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Impact of Planting Distances and Sowing Dates on Yield Attributing Traits of Okra [*Abelmoschus esculentus* (L.) Moench] cv. Kashi Pragati

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A B S T R A C T

Optimum plant density along with appropriate sowing date plays a significant role with respect to the growth, yield, and quality in okra. The present experiment was conducted to assess the suitable combinations of sowing dates and planting distances and their effects on various quantitative and qualitative attributes of okra at two locations viz., Vegetable Research Farm, I.Ag.Scs., BHU, Varanasi and Lalganj Village, Mirzapur, Uttar Pradesh during the year 2015 and 2016. The intermediate spacing (60 × 60 cm) with D_3 (30^{th} June sowing) amongst various treatments, found to be the best in relation to most of the growth, flowering, yield, and quality characteristics, followed by closer spacing (60 × 45 cm) with D_3 (30^{th} June sowing). Further trials are needed to be conducted before arriving at a decisive finding and to recommend the appropriate combination to the farmers of Varanasi, Mirzapur, and adjoining areas.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is a quite popular crop due to its easy cultivation, dependable yield adaptability to varying moisture conditions, soil types, and is also tolerant to wide variation in rainfall. Okra has been treated as the staple food in Africa and in Asia as diaspora cuisine for a long time. It is a semi-woody, fibrous, herbaceous annual plant with indeterminate growth habit, but the extent of the fruiting period depends on the combination of the photoperiod sensitivity of the cultivar and day light duration. Okra has originated from Ethiopia in Africa (Khalid *et al.,* 2005) and was first cultivated by Egyptians in the 12^{th} century (Thompson *et al.,* 1979). The plant often reaches 60 to 180 cm in height and sometimes even up to 4 m.

The leaf is simple (lobed or un-lobed but not separated into leaflets), and its arrangement is alternate. Red pigmentation can occur in stems, petioles, leaf veins, pedicel, petal bases and fruits, which gives the plant ornamental look. Okra has large, attractive hibiscus like flowers which are auxiliary and solitary. Regarding nutritional enrichment, okra is an essential source of carbohydrate, protein, vitamins A, B, C, calcium, potassium, dietary fibers, and minerals. Plant spacing less than optimum results in reduced growth, less yield, and poor quality fruits while high plant

density may lead to vigorous growth, poor quality fruits and low yield due to intra specific competition, (Moniruzzaman *et al.*, 2007). One of the principal aspects of crop production is the adoption of inappropriate plant spacing systems in the field. This either reduces the number of plants per hectare or causes overcrowding, making weeding and other farm operations difficult. Both the cases lead to the yield penalty and ultimately the loss to the growers. Okra must be harvested on a regular basis for better yield returns. If the fruits are allowed to mature on the plant then flowering will be reduced and further fruiting will be hindered. Among the constraints in production of okra, conventional methods such as sowing dates and proper plant spacing are important issues to handle; each and every crop needs a proper sowing date depending upon climatic conditions, soil and variety so that its critical stage should coincide with favorable weather conditions. If a good cultivar is sown at proper time, at a proper location with optimum spacing, it may give maximum yield.

Materials and Methods

The research work was conducted in two locations i.e., first one on Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and the second trial of this research was conducted in Lalganj village of Mirzapur district of Uttar Pradesh during both the years 2015 and 2016. The experimental field was well drained with uniform topography and having assured source of water supply. Harrowing and planking were done before the execution of layout of the experimental field. Proper ploughing was performed in order to bring fine tilth. 27 plots, each of 3 × 3 m^2size were prepared. The seeds were planted on raised ridges with different sowing dates and planting spacings. About two to three seeds were sown at one place then thinning of seedlings was performed maintaining one plant per stand after germination. Fertilizers were applied as per the recommendation i.e., 100:60:50 kg N, P_2O_5, and K_2O.As per the need, the experimental plots were irrigated during the cropping period. Four weedings were practiced as per the requirement with the view to maintain the proper growth of the crop. Five plants from the total population were randomly selected for recording of the observations. The various yield and qualitative parameters taken under study are days to 50% flowering, node at which first flower appears, days to first fruit setting, fruit length (cm), fruit width (cm), number of fruits per plant, average fruit weight (g), fruit yield per plant (kg), and fruit yield (q/ha). The observations recorded were summed up and divided by five to get the mean value. The experiment was laid out in Randomized Complete Block Design with three replications. Three sowing dates i.e., 10^{th} (D_1), 20^{th} (D_2), and 30^{th} June (D_3) at ten days interval and three spacing i.e., 60 ×45 cm (S_1), 60 × 60 cm (S_2), and 60 × 75 cm (S_3) and their combinations were practiced at both the locations. Statistical analysis of data collected was based on the procedure for Randomized Complete Block Design (RCBD) for factorial experiment as outlined by Steel and Torrie (1980).

Results and Discussion

Significant effect was observed from the findings on planting distances, sowing dates and their interactions depicting their importance on growth, yield, and quality attributes in okra.

During the year 2015 and 2016 at both the locations, for the days to 50% flowering S_3 spacing (60 × 75 cm) exhibited minimum number of days to 50% flowering. In case of

date of sowing D_3 (30^{th} June) sowing exhibited minimum number of days to 50% flowering in both the year at both the locations. The data pertaining to interaction effect on spacing and sowing dates in the year 2015 at location I and II and in 2016 at location I, S_3D_3 exhibited minimum number of days to 50% flowering, while in 2016 at location II, S_3D_3 exhibited minimum days to 50% flowering as demonstrated in table 1. Yadav and Dhankhar (1999); Amjad *et al.,* (2001); Rahman *et al.,* (2005), EL-Waraky (2014) and Celline *et al.,* (2015) reported similar result that wider spaced plants recorded early or minimum days to flowering than plant spaced at closer. In respect of sowing dates, the findings of Fondio*et al.,* (2003); Bajpai *et al.,* (2004); Ahmad *et al.,* (2007) and Ekwu and Nwokwu (2012) are in agreement with the present findings.

The data (shown in Table 2) pertaining to the node at which first flower appears reveal that in the year 2015 at location I and 2016 at both the locations, S_3 spacing (60 × 75 cm) produced first flower at lowest number of node, while in the year 2015 at location II the first flower appeared at the lowest number of node in S_2 spacing (60 × 60 cm). In case of date of sowing D_3 (30^{th} June) sowing registered the lowest number of node at which first flower appears. The data pertaining to the interaction effect on spacing and sowing dates reveal that, S_3D_3 exhibited the lowest number of node at which first flower appears in the year 2015 at location I and in the year 2016 at both the locations, whereas in 2015 at location II, S_2D_2 and S_2D_3were at par with equal minimum mean value. Mousa *et al.,* (2007) and Kumar (2015) reported similar results in respect to spacing and dates of sowing.

During the year 2015 and 2016 at both the locations, S_3 spacing (60 × 75 cm) registered the minimum number of days to first fruit setting, whereas in case of sowing dates, in the year 2015 at location I and II, and in the year 2016 at location II, D_3 (30^{th} June) sowing recorded the minimum number of days to first fruit setting and in the year 2016 at location I, D_2 (20^{th} June) registered the minimum number of days to first fruit setting. The interaction effect of spacing and sowing dates reveal that S_3D_3 registered the minimum number of days to first fruit setting among the treatments as illustrated in table 3. Yadav and Dhankar (1999); Bajpai *et al.,* (2004); Paththinige *et al.,* (2008); Singh *et al.,* (2013) and Celline *et al.,* (2015) reported similar results in respect of spacing and sowing dates.

From the table 4 it is clear that in the year 2015 at both the locations and in 2016 at location II, S_2 spacing (60 × 60 cm) registered maximum fruit length, while in 2016 at location I; S_1 spacing (60 × 45 cm) recorded maximum fruit length. In case of sowing dates, D_3 (30^{th} June) sowing registered maximum fruit length in both the years and at both the locations. The interaction effect of spacing and sowing dates, in the year 2015 at location I and in 2016 at the same location, the maximum fruit length was found in S_2D_3, whereas at location II in the year 2015 and at same location in 2016, S_1D_3 produced maximum fruit length. Talukder *et al.,* (2003) and Maurya *et al.,* (2013) reported similar results in respect of spacing and sowing dates.

In both the years 2015 and 2016 at both the locations, S_2 spacing (60 × 60 cm) recorded maximum fruit width, whereas in case of sowing dates D_3 30^{th} June sowing recorded the maximum fruit width. The result of interaction effect on spacing and sowing dates in the year 2015 at both the locations, S_2D_2 registered maximum fruit width, while in the year 2016 at location I, S_2D_3 produced maximum fruit width, while in the same year at location II, S_1D_3 and S_2D_3 recorded maximum fruit width (Table 5). The

maximum fruit width got in intermediate spacing might be as a result of micro-climate or it may be the optimum spacing for growth of okra in the particular location which is in agreement with the finding of El-Waraky (2014).

The data, as illustrated in table 9, pertaining to both the years 2015 and 2016 and both the locations, S_1 spacing (60 × 45 cm) exhibited highest number of fruits per plant, while in case of sowing dates, S_3 (30^{th} June) sowing recorded maximum number of fruits per plant. The data pertaining to the interaction effect on spacing and sowing dates in the year 2015 at location I, S_1D_1 exhibited maximum number of fruits per plant, while in the year 2015 at location II and in 2016 at both the locations S_1D_3 registered maximum number of fruits per plant. It showed that plant population affected the production of fruits per plant, as the maximum number of fruits was influenced by plant density.

Talukader *et al.,* (2003); Firoz *et al.,* (2007) and Madisa *et al.,* (2015) reported similar results in respect to spacing and dates of sowing. During both the years 2015 and 2016 at both the locations, S_2 spacing (60 × 60 cm) recorded maximum average fruit weight among all the treatments; while in case of sowing dates D_3 (30^{th} June) sowing registered the maximum average fruit weight. The interaction effect of spacing and sowing dates indicate that S_2D_3 registered maximum average fruit weight in the year 2015 at location I and in 2016 at location I and II, while S_2D_2 registered the maximum fruit weight in 2015 at location II as demonstrated in table 6. The higher number of plant population lowers the fruit weight of okra, while the low plant population density leads to more fruit weight. Ekwu and Nwokwu (2012) reported similar results in respect to date of sowing.

From the table 7, it is clear that in both the years 2015 and 2016 as well as at over all locations S_2 spacing (60 × 60 cm) registered the maximum fruit yield per plant (kg), while in case of sowing dates D_3 (30^{th} June) sowing registered the maximum fruit yield per plant. In respect of interaction effect of spacing and sowing dates, S_1D_3 exhibited the highest fruit yield per plant in the year 2015 at location I, while in 2015 at location II and in the year 2016 at both the locations S_2 D_3 registered highest fruit yield per plant. These results are in accordance with the findings of Talukdar *et al.,* (2003) and Firoz *et al.,* (2007).

During the years 2015 and 2016 at both the locations, S_2 spacing (60 × 60 cm) exhibited the maximum fruit yield (q/ha), while in case of sowing dates, D_1 (10^{th} June) sowing registered maximum fruit yield (q/ha). The data pertaining to the interaction effect of spacing and sowing dates, in the year 2015 at both the locations and in the year 2016 at location II, S_2D_1 registered the maximum fruit yield per plant, while in the year 2016 at location I; S_1D_1 exhibited the highest fruit yield per plant (Table 8). Talukdar *et al.,* (2003) and Paththiniage *et al.,* (2008) reported similar results in respect of spacing, while in case of date of sowing similar findings have been reported by Yogesh *et al.,* (2001) who reported that early sowing gave higher fruit yield than late sowing. Among the different treatments intermediate spacing (60 × 60 cm) along with D_3 (30^{th} June) sowing found to be superior than the other treatments for most of the yield attributing traits, followed by closer spacing (60 × 45 cm) with D_3 (30^{th} June) sowing. The maximum fruit length (cm) and number of nodes per plant were achieved in closer spacing (60 × 45 cm), while fruit width (cm), average fruit weight (g), fruit yield per plant, and fruit yield (q/ha) were attained in intermediate spacing (60 × 60 cm).

Table.1 Effect of spacing and sowing dates on days to 50% flowering

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	43.33	42.55	43.55	44.77
S_2	44.44	44.22	43.33	45.33
S_3	42.33	40.55	41.55	43.44
S.E.	0.62	0.38	0.69	0.56
C.D. at 5%	NS	NS	NS	NS
Sowing dates				
D_1	43.55	42.88	44.00	45.66
D_2	43.55	42.66	42.88	44.33
D_3	43.00	41.77	41.55	43.55
S.E.	0.37	0.32	0.60	0.50
C.D. at 5%	NS	NS	1.80	1.50
Interactions (spacing and sowing date)				
S_1D_1	42.33	42.66	44.33	45.66
S_1D_2	43.66	42.66	43.33	45.00
S_1D_3	44.00	42.33	43.00	43.66
S_2D_1	45.33	45.33	44.66	46.33
S_2D_2	44.33	44.33	43.66	45.66
S_2D_3	43.66	43.00	41.66	44.00
S_3D_1	43.00	40.66	43.00	45.00
SD_2	42.66	41.00	41.66	42.33
S_3D_3	41.33	40.00	40.00	43.00
S.E.	0.90	0.79	1.47	1.23
C.D. at 5%	1.92	1.69	3.12	2.60

Table.2 Effect of spacing and sowing dates on node at first flower appears

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	6.15	6.12	6.56	6.68
S_2	5.36	5.27	5.70	5.82
S_3	5.24	5.28	5.11	5.47
S.E	0.12	0.20	0.20	0.08
C.D. at 5%	0.47	NS	NS	0.34
Sowings dates				
D_1	5.96	5.95	6.06	6.60
D_2	5.54	5.48	5.81	5.91
D_3	5.25	5.24	5.50	5.47
S.E.	0.05	0.08	0.12	0.09
C.D. at 5%	0.15	0.24	0.38	0.27
Interactions (spacing and sowing date)				
S_1D_1	6.56	6.66	7.13	6.96
S_1D_2	6.16	6.10	6.40	6.76
S_1D_3	5.73	5.60	6.16	6.33
S_2D_1	5.80	5.76	5.93	6.56
S_2D_2	5.26	5.03	5.86	5.83
S_2D_3	5.03	5.03	5.30	5.06
S_3D_1	5.53	5.43	5.13	6.26
S_3D_2	5.20	5.33	5.16	5.13
S_3D_3	5.00	5.10	5.03	5.03
S.E.	0.12	0.19	0.31	0.22
C.D. at 5%	0.26	0.41	0.66	0.47

Table.3 Effect of spacing and sowing dates on days to first fruit setting

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	45.17	44.71	47.30	45.77
S_2	46.26	45.81	45.78	45.44
S_3	44.28	41.96	44.66	44.88
S.E.	0.44	0.99	0.57	0.56
C.D. at 5%	NS	NS	2.248	NS
Sowing dates				
D_1	45.34	44.65	46.03	46.22
D_2	45.73	44.21	45.23	45.55
D_3	44.65	43.62	46.48	44.33
S.E.	0.32	0.45	0.24	0.36
C.D. at 5%	NS	NS	0.746	1.103
Interactions (spacing and sowing date)				
S_1D_1	44.36	45.00	47.13	46.33
S_1D_2	45.20	44.26	45.23	45.33
S_1D_3	45.96	44.86	49.53	45.66
S_2D_1	46.53	47.13	45.96	46.00
S_2D_2	47.13	45.80	45.40	46.33
S_2D_3	45.13	44.50	46.00	44.00
S_3D_1	45.13	41.83	45.00	46.33
S_3D_2	44.86	42.56	45.06	45.000
S_3D_3	42.86	41.50	43.93	43.33
S.E	0.79	1.11	0.60	0.90
C.D. at 5%	1.69	2.35	1.29	1.90

Table.4 Effect of spacing and sowing dates on fruit length (cm)

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	10.37	10.50	12.28	10.78
S_2	10.72	10.72	12.07	11.11
S_3	8.77	8.96	9.32	8.63
S.E.	0.32	0.16	0.37	0.20
C.D. at 5%	1.28	0.65	1.47	0.82
Sowing dates				
D_1	8.65	8.86	9.61	8.85
D_2	9.95	10.11	10.86	9.92
D_3	11.26	11.21	13.21	11.75
S.E.	0.14	0.16	0.23	0.16
C.D. at 5%	0.42	0.48	0.70	0.50
Interactions (spacing and sowing date)				
S_1D_1	9.10	9.13	10.66	9.36
S_1D_2	9.86	10.03	11.73	9.80
S_1D_3	12.16	12.33	14.46	13.20
S_2D_1	8.93	8.76	10.20	9.06
S_2D_2	11.00	11.30	11.33	11.26
S_2D_3	12.23	12.10	14.70	13.00
S_3D_1	7.93	8.70	7.96	8.13
S_3D_2	9.00	9.00	9.53	8.70
S_3D_3	9.40	9.20	10.46	9.06
S.E.	0.34	0.39	0.57	0.41
C.D. at 5%	0.73	0.84	0.21	0.87

Table.5 Effect of spacing and sowing dates on fruit width (cm)

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	1.17	1.13	1.44	1.26
S_2	1.32	1.27	1.48	1.32
S_3	1.17	1.12	1.26	1.15
S.E.	0.04	0.03	0.01	0.04
C.D. at 5%	NS	0.131	0.076	NS
Sowing dates				
D_1	1.14	1.10	1.28	1.16
D_2	1.24	1.20	1.42	1.23
D_3	1.28	1.23	1.48	1.34
S.E.	0.03	0.02	0.01	0.03
C.D. at 5%	0.09	0.08	0.05	0.11
Interactions (spacing and sowing date)				
S_1D_1	1.10	1.03	1.33	1.16
S_1D_2	1.13	1.13	1.46	1.23
S_1D_3	1.30	1.23	1.53	1.40
S_2D_1	1.26	1.20	1.36	1.23
S_2D_2	1.36	1.33	1.50	1.33
S_2D_3	1.33	1.30	1.60	1.40
S_3D_1	1.06	1.06	1.16	1.10
S_3D_2	1.23	1.13	1.30	1.13
S_3D_3	1.23	1.16	1.33	1.23
S.E.	0.07	0.07	0.04	0.09
C.D. at 5%	0.15	0.14	0.09	0.19

Table.6 Effect of spacing and sowing dates on average fruit weight (g)

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	10.81	10.52	11.10	10.87
S_2	12.66	12.76	13.02	12.72
S_3	11.41	11.14	11.53	8.91
S.E.	0.25	0.37	0.22	0.37
C.D. at 5%	1.00	1.46	0.88	1.45
Sowing Dates				
D_1	10.34	10.21	10.67	9.84
D_2	11.91	12.04	12.08	10.83
D_3	12.63	12.17	12.88	11.83
S.E.	0.33	0.32	0.32	0.23
C.D. at 5%	1.00	0.98	0.98	0.70
Interactions (spacing and sowing dates)				
S_1D_1	9.06	8.93	9.20	9.56
S_1D_2	11.40	10.70	12.03	10.96
S_1D_3	11.96	11.9	12.06	12.10
S_2D_1	11.30	11.06	11.80	12.16
S_2D_2	12.73	14.10	13.06	12.53
S_2D_3	13.96	13.13	14.20	13.46
S_3D_1	10.66	10.63	11.03	7.80
S_3D_2	11.60	11.33	11.16	9.00
S_3D_3	11.96	11.46	12.40	9.93
S.E.	0.82	0.80	0.80	0.57
C.D. at 5%	1.74	1.70	1.70	1.22

Table.7 Effect of spacing and sowing dates on fruit yield per plant (kg)

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	147.56	147.20	158.44	153.34
S_2	159.20	156.06	162.43	156.72
S_3	121.48	120.44	122.72	119.25
S.E.	2.83	1.98	2.40	3.12
C.D. at 5%	11.13	7.79	9.43	12.27
Sowing dates				
D_1	129.35	122.11	134.61	126.45
D_2	138.88	136.67	143.84	140.82
D_3	160.01	159.92	165.14	162.02
S.E.	1.62	1.69	2.08	1.81
C.D. at 5%	4.85	5.06	6.25	5.43
Interactions (spacing and sowing date)				
S_1D_1	135.66	133.10	145.30	135.26
S_1D_2	137.13	135.10	154.76	147.43
S_1D_3	169.90	173.40	175.26	177.33
S_2D_1	139.26	136.13	142.63	137.73
S_2D_2	160.03	157.10	162.43	152.10
S_2D_3	178.30	174.96	182.23	180.33
S_3D_1	113.13	112.10	115.90	106.36
S_3D_2	119.50	117.83	114.33	123.00
S_3D_3	131.83	131.40	137.93	128.40
S.E.	3.96	4.14	5.10	4.44
C.D. at 5%	8.41	8.77	10.82	9.41

Table.8 Effect of spacing and sowing dates on fruit yield (q/ha)

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	41.56	41.26	44.66	43.14
S_2	44.66	43.76	46.11	43.91
S_3	34.36	34.08	35.97	33.60
S.E.	0.70	0.64	0.71	0.78
C.D. at 5%	2.77	2.52	2.81	3.07
Sowing dates				
D_1	47.84	47.04	49.88	47.00
D_2	37.53	36.90	40.50	38.02
D_3	35.22	35.17	36.36	35.63
S.E.	0.45	0.49	0.90	0.50
C.D. at 5%	1.35	1.47	2.72	1.52
Interactions (spacing and sowing date)				
S_1D_1	50.16	49.20	53.60	50.66
S_1D_2	37.13	36.46	41.76	39.76
S_1D_3	37.40	38.13	38.63	39.00
S_2D_1	51.53	50.36	52.70	51.00
S_2D_2	43.20	42.43	45.53	41.06
S_2D_3	39.26	38.50	40.10	39.66
S_3D_1	41.83	41.56	43.36	39.33
S_3D_2	32.26	31.80	34.20	33.23
S_3D_3	29.00	28.90	30.36	28.23
S.E.	1.11	1.20	1.22	1.24
C.D. at 5%	2.35	2.55	4.71	2.63

Table.9 Effect of spacing and sowing dates on number of fruits per plant

Treatment	2015		2016	
	Location I	Location II	Location I	Location II
Spacings				
S_1	13.80	14.74	15.75	14.15
S_2	12.44	13.00	12.92	12.33
S_3	10.78	11.17	11.70	13.33
S.E.	0.26	0.28	0.31	0.34
C.D. at 5%	1.03	1.09	NS	NS
Sowing dates				
D_1	12.68	12.63	13.96	13.03
D_2	11.58	12.10	12.58	13.11
D_3	12.75	14.18	14.82	13.67
S.E.	0.34	0.29	0.35	0.25
C.D. at 5%	1.02	0.87	NS	NS
Interactions (spacing and sowing date)				
S_1D_1	15.00	14.90	16.36	14.33
S_1D_2	12.13	13.90	13.96	13.46
S_1D_3	14.27	15.43	17.93	14.66
S_2D_1	12.37	12.36	12.96	11.43
S_2D_2	12.20	11.83	12.60	12.16
S_2D_3	12.76	14.80	13.20	13.40
S_3D_1	10.70	10.63	12.56	13.33
S_3D_2	10.43	10.56	11.20	13.70
S_3D_3	11.23	12.33	11.33	12.96
S.E.	0.83	0.71	0.91	0.61
C.D. at 5%	1.77	1.50	1.96	1.30

Considering the days to 50% flowering, node at which first flower appears, days to first fruit setting, fruit length (cm), fruit width (cm), number of fruits per plant, average fruit weight (g), and fruit yield per plant. Based on these findings, okra seeds sown on D_3 (30^{th} June) with intermediate spacing (60 × 60 cm) is therefore can be recommended for the farmers of Varanasi district and adjoining areas after conduction of more necessitating trials at various locations.

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