REVIEW OF LITERATURE
CHAPTER II

REVIEW OF LITERATURE

An attempt has been made to collect the available literature on performance of okra in relation to different aspects of present study. Okra (*Abelmoschus esculentus* (L.) Moench) is one of the important vegetable crops having better dietary value with medicinal and industrial importance. It is raised through seed, which loose its viability quickly. Seed may remain viable for two years under ordinary storage conditions (Thakur and Arora, 1993), therefore it is necessary to produce good quality seed every year.

Good seed is essential for success in vegetable production. There are several factors, which affect the quality and quantity of seeds. Scientists assert that genetic quality of the variety contributes about 24% alone towards the total yield. Critical input especially nutrients in association with water and other factor accounts for the rest (Sankaram, 1989). Further, increase in yield and improvement in quality of the produce can be exploited by use of high-yielding cultivars and manipulation of improved cultural practices. Among the cultural practices, proper crop geometry and application of fertilizer are the most important factors, which influence both yield and quality of green pods and seed yield, which have direct relationship with nutrient uptake, vegetative growth, yield attributes, infestation of pests and diseases, fruit quality etc.
The seed production is affected by climatic factors and various agronomical practices, among that planting density and amount of nitrogenous fertilizers applied are the two most important aspects. Okra produces fruit continuously for a longer period of time and therefore, it needs higher supply of nutrients and it is highly responsive to fertilizer application (Muhammad et al., 2001) throughout the growing period.

Various research studies have been conducted by many workers to find out appropriate planting density and level of nitrogenous fertilizer, for higher yield of okra. However, information regarding the effect of nitrogen and spacing on seed yield of okra in Chhattisgarh is meager. Hence, work done on these aspects in other state of India and abroad has been briefly reviewed in this chapter under the following sub-heads:

2.1 Effect of various planting geometry and/or density on growth and seed yield of okra,

2.2 Effect of nitrogenous fertilizers on growth and seed yield of okra,

2.3 Effect of various plant spacing and nitrogen levels on growth and seed yield of okra,

2.4 Economic variations with different plant spacings and nitrogen levels.
2.1 Effect of various planting geometry and/or density on growth and seed yield of okra

To maximize seed yield of okra many scientists evaluated various planting geometry/spacing and obtained elegant results. Some advocated closer spacing and some wider spacing for getting higher seed yield of okra, it depends on various factors like variety, agro-climatic condition, edaphological condition, agronomical practices particularly fertilizer and plant protection measures etc.

Joshi et al. (1960) worked out the spacing requirement for var. 'Pusa Sawani' variety as 60 cm row to row and 30 cm plant to plant for good yield. Similar results have been also reported by various workers from different parts of the country like (Palanisamy et al., 1986; Sarnaik et al., 1986 a; Singh et al., 1986 and Rastogi et al., 1987). However, Pandey and Singh (1979), Singh et al. (1988), and Pandey and Minocha (1989) advocated to follow little closer spacing (45×15 cm) for okra seed production. Similar results were also found by Randhawa (1967), Randhawa and Panna (1969), Grewal et al. (1972), Nandpuri et al. (1974), Pandey and Singh (1974) and Gill et al.(1982).

Okra crop is successfully cultivated during kharif, rabi and summer season. During summer season optimum plant spacing is nine inches for row to row while three inches for plant to plant (Singh and Sikka, 1955). During rainy season it is recommended that okra crop is better to grow at the distance of two feet row to row and one feet for plant to plant. Spacing suitable for summer crop is one feet row to row with four inches for plant-to-plant (Joshi et al., 1960).
Plant spacing is very important to optimize total yield of okra crop. Moterran et al. (1963) observed that close spacing increased yield and reduced the number of lateral branches per plant. Further Taj and Gardner (1968) described that plants at the closer spacing gave the highest yield, but harvesting was difficult. Plants at the widest spacings were generally shorter and leafy than at closer spacings. Randhawa and Panna (1969) reported that the number of branches, flowers and fruits per plant in okra increased with the wider row spacing at 60 cm but the highest yield was obtained from the closer row spacing of 30 cm. Similarly, Kamalanathan et al. (1970) observed that spacing of 60×30 cm had significantly and consistently produce higher yield per hectare of okra, while spacing of 60×20 cm recorded higher yield in the pooled analysis (two years) over 60×40 cm and 60×30 cm in terms of number of fruits per hectare but the yield per plant was more in wider spacing. The fruit weight was higher in wider spacing of 60×30 cm as compared to 60×20 cm spacing.

In flat bed system Rizvi and Jagirdar (1973) found row spacing of 1.5 feet is the best practice for higher yield of okra. Although, total yield per hectare increases with adoption of closer spacing but fruit size was decreased with increasing plant density of okra (Albregts et al., 1974). Even within okra varieties number of fruits and marketable yield per unit area were not affected by plant density, but number of fruits and marketable yield per plant decreased with increasing plant density (Albregts et al., 1976).
Gonzales and Dej (1976) studied the effect of different six row spacing and four plant spacing on two varieties of okra. The highest yield was obtained from plants spaced at $90 \times 10$ cm but yield was reduced with increase in the spacing.

Pandey et al. (1976) studied the effect of three spacings in seed production of okra. Spacing of $45 \times 45$ cm gave the maximum number of branches and fruits per plant. The best results with regard to seed yield of okra were noted under closer spacing ($30 \times 30$ cm) but the number of seeds per fruit was not significantly influenced by different spacing. However, wider spacing ($60 \times 60$ cm) recorded maximum seed weight (1000 seeds) under the study.

Godzhonov (1977) compared the three spacings in okra and observed that wider spacing increased plant height, fruit number and fruit size, whereas in close spacing, the yield was high. Similarly, Lee and Leong (1979) noted that the closer spacing of okra produced higher yield than wider spacing.

During both the season spring as well as summer, Pandey and Singh (1979) studied the effect of plant spacing and they found that highest plant height, number of fruits, length of fruit per plant, weight of seeds per fruit and seed yield per plant under medium plant spacing ($45 \times 30$ cm). While, number of lateral branches per plant was highest with the widest planting (Patterson and Moralock, 1979). In Pusa Sawani, Palanisamy et al. (1986) evaluated two plant spacing ($60 \times 30$ and $60 \times 20$) at monthly intervals between March and November (nine months) and they found $60 \times 20$ cm in March, April or May gave the best quality seeds. Sarnaik et al. (1986) compared various plant spacing of inter row distances ($50$ and $60$ cm)
and intra row distances (20, 30, 40, 50 and 60 cm). They recorded highest seed yield from 1020.40 to 1774.98 kg per ha at the 60 × 20 cm spacing.

In cv. Pusa Sawni, Singh et al. (1986) conducted two years trial to optimize sowing date (15th or 30th June or 15th or 30th July) and spacing (60 × 30, 45 × 30 or 30 × 30 cm) to maximize seed production. They found that highest seed yield in both year (19.4 and 21.19 q/ha) on plot sown on 15th June with 60 × 30 cm plant spacing. In the same variety, Mondal et al. (1989) found 45 × 30 cm is the best plant spacing for maximum fruit yield/ha and showed lowest number of fruits/plant and fruit yield/plant. Gupta (1990) also found with cv. Pusa Sawani that closest plant spacing (50 × 10 cm) gave the lowest fruit weight (11.6 g/fruit) and the highest yield/ha (150.8 q).

Mondal et al. (1990) sown okra crop at 15 days intervals from 20th April to 20th June (three months) and at three intrarow spacings (30, 45 and 60 cm) with constant inter row spacing of 45 cm. They obtained highest plant height (85.5 cm) and green pod yield (99.0 q/ha) from sowing on 20th April and spacing of 30 × 45 cm.

Singh (1990) find out the effect of different plant spacing (40 × 20, 50 × 20, 40 × 30, 50 × 30, 40 × 40 or 50 × 40 cm) on okra. The highest yield (60.37 q/ha) was obtained with the 40 × 20 cm spacing. The highest average fruit weight (35.58 g) and fruit length (19.08 cm) were obtained at the widest spacing (50 × 40 cm).
Saimbhi *et al.* (1997) carried out field trial at Ludhiana and Jalandhar on okra cv. Punjab-7 for plant spacing of 45 × 25, 45 × 20 or 45 × 15 cm on flat or ridges during spring and three row spacing (30, 45 or 60 cm) with two plant spacing (15 or 30 cm) during rainy season. They found that fruit yield increased as plant spacing decreased in both spring and rainy season. The highest fruit yields were observed in spring (45 × 15 cm) and rainy (30 × 15 and 45 × 15 cm) season. The 45 × 15 cm spacing was considered as most suitable for okra cultivation for both spring and rainy seasons.

Fondio *et al.* (1999) conducted experiment on four sowing densities and found that 0.50 × 1.00 m spacing is the best in term of fruit production over 0.25 × 1.00 m, 0.5 × 0.5 m and 0.25 × 0.5 m plant spacing for okra crop.

Yadav and Dhankar (1999) keenly observed the effect of nine different sowing dates and two sowing distance. They found that 13th June is most suitable as per higher plant height, more number of branches per plant, pollen viability, higher fruit set and fruit length and girth. Days taken to 50 per cent flowering was significantly affected by sowing date and spacing but not by their interaction. A spacing of 67.5 × 20 cm resulted in earlier flowering (50.95 days) than 45 × 30 cm (51.96 days).

Muhammad *et al.* (2001) studied about impact of phosphorus and planting geometry. Plants were grown at a distance of 15, 30 or 45 cm, while distance between rows was maintained as 60 cm. Phosphorus did not have any significant effect on days taken to flowering and plant height, while the parameters were
significantly affected by the planting geometry. Plants spaced at 30 and 45 cm took significantly lesser number of days to flower than those spaced at 15 cm but plant height was maximum at 15 cm. Green pod length was maximum with 33 kg P$_2$O$_5$/ha and at plant spacing of 45 cm. Number of green pods per plant and average weight per green pod were significantly affected by planting geometry but not by the phosphorus application and both were highest at the widest plant spacing (45 cm). The yields of green pods per plant and per hectare increased significantly with the application of phosphorus but both the levels of phosphorus (33 and 66 kg P$_2$O$_5$/ha) were statistically alike. As far as effect of planting geometry is concerned, the pod yield per plant was highest at 45 cm, while pod yield per ha was the highest at 15 cm.

Muhammad et al. (2001a) carried out the study to observe the effect of various doses of phosphorus and different planting densities on seed yield and quality of okra cv. Sabz Pari. Plants were grown at a density of 111000, 55500 or 37000 plants/ha. Phosphorus application had no significant effect on number of pods per plant and seed moisture content. Weight of pods per plant, number of seeds per pod, seed yields per plant and per hectare and 1000 seed weight were significantly affected by the phosphorus levels, being maximum at the highest level and minimum at the lowest one. Planting densities could not affect the number of seeds per pod, 1000 seed weight and seed moisture content. However, number and weight of pods and seed yields per plant and per hectare were significantly influenced by the planting densities. The lowest planting density resulted in maximum number of pods per plant, highest weight of pods per plant
and also highest seed yield per plant, while seed yield per hectare was highest at
the highest planting density.

Yadav and Dhankar (2001) conducted the experiment on different sowing
dates and spacing effects on seed yield and quality of okra cv. Varsha Uphar at
Haryana. They noticed that crop sown at 45 × 30 cm recorded the highest test
weight (57.4 g), standard germination (81.35%), seedling vigour (25) and vigour
index (1970). However, sowing on 13th June at a spacing of 45 × 30 cm gave the
highest seed yield and quality.

Hossain et al. (2003) evaluated the effect of sowing time and spacing on
the growth and fruit yield of okra in Bangladesh. The fruit yield, number of fruits
per plant, fruit length and weight per fruit were higher when okra was sown on 5th
March, 5th April and 5th May, 2000 with spacing of 45 × 45 cm followed by 20th
March, 20th April and 20th May, 1999 spaced at 35 × 40 cm. They also found that
okra crop was least affected with mosaic disease sown at wider spacing (45 × 45
cm).

2.2 Effect of nitrogenous fertilizers on growth and seed yield of okra

Fertilizer being the kingpin of vegetable crop production and its use is one
of the quickest way to increase vegetable production. Among the nutrients,
nitrogen is the most important nutrient for plant growth and development. Okra is
very sensitive for environmental condition and edaphological condition
particularly fertility status of the soil and higher yield of okra obtained with only
highly fertile soil (Mangal et al., 1987). Requirement of nitrogen in okra is
particularly higher during the pre flowering stage than post flowering stage, (Sen and Mukherjee, 1998). In general, it has been proved that plants with high yield removed higher N. Positive relationships was observed between uptake of major nutrients and yield (Prabhu et al., 2004). In okra, by increased N supply there was increased in N with depressed in K without any effect on P concentration in leaves (Ogunlela et al., 1989).

Chhonkar et al. (1963) conducted experiment on sand culture and reported that increase in N concentration upto 210 ppm stimulated height of plants but further increase retarded the height of plants where as, P also increased the height upto 237 ppm concentration but K was not significant. Increase in N upto 630 ppm induced thicker diameter of stem, whereas diameter increase was inconspicuous by N and K treatments. Increase in N also produced more leaf formation and larger sized leaves over P and K. Foliage colour of okra was largely dependent on N fertilization.

Plants supplied with ammonium sulphate flowered earlier than others but earlier flowering did not make any difference in fruit set. Urea and calcium ammonium nitrate were effective in producing maximum number of fruits per plant. Longest fruits were obtained with the use of urea fertilizer (Singh and Singh, 1965).

Verma et al. (1966) reported that the total yield of fruits per ten plants was maximum at 90 kg/ha. This investigation conclude that the application of 90 kg N/ha and 80 kg P/ha improved the qualitative and quantitative yield of okra.
Compos et al. (1968) reported that the germination was adversely affected when the seeds were in direct contact with the fertilizer. They recommended that higher fertilizer dose should be soil-incorporated before sowing of the seeds. While lower dose should be placed below or at the sides of the seeds.

Hooda et al. (1980) reported that the highest green fruit yield was found with N @ 120 kg/ha and every successive increment in N level resulted increased vegetative growth and fruit parameters in okra cv. Pusa Sawani such as plant height, branches/plant, fruits/plant, fruit length and green fruit yield. They also reported significant increased in vegetative growth and yield by application of P @ 30 kg/ha under Hissar condition. Similarly, Pandey et al. (1980) studied the effect of nitrogen and phosphorus levels on seed production of okra. Four levels on N (0, 40, 80 and 120 kg/ha) were tested and found that the height of plants, number of fruits per plant, number of seeds per fruit were significantly improved by the application of 120 kg N/ha. Yield of seed was significantly increased with the application of N at the rate of 120 kg/ha over rest of the N levels. Hooda (1981) suggested that the height of plant, number of branches per plant, number of pods per plant, length of pod, 100 grain weight and seed yield increased significantly with increase in nitrogen levels. The highest yield was obtained by 120 kg N/ha.

Singh and Singh (1982) reported that the highest seed yield (16.40-18.20 kg/ha) of okra was obtained when plants receiving N 120 kg/ha and P 25 kg/ha. The treatment had no appreciable effect on seed quality or on the vigour of plants raised when they are swon.
Majanbu et al. (1985) studied about response of nitrogenous and phosphoric fertilizer on two okra cultivars and they found nitrogen application significantly increased green pod yield, pod diameter, number of fruits/plant, number of seed/pod and pod weight. Application of phosphorus also significantly increased green pod yield, pod number and number of seeds/pod.

Majanbu et al. (1986) observed the effects of nitrogenous and phosphoric fertilizers on okra. Nitrogen application markedly increased fruit and shoot dry weight, whereas phosphorus increased them moderately. Leaf, primary branch production and plant height were also enhanced by nitrogen fertilization upto 100 kg N/ha, but they were not influenced by phosphorus application.

Mishra and Pandey (1987) reported that the N at 80 kg/ha and K at 40 kg/ha significantly increased the number of fruits/plants, 1000-seed weight and seed yield of okra. Application of N above 80 kg/ha and K above 40 kg/ha adversely affected seed yield. Interaction effect was significant with 80 kg N and 40 Kg K/ha given the highest seed yield of 15.47 q/ha.

Vethamoni and Balakrishnan (1990) reported that increased ascorbic acid content of okra fruits were obtained by increasing levels of Nitrogen. It might be due to increase in the uptake of nutrients by N which would have promoted ascorbic acid content in okra fruits, whereas, every increase in the level of N correspondingly decreased the crude fibre content of okra fruits. The lowest crude fibre content was recorded by application of 55 kg N/ha. They also reported that every increase in the N dose, there was progressive increases in the NPK uptake.
might be due to higher concentration of available soil N and increased plant dry matter production.

Vijay and Manohar (1990) observed highly positive and significant correlation of fruit yield/plant with number of fruits/plant, nodes/plant and plant height. The increase in growth attributes of okra such as plant height, branches/plant, stem girth, nodes/plant and leaves/plant etc. by increasing the fertilizer levels may be ascertained to increased the amount of nutrients such as NPK in plants, which leading to increased formation of plant metabolites that help to build up the plant tissues.

Arora et al. (1991) observed that significant increase in marketable fruit yield with an increase in application of N from 0 to 90 kg (100.9 to 156.0 q/ha) and P from 0 to 60 kg/ha (116.0 to 136.5 q/ha). They also reported that optimum dose of 90 kg N/ha and 60 kg P₂O₅/ha was best to obtain significantly better vegetative growth, yield parameters and total fruit yield of okra.

Pandey et al. (1994) found that internodal length was more with increased level of N, through its simulative effect on the meristematic actively tissues.

Kurup et al. (1997) found that application of nitrogen upto 100 kg/ha could increase the setting percentage, length and girth of fruits, fruit number and weight per plant and total fruit yield of okra cv. Kiran. Higher levels of 200 and 300 kg N/ha were significantly inferior. The application of 100 kg N/ha as neem cake blended with urea produced the highest yield and profit.
Somkuwar et al. (1997) compared three nitrogen levels (25, 50 and 75 kg/ha) and three varieties Punjab 7, Parbhani Kranti and Sel. 2. Among the nitrogen levels higher nitrogen concentration (75 kg/ha) increased fruit yield per plant and per hectare and var. Parbhani Kranti was performed best.

Ganeshe et al. (1998) compared the effect of nitrogen and azotobacter on yield performance of okra. They found 80 kg nitrogen per hectare is equally effective as 40 kg nitrogen with soil application of azospirillum.

Lal (1998) compared various combination of NAA and urea as foliar spray in okra var. Pusa Sawani, among combinations seed treatment with NAA at 20 ppm + foliar spray of 2 per cent urea at 30 days after sowing is the best combination for producing maximum number of pods per plant.

Singh (1998) found that the higher levels of nitrogen application increased the contents and uptake of almost all the nutrients.

Singh et al. (1998) found that higher dose of nitrogen (90 kg N/ha) increased plant height by 14.03 per cent, advanced flowering by 4.08 days and increased pod yield by 67.20% compared with control in okra cv. Pusa Sawani.

Tomar and Rathore (1998) observed that the yield was highest in plants, which received 75 kg N/ha.

Bhat and Dhar (1999) conducted an experiment on okra at Jammu and Kashmir and recorded highest seed yield (9.93 q/ha) from 70 kg N/ha. Number of pods per plant, seeds per pod and seed weight per pod increased with increasing N
levels. Highest number of seeds per pod (57.65), seed weight per pod (5.77 g), 100 seed weight (8.63 g) and seed yield (9.79 q/ha) were recorded from 70 kg P/ha.

Fayaz et al. (1999) compared the different levels of nitrogen (0, 100, 120, or 140 kg/ha) alone and with combination of (90 kg and 60 kg/ha) potassium on growth and yield of okra cv. f-13 at Pakistan. The maximum plant height (1.85 m), number of pods per plant (24.59) and the highest pod yield per hectare (16950.79 kg) were recorded under 120 kg N + 90 kg P + 60 kg K / ha but no significant differences were observed in days to seedling emergence and first picking.

Gowda et al. (1999) compared the three okra varieties with nutrients and found that the Varsha is the best for higher nutrient accumulation and uptake of nutrient. It performed best with higher level of fertilizer (175:125:100 kg NPK/ha).

In okra cv. Pusa Sawani, application of N @ 120 kg/ha was found to be the optimum dose for maximum branches/plant, stem girth, leaf area, fruits/plant, fruit length, fruit weight, fruit girth, number of fruits/plant and fruit yield (Paliwal et al., 1999), whereas Naik and Singh (1999) obtained increased fruit yield (per plant and total) by increasing the N upto 150 kg/ha.

Inder and Batra (2000) conducted an experiment at Haryana on okra cv. Varsha Uphar. They compared different irrigation and nitrogen levels and found that 1.2 and 0.9 ID/CPE and 200 kg N/ha were best in respect of leaf area index, leaf area duration and crop growth rate.
Gowda et al. (2001) conducted a field experiment in Karnataka to determine the response of okra cultivars to various fertilizer doses and found highest dry matter production in leaves (20.40 g), stems (35.17 g), roots (18.03 g), fruits (31.11 g), and whole plants (104.71 g) with 175:125:100 kg NPK/ha application.

Gowda et al. (2002) highlighted the usefulness of different fertilizer doses during their investigation and they applied N:P:K at 125:75:60, 150:100:75 and 175:125:100 kg/ha on okra cultivar Arka Anamika, Varsha and Vishal. They found that dry matter accumulation and nutrient (N, P and K) accumulation increased with increasing fertilizer levels. The highest fertilizer level resulted in the highest nutrient uptake. Varsha showed the highest nutrient uptake and accumulation in leaves and fruits at the highest level of fertilizer.

Patton et al. (2002) reported that N and P @ 150 and 90 kg/ha, respectively produced the highest plant height, leaves/plant, longest flowering duration and earliness in flowering of okra cv. Arka Anamika, whereas N @ 100 and 150 kg/ha resulted better fruit characters such as fruit length, diameter, weight, fruits/plant and fruit yield/plant.

Shanke et al. (2004) reported that in okra cv. Parbhani Kranti, linear increase in plant height with the application of N and P. Application of N @ 125 kg/ha resulted tallest plants with highest fruits/plant, fruit weight and length whereas, P @ 75 kg/ha produced significantly highest fruits/plant, fruit weight and length.
Ambare et al. (2005) reported that higher levels of N significantly influenced all the characters under study except fruit diameter under Maharashtra condition.

Singh et al. (2005) reported earlier flowering in okra with higher levels of N than control. They also reported that fruit yield was increased significantly with increased levels of N from 0 to 140 kg/ha.

### 2.3 Effect of various plant spacing and nitrogen doses on growth and seed yield of okra

Sarnaik et al. (1986a) conducted a field trial on okra cv. Pusa Sawani and they found no significant difference due to various N and K on plant height, pod number/plot, pod weight/plot, seed yield/plot, 100 seed weight and seed yield/ha. But high levels of P (60 and 80 kg/ha) decreased seed yield. The highest seed yields and plant height were obtained with 120 kg N/ha + 60 kg P/ha and 80 kg N/ha + 40 kg P/ha.

Lee et al. (1990) conducted an experiment on different sowing dates and spacings (45, 60 or 90 × 30 cm) with nitrogen application of 40, 80 or 100 kg N/ha in okra. They found average green pod yields 11.36 t/ha with 40 kg N/ha, 13.27 t/ha with 80 kg and 12.64 t/ha with 100 kg and recorded highest yield at the most dense spacing and lowest at the least dense. Green pod yield was 7.2 t/ha with the earliest sowing and 12.7 t/ha with later sowing (1st May).
Birbal *et al.* (1995) carried out an experiment on okra *cv.* Varsha Uphar sown on a sandy-loam soil at the different spacings (30×30, 45×30, 45×45, 60×20 or 60×30 cm) and nitrogen application (0, 50, 100 or 150 kg/ha). The tallest plants (109.2 cm) were obtained with spacing at 30×30 cm. The number of branches per plant (2.5) was highest at 45×45 cm. Nitrogen (100 and 150 kg/ha) produces taller plant with more branches per plant. Days to 50 per cent flowering did not effected by spacing, but nitrogen at 100 and 150 kg/ha delayed it by 4.0 to 6.0 days, respectively compared with no nitrogen. Number of fruits/plants, fruit weight and yield/plant were noted highest with the spacing of 45×45 and 60×30 cm. These parameters and yield (q/ha) were also increased by nitrogen at 100 kg/ha. Yield per ha was highest with spacing at 60×20 cm (138.9 q/ha) and 45×30 cm spacing gave statistical similar yield.

Pandey and Dubey (1997) found appropriate combination of nitrogen, phosphorus and potassium for their maximum uptake by okra *cv.* Pusa Sawani. They found that N uptake was highest with an application of 120 kg N + 40 kg P₂O₅/ha planted at a spacing of 30 cm. P uptake was highest at 120 kg N + 120 kg P₂O₅/ha with intra-row spacing of 30 cm. K uptake was highest with an application of 60 kg N + 80 kg P₂O₅/ha at 30 cm intra-row spacing.

Naik and Singh (1999) observed that the highest yields was recorded at the spacing of 90×15 cm over 90×20 and 90×25 cm with higher dose of nitrogen 150 kg N/ha in variety Pusa Sawani.
Singh and Singh (1999) reported that seed yield increased with increasing nitrogenous fertilizer to reach a maximum at 120 kg/ha with closer spacing. Whereas the seed quality was not affected.

Yadav and Dhankhar (1999) evaluated okra cv. Varsha Uphar in Haryana to nine sowing dates (March to August at 20 days interval) and two sowing distances (45×30 and 67.5×20 cm). Days to 50% flowering was significantly affected by sowing date and spacing but interaction was non-significant. The number of days required to produce 50% flower increased with the delay in sowing time and the lowest number of days (45.33) attained by sowing on March. A spacing of 67.5×20 cm resulted in earlier flowering (50.95 days) than 45×30 cm (51.96 days). Sowing on June resulted in the highest values for fruit set (90.86%), number of fruits per plant (24.13), fruit length (19.11 cm) and girth (1.64 cm).

Muhammad et al. (2002) reported that the seed germination, growth and green pod yield were not affected by the fertilizer application. However, number of seed per pod and seed yield were affected significantly and highest with higher doses of fertilizer. Plant spacing had no significant influence on seed germination, days taken to flowering and number of seeds per pod. However, length of green pod, number of green pods per plant, average weight per green pod, green pod yield per plant, number of pods per plant, 1000 seed weight and seed yield per plant were highest at the widest spacing. While, plant height at the time of flowering, green pod and seed yields per hectare were highest at the closest spacing. The highest green pod and seed yields per plant were recorded at all the fertilizer doses with the widest plant spacing. On the other hand, the highest green
pod and seed yields per hectare were obtained at the higher fertilizer doses with the closest plant spacing.

Sajjan et al. (2004) exhibited that spacing of 60×30 cm coupled with the application of nitrogen @125 kg /ha recorded higher seed yield and seed quality.

Ramphal et al. (2005) compared two okra cultivar HRB 108-2 and Varsha Uphar with three planting spacing and nitrogen levels. They found that plant height of both the cultivars improved significantly at 10 cm spacing with 120 kg N/ha. Number of branches per plant and internodes length did not show any significant variation due to varying level of nitrogen and plant spacing. Highest yield was noted with 120 kg N/ha with 10 cm spacing. Whereas lowest was obtained at 12.5 cm spacing and 80 kg N/ha.

2.5 Economic variations with plant spacings and nitrogen doses

Singh (1995) found that the nitrogen application improved the productivity of okra plants upto 200 kg/ha. Fruit length and diameter significantly improved upto 160 kg N/ha, whereas fruit weight showed improvement upto 120 kg N/ha only. The maximum marketable yields for okra was recorded with 160 kg and at par with 120 kg N/ha. Whereas, the highest net returns was observed with 120 kg N/ha. Phosphorus application did not significantly influence the performance of okra and net returns also unprofitable with increased levels of P.

Rani et al. (2001) compared different doses of fertilizer, different varieties and nutrient uptake in okra and they found that the cultivar Arka Anamika showed
comparatively lower uptake of nitrogen and potassium but produced considerable growth for economical yields. The results showed that maximum yield and economical returns with moderate level of fertilizer application (100-50-50 N, P₂O₅ and K₂O kg/ha).

Yadav et al. (2004) studied the effects of different doses of organic manures and N fertilizer on the growth and yield of okra cv. Varsha Upchar and observed that all treatments significantly increased plant height, number of branches per plant, leaf area and yield over the control. The treatment involving 50% N as urea + 50% N as poultry manure recorded the highest yield (90.61 q/ha), net return (Rs. 72,067/ha) and benefit cost ratio (3.88).