REVIEW OF LITERATURE
Edible oils constitute a very important and essential part of human diet. The distribution of fat calories in India is 20 % against 30.6 % in U.K. and U.S.A. Calorie deficit in India is due to insufficiency of oils and fats, their non-availability to vulnerable groups of population and high costs. The per capita per annum availability of oilseeds in the developed countries is over 40 Kgs, while in India it is less than 7.3 Kgs, an average which is much less than that of even Pakistan with 16.8 Kgs (Symposium on oilseed production, 1984). Therefore, there is an urgent need to increase oilseed production by the turn of the century when the requirement will be double than that of present production. At present we have little more than 19 m hectares under oilseeds cultivation and the average yield is about 650 kg/ha. Of the different oilseeds being cultivated in India, 50 % comes from groundnut, rapeseed accounts for 25 %, sesame 16 %, safflower 5 % and niger 4 %. More than 90 % of the oilseed area is under rainfed conditions or on marginal lands (Symposium on oilseed production, 1984). So our effort should be to turn towards the increased production of those oilseeds which are known to grow in less irrigated soils as well as tolerant to different weather conditions as prevailing in different parts of our
country. It is highly essential to search and study thoroughly such alternative sources of edible oils to become self-sufficient.

Niger is known to be one of such oilseed crops. Besides being used for edible purposes, it is also used for industrial purposes in the preparation of paints and soaps. Low grade niger seed oil is at present being used as an adulterant for sesame and mustard oil.

*Guizotia abyssinica* (L.F) Cass. is an annual herbaceous oil seed plant which belongs to family Asteraceae. It is widely cultivated in Ethiopia, Rhodesia and India. In Ethiopia 'noug' as it is known as provides 50 to 60% of edible oil (Riley & Belayneh, 1989) while in India niger commonly called "Karala", "Khurasani" or "Kala Til" accounts for only 4% of the total oil seeds produced (Symposium on oil seeds production, 1984).

It is cultivated in an area of over six lakh ha. with an annual production of 1.75 lakh tons (Basappa & Singh, 1990). At present the average yield is 236 kg/ha, but the crop has yield potential of 300-350 kg/ha. in dry conditions in our country. It is generally being grown under marginal and submarginal dry lands. The major states producing niger in India are Orissa, Madhya Pradesh, Maharashtra, Bihar and Karnataka with Orissa overtaking...
Madhya Pradesh as the chief niger producing state (Achaya, 1986). It is contributing 36% of the national production (Anon, 1987). The principal niger growing districts are Koraput, Phulbani, Keonjhar and Mayurbhanj which together account for 93% of the area and production (Anon, 1985-86).

In India and Ethiopia farmers recognise that niger has the ability to produce a crop on water logged or infertile soils and is a good precursor for crops following niger. The tolerance of this crop to high salinity, high boron and low soil oxygen levels have been documented by Abbe et al. (1978). Niger is invariably grown in the wet or monsoon season and except for experimental trials it is not irrigated. There are indications of increased tolerance to salinity in some varieties of niger as observed by Kachapur and Badanur (1977). Niger is also considered to be more susceptible to calcium chloride than sodium chloride (Weiss, 1983).

In Ethiopia, the crop is grown in the mid altitude and high land areas (1500-2500 m), generally planted in July and harvested in December or January taking almost 150-180 days to mature whereas in India it is generally planted on light gravelly shallow soils (common to hills) but the productivity of niger in northern hill region of Chattisgarh is below 166 kg/ha., the state
average being 181 kg/ha. (Directorate of Agriculture, Bhopal, 1982). According to Singh et al. (1987) it could be due to nonavailability of good quality seeds of improved varieties and poor agronomical practices. The crop is generally planted after the rainy season is well advanced and it takes 75-150 days to mature depending on elevation and sowing date.

Niger is normally grown alone but it can be interplanted with teff (Eragrostis tef) in northern Ethiopia and finger millets (Eleusine ceracoma) in India (Condussia, 1941, Chavan, 1961). Now it is grown as a mixed crop with various pulses and grain crops including millets in different states. Crop rotation is recommended for different states, in Orissa millet (Panicum millare or P. milliaceum) is alternated with niger and mixed cropping of niger with Ragi, Castor, Groundnut or Mungbean is done, whereas in Karnataka it is niger with Sunflower, Groundnut, Gram or Ragi (Oilsseeds News 1988) and in the black soils of Maharashtra and Karnataka, intercropping with Sorghum (Sorghum bicolor) and Cotton (Gossypium hirsutum) is common (Chavan, 1961). Roy's (1989) investigations on delayed sowing of niger to accommodate safely a monsoon crop or replacing it by sunflower on sandy clay loamy soil revealed that maize-niger could be a profitable crop adjustment which gives maximum total grain yield (32-93 q/ha.) and maximum profits. This crop can also be
accomodated in 145-175 days duration and hence have the high potentiality of escaping adverse climatic conditions.

About 200-400 kg/ha is the common yield in India and at this level niger cannot compete with other oil crops whereas Patil (1979) gave the figure of 500-600 kg/ha. Selected strains give a yield of 1 ton/ha without any additional inputs (Weiss, 1983). When intercropped, niger yielded mostly 406 kg/ha when the other component was sunflower and least 100 kg/ha when intercropped with Sorghum (Kachapur et al. 1977). So for better yield and returns, Indian Council of Agricultural Research (ICAR) at 34th annual monsoon oilseed workshop recommended the intercropping of niger as Niger + Soyabean (3:3 or 2:2) and Niger + Groundnut (3:3) alongwith the application of 15-30 kg/ha. of nitrogen in the field.

There is evidence that niger originated in highlands of Ethiopia (Baagoe, 1974). Harlen (1975) considers niger to be among the earliest of the domesticated crops in Ethiopia along with teff, finger millet and coffee (Coffee arabica). From Ethiopia it is believed to have migrated into East African Highlands and during second millenium B.C. moved across to India with other crops such as finger millets.
SYSTEMATICS

The genus *Guizotia* was named in 1829 by Cassini after a French historian Guizot and has been studied and taxonomically included in Compositae family, the tribe Helianthoides and sub tribe verbisininae by Baagoe (1974). Turner and Powell (1962) did the systematic review of *Guizotia* and found it to be quite similar to *Jaumea* especially in style, branches, achenes and habit and suggested that *Guizotia* borders upon verbisininae, that it might be positioned with members of the Jauminae instead of the usual members of sub tribe Coreopsidinae.

Boulter et al (1972) considering cytochrome-C data suggested that it is phyletically quite removed from the tribe Heliantheae. Turner (1975) considered Coreapsideae to be comprised of two sub tribes Jauminae and Coreopsidinae and the tribe itself between the tribes Heliantheae, Tageteae and Senacioneae. In chemotoxonamical survey, Baagoe (1974) reported the presence of thio-ether (-SCH3) in *Guizotia*.

*Guizotia* is a small genus of six species. All the species are native to tropical Africa and five are found in Ethiopia. *G. abyssinica* is almost certainly derived from *G. scabra* most likely from subspecies Schimperi. This has been confirmed by Karyo-morphological investigations (Hiramath, 1985).
CYTOLOGY

Guizotia abyssinica has 2n=30 chromosomes, during meiosis, 15 bivalents are generally seen with occasional trivalent or tetravalent association (Chavan, 1961).

Cultivated niger has been reported to hybridize easily with G. scabra subsp. schimperi and sets viable seeds but rarely with other wild species (Hiramath, 1985). In Ethiopia, Condussia (1941) reported a spontaneous hybrid between G. abyssinica and G. scabra subsp. scabra but was not able to find another such hybrid. All the crosses between G. abyssinica and G. scabra subsp. schimperi failed to set seed although crosses between lines of G. abyssinica were easily made at Holotte Research Station (unpublished report).

POLLINATION

Shrivastava and Shamwanshi (1974) suggested that flowers from two parent plants be rubbed together, however rubbing the flowers may result in some selfing. Thus it may be preferable to make specific crosses by removing all disc florets just as the bud begins to open, but leaving the female florets intact. By bagging the emasculated head and pollinating the ray florets the next morning, when the stigma arms have opened, several crossed seeds
per head can be obtained. The physical structure of the niger flower forces cross pollination, but this appears to be reinforced by sporophytic self-incompatibility system. Little or no seed set was obtained under bagging with muslin bags, even when the bagged heads of the same plant are rubbed together. When the pollen from the same plant is applied to the stigmas of one to three day old buds seedset is increased than that found in bagged head, but if the buds are over four days old, no seed is set on selfing (Naik and Panda, 1968; Ramchandran and Menon, 1979).

Maintenance of pure lines is a problem because of the self-incompatibility of the crop. The niger gene pool in Ethiopia and India have been separated for several thousand years and have become adapted to rather different conditions. Ethiopian niger has a large growing period (Prinz, 1976) and is more sensitive to temperature and photoperiod than is Indian niger. A preliminary evaluation of Indian niger at Holette Research station, Ethiopia (Unpublished) indicated that some Ethiopian niger lines have very high weight per 1000 seed, but yields of all Indian niger lines were rather low in comparison with Ethiopian niger.
VARIETIES

Seegler (1983) and Chavan (1961) were unable to distinguish distinct forms and land races of niger but in 1982 survey, three distinct types were reported to be under cultivation in Gujjam region of Ethiopia (G. Alemaw, 1982, personal communication). The predominant and main season type "Abot noug" is grown during the rainy season from June to December while "Mesno noug" is planted late, about September and harvested in January. "Mesno noug" is sown where water logging of soil is severe. A third fast maturing type known as "Bunenge noug" is used in lowlands where rainfall is more limited, it is planted in July and harvested in October. In Ethiopia, the plant improvement of niger started only 10-15 years ago. At present one variety "Sandafa" is recommended for central high land area whereas in India, selection of improved varieties has been taken up for many years. Chavan (1961) listed eleven improved varieties which are recommended for cultivation in different regions of the country. Niger improvement programme is carried out at seven centres in India.

The recommended varieties (Oilseed News, 1989) are:

1. Ootacamund-5 (Ooty-5) with 42 % oil and recommended for growing in Madhya Pradesh, Orissa, Maharashtra and Karnataka.
2. N-5 with 40 % oil in Maharashtra (Vidarbha region)
3. N-71 with 42 % oil in Karnataka
4. Gaudeguda local with 39 % oil in Andhra Pradesh
5. Phulbani local yielding 40 % oil grown in Orissa
6. IGP-76 with 40 % oil grown in Maharashtra, Gujarat and Orissa.

Singh, Pandey and Tripathi (1987) found while comparing the performance of various varieties in northern hill region of Chhattisgarh (Madhya Pradesh) that Chindwara I gave the highest grain yield followed by N-35, GA23 and Ootacamund-5. Chindwara I constantly performed well during both the years, 21.26 % more than local and 6.09 % more than Ootacamund-5, a recommended variety for Madhya Pradesh (Thakur 1971, Reddy and Reddy, 1980, ICAR 1984).

Niger crop is grown as rainfed crop in monsoon and winter season. The sowing time for different states of India is different. In Madhya Pradesh, the optimum time of sowing is third week of July. In Orissa, it is third week of July to 1st week of August. In Maharashtra, it is being grown by June end to early August, whereas in Andhra Pradesh, the best time is second week of August and in Karnataka, it is from June to August. Productivity of the crop could be greatly improved by ensuring timely sowing and optimum plant population in the field as is shown by the work of Nayak and Paikray (1991) where crops grown on 1st September
produced the plants with maximum height, total branches per plant, maximum leaf area index, dry matter accumulation, maximum effective capitula per plant, maximum fertile seeds/capitula and 1000 seed weight in gm and the values decreased with the delay in sowing reaching minimum when sowing was done in middle of October. Planting density also affects the crop. The plant height, leaf area index and 1000 seed weight (gm) was maximum when the plants were densely grown (4.44 lakh/ha.) whereas the low density of plants (1.66 lakh/ha.) resulted in more number of branches, dry matter accumulation, effective capitula and fertile Seeds/capitulum, seed yield (kg/ha.) and thus the net return (Rs.910/ha.) and benefit cost ratio (1:52) was more when the seeds were sown early and density of plants was more. Nayak and Paikray (1991) found from their work that of various treatment combinations September 1 sowing with 3.33 lakh plants/ha. was most remunerative closely followed by September 1 sowing with 4.44 lakh plants/ha.

MORPHOLOGY

Niger is a short, erect moderately branched herb usually less than 1 m, with attractive yellow flowers. The root system is usually well developed with a central tap root and lateral branching, roots normally do not develop to the maximum as niger is
often grown in poor and stony soils. There are few studies on the rate or total growth of niger roots, but the rate of root elongation was doubled with the application of gibberellic acid (Kanevskaye et al. 1971). Niger roots show exceptional resistance to water logging, attributed to the existence of aerenchyma which appear to vary with the degree of soil saturation (Prinz, 1976). The stem is usually round, approximately 2 cm. in diameter, usually upto 1.5 m in height bearing small soft hair. Colour is usually green to reddish green becoming more or less yellow with age. The anatomy of stem has been studied by Chavan (1961). Stem is moderately branched, the extent of branching directly affects the yield as the capitula are borne terminally on stems and branches. In an attempt to increase branching and thus the number of flower heads, growing shoots of seedlings are nipped off, although branching was increased to some extent, the seed yield was depressed (Singh et al., 1973). Kandaswami (1973) determined that number of branches and their capitula accounted for 52% of variation in seed yield.

The leaves are opposite, sometimes alternate on the upper part of the stem, sessile and slightly hairy on both the surfaces. Leaves are usually dark green in colour but the lower leaves frequently show a distinct yellow colour tinge or sometimes a reddish tinge. The plants produce thirty to forty flower heads
under suitable conditions exceptionally, twice this number is produced. Weiss (1983) found eighty two heads over a period of 26 days with numerous branches. Flowering is extended over a period of 15-30 days and results in uneven ripening, losses from shattering is quite high. Rao and Raj (1967) reported that soaking seeds of niger in Diethyl sulphate produced plants with less heads liable to shatter although it cannot be a practical solution.

The period from emergence to flowering is approximately 90 days but niger is grown in a wide range of environment and this period is directly affected by climate, it is more often shorter than longer. Maugini (1946) and Prinz (1976) found it to be shortened by reduction in day length.

PHOTOPERIOD AND TEMPERATURE

Temperature at flowering affects the duration of flowering period and also the fertility of pollen and for Indian strains of niger a temperature of 30°C or above adversely affects both (Prinz, 1976), whereas Ethiopian strains are less tolerant of high temperature at flowering and it occurs only in the ranges of 15-21°C (Abebe et al., 1978). Niger is basically a short day temperate region plant that has also adapted to semi-tropical environment (Maugini 1946).
Fruit is an achene, typical of compositae, normally 1000 seed weight is in the range of 3-5 gm (Weiss, 1983). Test weight of seeds was unaffected by planting density (Naik and Paikray, 1991) and this factor is not liable to major change in a particular genotype (Donald, 1963).

Niger can grow under poor soil conditions, but requires adequate rainfall over the main growing period to produce a commercially acceptable yield. A rainfall of 1000-1300 mm. is considered the optimum. Niger is commonly grown on soils with a range of pH 5.2-6.5 (Westphal, 1975).

Some varieties of niger are moderately salt tolerant which is a valuable characteristic for an oil seed plant especially in India where the area of salt affected soil is increasing. Kachapur and Badanur (1977) reported from the trials conducted by them that increasing salinity from 0 to 4 m mhos/cm. depressed emergence by less than 10% but at 8 m mhos/cm emergence was halved, the effect of salinity on mature plants has not been established so far.

Yantasath (1975) observed in green house trials that inoculation of soil used in the trials with soils in which niger has been previously grown, considerably increased the yield and
thus suggested that mycorrhiza which grew on the roots of the plants growing in the inoculated soil contributed by increasing uptake of phosphate and thus explained that niger grows well on relatively infertile soils because of this beneficial association.

**MANURING**

Bhonsale and Patil (1977) could not find any significant increase in the yield when 4000 kg/ha. of farmyard manure was added to the soil over nil farmyard manure. Similarly Patil (1979b) could not find any significant increase in the yield even when the amount was doubled from 5000 kg/ha to 10,000 kg/ha. and the same results were confirmed by Weiss (1983).

Out of the three major plant nutrients only nitrogen consistently increased niger yields. 40 kg/ha. of nitrogen when applied could bring about an increase in the yield (Patil, 1979b) and the nitrogen should be applied as a top dressing when the first buds appeared and not in the seed-bed. Rai (1986) advocated that half of nitrogen and full dose of phosphorus and potash should be applied as basal dose at the time of planting, the remaining half dose of nitrogen should be applied 30-35 days after planting when there is good soil moisture in the field. Even if small qualities of fertilizer is to be applied, it is better to apply the balanced amounts of fertilizers (NPK) rather than
applying nitrogen alone which is usually the case. Patil and Patil (1981) applied five cartloads of well decomposed farm yard manure/ha. as a basal dose and recommended 20 kg N /ha. for increasing yields as well as for improving the fertility of the soil. They could get 500-600 kg/ha. with good practices.

Tiwari and Bissan (1965), Bhattacharya (1973), Singh and Verma (1975) found that there was no response or irregular results to phosphate application and attributed this to mycorrhiza/root relationship.

Niger seed is small, therefore a level seed bed is essential to ensure even depth of planting and subsequent emergence.

CROP PATTERN

Rajput and Gupta (1978) found that radicle elongation after germination is faster in clay than in sandy soil. A seed bed temperature of 17-25°C is optimum, below 10°C impairs germination and above 35°C causes uneven emergence as was observed by Pasha and Salehuzzaman (1978). Under optimum conditions, niger germinates quickly and is above the ground in 3-5 days in India. Rao et al. (1976) found that a spacing of 60 cm rows x 10 cms between the plants gave twice the yield of 60 cms rows x 5 cms
spacing. Niger grows rapidly once the seedlings are established and its dense growth allows it to compete with annual weeds. Two weeding are generally sufficient. Traditional method of control by hand weeding is seldom wholly successful.

EFFECT OF HERBICIDES AND PESTS

Tosh et al (1978) found propyzamide and chloropropham among the herbicides to be effective when applied post emergence to cuscuta and also up to 25 days later with no effect on niger seedlings.

Niger may be more resistant to many common pests as it often appears to suffer less damage than other crops when interplanted but not much work has been done in this area in India.

Narayanan (1961) mentioned of safflower caterpillar Perigea capensis (Guenee) and safflower aphid Dectynotus carthami (Hilli Ris Lambels) on niger plants whereas Basappa and Singh (1990) found six major and nine minor insect pests attacking niger plants from seedlings stage till harvest. Besides this they reported the attack of Bihar hairy caterpillar (Spillo soma obliqua walker) in Maharashtra and cut worm (Agrotis sp.) in
Madhya Pradesh causing severe damage to niger crop. The incidence of spittle bug was also common in both the states.

The major diseases of niger crop reported in NDDB Extension Bulletin (1988) are Powdery mildew which can be controlled by spraying sulphur, *Cercospora* leaf spot by 0.3g thiram, *Altervaria* leaf spot and seed rot by 0.2% Zincab and root rot by 0.3% thiram.

**OIL ANALYSIS**

Nasirullah et al. (1982) analysed nine niger seed samples from different parts of Maharashtra and Gujarat and found oil content ranged from 30.0 to 32.4%. Oil content of niger is reported to range from 30 to 35% (Seegler, 1983) while the surveys in Ethiopia show that it ranges from 35 to 42%. Nema and Singh (1965) reported the range to be 39.0 to 47.0% in some Indian samples.

**FATTY ACID PROFILE**

As early as in 1944, Hilditch et al studied the fatty acid components of niger seed oil and reported the presence of myristic, palmitic, stearic, arachidic, hexadecanoic and oleic acid whereas Dunn and Hilditch (1950) reported that niger seed oil is reported as one of linoleic acid rich oil and also contains
little linolenic acid. Even Vidyarthi et al (1950) studied niger seed oil and reported the presence of myristic, palmitic, stearic, oleic and linoleic acids with traces of arachidic, balenic and lignoaric acid. Nasirullah et al (1982) studied the physico-chemical properties of niger seed oil and reported the presence of palmitic, stearic, arachidic, oleic and linoleic acid, the latter two constituting major portion of total fatty acids.

Niger seed oil may be categorised among linoleic rich oils, the content of which ranges from 50 to 73 % and thereby showing the semidrying nature of the oil. Range for fatty acid distribution tentively adopted by Food and Agricultural Organisation and World Health Organisation Committee for fats and oils for sunflower, corn and safflower oils showed great similarity with niger seed oil especially in oleic and linoleic acid content. Seegler (1983) observed that the fatty acid composition of oil is similar to that of safflower and sunflower with linoleic acid going upto 75% and difference from other is that it contains small amount (2%) of lignoceric acid.

Saturated fatty acid contents are usually low in niger seed oil particularly in South Rhodesian varieties (Spencer et al., 1976) where saturates contained upto a maximum of 13.8 % and even Nasirullah et al (1982) found the percentage of saturates to be
12.5 to 20.8% where palmitic acid was dominating. Barker and Hilditch (1950) found 74.4% linoleic acid and 4% oleic acid in Rhodesian oil samples and concluded that environment is the main cause for the difference in the fatty acid composition and the predominant factor is apparently the rate of development or ripening of the newly formed seeds in the flower heads.

Even Nayak and Paikray (1991) observed that the oil content was depressed by delay in sowing but the plant density had no effect on oil content. The difference between oil content of September 1 and October 16 sown crops was 1.7%. Sowing beyond October 1 caused greater reduction than the other dates. Singh et al (1982) have also reached similar conclusion. A sharp increase in oil content could probably be achieved through selection for thin hull type, as was successfully done in sunflower and safflower. Reduction in the hull thickness could also be expected to reduce fibre levels in the meal, thus making it more desirable as livestock feed.

Administration of niger seed in diet of rabbits lowered the incidence of arteriosclerosis in treated animals without effecting the blood serum cholestrol levels (Chin Wu, Hsuch Pao, 1977).
The moisture content in niger seed oil varies between 1.7 to 3.0\% (Nasirullah et al 1982) whereas the iodine value ranged from 112.8 to 129.0 and saponification value between 187.0 to 195.0. Rao and Swaminathan (1953) reported a lower iodine value of 90 in certain varieties of niger seed oil. Wealth of India (1956) compilation has quoted the range to be 120.5 to 135.44, even Hilditch et al (1944) got the iodine value of niger oil of 138.7 and saponification number to 293.3. Free fatty acid in Nasirullah et al’s (1982) experimental observations were from 0.2 to 2.0\% and refractive index ranged between 59.5/1.4655 and 62.2/1.4673. Unsaponifiable matter was between 0.5 and 1.0\% and they confirmed the results of Narayan and Swaminathan (1953), Barkar and Hilditch (1950) and Hilditch et al (1944). Rashmi, N and R.S. Mehrotra (1990) observed that determination of refractive index furnishes a useful and easily applied preliminary means of judging the purity of samples. A deviation from normal value indicates adulteration. The index is raised by polymerisation and oxidation (Friend, 1977) and indicates the presence of more saturated acids in the oil (Sahasrabudhe and Kale, 1933). Sankaram (1966) is of the view that increase in the refractive index of fat is due to increase in the length of hydrocarbon chain and the number of double bonds.
The cake which is recovered after oil extraction is normally used as animal feed, although in Ethiopia it may also be used as fuel and in India it is sometimes used as fertilizer (Seegler, 1983). Niger cake compares well with other oil seed cakes in its chemical composition. It contains about 36% crude protein and 5.98% mineral matter but contains about 14-18% of crude fibre. Its protein digestibility is about 80%. It is richer in available lysine (400mg/100gm) and methionine content than groundnut cake (Animal Nutrition by G.C. Banerjee). M.E. value varies between 2700-2800 K.cal/kg.

The average mineral content of niger seed cake was also found to be higher (Sharma and Mishra, 1978). Ethiopian cake was found to be high in fibre (24%) lower in protein (24%) and total digestible nutrients than other oilseed cakes (Seegler 1983, Beyene et al, 1977). Indian niger seed cake was found to have low fibre (14%) and higher protein (30%) than that reported for Ethiopian cakes (Chavan, 1961). An experimental lipoprotein concentrate had 40% protein. Lysine was the limiting amino acid (Ellund, 1971). Mohan et al (1983) studied the comparative nutritional value of groundnut, niger seed and safflower and found that niger seed cake is equivalent in their crude protein content and contains more methionine than groundnut.
It is suggested that niger cake can completely replace groundnut cake on protein equivalent basis for growing chicks and the two oil cakes have a complementary effect on chick growth. The use of niger cake in cattle ration is also encouraging. Its inclusion in cattle ration is as high as 10-15% (Animal Nutrition, G.C. Banerjee). Tripathi and Saraswat (1984) reported maximum crude protein in leafy proteins 24.39% whereas Kelhekar (1976) reported that niger cake has 37.5% crude protein but Tripathi and Saraswat recorded it as 32.7% with 33.4% oil recovery from the seeds. Makkar et al. (1990) reported that the total phenols (TP) and condensed tannins (CT) were low in niger cake, protein precipitating capacity (PPC) could not be detected so it can be considered safe for incorporation into livestock feed subject to the absence of other deleterious factors. Kabaija and Little (1989) observed that when crossbred dairy calves were fed with a basal diet of meadow hay and supplemented with niger cake the gain in weight was high (287g/day), there was no difference in food intake, nutrient digestibility or rumen NH3 and total free fatty acids, although noug-fed animals exhibited much higher levels of branched chain fatty acids and increased thickness of compact bone. Thus a steady supply of rumen microflora together with amino acids were the basis of superior performance observed with noug supplementation.
The most typical and striking plant response to treatment with gibberellins is stem elongation (Yabuta and Hayashi 1939b, Brian et al 1954, Brian and Hemming 1955, 58, Mark et al 1956, McComb 1965, Nanda and Purshit 1964, 64a, Dhindsa 1966, Nanda et al 1967 and many other). Often the number of internodes remain unchanged (Brian, 1957), but the plants become taller. The increase in the internodal elongation by the gibberellin treatment has been reported by Brian and Hemming (1955), and Nanda et al (1967) in soyabean (*Glycine max* L.).

The effect of gibberellin can be prolonged by applying it at small intervals. Very high concentrations are inhibitory but not always toxic and the effective range is extraordinarily broad. In rice and other cereals also, the internodal length increases with gibberellin and a considerable increase in the length of both leaf blade and leaf sheath is caused. Repeated GA treatment reduces tillering indicating an enhancement of apical dominance (Yabuta and Hayashi 1939b, Hayashi, Takijima and Mirakami 1953 and Brian et al 1954). Gibberellin treatment increases the yield of hemp (Lona, 1956) although not the fibre length.
Nanda and Purohit (1964, 1964a) found that the effect of gibberellin on extension growth of *Salmalia malabarica* increased with an increase in its concentration and that there was a more pronounced effect of higher concentrations. The total number of internodes produced per plant was not affected by GA3 treatment. Nanda et al. (1967) and the effect of treatment manifested itself within a week and disappeared after about three weeks. Ho Sun Kwack and Beyoung Hwa also confirmed the increase in the length of internodes. There was a rapid fall in the rate of extension growth after an initial increase as a result of GA treatment and fall was earlier and steeper in treated plants than in the controls (Dhindsa, 1966). Sircar and Chakravarty (1960) observed that in *Corchorus capsularis*, the number of leaves and nodes increased with GA treatment. Ho Sun Kwack and Beyoung (1991) found that there was no change in the number of leaves or nodes.

**ROOT GROWTH**

Gibberellin is not known to stimulate the root growth of intact plants but an inhibition of root growth was recorded by early Japanese workers (Yabuta and Hayashi, 1939b, Yabuta et al. 1941, Yabuta et al. 1951). These findings have been confirmed by Brian et al. (1954). Nanda et al. (1967) reported that GA stimulates root growth in stem cuttings of *Bryophyllum tubiflorum*. 
DRY MATTER ACCUMULATION

Increase in dry weight has been reported in pea and wheat seedlings grown in culture solutions and in Pinto beans and Soyabean grown in soil (Brian et al, 1954 and Marth et al, 1956). Dhindsa (1966) found that dry weight increased with age in all plant parts except cotyledons and was more in treated than in control plants. The differences in dry weight of control and treated plants narrowed down towards the end.

Brian et al (1959) reported the delaying of leaf fall of some woody species with GA treatment. Dormancy of seeds of Lettuce, resting buds of Fagus sylvatica and Marglobe tomato is also broken by GA treatment.

NITROGEN CONTENT

Total N- content of rice seedlings is not changed by GA treatment (Yabuta et al 1951). Rai and Laloraya (1965) studied the changes in soluble-nitrogen and protein nitrogen contents accompanying GA induced growth in Lettuce seedlings. They showed that GA treatment results in enhanced mobilization of the reserve nitrogen from the cotyledons to the growing regions. Thus GA treatment alters the internal distribution of translocatable nitrogen. Ho Sun Kwack (1991) observed that the treatment of GA on Phlox brought about no change in carbohydrate or total N-content.
ANATOMICAL FEATURES

Lang (1956a) reported that stem elongation in gibberelin treated Hyoscymas niger must be due to increase in the number of cells. Increase in the meristematic activity of Acer pseudo-platymides and Populus nigra by GA treatment has been reported by Wareing (1958). Bostrack and Struckmeyer (1964) reported that GA application reduced the diameter of cells resulting in thinner stems of soya bean as compared to control plants.

CHLOROPHYLL CONTENT

The application of GA generally results in the reduction of chlorophyll content as has been shown by Bashisht (1988) when Sesame seedlings grown under continuous light were given GA3 treatment, the chlorophyll content became low besides some other effects. Miroshnichenko and Manankov (1991) found that onion leaves on soaking in GA (1-500 mg/l) for 1-3 h decreased chlorophyll a and b especially at higher concentrations. Carotenoids were affected a little by GA, whereas Khare and Guruprasad (1991) observed that GA3 application on raddish Cotyledons reduced the level of anthocynins but did not alter chlorophyll levels significantly. But Nam and Beyoung (1992) observed on spraying of gibberellin on the leaves of Lonicera
that total chlorophyll content was reduced along with reduction in total N-content whereas plant height showed no difference. Ho Sun Kwack, Beyoung Hwa (1991) also found that chlorophyll level decreased after GA treatment to Phlox paniculata (Indeg. var.) Spraying of GA3 increased the leaf area, chlorophyll and the rate of photosynthesis in the water logged chickpea Cicer arietinum L. showing that GA3 treatment could partially alleviate the adverse effects of water logging (Bishnoi and Krishnamoorthy, 1992) but Mouselase and Halevy reported a decrease in the leaf area by GA in citrus seedlings, therefore the effect of GA on leaf area appears to differ from species to species. Higher concentration of GA3 increased the chlorophyll content of leaves at later stages. This may be because of its effect on delaying the breakdown of chlorophyll and onset of senescence.

FLOWERING AND YIELD

Gibberellin application does not seem to cause flower formation. It is shown to delay flowering in certain obligate SD plants (Lang 1965) Brian reported that GA treatment of pea plants accelerated the visible production of first flower bud by about 4 days whereas Dhindsa (1966) observed that GA delayed flowering by 3-4 days in Soyabean but Bindra (1967) found that GA3 accelerated the appearance of floral buds and flowers under ND conditions and
hastening was slightly more marked with higher concentrations of GA3. Recently HoSun Kwack and Beyoung Hwa (1991) found that GA treatment on Phlox delayed the flowering in the plants. Phillips (1975) opined that exogenous application of growth regulators might enhance the endogenous balance in favouring bud sprouting. Tanimoto and Tadayashi (1989) observed that when plants of Chinese arrowhead, Sagitaria trifolia var. adulis were treated with the solution of 30 and 300 ppm of GA3, 300 ppm treatment was more effective in promoting the production of inflorescence as well as the production of fertile pollen and seeds than of low concentration (30 ppm) GA3.

Sharma et al (1988) from their experiment on garlic observed that GA3 treatment (100 ppm) increased the yield significantly over control and this increase in yield was mainly by increase in the number of cloves, but the size of individual cloves was not improved. Chauhan et al (1987) also observed that grain yield was affected significantly by GA3 and Kinetin application, as shown by higher spikelet fertility in the main crop. Hou (1983) also observed reduced spikelet sterility in the ratoon crop after the GA3 treatment but no significant difference came up for ratoon grain yield and its components.
Doijode (1982) observed that seed treatment with GA produced higher yield in peas while foliar application of GA showed tendency for reduction in the yield and GA significantly increased the yield at lower concentrations. Choudhary and Singh (1968), Sadawarte and Gupta (1968) and Singh (1970) also found that seed and foliar application of growth regulator exhibited increase in the yield of several vegetable crops.

The best known effect of IAA on plants is the elongation of stems and coleoptiles. Thimann (1937) observed that stems, buds and roots each show a two phase type of growth response to auxins with promotion at lower concentrations and inhibitions at higher ones. Stems have highest optimum auxin concentration for growth so auxin levels which promote stem growth may inhibit bud or root growth.

Clark and Kerns (1942) reported that it effectively induced flowering in pineapple and has been used commercially for this purpose ever since. It has less effect on flowering of other species and most effects are inhibitory (Thurlow and Bonner 1947, Leopold and Thimann 1949). Galston and collaborators (1964) found that IAA formed a complex with a macromolecule which resembled RNA—most probably soluble RNA (Bendana and Galston 1965) so they suggested that very low concentration of auxin could exert a major
role on growth through an effect on RNA controlled protein synthesizing system. Masuda and Yangishima, Masuda (1959, 1965) Masuda and Yangishima (1964, 1965) have also suggested that auxin interacts with cellular RNA to produce its effect. The effect of IAA in Avena coleoptile tissue has been shown by Biswas and Sen (1959) in soya bean hypocotyl by Key and Sharon (1964) in pea by De Hertogh et al (1965) and in coconut milk nuclei and pea by Roychoudhary and Sen (1964).

One of the most striking effects of this regulator is on differentiation as it induces buds on callus cultures (Skoog and Miller 1957). Terry (1958) found that roots of some types of convolvulus which have strong tendencies to regenerate buds when disturbed are relatively rich in endogenous Kinins. Vardjan and Nitsch (1961) found that at the base of cuttings, where roots are differentiated Kinetin content is low and auxin is high, the conditions which favour differentiation of roots. (Skoog and Tsui 1948) Kinetin is a strong promoter of bud growth, thus modifies apical dominance Thimann and Wickson (1951) found bud growth promotion in pea stem cutting, this was confirmed by von Maltzahn (1959). Kinetin also stimulates leaf enlargement (Kuraishi and Okumura, 1956). Kinetin can modify many developmental activities like dormancy (Miller 1956, Ogaware and Ono 1961), polarity of growth (Somer 1961) and flowering (Nakayama et al 1961).
1962). The kinetin may increase the effectiveness of light in seed germination (Miller 1956), leaf enlargement (Scott and Liverman 1956) stem elongation (Fries 1960) or bud formation (Suzweykowske 1963).

The structure and ontogeny of normal stomata are studied in the compositae by Pant and Verma (1963); Ramayya and Rao (1968); Rawson and Craven (1975); Bhatt and Inamdar (1975) and Ravindra Nath (1982). Inamdar et al (1976) studied the response of stomatal meristemoid of Helianthus annus L., var. E.C. 68414 to maleic hydrazide. Inamdar et al (1980) investigated the effect of growth regulators on the structure and ontogeny of cotyledonary stomata of Helianthus annus. Gertz (1919) induced guard cell division in the hypocotyl of Cucurbita pepa and cotyledans of Luffa cylindrica but Thailman (1925) failed to induce guard cell division in culture while Tucker (1974, 1975) reported the division of guard cells during wound repair in some Magnoliaceae members. Inamdar et al (1976) observed the division of guard cell nuclei in cotyledons of Luffa aegyptica treated with colchicine.