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Effect of spacing and cultivars on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT : This experiment was laid out in March 2008 at college campus, P.G. College Ghazipur (U.P.) in Randomized Block Design with three replications. In this investigation four varieties with three spacing for finding best variety with optimum spacing was studied. Characters studied regarding growth attributes were plant height (cm), number of leaves per plant, and number of branches, while regarding to yield attributes, number of pods, dry weight of pods and fresh weight of pods. The data revealed significant differences among the varieties and spacing for all the traits. Among four varieties *viz.*, V.R.O.-6, Parbhani Kranti, Arka Anamika and Arka Abhay, variety V.R.O.-6 proved its dominance over other varieties regarding to both attributes (yield and growth) while among three spacing *viz.*, 30×15,30×30 and 30×45 cm, spacing of 30×15 cm was found best and optimum for okra crop. Among all interactions V.R.O.-6 with spacing 30×15 cm performed best. On the basis of this investigation it is concluded that V.R.O.-6 with spacing 30×15 cm should be adapted in eastern U.P.

KEY WORDS : Okra, Spacing, Variety, Vegetative growth, Yield

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Okra (*Abelmoschus esculentus* L.) is locally known as *Bhindi* belongs to family Malvaceae. The genus contains about 150 known species with esculentus as the species of okra (Thompson and Kelly, 1957). It is also known as lady's finger or gumbo in England (Tindall, 1983).

Okra is one of the world's oldest cultivated crops. The Egyptians made the first recorded reference to okra in 1216 A.D. It is originated in tropical Africa and was also grown in Mediterranean region and its wild forms are found in India. It is widely cultivated as summer and rainy season crop in north India and winter crop in Andhra Pradesh, Chhatishgarh, Gujrat, Karnataka, Orissa, West Bengal, Andman and Nicobar, Dadar and Nagar Haveli, Daman and Diu. It is now grown in all parts of the tropics and during the summer in the warmer parts of the temperate region (Baloch, 1994). It is a semi woody, fibrous herbaceous annual with an indeterminate growth habit. The plants form a deeply penetrating taproot with dense shallow feeder roots reaching out in all direction in the upper 45cm of the soil. The seeds are dicotyledonous and kidney shaped with epigeal germination (Nonnecke, 1989). Okra is mainly a self pollinated crop however; insects such as honey bees and bumblebees do cross-pollination occasionally.

Okra is adapted to a wide range of soil. A well drained fertile soil with an adequate content of organic matter and reserves of the major elements are generally suitable for cultivation. Some cultivars are sensitive to excessive soil moisture. Others are slightly tolerant to salt. Optimum pH ranges from 6.6 to 8.0. Most cultivars are adapted to high temperature throughout the growing period with little seasonal fluctuation. Seed will only geminate in relatively warm soils, no germination occurs below 16^0 C. A monthly average temperature range of 21^0 C to 30^0 C is considered appropriate for growth, flowering and pod development (Tindall, 1983 and Nonnecke, 1989).

There are several reasons for poor growth and yield of okra, among those, intra-row spacing play an important role (Yadev and Dhankhar, 2005). Spacing determines the available area for a plant to source for growth resources, such as water, light and nutrients. Absar and Siddique (1982) noted that plant density is another important factor that affects okra seed

production. Suitable plant spacing can lead to optimum seed yield while too high or too low plant spacing could result to relatively low yield and quality. Plant spacing for okra seed production suggested by different authors ranges from 20cm to 40cm and 30cm to 60cm between rows (Thakur and Arora, 1986; Rastogie *et al.*, 1987, Khan and Jaiswal, 1988; Hossain *et al.*, 1999).

In a trial on okra using three rates of phosphorus – 0, 33 and 60kg P_2O_5 /hand three planting densities – 11100, 37000 and 55500plants/ha, Amjad *et al.* (2002) reported that planting density (37000plants/ha) resulted in maximum seed yield per plant while seed yield per hectare was highest at the highest planting density.

Two high yielding okra cultivars - "Pusa Sawani" and " Ibk – 2" was grown at different population densities. Fatokun and Chheda (1975) observed that at 108,000 plants/ha which was the highest plant population used, yield was increased by 675 per cent when sown early in the season and by 365 per cent when sown late in the season. The number and weight of fruits per plant as well as the number of the vegetative branches per plant decreased significantly with increase in population density.

The effect of sowing densities *viz.*, 0.50m x 0.50m, 40,000plants/ha, 0.25m x1.00m, 20000plants/ha and (0.25m x 0.50m, 80000plants/ha) on two okra cultivars – Koto and Tomi showed that 0.25 x 1.0m, 20000/ha produced the highest number of fruits while the least was at 0.25m x 0.50m, 80000plants/ha (Kouame and Djidji, 1999). Four planting densities – 1184plants/ha, 1538plants/ha, 1575 plants/ha and 2844plants/ha were tested to determine the optimum planting density of okra. Hiyane and Kawamura (2001) reported that dry matter production and leaf area index for 1538plants/ha were higher than that of other planting densities. The effect of row spacing on the yield and yield components of okra and groundnut showed that the productive nodes increased with increasing row spacing. Row spacing of 90cm x 50cm had 77 per cent nodes while row spacing of 75cm x 50cm and 60cm x 50cm had 69 per cent and 66 per cent nodes, respectively. The closest row spacing (30cm x 50cm) suppressed weeds better, had low fruit yield when compared to other plant densities (Ibeawuchi *et al.*, 2005). Olasantan (2001) also reported that okra planted at densities of 25000, 35000 and 50000plants/ha took the longest time to flower at 50000plants/ha.

Since okra is an important crop in India, different varieties are used by farmers in order to meet the demand of okra by consumers. These varieties have different response on a given soil and season.

Singh (2000) conducted field trials from 1989 to 1991 during *Kharif* season to identify the suitable varieties for western U.P. and found that Parbhani Kranti gave higher pod weight and yield than other varieties. Kunwar *et al.* (2001) also reported that Parbhani Kranti produced significantly higher yield of green fruits over AKOV-97 and closely followed by Arka Anamika. In another field trial Gautam *et al.* (2004) found that pod diameter, pod weight and yield per plant were found highest with VRO-6 where as Varsha Uphar was maximum in pod number and pod length.

Different cultivars of okra require different sowing times and plant spacing. A good cultivar which is sown at an improper spacing will give very poor yield. Proper plant spacing and suitable cultivar is critical to increased production of okra. The objective of this study was to determine the most suitable variety and plant spacing for optimum production of okra in eastern U.P.

RESEARCH METHODS

The experiment was carried out in Shiva Vatika of Post Graduate College, Ghazipur during the spring season of 2007-2008. This area has typical subtropical/tropical climate prevailing in the eastern part of U.P., India with temperature range 3^0 C minimum to 46^0 C maximum during winter and summer season, respectively. The soil of experimental site was sandy loam with pH 7.4. The experimental field measured 22.5m long by 3.60m wide, giving a total of $81m^2$ area. Manually tilled field beds were used. Each plot measured 1.20m x 0.90m with 0.30m bund width.

The experiment was laid out in Randomized Complete Block Design (RCBD). Each treatment was replicated three times and the treatments comprised of four cultivars (V.R.O.-6, Arka Anamika, Arka Abhay, and Parbhani Kranti) and three plant spacing, *vlz.*, 30cm x 15cm, 30cm x 30cm and 30cm x 45cm). Two seeds of each cultivar were sown per hole and after two weeks, it was thinned down to one seedling per stand. Fertilizer N.P.K. and F.Y.M. was applied at the rate of 100:60:60kg/ha and 20t/ha, respectively with proper agronomical practices. Data were collected on the basis of selected five plants' average on following parameters – plant height, number of leaves, number of branches, dry weight of pods, and fresh weight of pods or yield.

RESEARCH FINDINGS AND DISCUSSION

Experimental findings described in proceeding lines and table is given after that. The nature of response obtained due to diverse treatments showed beneficial effect on growth and yield parameters of okra. For the sake of convenience the whole discussion has been categorized in to different major heads in accordance with the objectives of the experiment.

Effect of varieties:

A considerable change in various growth characters and yield parameters was noticed due to effect of different okra cultivars. The okra cultivar V.R.O.-6 (V_1) is a promising high yielding one released by IIVR, Varanasi. The second and third

cultivar tested in this experiment was Arka Anamika (V_2) and Arka Abhay (V_3) is popular cultivar of South India released by IIHR, Banglore. The fourth cultivar was Parbhani Kranti (V_4) which is also a well known cultivar improved by Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra.

The performance of V.R.O.-6 (V_1) proved superior in all the growth and yield attributes. V.R.O.-6 has produced 103.97q ha^{-1} pod yield which was far superior to Arka Anamika (97.00q ha^{-1}) and Arka Abhay (93.47q ha^{-1}) and Parbhani Kranti (77.58q ha^{-1}) (Table 5). As far as dry weight is concerned the cultivar V.R.O.-6 again proved its superiority over other three cultivars by recording 5.04 g pod^{-1} against 4.52 g by Arka Anamika 4.19 g by Arka Abhay and 3.99g by Parbhani Kranti (Table 4). This finding has got support from other investigation also. Gautam *et al.* (2004) reported that average weight of pod, diameter of pod, yield of pods $plant^{-1}$ were found highest with V.R.O.-6 as compared to Varsha Uphar, Parbhani Kranti and NDO-10.

Effect of spacing:

In the present investigation three spacing *viz.*, 30cm x 15cm (S_1), 30cm x 30cm (S_2) and 30cm x 45cm (S_3) were tested. Finding indicates that the widest spacing of 30cm x 45cm (S_3) responded best in case of plant height number of leaves per plant and number of branches per plant (Table 1, 2 and 3).

Table 1 : Effect of cultivars, spacing and interaction on plant height

Cultivars	Spacing			Cultivar mean
	30cm x 15cm (S_1)	30cm x 30cm (S_2)	30cm x 45cm (S_3)	
V.R.O.-6 (V_1)	78.90	80.30	82.60	80.60
Arka Anamika (V_2)	75.40	77.30	78.30	77.20
Arka Abhay (V_3)	74.30	75.70	76.80	75.60
Parbhani Kranti (V_4)	72.30	74.00	75.10	73.80
Spacing mean	75.225	76.325	78.20	

C.D. for cultivars 5% - 0.911 C.D. for spacing 5% - 0.789 C.D. for interaction 5% - 1.579

Table 2 : Effect of cultivars, spacing and interaction on number of leaves

Cultivars	Spacing			Cultivar mean
	30cm x 15cm (S_1)	30cm x 30cm (S_2)	30cm x 45cm (S_3)	
V.R.O.-6 (V_1)	23.90	25.00	25.50	24.80
Arka Anamika (V_2)	22.30	22.80	23.40	22.80
Arka Abhay (V_3)	21.70	22.70	23.60	22.60
Parbhani Kranti (V_4)	21.10	21.70	22.70	21.80
Spacing mean	22.20	23.05	23.80	

C.D. for cultivars 5% - 0.267 C.D. for spacing 5% - 0.309 C.D. for interaction 5% - 0.535

Table 3 : Effect of cultivars, spacing and interaction on number of branches

Cultivars	Spacing			Cultivar mean
	30cm x 15cm (S_1)	30cm x 30cm (S_2)	30cm x 45cm (S_3)	
V.R.O.-6 (V_1)	2.20	2.30	2.80	2.43
Arka Anamika (V_2)	2.06	2.46	2.66	2.39
Arka Abhay (V_3)	1.73	2.06	2.26	2.01
Parbhani Kranti (V_4)	2.00	2.40	2.53	2.31
Spacing mean	1.99	2.30	2.56	

C.D. for cultivars 5% - 0.911 C.D. for spacing 5% - 0.789 C.D. for interaction 5% - 1.579

Table 4 : Effect of cultivars, spacing and interaction on dry weight of pod (g)

Cultivars	Spacing			Cultivar mean
	30cm x 15cm (S_1)	30cm x 30cm (S_2)	30cm x 45cm (S_3)	
V.R.O.-6 (V_1)	4.13	5.07	5.94	5.04
Arka Anamika (V_2)	3.92	4.56	5.08	4.52
Arka Abhay (V_3)	3.50	4.10	4.98	4.19
Parbhani Kranti (V_4)	3.13	3.99	4.87	3.99
Spacing mean	3.67	4.43	5.21	

C.D. for cultivars 5% - 0.698 C.D. for spacing 5% - 0.403 C.D. for interaction 5% - 0.349

Table 5 : Effect of cultivars, spacing and interaction on yield of okra q ha^{-1}

Cultivars	Spacing			Cultivar mean
	30cm x 15cm (S_1)	30cm x 30cm (S_2)	30cm x 45cm (S_3)	
V.R.O.-6 (V_1)	108.02	105.06	98.83	103.97
Arka Anamika (V_2)	104.40	95.91	90.71	97.00
Arka Abhay (V_3)	98.95	94.07	87.41	93.47
Parbhani Kranti (V_4)	82.60	77.99	72.15	77.58
Spacing mean	98.49	93.25	87.27	

C.D. for cultivars 5% - 0.863 C.D. for spacing 5% - 0.498 C.D. for interaction 5% - 0.586

It is clear that in wider spacing or in the other words lower plant population per unit area, the individual plant got more area for plant nutrients and more light and air for better development of growth characters. As the plant population increased it brought about a keen competition among plants for nutrients, light and air resulted in poor vegetative growth. So far yield is concerned highest plant population per hectare or closet spacing of 30 cm x 15cm (S_1) proved optimum.

The most interesting point is to note that at wider spacing where the best growth attributes have been recorded, yield reduced due to less number of plants. The better vegetative growth attributes could not compensate for the loss in yield due to lower plant population.

Birbal *et al.* (1995), Farag and Damarany (1994), Sharma *et al.* (2002), Sajjan *et al.* (2002), Rastogi *et al.* (1987) and Khan and Jaiswal (1998) also reported similar results in plant density trials with okra.

Effect of inter-relationship between spacing and cultivar on okra crop:

In the present investigation the highest yield of fresh okra pods 108.02 q ha^{-1} was recorded with the combination of cultivar V.R.O.-6 and spacing 30cm x 15cm (S_1V_1) (Table 5). It was significantly higher than all other combinations of cultivars and spacing. All other combinations have been proved non significant. Similar finding were reported by Baruah *et al.* (1995), Farag and Damarany (1994), and Rao *et al.* (1989).

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