Chapter-II

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The present investigation entitled "Effect of irrigation and nitrogen levels on the growth and yield and quality of linseed under the Bundelkhand Region in U.P." was conducted during Rabi season of 2003-04 and 2004-05. In India a number of oilseed crops are grown throughout the year. Research on oilseed crops in the country dates back to the early period of the establishment of Indian (Imperial) Agricultural Research Institute, Pusa (Bihar). Systematic research for improvement of oilseeds was initiated by the All India Coordinated Research Project on Oilseeds in 1967 and was further strengthened with the establishment of Directorate of Oilseed Research in 1977 at Hyderabad. Linseed (Linum usitatissimum L.) is one of the oldest plants brought under cultivation. Amongst the agronomic management, nutrient supply (particularly nitrogen) and scheduling of irrigation specially for crop under Bundelkhand Region conditions become increasingly important. Therefore, agronomic research work done on linseed alone is briefly described here under the following heads.

A. **Response to Moisture Regimes :-**

Water is essential for plant growth, and it is needed too much larger quantities than the plant nutrients. Water deficits can, however, reduce yields seriously if they occur to certain critical periods during the growth of the crop. Soil moisture greatly influences the growth, development and consequently the yield of
the crop through availability of water in soil. There had been some experimental evidences, linseed respondents to supplemental irrigation to produce higher biomass per unit area due to large foliage and high transpiration rate.

**Growth Characters:**

a. **Plant height** :-

*Pande et al. (1970)* studied the effect of different levels of irrigation on linseed and observed significant increase in plant height with increasing levels of irrigation. Nordestgaard (1971) noticed that the drought during stem elongation benefited seed-yield and adversely affected straw-yield. Hassan and Rahman (1987) reported that irrigation once with 6 cm. water 20-25 days after sowing gave higher plant height. Raghuvanshi et al. (1987) found that IW/CPE ratio of 1.2 resulted in the maximum plant height. Jain and Agrawal (1998) reported that irrigation twice (0.8 IW/CPE ratio) significantly increased plant height. Vyas (1997) reported that growth parameters increased as the number of irrigation increased.

*Clark and Simpson (1978)* observed that number of primary and secondary branches plant⁻¹ were rarely affected by irrigation schedule. Khan and Agrawal (1985) reported that IW/CPE of 0.4 enhanced number of branches and all the growth characters. Tomar et al. (1985) reported that the crop irrigated at branching stage alone or in combination with flowering or capsule formation stage produced significantly more number of branches per plant. Raghuvanshi et al. (1987) evaluated irrigation requirement on a sodic clay soil and found that IW/CPE ratio of
1.2 resulted in the maximum number of branches. Tomar and Shrivastava (1987) found that harvest index was highest in crop irrigated at branching stage. Jain and Agrawal (1998) reported that irrigation twice significantly increased no. of branches plant⁻¹. Larsen (1960) found that moisture content of soil influenced the dry matter production, growth and net assimilation rate in flax. Khan et al. (1985) found that IW/CPE ratio of 0.6 increased the dry matter accumulation. Ehasanullah (1986) concluded that maximum dry matter per plant was obtained when irrigation was scheduled at 0.6 IW/CPE ratio. Raghuwanshi et al. (1987) reported that 6-7 irrigations each of 5 cm. based on IW/CPE ratio of 1.2 resulted in the maximum dry matter yield.

Tiver (1942) concluded that for better seed production, an adequate soil moisture must be available during and after flowering but it is not so important during the period of vegetative growth. Richharia (1950) recorded that the seedling stage and the stage just before flowering are critical for water application. Larsen (1962) suggested that linseed requires an adequate water supply pre and after flowering. Pathak et al. (1963) reported that one irrigation was required at the flowering stage on alluvial (loam) soil at Kanpur whenever the winter rainfall was negligible. Prashar and Sachan (1967) reported that one irrigation at flowering or fruiting was required for getting higher yield of linseed. Nordestgaard (1971) also noticed that drought during and after flowering reduced the yields of both seed and straw. Bhan (1975) recorded response upto two irrigations given at pre-flowering and pod filling stages (60 and 105 days after sowing) of the crop.
Yield attributes:

Raghuwanshi et al. (1987) noted that highest number of capsules plant\(^{-1}\) was observed at IW/CPE ratio of 1.2. Tomar and Shrivastava (1987) also reported that harvest index was lowest when irrigated at the capsule formation stage. Ghatak et al. (1990) observed that yield showed a positive correlation with effective capsules plant\(^{-1}\) with 1, 2 or 3 irrigations. Thosar et al. (1990) found that number of capsules per plant were highest with three irrigations. Jain and Agrawal (1998) reported that irrigation twice (0.8 IW/CPE ratio) significantly increased number of capsules plant\(^{-1}\). Rana et al. (2000) reported that linseed cv. Subhra produced highest number of capsules per plant with irrigation at 0.25 IW/CPE ratio. Vyas (1997) reported that yield attributes improved at the number of irrigation increased. Singh et al. (1997) reported that the yield components were highest with 4 irrigations i.e., 0.8 IW/CPE ratio in linseed cv. Garima.

Work carried out in South Dakota (America) by Sanders, as quoted by Rolf manner (1956), indicated that 20 and 30 percent soil moisture gave 3.27 and 7.47 seeds per capsule, respectively. Tomar et al. (1985) found that the crop irrigated at branching stage alone or in combination with flowering or capsule formation stage produced significantly more number of grains per capsule. Ghatak et al. (1990) reported that 1-3 irrigations showed positive effect on number of seeds per capsules. Thosar et al. (1990) found that 3 irrigations applied before sowing, at flowering and/or seed filling stages gave highest number of seeds per capsule.
Singh (1984) observed significant increase in 1000 seed weight and seed yield per plant due to irrigation. Ghatak et al. (1990) concluded that 1000 seed weight increased in linseed crop upto 3 irrigations. Thosar et al. (1990) reported that 1000 seed weight was highest with three irrigations. Rana et al. (2000) reported that linseed cv. Subhra produced highest 1000 seed weight with irrigation as 0.25 IW/CPE ratio.

Yields :-

Pande et al. (1970) reported that increasing levels of irrigations significantly increased the seed and straw yield. Nordestgaard (1971) noticed that drought during and after flowering reduced yields of both seed and straw, Prasad and Sharma (1975) recorded a favourable influence of two irrigations on the yield and yield attributes of linseed. One and two irrigations registered an increase in grain yield of 19.67 and 42.20 percent, respectively, over no irrigation. Mahapatra and Singh (1976) reported that 1-4 irrigations on light sandy loam soils at Delhi, 1-2 irrigations on black soils at Jabalpur and one irrigation in tarai region of Uttar Pradesh gave high seed yields. Yusuf et al. (1978) reported that 4 irrigations at the seedling, branching, flowering and seed maturation stages gave the highest average seed yields of 2.59 t ha$^{-1}$, followed by 2.26 t with 3 irrigations and 1.26 t ha$^{-1}$ under rainfed conditions. Tomar et al. (1985) reported that crop irrigated at branching stage alone or in combination with flowering or capsule formation stage produced significantly highest grain yield. Mahajan et al. (1986) found that seed yields of
linseed with one irrigation at the flowering stage or two irrigations at flowering and seed development stage were similar.

Tiwari et al. (1988) reported that irrigation with 7.5 cm water/irrigation at IW/CPE ratio of 0.4, 0.6 and 0.8 gave yields of 0.82, 1.11 and 1.24 t ha\(^{-1}\) respectively, compared with 0.86 t without irrigation.

Ghatak et al. (1990) reported that yields with 1, 2 or 3 irrigations were 407, 452 and 499 kg ha\(^{-1}\), respectively. Thosar et al. (1990) reported that average seed yields of linseed increased with increase in the levels of irrigation from 1-3.

Rana et al. (2000) reported that linseed cultivar Subhra produced high yield with irrigation at 0.25 IW/CPE ratio. Singh et al. (2000) reported that seed yield increased with increasing N rate.

Vyas (1997) reported that seed yield increased with increasing irrigation. Singh and Verma (1997) reported that mean seed yield of linseed cv. Garima was highest (0.87 t ha\(^{-1}\)) with 2 irrigation i.e. 1\(^{st}\) at branching 2\(^{nd}\) at capsule initiation.

**Uptake of Nutrients :-**

**Uptake of nitrogen, phosphorus and potash :-**

Kramer (1969) suggested that adequate moisture supply is associated with the higher uptake of nutrients by plant. From a study of six linseed cultivars, Dai and Zhang (1981) found that there were two peaks of N uptake, the first between 35-45 days and the second between 52-62 days after emergence. Evans et al. (1987), however, showed that dryland linseed ceased to take up nitrogen earlier than wheat. Vivek (1989) observed significantly
higher nitrogen uptake in seed with 0.9 IW/CPE than lower levels of irrigation (0.6, 0.3 IW/CPE ratio and unirrigated control).

Concentrations of N, P and K are highest in the young linseed plant and decrease in all vegetative organs as the plant ages, particularly during flower and capsule development (Dastur and Bhatt, 1965). Contrary to this, Tripathi (1979) observed continuous increase in phosphorus content up to maturity under optimum soil moisture conditions, while under lower levels of irrigations (inadequate soil moisture conditions), it practically ceased 85 days after sowing. Tripathi and Sawhney (1989) observed higher uptake of potassium under irrigation applied at 50 mm cumulative pan evaporation which was almost twice that of 125 mm CPE.

**Seed Quality :-**

**Oil and protein content :-**

Pixton and Warburton (1971) found that before drying, seed sample of oil seed flax contained an average of 40.9 per cent oil and the oil content did not vary with moisture content. Yusuf et al. (1978) found that seed oil contents were not affected by either the stage of the crop at which irrigation was given or the frequency of irrigation. Talha and Osman (1978) reported highest oil and protein content in linseed when the soil water potential was maintained at 1.7 atm by irrigation or when 360 m³ acre⁻¹ irrigation water was applied at 18 days interval. They revealed that soil water stress during the later stages of plant growth was more detrimental to seed and oil yield than early stages. Talha and Osman also reported that as the irrigation amount or frequency
increased the contents of oil, linoleic and linolenic acids decreased. Vyas (1997) reported that as the number of irrigation increases the oil content remain unaffected.

**Soil Moisture Studies :-**

a. **Moisture Depletion Pattern :-**

_Hamdi et al. (1972)_ found that the uptake of water by flax during the growing season reached 3, 753, 3, 390, 3, 097 and 2, 596 m³ ha⁻¹ for soil moisture contents of 14.2, 11.0, 9.0 8.0 and 7.5 percent respectively. Jaggi _et al._ (1977) reported that upper layer always contributed more water than that of deeper layers. Acharya _et al._ (1979) stated that about 78 percent of total water extracted by roots came from 0-15 cm top layers. The magnitude of moisture use by the crop irrespective of treatments decreased with the increase in depth of soil.

b. **Consumptive use (cm).:-**

_Prashar and Sachan (1967)_ reported that the consumptive use was 9.35 – 14.86 cm, depending on irrigation treatments. The rate of water use was highest at flowering and grain development stages. Experiments conducted at Kanpur showed increase in seasonal consumptive use in several crops with increase in soil moisture (Anonymous, 1973). Singh and Singh (1978) reported that the total water use by the crop was associated with the availability of moisture in the root zone. Rainfall during the crop growth period increased the total moisture use. Yusuf _et al._ (1978) observed that the consumptive water use increased with increase in the irrigation frequencies.
c. **Water use efficiency:**

Singh and Singh (1978) found that application of 40 kg nitrogen ha\(^{-1}\) enhanced the moisture use efficiency. Yusuf *et al.* (1978) reported that the water use efficiency was the highest with one irrigation and decreased with increase in the irrigation frequency. Tomar and Singh (1989) reported that the moisture use efficiency decreased with increase in the number of irrigations and was highest with two irrigations at branching and flowering. Rana *et al.* (2000) reported that water use efficiency was greater with irrigation at 0.25 IW/CPE ratio.

**B. Response to levels of nitrogen:**

Nitrogen is an important constituent of proteins, enzymes and chlorophyll and is involved in all process associated with protoplasm, enzymatic reaction and photosynthesis (Tisadale and Nelson, 1975; Gauch, 1972). Optimum crop yield is obtained only when a set of favourable factors operate jointly. The yield of a crop in a particular locality is influenced amongst other by vigour of plant growth which in turn is determined by the supply of properly balanced nutrition. The problem of correct nutrition of crop plants is highly complicated. Each of the major fertilizer nutrients, viz. nitrogen, phosphorus and potassium have specific influence on growth and development of crops and thus on the ultimate yield. Nitrogen is found to control upto certain extent, the efficiency of phosphorus and potassium taken by the plants.

No doubt, therefore, if nitrogen in soil is recognized as the largest single factor causing variation in the crop yields.
Growth characters:

Howard and Khan (1924) reported that nitrogen levels caused significant differences in plant height. Khandkara (1951) observed that 20 lb N acre⁻¹ increased the plant height of all the varieties of linseed significantly. Singh (1962) reported that plant height was influenced significantly by the application of nitrogen.

Many workers reported that increasing levels of nitrogen above 30 kg ha⁻¹ significantly increased the plant height (Canev, 1962; Saxena and Sinha, 1966; Kondratowicz, 1970). Dybing (1964) concluded that the vegetative growth was responsive to increased levels of N in nutrient culture. Russel (1973) pointed out that nitrogen increase the plant height. This attributed to the fact that nitrogen is a constituent of protoplasm and stimulates cell division and cell elongation. Singh (1980) reported that path coefficient analysis showed that plant height had a negative direct effect on yield under sodic soil condition.

Tomar et al. (1985) found that 0 to 75 kg N ha⁻¹ showed positive effect on plant height. Khurana et al. (1988) observed linear increase in plant height with increase in dose of nitrogen upto 45 kg ha⁻¹. Jain et al. (1989) found that plant height responded to nitrogen significantly upto 50 kg N ha⁻¹. Park et al. (1989) reported that application of 80 kg N ha⁻¹ gave longest stems in all the three cultivars viz. Wiera, Stoment - Goss and Jai jungsun. Kanpур (1990) found that increasing levels of nitrogen upto 120 kg ha⁻¹ significantly increased the plant height.
Venkatachari (1955) stated that basal branches were influenced by the application of 40 lb of nitrogen. Tiwari (1956) concluded that the application of nitrogen increased the number of basal branches. Singh (1962) reported that there was no significant difference in the basal branches of the plant. Prashar et al. (1968) reported that application of 50 kg N ha$^{-1}$ increased the number of basal branches in linseed crop. Sitaram (1982) observed that primary and secondary branches plant$^{-1}$ increased with the successive increasing levels of nitrogen from 0 to 50 kg N ha$^{-1}$. Rafey et al. (1988) found that application of 40 kg N ha$^{-1}$ increased the number of primary branches per plant. Jain et al. (1989) found that number of primary and secondary branches plant$^{-1}$ increased significantly upto 50 kg N ha$^{-1}$.

Dastur and Bhatt (1965) observed at Indore that the dry matter production of variety “Mahoba” increased under varying levels of fertilizer application over control. Schchibraev and Tyrin (1970) reported that N and NP combination increased the photosynthesis and thereby crop productivity. Scarisbrick et al. (1980) observed that N rate did not affect the plant dry weight. Sitaram (1982) found that dry matter increased by 52.8 percent under 60 kg N ha$^{-1}$ over control. Ivanov et al. (1985) observed in laboratory experiments that highest dry matter yield in linseed recorded with 80 kg N ha$^{-1}$. Sanchez and Fiores (1999) reported that N increased seed dry matter as a proportion of total dry matter.

Gupta (1955) concluded that the duration of flowering and maturity was prolonged by the application of nitrogen. Singh
(1980) reported that days to 50 percent flowering had the maximum direct effect on seed yield while plant height had a negative direct effect on yield under sodic soil conditions, but influenced the yield via days to 50 percent flowering. **Yield attributes:**

Venatachari (1955) also reported that the application of 40 lb of nitrogen increased the number of capsules significantly. Khan et al. (1963) reported that the number of capsules per plant increased significantly by the application of 30 and 60 kg N ha⁻¹. Singh et al. (1974) reported that nitrogen at 30 kg/ha gave significantly more capsule and yield/plant. Mukherjee et al. (1987) found that increasing rates of N from 0 – 120 kg/ha increased the number of capsules/plant. Awasthi et al. (1989) noted that increasing N rates from 0- 45 kg /ha increased the number of capsules/plant. Jain et al. (1989) found that number of capsules/plant increased significantly upto 60 kg N ha⁻¹. Singh and Verma (1999) reported that linseed cv. Sweta gave the highest yield attributes with 75 kg N ha⁻¹ as compared to lower and higher levels. Singh et al. (1997) reported that yield components were highest with 75 kg N ha⁻¹ in linseed cv. Garima as compared to lower rates.

Gupta (1955) concluded that number of seeds/capsule did not show any appreciable variation under different manurial treatments. Many workers reported that there was increase in number of seeds/capsule with the increasing levels of nitrogen (Rolfmanner, 1956, Sinha and Saxena, 1965). Sitaram (1982) observed that number of seeds capsules⁻¹ increased with the
increasing levels of nitrogen 0 to 60 kg ha\(^{-1}\). Similar findings was reported by Jain et al. (1989). Khurana et al. (1989) also reported that increasing levels of nitrogen increased significantly the number of seeds/capsule.

Baporikar (1952) reported from IARI that 1000 seed weight was not significantly affected by the application of nitrogen. Remussi et al. (1967) found that 1000 seed weight was influenced mainly by variety. Woodhead and Neilson (1976) observed that N or K alone increased the 1000 seed weights but in the presence of both nutrient it did not increase. Tomar et al. (1985) found that test weight could not increase with N application beyond 60 kg N ha\(^{-1}\). Yadav et al. (1990) reported that increasing rates of N from 0 to 90 kg ha\(^{-1}\) increased 1000 seed weight.

Yields :-

Pande et al. (1970) concluded that seed and straw yields/ha increased with the increasing levels of nitrogen. Singh et al. (1974) reported that application of 30 Kg N ha\(^{-1}\) increased seed yield by 15.7 percent. Yayock and Quinn (1977) observed that seed yields increased linearly with increase in N rate upto 55 kg N ha\(^{-1}\) and 88 kg N ha\(^{-1}\) in two subsequent years. Thosar (1986) reported that seed yields were increased by increasing N rates form 0 to 30 and 60 kg ha\(^{-1}\). Sharma and Roy (1987) fond that seed yields increased with the application of 67.5 kg N ha\(^{-1}\) as compared to 45 kg N ha\(^{-1}\) and control. Rawal and Yadav (1988) noted that increasing rates of nitrogen from 0 to 60 kg/ha increased seed yields. Ghatak et al. (1990) reported that seed yields of linseed increased with increasing rates of N from 0 to 80 kg/ha. Singh and
Verma (1999) reported that linseed cv. Sweta gave the highest yield with 75 kg N ha\(^{-1}\) as compared to lower and higher levels. Sanchez and Flores (1999) reported that nitrogen increased and seed yield with no significant differences among N rates. Sarode et al. (1998) reported that seed and straw yield increased with up to 60 Kg N 30 Kg P\(_2\)O\(_5\) ha\(^{-1}\). Singh and Verma (1997) reported that mean seed yield of linseed cv. Garima was highest (1.12 t ha\(^{-1}\)) with kg NPK as compared with lower rates.

**Uptake of nitrogen, phosphorus and potash:**

Clagett et al. (1952) concluded that linseed removed less, N, P and K per hectare than grain of wheat, oats or barley. Saxena and Sinha (1966) observed that seeds had the highest N content (20.7%) when supplied with nutrient solutions containing 33 ppm N and 12.4 ppm P at pH 5, and values decreased with increase in pH. Kolomnikova (1979) reported that the nutrients uptake/100 kg seed + associated straw were 5.1 - 6.3 kg N 1-2.2 kg P\(_2\)O\(_5\) and 4.1 - 5.5 kg K\(_2\)O. Rao (1973) indicated that the maximum rate of nitrogen uptake was in between flowering and grain fillings stages. The total nitrogen accumulation at grain filling stage at 0, 30, 60 90 and 120 kg N ha\(^{-1}\) rates were 67.8, 65.5, 72.3, 91.4 and 111.1 kg ha\(^{-1}\), respectively. Tesu et al. (1979) found that in the stems and leaves of flax P\(_2\)O\(_5\) content increased while N contents decreased with increase in salinity. Nayital and Singh (1984) reported that N, P and K uptake was highest in crop sown at the seed rate of 20 kg/ha on the seed bed and applied 90 kg N ha\(^{-1}\) as compared to the crops sown at 35 or 50 kg/ha. Bailey and Soper (1985) reported that although a high yielding linseed crop may
contain up to 150 kg K ha\(^{-1}\) in its mature shoot, the proportion of the K present in the seed at harvest can be as low as 5 percent. Ivanov et al. (1985) reported that increasing N rates increased the uptake of fertilizer N and the proportion of fertilizer K in the total potash uptake. Harbison et al. (1986) assessed that linseed crop which yielded 2.0 tonnes grain ha\(^{-1}\) removed 56 kg N ha\(^{-1}\) and they also reported a much lower N concentration (1.75%) for linseed grain in Australia. Sarode et al. (1998) reported that uptake of NPK followed similar pattern, while uptake of Ca and Mn increased up to the highest P rate, uptake of Zn & Fe was increased by N application but decreased by the highest P rate.

**Seed quality:**

**Oil and protein content:**

Gupta et al. (1961) reported that the oil content decreased with increasing doses of nitrogen. Khan et al. (1963) observed that no treatment influenced the oil content or iodine value, whereas Singh (1964) found that the application of 40 lb nitrogen increased the oil percentage of linseed. Singh (1968) reported that the seed oil content was highest (44.1%) with 25 kg N ha\(^{-1}\). Singh et al. (1968) observed that nitrogen decreased seed oil content and had a little effect on iodine value. Mehrotra et al. (1972) reported that there was an inverse relationship between seed oil and seed protein contents. Woodhead and Neilson (1976) found that N decreased the oil content of the seed. Gad and El-Farouk (1978) found that increasing N supply up to 45 kg ha\(^{-1}\) increased linseed oil concentration. Peter et al. (1987) reviewed that oil content in seed usually decreases significantly with increasing
N supply especially at application rates above 50 kg N ha\(^{-1}\). Rafey
*et al.* (1988) found that the oil content in seed was maximum
(40.3\%) with no nitrogen application. After that a decreasing trend
was noticed with increasing doses of nitrogen upto 80 kg N ha\(^{-1}\). These findings are in conformity with the findings of Singh and
Singh (1978). Anonymous (1953) and Singh *et al.* (1968) reported
that the protein content increased, though not significantly with
the increasing levels of nitrogen. Similar findings were reported by
Singh *et al.* (1973). El-Nekhlawy *et al.* (1978) and Singh and Singh
(1978) also reported that increasing nitrogen levels increased
protein content of seed. Noyital and Singh (1984) observed that by
increasing N rates from 0 to 60 and 90 kg ha\(^{-1}\) gave average seed
yields of 476 and 896 kg ha\(^{-1}\) and seed protein content of 20.3 and
20.8 percent respectively. Singh *et al.* (1997) reported that the
maximum oil content was recorded with 90 Kg N with 4
irrigations.

**Water use efficiency:**

*Rana et al.* (2000) reported from a field trial in rabi
1992-93 conducted in New Delhi India. That linseed cv. Shubhra
provides greater water use efficiency with 50 kg N ha\(^{-1}\) and split
application of nitrogen. Singh *et al.* (2000) reported that total water
use and water use efficiency increased with increasing N rate.
Vyas (1997) reported that water use efficiency increased as the
levels of nitrogen increases.
Economics :-

Singh and Verma (1999) reported that linseed cv Sweta gave the highest yield. Yield components value net return & benefit cost ratio with 90 kg N ha\(^{-1}\) as compared to lower and higher levels.

C. **Response of moisture regimes and nitrogen levels (IxN)**-

Vyas (1997) reported that growth parameters and yield attributes improved as the number of irrigations and levels of nitrogen increased, ultimately to increase biomass and seed yield. Oil content remain unaffected. However, the water use efficiency increased as the levels of nitrogen increased.

Singh and Verma (1997) conducted experiment during the winter season of 1991-93 in Uttar Pradesh. Linseed cv. Garima was irrigated at branching and/or at capsule initiation and given no NPK or 30 : 15 : 10, 60 : 30 : 20 or 90 : 45 : 30 kg NPK ha\(^{-1}\). They observed that mean seed yield was highest with two irrigations (0.87 t ha\(^{-1}\)) and with the highest NPK rate (1.12 t ha\(^{-1}\)).

Jain and Agrawal (1998) They reported from trials conducted during Rabi 1986-87 and 1987-88 at Jabalpur that irrigation twice (0.8 IW/CPE ratio) significantly increased plant height, branch number, capsule number per plant, seed number per capsule, test weight, crop biomass and seed number per capsule, test weight, crop biomass and seed yield of linseed as compared to irrigation once (0.4 IW/CPE) and no irrigation. Higher fertilizer input also significantly increased all plant growth parameters in comparison with the lower fertilizer rate. The highest net profit of Rs. 10432 ha\(^{-1}\) was obtained with irrigation
twice at the higher fertilizer input also significantly increased all plant growth parameters in comparison with the lower fertilizer rate. The highest net profit of Rs. 10432 ha\(^{-1}\) was obtained with irrigation twice at the higher fertilization rate and hand weeding twice.

Agrawal et al. (1997) conducted a field trial at Jabalpur, Madhya Pradesh in winter 1989-90, 3 linseed cultivars the grown without irrigation or irrigated at 30 or 30 + 60 days after sowing and were given no fertilizer, 30 kg N + 15 Kg P\(_2\)O\(_5\) + 10 kg K\(_2\)O or double these NPK rates. They observed that yield, net returns and energy output were highest with 2 irrigations and the higher NPK rates.

Singh et al. (1997) observed that linseed cv Garima was given 0-90 kg N ha\(^{-1}\) and irrigated at irrigation water : cumulative par evaporation ratio of 0.4, 0.6 or 0.8 (2, 3 and 4 irrigations, respectively). Yield components and oil contents were highest with 90 kg N and 4 irrigations.