) in eggplant.

Treatment T_7 (25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ha) recorded, maximum total soluble sugar (2.39%), total phenol content (0.163%), mucilage (2.47%), total chlorophyll (0.485 mg/g) and ascorbic acid (19.72, 19.32 and 19.52 mg/100 g) contentin pod in year 2022, 2023 and pooled data. Application of major nutrients in the form of inorganic fertilizer and through vermicompost as well as with NPK consortium which increased metabolism activity in plant and that visualized in the form of total soluble sugar content. Results are in accordance with the findings of Smriti & Ram (2018) in okra. According to Ukey and Sarode (2003), the combined application of organic and inorganic sources that leads to increased phenol content, accumulation of phenols might be due to the excess reduction in H_2O_2 by increased respiration (Farkas and

Kiraly, 1962). Similar type of results was also reported by Balasankar *et al.*, (2013) in okra. INM treatment, increase mucilage content in okra fruit might be due to increase in D- galactose, L. rhamnose and D- galacturonic acid contents (Mani and Ramanathan, 1981). Addition of the organic sources like vermicompost as well as NPK consortium facilitates to the supply of essential micronutrients and traces of secondary metabolites which act as stimulants for the synthesis of the mucilage. Similar results were obtained by Sanni and Adesina (2012) and Thirunavukkarasu and Balaji (2015) in okra. INM sources provided all essential macronutrients (N, P and K) as well as micronutrients (zinc, iron, copper, manganese, *etc*.,) in an optimum level. That play important role in increasing chlorophyll synthesis in plant. Singh *et al.*, (2016), Baliah and Muthulakshmi (2017), Kumar *et al.*, (2017) in okra also reported similar results.

Interaction effect of spacing and INM on pooled basis for quality parameters *viz.*, total soluble sugar, phenol, mucilage, total chlorophyll content and ascorbic acid in pod was found non-significant.

Conclusion

From the two years field study, it can be concluded that sowing of okra at 60 × 30 cm spacing observed better yield parameters *viz.*, number of pods per plant, pod length, pod diameter, yield per plant and total numbers of picking; quality parameter *viz.*, total soluble sugar, total chlorophyll and ascorbic acid content in pods. While, maximum yield/ ha and phenol content in pod was found in 45 × 30 cm spacing. Application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ha recorded maximum yield parameters and all quality parameters. Sowing of okra at 60 × 30 cm spacing with application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha recorded the higher yield parameters and yield per plant. Whereas, maximum yield/ ha was found in 45 × 30 cm spacing with application of 25% RDF + 50% RDN through Vermicompost + NPK consortium 1L/ ha, while quality parameter was not affected significantly.

Conflict of interest: Authors have no conflict of interest.

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