REVIEW OF LITERATURE

In this chapter, an attempt has been made to present a critical review of the researches carried out on intercropping of oilseed with winter legumes particularly lentil and chick pea. The review though largely confined to rainfed agriculture but information on intercropping systems involving other crops both under rainfed and irrigated conditions has been included to understand the nature of competition between crops. The review of literature on the effect of planting pattern and nitrogen fertilization on the component crops has been presented under various heads and sub-heads.

2.1. EFFECT OF INTERCROPPING:

In India mixed cropping is a common practice (based on the experience through centuries by the farmers) under limited water supply conditions. The popularity of intercropping is due to an insurance against the unfavourable water conditions, proper utilization of interspaces between two rows of the main crop, efficient
utilization of various growth factors, conservation of soil fertility, less incidence of pest and diseases, better distribution of labour and farm resources along with the fulfilment of diversified need and more economical to the growers (Gupta, 1975).

2.1.1 EFFECT ON GROWTH AND DEVELOPMENT OF COMPONENT CROPS:

The growth and development of pure as well as intercrops depend upon inter- and intraplant competition offered by edaphic and environmental conditions on plant population/unit area and grain yield/plant (Singh, 1978).

Wijlans (1964) observed reduced plant weight and leaf area at high densities in mixture and in pure stands.

Osiru and Willey (1972) observed 55% higher yield in mixture of dwarf sorghum and beans due to greater utilization of environmental resources and also probably due to different rooting depth of two crops and their different cycles. They reported the highest yield with 2:1 mixture of sorghum/bean and also noted higher intraspecific competition than interspecific competition in these crops. Willey and Osiru (1972) reported that the yields of mixture were 38% higher than their pure stands. The mixtures achieved a greater utilization of environmental resources due to the
marked height differences of the two crops and an increased utilization of light was probably a major contributing factor.

Ali (1975) observed that linseed as mixed crop with wheat and barley did not compare better than mustard and gram under Paninagar conditions. Giri and De (1975) noticed reduction in plant height and number of branches/plant of pigeon pea in intercropping with either mung or black gram under rainfed condition. Intercropping of pigeon pea grown at 50 cm row distance with one row of either mung or black gram in between pigeonpea rows did not influence dry matter production, number of grains/pod or 1000-grains weight in pigeonpea when compared with sole pigeonpea. A significant reduction in plant height of pigeon-pea was recorded when intercropped with mung in 1:2 and 1:3 ratios. In 1:3 ratio, 1000-grain weight was also reduced.

Plants require light, water, nutrients and CO₂ for their growth. The growth is responsive to these factors particularly when any of them is relatively in short supply. This situation most commonly occurs when the plants are sown in communities. Most of these factors are well dominated in plant interactions in mixed crop communities (Trenbath, 1976).
Matarajan and Willey (1980) observed in sorghum + pigeonpea intercropping that full sorghum yield was realized at its plant density equivalent to sole crop optimum. In case of pigeonpea initial growth was very much suppressed with the presence of sorghum but some compensation occurred in the pigeonpea attiger the harvest of sorghum and a much higher ratio of seed yield to total above ground dry matter resulted in the seed yield upto 73% of sole crop of pigeon-pea.

Reddy and Willey (1981) concluded that the dry matter and yield advantages were in 1:1 row ratio of safflower - chickpea and these were due to improved efficiency of conversion of light. Similar observations were also reported by Willey and Rao, (1981).

Singh and Yadav (1980) tried intercropping of wheat with winter pulses (gram, lentil and pea) and oil seeds (mustard, safflower and linseed) under rainfed conditions at Faizabad and found higher dry matter accumulation and plant height in wheat when intercropped with gram and mustard, respectively. As compared with other treatments. The yield components (ear head/running) metre, test weight, No. of grains/ear and grain yield/plant) in wheat were also higher when intercropped with gram.
Patel et al. (1980) carried out a study with sole
gram and mustard and their intercropping in 3:1, 5:1, 7:1
and 9:1 row ratios. They found that intercropping systems
except in 9:1 ratio significantly reduced dry matter/plant
as compared to sole crop at harvest. In the contrary, dry
matter accumulation in mustard significantly increased in
intercropping system over sole planting. Gram planted in
narrow row ratios produced significantly lower number of
branches, pods and grains/plant than sole crop. All
intercropping systems being on par in respect of number of
silique, branches and grains/plant of mustard were
significantly superior to sole mustard.

Sachan and Ullam (1992) observed at Kanpur that
tallest plants, maximum number of pods/plant number of
grains/pod, grain weight/plant and 1,000-grain weight were
recorded under 2:2 in gram crop whereas in mustard 3:1
treatment produced maximum height, silique/plant,
seeds/siliqua and seed weight/plant compared with the other
treatment of 2:1 and 2:2 ratios.

Singh and Yadav (1992) tried the treatments comprised
pure crop of chickpea, chickpea + barley (mix), chickpea +
barley (2:2), chickpea + mustard (mix), chickpea + mustard
(4:1), chickpea + mustard (8:1), chickpea + safflower (2:2),
chickpea + linseed (2:2), chickpea + wheat (mix) and
chickpea + wheat (2:2) rows under Faizabad (U.P.) conditions. They reported that pods/plant, seeds/pod, test weight and grain yield/plant were the highest in the pure chickpea except in the intercropping with linseed and wheat. Mixed cropping of mustard and barley with chickpea reduced the yield components of chickpea more than their intercropping with chickpea.

Mandal et al. (1994) studied with 16 cropping systems viz. sole yellow sarson, sole safflower, sole lentil, sole chickpea, yellow sarson + lentil (1:1), yellow sarson + lentil (2:1), yellow sarson + lentil (1:2), yellow sarson + chickpea (1:1), yellow sarson + chickpea (2:1), yellow sarson + chickpea (1:2), safflower + lentil (1:1), safflower + lentil (2:1), safflower + lentil (1:1), safflower + chickpea (1:1), safflower + Chickpea (2:1) and safflower + chickpea (1:1) at Mohanpur (West Bengal). They reported that the sole crop of safflower always reported the highest amount of dry matter accumulation, root dry weight and leaf area index. However, safflower + chickpea at 2:1 planting ratio recorded the highest amount of combined root dry weight as well as combined leaf area index.

2.1.2. **Effect on yield of component crops**

Singh and Ram (1972) tested the performance of wheat
and gram intercropping at Sabour (Bihar). Wheat and gram were grown at uniform row spacing of 23 cm using 100- and 75 kg seed/ha in sole stands, respectively while seed rates were adjusted according to row proportion in intercropping. Growing of wheat and gram in alternate rows (1:1 ratio) was significantly superior to other row proportions in respect of total productivity.

Singh et al. (1977) reported that wheat + gram (2:1 ratio) was best under rainfed condition than other mixtures. They also reported the superiority of wheat mixtures with oil seed crops like mustard and linseed over pure crop of wheat under Kulu (H.P.) valley.

Rahman et al. (1981) found that the optimum combination was 30% wheat + 70% lentil in wheat + lentil intercropping system yielding 0.71 and 1.48 t grain/ha, respectively.

Grewal et al. (1983) studied the association effect of dwarf wheat and gram in 1:1 or 2:2 row ratios (parallel rows) and 1:1 in rows sown across each other in equal mixture sown in the same row. The rows were sown in NS or EW directions. Wheat + gram in 1:1 and 2:2 geometries gave higher yields than other sowing methods due to efficient
utilization of solar energy. Results also showed that no irrigation or a single irrigation resulted in higher gram yields than 2 irrigations.

Kumar and Singh (1987) working at Pantnagar reported that gram intercropped with mustard in 3:1 and 4:1 row ratios gave grain yield of 0.87 and 0.8 t/ha, respectively, while seed yields of mustard were 0.68 and 0.54 t/ha, respectively. Gram in 30 cm paired rows with 1 row of mustard in between two pairs yielded 0.53 t/ha gram and 0.95 t/ha mustard. In pure stands gram and mustard gave yields of 1.32 and 1.71 t/ha, respectively.

Sharma et al. (1987) tried wheat and gram seed mixtures in the ratios of 1:1, 2:1, 3:1 and 5:1 and wheat and gram in 1:1, 4:2 and 10:2 row ratios. The highest values of wheat equivalent yield, IER and net return were obtained with wheat and gram seed mixtures at 5:1. These values were similar of those of wheat in pure stand and wheat and gram in 10:2 row ratio.

Gajendra Giri (1990) reported from IARI, New Delhi that sole groundnut gave highest (14.60 q/ha) total productivity and sole pigeonpea the lowest (8.65 q). Intercropping of two rows of groundnut in paired planting of
pigeonpea at 30/120 cm, three rows in uniform planting of pigeonpea at 120 cm and five rows in pigeonpea at 180 cm were comparable to each other and recorded significantly higher total productivity over sole pigeonpea. These intercropping systems increased the LER by 10 to 19 per cent over sole cropping.

Hiremath et al (1990) working at Dharwad (Karnataka) found that wheat and linseed in 1:1, 1:2, 2:2, 3:1 and 3:2 ratios yielded 1.02-1.71 t/ha of wheat and 0.05-0.79 t/ha of linseed while solid stand of wheat and linseed gave yields of 1.45 and 0.41 t/ha, respectively. The highest LER and gross returns were obtained in 1:2 and 3:1 ratios of wheat, linseed, respectively.

Mandal et al. (1990) working at Kalyani (West Bengal) on intercropping of barley with lentil and fibre flax reported that intercropped barley yielded 73-81% of the sole crop yield while intercropped lentils and fibre flax yielded 30-34 and 27-31% of the sole crop yield of lentil and fibre flax, respectively. Barley + lentil intercropping recorded higher values of land ratio, monetary advantage and intercropping advantage of area time equivalent ratio than barley + flax intercropping.

Nayital and Sharma (1991) observed that intercropping
of oil-seeds and legumes did not suppress the yield of wheat. Total productivity (Wheat equivalent) was the highest (44.3 q/ha) from wheat + brown sarson being significantly higher than the other systems except wheat + lentil. The increase in total productivity due to wheat + grown sarson was higher by 29% compared with the sole wheat.

Autar et al. (1991) found that chickpea intercropped with wheat, mustard, linseed or safflower in row ratios of 2:2, 4:1 or 8:1 yielded 0.40-1.17 t/ha compared with 1.44 t/ha in pure stand. The four intercrops gave yields of 0.26-0.90, 0.37-0.62, 0.10-0.32 and 0.71-1.20 t/ha compared with their respective sole crop yields of 1.68, 0.88, 0.67 and 1.56 t/ha.

Singh and Turkhede (1991) observed at I.A.R.I., New Delhi that growth and yield components and yield of wheat and grain straw were maximum in wheat + lentil in 4:1 system and least in 1:1. However, in linseed the reverse was true.

Shah et al. (1991) studied at Shalimar and found that intercropping of maize with cowpea, rajmash or soybean in 2:1 ratio was most productive in terms of maize equivalent yield and declined, thereafter, with increase in the legume
proportion, though maintained its superiority over sole planting of maize.

Hiremath et al. (1991) reported from Dharwad (Karnataka) that there was a drastic reduction in safflower seed yield due to intercropping, but intercropping of safflower with chickpea in row ratios of 1:2, 1:3 or 2:3 gives higher total yield.

Sachan and Uttam (1992) reported from Kanpur the sole crops of gram and mustard gave the highest yield compared with intercropping of mustard and gram. The intercropping of gram and mustard in the ratios of 3:1 and 2:2 respectively gave maximum yield compared with the 2:1 ratio.

Singh and Yadav (1992) observed at Faizabad (U.P.) that the highest grain yield of 20.16 and 30.25 q/ha in chickpea equivalents was computed in chickpea + mustard (4:1) intercropping system during 1987-88 and 1988-89 respectively. Similarly, intercropping of mustard, wheat and barley were more productive and gave higher yield advantages than their mixed cropping with chickpea.

Kushwaha (1992) tested sole mustard, sole lentil, sole chickpea two thirds mustard + one third lentil or
chickpea, half mustard + half lentil or chickpea and one third mustard + two thirds lentil or chickpea treatments under Kanpur conditions. He pointed out that the land equivalent ratio was invariably higher (more than 1) in intercropping of mustard with legumes (Chickpea or lentil) (greater than 1) than the sole crops. Among the intercrop treatments, half mustard + half lentil or chickpea recorded significant by more advantages (higher ratio) than the rest of the treatments. The higher yield advantages and productivity achieved with half mustard + half lentil or chickpea.

Upasani (1993) conducted experiment at Chianki, Daltonanj to compare the feasibility of para cropping of various crops, viz. lentil, linseed and gram with normal sowing method. Amongst various crops tested, gram gave significantly higher yield than the other crops.

Upasani (1994) reported from Chianki, Daltonanj that a significantly higher gram equivalent yield (mean, 12.75 q/ha) was in gram + rapeseed intercropping at 20 cm row spacing in 1:1 ratio and was on a par (11.90 q/ha) with that of gram + rapessed at 20 cm.

Chaudhry and Singh (1993) working at Palampur observed that intercropping of lentil and toria in alternate
rows at 20 cm row spacing resulted in significantly higher lentil equivalent yield, net returns and land equivalent ratio over sole cropping vis-a-vis other cropping systems. However, the seed yield of lentil reduced significantly when toria was intercropped irrespective of system of cropping. Aktar et al. (1993) conducted trials on mixed cropping of lentil with linseed at Jessore (Bangladesh) to compare the yields of monoculture lentil, monoculture linseed and five cropping mixtures of lentil and linseed (100:25, 100:50, 75:50 and 80:40). Lentil yields were reduced in mixed cropping with linseed proportion to the increasing linseed population. The seed yield of linseed increased with the increase in its seed rate and was not dependent on the seed rate of lentil. The highest lentil equivalent yield, land equivalent ratio, grass monetary return and monetary advantage were recorded in the 100:50 lentil linseed combination.

Singh and Rajput (1996) observed at Bahraich (U.P.) that 'Kranti' proved the best among tested varieties of Indian mustard when raised in association with lentil as it gave the highest seed yield with a minimum decrease in the yield of lentil. The highest lentil-equivalent yield (q/ha) and net profit (Rs. 27.75 and 10,692/ha) were obtained under lentil + 'Kranti' Indian mustard at 6:1 row ratio and formed
significantly superior among all the combinations.

Tomar et al. (1996) conducted experiment to study the effect of wheat-based legum intercropping systems to nitrogen under limited moisture availability conditions. Higher values of growth and yield attributes (shoots/m, leaf area index, effective shoots, grains/spike, grain weight/m) of wheat were recorded in intercropping with legumes than those of sole crops. The highest values were noted in wheat and gram or chickpea in 2:2 ratio wheat responded to N favourably upto 90 kg/ha in terms of yield and yield attributes (effective shoots/m and grain yield/m). In legumes, sole crops recorded higher growth and yield attributes and grain yield. Legumes showed marked response upto 30 kg N/ha only. Highest total productivity in terms of wheat-equivalent yield was registered in sole chickpea (40.3 q/ha) and sole lentil (43.4 q/ha) in respective years. Among the intercropping systems wheat and chickpea in 2:2 ratio recorded the highest wheat-equivalent yield and land equivalent ratio the response to N on wheat equivalent yield was marked upto 30 kg N/ha only.

2.1.3. EFFECT ON NITROGEN UPTAKE

Sanchez (1976) reported that maize/red gram
intercropping system showed greater removal of nutrients in intercropping stands than in pure stand. Similar results were obtained in a redgram based intercropping system by Soundarajan (1978).

Chinnappan (1978) working under Coimbatore conditions concluded that application of 25% less N than the recommended level would be sufficient for castor based multitier cropping system which includes a legume component.

Selvaraj (1976) reported that sorghum intercropping with cowpea and green gram had no effect on N uptake by sorghum compared to solid stand of sorghum. Legumes, however, did not increase N uptake in sorghum. Similar results were obtained by Ravichandran and Palaniappan (1979).

Pawar and Khade (1989) reported sorghum + gram intercropping had no effect on N content in sorghum and gram grain and fodder/straw. The uptake of N by sorghum was also not affected by planting pattern. Singh and Ahuja (1990) observed that response of sorghum to N, varied with associated legume. Soil in corporation of legume significantly increased the sorghum yield and nitrogen uptake when compared to the treatments where legumes were harvested for fodder.
Rana and Singh (1992) reported that potato and mustard cropping systems recorded differential N uptake. The potato + mustard system removed significantly higher amount of N followed by sole potato and sole mustard.

Singh and Gupta (1992) observed that total N uptake in wheat was significantly affected by intercropping treatments. The highest total N was recorded by sole wheat followed by intercropping of 6:2 and 10:2 wheat + mustard. The trend of total N uptake was closely linked with the grain and straw yields of both the crops.

Tomar et al. (1997) conducted experiment at Bareat (U.P.) to study the nitrogen uptake pattern in wheat based intercropping systems as affected N fertilizer. They found that sole crop of lentil recorded highest N-uptake (94.6 and 103.0 kg/ha) over other cropping systems, closely followed by sole chickpea in 1989-90. Application of 90 kg N/ha recorded 46.3, 13.1 and 6.2% higher N-uptake than 0, 30 and 60 Kg N/ha respectively in 1989-90. The corresponding values in 1990-91 were 43.4, 12.5 and 5.3%.

2.1.4. **EFFECT ON MONETARY ADVANTAGE**:

Ayier (1949) found that wheat + linseed and wheat + gram in 75:25 ratio and gram + linseed in 50:50 ratio proved...
more profitable. Sahasrabudhe (1949) working with wheat and gram mixture at Nagpur found that the proportionate benefit in wheat was achieved by increasing the proportion of gram in mixture.

Singh (1953) recommended sowing of wheat and gram in alternate rows or in 2:1 row ratio. Dayal et al (1957) reported that the sum of yield of wheat and gram in case of mixed cropping of two crops was higher than the yield of either wheat or gram in pure cropping. Hegde (1964) reported that mixed cropping of barley and chickpea was more profitable as compared to their sole cropping under rainfed conditions. Baldy (1963), Donald (1963) and Saxena and Yadav (1975) also reported that under rainfed conditions mixed cropping was found more remunerative than pure crops.

Singh and Katyal (1966) reported that higher returns from mixtures of rabi cereals and legumes were obtained when compared with their pure stands under scarcity of soil moisture. Panwar and Singh (1973) found that inter and mixed cropping of legume and cereal (1:1 of wheat-gram mixture) in rows 22.5 cm apart brought out highest monetary return.

Itnal et al. (1980) observed higher net profit by growing gram in 3 rows alternated with one row of safflower
than growing gram, safflower, cotton or rabi sorghum in pure stands. Singh and Bajpai (1982) also found the highest net profit in gram + mustard intercropping.

Parkash et al. (1986) reported that marked reduction in wheat yield was observed when intercropped with field pea and lentil. The highest net return was recorded in wheat + pea followed by wheat + lentil on a and wheat + mustard.

Singh and Turkhode (1991) found that wheat and linseed grown in pure and inter-cropped stand (4:1, 2:1 and 1:1 row ratios) were superior to wheat in pure stand in terms of WEY, LER and net returns.

Studies conducted by Panwar et al. (1990) revealed that sugarcane + lentil intercropping fetched the highest net returns being higher over pure sugarcane, lentil, maize and maize + lentil. Singh and Yadav (1990) reported that no marked reduction in wheat yield was observed by intercropping of pulses. Highest total yield and net return were obtained in wheat + gram combination.

Raghuvanshi (1991) reported that intercropping of wheat + linseed in 4:2 row ratio gave the highest net return. Hiremath et al. (1991) tried various of row ratios of wheat and linseed (1:1, 1:2, 2:2, 3:1, 3:2) in
intercropping system and obtained the highest gross return and benefit cost ratio with 3:1 while highest LER (1.36) was obtained with 1:2 ratio.

Shah et al. (1991) observed at Shalimar that intercropping of legumes with maize appeared to be more aggressive than sole planting of maize or legumes. Maize + rajmash (2:1) recorded that highest mean monetary advantage index (7789.0). Highest benefit/cost ratio (5.09 and 4.45) was obtained with maize + soybean (4:1) during 1986 and 1987 respectively.

Patel et al. (1991) reported from Udaipur that intercropping of gram and mustard in 3:1 ratio gave highest net monetary returns (Rs 5986/ha) which was higher than sole crops and other row combinations in intercropping.

Bhatnagar et al. (1991) tested intercropping of chickpea with mustard, safflower or linseed in row ratios ranging from 1:1 to 7:1. Higher gross return and LER was obtained with chickpea intercropped with safflower, mustard and linseed in 1:1, 2:1 and 3:1 row ratios, respectively. Model et al. (1968) reported that plant height, number of tillers/plant and dry matter increased significantly with application of nitrogen under lara conditions of U.P.
Similar results were also obtained by Syme (1967), Tiwari and Singh (1969), Sharma et al. (1970), Sandhu & Gill (1971), Gill et al. (1971), Singh and Singh (1975), Agarwal and Yadav (1978), Agarwal and Moolani (1978), Patel and Khuspe (1978) and Singh and Anderson (1978).

Sachan and Uttam (1992) observed at Kanpur that the sole crops of gram and mustard gave lowest net return of Rs. 1,876/ha whereas intercropping of gram with mustard in the ratio of 2:2 gave the highest return of Rs. 3,368/ha in comparison to other ratios of intercropping (2:1 and 3:1).

Singh and Yadav (1992) observed that chickpea + mustard (4:1) gave the maximum net returns (Rs. 8,158/ha) as well as cost : benefit ratio 2.98 on the basis of two years study under Faizabad conditions.

Kushwaha (1992) reported from Kanpur (U.P.) that half mustard + half chickpea or lentil appeared most productive under irrigated conditions.

Upasani (1994) observed a highest net return of Rs. 11,538/ha under gram + rapeseed intercropping at 20 cm spacing with a row spacing of 1:1.
2.2. **EFFECT OF NITROGEN ON LINSEED**

A large number of field experiment were done to study effect of N on growth, yield and yield attributes of linseed crop. The response of crop to nutrient application differed greatly depending upon the purpose for which the crop was raised (oilseed, flax fibre or both) and whether the crop was raised as a rainfed are grown under irrigation.

2.2.1. **Plant Growth and Development:**

Parashar et al. (1968) studied effect of nitrogen fertilization on linseed growth and observed significant increase in height and branches/plant when fertilized with nitrogen. Similar increase in height and branch number was noted by El-Nekhlway et al. (1978), Reddy (1983) and Jain et al., 1989). Besides, height and branch number, nitrogen promoted growth and enhanced production of dry matter (Reddy, 1983). The fertilizer N also increased length and diameter of stem (Les, 1974).

2.2.2. **Yield Components:**

Nitrogen increased number of capsules, capsule weight/plant, number o grains/capsule, weight of seeds/plant and 1000 grain weight, the effect of doses though showed
large variations in these values in most attributes studied, the increased recorded were significant.

The number of capsules/plant, weight of capsule, number of seeds/capsule and 1000 grain weight of linseed increased as the dose of N increased. The highest increase in these components was recorded at 75 kg N/ha dose by Singh (1968). Similar improvement in these components was reported by Gad and El-Farouk (1978) and Jain et al., (1989) at a much lower dose of 15 kg N/feddan. A progressive increase with increase in nitrogen dose in number of capsules/plant was noted by Dean dybing (1964), Khan et al., (1963), Parashar et al. (1968), Singh (1974), Reddy (1983) and El-Nekhlway et al. (1978).

Besides, the capsules/plant, a marked increase was reported in seed weight/capsule by Parashar et al. (1968), in grain weight/plant by Khan et al. (1963), Reddy (1983) and of seed weight/plant and test weight by Singh (1974) and Reddy (1983). El-Nekhlway et al. (1978) studied effect of increasing doses of nitrogen on linseed test weight. The test weight increased up to the dose of 150 kg N/ha, at 75 kg N/ha dose it was 7.67 g when the dose was double to 150 kg N/ha it increased to 8.38 g. Contrary to this, Woodhead and Neilson (1976) failed to observe any change in seed weight.
at any of the rates of N they applied. The experiment was conducted at Dunedin, in New Zealand.

Choursia et al. (1992) reported from Noshangabad (M.P.) that yield components in linseed viz: number of fertile and sterile capsules/plant, capsule weight/plant, seeds/capsule seed weight/capsule and 1,000 seed weight were remarkably and significantly increased due to increasing levels of N upto 90 kg/ha. Significant increase in the yield attributing characters like capsule/plant and 1,000 grain weight increased upto 80 kg N/ha under lakhaoti (U.P.) conditions (Vashishtta, 1993).

Dutta et al. (1995) reported from Hisar that application of 80 kg N/ha increased the number of seeds/capsule, test weight and seed yield of linseed. Increasing rate of N increased the plant height, yield attributes (Samui et al., 1995).

Singh and Kumar (1996) found at Faizabad (U.P.) that plant height, number of silique/plant and 1,000 seed weight increased significantly with the increasing levels of N upto 60 kg/ha. Similar results were reported by Mohan and Sharma (1992).
2.2.3. Yield:

Nitrogen increased seed as well as stalk yield of linseed significantly (Mathur et al., 1958; Gupta et al., 1960; Dalal and Gill, 1966; Singh, 1968; Parashar et al., 1968; Kinra et al., 1970; Singh and Singh, 1978; Bhan and Singh, 1973; Les, 1974; Nayital and Singh, 1984; Pasricha et al., 1986 and Jain et al., 1989) under irrigated conditions. Similar increase in grain and stalk yield with N fertilization was noted under rainfed conditions (Panwar and Bhardwaj, 1975; Singh and Prasad, 1975 and Tomar and Singh, 1973). In addition to stalk and seed yield, the fibre production was also more when the crop was fertilized with nitrogen, increase being still higher when P and K were combined with nitrogen (Hamdi et al., 1971).

On drylands compared to irrigated soils, the yield increased at a lower dose of fertilizer application. Singh and Prasad (1975) noted high yield with only a dose of 25 kg N/ha. Khurana, Dubey and Namdeo (1989) noted high yield at 30 kg N/ha. Tomar and Singh (1973) also got similar results but at application of slightly high dose of nitrogen (35 kg N/ha). Increase in dose of N beyond this was not found advantageous in that it either increased the yield only marginally as reported by Panwar and Bhardwaj (1975) or it
depressed the yield when the dose of N was raised (Singh and Prasad, 1975). Beneficial effect of application of low dose of N (25 kg/ha) were also reported by Mathur et al. (1958). The work was done at Kangra in Punjab. The results reported thus bring out clearly that on dryland, moisture being the most important limiting factor, application of nitrogen did not bring uniform benefits at all places.

Compared to drylands, the crop responses to nitrogen at most centres were uniform when it was raised as an irrigated crop. The crop at 30 kg N gave 15.7% increase in yield over unfertilized control (Singh et al., 1974), the increase further was small when the N dose was raised to 44.0 kg/ha (Mathur and Kavitkar, 1963; Singh and Singh, 1978 and Dalal and Gill, 1966). The first two authors recorded 50% increase over the no nitrogen treatment and the last worker obtained an additional increase of 7.6 q/ha, when fertilized. Similar high yields were reported with 64.8 kg N/ha by Singh et al. (1968), with 50 kg N/ha and by Parashar et al. (1968) and with 60 kg N by Sekhawat et al. (1972) and Yadav et al., (1980). Kinra et al. (1970) reported equally good yield at Kanpur (U.P.) when 67.2 kg N/ha was given, the additional increase obtained was between 3-4.5 q/ha.

Singh (1968) applied graded doses of N (0-75 kg/ha)
to linseed crop and studied its effect on grain yield; they recorded maximum production of 85 q/ha at 75 kg N/ha. Response of higher N dressing of 88 kg/ha was reported by Yayock and Quinn (1977) at Hadajeja (Nigeria) and at 150 kg N at Alexandria (Egypt) by El-Nekhlway et al. (1978). Al-Sharma and Jabro (1972) at Baghdad (Iraq) also reported similar results.

The response of linseed to N improved substantially when the crop was irrigated (Singh and Singh, 1978; Singh and Ramakrishna, 1977; Moursi and El-Hariri, 1977; Thimmappa, 1980 and Reddy, 1983). The increase, however, differed depending upon the stage at which the crop received irrigation (Tuzal et al., 1965 and Yusuf et al., 1978).

The irrigation in presence of N also modified the pattern of water use by the crop. Singh and Singh (1978) studied effect of nitrogen on water use by rainfed crop. Nitrogen at 40 kg/ha showed best water use efficiency (WUE). They also found that the crop used more water (45-60 cm) in the first 32 days, water use decreased later as the crop advanced in age and during the last 47 days of harvest, water used was only 9-20 mm. A similar study was planned by Singh and Ramakrishna (1975). They tested 6 fertilizer doses (control; 0N + 20 P + 20 K; 20 N + 20 P + 20 K; 40 N + 20 P
20 K; 60 N + 20 P + 20 K and 80 N - 20 P - 20 K) and studied its effect on moisture use by rainfed linseed. The experiment was done at Delhi. They observed highest consumptive use (CU) of water (284 mm) in the first season and least (195 mm) in second season when the dose of fertilizer was 40N; 20P; 20K. But moisture use efficiency was best (4.36 kg/mm) with 60N; 20P; 20K dose and it declined to 2.12 kg/ha at 60N; 20P; 20K dose. They also remarked fertilized application influenced pattern of moisture extraction by linseed. The crop extracted moisture from 50 cm depth upto 90 days and between 50-75 cm depth later upto harvest (164 days). The crop used a total of 30.54 mm of water with a moisture use efficiency of 3.01 kg/ha mm. The yields increased as the levels of N and irrigation increased (Moursi and El-Marli, 1977). The grain and fibre yield were low (grain 215 kg/ha; fibre-140 kg/ha) without nitrogen, both doubled when nitrogen was combined with irrigation. The results reported by Thimmappa (1980) and Koshta and Bhattawar (1981) however, showed different trends, the crop responded to N; in first study the yield being maximum at 30 kg N/ha and in second best production was at 60 kg N/ha. The crop in both the experiments did not respond to irrigation and no interaction was noted between N and irrigation levels.
A significant increase in seed yield (868 kg/ha) was obtained with a fertilizer dressing of 60N: 40 P_{2}O_{5}: 20 K_{2}O kg/ha. The increase was 17.2% over the previous dose, which is held to that mentioned above (Reddy 1983). Besides fertilizer application, the stage of irrigation played an important role in linseed production (Tomar et al., 1985). Application of 60N + 40 P_{2}O_{5} + 20 K_{2}O gave highest yield when it was irrigated at branching, flowering, and capsule formation stage. The increase obtained over no fertilizer and no irrigation treatments were substantial. Yusuf et al. (1985) reported higher water use when the crop was irrigated at 14 day intervals. The total water used was only 166.9 mm (per control the irrigation) against 37 mm where 4 irrigations were applied at four stages (seeding, branching, flowering and grain development). The water use efficiency in this treatment was also highest (8.64 kg/ha mm).

Sahasulk (1989) reported from Rewa (M.P.) that yield and yield attributes in linseed were significantly improved with each increase in the level of nitrogen (upto 3 kg/ha) and phosphorus.

Shrestha et al. (1992) observed at Noshangabad (M.P.) that seed yield of linseed was significantly increase to 15.22 and 16.84 q/ha at 90 and 60 kg N/ha during first and
second year respectively under protective irrigations.

Vashishtha (1993) working at Lakhaoti (U.P.) found that seed yield of linseed increase significantly with an increase in N level upto 80 kg/ha. Dubey and Singh (1994) reported that application of N upto 100 kg/ha markedly improved all the yield attributes and yield compared with no nitrogen and 50 kg/ha under Lakhaoti (U.P.) conditions.

Dwivedi et al. (1994) observed at Rewa (M.P.) that linseed yield increased significantly upto 30 kg N/ha only in first year. Nitrogen application significantly increased seed yield of linseed upto 80 kg N/ha (Samui et al., 1995).

Arthanwar et al. (1996) reported from Parbhani (Maharashtra) that application of 100 and 50 kg N/ha were at par but significantly superior in seed yield/ha over no nitrogen during 1989-90. However, during 1990-91 and in pooled data, there was linear increase in seed yield/ha with increase in nitrogen level from 0-100 kg/ha. The seed and stover yields of Indian mustard increased significantly with increasing levels of N up to 90 kg N/ha. Mohan and Sharma (1992) also reported that application of N upto 75 kg/ha increased the seed yield of Indian mustard.
Thakuria and Cogoi (1996) working at Jorhat reported that nitrogen application significantly increased the seed yield and almost all yield attributes up to 80 kg N/ha in Indian Mustard.

Khare et al. (1997) reported from Sagar (M.P.) that significant improvement in branches/plant, capsules/plant and seeds/capsule owing to increasing level of N application up to 45 kg/ha resulted in significantly increased seed yield and profit of linseed.

2.3 NUTRIENT CONTENT AND ITS UPTAKE:

The studies done on nutrient contents (%) and its uptake (kg/ha) were confined to nitrogen and information on other two nutrients, P and K is almost absent for this crop.

A study made by Panwar and Bhardwaj (1976) on saline soils showed higher N, P and K in grain when the crop was fertilized. The grain from control treatment contained 2.00, 0.47 and 0.79% of N, P and K, respectively, when fertilized the corresponding values were 2.31, 0.67 and 0.98 per cent. Similar improvements in N, P and K in linseed grain was reported by Singh and Singh (1975).

The experiment was conducted at Varanasi (U.P.). In
unfertilized treatments the grain analysed 3.01, 1.26 and 1.16% N, P and K respectively, when fertilized all values increased. The N in grain was 3.40 and P and K were 1.39 and 1.25% respectively.

The fertilizer besides enhancing nutrient contents also promoted the total N uptake by the crop. At 40 kg N dose, the nitrogen removed by linseed crop was 42.2%. The dose of N application ranged between 0-60 kg N/ha (Singh and Singh, 1978). Singh and Prasad (1975) applied different doses of N (0, 20, 40, 60 and 80 kg/ha); half of the dose was given through soil at seeding and the remaining half top dressed through foliar spray before flowering. The work was done at Delhi. They estimated that at 20 kg N/ha dose the crop removed 80.7 N from soil, the uptake changed to 79.5, 76.3, 65.3 and 40.0 kg for the 4 doses- 80, 60, 40 and 0 kg N/ha applied respectively.

Vashishlta (1993) reported from Lakhaoti (U.P.) that maximum uptake of N was at 120 kg N/ha.

2.4. **SEED QUALITY:**

Like wheat, N fertilization and irrigation increased oil in seed of linseed (Pande et al., 1970 and Sekhawat et
al., 1972). Nitrogen in general, increased oil % in seed (40-45%), the increase was noted only up to the dose of 60 kg N/ha beyond this dose increase was very marginal.

Pande et al. (1970) studied effect of irrigation on oil content of linseed. The experiment was conducted at Rewa in Madhya Pradesh. Irrigating the crop at 30 days after sowing gave more oil in seed, irrigating the crop both at 30 and 55 days was not advantageous. Similarly relation between fertilizer doses and irrigations were studied by Sekhawat et al. (1972) at Kota (Rajasthan). They tried 4 irrigation levels, (no irrigation, irrigation at 30 days, 60 days; at 30 + 60 days) with 4 fertilizer doses (0-0-0; 15N + 15P₂O₅ + 0 K; 30 N + 30 P₂O₅ + 15 K₂O and 60 N + 60 P₂O₅ + 60 K₂O). The highest oil in seed was noted at 60 N 60 P₂O₅ + 60 K₂O/ha dose where only two irrigations were given at 30 and 60 days. The oil yield was also maximum in this treatment. In another experiment the crop was subjected to water stress for 18 days during different crop stages and its effect studied on oil in seed. The oil in seed was maximum (43.3%) when soil moisture maintained was sufficient throughout. The results thus did not indicate definite relationship between N and irrigation on oil contents of linseed. This view was also expressed by Mingeau and Vernede (1977). They noted
that water stress during flowering although reduced seed yield, it did not reduce oil in seed. The oil % declined to 40.8% when stress was imposed between 81-94 days age of the crop (Mingeau and Vernede, 1977). This stage coincided with grain development stage of the crop and appeared more sensitive for oil production in seed. This experiment was done at Ferr in France. In a similar study at Cairo in Egypt (Talha and Osman, 1978) the crop was raised under various water regimes and its effect studied on oil percentage of seed. Application of frequent irrigations at shorter interval produced maximum oil yield (586 kg/ha). They also remarked that soil water potential of 1.7 atm was necessary to be maintained between flowering and ripening stage of the crop. The observation made by Drewitt (1976) and Yusuf et al. (1978) were contrary in that no change in oil percentage when crop was irrigated during seedling, branching, flowering and seed development.

Choursia (1992) found that seed oil in linseed was decreased slightly whereas seed protein increased significantly with 90 kg N/ha. Vashishtha (1993) report that protein (%) increase with the application of 120 kg N and 40 kg P₂O₅/ha whereas the oil content and iodine increase up to 40 kg N and 20 kg P₂O₅/ha.
Sarui et al. (1995) found that the increase in oil yield of linseed was 61.6 and 141.8% during 1988-89 and 35.6 and 52.6% during 1989-90 at 40 and 80 kg compared with 0 kg N/ha respectively.

2.5. **EFFECT OF NITROGEN ON LENTIL**

Application of N alone at 25 and 50 kg/ha significantly increased the yields by 2.5 and 4.5 q/ha over control (27.6 q/ha) (Sharma & Chaudhary, 1971).

Verma and Kalra (1981) working at Meerut tested three levels of N (0, 20 and 40 kg/ha) and marked that the economic optimum dose of N ranged between 24-28 kg/ha and P$_2$O$_5$ between 70-78 kg/ha.

Data et al. (1985) and Sharma and Singh (1986) did not observe any beneficial effect of applied N on grain yield.

Singh (1986) obtained highest seed yield of lentil with 20 kg N and 80 kg P$_2$O$_5$/ha.

Singh et al. (1994) concluded from Pantnagar (U.P.) that 20 kg N + 40 kg P$_2$O$_5$ + 20 kg K$_2$O/ha for lentil and 90
kg P₂O₅ + 60 K₂O/ha for Indian mustard would be the optimum fertilizer level to get higher productivity and net return in Inceptisols of Western Uttar Pradesh.

Kumar and Agarwal (1993) observed at Gurukul-Narsan (U.P.) and found that 20 kg N/ha had significant effect of plant height and branches/plant. The grain yield was significantly higher with 20 kg N/ha compared with that in the control.

2.6. EFFECT OF NITROGEN ON GRAM

Simpson (1965) reported that legume may increase the supply of nitrogen in the root medium by nitrogen fixation, but it may also compete with mineral nitrogen. Black (1973) suggested that the exudation of fixed nitrogen from leguminous plants grown in field might be expected to occur in regions where weather during the growing season is cool, slightly wet and cloudy.

Chickpea like other legumes require only a starter dose of N ranging from 15 to 25 kg/ha depending upon the N status of soil (Mishra and Ram, 1971).

Chaudhary et al. (1971) at Delhi and Singh et al. (1980) at Hisar did not find any response to fertilizer
application in chickpea.

Marked increased in yields have been reported with the application of 22.5 to 30 kg N/ha (Panse and Khanna 1964; Singh and Yadav 1971, Singh et al., 1972; and Mudhalkar and Ahlawat, 1979). The higher doses of N may encourage vegetative growth adversely affecting the harvest index.

Mahapatra et al. (1973) reported that application of N alone gave low response but when applied with adequate amount of other nutrients especially P (30 to 60 gk P2O5/ha), the response to the starter dose of N was much higher over control. Singh (1971) and Maheshwari and Singh (1976) also reported significant increases in grain yields when N was applied in combination with P.

Rathi and Singh (1976) observed that N application significantly increased the yield of grain and straw/ha, plant height, pods/plant, 1000-grain weight and grain yield/plant. Application of 20 kg N/ha gave highest yield of grain and straw, whereas the lowest yields were recorded under no N plots.

Raghu and Choubey (1983) observed that yield was
significantly increased by application of 25 kg N/ha alone and in its combination with 50 kg P₂O₅/ha. Rhizobium + 25 kg N + 50 kg P₂O₅/ha gave significantly higher yield as compared to rest of the treatments.

Dobariya et al. (1985) reported that 40 kg N/ha produced significantly higher grain yield over 0 and 20 kg N/ha. Higher yield obtained with 40 kg N/ha resulted from this favourable effect on plant height and seed weight.

Kawal and Bansal (1986) and Kawal et al. (1986) reported significant grain yield response to the application of 10-20 kg N and 20-40 kg P₂O₅/ha and N, P + 20 kg K₂O/ha.

Khokhar and Warsi (1987) observed that yield increased by 22% with 18 kg N/ha as compared to control. Yield increased by 72% with application of 18 kg N, 46 kg P₂O₅, 60 kg K₂O and 25 kg ZnSO₄/ha over the control. Straw yield also followed similar trend.

Prasad and Singh (1987) observed that application of 20 kg N + 60 kg P₂P₅/ha gave significantly higher yield over no fertilizer and 10 kg N + 30 kg P₂O₅/ha.

Sarawgi and Singh (1989) observed significant
significantly increased by application of 25 kg N/ha alone and in its combination with 50 kg P₂O₅/ha. Rhizobium + 25 kg N + 50 kg P₂O₅/ha gave significantly higher yield as compared to rest of the treatments.

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Sarawgi and Singh (1989) observed significant
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**N Levels (Kg/ha)**

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**SEM** = Not significant.

**DAS** = Days After Sowing.