NIGER

TECHNOLOGY FOR MAXIMIZING PRODUCTION

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Niger [*Guizotia abyssinica (L.f.)* Cass.] is commonly known as *ramtil, jagni* or *jatangi* (Hindi), *ramtal* (Gujrati), *karale* or *khurasani* (Marathi), *uhechellu* (Kannada), *payellu* (Tamil), *verrinuvvulu* (Telugu), *alashi* (Oriya), *sarguza* (Bengali), *ramtil* (Punjabi) and *sorguja* (Assamese) in different parts of the country. Niger although considered a minor oilseed crop, is important in terms of its 32 to 40% content of quality oil with 18 to 24% protein in the seed. Niger oil is slow drying, used in food, paint, soap, and as an illuminant. It is used as a substitute for olive oil, can be adultrated with rapeseed, sesame and linseed oil. The oil is used in cooking. The oil from the seed is used to treat burns and in the treatment of scabies. The seed is eaten fried and used as a condiment. The press cake from oil extraction is used for livestock feed. Niger oil has good keeping quality and has < 70% unsaturated fatty acids free from toxins. The oil is considered good for health. Whole plants are used as green manure in the pre flowering stage. Plants are used as a 'bee plant'. The crop is capable of giving better seed yield even under low soil fertility, moisture stress and poor crop management. Niger has an advantage of yielding oil and has good degree of tolerance to diseases, insect pests and attack of wild animals. Niger has great potential for soil conservation. These attributes favour its cultivation on hilly areas, marginal and sub marginal lands in and around the forests. Niger is primarily grown on the denuded soils in the tribal pockets under input starved conditions in India. Further it is the life line of tribal agriculture and economy. India ranks first in area, production and export of niger in the world. Niger crop grows successfully without chemicals. It has the yield potential of 800-1000 kg/ha under optimum growing conditions. The low seed rate, capability to grow on a wide range of soils and sowing period starting from the onset of monsoon in June to September-October, makes this crop ideal for contingent cropping under rainfed situations.

The All India Coordinated Research Project on Niger, under the Indian Council of Agricultural Research, has developed and refined the improved production technology for enhancing productivity and profitability of niger. The states contributing primarily to the niger production of the country are Madhya Pradesh, Odisha, Maharashtra, Karnataka and Chhattisgarh (Table 1). Besides, the crop is also cultivated to some extent in hilly areas of Andhra Pradesh, Bihar/Jharkhand, Gujarat, Uttar Pradesh, Rajasthan, Tamil Nadu, West Bengal, Assam and Arunachal Pradesh in North Eastern Hill region.

Table 1: Area, production and productivity of niger in major growing states of India (2012-13).

State	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)	State	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Madhya Pradesh	86.9	29.8	343	Gujarat	7.0	2.0	286
Odisha	76.0	27.4	360	Assam	8.0	4.0	500

Chhatisgarh	64.2	11.4	178	Jharkhand	4.6	2.4	526
Maharashtra	28.0	8.0	286	West Bengal	4.0	2.8	700
Karnatka	14.0	5.0	357	Others	0.1	0.1	1000
Andhra Pradesh	8.0	6.0	750	**All India**	**300.8**	**98.9**	**329**

ANALYSIS OF NIGER SCENARIO: The productivity of Niger is low, around 300 to 350 kg/ha in India. Niger production during 2012-13 has increased by 7 % and productivity by 88%, even after a reduction of 42% in the area over 1965-66. Despite the maximum area (86.9 thousand hectares) and production (29.8 thousand tones) in Madhya Pradesh, Andhra Pradesh has the maximum seed yield of 750 kg/ha during 2012-13.

Table 2: Change in Area, Production and Productivity of niger crop over 1965-66

- **Area of major niger growing states ('000 hectares)**

State	Area ('000 hectares)							
	1965-66	1975-76	1985-86	1995-96	2005-06	2011-12	2012-13	% Changes over 1965-66
Andhra Pradesh	14.00	9.40	12.60	19.30	16.00	7.00	8.00	-42.9
Karnataka	22.50	47.40	54.80	44.70	30.00	21.00	14.0	-37.8
Madhya Pradesh	282.20	275.90	227.80	216.40	178.70	117.80	86.9	-69.2
Maharashtra	74.50	104.50	95.90	76.80	54.00	37.00	28.0	-62.4
Orissa	75.90	112.90	201.20	210.00	119.40	85.7	76	0.1
All India	525.40	615.30	635.00	600.60	414.40	364.40	300.8	-42.7

*****Estimates

- **Production of major niger growing states ('000 tonnes)**

State	Production ('000 tonnes)							
	1965-66	1975-76	1985-86	1995-96	2005-06	2011-12	2012-2013	% Changes over 1965-66
Andhra Pradesh	1.80	7.90	2.70	7.90	6.00	3.00	6	233.3
Karnataka	2.90	9.30	9.80	7.00	6.00	7.00	5	72.4
Madhya Pradesh	42.60	52.60	49.20	44.60	36.00	20.70	29.8	-30.0
Maharashtra	10.50	13.40	20.70	15.20	14.00	12.00	8	-23.8
Orissa	15.60	47.60	94.00	98.80	37.70	31.80	27.4	75.6
All India	91.90	150.50	192.30	190.30	108.00	98.10	98.9	7.6

*****Estimates

- **Productivity of major niger growing states (Kg/ha)**

State	Yield (Kg/ha)							
	1965-66	1975-76	1985-86	1995-96	2005-06	2011-12	2012-13	% Changes over 1965-66
Andhra Pradesh	129.00	840.00	214.00	409.00	375.00	429.00	750	481.4
Karnataka	129.00	196.00	179.00	157.00	200.00	333.00	357	176.7
Madhya Pradesh	151.00	191.00	216.00	206.00	392.71	176.00	343	127.2
Maharashtra	141.00	128.00	216.00	198.00	259.26	324.00	286	102.8
Orissa	206.00	422.00	467.00	470.00	318.26	371.00	360	74.8
All India	175.00	245.00	303.00	317.00	261.00	269.00	329	88.0

Source: - Directorate of Economics and Statistics New Delhi.

CLIMATIC REQUIREMENT: The optimum plant growth in niger is seen when the temperatures range between 20-38^{0}C during the growing season. Niger may grow on a variety of soils but very coarse or heavy soils are not suitable as one will not hold the water and the other would stagnate it. Niger grows

well with pH values ranging between 5.2 to 7.3. The rainfall ranging between 1000 to 1300 mm is optimum for the crop. However, rainfall beyond 800 and 2000 mm would be unsuitable.

VARIETAL REQUIREMENT: For improving seed yield dwarf types must be developed which have uniform maturity resulting in reduced shattering losses. The Ethiopian germplasm collection contains short stature plants which could be used for the development of dwarf types. There is also genetic variation for number of heads per plant that could be utilized in breeding programmes to select single headed types. The presently used normal height niger material has many leaves and a low harvest index. Reducing plant height would decrease the number of leaves per plant and result in a better harvest index. Shorter plants would be capable of utilizing fertilizer more efficiently thus seed yield could be increased through the application of fertilizer. Standard niger types respond to fertilizer application with increase vegetative growth, promotes lodging of the crop and with seed yield.

The second most important breeding objective in niger improvement is increasing the seed oil content. There exists a great genetic variability for oil content in Ethiopian and Indian germplasm collections which could be used, in a breeding programme, to significantly increase oil content. An increase in oil content of 5 percentages seems to be feasible. A genetic improvement programme for niger must be based on its pollination behavior. Because of its self incompatibility nature, breeding procedures used in the improvement of cross pollinating crops are the methods of choice for niger breeding. The standard breeding procedure for cross pollinating crops is recurrent selection. The resulting varieties are open pollinated population's varieties. Thus niger is a candidate for hybrid development. The identification of genetic male sterility in India and recently in Ethiopia has opened the way for the exploitation of heterosis in niger.

Niger is less attacked by insects and fungal diseases. As modern high yielding, genetically uniform cultivars are used, threats from diseases will increase which will require increased emphasis on resistance breeding. Wild species of the genus *Guizotia* could serve as sources for disease resistance genes which could be introgressed into the cultivated species. During the last few years modern techniques of plant tissue culture, doubled haploid technology and transformation are increasingly used by breeders. Protocols to regenerate plants from niger hypocotyl and cotyledon tissues and seedlings were developed. Plant regeneration was dependent on genotype and media composition. If niger is susceptible to *Agrobacterium tumefaciens* infection, then it will be a good candidate for gene transfer. Dihaploid plants of niger have been produced by anther culture. Self compatible lines, dwarf and single headed doubled haploid plants were obtained from anther culture. Anther and microspore derived dihaploids can be used to develop homozygous inbred lines in a short time. Recessive, simply inherited and easily identifiable marker traits which are important for niger seed production to ensure genetic purity of varieties could be obtained through microspore culture technology. Germplasm exchange between Ethiopia and India, already a delicate issue, should be explored. However, the Indian materials are early to make use of the long Ethiopian growing seasons. Therefore elite lines, e.g. male sterile and dwarf lines, rather than

accessions would be preferred for Ethiopia. Striking genetic differences exist between the Ethiopian and Indian niger. These differences could be investigated using isozyme and molecular markers. It would be interesting to investigate which niger ecotype migrated to India. The variation among 'abat', 'bungne' and 'mesno' niger ecotypes could be differentiated using isozyme and molecular markers. All species within the genus *Guizotia* are diploids with chromosome number of 2*n*=30. Speciation within the genus *Guizotia* was not as a result of changes in chromosome number. The four species *G. abyssinica*, *G. scabra* subsp. *scabra*, *G. villosa* and *G. scabra* subsp. *schimperi* are not reproductively isolated so hybrids among these species could be obtained with ease. It would be important to study the progenitor of niger using isozyme and molecular markers such as random amplified polymorphic DNAs. The solution to the problem of the phylogeny of the species could come from molecular techniques.

It is often reported that niger has an allopathic and mycorrhizal association. It will be interesting to identify the substance associated with the weed suppressing effect of niger. It is important to study the mycorrhizal association of niger further. Efficient genotypes and the possibility of biofertilizers should be investigated.

IMPROVED VARIETIES: Under the All India Coordinated Research Project on Niger, a number of varieties have been developed and recommended for different niger growing areas. Farmers generally prefer particular varieties in different regions/ states for their popularity on the basis of the desirable traits viz., seed colour, resistance to biotic and abiotic stresses and higher market prices. The salient features of the recommended varieties are given in Table 4.

Table 3: Statewise farmers preferred varieties

State	Varieties	Reasons for preference by farmers
Madhya Pradesh /Chattisgarh	JNC-6	Black Seed
	JNC-1	Black Seed, higher seed yield
	JNS-9	Black Seed, higher seed yield
Maharashtra	IGP-76 (Sahyadri)	Black Seed, higher seed yield
	IGPN-2004-1, (Phule Karala-1)	Shining black Seed, higher seed yield, higher market price
Karnatka	RCR-317	Black Seed, higher seed yield
	RCR-18	Shining black Seed, higher market price
	KBN-1	Black Seed, higher seed yield
Odisha	GA-10	Dark black Seed, higher seed yield
	Utkal Niger-150	Black Seed, higher seed yield
Jharkhand	Birsa Niger-1	Light black Seed, higher seed yield
	Birsa Niger-2 (BNS-8)	Black Seed, higher seed yield
	BNS-10 (Pooja-1)	Shining black Seed, higher seed yield, higher market price
Gujarat	Guj. Niger-1	Black Seed, higher seed yield
	Guj. Niger-2 (NRS-96-1)	Black Seed, higher seed yield
Tamil Nadu	Paiyur –1	Black Seed, higher seed yield

Table 4: Varieties recommended, state wise and their characteristic features.

State/ Recommended Variety	Year of Release	Average Seed Yield (kg/ha)	Oil content (%)	Days to maturity	Salient features
Madhya Pradesh/					

Chhattisgarh					
JNC-6	2001	650-700	37-38	95-100	Shining dark black seed. Recommended for Madhya Pradesh, Bihar, Maharashtra, Karnatka and Rajasthan states
JNC-1	2002	650-700	38-40	90-100	Black seed. Recommended for Madhya Pradesh, Bihar, Maharashtra, Karnatka and Rajasthan states
JNS-9	2004	650-700	38-40	95-100	Black seed, tolerant to moisture stress. Recommended for all major growing states of the country
Odisha					
GA-10	1991	600-650	39-41	115-120	Tall, dark black seed. Recommended for tribal areas of Odisha
Utkal Niger-150	2007	650-700	38-40	105-110	Black seed, tolerant to Alternaria and Cercospora leaf spot
Maharashtra					
IGP-76 (Sahyadri)	1982	500-550	35-38	95-100	Black Seed, Widely adopted to all over India
N-5	2001	500-600	36-39	95-100	Small black and sickle shaped seed. Recommended for Maharashtra and Bihar states
IGPN-2004-1, (Phule Karala-1)	2007	650-700	39-41	98-105	Shining black seed, Recommended for high rainfall areas of Maharashtra and Karnatka states. Tolerant to Alternaria leaf spot, powdery mildew.
Bihar/ Jharkhand					
Birsa Niger-1	1994	550-600	36-38	95-100	Light black seed. Recommended for uplands of Bihar/ Jharkhand and Madhya Pradesh
Birsa Niger-2 (BNS-8)	2003	600-650	35-38	95-100	Black seed. Recommended for all niger growing states of the country
BNS-10 (Pooja-1)	2008	650-700	36-38	95-100	Shining black seed. Recommended for all niger growing states of the country
Karnataka					
RCR-317	1987	500-550	35-38	90-95	Black seed
RCR-18	2000	400-450	34-35	100-110	Light black seed and robust growth habit
KBN-1	2007	550-650	36-38	85-95	Black seed
DNS-4	2012	500-600	39-41	90-95	Shining black bold seed
Gujarat					
Guj. Niger-1	2000	600-650	35-38	95-100	Black seed
Guj. Niger-2 (NRS-96-1)	2003	650-700	35-38	90-95	Black seed. Recommended for all niger growing states of the country
Tamil Nadu					
Paiyur –1	1996	600-650	35-38	90-95	Black seed. Recommended for hilly regions of Tamilnadu state

Andhra Pradesh- JNS-9 variety of Madhya Pradesh, BNS-2 and BNS-10 varieties of Jharkhand are recommended.

Rajasthan- JNC-1, JNC-6 and JNS-9 varieties of Madhya Pradesh are recommended.

West Bengal- Birsa Niger-2 and BNS-10 varieties of Jharkhand are recommended.

North Eastern Hill Region- JNC-6 variety of Madhya Pradesh and IGP-76 (Sahyadri) variety of Maharashtra are recommended.

- JNC-1, JNC-6 and JNS-9 are also recommended to Maharashtra, Bihar, Rajasthan and Karnataka besides Madhya Pradesh state.
- Birsa Niger-2 and BNS-10 are also recommended to all niger growing states.

- IGP-76 is also recommended to Odisha, Gujarat, Tripura, Daman besides Maharashtra state.

Note: The details of varieties like seed yield and other salient features are given in the respective states.

Seed Scenario: The All India Coordinated Research Project on Niger has developed the technology for enhancing seed production. The production areas may not necessarily be suitable for seed production due to parallel build up of diseases and pests. The seed production shall be undertaken in the areas where the environment allows full expression of the diagnostic characters; facilities for protective irrigation exist and the productivity and seed quality is high. *Cuscuta* weed is the major menace for seed production. The areas for seed production have to be essentially free from this problem. The suitable areas for seed production are Vishakhapatnam and Rangareddy districts in Andhra Pradesh; Singhbhun, Dumka and Ranchi in Bihar; Chitradurga, Tumkur and Bangalore in Karnataka; Sidhi, Narsingpur, Vidisha, Khandwa and Shivpuri in Madhya Pradesh; Bilaspur in Chattisgrah; Solapur, Ratanagiri, Nasik and Latur in Maharashtra; Malakangiri, Koraput, Kalahandi and Navrangpur in Orissa.

Table 5: Estimated requirements of the quality seed in India

Category	Seed (Quintals)	Area (ha)
Nucleus seed	0.15	0.03
Breeder seed	10.50	2.00
Foundation seed	675.00	135 .00
Certified seed	40000.00	8000.00

Niger being cross pollinated crop with self incompatibility mechanism it is very difficult to maintain the genetic purity without adopting appropriate isolation distance. An isolation distance of 1000 m is recommended for nucleus, breeder and the foundation stages of seed production, whereas 500 m for certified stage production and should be rigorously followed to produce genetically pure quality seed. Rouging should be done strictly to remove all the off type plants, which exhibit variation from the parental variety. The plants infested by diseases and pests especially by *Cuscuta* weed, should be removed. The field should be inspected thoroughly at seedling, vegetative, flowering and maturity stages by monitoring team consisting of experts. Presently two seed production systems are operating in the country.The formal system is being operated through public sector agencies like NSC, SFCI, SSC's, SAU and oil federations etc. The seed multiplication ratio in this system is extremely poor. The main advantage of this system is that the identity, genetic purity, quality and source of the seed is known to the farmers. The Informal system includes multiplication of varieties by private growers or individual farmers and sharing the seed by the farmers. The seed of most of niger varieties under cultivation is being produced and supplied through this system. The main disadvantage of this system is that the identity, genetic purity, quality and source of the seed is not authenticated. However, the seed produced through this system is less expensive and easily available to the farmers. The existing formal system of seed production had been hardly sufficient to cope up with the seed requirement. The minor crops like niger receive least priority of seed producing agencies and therefore the production of quality seed to the farmers in this crop is pathetic. The possibility of improving the supply of quality seed in minor crop like niger through the

formal system in near future appears not to be so bright. Therefore in this crop, alternative systems of seed supply may prove worthy for fulfillment of the requirement. Both, the formal and informal systems of seed supply, have their own limitations. To overcome the limitations of the prevalent informal system and the existing formal seed supply system, the seed production can be undertaken by the research institutes and distributed through farmer fairs/field days/sale counters. The direct supply is quite feasible and will be rather more effective in view of the specific advantages. This system has been quite successful to cover the maximum area under quality seed of improved varieties.

Another option to augment the seed supply in niger is seed village concept. The institutes can choose a single variety produce seed sufficient to cover one village with the single variety. The seed village should grow one and the only one variety. The local or other varieties should not be grown in seed village. Clubbing together the programme of demonstrations and seed village will prove synergistic for the improvement of seed replacement rate.

SOILS: Niger is adapted to a wide range of soil types from sandy, sandy loam, clay loam and gravely soil, however it thrives best on well drained, loamy soils of good depth and texture with pH range of 5.5 to 7. It can with stand slight alkalinity and salinity also. Heavy clay and black cotton soils are not suitable for high yield.

CROPPING SYSTEM: Generally, niger is grown as *kharif* and late *kharif* crop. Short duration crops like cowpea and french bean can be taken up before niger in Odisha. For getting higher yield of both the crops the first crop should be sown in such a way that niger could be sown latest by August.

Sequence cropping: Some of the common crop sequences followed in different niger growing states are given below (Table 6).

Table 6: Sequence cropping in different states.

State	Crop sequence
Madhya Pradesh/ Chhattisgarh	Early Black gram – Niger
Maharashtra	Little millet/ Finger millet – Niger
	Horse gram – Niger
Odisha	Common millet (*Panicum miliaceum*) – Niger
	Little millet (*Panicum miliare*) – Niger
	Early Finger millet – Niger
	French bean – Niger
Bihar/ Jharkhand	Little millet – Niger
	Early Finger millet – Niger
	Black gram – Niger
	Early rice – Niger

Intercropping: Niger is grown as a mixed crop with various pulses and other crops including millets in different states. However, the seed yield of sole crop is higher than that of mixed/intercropping system. Following intercropping systems have been found profitable and feasible in certain situations (Table 7).

Table 7: Inter cropping in different states.

State	Intercropping	Row ratio
Madhya Pradesh	Niger + Kodo/ Kutki/ Pearl millet/ Green gram	2:2
	Niger + Groundnut	4:2 or 6:2

Maharashtra	Niger + Finger millet / Horse gram/ Rice bean	2:2 or 4:2
	Niger + Finger millet/Little millet	2:4 or 3:6
	Niger + Pearl millet/ Groundnut	3:3
	Niger + Groundnut	2:6 or 3:6
Odisha	Niger + Finger millet / Black gram	2:2 or 4:2
	Niger + Ricebean/ Cowpea/ French bean	4:2
Bihar	Niger + Finger millet / Black gram	2:2
	Niger + Red gram	3:2
	Niger + Rice bean / Groundnut	4:2
Andhra Pradesh	Niger + Cow pea	4:2
Karnataka	Niger + Groundnut	6:3
	Niger + Finger millet	1:1

AGRONOMIC MANAGEMENT: Niger is sown under rainfed situations in *kharif*, late *kharif* and *rabi* seasons as a sole crop or mixed with little millet, finger millet, pearl millet, groundnut or pulse crops in different states.

Land Preparation: Two deep ploughings followed by harrowing and planking are recommended to obtain optimum soil tilth to ensure even depth of seed placement and subsequent emergence.

Optimum time of Sowing: Niger is mainly grown in *Kharif*, but it can be successfully grown in semi *rabi* and late *kharif* seasons with limited irrigation. However it is a winter loving crop and high yield are obtained in semi *rabi* season with protective irrigation. Being exclusively a rainfed crop, niger is grown with the onset of monsoon. The optimum sowing time is middle of July to early August for *kharif* crop and September for semi *rabi* crop. Appropriate sowing period for different states is given below (Table 8).

Table 8: Sowing period in different states.

State	Optimum time of sowing
Madhya Pradesh/ Chhattisgarh	Third week of July to second week of August
Maharashtra	July to early September
Odisha	Second fortnight of August to first week of September
Bihar/ Jharkhand	Second fortnight of August to first week of September
Andhra Pradesh	Second week of August
Gujarat	July-August
Karnataka	June-July

Seed rate: The seed rate depends on the method of sowing. Generally 5 kg/ha seed is required for the sole crop. Under inter cropping system, seed rate depends upon the spacing and row proportions of the inter crop.

Seed treatment: To protect the crop from seed and soil borne diseases, seed should be treated with Carbendenzim 5 g/kg or *Trichoderma viride* 10 g/kg of seed before sowing. Seed treatment with Phosphorus solublising bacteria (PSB)/Azotobactor/ Azospirillum 10g/kg of seed results in higher seed yield.

Sowing method: The crop is generally sown by broadcasting. However, line sowing behind the seed drill or plough has been found beneficial and recommended. Seeds are mixed with sand/ powdered FYM/ ash to increase the bulk, 20 times to ensure even distribution of seed. Planking is done to cover the seed. On slopes, line sowing, across the slope is recommended for better soil as well as moisture conservation and efficient utilization of available moisture.

Seeding depth: In niger Seed should be sown to 2-3 cm deep depending upon soil type in and moisture. Sowing should be done in adequate moisture for better germination. Seed bed temperature of 15-22^{o}C is optimum. Temperatures below 10 ^{o}C and above 35 ^{o}C impairs germination.

Spacing: Spacing depends upon soil type and varieties. To obtain optimum yield, appropriate spacing and recommended plant population should be maintained (Table 9).

Table 9: Plant spacing in different states.

State	Spacing (cm)
Maharashtra	30 x 10 20 x 10 (High rainfall areas)
Madhya Pradesh/ Chhattisgarh, Bihar, Jharkhand, Andhra Pradesh, Karnataka and Odisha	30 x 10

Thinning The normal seed rate recommended for niger results in higher plant stand under optimum soil moisture. To maintain optimum plant population (3.3 lakh/ha), thinning is recommended to remove extra plants after two weeks of sowing or when the seedlings attain 8-10 cm height.

Nutrient management: Following fertilizer doses are recommended to obtain higher seed yield (Table 10).

Table 10: Nutrient management in different states.

State	Recommended dose of fertilizer
Madhya Pradesh	20:20:10, N:P:K (kg/ha) at the time of sowing as basal and remaining 20 kg N/ha at 30 days after sowing
Maharashtra	Four tonnes of FYM and 20:20, N:P (kg/ha) at the time of sowing and 20 kg N/ha 30 days after sowing (Top Dressing)
Odisha	20:40, N:P (kg/ha) at sowing and remaining 20 kg N/ha at 30 days after sowing
Bihar/ Jharkhand	20:20:20:15, N:P:K:S (kg/ha) as basal
Andhra Pradesh	Five tonnes of FYM and 10 kg N/ha at sowing
Karnataka	20:20-40:10, N:P:K (kg/ha) at sowing

- Application of recommended N through urea + seed treatment with PSB 10 g/kg seed enhances seed yield significantly.
- Application of sulphur (20-30 kg/ha) increases seed yield and oil content.

Weeding: First weeding is done 15-20 days after sowing coupled with thinning. Second weeding may be repeated after 15 days after the first weeding if the weed intensity is too high before top dressing of nitrogenous fertilizer. In some states like Odisha, *Cuscuta* (*Cuscuta hyalina/ C. chinensis*) infestation has become a major problem. Seed should be obtained from *Cuscuta* free areas. If the *Cuscuta* seed is found mixed with niger seed, sowing should be done after separation by sieving with a 1 mm sieve. The niger seed infested with *Cuscuta* may be treated with 10 % brine solution (Table salt) to obtain a *Cuscuta* free crop.

Irrigation: Niger is invariably grown in rainy season without any irrigation. Prolonged moisture stress adversely affects plant stand and growth of the plant. In such situations, protective irrigation, wherever possible, helps in plant stand establishment and gives better seed yield. For semi-*rabi* crop one or two need based irrigations, one at flowering and other at seed filling stage gives higher yield.

PLANT PROTECTION: The major insect pests and diseases and their management are given in Table 11 and 12 respectively.

Table 11: Insect pests and their management.

Common name	Nature of damage	Management / control
Niger caterpillar (*Condica conducta*)	The caterpillar green with purple markings, feed on leaves and defoliates the plants.	• Proper weeding reduces hiding places • Crop rotation is effective in reducing pest population • Birds readily eat the caterpillars and help to check when they are numerous, 40-50 bird perches are sufficient for one hectare • For effective control of the pests particularly at early stage, apply phorate 10G 10 kg /ha as basal application. • Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l water) • Two sprays of Chloropyriphos 20 EC 1.5 ml/l or Quinalphos 25 EC 1.5 ml/l or Triazophos 40 EC 1 ml/l of water
Cutworm (*Agrotis ipsilon*)	The moth hides under dried twigs during day time and lays eggs on leaves. Larvae attack the crop and plants at ground level.	• Keep grass bundles or crop refuges in cluster in field for the caterpillars to hide during evening and collect the caterpillars early in the morning and kill by dusting 4% phosalone or malathion 5% dust • Proper weeding reduces hiding places • Crop rotation effective in reducing pest population • For effective control of the pests particularly at early stage, apply phorate 10 G 10 kg/ha as basal application • Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l water) • Two sprays of Chloropyriphos 20 EC 1.5 ml/l or Quinalphos 25 EC 1.5 ml/l of water
Bihar Hairy caterpillar (*Spilosoma obliqua*)	The caterpillars remain gregarious under neath leaves in early stages and cause serious loss in yield at third and fourth instar.	• Collection and destruction of egg masses of early instars of caterpillars • Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l water) • Two spraying of any one of the following insecticides Chloropyriphos 20 EC 1.5 ml/l or Triazophos 40 EC 1 ml/l or Quinalphos 25 EC 1.5 ml/l or Acephate 75% SP 1.5 g/l or Indoxacarb 15.8 EC 0.5 ml/l
Surface grasshopper (*Chrotogonus sp.*)	These are usually active in early stage of the crop. These grass hoppers being general feeders also cause damage to a great extent in its early stage.	• Dusting with 4% phosalone or malathion 5% dust 25 kg/ha can control the pest in early stage
Aphids (*Uroleucon carthami*)	This is one of the sucking pest of niger during later period of crop growth.	• Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l) • Spray crop at bud initiation stage with any one of the following insecticides dimethoate 30 EC 1.5ml/l or Quinalphos 25 EC 1.5 ml/l or Dichlorvos 76 EC 1 ml/l or Triazophos 40 EC 1 ml/l or Imidacloprid 17.8% SL 0.25ml/l
Semilooper (*Plusia orichalcea*)	The semilooper feeds on the leaves and defoliates the plant.	• As recommended in case of hairy caterpillar

Niger capsule fly (*Dioxyma sarorcula*)	Maggot feed on seed and pulp inside the capitula.	• Install the light trap one per ha. • Spray Quinalphos 25 EC 1.5 ml/l or Acephate 75% SP 1.5 g/l of water

Table 12: Important diseases and their management.

Disease (Causal organism)	Symptoms	Management
Cercospora leaf spot (*Cercospora guizoticola*)	Disease appears as small straw to brown coloured spots with gray centre on the leaves, spots may coalesce causing defoliation.	• Seed treatment with Thiram (0.2%) + Bavistin (0.1%) • Two foliar sprays with Bavistin (0.1%) + Dithane M 45 (0.25%)
Alternaria leaf spot (*Alternaria sp.*)	Spots are brown to black with concentric rings.	• Seed treatment with Thiram (0.2%)+ Bavistin (0.1%) • Spraying with Dithane M 45 (0.25%) + Bavistin (0.1%) at 15 days interval
Powdery mildew (*Sphaerotheca* sp.)	Small powdery spots appear on leaves, which gradually spread on the lamina and stem resulting in defoliation.	• Foliar spray of 0.2% Wettable sulphur or Bavistin (0.1%) or Karathane (0.1%) when disease appears
Stem/root rot (*Macrophomina phaseolina*)	Infected roots are light blackish to black in colour, which are covered with black sclerotia and are brittle. The blackening extends from ground level upward on the stem giving black colour to stem.	• Seed treatment with Thiram (0.2%) + Bavistin (0.1%) • Deep ploughing in the summer • Crop rotation • Apply 2.5 kg/ha *Trichoderma Viride* mixing with 50 kg FYM in the field before sowing
Cuscuta weed (*Cuscuta chinensis/ C. hyalina*)	Infested plants are stunted, pale yellow with small flowers.	• Removal of *Cuscuta* seed by seiving before sowing • Steeping of *Cuscuta* seed in brine solution before sowing • Removal of *Cuscuta* infested niger seedlings at the early crop growth • Pre sowing soil application of Fluchloralin (1 kg a.i./ha) • Pre emergence application of Pendimethalin (1 kg a.i./ha)

HARVESTING: Niger usually matures in 95-105 days after sowing. The crop should be harvested when the leaves dry up and the capitula turns brownish / blackish in colour.

THRESHING: After drying for a week by stacking, the crop is threshed by beating with sticks.

POST HARVEST HANDLING: The threshed material is cleaned by winnowing. The produce is dried for quality upgradation to reduce moisture content upto 8% and then stored properly. The quality of produce should be upgraded through sieving, as neat and clean produce with bold lustrous seed, free from trash, pests and discoloured unfilled seed, find greater demand and fetch better price in the market.

BEE KEEPING: Existence of self incompatibility, sticky pollen grains not amicable for wind pollination, consequently results in entomophyllous pollination. Large number of attractive coloured flowers, well distributed long flowering period of 45-80 days, make niger the ideal crop for bee keeping. The productivity and profitability of niger is substantially increased through bee keeping. An additional yield (10 to 20 %) + Rs. 1500/ha from honey can be realized through bee keeping with niger over open pollinated crop.

ECONOMICS OF CULTIVATION: With the adoption of improved technology, the seed yield upto 450 kg/ha, gross returns of Rs. 15000/ha and the net additional returns of Rs. 4200/ha can be obtained.

Table 13: Economics of improved technology under real farm situations (FLD's).

State	Seed yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Additional net returns (Rs./ha)	Benefit cost ratio
Bihar	446	7586	15598	4328	2.05
Jharkhand	407	8000	12210	2370	1.53
Haryana	422	11700	21200	5340	1.81
Maharashtra	498	9740	21260	7137	2.18
Odisha	332	7603	9660	1700	1.27
India	**421**	**8926**	**15986**	**4175**	**1.79**

CROP DEVELOPMENT PROGRAMME: In India Niger is predominantly grown in tribal pockets of Madhya Pradesh, Orissa, Chattisgarh, Maharashtra, Andhra Pradesh and Karnataka. Niger is cultivated under varying agro climatic conditions. Inspite of maximum acreage in the world, the productivity of the crop is low in India, around 300 to 350 kg/ha. The short term and long term strategies, which could increase the production and productivity of the crop need to be followed. The quality seed of high yielding varieties to the farmers is not available. For that improvement in the seed chain is needed so that foundation and certified seed are produced in larger quantities. Replacement of old local varieties, development of integrated nutrient management, integrated weed management for *Cuscuta* and low cost production technology has to be ensured for improvement in production. The improved production technology for niger would increase productivity considerably. Farmers should be encouraged to include organic manures and bio pesticides for sustainability in production. For export promotion development of black, bold seeded varieties is needed. Seed production programme and quality seed supply could be taken through seed villages.

Improved production technology has been developed for niger. However because of poor extension system, the technology does not reach to the farmers. In order to motivate them, they must be approached through mass media. Improvement in transfer of technology through large number of FLDs to demonstrate the benefit of technology in remote tribal pockets must be encouraged. Supply of bee hives in niger growing areas should be ensured.

Research responsibility of niger centres	
Development of high yielding, fertilizer responsive varieties	Chhindwara, Semiliguda, Kanke, Igatpuri, Vanarasi
Seed production technology	Chhindwara, Semiliguda, Kanke, Igatpuri, Vanarasi,
Integrated management of Cuscuta	Semiliguda, Kanke

Export of Niger: Despite low productivity and production, the contribution to the export earnings has been encouraging. India is the world leader in production and export of niger therefore, the world markets will continue to be influenced by the niger production and marketable surplus. The quality of the produce to suit the international standards will continue to be important. Therefore, to enhance the export, a three tier strategy involving research, production and export agencies need to be developed. A close

coordination of these agencies can produce synergistic effect on the export promotion. Niger seed is one of the major ingredients of the bird feed, which comprises a mixture of safflower, sunflower seed, peanuts, field peas, corn and other ingredients. The size of world bird feed market is increasing every year. India could earn the foreign exchange of Rs. 100 crores by export of niger seed and the oil meal. India is the largest exporter in the world and USA, Netherlands, Italy, Germany, Belgium and Spain are the regular buyers. USA is the largest buyer in the world. In fact, India faces competition from Nepal in the export.

Table 14 : Year-wise Export status of Niger(India)

Year	Quantity ('000 tonnes)	Value (Rs. in crores)	Year	Quantity ('000 tonnes)	Value (Rs. in crores)
2001-02	22.22	47.85	2007-08	21.68	90.23
2002-03	36.13	77.99	2008-09	13.72	64.23
2003-04	17.89	45.41	2009-10	6.00	24.23
2004-05	26.14	64.74	2010-11	12.86	44.51
2005-06	28.42	60.25	2011-12	28.22	117.27
2006-07	30.02	66.87	2012-13	17.90	90.13

SWOT Analysis: Lifeline of tribal agriculture and economy; Maximum production and largest area in world; Maximum export in international market; High export potential, best bird feed; Low vulnerability to pests and diseases; Low input requirement, grows successfully without costly chemicals is the strength. Low yield levels; Low harvest index; Poor transfer and adoption of improved technology; High susceptibility to *Cuscuta* are the weaknesses. Best crop for waste lands; Honeybees rearing for higher productivity and profitability; Contributes to soil conservation and land rehabilitation; Weed suppression due to allelopathic effect; Oil good, taste akin to *desi ghee*; Good for health <70% unsaturated fatty acids; Organic production of edible oil, a commodity for 21st century are opportunities. Exploitation of the farmers by the traders; Nepal is a potential competitor in the international market; *Cuscuta*-a major menace of the crop are the threats.

Diversified uses: The niger oil is used for cooking, lighting, anointing, painting and cleaning of machinery. The oil is used for pharmaceutical purposes and can be used for soap-making. The meal remaining after the oil extraction contains about 24% protein and 24% crude fibre. A niger-based agar medium can be used to distinguish *Cryptococcus neoformans* (Sant) Vaill, a fungus that causes a serious brain ailment, from other fungi. The oil is used for birth control and for the treatment of syphilis. Niger sprouts mixed with garlic and 'tej' are used to treat coughs.

Exploitable Yield Reservoir: The impact of improved niger production technologies implied that there exists a wide yield gap that could have been harnessed by the adoption of recommended niger production practices. The efforts were made to work out the extent of exploitable yield reservoir that could be harnessed in niger. Keeping in view, the whole package demonstrations of three years (2010-11, 2011-12 and 2012-13) conducted in Maharashtra (35), Odisha (32), Madhya Pradesh (38), Jharkhand (52) and All India (157) were considered (Table 13). The yield Gap-I (between IT and FP) was ranging from 60.0 % in Maharashtra to

149.0 % in Odisha. The national niger production could be increased to 185.0 thousand tonne from 101.0 thousand tonne, if the yield gap-I is bridged. The yield gap-II (Which is the percent increase in the yield in IT over the state average yield) ranged between 68 % in Jharkhand to 146 % in Madhya Pradesh with an overall yield gap-II of 75.0% for whole country. The exploitable yield reservoir I (EP-I) ranged between 6.89 thousand tonnes in Jharkhand to 81.0 thousand tonnes in Odisha. The EP-II value ranged between 7.0 thousand tonnes in Jharkhand to 60.0 thousand tones in Madhya Pradesh. The over all EP-I was 185 thousand tonnes in India while EP-II was of 178.0 thousand tonnes.

Table 13 : Exploitable yield reservoir in niger

State	No. of Demos.	FLD'S Average Yield (kg/ha)		Yield gap-I (%)	Average yield (kg/ha)	Yield gap-II (%)	Average Production ('000 tonnes)	Expected production ('000 tonnes)	
		IT	FP					EP-I	EP-II
Jharkhand	52	704.6	426.3	65.2	419.33	68.04	4.17	6.89	7.00
Maharashtra	35	496.0	310.00	60.0	279.67	77.35	9.33	14.93	16.55
Madhya Pradesh	38	603.0	293.33	105.5	245.00	146.12	24.50	50.36	60.30
Odisha	32	277.6	111.33	149.4	382.33	-	32.67	81.47	23.72
All India	157	520.3	285.25	82.4	296.00	75.79	101.57	185.27	178.54

IT=Improved Technology; FP=Farmer's Practices; yield gap-I=Increase in IT over FP expressed in percentage.

Tips to obtain higher yield:

- Use good quality seed of recommended variety for the region.
- Treat the seed with fungicide before sowing.
- Apply recommended dose of fertilizers at proper time.
- Prepare fine seed bed free from clods.
- Take up sowing at appropriate time with proper spacing between rows and maintain proper spacing between plants within the rows by thinning 15-20 days after sowing.
- Keep the field weed free up to 30 days after sowing.
- Adopt plant protection measures as and when needed against insect pests and diseases. Avoid applying insecticide during flowering period to safeguard the honey bees aiding pollination.
- Harvest the crop at physiological maturity i.e. when the leaves turn yellow and achene's turn black to avoid damage and shattering of seed.
- Dry the plants well before threshing; dry the seed well before storage.
- Rearing honeybees in bee hives near niger field will add Rs. 3500/ha in the net income of farmers.



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