DISCUSSION
CHAPTER - V

DISCUSSION

The increasing population of the country compels judicious cropping of the cultivated land which rapidly depletes its fertility, thereby necessitating continuous work on nutritional requirement of vegetable crops. Keeping this in view the project in hand “Nutritional Studies Under Varying Plant Density In Okra (Abelmoschus esculentus (L). Moench)”, was conducted at the Horticulture Garden of Chandra Sekar Azad University of Agriculture And Technology Kanpur during the rainy season of 1997 and 1998, on green pod production of “Parbhani Kranti” cv. of okra. The observations on various vegetative growth attributes, flowering and fruiting parameters and fruit quality primarily offer and information of paramount importance to the research worker as well as commercial vegetable growers. The salient features of the achievements and findings described at length in the preceeding chapter are elaborated in this chapter and discussed in the light of the work of other scientists.

A. Growth Attributes :

Growth and yield attributory parameters in the present investigation were some what better in the second year (1998) of study than in the first year (1997). The variation observed, though negligible between two years of experimentation at the same site and within the same treatments were most probably due to more conducive conditions during the second year. The average minimum and maximum temperature with optimum humidity during the second year of investigation particularly in the month of August appear to have resulted in greater photosynthesis which in turn increased the growth of the plants and ultimately pods yield. The higher maximum temperature during early stages of plant growth in the second year might have also encouraged the growth
during night as Miller (1948) states that if stem elongation is taken as measure of growth, it will be seen that in most of the instances the rate of growth during night will exceed that during the day, provided that temperature is not too low during night. Thus, the question arises as to what is the cause of greater elongation of stem during night. In many cases it is apparently due to a better water supply for growth, the demands for water loss by transpiration are also greater during day. There is not sufficient amount of water available in the growing regions for the maximum cell elongation.

The vegetative growth attributes viz., height of plant, number of nodes, number and area of leaves and diameter of main shoot improved significantly under influence of nitrogen, phosphorus and plant density treatments during both the years of investigation. Increasing levels of both the nutrients were noted to be effective right from the initial stages of plant growth. Nitrogen nutrition affected the morphological parameters of okra during both the year of observations. As the amount of nitrogen fertilizer was increased, the growth attributes were stepped up significantly when compared with control. These improvements may be attributed to the better translocation of food material to the top thereby accelerating the vegetative growth of plant. The height of okra plants increased progressively and at the final stage 140 Kg. N per hectare caused 29.22 and 29.53 per cent greater height when compared with control during first and second years of experimentation. Pandey (1989) working with okra at Jabalpur, reported that increasing levels of N from 40 to 120 Kg. per hectare improved the height of plant and leaf area index which are most important to judged the vegetative growth of plant. In the present investigation, the maximum number of leaves per plant was noted to be 21.37 and 21.49 during 1997 and 1998 respectively. But contrary to this, as high as 31.35 leaves per plant were reported by Tyagi and Khandelwal (1985). The variations might be due to agroclimatic reasons. Present findings are in agreement with the reports
of Hooda et al. (1980), Sarinaik et al. (1986), Ahmed and Tanki (1991), Pawar and Karale (1997), Singh et al. (1997), Khurana et al. (1998) and Singh and Singh (1998) the number of leaves and leaf area per plant in the present investigation increased correspondingly and significantly with each increased in the level of nitrogen from 0 to 140 Kg per hectare. Nitrogen @ 140 Kg produced 6.18 and 6.20 more leaves during first and second years of investigation respectively.

The leaf area per plant directly depends upon the number of leaves per plant and higher nitrogen dose in the present study obviously revealed greater leaf area per plant during both the years. Nitrogen @ 140 Kg per hectare expressed 70.99 and 70.26 per cent greater leaf area per plant when compared with control during the corresponding years of study. Similar results with respect of leaf number and leaf area have been reported by Randhawa (1962), Tomar and Chauhan (1982), Mishra and Pandey (1987), Pandey (1989), Davies and Linderson (1991), Singh et al. (1997) and Naidu et al. (1998).

The diameter of main shoot and number of nodes were promoted significantly under the influence of increasing levels of nitrogen. Nitrogen levels were found to improve the diameters of main shoot right from the initial stages. At the final observations, 140 Kg nitrogen per hectare brought about the increase of 32.63 and 52.27 per cent in the diameter of main shoot when compared with control during first and second years of investigation respectively. The findings of the present investigation are in accordance with the reports of Chauhan and Gupta (1973) who noted beneficial effect of highest dose (67.5 Kg/ha.) of nitrogen in boosting the diameter of main shoot. Whereas Tomar and Chauhan (1982) observed significant increase in the diameter of main shoot with relatively higher level of N i.e. 100 Kg/ha. The number of nodes per plant in the present trial increased significantly under the increasing levels of nitrogen during both the years of investigation. All the levels of nitrogen at all the stages of plant
growth studies expressed marked increase in the number of nodes per plant. At the final observations 41.92 and 4.42 per cent increase in the number of nodes per plant were recorded during first and second years of investigation respectively.

Sharma and Shukla (1973) working with similar level of nitrogen nutrition (130 Kg N/ha) recorded higher number of nodes per plant. The findings of the present investigation are in conformity with the reports of Randhawa (1962), Randhwa and Pannam (1969), Kamalanathan (1970), Tomar and Chauhan (1982), Abusalecha and Shanmugavelu (1988), Pandey (1989) and Naidu et al. (1998) in okra.

Nitrogen universally accepted to promote vegetative growth, played a significant role in improving all the growth attributes in the present investigation. It plays key role and as a matter of fact, life would not be possible without this element. Contrary to other elements, this is not found in parent soil minerals. On the other hand, it is added to the soil from atmosphere through rain water and biological agencies. The large amount of N required by the plants is of special significance in olericulture. Besides, the N actually utilised by the plants, much of it is lost through leaching, erosion or escape ammonia.

Vegetable crops require nutrient elements like the other agriculture crops. They are, however, distinguished from other crop plants in several ways. Most of the vegetable crops are annuals having short crop duration. Vegetables are harvested mostly when they are in physiologically immature stage, unlike fruits they contain high moisture content to ensure succulence and good quality of produce. Vegetable crop growth, therefore, should be rapid and uninterrupted. Consequently high rate of fertilizer and manures are required for vegetable production to promote vigorous growth and quality.
In plant life nitrogen has many functions. Being a part of protein it is an important constituent of protoplasm, enzyme and the biological catalytic agent which regulate the physiological processes. Nitrogen also occur as nucleoprotein, amino acids, amines, amino sugars polypeptides and many other organic compounds in plant system. A sufficient supply of various nitrogenous compounds is, therefore, required in each plant all for its proper functioning. Chlorophyll which changes the energy of sunlight to form carbohydrates and fats from carbon dioxide and water is a nitrogenous compound.

Phosphorus treatments played significant role and promoted height of main shoot, diameter of main shoot, number of nodes, number of leaves and leaf area during both the years of study. The growth attributes increased progressively with each increase in the level of P$_2$O$_5$. The superiority of higher levels of this nutrient were observed from initial stages. All the growth parameters increased significantly and correspondingly with increasing levels of phosphorus from 0 to 100 Kg P$_2$O$_5$ per hectare during both the years of experimentation. The highest level of P$_2$O$_5$ i.e. 100 Kg per hectare in the present investigation, increased the height of main shoot by 22.75, 23.06 per cent, diameter of main shoot 17.85, 18.50 per cent, number of nodes per plant 73.42, 66.16 per cent, number of green leaves 32.11, 31.90 per cent and leaf area 33.32, 28.42 per cent over control during the first and second year of investigations respectively. The findings are in agreement with the reports of Chauhan and Gupta (1973), Niranjan and Devi (1990) and Devi Linderon (1991). Singh and Singh (1965) reported that an increase in the levels of phosphorus above 57 Kg per hectare proved to be detrimental and reduced vegetative growth of okra plants. However, Sarnaik et al. (1986) applied three rates of P$_2$O$_5$ i.e. 40, 60 and 80 Kg per hectare but failed to get significant effect on any growth parameter. However, the increase in vegetative growth was attribute to the influence of phosphorus in accordance with its applied amount due to the
beneficial effect of phosphorus on cell development, cell enlargement and photosynthetic activities in the leaves.

In plants, organic phosphorus is mainly present as orthophosphate. The organic phosphate are mainly phosphorylated sugars and alcohols. Phospholipids like lecithin and nucleotide like ATP, GTP, CTP and UTP etc. are also important phosphorus containing plant organic compounds. The the important role of phosphate in metabolic processes lies in its capacity to form pyrophosphate bonds which permits energy transfer. Phosphorus acts as a linkage unit or binding site. The stability of phosphorus enables it to participate in numerous energy catcher, transfer and recovery reactions which are vital for plant growth. Phosphorus has been associated to development of roots and early maturity of crops.

The beneficial effect of phosphorus may be ascribed to its role as a structural compound of the cell constituents and metabolically active compound. It has integral role as structural compound of membrane system of chloroplasts and the mitochondria. Phosphorus plays an important role in energy transformation and metabolism of plants. Being a constituent of Adenosine di-phosphate, Co-enzyme, it is involved in the basic reaction of photosynthesis. It is also involved in the activation of enzymes participating in the dark reactions of photosynthesis. Moreover, sufficient supply of phosphorus provides conducive conditions for the better utilization of photosynthates for the growth and development of plants. As it was also observed by Reed (1907) that the transformation of starch into water soluble carbohydrates, was seriously impaired in the absence of phosphorus.

Plant geometry affected the growth parameters judged in terms of height and diameter of main shoot, number and area of leaves and number of nodes per plant during both the year of study. However, it caused significant
Plate I: Size of okra leaf under the treatment $N_3P_2S_2$
alterations right from the initial stages of plant growth. At the final observations, lower plant density (50 x 40cm) brought about 4.90 and 4.91% increase in height of main shoot, 5.28 and 5.19% in diameter of main shoot, 24.20 and 24.01% in number of leaf, 22.90 and 21.65% in leaf area and 10.56 and 12.14% in number of nodes per plant as compared to high plant density ( 50 x 30 cm ) during first and second years of study respectively. The better performance exhibited by widely spaced plants may be attributed to more available growing space and resources and perhaps, their better utilization under this spacing. The findings of the present investigation are in accordance with the reports of Randhawa and Pannum (1969), Singh and Singh (1975), Gadzhonov (1978), Gupta et al. (1981), Pandey and Singh (1982), Palanisamy and Kariverthraju (1984), Singh (1986), Barauh (1997) and Singh and Singh (1998).

The interaction of nitrogen, phosphorus and plant geometry both first as well as second order failed to exert significant influence on the growth attributes under both the trials barring interactive effect of N x P on plant height in the first year and number of green leaves in second year study. However, numerical increases in various growth attributes were registered particularly under second order interaction. Application of 140 Kg N in conjunction with 100 Kg P₂O₅ applied to low density crop expressed increased values under all the growth characters (Plate 1). The findings of the present investigation are in consonance with the observations of Sarnaik et al. (1986) and Suwandi (1988).

B. Flowering and Fruiting :

The effect of nitrogen observed on days to first flowering, days to first fruiting, number of pods, size, weight and volume of pods and yield of green pods are discussed below. The initiation of flower bud from date of sowing under normal conditions takes on an average 22 to 26 days and days to flowering begins from 42 – 45 days after sowing in okra. Flowers which are yellow in
colour remain open for only one day and pods develop rapidly thereafter. Flowering in the present investigation was significantly affected by nitrogen treatments. Increasing nitrogen levels hastened the flowering during both the years of investigation.

The plants fertilized with 140 Kg N per hectare required 44.25 and 45.52 days against 46.73 and 47.69 days under control during the corresponding years of study and it was 2.18 and 2.17 days earlier in the former when compared with the latter. The superiority of higher levels of nitrogen nutrition with respect to phenolic parameter (days to flowering) may be ascribed to the optimum supply of nitrogen which resulted in greater synthesis of carbohydrate which in turn might have accelerated the formation of flower bud and its development. Nitrogen above the optimal level is universally accepted to promote vegetative growth, increase succulence and delay flowering. In the present investigation, days to first flowering was correspondingly hastened and 140 Kg N per hectare proved optimum which is in line with the reports of Eguchi (1958) in tomato. However, Pawar and Karale (1997) observed delayed flowering in tomato due to higher levels of N i.e. 200 and 250 Kg per hectare.

Nitrogen in increasing levels hastened first fruit set during both the years. Its 140 Kg /ha application required the minimum i.e. 46.79 and 47.73 days for the same against the maximum (47.45 and 48.37 days) noted under control during both the years. Nitrogen @ 80 Kg, however, remained statistically at par in this regard with control during both the years.

The yield contributing components e.g. number and weight of fruits, their size and volume and yield of green pods improved significantly under the influence of increasing levels of nitrogen nutrition during both the years. Nitrogen applied @ 140 Kg per hectare caused 22.84 and 25.27 per cent increase in the number of pods, 21.17 and 21.72 per cent in fresh weight of pods,
8.93 and 9.48 per cent in length of pods, 17.87 and 23.16 per cent in diameter of pods and 21.10 and 21.61 in yield of green pods as compared to control during first and second years of investigation respectively. The harvest of green pods of bhindi under 140 Kg and 120 Kg N per hectare remained statistically at par during both the years of investigation. The findings with respect to yield attributory components are in conformity with the reports of Mishra and Pandey (1987), Tomar and Rathore (1988), Tyagi and Khandelwal (1985), Marry and Balakrishan (1990), Aliya and Yusuf (1991), Subramanyan and Bhatia (1993), Pawar and Karale (1997), Singh et al. (1997) and Naidu et al. (1998).

Okra is harvested when it is physiologically mature and contains high moisture content to ensure succulence and quality. The plants growth is therefore, rapid and uninterrupted, consequently, high rates of fertilizers particularly nitrogenous are required.

The yield of green pods per hectare depends upon a number of factors viz., number of fruits per plant, weight of individual fruit and their size. This traits, in the present investigation, increased correspondingly with increasing levels of N from 0 to 140 Kg per hectare under both the years of investigation. The number of fruits per plant depends upon the number of nodes of main stem and number of branches per plant. These parameters, in the present investigation increased significantly and correspondingly with the increasing levels of fertilizer. Fruit weight also enhanced progressively with increasing doses of nitrogen. The improvement in these parameters including the yield of green pods may be attributed to the improved vegetative parameters due to N facilitating more translocation of organic food materials in the fruit from stem and leaves which accelerated the formation and development of fruits exhibiting greater size and weight.
Days to first flowering as influenced by $P_2O_5$ treatments did not differ significantly though, increasing levels hastened it numerically during both the years of observations. But days to first set was significantly earlier when 100 Kg $P_2O_5$ per hectare was applied. The plants under control did not differ significantly with 80 Kg $P_2O_5$ per hectare and similarly 100 Kg level when compared with the 80 Kg failed to cause significant variations with respect to first fruit set during both the years of investigation.

The yield contributory parameters e.g., number, weight, size, volume and yield of pods were improved significantly barring volume during second year of study. Application of 100 Kg $P_2O_5$ per hectare proved significantly superior over its 80 Kg level under all the above attributes except number and length of pods during second year of study. The plants fertilized with 100 Kg $P_2O_5$ per hectare brought about an increase of 2.14 and 2.91 per cent in number of pods, 8.33 and 8.44 per cent in fresh weight of pods, 2.38 and 2.76 per cent in length of pods and 19.12 and 20.65 per cent in diameter of pods. These findings are in agreement with the reports of Verma et al. (1970), Sharma and Mann (1971), Davies and Linderman (1991) and Naik and Srinivas (1992).

The number, weight and size of pods in the present investigations increased correspondingly with increasing levels of phosphorus during both the years of investigations. As in case of nitrogen, the vegetative growth parameters also increased due to phosphorus fertilization which ultimately resulted in increased number, weight and size of pods. The size of pods was, however, positively correlated with its weight. The size of fruit under the present investigation, judged in terms of its length, diameter and volume increased correspondingly with increasing levels of $P_2O_5$ during both the years of study.

Phosphorus nutrition in increasing levels improved the yield of green pods of okra progressively. The highest dose registered the maximum yield
i.e. 104.33 and 105.18 q/ha against the minimum harvest of 96.96 and 97.06 q/ha under control during first and second year of investigations. Phosphorus applied @ 80 Kg/ha remained intermediary in this regard producing 100.91 and 100.99 q yield/ha during the corresponding years of study. Application of 100 Kg P₂O₅/ha brought about 7.60 and 8.36 percent increase in the yield of green pods when compared with control during first and second year of investigation respectively. The findings are in agreement with the reports of Singh (1979), Reddy et al. (1984) who noted relatively lower yield of pods per hectare in okra. Similars findings due to P₂O₅ treatments have also been forwarded by Mohammed and Al-Hassan (1986), Navarro et al. (1986), Damke et al. (1988), Singh et al. (1988), Arora et al. (1991) and Singh et al. (1997). However, conversely to the present findings, Asif and Greig (1972) failed to record significant effect of P₂O₅ applied @ 43 lb/acre.

Plant density did not affect the phenological parameters i.e. days to flowering and fruiting during both the years. But number of pods per plant, size, weight, volume and yield increased barring length of pods significantly during both the years of study. Low plant density revealed the increase of 4.98 and 5.12 per cent in fresh weight of pods, 6.18 and 6.12 per cent in diameter of pods and 4.14 and 6.78 per cent in the volume of pods during both the years of investigation.

But contrary to the trend exhibited by above attributes the yield per hectare was registered significantly maximum under high density cropping during both the years. The yield of green pods increased by 27.59 and 26.83 percent under closer spacing when compared with the wider during first and second years of study respectively. The superiority of low plant density in improving the contributory component e.g., number, weight, size and volume of pods may be attributed to better vegetative growth of the plant availed by wider spacing. The results are in agreement with the reports of Palanisamy and
Plate II: Size of okra leaf under the treatment $\text{N}_3\text{P}_2\text{S}_2$

The interaction of N x P, N x S, P x S and N x P x S did not cause significant effect on the flowering, fruiting, yield and yield contributory components barring volume of the fruits under N x P during both the years and yield of pods under N x S during second years of study. However, numerical improvements were noted under all the interactions both first and second orders. Nitrogen @ 140 Kg applied with 100 Kg P₂O₅ /ha; 140 Kg N/ha with 50 x 40 cm spacing and 100 Kg P₂O₅ /ha with wider spacing proved more effective during both the years with respect to flowering, fruiting and yield contributory components. Nitrogen @ 140 Kg/ha associated with 100 Kg P₂O₅ applied to low plant density proved beneficial during both the years of study (Plate II & III). The yield of green pods increased under high density cropping associated with 140 Kg N or 100 Kg P₂O₅ or both. Similar results have been furnished by Gill et al. (1974) in sweet pepper, Gupta et al. (1981) and Reddy et al. (1984) in okra for N x P; Gupta et al. (1981) in okra and Pawar and Karale (1997) in tomato for N x S and Suwandi (1988) in tomato for N x P x S interactions.

The interactions of N x S increased the yield of pods during both the years but it was significantly higher during second year of study. The maximum yield of 121.64 and 121.95 q/ha was noted when 140 Kg N was given to the cropping density at 50 x 30 cm spacing which registered 20.62 and 21.01
Plate III: Size of okra pods under the treatment $N_2P_2S_2$
per cent increase over N₀P₀ during first and second years of study respectively. The improvement in the yield and yield components may be attributed to the greater translocation of organic food materials in the pods from the stem and leaves of okra plants. The translocation of foods in the fruits from stem and leaves increases with the manufacture of surplus food material by photosynthesis which is increased with increasing photosynthetic site (leaf area). In the present investigations, the vegetative growth attributes of okra plants were significantly boosted by the interactive treatments of nitrogen and plant density during both the years of investigations which ultimately affected the fruiting.

The interaction of nitrogen and phosphorus in the present investigation, brought about considerable improvement when compared with control during both the years. It has been reported by early workers that where phosphorus is not applied, nitrogen has little effect on growth and yield attributes of vegetable crops. Phosphorus applied in conjunction with nitrogen improved the yield of green pods significantly.

The interaction of nitrogen with plant density caused beneficial effect on growth and yield of plant which may be attributed to the optimal level of nitrogen and wider intra row spacing facilitating vegetative growth due to more availability of nitrogen and greater nourishment, moisture aeration and sunshine due to wider spacing which ultimately resulted in manufacturer of more photosynthates and consequently its translocation to the pods.

C. Chemical Composition:

Nutrition of nitrogen, phosphorus and plant geometry affected the chemical composition and metabolites of okra pods and plants singly and in combinations with other factors during both the years of investigation. Application of nitrogen @ 140 Kg per hectare induced significantly greater, ingredients both in leaves as well as pods. The improvement in the ingredients of
leaves and pods of okra under the influence of 140 Kg N per hectare was registered to be 55.39, 60.29 and 31.60, 31.23 per cent in dry matter; 16.48, 16.91 and 20.99, 19.17 per cent in protein content; 18.70, 17.61 and 20.24, 22.00 per cent in nitrogen content and 20.22, 20.67 and 29.32, 17.37 percent in phosphorus content over control during first and second years of study respectively. Similarly the ash content of the pods was estimated to be 18.31 and 17.53 percent greater over control during corresponding years of study.

The dry matter accumulation in leaves as well as pods increased significantly with increasing levels of nitrogen during both the years of investigation. Nitrogen nutrition might have increased the absorption of nutrients and manufacture of photosynthates which ultimately caused improvement in the dry matter content. The findings are in agreement with results of Subbiah and Perumal (1986) in tomato. Conversely nitrogen is suggested to increase the succulency in plants and plant parts and lower the rate of transpiration (Pearsall and Eveing 1929). However, working with okra Natraj et al. (1992) failed to get significant effect of nitrogen on dry matter accumulation. Protein content of both leaves and pods in the present investigation were significantly greater under 120 Kg and 140 Kg N per hectare when compared with control. Application of 140 Kg N proved significantly superior than 120 Kg with respect to protein content both in leaves and pods during both the years of investigation. The results are in consonance with the reports of Sharma and Prasad (1973), Zanin and Kimoto (1980), Mani et al. (1981), Arora et al. (1985) and Abusalecha and Shanmugavelu (1988).

The nitrogen and phosphorus contents of leaves and pods in okra were improved significantly under the influence of nitrogen nutrition. The maximum uptake of both the nutrients was noted under 140 Kg N per hectare followed by 120 Kg. does. The increase in these parameters may be attributed to the vegetative growth of okra plants which affected the accumulation of minerals
and metabolites in the different plant organs including the pods. Similar results have been forwarded by Asif and Greig (1973), Singh et al. (1986), Dimri and Lal (1988) and Singh and Shrivastav (1988). As regards the ash content of okra pods it increased with increasing levels of nitrogen fertilization during both the years.

Application of phosphorus in increasing doses increased the dry matter, protein, nitrogen, phosphorus and ash content during both the years. Higher dose of phosphorus registered and improvement of 12.57, 14.45 and 7.47, 6.61 percent in dry matter; 8.18; 11.17 and 1.98, 2.54 percent in protein; 12.19, 8.48 and 8.71, 10.04 per cent in nitrogen; 32.25, 32.94 and 26.35, 28.72 percent in phosphorus content of leaves and pods when compared with control during first and second years of observations respectively. The ash content estimated in the pods revealed 4.71 and 4.06 percent greater values under 100 Kg P\textsubscript{2}O\textsubscript{5} per hectare over control during corresponding years of study. The superiority of phosphorus fertilization in improving the metabolites and minerals may be ascribed to the increase in absorption of nutritents from the soil and translocation of photosynthates from the leaves to the pods under the influence of phosphorus nutrition. The optimum supply of phosphorus increases the utilization of other elements which result in more uptake of mineral elements from the soil. The findings of the present investigations are in agreement with the reports of Orth (1965), Asif and Greig (1972), Balasubryamani and Pappaih (1988) and Niranjan and Devi (1990).

Plant geometry i.e., intra-row spacing brought about significant improvement in the chemical composition of leaves and pods barring protein and nitrogen contents in pods during the second year of study. The plant geometry of 50 x 40 cm caused improvement of 9.46, 8.82 and 6.33, 5.08 percent in dry matter; 4.92, 4.94 and 0.69, 0.68 percent in protein; 9.69, 6.62 and 2.57, 3.62 percent in nitrogen and 4.82, 4.79 and 5.41, 3.54 percent in phosphorus contents
of leaves and pods over 50 x 30 cm spacing during first and second year of study respectively. Under lower density the ash content estimated in the pods of okra increased by 5.75 and 6.75 percent when compared with high density during the corresponding years of study. The findings of the present investigations with respect to plant density are, however, in conformity with the reports of Pandey (1976), Gandhi et al. (1990) in bhindi and Dimri and Lal (1988) in tomato.

Nitrogen and phosphorus contents of the fruits, however, are directly related with the dry matter contents of leaves and plants, because these contents migrate from different plant organs to the fruits. Relatively better growing condition due to wider spacing might have resulted in better vegetative growth of individual plants and higher yield of fruits enhancing the uptake of phosphorus. Poor mineral status under closer spacing may be attributed to the competition for the nutrients, moisture, aeration and sun shine due to higher plant density.

Interactive effect of N$_3$P$_2$ improved the leaf area per plant and phosphorus contents of leaves and pods significantly during both the years, whereas, N$_3$S$_2$ improved the ash content in pods during both the years and dry matter and protein contents in leaves during first year of study. Higher level of P$_2$O$_5$ interacting with lower plant density (P$_2$S$_2$) induced significantly greater dry matter and nitrogen content in the leaves during first and second years of study respectively. Rest of the first and second order interactions, improving the chemical composition and metabolites of leaves and pods numerically, remaining statistically non-significant.

The dry matter, protein, nitrogen and phosphorus contents of leaves and pods and ash contents of the pods improved under the higher levels of both the fertilizers. However, minerals and metabolites were noted to improve further when the fertilizers were applied together.
The interactions of phosphorus and intra-row spacing improved the nutritional status of plants i.e. dry matter, protein, nitrogen and phosphorus contents of leaves and pods and ash content of pods considerably during both the years. It was noted to be the maximum when 100 Kg P$_2$O$_5$ was applied to 50 x 40 cm plant geometry. The second order interaction i.e. N x P x S failed to influence the chemical composition of leaves as well as pods under both the years of investigation. Dry matter and mineral contents accumulation were observed to be numerically higher when 140 Kg N was applied in conjunction with 100 Kg P$_2$O$_5$ to low plant density crop during both the years of study. Higher plant density devoid of N and P fertilizers expressed the minimum values in this regard.

The findings of the present investigations confirm the fact that sufficient and simultaneous supply of nitrogen and phosphorus increases their better utilization which results in greater uptake of mineral elements from the soil. Miller (1938) noted that plant growing in a medium lacking in sufficient content of total nitrogen expressed poor performance with regard to dry matter accumulation than those grown in complete nutrient solution. If nitrogen is deficient, the phosphorus may accumulate, because it is not used in the synthesis of nitrogenous and organic compounds. This interaction between nitrogen and phosphorus is properly caused by their utilization by the plants. Similar results of interactive treatments were reported by Balasubramani and Pappaih (1988) and Singh and Srivastava (1988).

**D. Cost/Benefit ratio:**

The maximum net returns of Rs. 22,727.00 and 23234.40 were obtained with 2.50 and 2.57 cost/benefit ratio when 140 Kg N/ha + 100 Kg P$_2$O$_5$/ha were applied to high density cropping during the year 1997 and 98 respectively. Lowest net returns were noted when low density crop did not receive any fertilizer treatment. The maximized production under the present
investigation is solely due to high density crop accommodating relatively larger number of plant per unit area associated with highest levels of N and P$_2$O$_5$ which promoted vegetative growth, phenological traits, yield contributory components and the yield improving the cost benefit ratio.