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EFFECT OF SPACING, NITROGEN AND PHOSPHORUS ON GROWTH, YIELD AND QUALITY OF OKRA [*Abelmoschus esculentus* (L.) Moench]

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Abstract: *It may be concluded form the findings of present investigation that the highest yield of okra variety VRO-6 may be obtained by sowing the crop at 30x20 cm spacing and applying 100 kg Nitrogen and 60kg P_2O_5 per hectare in eastern U.P. conditions. From the point of view of obtaining bigger size of pod the wider spacing of (30x40 cm) between plants with same doses of nitrogen and phosphorus is recommended.*
Keywords: *Analysis of spacing, Nitrogen and phosphorus on growth yield of okra.*

Introduction: The okra or Lady's finger *Abelmoschus esculentus* (L) Moench is of old world origin, somewhere in the African continent. There are 38 species of the genus *Abelmoschus* [1-2]. It is an important vegetable crop grown in summer and rainy seasons throughout India. It is rich in vitamins, calcium, potassium and other minerals. The root and stems are used for clarification of sugarcane juice before it is converted into jaggery and brown sugar. The medicinal properties of okra are associated with genitor–urinary disorders spermatorrhoea and chronic dysentery. Okra is grown for is green, tender and nutritive fruits which are used for canning and frozen despite the use as vegetable. The majority of investigators however agree that the species has 2n =130 chromosomes. There are a number of factors, namely cultural, environmental, fertility of lands, variety, time of sowing, irrigation etc. which affect the yield of any crop. Among various factors stated above, spacing between the plants in the row and fertility of soil are the two major factors which affect the yield of any crop including okra. Nitrogen is essential constituent of protein, nucleic acid, chlorophyll, phospholipids, alkaloids, enzyme etc. Imparts dark green colour to plants, improves quality and succulence of leafy vegetables and fodder crops. Nitrogen promotes vegetative growth flower and fruit set but excess of nitrogen delays maturity and decreases fruit size. Due to deficiency of single element, phosphorus, plants can not complete their life cycle hence "P" is called "key to life" Phosphorus governs the root growth. High level of phosphorus throughout root zone is essential for rapid root development and for good utilization of water and other nutrients by the plants.

Materials and Methods

The present investigation to determine the efficacy of different sources of nutrition and spacing of okra an experiment entitled "Effect of spacing, nitrogen and phosphorus on growth, yield and quality of okra *Abelmoschus esculentus* (L.) Moench" was at the main Research Farm of the Indian Institute of Vegetable Research Varanasi 2010-11. There were 2x3x2=12 treatment combinations which are $S_1N_1P_1$, $S_1N_1P_2$, $S_1N_2P_1$ $S_1N_2P_2$, $S_1N_3P_1$, $S_1N_3P_2$, $S_2N_1P_1$, $S_2N_1P_2$, $S_2N_2P_1$, $S_2N_2P_2$, S_2 N_3P_1 and $S_2N_3P_2$.The design adopted was randomized block design. The required amount of nitrogen was supplied half through urea (46%N) and the required amount of phosphorus was supplied through single super phosphate (16% P_2O_5). Farm Yard Manure @ 20t/ha was applied at the time of field preparation as basic source of nutrients. In the field trial it is rather difficult to record the observations of each plant

due to large population of plants since all the plants have equal opportunity for their growth and development. Hence technique of random sampling was adopted for recording observations on various growths and yield attributes during the course of investigation. A sample of five plants from each plot was drawn to record the observations. The observation was recorded at regular intervals throughout their life period to measure the relation between growth attributes and final yield. The observation were Height of plants (cm), Number of leaves per plant, Number of branches, Number of pods per plants, Pod length, Average weight of pod (g),Yield of pods per plant (g), and Total yield of pods (q ha-1).

Results and Discussion

The plant height of five randomly selected plants was measured in centimeters from ground level up to the top level reached by the leaves. The effect of interaction between nitrogen and phosphorus and between phosphorus and spacing however, were in significant. For further interpretation the mean data were presented in two way table 1. The table indicates that with each increase in dose of nitrogen there was significant increase in plant height. The dose N_1 (60 kg N ha^{-1}) produced 19.915 cm plant height, N_2 (80 kg N ha^{-1}) produced 23.662 cm plant height and N_3 (100 kg N ha^{-1}) produced 26.88 cm plant height which is clear indication of significant increase due to nitrogen application. The effect of phosphorus application was similar to the nitrogen application. By applying 60 kg P_2O_5 ha^{-1} (P_2) the average plant height found to be 24.10 cm which was significantly better than P_1 (40 kg P_2O_5 ha^{-1}) where plant height was 22.86 cm.

Table-1. Analysis of Variance for plant height at 30 days.

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	1.16	0.58	2.32	3.44	5.72	9.61
N	2	291.78	145.98	583.92***	3.44	5.72	9.61
P	1	13.94	13.94	55.76***	4.3	7.94	14.38
S	1	152.11	152.11	608.44***	4.3	7.94	14.38
N x P	2	0.09	0.045	0.18	3.44	5.72	9.61
N x S	2	10.2	5.1	20.4***	3.44	5.72	9.61
P x S	1	0.22	0.22	0.88	4.3	7.94	9.61
N x P x S	2	4.31	2.15	8.6**	3.44	5.72	14.38
Error	22	5.59	**0.25**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

Number of Leaves of Okra at 30 Days after Sowing: In number of leaves of five randomly selected plant were counted and the data obtained were but to statistical analysis. The analysis shows that effect of different levels of nitrogen and different spacing is highly significant. For further examination of the result a mean data table 2 is prepared. The highest number of leaves 7.43 is produced by application of 100 kg nitrogen ha^{-1} (N_3) which is significantly higher than lower dosage of nitrogen. N_2 80 kg N ha^{-1} has recorded 6.27 leaves and N_1 60 kg N ha^{-1} has produced 5.36 leaves per plant.

Table-2. Analysis of Variance for number of leaves at 30 days.

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	1.83	0.91	2.16	3.44	5.72	9.61
N	2	25.74	12.87	30.64***	3.44	5.72	9.61
P	1	1.07	1.07	2.54	4.3	7.94	14.38
S	1	4.41	4.41	10.50**	4.3	7.94	14.38
N x P	2	0.09	0.04	0.09	3.44	5.72	9.61
N x S	2	0.68	0.34	0.80	3.44	5.72	9.61
P x S	1	0.09	0.09	0.21	4.3	7.94	9.61
N x P x S	2	0.07	0.03	0.07	3.44	5.72	14.38
Error	22	9.45	**0.42**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

**Significant at 5% level of significance; **Significant at 1% level of significance; ***Significant at 0.1% level of significance*

Number of Branches of Okra at 30 Days after Sowing: Data on effect of spacing nitrogen and phosphorus treatment on number of branches at 45 days after sowing have been presented in table 3. The analysis of variance table shows that the effect of nitrogen and spacing are significant at 0.1% level of significance. The critical analysis of mean table-3 shows that various nitrogen treatments showed significant increase in number of branches. It was recorded to be 0.47 branches by applying 100 kg nitrogen ha^{-1}(N_3) while N_1 (60 kg ha^{-1}) and N_2 (80 kg ha^{-1}) dose

produced only 0.31 and 0.40 number of branches respectively.

Table-3. Analysis of Variance for number of branches at 45 days.

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	0.02	0.01	3.33	3.44	5.72	9.61
N	2	0.18	0.09	30.00***	3.44	5.72	9.61
P	1	0.01	0.01	3.33	4.3	7.94	14.38
S	1	0.23	0.23	76.66***	4.3	7.94	14.38
N x P	2	0.01	0.005	1.66	3.44	5.72	9.61
N x S	2	0.01	0.005	1.66	3.44	5.72	9.61
P x S	1	0.007	0.007	2.33	4.3	7.94	9.61
N x P x S	2	00	00	00	3.44	5.72	14.38
Error	22	0.07	**0.003**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

Effect of Spacing, Nitrogen and Phosphorus on Length of Pod: The analysis of variance table shows that the effect of N, P, spacing and interaction between N and S was significant at 0.1%level of significance. It is recorded to be 13.93cm by applying 100 kg ha^{-1} while N_1 (60 kg ha^{-1}) and N_2 (80 kg ha^{-1}) dose produced only 12.88 and 13.42 cm length of pod respectively. Mean table 4 also shows that different doses of phosphorus brought significant effect on pod length. It is recorded to be 13.49 cm length of pod with application of P_2 (60 kg ha_1) while only 13.33 cm by applying P_1(40 kg ha^1). The spacing has also produced significant effect. The length of pod is recorded to be 13.84 cm by spacing S_2 (30x40 cm) while only 12.97 cm could reach by S_1 (30x20 cm). The interaction between nitrogen and spacing was highly significant. The combined effect of N_3 and S_2 produced 14.48 pod length which was better than 13.87 cm produced by N_2 S_2. All other treatment like NxP, PxS and NxPxS remained in significant.

Table-4. Analysis of Variance for length of pod (cm).

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	0.04	0.02	1.42	3.44	5.72	9.61
N	2	6.65	3.32	237.14***	3.44	5.72	9.61
P	1	0.22	0.22	15.71***	4.3	7.94	14.38
S	1	6.81	6.81	486***	4.3	7.94	14.38
N x P	2	0.04	0.02	1.42	3.44	5.72	9.61
N x S	2	0.35	0.17	12.14***	3.44	5.72	9.61
P x S	1	0.008	0.008	0.57	4.3	7.94	9.61
N x P x S	2	0.012	0.006	0.42	3.44	5.72	14.38
Error	22	0.32	**0.014**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

Effect of Spacing, Nitrogen and Phosphorus on Number Green Fruit / Plant^{-1} : The analysis of variance shows that the effect of nitrogen, phosphorus, spacing and interaction between N and S was significant at 0.1% level of significance [3]. The critical analysis of mean shows that various nitrogen treatments showed significant increase in number of green fruit / plant. It was recorded to be 13.66 green fruit / plant by applying 100 kg N/ ha^1 (N_3) while N1 (60 kg / ha^1) and N_2 (80 kg/ ha^1) dose produced only 11.13 and 12.35 green fruit / plant respectively. Mean table 5 also shows that different doses of phosphorus brought significant effect on number of green fruit /plant. It was recorded as 12.59 green fruit with application of P_2 (60 kg ha^1) while only 12.17 green fruit / plant by applying P_1 (40 kg / ha^1).The spacing between plant has also produced significant effect. The number of green fruits recorded as 13.91 at spacing S_2 (30x40cm) while only 10.85 green fruit could be recorded by S_1 (30x20cm) spacing. The interaction between nitrogen and spacing was significant. The combined effect of N_3x S_2 (100kg N with 30x40cm spacing) produced 15.63 green fruits which was better than 13.78 green fruit produced by N_2 S_2 (80kg with 30x40cmspacing).

Table-5. Analysis of Variance for weight (g) of green fruit plant.$^{-1}$

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	70.00	35.00	2.73	3.44	5.72	9.61
N	2	9576.64	4788.32	373.50***	3.44	5.72	9.61
P	1	419.81	419.81	32.74***	4.3	7.94	14.38
S	1	26721.35	26721.35	2084.34***	4.3	7.94	14.38

N x P	2	43.97	21.98	1.71	3.44	5.72	9.61
N x S	2	1496.13	748.06	58.35***	3.44	5.72	9.61
P x S	1	36.81	36.81	2.87	4.3	7.94	9.61
N x P x S	2	69.42	34.71	2.70	3.44	5.72	14.38
Error	22	282.06	**12.82**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

**Significant at 5% level of significance; **Significant at 1% level of significance; ***Significant at 0.1% level of significance*

Effect of Spacing, Nitrogen and Phosphorus on Weight (g) of Green Fruit/Plant^{-1} : The analysis of variance table shows that the effect of nitrogen, phosphorus, spacing and interaction between N and S was significant at 0.1% level of significance [4]. The critical analysis of mean table 6 shows that various nitrogen treatments showed significant increase in weight of green fruit plant^{-1}. It was recorded to be 157.15 g. green fruit^{-1} by applying 100 kg N ha^{1} (N_3) while N_1 (60 kg N ha^{1}) and N_2 (80 kg N ha^{1}) dose produced only 117.24 and 138.8 g. green fruit plant^{-1} respectively. Mean table-6 also shows that different doses of phosphorus brought significant effect on weight of green fruit plant^{1}. It was recorded as 140.25g weight of green fruit with application of P_2 (60kg ha^{-1}) while only 134.55g green fruit was recorded by applying P_1 (40kg ha^{-1}).

Table-6. Analysis of Variance for number of green fruit plant.$^{-1}$

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	0.10	0.05	2.50	3.44	5.72	9.61
N	2	38.27	19.13	956.5***	3.44	5.72	9.61
P	1	1.95	1.95	97.50***	4.3	7.94	14.38
S	1	84.64	84.68	4234.00***	4.3	7.94	14.38
N x P	2	0.12	0.06	3.00	3.44	5.72	9.61
N x S	2	3.66	1.83	91.50***	3.44	5.72	9.61
P x S	1	0.08	0.08	4.0	4.3	7.94	9.61
N x P x S	2	0.01	0.005	0.25	3.44	5.72	14.38
Error	22	0.57	**0.02**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

Effect of Spacing, Nitrogen and Phosphorus on Okra Yield Q/ ha: The analysis of variance table shows that effect of nitrogen, phosphorus and spacing were significant at 0.1% level of significance. However, combined effect of different factors remained insignificant [5]. The mean table 7 reveals that different nitrogen treatments showed significant increase in case of fruit yield. Highest yield was recorded to be 118.49 Q ha^{-1} by applying N_3 (100 kg N ha^{1}) while N_2 (80 kg N ha^{1}) and N_1 (60 kg N ha^{1}) dose produced 113.83 Q ha^{-1} and 107.74 Q ha^{-1} fruit yield respectively. Table 7 also shows that phosphorus doses brought significant effect. The highest yield was recorded as 114.49 Q ha^{-1} by applying P_2 (60kg ha^{-1}) while only 112.21 yields were recorded by applying P_1 (40kg P ha^{-1}).The effect of spacing between plants has produced significant result [6-7]. The close spacing of S_1 (30x20cm) has recorded 118.82 Q ha^{-1} yield while wider spacing of S_2 (30x40cm) could reach up to 107.88 Q ha^{-1} only. The combined effect of different factors although produced some variation in per hectare yield but no combination could reach significant level.

Table-7. Analysis of Variance for okra yield Q ha.$^{-1}$

Source of Variance	D.F.	S.S.	MSS	F. Calculated	Table value of (F)		
					5%	1%	0.1%
RSS	2	2.72	1.36	0.59	3.44	5.72	9.61
N	2	697.39	348.69	153.60***	3.44	5.72	9.61
P	1	46.69	46.69	20.56***	4.3	7.94	14.38
S	1	1078.03	1078.03	474.90***	4.3	7.94	14.38
N x P	2	1.06	0.53	0.23	3.44	5.72	9.61
N x S	2	10.05	5.02	2.21	3.44	5.72	9.61
P x S	1	0.03	0.03	0.01	4.3	7.94	9.61
N x P x S	2	0.39	0.19	0.08	3.44	5.72	14.38
Error	22	49.95	**2.27**	----------	------	------	--------
Total	35		---------	----------	------	------	--------

**Significant at 5% level of significance; **Significant at 1% level of significance; ***Significant at 0.1% level of significance*

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