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EFFECT OF PLANT GEOMETRY AND NUTRITION ON THE GROWTH ATTRIBUTES OF OKRA [*Abelmoschus esculentus* (L.) Moench] CV. PUSA SAWANI

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ABSTRACT : The investigations were carried out with an objective to asses the effect of plant geometry and nutrition on the growth attributes of Okra [*Abelmoschus esculentus* (L.) Moench] at the Department of Horticulture, C.S.A.U.A. & T., Kanpur during rainy season of two consecutive years. The experiment comprised of four levels of nitrogen (0,60, 90 and 120 Kg ha^{-1}), three levels of phosphorus (0,60 and 90 Kg ha^{-1}) and two levels of plant spacing (30 x 40 and 40 x 40 cm) in Factorial Randomized Block Design with three replications Application of 120 kg nitrogen ha^{-1} caused to produce highest plant height (118.73 and 127.26 cm), number of leaves/plant (16.64 and 17.98), diameter of main shoot (2.38 and 2.46 cm), number of nodes per plant (14.88 and 16.79), fresh weight per plant (153.47 and 155.80 g), and dry matter percentage (22.71 and 17.83%), whereas 90 Kg N ha^{-1} revealed highest leaf area per plant (784.13 and 795.12 cm^2) and control (N_0) showed maximum dry weight percentage (24.09 and 19.65%) during both years of trials. Phosphorus @ 90 kg ha^{-1} showed highest plant height (112.93 and 117.94 cm), number of green leaves per plant (13.12 and 14.40), number of nodes per plant (12.22 and 14.05), diameters of main shoot (1.93 and 2.02 cm), leaf area (784.85 and 795.43 cm^2) and fresh weight per plant (149.55 and 151.51 g), but highest dry matter percentage 27.79% and 18.65% were found in 0 kg phosphorus ha^{-1} in first year and 60 kg phosphorus ha^{-1} during second year of investigation. 40 x 40 cm spacing caused to show highest plant height (112.39 and 117.33 cm), number of green leaves (12.27 and 13.36), number of nodes per plant (11.48 and 13.40), diameter of main shoot (1.91 and 1.98 cm), leaf area per plant (753.37 and 764.72 cm^2), fresh weight per plant (145.19 and 147.36 g) and dry matter percentage (24.99 and 18.44%) during both the years.

Keywords : *Nitrogen, phosphorus, plant geometry, leaf area, dry weight.*

Okra is an annual vegetable crop grown in tropical as well as sub-tropical regions. It is native of South Africa or Asia and belongs to family Malvaceae. Okra is sensitive to frost and extremely low temperature and for better growth and development a temperature between 24-28°C is preferred. Due to high iodine content, fruit help to control goiter while leaves are used in inflammation and dysentery. The fruits also help in renal colic, leucorrhoea and general weakness. Fruits are rich in carbohydrates, protein several minerals like sulphur, phosphorus, calcium and many vitamins. Nitrogen, phosphorus plant density is important factors which are effecting to increase growth attributes and yield of okra. High plant density affects the yield directly by accommodation of greater number of plants and suppressing weed populations. In view of above beneficial facts research was therefore, conducted to study the effect of plant geometry and nutrition on the growth attributes of Okra.

MATERIALS AND METHODS

The experiment was conducted in the garden of the Department of Horticulture, C.S. Azad University of Agriculture and Technology Kanpur during the rainy season of two consecutive years, 2003 and 2004. The soil of experimental field was of moderate fertility with pH of 7.60. The study comprised four levels of nitrogen (N_0, N_{60}, N_{90} and and N_{120} kg ha^{-1}), Three levels of phosphorus (P_0, P_{60} and P_{90} Kg ha^{-1}) and with two plant geometry (30x40 and 40 x 40 cm). Thus there were 24 treatments replicated thrice in Randomized Block Design. Certified seeds of okra cv. Pusa Sawani was obtained from Vegetable Research Station Kalyanpur, Kanpur. The N, P and K estimations of soil were made prior to experimentation. The plots were treated with 10% BHC dust @ 25 kg ha^{-1} before sowing to prevent the menace of termites. Application of manures and fertilizers were done as per recommendation. The doses of nitrogen as per the treatment were supplied through Urea. Phosphorus and potash were applied through single super phosphate and muriate of potash, respectively through basal dressing. Half of N as per treatment was given as basal dressing prior to sowing and remaining half dose was given after one month of sowing as top dressing. Other intercultural operations were done as and when

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required. Observations on growth attributes were recorded by routine methods.

RESULTS AND DISCUSSION

Observations regarding the height of plant of okra were recorded at fortnightly intervals right from thirty days after sowing. The final observations (90 DAS) were processed statistically. 120 kg N ha^{-1} showed highest plant height (118.73 and 127.86 cm) during both consecutive years (Table 1). The difference between 90 and 120 kg N ha^{-1}, however, did not differ significantly during first year of trial. But the highest dose *i.e.* 120 kg N ha^{-1} Produced significantly taller plants than the rest of treatments during the second year of study. The plants under control exhibited the shortest plants (99.47 and 102.34 cm) during corresponding years of study, confirming to the reports of Singh *et al.* (12), Omotoso *et al.* (7) and Rahman and Akter (11). Application of increasing levels of phosphorus increased the plant height significantly during both the years of trial. All the phosphorus levels differed significantly when compared with each other. The maximum plant height (112.93 and 117.94 cm) was recorded when 90 kg ha^{-1} P was applied followed by 60 kg P ha^{-1}. Present findings are in agreement with the reports of Lee *et al.*(5) and Naik and Singh (6).

It is obvious from the mean values (Table 1) that wider plant spacing (40 x 40 cm) produced significantly

Table 1: Effect of plant geometry and nutrition on the growth attributes of okra cv. Pusa Sawani.

Treatments	Year 2003						
	Height of main shoot (cm)	Number of leaves / plant	Diameter of main shoot (cm)	Number of nodes/ plant	leaf area / plant (cm^2)	Fresh weight/ plant (g)	Dry weight (%)
0 Kg N	99.47	6.96	1.23	7.23	563.73	119.91	24.09
60 Kg N	107.49	11.47	1.66	10.39	706.21	143.44	23.07
90 Kg N	115.43	13.73	2.11	13.01	768.13	149.17	22.08
120 Kg N	118.73	16.64	2.38	14.88	773.64	153.47	22.71
C.D. (P=0.05)	3.72	0.78	0.07	0.68	6.94	2.53	0.47
0 Kg P_2O_5	107.18	11.26	1.76	10.49	621.17	133.11	27.79
60 Kg P_2O_5	110.72	12.21	1.84	11.42	709.18	141.79	23.29
90 Kg P_2O_5	112.93	13.12	1.93	12.22	784.85	149.55	17.87
C.D. (P=0.05)	3.22	0.68	0.06	0.59	6.01	2.19	0.41
30 x 40 cm	108.17	12.12	1.78	11.27	660.50	137.78	20.98
40 x 40 cm	112.39	12.27	1.91	11.48	753.37	145.19	24.99
C.D. (P=0.05)	2.63	0.55	0.05	0.48	4.91	17.79	0.33
Year 2004							
0 Kg N	102.34	7.07	1.31	8.25	581.56	122.31	19.65
60 Kg N	111.17	13.14	1.74	12.45	16.74	145.59	18.64
90 Kg N	120.70	14.86	2.17	15.72	95.12	151.03	17.20
120 Kg N	127.86	17.98	2.46	16.79	777.45	155.80	17.83
C.D. (P=0.05)	2.88	0.90	0.08	0.66	4.74	2.58	0.33
0 Kg P_2O_5	112.76	12.16	1.83	12.57	636.16	135.48	17.85
60Kg P_2O_5	115.85	13.24	1.91	13.29	721.56	143.95	18.65
90Kg P_2O_5	117.94	14.40	2.02	14.05	795.43	151.51	18.49
C.D. (P=0.05)	2.50	0.78	0.07	0.57	4.10	2.23	0.29
30 x 40 cm	113.30	13.17	1.86	13.21	670.72	140.00	18.22
40 x 40 cm	117.73	13.36	1.98	13.40	764.72	147.36	18.44
C.D. (P=0.05)	2.04	0.64	0.06	0.47	3.35	1.82	0.23

taller plants (112.39 and 117.73 cm) when compared with 30 x 40 cm spacing (108.17 and 113.30 cm) during both the yeas. The interactive effect of N x P, N x S, P x S. and N x P x S did not bring significantly influence on this regards.

It is apparent from the mean values (Table 1) that nitrogen application brought significant effect in improving the number of leaves per plant and the highest dose 120 kg revealed 16.64 and 17.98 leaves during both years of trial respectively. All the doses of nitrogen showed significantly higher number of leaves than control. These results are in line with the reports of Singh *et al.* (13) and Rekoumi *et al.* (10).

Phosphorus application on okra plants brought about significant variation in number of leaves during both the years of studies. 90 kg phosphorus ha^{-1} produced significantly higher number of leaves (13.12 and 14.40), However, increasing level of phosphorus increased the number of leaves per plant significantly during both corresponding years. Plant geometry influenced the number of leaves in okra but failed to touch the level of significance during both the years of study. Wider plant geometry *i.e.* 40 x 40 cm expressed highest number of leaves per plant (12.27 and 13.36) followed by 30 x 40 cm spacing (12.12 and 13.17 leaves/plant) under first and second year of trial, respectively.

The data on number of nodes per plant were collected at fort nightly intervals during both the years of study. Number of nodes per plant in okra varied significantly due to nitrogen treatment. Data obtained at final observation at 90 days after sowing showed that application of 120 kg N ha^{-1} induced maximum number of nodes (14.88 and 16.79) during first and second year of trials, respectively. All the N doses proved significantly superior over control in respect of number nodes per plant during both the years. The mean values in Table 1 indicated that higher number of nodes (12.22 and 14.05 nodes/plant) were obtained with application of 90 kg P_2O_5 ha^{-1} whereas, lower dose *i.e.* 60 kg P_2O_5 ha^{-1} revealed 11.42 and 13.29 nodes/plant during both corresponding years of study.

Plant geometry did not bring any significant alteration in the number of nodes in okra plant recorded at 90 days after sowing during both the years of experimentation. However, wider plant geometry (40 x 40 cm) induced numerically increased number of nodes per plant *i.e.* 11.48 and 13.40 when compared with closer spacing 30 x 40 cm (11.27 and 13.21 nodes) during both the years. These finding are in conformity with the reports of Rajaraman and Pugalendhi (9) and Ibeawuchi (3). The interaction effect of N x P, P x S and N x P x S could not had significant effect in increasing number of nodes per plant during both the years of trial.

The data obtained at the final observation (90 DAS) in indicated that nitrogen nutrition influenced the diameter of main shoot of okra significantly during both the years of study (Table 1). Increasing doses of nitrogen increased the diameter significantly during both the years. Highest dose of nitrogen *i.e.* 120 kg ha-1 hastened 2.38 and 2.46 cm diameter of okra stem being greater than the rest of treatments during both the years. Application of P_2O_5 influenced the diameter of stem significantly. 90 kg P_2O_5 ha^{-1} showed 1.93 and 2.02 cm diameter of main shoot when compared with its lower level 60 kg P_2O_5 ha^{-1} (1.84 and 1.91 cm diameter) and control (1.76 and 1.83 cm diameter). Distance also significantly influenced the diameter of main shoot. The planting geometry 40 x 40 cm showed 1.78 and 1.86 cm diameter during first and second year of trials respectively. Wider spacing exhibited thicker main shoot when compared with closer spacing during both the years. All the interactive effect did not show significant variation in this regard during both the year of trials.

Nitrogen @ 90 kg ha^{-1} produced significantly maximum leaf area per plant *i.e.* 784.13 and 795.12 cm2 during both the year followed by 120 kg N ha^{-1} (773.64 and 777.45 cm^2). In this regard control (N_0) produced significantly minimum leaf area/plant (563.73 and 581.56 cm^2) during both the years of experimentation. The highest dose of P_2O_5 *i.e.* 90 kg ha^{-1} expressed 784.85 and 795.43 cm^2 leaf area followed by its lower dose *i.e.* 60 kg ha^{-1} showing 709.18 and 721.56 cm^2 against the minimum noted under control (P_0) which showed 621.17 and 636.16 cm^2 leaf area/plant. Plant geometry proved effective in increasing the leaf area during both the years of experimentation. Wider spacing 40 x 40 cm expressed significantly greater leaf area (753.37 and 764.72 cm^2) as compared to 30x40 cm spacing (660.50 and 670.72 cm^2) at final stage of observation during both the years. The interaction of N x P brought about significant effect during both the years. Application of 90 kg N ha^{-1} in conjunction with 90 kg P_2O_5 ha^{-1} exhibited the maximum leaf area (851.05 and 861.70 cm^2). The maximum leaf area was recorded when the sowing was done 40x 40 cm apart and plants received 90 kg N ha^{-1} revealing 830.46 and 841.42 cm^2 leaf area during both respective years of investigation, respectively

Table 2: Effect of nitrogen and phosphorus interaction (N x P) on the leaf area / plant (sq. cm) in okra during rainy season of 2003 and 2004.

Treatments	Phosphorus level (Kg/ha)					
	2003			2004		
	0 (P_0)	60 (P_1)	90 (P_2)	0 (P_0)	60 (P_1)	90 (P_2)
(0 Kg N/ha N_0)	418.04	599.07	674.09	434.12	619.80	690.76
60 Kg N/ha (N_1)	647.20	698.14	773.31	657.70	708.76	783.77
90 Kg N/ha (N_2)	725.19	776.17	851.05	735.74	787.94	861.70
120 Kg N/ha (N_3)	714.24	765.74	840.95	717.10	769.75	845.51
C.D. (P = 0.05)	12.03			8.21		

Table 3: Effect of nitrogen and spacing interaction (NXS) on the leaf area/ plant (cm^2) in okra during rainy season of 2003 and 2004.

Treatments	Spacing (cm)			
	2003		2004	
	30 x 40 (S_1)	40 x 40 (S_2)	30 x 40 (S_1)	40 x 40 (S_2)
(0 Kg N/ha N_0)	517.20	610.26	532.13	630.99
60 Kg N/ha (N_1)	659.61	752.82	670.19	763.30
90 Kg N/ha (N_2)	737.81	830.46	748.83	841.42
120 Kg N/ha (N_3)	727.36	819.93	731.73	823.17
C.D. (P = 0.05)	9.82		6.70	

Table 4: Effect of nitrogen and phosphorus interaction on fresh weight (g/plant) of pod in okra plant during rainy season of 2003 and 2004.

Treatments	Phosphorus levels (Kg/ha)					
	2003			2004		
	0 (P_0)	60 (P_1)	90 (P_2)	0 (P_0)	60 (P_1)	90 (P_2)
(0 Kg N/ha N_0)	106.93	122.71	130.08	109.60	124.89	132.46
60 Kg N/ha (N_1)	136.17	143.80	150.36	138.51	145.76	152.50
90 Kg N/ha (N_2)	145.52	147.15	154.84	148.05	149.03	156.02
120 Kg N/ha (N_3)	143.82	153.50	162.94	146.18	156.14	165.07
C.D. (P = 0.05)	4.39			4.47		

Table 5: Effect of nitrogen and spacing interaction on fresh weight (g/plant) of pod in okra during rainy season of 2003 and 2004.

Treatments	Spacing (cm)			
	2003		2004	
	30 x 40 (S_1)	40 x 40 (S_2)	30 x 40 (S_1)	40 x 40 (S_2)
(0 Kg N/ha N_0)	116.88	122.94	119.16	125.47
60 Kg N/ha (N_1)	139.61	147.27	141.89	149.29
90 Kg N/ha (N_2)	145.71	152.63	147.80	154.26
120 Kg N/ha (N_3)	148.91	157.92	151.16	160.44
C.D. (P = 0.05)	3.58		3.65	

(Table 2 and 3). Above findings regarding leaf area per plant are in line with the reports of Paththinige *et al.* (8), Khan *et al.* (4) and Gandhi *et al.* (2).

Regarding fresh weight, highest dose of N *i.e.* 120 kg ha^{-1} significantly increased the fresh weight of plant during both the years expressing the maximum values of 153.42 and 155.80 g during corresponding years of study when compared with control showing 119.91 and 122.31 g per plant at final picking during both the years. 90 kg P_2O_5 ha^{-1} recorded greater weight at all stages of picking. At last picking, application of 90 kg P_2O_5 ha^{-1} showed 149.55 and 151.51g fresh weight of plant being significantly greater than rest of treatments during both the years. The plants under control resulted minimum fresh weight recording 133.11 and 135.58 g values during corresponding years of study,

respectively. The sowing distance of okra brought about marked differences in the fresh weight of plants. The maximum fresh weight per plant was 145.19 and 147.36 g with wider (40 x 40 cm) sowing, which was significantly higher than the closer (30 x 40 cm) sowing during both the years. The interaction effect of nitrogen and phosphorus improved the fresh weight of okra plants at last picking stage. The maximum fresh weight was recorded under 120 kg N in conjunction with 90 kg P_2O_5 ha^{-1} showing 162.94 and 165.07 g values during both years of trials, respectively. It was, however, significantly greater than the rest of interactive treatments. The interactive effects of N x S proved significantly effective in increasing the fresh weight of plants observed at last picking during both the years. The maximum fresh weight of 157.92 and 160.44 g was registered when the plants were spaced 40 cm apart receiving 120 kg N ha^{-1} during first and second year of study respectively (Table 4 and 5). The findings are in line with the reports of Singh *et al*. (12), Lee *et al.* (5) and Ekwu and Nwokwu (1).

The control (No) showed significantly higher dry matter (24.09 and 19.65%) when compared with rest of the nitrogen doses during both the years at last picking observation (last picking). There was no definite trends of different phosphorus treatments on the increase or decrease of dry matter percentage, but at last picking stage maximum dry matter (27.79 and 18.65%) was produced by P_o (control) and 60 kg P_2O_5 ha^{-1} during both corresponding years of trial, respectively. It is evident from Table 1 that 40 x 40 cm spaced sowing induced significantly higher dry matter accumulation presenting 24.99 and 18.44% at final stage picking during both the years, respectively. The interaction of n x S expressed significant difference in the percentage of dry matter content during both the years. 40 x 40 cm spacing with conjunction of without nitrogen nutrition (N_oS_2) registered significantly higher dry matter (26.09 and 27.65%) production than the rest of the interactive treatments during both the years at the last picking stage. Interactive treatment N_0P_0 expressed maximum dry matter product *i.e.* 28.89 and 30.15% during corresponding years of experimentation at last picking stage. (Table 6 and 7). Remaining other interactive effect regarding this parameter releazed lesser dry matter during both the years of trial. These findings with regards of dry matter percentage are in conformity with the reports of Naik *et al.* (6), Singh *et al.* (13) and Paththinige *et al.* (8).

Table 6: Effect of nitrogen and phosphorus interaction on (NxP) dry weight / plant (%) in the last picking of okra plant during rainy season.

Treatments	Phosphorus levels (Kg/ha)					
	2003			2004		
	0 (P_0)	60 (P_1)	90 (P_2)	0 (P_0)	60 (P_1)	90 (P_2)
(0 Kg N/ha N_0)	28.89	24.80	18.58	30.15	26.63	20.27
60 Kg N/ha (N_1)	27.89	23.27	18.06	29.59	25.15	20.08
90 Kg N/ha (N_2)	26.85	22.23	17.15	28.60	24.16	19.02
120 Kg N/ha (N_3)	27.53	22.88	17.51	29.23	24.67	19.56
C.D. (P = 0.05)	0.82			0.88		

Table 7: Effect of nitrogen and spacing interaction on dry weight/plant (%)in the last picking of okra during rainy season of 2003 and 2004.

Treatments	Spacing (cm)			
	2003		2004	
	30 x 40 (S_1)	40 x 40 (S_2)	30 x 40 (S_1)	40 x 40 (S_2)
(0 Kg N/ha N_0)	22.09	26.09	23.71	27.65
60 Kg N/ha (N_1)	21.05	25.09	22.90	26.97
90 Kg N/ha (N_2)	20.05	24.11	21.92	25.93
120 Kg N/ha (N_3)	20.75	24.66	22.49	26.48
C.D. (P = 0.05)	0.67		0.71	

(Table 1). The highest level of N (120 ha^{-1}) produced significantly lesser dry weight revealing 22.71 and 17.83% dry weight during both the years at last

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