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Selection of Suitable Growth Regulator and Spacing for Seed Yield and Quality of Okra [*Abelmoschus esculentus* (L) Moench]cv. KS-404.

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ABSTRACT An investigation carried out during *kharif* 2000 & 2001 to evaluate the performance of growth regulators (GA_3, IBA and NAA) each with three concentrations (50,100 and 150ppm) and spacings (45x30,60x30 and 60x45cm) revealed that seed yield/plant increased significantly with the treatment of GA_3 in wider spacing (60x45cm) with pronounced improvement in seed quality of harvest i.e. vigour index and speed of germination. Though maximum yield was obtained in close spacing (45x30cm) whereas emergence remained unaffected with spacings. Significant beneficial effect of GA_3 (150ppm concentration) was found good for seed yield.

Keywords: Okra, growth regulators, spacing, seed yield, seed quality

In order to meet the requirement of increasing population, the production of vegetables must be stepped-up considerably. The production can be increased by two means either by bringing more area under cultivation which is not possible or through increasing the production. The productivity can be increased through development of high yielding varieties and through agronomical / physiological manipulations.

Plant growth regulators have been used to modify and control the growth and development of vegetable crops. They have, therefore, become one of the most important tools to increase vegetable production. Hence, the manipulation of production techniques to achieve optimum source - sink ratio that would augment the high seed yield which can be realized by using optimum plant spacing with a suitable growth regulator. Therefore, the present study was carried out to investigate the optimum dose of growth regulators and proper density of plants for improving the seed yield and quality of okra.

MATERIALS AND METHODS

The okra variety KS-404 was sown at Vegetable Research Station, Kalyanpur, CSAUA&T, Kanpur in *kharif* 2000 and 2001 on 28th and 25th July, respectively, in three spacings i.e. 45 x 30cm (S_1), 60 x 30cm (S_2) and 60 x 45cm (S_3) after 8 hours of soaking at 25°C in growth regulators viz. Gibberellic Acid (G_1:GA_3), Indole Butyric Acid (G_2:IBA) and Naphthalene Acetic Acid (G_3:NAA) in three doses (D_1:50, D_2:100 and D_3:150 ppm) each along with a control (soaking in distilled water) and then air dried to original weight. The field experiment was laid out in split plot design(factorial) with spacing in main plot, growth regulator and doses in sub plot with four replications of 120 plot of each 3m X 2.25m size. On maturity field observations were recorded on yield/plant (g) and yield/plot (kg). The seed germination (%), vigour index and speed of germination were assessed as per the ISTA [1] procedure and analyzed in CRD (factorial) from the harvested seeds.

RESULT AND DISCUSSION

In both the years (2001 & 2002) treatment effect was found significant for field and lab parameters viz. seed yield/plant, seed yield/plot, germination, vigour and speed of germination (Table 1 & 3). Effect of growth regulators was significant for all parameters studied. In both years highest yield / plant (30.48 & 29.40g) and yield /plot (0.73 & 0.66kg)

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Table 1. Response of okra to different concentrations of growth regulators and spacing tested during 2000 and 2001 for seed yield/plant(g) and seed yield/plot (kg).

Treatments	Seed Yield /Plant (g) 2000 S X G X D			G X D	2001 S X G X D			G X D	Treatments	Seed Yield/Plot (kg) 2000 S X G X D			G X D	2001 S X G X D			G X D
	S_1	S_2	S_3		S_1	S_2	S_3			S_1	S_2	S_3		S_1	S_2	S_3	
D_1	27.26	29.76	31.48	29.62	26.27	27.93	30.14	28.11	D_1	0.85	0.69	0.48	0.67	0.79	0.60	0.46	0.62
G_1D_2	28.86	30.80	32.79	30.82	27.56	29.08	31.71	29.45	G_1D_2	0.92	0.73	0.53	0.73	0.84	0.66	0.48	0.66
D_3	30.15	32.18	33.89	32.07	28.94	30.29	32.65	30.63	D_3	0.97	0.78	0.57	0.77	0.91	0.71	0.52	0.71
D_1	26.64	28.44	30.57	28.55	25.45	27.56	29.45	27.49	D_1	0.80	0.64	0.46	0.63	0.73	0.59	0.43	0.58
G_2D_2	27.86	29.75	31.75	29.80	26.74	28.75	30.51	28.69	G_2D_2	0.84	0.67	0.49	0.67	0.78	0.63	0.45	0.62
D_3	26.75	28.65	31.00	28.80	26.00	26.90	29.78	27.56	D_3	0.81	0.65	0.47	0.64	0.76	0.58	0.43	0.58
D_1	27.75	30.03	32.16	29.88	26.45	28.69	30.17	28.44	D_1	0.86	0.69	0.51	0.69	0.78	0.63	0.46	0.66
G_3D_2	27.10	28.70	31.10	28.97	25.76	27.51	29.28	27.52	G_3D_2	0.77	0.62	0.45	0.61	0.73	0.58	0.42	0.60
D_3	26.83	28.16	31.28	28.42	24.79	26.74	28.73	26.75	D_3	0.69	0.55	0.40	0.55	0.64	0.51	0.39	0.57
		S X D			Mean		S X D		Mean					Mean			Mean
G_1	28.88	30.91	32.72	30.84	27.59	29.10	31.50	29.40	G_1	0.91	0.73	0.53	0.73	0.85	0.66	0.49	0.66
G_2	27.08	28.95	31.11	29.05	26.06	27.74	29.91	27.90	G_2	0.82	0.65	0.47	0.65	0.76	0.60	0.41	0.60
G_3	27.23	28.96	31.18	29.12	25.67	27.65	29.39	27.57	G_3	0.77	0.62	0.45	0.62	0.72	0.57	0.43	0.57
		S X D			Mean		S X D		Mean			S X D		Mean			Mean
D_1	27.34	29.41	31.40	29.38	26.06	28.06	29.92	28.01	D_1	0.84	0.67	0.48	0.66	0.77	0.61	0.45	0.61
D_2	27.94	29.75	31.88	29.86	26.69	28.45	30.50	28.54	D_2	0.84	0.67	0.48	0.66	0.78	0.62	0.45	0.62
D_3	27.91	29.66	31.72	29.77	26.58	27.88	30.39	28.31	D_3	0.82	0.66	0.48	0.65	0.77	0.60	0.45	0.61
SX (Cont. vs Treat.)				Mean	SX (Cont. vs Treat.)			Mean		SX (Cont. vs Treat.)			Mean	SX (Cont. vs Treat.)			Mean
Treat.	27.73	29.61	31.67	29.67	26.44	28.16	30.27	28.29	Treat.	0.83	0.67	0.48	0.66	0.77	0.61	0.45	0.61
Cont.	23.16	25.32	27.26	25.25	21.88	23.50	25.68	23.69	Cont.	0.66	0.54	0.39	0.53	0.61	0.48	0.37	0.49
Mean	27.27	29.18	31.23		25.98	27.69	29.81		Mean	0.82	0.66	0.47		0.75	0.60	0.44	

	S.E. (d)	C.D (0.05)	S.E. (d)	C.D (0.05)	S.E. (d)	C.D (0.05)	S.E. (d)	C.D. (0.05)
Spacing (S)	0.06	0.15	0.07	0.17	0.01	0.03	0.01	0.03
Growth regulator (G)	0.32	0.65	0.35	0.69	0.01	0.02	0.02	0.04
Dose (D)	0.32	NS	0.3	NS	0.01	NS	0.02	NS
GXD	0.56	1.12	0.60	1.19	0.02	0.04	0.03	0.05
Cont. vs. Treat.	0.42	0.83	0.45	0.89	0.02	0.04	0.02	0.04

Table 2. Response of okra to different concentrations of growth regulators tested during 2000 and 2001 for germination (%).

Treatments	2000				2001			
	S X G X D			G X D	S X G X D			G X D
	S_1	S_2	S_3		S_1	S_2	S_3	
D_1	69.95	70.18	70.63	70.25	68.65	68.87	69.39	68.97
	(88.25)*	(88.50)	(89.00)	(88.58)	(86.75)	(87.00)	(87.50)	(87.12)
G_1D_2	72.05	72.54	73.05	72.55	70.03	71.09	71.57	71.10
	(90.50)	(91.00)	(91.50)	(91.00)	(89.00)	(89.50)	(90.00)	(89.50)
D_3	93.57	74.11	74.66	74.11	73.05	73.57	73.84	73.49
	(92.00)	(92.50)	(93.00)	(92.50)	(91.50)	(92.00)	(92.25)	(91.92)
D_1	68.23	68.65	68.87	68.58	65.44	68.65	68.87	68.65
	(86.25)	(87.75)	(87.00)	(86.66)	(86.50)	(68.75)	(87.00)	(86.75)
G_2D_2	69.73	70.18	70.63	70.18	69.39	69.73	70.18	69.77
	(88.00)	(88.50)	(89.00)	(88.50)	(87.50)	(88.00)	(88.50)	(88.04)
D_3	69.08	69.32	69.76	69.38	69.08	69.64	69.51	69.41
	(87.25)	(87.50)	(88.00)	(87.60)	(87.25)	(87.90)	(87.75)	(87.63)
D_1	68.03	68.44	68.87	68.45	67.62	68.03	68.23	67.96
	(86.00)	(86.50)	(82.00)	(86.50)	(85.50)	(86.00)	(86.25)	(85.92)
G_3D_2	65.65	65.84	66.23	65.91	65.46	65.65	65.84	65.65
	(83.00)	(83.25)	(83.75)	(83.34)	(82.75)	(83.00)	(83.25)	(83.00)
D_3	64.34	64.53	65.08	64.65	64.34	64.53	64.99	64.62
	(81.25)	(81.50)	(82.25)	(81.67)	(81.25)	(81.50)	(82.13)	(81.63)
		S X G		Mean		S X G		Mean
G_1	71.86	72.28	72.78	72.31	70.78	71.18	71.60	71.18
	(90.31)	(90.74)	(91.24)	(90.77)	(89.16)	(89.59)	(90.04)	(89.59)
G_2	69.01	69.38	69.74	69.38	68.97	69.34	69.52	69.28
	(87.17)	(87.60)	(88.01)	(87.60)	(87.12)	(87.55)	(87.76)	(87.48)
G_3	66.01	66.27	66.73	66.34	65.81	66.07	66.35	66.08
	(83.47)	(83.80)	(84.29)	(93.90)	(83.21)	(83.55)	(83.91)	(83.56)
		S X G		Mean		S X G		Mean
D_1	68.74	69.09	69.46	69.09	68.24	68.52	68.83	68.53
	(86.85)	(87.26)	(87.69)	(87.26)	(86.26)	(86.59)	(86.96)	(86.60)
D_2	69.14	68.52	69.97	69.54	68.49	68.82	69.20	68.84
	(87.32)	(86.59)	(88.27)	(87.78)	(86.56)	(86.95)	(87.39)	(86.97)
D_3	69.00	68.32	69.82	69.38	68.82	69.25	69.45	69.17
	(87.16)	(86.35)	(88.10)	(87.60)	(86.95)	(87.45)	(87.68)	(87.36)
	S X (Cort. vs treat.)			Mean		S X (Cont. vs. Treat.)		Mean
Treat.	68.96	69.31	69.75	69.34	68.52	68.86	69.16	68.85
	(87.11)	(87.52)	(88.02)	(87.55)	(86.59)	(86.99)	(87.34)	(86.98)
Cont.	64.91	65.27	65.46	65.21	64.16	64.53	64.99	64.56
	(82.02)	(82.50)	(82.75)	(82.42)	(81.00)	(81.51)	(82.13)	(81.55)
Mean	68.56	68.91	69.32		68.08	68.48	68.74	
	(86.64)	(87.05)	(87.53)		(86.06)	(86.48)	(86.85)	

	S.E (d)	C.D. (0.05)	S.E. (d)	C.D. (0.05)
Spacing (S)	0.31	NS	0.37	NS
Growth regulator (G)	0.66	1.30	0.63	1.25
Dose (D)	0.66	NS	0.63	NS
GXD	1.14	2.26	0.77	2.16
Cont. vs. Treat.	0.85	1.68	0.81	1.61

* Figures in parenthesis are actual values

Table 3. Response of okra to different concentrations of growth regulators and spacing tested during 2000 and 2001 for vigour index and speed of germination.

Treatments	Vigour index 2000 S X G X D			G X D	2001 S X G X D			G X D	Treatments	Speed of germination 2000 S X G X D			G X D	2001 S X G X D			G X D
	S_1	S_2	S_3		S_1	S_2	S_3			S_1	S_2	S_3		S_1	S_2	S_3	
D_1	2094.17	21.24.00	2171.60	2129.92	1870.33	1897.47	1955.63	1907.81	D_1	23.65	24.00	24.33	23.99	23.70	23.90	24.30	23.97
G_1D_2	2290.55	2315.95	2351.55	2319.35	2048.78	2100.57	2138.40	2095.92	G_1D_2	25.00	25.75	26.00	25.58	25.00	25.70	26.20	25.63
D_3	2431.56	2459.58	2494.26	2461.80	2228.03	2205.24	2240.75	2224.67	D_3	26.20	26.80	27.10	26.70	26.30	26.75	27.10	26.75
D_1	1943.75	2013.47	2042.76	1999.99	1881.37	1905.89	1828.60	1871.85	D_1	21.55	22.00	22.35	21.96	21.35	21.60	21.80	21.58
G_2D_2	2075.92	2110.73	2143.12	2109.92	1960.00	2006.40	2034.62	1000.34	G_2D_2	23.45	23.90	24.25	23.88	23.50	23.80	24.00	23.77
D_3	1998.03	2034.38	2071.52	2034.64	1884.60	1929.38	1965.60	1926.53	D_3	22.25	22.65	23.00	22.63	22.40	22.50	22.90	22.60
D_1	1846.42	1880.51	1925.31	1884.08	1715.13	1750.10	1776.75	1747.33	D_1	22.00	22.30	22.66	22.32	22.10	22.40	22.75	22.42
G_3D_2	1692.37	1718.28	1756.24	1722.30	1559.84	1585.30	1607.57	1584.24	G_3D_2	19.55	20.00	20.33	19.96	19.45	19.70	19.95	19.70
D_3	1486.88	1511.83	1562.75	1520.48	1363.38	1387.95	1410.40	1387.24	D_3	15.40	15.75	16.10	15.75	15.50	15.65	16.00	15.72
		S X D		Mean		S X D		Mean					Mean				Mean
G_1	2272.09	2299.84	2339.13	2303.69	2049.05	2067.76	2111.59	2076.13	G_1	24.95	25.52	25.81	25.43	25.00	25.45	25.87	25.41
G_2	2005.90	2052.86	2085.80	2048.19	1908.86	1947.22	1942.94	1932.94	G_2	22.42	22.85	23.20	22.82	22.42	22.63	22.90	22.65
G_3	1675.22	1703.54	1748.10	1708.96	1546.12	1574.45	1598.24	1572.94	G_3	18.98	19.35	19.69	19.34	18.02	19.25	19.57	19.28
		S X D		Mean		S X D		Mean			S X D		Mean				Mean
D_1	1961.45	2005.99	2046.56	2004.62	1822.28	1851.15	1853.66	1842.36	D_1	22.40	22.77	23.11	22.76	22.38	22.63	22.95	22.66
D_2	2018.61	2048.32	2083.64	2050.52	1856.21	1897.42	1926.86	1893.50	D_2	22.67	23.22	23.53	23.14	22.65	23.07	23.38	23.03
D_3	1972.16	2001.83	2042.84	2005.64	1828.34	1840.86	1872.25	1846.15	D_3	21.28	21.73	22.07	21.69	21.40	21.63	22.00	21.68
	SX (Cont. vs Treat.)			Mean	SX (Cont. vs Trate.)			Mean	SX (Cont. vs Trate.)				Mean	SX (Cont. vs Trate.)			Mean
Treat.	1984.41	2018.75	2057.68	2020.28	1834.61	1863.14	1884.26	1860.67	Treat.	22.12	22.57	22.90	22.53	22.14	22.44	22.70	22.46
Cont.	1635.90	1661.55	1692.24	1663.23	1482.30	1524.87	1558.00	1521.93	Cont.	19.25	19.50	19.80	19.52	19.40	19.70	20.00	19.70
Mean	1949.56	1983.03	2021.14		1817.51	1839.31	1851.63		Mean	21.83	22.26	22.59		21.87	22.17	22.50	

	S.E. (d)	C.D (0.05)	S.E. (d)	C.D (0.05)	S.E. (d)	C.D (0.05)	S.E. (d)	C.D. (0.05)
Spacing (S)	11.11	27.19	6.96	17.02	0.13	0.31	0.07	0.17
Growth regulator (G)	21.76	43.30	18.00	35.80	0.38	0.76	0.33	0.66
Dose (D)	21.76	43.30	18.00	35.80	0.38	0.76	0.33	0.66
GXD	41.16	81.89	31.17	62.01	0.66	1.31	0.57	1.14
Cont. vs. Treat.	30.68	61.04	23.33	46.22	0.49	0.98	0.43	0.85

as well as increased seed quality parameters like germination (90.77 & 89.59%), vigour index (2303.69 & 2076.13) and speed of germination (25.43&25.41) was observed in the treatment of GA_3 followed by IBA and NAA (Table 2 & 3) whereas performance of NAA and IBA was at par for seed yield/plant(Table 1). Partially similar findings have also been reported in okra[2,3].

Effect of growth regulators' doses was found non-significant for seed yield/plant, seed yield/plot and standard germination but for vigour index and speed of germination it was significant and 100 ppm concentration was significantly superior than other concentrations.

Effect of different spacings i.e.S_1(45x30cm), S_2(60x30cm) and S_3(60X45cm) was significant for all observed parameters except germination(%). Significantly maximum seed yield/plant (31.67 & 30.27g) was observed in wider spacing along with the significantly highest seed quality like vigour index (2057.68 & 1884.26) and speed of germination (22.90 & 22.70) in both years due to greater availability of nutrients and leads to more photosynthesis to better vegetative growth. But seed yield/plot was found highest (0.83 & 0.77 kg) in closer spacing (45 x 30 cm) because of more plant populations per plot. Similar increase in seed yield with the increased plant populations have also been reported in okra [4, 5] and in radish [6].

Interaction effect of growth regulators and doses was found significant for all observed characters and other interactions were non significant. Gibberellic acid 150 ppm dose showed maximum improvement in yield and quality of seeds whereas its dose of 100 ppm also showed at par performance for germination and speed of germination and these results were also reported in okra [7, 8].

The findings of this study suggest that sowing of okra at 45 x 30 cm spacing after seed treatment of gibberellic acid with 150 ppm dose gives maximum seed yield with adequate seed quality which is economically beneficial.

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