Mixed/intercropping system is an ancient practice in Indian agriculture. About 40 years ago, the attention of agricultural scientists turned up towards the intercropping to explore the possibilities of getting higher productivity and net returns from intercrops. But, so far, an adequate research information is not available on the nutritional aspects of the intercropping systems. In this chapter, therefore, an attempt has been made to review the research information available on mustard (Brassica juncea L.) and chickpea (Cicer arietinum L.) intercropping system. It also covered the effect of nitrogen and phosphorus on growth, development, yield and yield attributing characters, quality and nutrient uptake by sole and intercrops. Similarly, the economic aspects of cropping systems are also presented here.

The information on growth, development, yield and quality in relation to nitrogen and phosphorus fertilization of mustard + chickpea intercropping is very meagre. Therefore, the information available on other cropping systems is also reviewed.

Before presenting the review, it is appropriate to discuss certain important concepts of intercropping.

2.1 Intercropping/mixed cropping

Several workers have defined the intercropping/mixed cropping in different situations. Willey (1979) defined the intercropping as "the growing two or more crops simultaneously in alternate rows or otherwise in the same area, where there is a significant amount of intercrop competition". The crops may or may not be grown or harvested exactly at the same time, but
usually grew together for a significant part of their growing period. Intercropping is different from relay cropping, in which growing period of two crops overlap for a short period, (2 to 3 weeks). It has been suggested that the intercropping should also imply in such a way that the crops are grown in separate rows and not grown mixed (Andrews and Kassam, 1975). The arrangement where there is irregular broadcasting or mixing with in the rows should be defined as "Mixed cropping" (Andrews and Kassam, 1975; Freyman and Venkateswarlu, 1977 and Ruthenburg, 1971).

Although mixed/intercropping is a primitive method of agriculture when the seeds of two or more component crops were mixed together in different ratios and broadcast. But this method was too difficult to attend the interculture operations and harvesting etc. and resulted low yield.

The importance of intercropping was highlighted by Aiyer (1949). He suggested that the intercropping system may get greater stability in yield, better use of growth resources, better control of weeds, pest and diseases, one crop provided physical support and shelter to the other crop, erosion control and more remunerative to small farmers.

Willey (1979) suggested three different situations under which the advantages of intercropping can be evaluated: i) where intercropping system give full yield of main crop and some yield of second crop; ii) the combined intercrop yield exceed the yield of any of component crop grown separately as a sole crop; iii) and the combined intercrop must exceed a combined sole crop yield.

When two or more crop are raised as intercrop, the tw
ituations occurs, the intercrop grows better in the presence of
other and exceed in yield advantages over the sole crop
(Willey, 1975) and other is an adverse effect of competition
between component crops are noted and yield advantage compared to
sole crop is the lowest (Donald, 1946 and Harper, 1961).

Donald (1963) suggested that two species of contrasting
habits in intercropping system will be able to exploit the total
environmental resources more efficiently than monoculture.

A yield advantage/return potential may be got through better
utilization of growth resources by the component crops. Some
certain causes are responsible for yield advantages; selection of
crops for minimising the intercrop competition, vary in growth
pattern and better control of weeds, pest and diseases. The
reason of dominance of intercropping is that if one crop failed
or showed poor growth, the other component crop could compensate.
It thus minimises the risk of total crop failure.

2.2 Mustard+chickpea intercropping system

2.2.1 Growth and growth characters

Kushwaha (1983) reported increase in number of primary and
secondary branches and dry matter accumulation/plant in mustard +
chickpea (1:2) as compared to sole mustard whereas number of
primary and secondary branches of chickpea reduced in this
system. The plant height of mustard decreased and of chickpea
increased in intercropping system. Kumar and Singh (1987) also
reported decrease in number of branches/plant of chickpea in
mustard + chickpea (1:3) intercropping and increase in mustard
branching in 1:4 ratio than their sole stands. Dhingra et al.
(1990) reported that mustard crop was more competitive and had suppressing effect on chickpea due to its tall growth nature. Vyas et al. (1991) reported highest dry matter production of mustard and lowest of chickpea from intercropping of mustard + chickpea in 1:3 row ratio. Rana (1991) conducted an experiment on mustard + potato (1:3) and reported that all the growth parameters of mustard except plant height were of higher order in intercropping system as compared to sole stand. Ali (1992) reported that the dry matter accumulation of chickpea in 4:1 row ratio was 81% of the sole crop while mustard dry weight in this system was higher than its sole stand throughout the crop growth. Similar results were reported by Mangaprabha (1994) under the same ratio of mustard + chickpea. She reported higher secondary branches and dry matter accumulation per plant of mustard in intercropping and number of primary and secondary branches and dry matter accumulation/plant of chickpea reduced in this system.

2.2.2 Yield and yield attributes

Kushwaha (1983) recorded significantly higher number of siliqueae, seed weight/plant and test weight in mustard and in chickpea these yield attributes decreased in intercropping. The total economic productivity was higher in intercropping of mustard+chickpea (1:2) than their sole crops. Increase in siliqueae bearing branches at harvest and total economic yield in mustard+chickpea (1:3) system was also reported by Meena (1985). Kumar and Singh (1987) reported that gram and mustard intercropping in 3:1 row ratio gave 1.94 tonne chickpea equivalent seed yield which was higher than their sole stand. Mustard and chickpea in intercropping gave yield of 0.87 and 0.6
tonne/hectare, respectively, while seed yield in sole stands of these crops were 1.32 and 1.21 t/ha, respectively. Number of siliquae/plant in mustard increased in intercropping system whereas number of pods/plant in chickpea reduced than its sole stands. Ali (1992) reported that intercropping significantly decreased the yield of all the chickpea genotype. The seed yield of Indian mustard in 4:1 row ratio declined (49%) due to reduction in its area. Sachan and Uttam (1992) conducted an experiment consisting different cropping system at Kanpur. They reported that the sole crops of mustard and gram gave the highest yield compared with intercropping of gram and mustard. The intercropping of gram and mustard in the ratios of 3:1 and 2:2, respectively gave maximum yield with the other ratios of intercropping. The maximum number of pods/plant, number of seeds/pod, seed weight/plant and 1000 seed weight were recorded under 2:2 row ratio in gram crop whereas in mustard, 3:1 ratio produced more siliquae/plant, seeds/siliqua and seed weight/plant compared with other row ratios 2:1 and 2:2. Singh and Yadav (1992) recorded the highest (chickpea equivalent) seed yield of 20.16 and 30.25 q/ha in chickpea+mustard (4:1) intercropping system in respective years, which was higher by 4.26 and 10.51 q/ha than sole chickpea and was higher than other combinations. Number of pods/plant, seeds/pod, test weight/plant seed weight/plant of chickpea were reduced in all the combinations of intercropping than sole stand. Mangaprabha (1994) reported superiority of siliquae and seed weight/plant of mustard and inferiority of pods/plant, seed weight/plant and 1000-seed weight
in intercropping system. Total biomass and mustard equivalent yield was higher in mustard + chickpea (1:4) than sole mustard and chickpea.

2.2.3 Oil content and yield

Kushwaha (1983) reported that oil content in mustard seed was not influenced by sole or intercrop mustard in either of the seasons, while Meena (1985) reported higher oil content in sole mustard and significantly reduced in mustard + chickpea intercropping in 1:2 and 1:3 ratio. Mangaprabha (1994) reported significantly lower oil yield in replacement series than sole mustard and other combinations of intercropping. Oil content was not influenced due to cropping system.

2.2.4 Protein content and yield

Kushwaha (1983) reported significantly lower protein content in sole mustard as compared to mustard in intercropping in second season. Singh and Yadav (1992) reported that intercropping of chickpea + mustard in 4:1 or 8:1 row ratio recorded significantly higher protein content than intercropping with safflower. Mangaprabha (1994) reported that protein content in mustard and chickpea was not affected due to cropping system, however, protein yield was higher in sole mustard and chickpea and lower in mustard + chickpea intercropping.

2.2.5 Nutrient content and uptake

Nutrient uptake by crops grown alone or in intercropping system is controlled by availability of water in root zone. It is assumed that component crops when raised alone exploit different soil layers and when grew in association exploit a greater volume of soil. This was considered by some worker (Trenbath, 1974)
as the possible cause of yield advantage in intercropping is due to the mutual avoidance of different root system. The difference in rooting pattern could occur, because of tendency of roots to avoid overlapping in rooting growth mutually. The crop thus avoids area that have already depleted the resources (nutrient and water) by an associated crop. Meena (1985) did not find any significant difference in content and uptake of nitrogen in mustard due to various mustard + chickpea intercropping system. In case of chickpea, nitrogen content also did not influenced significantly but nitrogen uptake was higher in sole chickpea. Kushwaha and De (1987) reported that 34% mustard + 66% chickpea combination removed more nitrogen from soil. Kanu (1991) reported that mustard + potato removed significantly higher amount of N, P₂O₅ and K₂O followed by sole potato and then sole mustard. Lower nitrogen uptake in replacement series compared to other combinations of intercropping was reported by Mangaprabha (1994). She also reported that nitrogen content was not influenced due to intercropping system.

2.2.6 Economic returns

Pulses and oilseeds when grown togather on same piece of land increased the net returns and improve the soil fertility by fixing the atmospheric nitrogen through root nodules of legume crop. Net returns was affected by total seed yield and shelling price of the produce of component crops in that year.

Singh and Rajpai (1982) obtained highest net profit in mustard + chickpea intercropping. On an average highest net returns of Rs 10339, 8158 and 16216/ha was reported by Verma et
al. (1989), Singh and Yadav (1992) and Mangaprabha (1994), respectively under 1:4 ratio of mustard + chickpea intercropping.

Kumar and Singh (1987) reported highest mean net profit when one row of mustard was alternated after every three rows of chickpea (Rs 2690). It was higher by Rs 1480 and Rs 463/ha than sole chickpea and mustard, respectively. Patel et al. (1991) conducted an experiment on gram+mustard (3:1) intercropping and reported highest net returns of Rs 5986/ha which was higher than sole crops and other row combinations in intercropping. Sachan and Uttam (1992) reported that sole crops of gram and mustard gave lowest mean net returns of Rs 1876/ha whereas gram + mustard in 2:2 row ratio gave significantly highest mean net returns of Rs 3368/ha in comparison to other row ratios (2:1 and 3:1) in intercropping and their sole crops.

2.2.7 Yield advantage in intercropping

LER as a measure is often used to evaluate the cropping systems. Kushwaha (1983) reported 19% higher LER in 1/3 mustard + 2/3 chickpea intercropping than sole cropping of either component crop. Meena (1985) also reported highest LER 1.37 under intercropping of mustard + chickpea in 1:3 row ratio. Under the same combination of intercropping, highest LER (1.23) was recorded by Kumar and Singh (1987). Rana (1991) reported highest LER (1.54) in mustard + potato (1:3). In a study of compatibility and spatial arrangement of chickpea+mustard in association at Kanpur, Ali (1992) reported that erect tall genotype of chickpea (B.G. 261) was most compatible for intercropping with mustard in 4:1 row ratio which increased the land equivalent ratio by 22%. Higher LER (1.55) was also reported by Mangaprabha (1994) under
same combination of intercropping.

2.3 Nitrogen

Nitrogen is an essential constituent of protein and chlorophyll and is present in many other compounds of great physiological importance in plant metabolism, such as nucleotides, phosphatides, enzymes, hormones, vitamins etc. The function of nitrogen is cell multiplication, cell elongation and tissue differentiation. It provides dark green colour to plants and promotes leaf, stem and other vegetative growth. It is responsible for rapid early growth and improves quality, succulence of leafy vegetable and fodder crops. It increases protein content of food and fodder crops. It governs the utilization of potassium and other elements to a considerable degree.

2.3.1 Sole mustard

Indian mustard mostly grown on poor soils without application of nitrogenous fertilizers. Experimental evidences reveal that mustard gives positive response to flourish the growth and yield and yield contributing character in rainfed and irrigated conditions with the nitrogen fertilization. The importance of nitrogen fertilization in Brassica has been emphasized by many workers (Pathak et al., 1963; Singh and Rathi, 1985 and Narang and Singh, 1985).

2.3.1.1 Effect of nitrogen on growth and development

Mudholkar and Ahlawat (1981) reported that the application of nitrogen promoted plant growth (plant height and dry matter production). Dry matter per plant increased with increasing
levels of nitrogen up to 80 kg/ha whereas plant height did not show any improvement beyond 40 kg N/ha. Joshi et al. (1991) working at Navasari (Gujarat) reported that the application of 60 kg N/ha significantly increased the plant height, primary and secondary branches per plant. Similar result were reported by Agarwal and Gupta (1991) from Udaipur. Bharadwaj (1991) observed significant differences in plant height and number of branches per plant up to 90 kg N/ha.

2.3.1.2 Effect of nitrogen on yield and yield attributes

Application of nitrogen produced higher seed yield of mustard over control. Singh et al. (1972) applied different doses of nitrogen to mustard crop and studied its effect on seed yield. They recorded increase of 51.6% with application of 101 kg N/ha and 36% with 74 kg N/ha. The study made under irrigated condition.

Mudholkar and Ahlawat (1981) reported that siliquae/plant and seed yield increased with increasing levels of nitrogen up to 80 kg/ha. The relation between seed yield and nitrogen application was found to be linear in nature. Similarly, Singh and Srivastava (1986) recorded highest seed yield 550 kg/ha with application of 80 kg N/ha in Meghalaya. Singh and Rathi (1985) reported a strong linear relationship of seed yield with nitrogen levels and even increase in seed yield after 120 kg N/ha was highly significant by a margin of 4.6 q/ha or 12.1% with a highest tested dose 160 kg N/ha. Similar result were reported by Singh et al. (1985). They observed a linear increase in seed yield with increase in nitrogen application. Yield component improved significantly up to 120 kg N/ha. The significant increase
due to nitrogen was observed in yield attributing characters, viz; number of siliquae/plant, seeds/siliqua, test weight and seed weight per plant. Narang and Singh (1985) recorded highest seed yield of 1.77 t/ha with the application of 150 kg N/ha in first year and with 100 kg N/ha in second year.

Singh and Singh (1987) reported that application of nitrogen increased yield attributes (number of siliquae and seed yield/plant) and seed yield of mustard significantly upto 75 kg/ha.

Gill and Sodhi (1988) working in Punjab reported that increasing nitrogen rates from 0 to 150 kg/ha increased the seed yield from 0.87 to 1.40 t/ha. The optimum rate of nitrogen was 142 kg/ha.

Prasad and Ehsanullah (1990) recorded highest seed yield of mustard cv. Varuna with 80 kg N/ha in first year while the response to nitrogen upto 60 kg/ha was in second year. The similar results were obtained by Ehsanullah et al. in 1991. Parihar (1991) working at Kharagpur recorded a significant increase in seed yield upto 60 kg N/ha. The length of siliqua, siliquae/plant and seeds/siliqua were also highest with 50 kg N/ha. Bharadwaj (1991) reported that nitrogen application increased the seed yield linearly upto 90 kg/ha. Katole and Sharma (1991) also obtained maximum (20.1 g/ha) seed yield and pods per plant with 90 kg/ha.

Rana et al. (1991) reported better performance of mustard in terms of yield attributes upto 100 kg N/ha. Mohan and Sharma (1992) also obtained significantly higher seeds/siliqua, test
weight and seed yield with 75 kg N/ha.

2.3.1.3 Effect of nitrogen on quality of seed

The oil content of mustard seed depends on nutrition and weather condition at ripening stage. Generally, nitrogen application showed negative relationship with oil content in seed. The depression is associated with increase in protein in seed (Singh and Rathi, 1985).

The advantage in oil yield with application of nitrogen is well established because of increase in seed yield rather than oil content. The increase in oil yield with increasing levels of nitrogen was reported by many workers (Singh and Rathi, 1985; Prasad and Ehsanullah, 1990 and Mohan and Sharma, 1992).

2.3.1.4 Effect of nitrogen on nutrient content and uptake

Mustard is more exhaustive crop in respect of removal of nutrients from the soil. The nutrient content and uptake depends on available and applied nutrient in the soil solution. Antil et al. (1986) reported that increasing levels of nitrogen upto 120 kg/ha increased nitrogen content and uptake. Similar results were reported by Rathore and Manohar (1990). Whereas Reddy et al. (1988) reported that N uptake significantly increased with increasing level of nitrogen from 0 to 80 kg/ha. Rana et al. (1991) obtained response in respect of N uptake upto 150 kg/ha. They reported that the application of nitrogen from 0 to 150 kg/ha significantly increased the N content and uptake in both seed and straw.

2.3.1.5 Effect of nitrogen on harvest index

Nitrogen plays an important role in plant system. Harvest index is a ratio between seed and total biological yield. Which
indicates the translocation of photosynthates from source to sink. Agrawal and Gupta (1991) observed increase in harvest index with increase in levels of nitrogen. They reported 33.4, 35.5 and 36.2% harvest index with the application of 0, 30 and 60 kg N/ha, respectively. Whereas Rana et al. (1991) reported that effect of different treatment on harvest index was not appreciable, except in case of N application in 1985-86. While more harvest index was recorded with 50 kg N/ha, followed by 100 kg and control. The lowest harvest index was recorded with 150 kg which was statistically lower than 50 kg N/ha and at par with remaining N levels.

2.3.1.6 Effect of nitrogen on economic returns

Singh and Rathi (1985) reported highest net profit (Rs 15704/ha) with application of 160 kg N/ha. Ehsanullah et al. (1991) was reported net profit Rs 5862 and 5479 and net return per rupee invested was Rs 2.52 and 2.32 in first and second year of the experiment, respectively with 80 kg N/ha.

2.3.2 Sole chickpea

Chickpea being a leguminous crop fixes atmospheric nitrogen through root nodules. The fertilizer requirement of chickpea is low but the results have revealed an increase in seed yield and yield attributes with N application under irrigated and rainfed conditions.

2.3.2.1 Effect of nitrogen on growth and development

Sharma et al. (1989) reported that an application of nitrogen upto 18 kg/ha increased the height and number of branches per plant. Number of root nodules/plant were augmented
significantly due to increase each level of nitrogen from 0 to 27 kg/ha.

2.3.2.2 Effect of nitrogen on yield and yield attributes

Khokher and Warsi (1987) reported that 18 kg N/ha significantly improved the grain and straw over the control. Similarly, Thakur et al. (1989) reported the seed yield 2.17 t/ha with the application of 18 kg N/ha as compared with 1.72 t/ha without nitrogen application under irrigated condition. The highest seed yield was 2.31 t/ha with NPK + Zn. Sharma et al. (1989) working on clay loam soil at Rewa, M.P. reported that on an average 18 kg N/ha increased the seed yield of gram (3.5 q/ha) over no nitrogen giving extra net profit of Rs 877/ha.

2.3.2.3 Effect of nitrogen on quality of seed

Gupta and Singh (1982) reported that in addition of nitrogen, phosphorus and sulphur enhanced the protein content in seed appreciably. The response to graded doses of these nutrients was quadratic in nature. The highest crude and true protein content was 25.9 and 23.7%, respectively in the first year and 21.5 and 19.5% in second year with 20 kg N/ha.

2.3.2.4 Effect of nitrogen on economic returns

Sharma et al. (1989) reported that 18 kg N/ha gave Rs 877 per hectare extra over the control.

2.3.3 Mustard+chickpea intercropping

Meena (1985) reported that the application of nitrogen at the rate of 30 kg/ha increased the seed yield of mustard in intercropping of mustard + chickpea under adequate moisture supply, but under the low moisture condition the response was obtained only at higher rate of nitrogen 60 kg/ha. He also
reported that LER in 1:2 system was comparable to 30 kg N level and that in 60 kg N was equal to 1:3 system.

Mongaprabha (1994) reported that nitrogen upto 30 kg level increased the number of secondary branches, 1000-seed weight, seed yield in 1991-92, harvest index, oil yield, nitrogen content in mustard and mustard equivalent yield, LER and gross returns, whereas dry matter/plant, number of siliqueae, seed weight, yield yield in 1992-93, nitrogen uptake and protein content and yield increased upto 60 kg. In chickpea, dry matter accumulation, secondary branches, yield, harvest index, protein yield were increased with 10 kg N/ha and grain weight/plant decreased markedly with 60 kg N/ha. Pods/plant, seeds/pod, 100-seed weight and protein content in chickpea were not influenced due to nitrogen application. Net returns were Rs 8722.0 when 30 kg N was applied.

2.4 Phosphorus

Phosphorus is a constituent of nucleic acid, phytin and phospho-lipids. It is also an constituent of majority of enzymes which are of great importance in the transformation of energy, in carbohydrate metabolism, fat metabolism and also in respiration in plants. It is closely related to cell division and development. Phosphorus stimulates early root development, rapid and vigorous start to plants, strengthen straw and decreases lodging tendency. Phosphorus brings early maturity of crops, particularly the cereals and counteracts the effect of excessive nitrogen. It also stimulates flowering, aids in seed formation, increases ratio of grain to straw or stalk and improves quality
of food grains and other crops. In legumes, it enhances the activity of rhizobia and increases the formation of root nodules. With phosphorus deficiency, leguminous plants may simultaneously suffer from nitrogen as well as potassium deficiency.

2.5.1 Sole mustard

Experimental findings reveal that efficient use of phosphorus fertilization has increased the mustard yield. Many research worker (Pathak et al., 1963; Singh et al., 1967 and Bhan, 1977) has emphasized the importance of phosphorus fertilization in Brassica. The application of phosphorus has positive effect on growth, quality, yield and yield attributes.

2.4.1.1 Effect of phosphorus on growth and development

Bhan and Singh (1976) reported that the application of phosphorus increased the plant height and number of pods per plant. Mudholkar and Ahlawat (1981) working on sandy loam soil reported that plant height increased with phosphorus application upto 80 kg P₂O₅/ha, but the difference between 40 and 80 kg P₂O₅ was not significant. The dry matter accumulation per plant increased significantly upto 80 kg P₂O₅. Lal and Dravid (1991) conducted a pot experiment on mustard and reported that the dry matter yield was highest with 30 kg P₂O₅/ha.

2.4.1.2 Effect of phosphorus on yield and yield attributes

Patel et al. (1980) conducted an experiment at Junagarh district of Gujrat and reported that the application of 50 kg P₂O₅/ha gave significantly higher seed yield (7.3 q/ha) over 0, 25 and 75 kg P₂O₅/ha. Mudholkar and Ahlawat (1981) reported that the siliquae/plant, 1000 seed weight and seed yield was significantly increased upto 40 kg P₂O₅/ha. The relationship
between seed and phosphorus was quadratic in nature. Singh et al. (1990) reported that application of 30 kg P₂O₅/ha gave higher seed yield (1.91 t/ha) against the control (1.70 t/ha). The yield did not further increased with 60 kg P₂O₅/ha.

Agrawal and Gupta (1991) also reported significant increase in siliquae/plant, seeds/siliqua, seed and oil yield with the application of 30 kg P₂O₅/ha over control.

2.4.1.3 Effect of phosphorus on quality of mustard seed

The reports on effect of phosphorus on oil content are contradictory. Gupta et al. (1972) and Vidyapatiroy et al. (1981) reported improvement in the oil content due to phosphorus application. However Monoz (1979) and Sheppard and Bates (1980) reported no effect of phosphorus on oil content. Agarwal and Gupta (1991) noted the increase in oil content and oil yield with the application of 30 kg P₂O₅/ha over no phosphorus.

2.4.1.4 Effect of phosphorus on nutrient content and uptake

Sheppard and Bates (1980) reported that phosphorus content increased with phosphorus application in both seed and stover and this increase was significant upto 30 and 60 kg P₂O₅/ha in seed and stover, respectively. Dillon and Vig (1985) observed that the application of phosphorus improved the efficiency of applied nitrogen. Reddy et al. (1988) reported that increasing phosphorus rates (0, 15 and 30 kg/ha) increased nitrogen uptake at flowering stage and phosphorus uptake in both the years. Similar result were obtained by Reddy and Sinha (1989b). Lal and Dravid (1991) reported that percentage phosphorus utilization was highest with 30 kg P₂O₅/ha whereas phosphorus uptake and percentage phosphorus...
derived from fertilizer were highest with 60 kg P₂O₅/ha.

2.4.1.5 Effect of phosphorus on harvest index

Agrawal and Gupta (1991) reported higher harvest index (35.22%) with 30 kg P₂O₅/ha over no phosphorus (35.13%).

2.4.2 Sole chickpea

Phosphorus is well known to play a beneficial role in legume growth by promoting extensive root development, nodulation and thereby ensuring a good seed yield (Sharma and Yadav, 1975). The enhanced root development and nodulation improve the supply of nutrient to the growing parts of the plant, increased photosynthetic area thereby more dry matter accumulation.

2.4.2.1 Effect of phosphorus on growth and development

Nayar et al. (1983) reported a significant increase in plant height with the application of 36 kg P₂O₅/ha over the control in first year and with 12 kg in second year. Phosphorus addition increased root nodulation. Parihar (1990) reported that plant height and branches/plant were significantly increased upto 75 kg P₂O₅/ha.

2.4.2.2 Effect of phosphorus on yield and yield attributes

Nayar et al. (1983 and 1984) reported that phosphorus addition upto 24 kg increased the seed yield. Singh and Yadav (1985) reported that increasing phosphorus rate upto 80 kg/ha increased the number of pods/plant, seed and straw yield. Roy and Tripathi (1985) working on alluvial soils in south west region of West Bengal reported that increasing levels of phosphorus significantly increased pods and seeds/plant. Significant increase in seed yield was noted upto 50 kg P₂O₅/ha in first year and upto 75 kg in second year. The test weight was also increased.
with increasing phosphorus levels in second year. Khokar and Warsi (1987) reported that the application of 46 kg P$_2$O$_5$/ha increased the seed yield by 48 to 53% over the control. Straw yield was also increased with increase in phosphorus levels. Manjunath and Sheelavant (1988) working on vertisol under irrigated conditions reported that the yield were increased from 2.27 to 2.64 t/ha with 40 kg P$_2$O$_5$.

Patel et al. (1989) working on clayey soils of south Gujrat reported that the application of 25 and 50 kg P$_2$O$_5$ gave average yield of 0.93 and 1.25 t/ha, respectively, compared with no phosphorus (0.72 t/ha). Yield did not further increased with 75 kg P$_2$O$_5$/ha.

Singh and Singh (1989) reported that application of 0, 25 and 50 kg P$_2$O$_5$/ha gave seed yield of 1.41, 1.84 and 2.21 t/ha, respectively. Yield did not further increased with 75 kg P$_2$O$_5$/ha. Parihar (1990) reported that phosphorus application significantly increased the seed yield upto 50 kg P$_2$O$_5$/ha. Phosphorus fertilisation had a marked influence on seed yield of chickpea. Increased levels of phosphorus significantly increased the number of pods per plant, number of seeds/plant and 1000 seed weight. The straw yield was also recorded significantly higher with 75 kg P$_2$O$_5$/ha. Singh and Ram (1990) working at Varanasi reported that application of 26 kg P$_2$O$_5$ increased seed yield to a maximum of 2.46 t/ha but 39 kg P$_2$O$_5$ decreased it. Patel and Patel (1991) reported that phosphorus markedly increased the seed yield upto 50 kg/ha.

2.4.2.3 Effect of phosphorus on quality of seed
Gupta and Singh (1982) reported that the response of phosphorus was quadratic in nature. Protein content showed significantly positive correlation with phosphorus content in seeds and increased with the application of phosphorus upto 80 kg/ha. Singh and Ram (1990) reported that the application of 26 kg P₂O₅ increased crude protein content but further dose of 39 kg P₂O₅ decreased it. Patel and Patel (1991) reported that phosphorus markedly increased protein content and yield upto 50 kg/ha.

2.1.2.4 Effect of phosphorus on nutrient content and uptake

Nayar et al. (1984) reported that invariably more nutrient were removed with phosphorus fertilization than control. Roy and Tripathi (1985) reported that, in general, 75 kg P₂O₅/ha increased the nutrient concentration both in seed and straw in both the years, as compared to control. Raju et al. (1991) reported that the increasing rates of phosphorus (20, 40 and 60 kg/ha) increased the nitrogen, phosphorus and potassium uptake.

2.1.3 Mustard+chickpea intercropping

The effect of phosphorus on mustard+chickpea in association and either as intercrop with other crops are reviewed here.

Vyas et al. (1991) conducted an experiment on mustard+chickpea under rainfed conditions of Delhi and reported that application of 30 kg P₂O₅/ha had no significant increase in dry matter production. Rana (1991) carried out an experiment to study the phosphorus and potassium requirement of potato (Solanum tuberosum) and mustard (Brassica juncea) in association at A.S. College Lakhaoti, Bulandshahr. He reported that phosphorus fertilization improved the growth parameters markedly upto 90 kg
$P_2O_5$/ha. Yield and yield attributes and yield index of mustard increased significantly with increasing level of phosphorus up to 90 kg $P_2O_5$/ha. Average net returns of Rs 13522 was obtained with 90 kg level. The oil content in mustard seed and LER in intercropping system remained statistically unchanged due to the different levels of phosphorus. The optimum dose of phosphorus for mustard was 71.01 and 68.06 kg/ha in intercropping and sole stand, respectively.

Rana and Singh (1992) reported that increasing levels of phosphorus up to 90 kg/ha markedly increased the removal of N, P and K by potato and mustard in their sole crop stands and intercropping during both the seasons. The increase in uptake was due to increase in yield.

2.5 Nitrogen and phosphorus in combinations

The effect of nitrogen and phosphorus on component crops in sole and intercropping system are reviewed here as under.

2.5.1 Sole mustard

Dongale (1990) reported that application of 90 kg N + 45 kg $P_2O_5$ increased seed yield, oil content and yield by 15.7, 14.6 and 19.8%, respectively with compared to unfertilized control. Uptake of N, P, K, Ca and Mg increased with increase in NP fertilizer rate. Singh et al. (1990) reported that the application of 80 kg N + 30 kg $P_2O_5$ increased number of pods/plant and seeds/pod. 1000-seed weight increased with increase in N and P rates and spacing.

2.5.2 Sole chickpea

Arvadia and Patel (1985) conducted an experiment on sowing
dates and fertility levels and reported that the highest seed yield (1.37 t/ha) and 1000-seed weight (142.2 g) was received with 25 kg N + 25 kg P₂O₅/ha. Khokar and Warsi (1987) reported that 18 kg N + 46 kg P₂O₅ raised seed and straw yield over its alone use and control. Increase in yield was attributed by more number of pods/branch, seeds/plant and bold seed obtained as evidence by higher 1000-seed weight. Straw yield increased due to increase in primary and secondary branches/plant. Prasad and Singh (1987) reported that the application of fertilizers increased plant/metre row length, dry matter per plant and seed and straw yield in both the years. Higher level of 20 kg N + 60 kg P₂O₅/ha recorded higher value of these parameters than 10 kg N + 30 kg P₂O₅/ha.

Paturde and Phirke (1990) reported that N+P₂O₅ @ of 15 + 50 25 + 50 and 35 N + 70 kg/ha gave average seed yield 0.76, 0.90 and 0.92 t/ha, respectively as compared with 0.62 t/ha without N and P. Thakur and Jadav (1990) reported seed yield of 3.23, 3.52 and 3.58 t/ha with applying N + P @ 12.5 + 25, 25 + 50 and 37.5 + 75 kg/ha, respectively as compared to 3.12 t/ha without NP. Mane et al. (1991) reported that seed yield, N and P uptake increased with increase in fertilizer rate. Application of 37.5 kg N + 75 kg P₂O₅/ha gave the highest seed yield and higher N and P uptake. Nimje (1991) conducted an experiment in deep vertisol soils. He reported that higher dose of 27 kg N + 69 kg P₂O₅/ha caused higher protein content due to increase in root activity and translocation of nitrogen. Kathore and Patel (1991) reported that application of 18 kg N + 46 kg P₂O₅/ha gave significantly more yield over lower levels. This increase in yield may be
ascribed due to better development of growth and yield attributes (branches, pods, seeds, dry weight/plant and 100 seed weight).

2.5.3 Mustard + chickpea intercropping

No information is available on mustard + chickpea intercropping in relation to N+P doses in combination, therefore, cropping systems consisted either mustard or chickpea as intercrop has also been reviewed here as under.

Kushwaha (1985) made a study under irrigated condition on mustard and lentil intercropping with different fertilizer levels. He reported that application of 40 kg N + 40 kg P₂O₅/ha gave significantly higher seed yield of mustard, LER, combined total yield and total economic productivity (mustard equivalent). The intercropping system led to economy in fertilizer use to an extent of 40 kg N + 20 kg P₂O₅/ha.

Sachan and Bhan (1986) grown mustard and safflower after green gram and reported significantly higher yields than when grown after fallow or sorghum. The yield were increased by applying 40 kg N + 40 kg P₂O₅/ha. The experiment was conducted under dry land conditions.