Chapter II

REVIEW OF LITERATURE ON NIGER (Guizotia abyssinica Cass.)

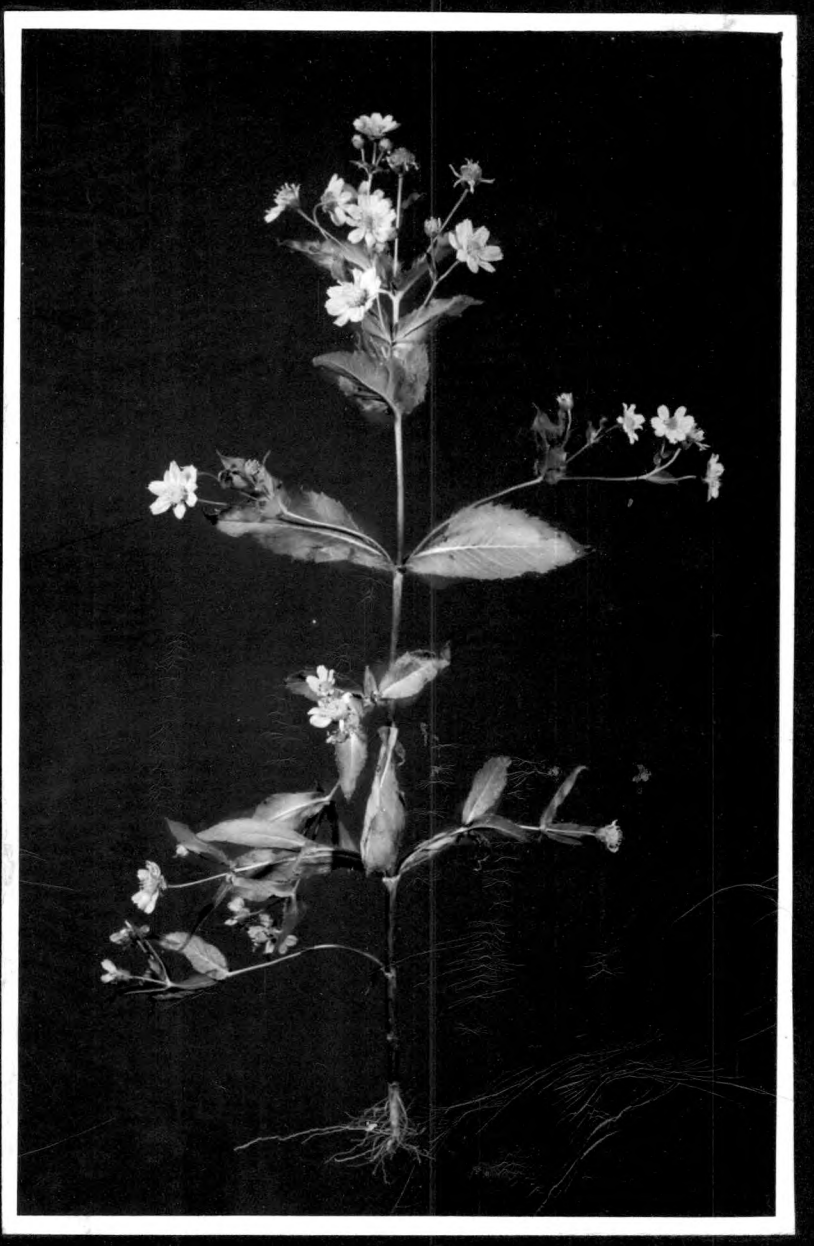
1. INTRODUCTION

Niger (Guizotia abyssinica Cass.) is an oil seed crop belonging to family compositae. Among the oil seed crops it occupies the place 8th and the other two compositae oil crops sunflower and safflower are far more superior to niger so far as the extent of cultivation and consumption is concerned. This crop is mainly cultivated in India, Abyssinia (Ethiopia) and part of East Africa. Hence the crop remained for a long time as a neglected minor oil seed crop. However in last few years niger has attracted attention of many workers due to application of niger oil in industries. Hence it was thought worthwhile to take a brief review of the literature on Guizotia abyssinica Cass.

2. HISTORY OF THE GENUS

The present genus became first known in Europe because of its cultivated species now named Guizotia abyssinica. As G. abyssinica was grown both in Africa and in India, specialist on African and Indian botany treated the taxon independently for a long time until at last the two lines were united in De Candolle's Prodromus (1836). Baagoe (1974) has presented an interesting account of the history of nomenclature of Guizotia.

Fig. 1. Guizotia abyssinica Cass. - Habit



The earliest name applied was Verbesina oleifera. This name was given to a plant grown in the Trianon garden in Paris, and analytically illustrated by Buchoz's work; this name is invalid.

Thus the first valid name become Polymnia abyssinica L.F. from 1781. This name is provided with a good description but no mention is given to the original specimen. The Linnean herbarium in London holds, however, a specimen matching the description of Linnaeus filius with the note "Polymnia bidentis" probably written by the older Linnaeus, and the note, 'abyssinica' added in Smith's hand. As no other specimen belonging to this taxon is present in any of the herbaria that were available to Linnaeus filius, this specimen is considered the type of Polymnia abyssinica (Baagoe, 1974). The specimen originates from Hortus uppaliensis, where it was probably raised from seeds sent to Linnaeus by one of the Jussieu's in Paris. According to Murray (in Bruce, 1805) Balugani had made a description of plant belonging to the taxon in question, but only fragments of this could be recovered.

Among the many botanists studying the plants raised from Bruce's seeds in the "Jardin du Roi" in Paris, were the Jussieu's. One of these unfortunately Jette Baagoe (1974) has unable to find out whom, described several plants including the present taxon and had them drawn. Drawings and descriptions were sent to Bruce, but being annoyed by the way in which the

French had made use of his gifts, Bruce paied little attention to Jussieu's work, and at least the description of G. abbysinica was lost. As a result, when Murray's revised edition of Bruce's Travels appeared in 1805, it provided only a rather wanting description of the "Nuk", but a fine drawing wearing the name Polymnia frondosa. The latter may be French or English, but definitely it represents a plant belonging to the same taxon as Linnaeus filius' plant.

Another plant probably originating from Bruce's seeds was in 1821 described by Cassini under the name of Heliopsis platyglossa. Eight years later (1829) Cassini realized that this taxon was identical to Polymnia abyssinica L.F., and he described a new genus, Guizotia, named after the French historian Guizot and typified by the species correctly named by him as G. abyssinica.

In the mean time the epithet, "abyssinica" has also been used by Ledebour 1824, who placed the species in Tetragonotheca. By all probabilities this was a new combination based on Polymnia abyssinica L.F., but unfortunately Jette Baagoe (1974) has been unable to trace the Ind. Sem. Hort. Dorpat. Suppl. 1824 and therefore missed the verification of this assumption.

The Indian line of history starts with Roxburgh, who described an Indian member of this taxon under the name "Werrinuwa" in such way as to render possible misunderstanding that he was describing a new genus, Werrinuwa. Judging from

the context this was not Heyne's intention and the name is therefore invalid.

In 1819 Sprengel transferred Roxburgh's Verbesina sativa to the genus Parthenium, and presumably under the Kew rule gave it the specific epithet "luteum". When publishing the 16th edition of Linnaeus, Syst. Veg. (1826), Sprengel included two names for the taxon in question. One was Jaegeria abyssinica based on Linnaeus filius' Polymnia abyssinica, the other was Verbesina sativa Sims (O. Roxb. ex Sims in Curtis). Obviously Sprengel failed to realize that the Ethiopian and Indian plants were conspecific, but furthermore he seems to have forgotten all about his own transfer, in 1819, of Verbesina sativa to genus Parthenium.

De Candolle, first unaware of the identy of Ethiopian and Indian plants, described in Wight 1834 a new genus, Ramtilla. Ramtill is a native Indian name, and has been used in Bidens ? ramtilla wall nom. in Sched. in Hamilton's herbarium in BM. De Candolle named the typifying species Ramtilla oleifera and described two varieties, α-sativa and β-angustior, using Roxburgh's Verbesina sativa as a basionym of the former. Two years later De Candolle recognized that this Ramtilla was the same as Cassini's Guizotia oleifera (DC. in DC. and Alph. DC. 1836). De Candolle knew of the older epithet "abyssinica", but thinking that the plant was native of India, and not to Ethiopia, he kept to his own "oleifera". The two varieties were maintained by De Candolle, and in 1877 correctly combined with G. abyssinica by Oliver and Hiern.

From that time the history of the genus has been rather straightforward, and may easily be inferred from Baagoe (1974). It should, however, be mentioned that the name Guizotia Cass. was conserved against Werrinuwa Heyne by the Vienna Congress in 1905.

With the introduction of the type species concept on the Cambridge Congress in 1930 followed an enumeration of type species for already conserved names, and in this list Guizotia abyssinica (L.f.) Cass was proposed as a type species of Guizotia Cass (Briquet, 1935). It is clear from the foregoing discussion that the history of establishment of genus Guizotia is quite interesting.

Several species of genus Guizotia are known, (i) G. abyssinica, (ii) G. raptans, (iii) G. arborescens, (iv) G. zavattarii, (v) G. villosa, (vi) G. scabra. G. abyssinica is reported to be native of Abyssinia (Ethiopia). In India it has various vernacular names which are as follows:

Hindi - Kalatil, ramtil, surguja.

Bengali - Ramtil, sirguja.

Marathi - Khurasni, karale, korata.

Gujarathi - Kalatel, ramtal.

Telgu - Verrinuvvula.

Tamil - Payellu, Ucheliu.

Kannada - Gurellu, huchellu, kadellu.

3. DISTRIBUTION

Niger is cultivated on large scale in Abyssinia (Ethiopia), East Africa (Somalia, Kenya, Uganda, Tanzania) and India (Fig. 2).

In India niger is grown in Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Orissa. The area and production of niger in different states are given in Table I.

TABLE I. Area and production of niger in different states (1972-73)*

State	Average (000 ha)	Production (000 tons)	Average yield kg/ha
Andhra Pradesh	8.3	5.7	686
Bihar	50.8	13.6	267
Karnataka	21.9	5.8	265
Madhya Pradesh	259.0	50.7	195
Maharashtra	81.6	15.5	189
Orissa	69.9	30.9	442

* After Patil and Patil (1981).

It is revealed from Table I that in Madhya Pradesh acreage under niger is highest (52 % of total area) but average yield per hectare is very low. In Maharashtra, the area under niger is 81,600 hectares that is about 18 % of total area under niger cultivation in India. In Maharashtra niger is grown

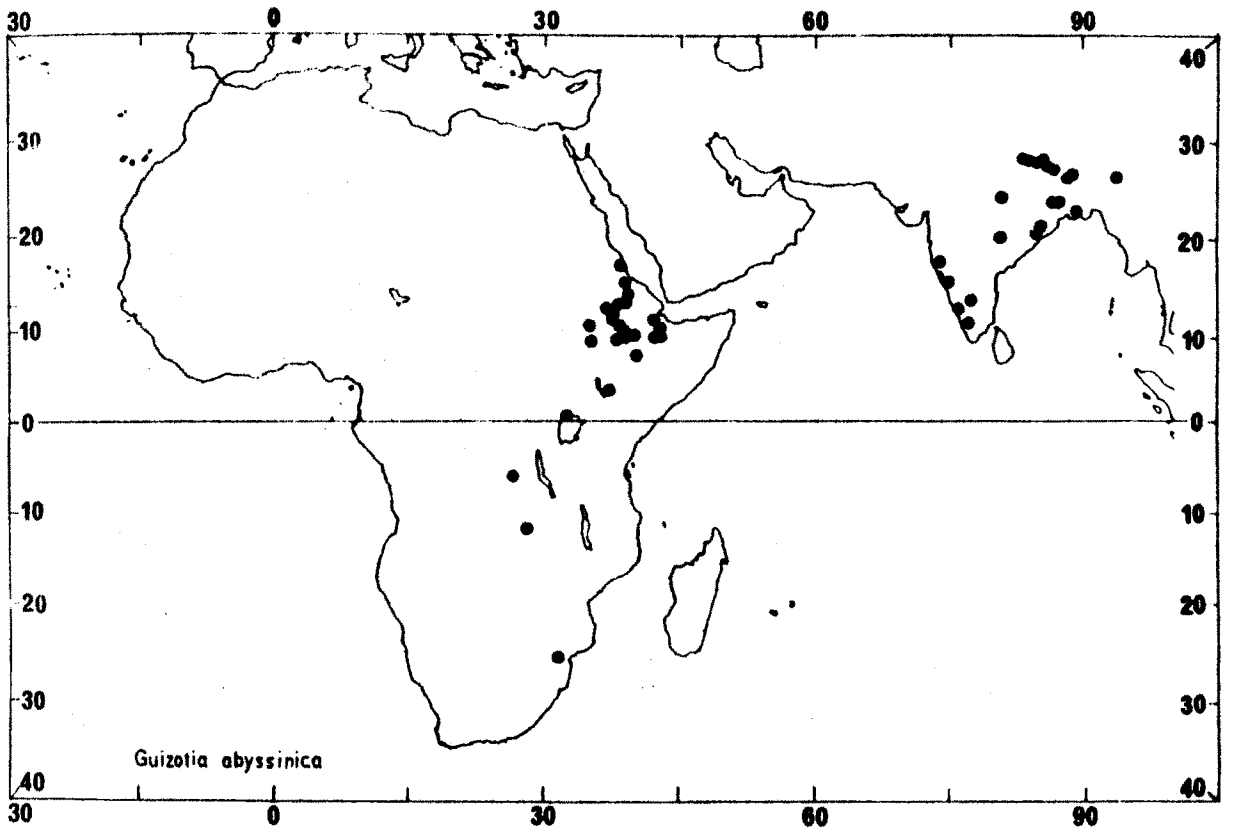


Fig. 2 Natural and naturalized distribution of *G. abyssinica*.

either alone or as a mixed crop in Sangli, Satara, Kolhapur, Solapur, Pune, Ratnagiri, Nasik, Dhule, Jalgaon, Ahemadnagar, Parabhani, Bid, Nanded, Osmanabad, Buladhana, Akola, Aurangabad, Amaravati, Yavatmal, Nagpur, Bhandara, Jalana districts. According to Patil (1981) average yield of niger in Maharashtra is the lowest, the reasons for low yield are as follows : (1) It is cultivated on marginal lands which are poor in fertility. (2) It is cultivated as a rainfed crop without following any improved package of practices. (3) It is a low economic value crop.

4. MORPHOLOGY

The morphological features of G. abyssinica Cass have been summarized by Jette Baagoe (1974) as follows.

Erect, annual, terrestrial, much branching herb to 2 m high, stems pale (purple stained) plants glabrous-puberulent-pilose. Heads large, pedunculata, in corymbous cymes. Tap root with many adventitious roots. Leaves sessile, subconnate (-perfoliate), herbaceous, broadly lanceolate, ovate-oblanceolate (-obvate) (upper), stemleaves 10-15 cm long, 2-6 cm broad, Apex tapering, base truncate-cordate. Margins entire-serrate±recurved, ciliate. Nerves visible on ventral side. Yellow oildrops between hairs and nerves on dorsal side.

Heads many, 1-2 cm diam. Receptacle hemispherical. Peduncles long, 2.5-5 cm, densely pilose distally, with or

without glandular hairs. Outer involucral leaves 5(-6), broadly ovate-obovate, 7-10 mm long, 4-6 mm broad. Nerves 5-12, yellow-light brown, somewhat prominent on dorsal side, slightly hairy, Midrib and two side nerves dominating, but never so much as to give the impression of the leaf being 3-nerved. Inner involucral leaves scarious, plane, oblong-obovate, 5-7 mm long, 2-3.5 mm broad. Apex obtuse-acute. Margins entire, delicate, especially apex ciliate. Ventral side glabrous-slightly puberulent, dorsal with sessile glands, and stiff, unicellular hairs. Nerves 5-8, yellow-light brown, somewhat prominent on dorsal side. Receptacular palaae like inner involucral leaves, 5-7 mm long, 1.5-2.5 mm broad. Nerves 5, light brown, distinct somewhat prominent on dorsal side. Ray florets 6-8(-15), ligule 8-14 mm long, 6-7 mm broad. Tube base with distinct hairzore, the hairs being partly reflexed over the achene, partly adpressed to the tube; tube 1-2 mm long, disc florets many. Hairs on tube base as in ray florets, tube glandular hairs 1.2-1.5 mm long. Limbbase with diffuse hairzone, limb 3.2-3.5 mm long. Achenes 3.5-5 mm long.

5. ANATOMY

Chavan and Tulpule (1957) in their anatomical studies in niger, have described the structure of the stem, root and leaf.

A) Young stem of niger :

(i) Epidermis : It is tne outermost continuous layer

consisting of a single row of small tubular cells with an external deposit of cuticle on them. A few multicellular hairs as well as scattered stomata are seen on it.

(ii) Cortex : This consists of three distinct parts : (a) collenchyma - 3 to 4 layers, (b) parenchyma - 3 to 4 layers, resin canals are present in parenchyma, (c) endodermis : single layer, cells barrel-shapped containing minute starch grains.

(iii) Pericycle : Thin layer consists of crescent-shaped patches of sclerenchyma alternating with groups of thin walled parenchyma situated in between adjacent vascular bundles.

(iv) Medullary rays : In between two vascular bundles these rays consisting of radially elongated, large, thin-walled, parenchymatous cells from alternate strips.

(v) Pith : This consists of very large, rounded or polygonal, thin walled cells occupying the entire region below the vascular ring upto the centre.

(vi) Vascular bundles : 'V' shaped, arranged in ring, collateral, open, present immediately below the patch of sclerenchyma and differentiated into (a) phloem : consisting of sieve tubes, companion cells and phloem parenchyma, (b) Cambium : consisting of small, rectangular thin walled cells, arranged in a thin strip between the phloem and xylem, (c) Xylem : consisting of wood vessels, tracheids, wood fibers and wood parenchyma. The old stem shows the secondary growth.

B) Young root :

(i) Epiblema : It consists of a single row of small, thin walled, tubular cells, forming the outermost layer, with unicellular root hairs.

(ii) Cortex : It consists of several layers of thin walled, rounded cells, having inter-cellular spaces, a few resin ducts are seen in the cortex above the endodermal region.

(iii) Endodermis : This forms the innermost layer of the cortex. It consists of a single layer of closely packed, barrel-shaped cells forming a ring round the pericycle, the walls show some thickening.

(iv) Pericycle : A row of small thin walled cells running internal to the endodermis.

(v) Conjunctive tissue : This is small-celled parenchymatous tissue closely surrounding the vascular bundles.

(vi) Vascular bundles : The vascular bundle is radial, alternate and separate.

(vii) Pith : It consists of rounded large cells, with intercellular spaces, occupying central position.

C) Leaf :

(i) Upper epidermis : This consists of a single layer of flattened cells with cuticle and multi-cellular hairs.

(ii) Lower epidermis : It is of similar layer of cells with stomata and a large respiratory cavity above each stoma protected by two guard cells. Multi-cellular hairs are present.

(iii) Mesophyll : This is made up of (a) Palisade parenchyma consisting of one layer of columnar cells, containing numerous chloroplasts; these cells also closely packed and arranged at right angles to the epidermis and (b) spongy parenchyma consisting of 3 to 4 layers of loosely arranged, thin-walled, rounded or irregular cells with inter-cellular spaces and air cavities. The cells contain chloroplasts.

(iv) Vascular bundles : Sections of veins are sometimes seen in the spongy parenchyma. These veins have the xylem towards the upper epidermis and phloem towards the lower.

(v) Mid-rib : A transverse section through the mid-rib has a structure similar to that of stem, but instead of a ring of vascular bundles, there is generally a single conjoint vascular bundle in the centre and one each at the base of the lamina on either side.

6. CYTOLOGY

Cytological studies on niger have been carried out by Richharia and Kalamkar (1938). Their findings are summarised below : (i) At anaphase in somatic division 30 chromosomes were observed in cells. Nucleolar fragments were rarely seen.

(ii) Seven plants were observed at various stages of meosis. At diakinesis fifteen bivalents and a nucleolus were observed. In some pollen mother cells a trivalent and univalent or a tetravalent were formed. Secondary association of bivalents was seen at metaphase I and II. The segregation of chromosomes was, however, regular. (iii) Pollen counts made in aceto-carmine for 104 plants from various localities (Vidarbha Region) showed sterility ranging from 1-21 per cent. Similar sterility may exist in ovules also.

7. COMPOSITION OF NIGER SEED AND ITS UTILITY

The niger seed resembles sunflower seed in shape, but is much smaller in size and quite black. It bears a fairly thick, adherent seed coat and can be stored for a year or so without deterioration. The components of niger seed and cake are shown in Table II. The oil content of niger seed varies from 30-50 %. The oil content reaches to maximum value at the end of about 45 days after the flower opening; the synthesis of lower saturated acids proceeds that of higher and unsaturated acids, during the later stages of ripening.

TABLE II. Components of niger seed and cake*

Seed		Cake	
Components	Percentage	Components	Percentage
Water	5.33	Water	7.60
Oil	39.95	Oil	6.40
Albuminoid	19.02	Proteins	37.00
Carbohydrates	17.99	Carbohydrates	25.80
Fiber	12.54	Fiber	14.30
Minerals	4.64	Ash	8.90
Sand	0.53	Lime	0.12
		Phosphorus	1.88
		Potash	1.76

* After Patil and Patil (1981).

Niger seed oil is extracted either by cold or hot pressing or by a combination of both. The usual method adapted in India is cold pressing in country ghanis, the recovery of oil ranging from 25-35 %. In some states, the seeds are crushed with small quantities of other oilseeds such as groundnut, sesamum or safflower. Niger oil is pale yellow or orange in colour with little odour and a pleasant nutty taste. According to Sahasrabudhe and Kale (1932) the ranges of characteristics for the Indian oil are as follows :

Sp. gr. 0.9157 at 28.6° C, refractive index at 40° C (Nd) 1.4662; M. pt. - 7.5 to 8.5° C, free acidity 3.8-4 mgms KOH per gram of oil, acetyl value 24.1, saponification value 194.6, Richert-Meissl number 0.85, iodine value 126.4 %, insoluble fatty acids 94.3 %; bromine absorption 79.8 %. The insoluble fatty acids give the following composition : 85.4 % unsaturated acids made up of 31.06 % oleic, 54.34 % linoleic and 14.6 % saturated acids made up of 0.35 % lauric and myristic, 8.41 % palmitic, 4.89 % stearic, 0.48 % arachidic and ligneceric.

On bromination, the oil gives 3-4 % of a tri-linolein-bromide melting at 76.5° C and 20-25 % of di-lino-olein-bromide melting at 54° - 56° C. Completely saturated glyceride is not present in the oil. The raw oil, when kept for some time, becomes rancid due to hydrolysis. It also thickens indicating polymerization. If the oil is heated to 110° C - 120° C and is kept out of contact with air, it remains unchanged for a long time. The oil on hydrogenation gives a white solid fat. The hydrogenation proceeds normally, no iso-oleic acid being formed.

Niger oil is much used for culinary purposes and as a substitute for ghee by the poorer classes in the regions where niger is cultivated. The oil is also used as a lubricant and in soft soap manufacture on a small scale. The oil, when refined, is fairly good for lighting purposes and has been reported as "capital for painting and cleaning machinery". Like sweet oils it is largely used for anointing the body and in rheumatism.

There appears to be some scope for its use in cosmetics on account of its odourless nature and capacity for absorbing fragrance of flowers. Niger seeds are largely used in making chatani in Maharashtra. The niger plant and oil cake is a valuable cattlefeed and is fed largely to mulch cattle. It is also used as manure.

8. CULTURAL PRACTICES

A) Adaptation :

Niger is grown in areas of moderate rainfall of 100 cm to 125 cm. It is not suited in areas of heavy rainfall. Light red soil is considered to be quite suitable for niger.

B) Land preparation :

In the month of May-June, before the monsoon starts, land may be ploughed with small iron plough. Stubbles of previous crop should be collected and land is kept clean and loose by harrowing across the slope.

C) Cultivation :

Line sowing is done by using light seed drill or marker. Distance between two rows may be 20 cm. Sowing time should be adjusted in view of local conditions of rainfall so as to have clear sunshine at the time of flowering. Such condition helps

in maximum seed setting and getting more yield per hectare. According to Patil (1979) mid June or mid-August sowing yielded significantly more than mid July or mid September sowing. Line sowing (20 cm x 10 cm) resulted in significantly more grain yield than that obtained with broadcasting and sowing behind the plough. High plant population (500,000/ha) gave significantly more yield than low plant population (166,666/ha). Singh et al. (1973) working at Jabalpur observed highest yield of niger at 30 cm x 15 cm spacing. Hoeing once or twice with tyne hoe will help to reduce the weeds. Hand weeding is also done in case of weed problem. The yield was significantly more with one hand weeding than with no-weeding and hoeing.

D) Manuring :

Five cartloads of well decompsed farmyard manure per hectare are applied as a basal dose. Application of chemical fertilizers to niger crop will depend on economic conditions. Effects of fertilizers on niger yield were studied by many workers. Patil and Ballal (1964) obtained increased yield by application of nitrogen, phosphorus and potash. Nitrogen and potash increased oil content. Grain yield of niger significantly increased over control when the crop received 20 kg of nitrogen, 20 kg of phosphorus and 5,000 kg of farmyard manure/ha (Patil, 1979). He also showed that the yield was not significantly affected by potash application. Application of 12.5, 25, 37.5 kg

nitrogen/ha gave proportionate increase in the yield in the Konkan region (KKV, Dapoli, 1974).

E) Harvesting :

Niger crop is ready for harvest within 110-120 days. At this time the leaves and flower petals become dry and fall on the ground. Shading of seeds is observed in delayed harvesting while shrivelled seeds are obtained in early harvesting. Plants are cut close to the ground with the help of sickle and dried in the sun for two days before they are collected. They are tied into a bundle and then brought to the threshing yard. Good hand threshing is required as the seeds are small. Heads of plants are beaten with stick and produce is winnowed and seeds are cleaned before storing or marketing.

It is evident from the foregoing account that generally primitive cultural practices are followed for niger cultivation in large part of the country. Similarly not much work has been done regarding response of niger to urea, potash, phosphate and micronutrient fertilizers.

F) Diseases and Pests and Niger :

A brief account of some of the major diseases and pests of niger is given below :

i) Diseases of niger :

1) Alternaria leaf spot :

Causal organism - Alterraria sp.

Symptoms : Small brown circular spots are formed on the leaves and later increase in size and number. The infected leaves turn yellow and drop prematurely.

Control measures : This disease can be controlled by spraying 0.3 % Zineb two times.

2) Powdery mildew :

Causal organism : Odium sp.

Symptoms : A powdery weft of micelium develops on the surface of the leaves.

Control measures : Spraying 0.3 % carathan once at the initiation of the disease and again 15 days later has proved effective in controlling powdery mildew.

3) Root rot :

Causal organism : Rhizoctonia bataticola

Symptoms : Roots turn black and rot. Infected plants suddenly wilt and die.

Control measures : Seed treatment with 0.2 % cerasan or 0.3 % Thiram before sowing is effective control measures.

ii) Pests of niger

1) Niger caterpillar (Perigaea capensis) :

Symptoms of damage : Feed on leaves and defoliate the plant.

Control measures : Spraying the crop with 0.07 % endosulfan 500 litres/ha can control the caterpillar.

2) Aphids (Dactynotus carthami) :

Symptoms of damage : Small, black, soft bodied insects that suck the sap from the tender parts of plant and completely devitalize them. In case of severe infestation the plants get stunted in growth and seed production is seriously affected.

Control measures : Spraying the crop with 0.05 % malathion can control the pest.

3) Tobacco caterpillar (Spodoptera litura) :

Symptoms of damage : Caterpillars feed on the green leaves.

Control measures : The tobacco caterpillar can be controlled by spraying the crop with 0.07 % endosulfan 500 litres/ha.

4) Surface grasshopper (Chrotogonus sp.) :

Symptoms of damage : Nymph and adult feed on young leaves of niger.

Control measures : Dusting with 5 % BHC at about 20 lb/acre is a good control measure.

9. CROP IMPROVEMENT

A) Floral structure

Inflorescence of niger is a small but showy, terminal capitulum surrounded by a green coloured protective involucre. It has an outer whorl of 9-15 ray florets which give the appearance of single flower to the capitulum; a single plant may bear from 20-40 or even more number of capitula, the petals of these florets are bright yellow in colour in the beginning and later they assume a golden yellow colour and finally become brown on fading. There are generally three worls of bisexual disk florets and in all there may be as high as 40-45 and the resulting mature seed may be about 30 per head. From the flowering stage it takes about 40-45 days for seed development.

B) Pollination and Fertilization

According to Howard and Khan (1919) the flowering period of each capitulum extends from 7-8 days. The tubular flowers open in the early morning and liberate their pollen in the tube at the time of opening. The style emerges covered with pollen about noon, the stigmas separating and curling back to the staminal tube the same evening. The self-fertilized seed formed under bag, however, germinates and develops normally.

From the character of the flowering, cross fertilization is generally to be expected but some self-fertilization is also likely.

C) Breeding methods

Breeding work has been very limited on this crop in India. Pure line selection has yielded some types giving high yield with increased oil content both in Madhya Pradesh and Maharashtra. Hybridization has also been attempted. Research work on improvement of niger crop has been done in Madhya Pradesh, Bihar, Maharashtra and Gujarat. Several high yielding strains of niger have been released by selection and some of these are N-5, Ootacamund, Niger-B, N-12-3, N-13-2, N-36, IGP-76 etc. Being a minor oilseed, very little attention has been devoted to this crop by plant breeders in India. There is, however, scope for research in developing new techniques in maintaining purity of an improved strain, in evolving easy methods of hybridization as well as in developing hybrids, economic synthetic varieties and polyploids. Being a highly cross-fertilized crop in nature it deserves greater attention of the geneticist, plant breeder and the agronomist.

10. PHYSIOLOGICAL STUDIES

As niger is minor oil seed crop, very little attention is paid to its physiology in past. Zanoni (1941-42) determined

the basic assimilation capacity, with a given light intensity, in case of G. abyssinica and Cannabis sativa. Maugini (1946) has observed that niger is short day plant. At Florence its flowering was accelerated by reduction of day length. The first significant attempt to study eco-physiology of niger has been made at California by Abebe (1975). He observed that the flowering in niger rhythm with short days and cool temperatures. In his studies flowering occured at day lengths $\leq$ 12 hr and temperatures $\leq 21^{o}$ C. He further reported that niger is tolerant to poor aeration and can grow well in environment with as little as 5 % oxygen. It was also noticed that niger is quite tolerant to boron and major portion of boron accumulated at the leaf tips and leaf margins.

Abebe (1975) also carried out extensive investigations on salt tolerance. The tolerance of niger to NaCl salinity and temperature was studied during germination and later growth stages. Germination studies were conducted in temperature controlled chembers. The growth studies were conducted in temperature controlled water baths using Hoagland solution with variable additions of NaCl. Niger germinated equally well at 15, 17 and 20^{o} C and tolerated -5.0 bars osmotic potential before a 50 % reduction in germination occured. At later growth stage, niger did best at the root temperatures of 17 and 25^{o} C where it withstood osmotic potentials as low as -4.5 bars before exhibiting a 50 % reduction in dry matter. With increasing salinity and temperature, sodium and chloride

accumulated in greater amounts in both shoot and root until a critical salinity was reached which promoted passive absorption. Root and leaf analysis for calcium, magnesium and potassium revealed no changes indicative of nutrient deficiency(s). These elements were taken up passively once the selective uptake mechanism was disrupted by excessive substrate salinity. The injury and reduced growth are ascribed to the combination of osmotic and specific ion(s) effects of sodium and chloride.

The tolerance of niger to salinity using iso-osmotic concentrations of calcium chloride, sodium chloride and sodium sulphate added to Hoagland solution was also investigated by Abebe (1975). Growth and transpiration were most adversely affected by calcium chloride and the least by sodium chloride. Leaf blade analysis for calcium, magnesium and potassium revealed no changes indicative of nutrient deficiency(s). Calcium, sodium and chloride, however, were highly concentrated, the last two, to levels considered toxic. It is hypothesized that the different salt transport characteristics of the three salt species greatly affected the turgor pressure and cell elongation. Based on above experiments Abebe (1975) concluded that niger is semi-tolerant to salinity and it can be used as an important food and oil crop for cool seasons when sesame can not be grown.

Rachapur and Badanur (1977) studied effect of salinity on the germination of niger varieties. Among the varieties tried N-33 and Alsi-1 are more salt tolerant, No.42-5-2, No.71 and N-14 are medium in salt tolerance and N-36 and N-78-9 are more

susceptible to salinity. Rajput and Gupta (1978) reported that the radicle elongation of wheat, niger and lentil were adversely affected at the low soil water potential. They also studied the effect of water potential on transpiration rate and leaf water potential of wheat, niger and lentil. They concluded that leaf water potential decreased almost linearly with the soil water potential along the crops used under similar soil and environmental conditions. They also concluded that lentil can withstand relatively high soil moisture stress than niger and wheat.

It is evident from foregoing account that except the excellent attempt of Abebe (1975) and Rajput and Gupta (1978) not much work is done on the basic physiology of this crop. Thus there are many discrepancies and deficiencies in our knowledge regarding the physiology of processes like growth, mineral nutrition, drought resistance, photosynthesis and senescence. Keeping this view in mind physiological studies in niger have been attempted in the present investigation.