DISCUSSION

Linseed among the oilseeds and gram and lentil among the pulses are of great national importance in our present day agriculture. All these crops are grown in rabi season. The nitrogen and water requirements of these crops are not uniform. Generally, linseed requires heavy doses of nitrogen (90 kg/ha) for realizing the optimum yield levels. Gram and lentil, on the contrary, require only a starter doses of 20-25 kg N/ha for maximum production. In view of the needs of these crops for feeding the nation and the recent escalations in the cost of fertilizers, there is a need to develop such cropping systems which may provide these crops with minimum inputs on fertilizers especially in areas where the irrigation water is a constraint.

Pulses fix the atmospheric nitrogen in the soil and also require relatively less water to complete their life cycle. It calls for to develop suitable intercropping systems involving linseed, gram and lentil which may give higher productivity per unit area with minimum of N input under limited supply conditions.

Keeping the above in view, the present investigation was conducted to evaluate the performance
of sole crop as well as intercropping systems involving the three crops with differential nitrogen doses under limited water supply conditions during rabi season of 1994-95 and 1995-96. The results obtained have been discussed in this chapter in the light of cause and effect relationship.

5.1. EFFECT OF WEATHER CONDITIONS

The weather conditions were normal and unfavourable for crop growth during both the seasons of study. A fair amount of rainfall was received during flowering stage in both the years.

5.2 EFFECT OF CROPPING SYSTEM

5.2.1. Effect on linseed

5.2.1.1. Growth attributes:

The plant height was not significantly affected by cropping systems. Branches/plant and leaf area index in intercropping recorded higher values than pure cropping. These attributes increased as the proportion of pulses increased in intercropping. Branches/plant in 2:2 row
ratio of linseed/gram or lentil were higher than 3:2 for ratio of linseed/gram or lentil. Lentil showed its superiority over gram to produce higher number of branches/plant and LAI probably to greater availability of fixed nitrogen. Increasing proportion of gram and lentil in intercropping resulted greater beneficial effects of linseed due to relatively more nitrogen availability and more horizontal space for both the rows of wheat in 2:1 intercropping pattern.

The dry matter accumulation/m row in linseed higher in intercropping systems, the highest being in linseed gram 2:2 row ratio. This is expected because of more branches and better development of individual branch owing to reduced competition for space and nutrient especially N. The improvement of growth attributes in intercropping may be attributed to greater utilization of environmental resources in crops of differential stature (Willey and Osiru, 1972) and relative pattern (Osiru and Willey, 1972). This better utilization of environmental resources might have resulted in accelerating the development of root system and physiological activity viz., efficient conversion of intercepted radiation (Redd and Willey, 1981) with its increased periphery (Sakamot
and Shaw, 1967) due to discontinuous canopies in intercropping patterns. The increased dry matter may also be ascribed to increased availability of soil nitrogen (Simpson, 1965; Trenbath, 1976) through current transfer by pulses.

5.2.1.2. Yield attributes

Yield attributes namely, number of capsules/plant, number of seeds/capsule and weight of capsule/plant increased markedly with increasing proportions of pulses in intercropping systems. Intercropping systems, F + G and F + L in 2:2 row ratio recorded higher values of yield attributes. Linseed and pulses having variable stature caused less competition for plant nutrients, moisture and solar radiation. Secondly, linseed might have been benefited by way of better N nutrition through symbiotic nitrogen fixation by legumes. This would have resulted in better plant growth in linseed as is evident by more dry matter accumulation/m² and number of capsules/plant. The improvement in growth attributes finally led to better development of yield attributes.

Number of seeds/capsule, and weight of capsule/plant were higher with sole linseed as compared to
cropping system and decreased with increasing proportion of legumes.

5.2.1.3 Yield

Yield is a function of yield attributes and effective branches/plant. Yield of grain and stalk in sole linseed was higher due to higher branches/plant and dry matter/ha and more values of yield attributes. In intercropping systems, the yields of grain and stalk recorded with F + L 2:2 were similar to F + G 2:2 and but higher than F + L 3:2. The higher yields in 2:2 row ratio of linseed and pulses may be due to higher population of linseed per unit area as compared to 3:2 row ratio. The growth and development of yield attributes which are the parameters constituting grain and stalk yields, were the deciding factors for variation in yield.

Aetkar et al. (1991) observed that none of the proportions of mixture of wheat and chickpea was better than their pure crops. Contrary to this, Howard (1916) obtained 34% increase in yield of wheat when grown with gram in 3:1 row ratio at Pusa (Sihar) Grewal et al. (1983) also reported higher yield of wheat with gram in 1:1 and 2:1 row ratio. Mandal et al. (1986) reported that wheat + chickpea intercropping gave higher grain yield and total
5.2.2 EFFECT OF CROPPING SYSTEM OF INTERCROPS

5.2.2.1 Growth attributes

The plant population/m² of the intercrops was not affected by cropping system. The plants of gram and lentil were taller in intercropping system as compared to solid stand of pulses. This could also be attributed to the shading effect of linseed on pulse crop which might have resulted in elongation of the main stem of pulse crop. Lockhart (1961) observed reduced plant height in gram and wheat under high light intensities where proportion of mustard with these crops remained lesser while in the high proportion of mustard, the plant height of wheat and gram increased. Such shading effect on plant height was also reported by Williams. (1964).

Number of branches/plant in gram and lentil was higher in sole crop and decreased with increasing proportions of linseed in the mixture. This was probably due to comparatively less space available for horizontal spread of plants in intercropping. In sole cropping, gram and lentil had relatively greater shade-free horizontal space to grow, minimizing the competition for space and nutrients which finally resulted in more branching than
intercropping. Greater shading in 3:2 row ratio of linseed with gram or lentil resulted in poor branching in both the pulses compared to their sole cropping. This indicates that elongation of apical meristem continued resulting in less branching in gram and lentil in intercropping systems.

Dry matter accumulation was higher in pure crops in comparison to intercropping. This could be ascribed to more number of branches/plant besides other growth attribute in sole stand. Higher leaf area index increased the surface for higher photosynthesis. Increased proportion of linseed decreased the dry matter accumulation in pulses owing to adverse effect on growth of pulses. Higher dry matter in sole pulses may also be due to increased availability of soil nitrogen (Simpson, 1965; Trenbath, 1976) and due to better nodulation (Black, 1973; Trenbath, 1976) in gram.

5.2.2.2 Yield attributes

It is well known that pod formation, seed setting, test weight and grain yield/plant are the resultant of accumulation of photosynthates in the plant. The yield attributes were adversely affected in intercropping due to
intra-specific competition for solar radiation and nutrients. Number of pods/plant and grain weight/plant decreased with increasing proportions of linseed from 2:2 to 3:2 row ratio with linseed. The development of yield attributes were better in sole crop of gram and lentil and poorest in 3:2 row ratio. Sahasrabudhe (1949) found that wheat had smothering effect on gram. Modhok (1940) reported that chickpea suffered in growth in association with non-legumes.

5.2.2.3 Yield

Yield of intercrops were lower in intercropping as compared to their sole crop due to adverse effect of linseed on growth and development of plants in intercropping. Poor yield in intercropping resulted owing to less number of branches/plant, number of pods/plant, grains/plant. As discussed earlier, gram and lentil in intercropping competed for space, light, water and nutrient etc. with main crop. The main crop being comparatively tall statured had shading effect on gram and lentil. This resulted in more elongation and poor development of plants of pulses as evident by tall plant height and less dry matter accumulation. Kumar and Singh, (1987) reported that chickpea yield was highest in pure stands and decreased in intercropping systems.
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5.2.2.2 Yield attributes

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5.2.2.4 Nitrogen uptake

The nitrogen uptake was significantly higher in sole crop of lentil/gram as compared to intercropping systems. In intercropping, linseed gram and lentil in 2:2 row ratio utilized markedly higher nitrogen over 3:2 row ratio. This was evidenced by higher dry matter and grain yield/ha in 2:2 row ratio compared to 3:2 row ratio because of increased proportion of legume crop in this intercropping pattern and comparatively higher availability of fixed nitrogen from its root nodules.

5.2.3. EFFECT ON TOTAL PRODUCTIVITY OF SYSTEM

5.2.3.1 Linseed equivalent yield:

The higher linseed equivalent yield was noted in sole linseed which could be attributed to higher market price of linseed. Among the intercropping systems, higher linseed equivalent yield was noted in F + G 2:2 and F + L 2:2 which may be ascribed to increased availability of nitrogen and efficient utilization of soil moisture and other nutrients by roots taking moisture from different soil layers.
Linseed equivalent yield is totally dependant on price and yield of crops. The yield of sole linseed was higher but when area allotted to it was reduced (2:2 row ratio) the yield advantage in intercropping was 21.31% with F + L and 33.27% with F + G compared to sole wheat in 1994-95. The respective advantage in 1995-96 was 42.44% with F + L and 57.25% with F + G. When area allotted to linseed was 60% (3:2 row ratio), the yield advantage was 15.02% with F + L and 22.05% with F + G in 1994-95 compared to sole linseed. The respective advantage in 1995-96 was 26.22 and 38.80%. This might be attributed to better growth and development of yield attributes in intercropping system. Secondly, it might have been possible due to better interception of solar radiation by the adjacent rows (Pandleton et al., 1963; Mohta and De, 1980). Natarajan and Willey (1980 a) reported the yield on the basis of land area population and found that higher seed yield was obtained in intercropping pattern compared to pure cropping. Jagannathan (1979) reported that linseed + Bengal gram gave yield advantage ranging from 70% to 157%, the maximum with new linseed variety (HD 2189) raised with Bengal gram in the row arrangement. He attributed this advantage to the legume effect. Yield of gram and lentil was higher in sole stands. This was
attributed to better growth and development which finally resulted in higher yield in sole crop. When linseed is intercropped with lentil or gram in 2:2 row ratio, the area allotted to linseed and pulses was 50% each. The yield of lentil and gram decreased by 21.77 and 20.44% in lentil and 11.80 and 17.02% in gram, respectively in 1994-95 and 1995-96 in comparison to sole crop based on the area occupied by pulse crops. However, when area under pulses decreased up to 40% as in 3:2 row ratio, the loss of yield based on the area occupied was 28.81 and 32.00% in lentil and 19.07 and 28.91% in gram, respectively in 1994-95 and 1995-96.

5.2.3.2 Land Equivalent Ratio:

The LER was higher in F + C 2:2 and F + L 2:2 row ratio. This was due to higher yield of linseed in intercropping with pulses in 2:2 row ratio. Similarly F + L 3:2 and F + C 3:2 produced comparatively lesser yield equivalent and LER due to increased proportion of linseed which caused interspecific competition for space, light, nutrient and soil moisture. In 3:2 row ratio, gram and lentil area was decreased so linseed in this ratio was less benefited from nitrogen fixed in soil by gram and lentil.
Bhatnagar et al. (1991) reported that higher LEI was obtained with chickpeas intercropped with safflower, mustard or linseed over their pure stand.

5.2.4. **TOTAL NITROGEN UPTAKE**

Nitrogen uptake by the component crop decreased with its decreasing proportion in the cropping system. The nitrogen uptake was highest in lentil followed by gram and F + G 2:2 row ratio. In intercropping system nitrogen uptake increased with increasing proportion of gram and lentil. This was attributed to higher nitrogen content in pulse crop due to higher nitrogen availability in soil through symbiotic fixation of nitrogen. Better utilization of soil nitrogen in linseed resulted from horizontally located interspecific competition and free root system near the surface. Sachez (1976) reported higher nitrogen uptake in maize/redgram intercropping. Chinnappan (1978) has also reported/beneficial effect of pulse crop in nitrogen uptake in intercropping systems.

5.2.5. **EFFECT ON MONETARY ADVANTAGE**

Crop return was comparatively higher in sole linseed as compared to all other cropping systems owing to relatively higher price of the produce. Linseed had
proportionately more yield to the area allotted to it in intercropping systems due to beneficial effect of associated pulse crops. Sole gram, lentil and F + G 2:2 gave higher gross returns than other cropping systems. The higher gross returns in sole crop of pulses was attributed to higher market price of these crops, while in intercropping higher gross return was attributed to yield advantage in linseed. In intercropping systems F + G 2:2 gave higher gross and net return in 1994-95, while in 1995-96 higher gross return was realized in linseed + gram 2:2 and F + L 2:2 whereas higher net return was obtained in F + L 2:2 due to higher cost of cultivation in F + G 2:2 as compared to F + L 2:2. Secondly, F + L 2:2 had about the same yield to that of F + G 2:2 row ratio. These results are in close conformity with those of Hegde (1964), Saxena and Yadav (1975), Itnal et al. (1980), Singh (1981) and Singh and Yadav (1990). Panwar et al. (1973) found that inter and mixed cropping of legume and cereal (1:1 of linseed and gram mixture) in rows 22.5 cm apart brought out highest monetary return in linseed + gram combination.

Sole linseed had highest net return/rupee invested and net return Rs./day. This was attributed to higher
total gross and net return. In intercropping, F + G 2:2 and F + I 2:2 had highest net return/rupee invested and per day over other cropping systems. This was attributed to yield advantage in intercropping treatments. These yield advantages may be due to the combined effect of better utilization of soil moisture (Baker, 1975, Singh and Singh, 1983), light (Natarajan and Willey, 1980 b) and nutrients (Dalal, 1974) by compatible component crops with differential rooting pattern, crop canopy distribution and nutrient requirement in an intercropping system as compared to sole cropping. Panwar (1973) reported that inter and mixed cropping of legume and cereal brought out higher monetary returns.

To avoid the risk of failure of sole crop, maintaining soil fertility and maximum use of resources for higher yield with minimum input, the present study clearly supports the intercropping of gram and lentil in linseed under limited moisture availability.

5.3 EFFECT OF NITROGEN

5.3.1.1 Effect on growth and yield of Linseed:

Growth attributes namely, plant height, number of branches/plant and dry matter accumulation/ m markedly increased with increasing levels of N up to 75 kg/ha. Leaf
area index, however, increased up to 50 kg N/ha. The improvement in growth attributes with N fertilization might have been noticed to greater availability of nitrogen to the plants. It is a well-known fact that nitrogen stimulates vegetative growth in plants. Several earlier workers have also reported that nitrogen application up to 50-75 kg/ha improved plant growth in linseed (Chaurasia et al. 1992, Vashishtha, 1993; Dutta et al. 1995 and Singh Kumar 1996). The N availability to plants improved growth attributes through synthesis of proteins which are essential for the development of tissues and help to increase in the rate of photosynthesis by rapid rate of CO₂ utilization by leaves and increased absorption rate of nutrients including nitrogen from the soil at the expense of lesser plant energy.

The development of yield attributes was promoted with the application of nitrogen. Number of capsules/plant and number of seeds/capsules increased markedly up to 75 kg N/ha. Weight of capsules/plant and 1,000 weight also increased by application of nitrogen. Similar findings were also reported by Parashar et al. 1968; Reddy, 1983; Singh, 1974; Vashishtha, 1993; Mohan and Sharma, 1992; Dutta et al. 1995 and Singh and Kumar, 1996.

Harvest index remained unaffected by N application indicating proportional increase in grain and non-grain dry matter.

5.3.1.2 Effect on nitrogen uptake of linseed:

Application of nitrogen significantly increased the N uptake upto 75 kg/ha in both grain as well as stalk (Table 4.8). Nitrogen uptake increase with the increase in the free availability of N to plants resulting in greater conversion of photosynthates to protein and ultimately resulting in higher N uptake. Higher N availability promotes the development of grow the and yield contributing traits and finally yield resulting in higher accumulation of N (Singh and Singh, 1978). Further higher
N application provides congenial surrounding for better root growth and distribution which enhances the scope to explore the nutrients from the greater soil volume.

Significant increase in nitrogen uptake in grain was noticed up to 120 kg/ha by Vashishtha (1993). Similar observations were reported by Panwar and Bhardwaj (1976) and Singh and Prasad (1975).

5.3.2.1 Effect on growth and yield of intercrops

The plant population was not markedly affected by N application. This indicated that N did not affect the germination and establishment of the crop. Growth attributes namely, plant height, number of branches/plant leaf area index and dry matter accumulation were favourably affected up to 25 kg N/ha only. Further increase in the level of N beyond 25 kg/ha did not cause any additional increase in aforesaid growth attributes. Application of N improved plant growth even during early stages of crop.

The dry matter accumulation/m was similar with 25 and 50 and 50 and 75 kg N/ha. This could be attributed to the fact that chickpea or lentil plant has to depend
solely on soil source of N till the nodule formation takes place. Once the nodulation takes place, plant meets its N requirement from biological N fixation. It is for this reason a starter dose of 20-25 kg N/ha has been recommended for pulses (Mishra and Ram, 1971). The N applied at sowing gave a boost to plant growth by making more N available to plant which was finally reflected in improved growth attributes.

The development of yield attributes was promoted by application of lower level of 25 kg N/ha only. At higher levels of N fertilization, no improvement was noticed. Instead a slight reduction in the values of yield attributes was noted which may probably be accounted for greater partition of the dry matter into non grain parts. The increase in yield attributes at lower levels of N was also observed by Rathi and Singh (1976). Among the yield attributes, 1,000 grain weight remained unaffected by N fertilization possible due to the fact that it is largely governed by genetic factors. The improvement in yield attributes with lower level of 25 kg N/ha was finally reflected in grain and straw yields. These finding are in agreement with those of Panse and Khanna (1964), Singh and Yadav (1971), Singh et al, (1972 b) and Mudhalkar and Ahlawat (1979) in gram, and Sharmak and Chowdhary (1971)
and Singh (1986) in lentil. However, Chaudhary et al. (1971) and Singh et al. (1980) did not observe any significant response to applied N in chickpea possibly due to higher initial N status of the soil. Mahapatra et al. (1973) reported that application of nitrogen alone gave poor response but when applied with adequate amount of other nutrients especially P, the response to the starter dose of N was much higher. Dobariya et al. (1985) found significant response up to 40 kg N/ha due to favourable effect on plant height and seed weight, the attributes which were significantly and positively correlated with yield.

In lentil also, Data et al. (1985) and Sharma and Singh (1986) did not observe favourable response of applied N because of higher available N status of the soil.

Harvest index was adversely affected both in gram and lentil at higher levels of 50 and 75 kg N/ha. This could be ascribed to greater contribution of N at higher rates to the development of vegetative parts rather than proportional increase in grain and non-grain factors.

5.3.2.2 Effect of nitrogen on N uptake of intercrops
Application of nitrogen significantly affected the N uptake in both the seasons. N uptake increased with the increasing N upto 25 kg/ha in grains. Further application of N significantly reduced the N uptake in grain. The higher level of N (75 kg/ha) had a very drastic effect on N uptake in grain. However, the N uptake in straw showed a favourable response to N upto 50 kg/ha and further increase upto 75 kg/ha did not affect N uptake. Every pulse plant is in itself a mininitrogen fertilizer factory by contributing substantially to the enrichment of the soil. The pulse crop itself fixes sufficient nitrogen and extra supply inactivates the inherent plant system resulting in an adverse effect on N uptake. However, initial application of a small dose of nitrogen 20-30 kg/ha is beneficial and increases N uptake.

5.4. **TOTAL NITROGEN UPTAKE**

Application of 25 kg N/ha increased nitrogen uptake markedly over no nitrogen in grain. Nitrogen uptake in grain increased with increasing levels of nitrogen upto 75 kg/ha. However, the differences in nitrogen uptake between 25 and 50 and 75 kg/ha were not significant.

Nitrogen uptake by straw increased with increased levels of nitrogen up to 75 kg N/ha. This may be due to
the favourable response of growth and developmental characters to the higher levels of nitrogen.

Application of nitrogen registered significant increased in total nitrogen uptake up to 75 Kg/ha.

The yield data for grain and straw of the component crops indicate that the trend of total uptake was closely linked with the trend in grain and straw yield of the component crops. Partitioning of N uptake between grain and straw showed higher N uptake in grain than in straw. This indicates that more N was mobilized into grain from straw. These results are in close conformity of the results obtained by Parihar and Tripathi (1989) and Prasad and Singh (1990-91).

5.5 TOTAL PRODUCTIVITY

Linseed equivalent yield increased with N fertilization in both the seasons. However, the differences between 25, 50 and 75 Kg N/ha were not marked. This could be attributed to the fact that linseed as sole or intercropped situations responded favourably to 50-75 Kg N/ha but the pulses suffered a setback at higher levels of N. Therefore, the advantage in linseed yields at higher N levels was marred by adverse effect of these levels of N on pulse crops.
LER was not significant affected by nitrogen application. Generally higher yield advantage in intercropping are observed level of fertility, especially of N because higher levels of N may make the cereal component more dominating which adversely affect the growth and development of the dominated pulse crops.

5.6. EFFECT ON ECONOMIC RETURNS

The gross returns increased with increasing doses of nitrogen upto 75 kg N/ha. All three doses being at par gave higher gross returns over control. Net return increased upto 25 kg N/ha and thereafter slightly decreased.

Net return/rupee invested and net return/day were similar at 25, 50 and 75 kg N/ha but higher over no nitrogen except 1995-96 where 25 kg N/ha gave higher net return/rupee and/day over 75 kg N/ha. It appears that the diminishing yield response of pulses at higher N levels could not compensate for the cost of the nutrients or the input cost. The prolonged duration of maturity with higher levels of N consequently resulted in lower net returns/day.