NMOOP

Handbook
on
Technologies for Oilseeds Production in Madhya Pradesh

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सत्यमेव जयते

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Joint Secretary

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MINISTRY OF AGRICULTURE
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KRISHI BHAWAN, NEW DELHI-110 001

FOREWORD

Edible oil constitutes an important part of our daily diet. Domestic consumption of edible oils has increased substantially over the years and has touched 19.82 m t during 2012-13. However, growth in production of domestic edible oils (9.22 m t in 2012-13) has not been able to keep pace with growth in consumption and the gap between production and consumption is being met through imports with huge drain on foreign exchange reserves.

As per the fourth advance estimates, an highest ever national production of 328.77 lakh t of oilseeds with a productivity of 1153 kg/ha has been recorded during 2013-14. It is a matter of great satisfaction that productivity of oilseeds has increased from 481 kg/ha in 1950-51 to 1153 during 2013-14.

Madhya Pradesh is the largest oilseeds growing State contributing to 20.24% of the total oilseeds production of the country. The State is the largest producer of soybean (44.7%), second largest producer of sesame (15.87%) and third largest producer of rapeseed-mustard (11.3%) in the country. The average productivity of oilseeds in the State is less than the national productivity and there is tremendous scope for increasing the productivity as demonstrated in farmers' fields under frontline demonstrations.

This publication comprises of improved package of practices including varieties and technologies recommended for different agro ecological regions of the State would be of great help to the stakeholders of the State in increasing production and productivity of oilseeds.

I congratulate Dr. K. S. Varaprasad, Project Director, Indian Institute of Oilseeds Research and his team for bringing this publication.

Date : 30.1.2015
New Delhi

(Sanjay Lohiya)

PREFACE

Madhya Pradesh is one of the pioneering States in oilseeds cultivation in India with an area of 66.55 lakh ha and production of 78.28 lakh t. The increased production of soybean in the country is linked to the status of the crop in Madhya Pradesh. Being the largest producer of oilseeds in the country, the State has tremendous scope to increase the productivity of oilseeds.

Effective and efficient production and protection technologies have been developed from time to time in tune with solving the limitations for realizing optimum yields and for achieving higher/potential yield and higher profits. In this book, it is attempted to compile and put together the effective and improved technologies on oilseeds for Madhya Pradesh State generated from different sources with a focus on latest and fine-tuned technologies for making oilseed production more profitable and competitive.

With the magnitude of improvement in productivity with the improved technologies across all oilseeds in the State to the tune of 21 to 96% compared to the farmers practice under real farm demonstrations, there is urgent need for large scale adoption of improved production and protection technologies to further enhance the productivity in oilseeds.

We acknowledge the contributions and collective scientific wisdom over the years in development of technologies on oilseeds by the Universities and the AICRP centres. Indian Institute of Oilseeds Research, Hyderabad has facilitated in compiling the information in consultation with the Directorate of Rapeseed-mustard, Directorate of Soybean Research and Directorate of Groundnut Research, AICRP, Linseed, Sesame & Niger. The presentation is made to understand the status of oilseeds in the State, latest improved production technologies under each crop is updated and presented in brief from the climatic requirement through soil, soil and moisture conservation, land configuration, varieties/hybrids, seed rate, plant population maintenance, balanced nutrition, plant protection to harvest. The additional general aspects of sources of information on oilseeds technology and input/services in the State and the financial support available for oilseeds production through National Mission on Oilseeds and Oil Palm (NMOOP) is provided as annexure for the oilseed growers and agencies. The encouragement and financial contribution from Department of Agriculture and Cooperation, Government of India through NMOOP is thankfully acknowledged. Hope the handbook will render technical support to all the stakeholders, especially the students and the progressive farmers involved in oilseed production in the State.

Date : 30.1.2015

IIOR, Hyderabad

(K.S. Varaprasad)

Director

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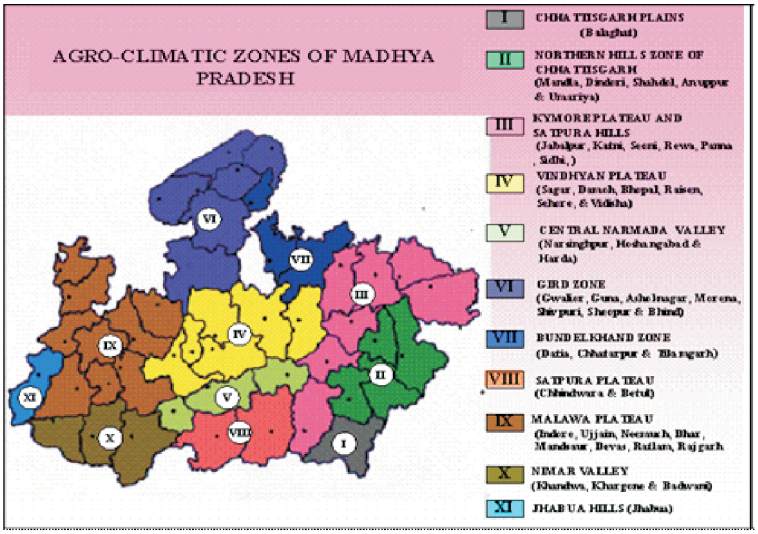
Technologies for Oilseeds Production in Madhya Pradesh

Status of oilseeds production in Madhya Pradesh

The economy of Madhya Pradesh depends mainly on the agricultural sector as more than 80% of the people of the state depend on agriculture for their livelihood. The agricultural sector contributes around 46% to the State's economy. The State has a subtropical climate with hot dry summer (April–June) followed by monsoon rains (July–September) and a cool and relatively dry winter. The average rainfall is about 1,370 mm. The South-eastern districts have the heaviest rainfall, some places receiving as much as 2,150 mm, while the western and North-western districts receive 1,000 mm or less.

Agro-climatic zones of the State

Madhya Pradesh is divided into following agro-climatic zones: Balaghat, Northern Hill Zone of Chattisgarh, Kaimur Plateau and Satpura Hills, Vindhyan Plateau (Hills), Narmada valley, Gird (Gwalior) Region, Bundelkhand Region, Satpura Plateau (Hills), Malwa Plateau, Nimar Plateau and Jhabua Hills



Agro-climatic zones of Madhya Pradesh

The black soils are most predominant found in Malwa region, red and yellow soils in Bundhelkhand region, alluvial soils in northern Madhya Pradesh, laterite soils in highland areas and mixed soils in parts of Gwalior and Chambal division. The most important crops grown are rice, wheat, sorghum, maize, pulses (legumes such as peas, beans, or lentils) and oilseeds. Madhya Pradesh is one of the pioneering States in oilseeds cultivation in India with an area of 66.55 lakh ha and production of 78.28 lakh t. The increased production of soybean

in the country is linked to the status of the crop in Madhya Pradesh. Being the largest producer of oilseeds in the country, the State has tremendous scope to increase the productivity of oilseeds. Amongst major oilseed crops cultivated in Madhya Pradesh, the total area covered in soybean was found maximum (79.10%) followed by rapeseed-mustard (10.7%), sesame (3.8%), groundnut (3.1%), linseed (1.7%) and Niger (1.6%). Similarly, production of soybean also recorded maximum (79.07%) followed by rapeseed-mustard (10.66%), sesame (3.77%), groundnut (3.08%), linseed (1.68%) and niger (1.58%). The State is the largest soybean producer in India.

Area, production and productivity of major oilseed crops in Madhya Pradesh

S. No	Crop	Area (lakh ha)		Production (lakh tonne)		Productivity (kg/ha)	
		MP	India	MP	India	MP	India
1	Soybean	63.80	121.99	53.68	119.89	842	983
2	Rapeseed-mustard	8.14	67.00	9.01	79.59	1108	1188
3	Sesame	2.56	16.66	1.07	6.74	418	405
4	Groundnut	2.00	55.26	1.98	96.72	990	1750
5	Linseed	1.02	2.86	0.53	1.42	523	498
6	Niger	0.74	2.77	0.25	0.88	338	319
7	Castor	0.02	10.00	0.01	16.89	500	1689
	Total oilseeds	66.55	285.25	66.55	328.76	850	1153

SOYBEAN

Soybean has established itself as a major rainy season crop in the rainfed agro-ecosystem of central and peninsular India. The crop is predominantly grown on Vertisols and associated soils with an average seasonal rainfall of about 900 mm. Introduction of soybean in these areas has led to a shift in the cropping system from fallow-wheat/chickpea system to soybean-wheat/ chickpea system. This has resulted in enhancing cropping intensity and profitability. Besides improving the socio-economic conditions of small and marginal farmers of this region, it also earns substantial foreign exchange by exporting de-oiled cake (DOC). Soybean contributes 43% and 25% to the total oilseeds and edible oil production of the country, respectively.

Shorter duration of the crop allows the farmers to take second crop and add to their income/ profits, which is not possible for kharif crop like cotton. One time harvest of the crop makes the harvesting operation comparatively easier. Easy cultivation of the crop and benefits in terms of improvement in soil fertility also prompted farmers to undertake soybean cultivation.

The unique chemical composition of soybean seed which constitutes 20% oil and 40% protein besides number of nutraceutical compounds such as isoflavons, tocopherol and lecithin has made it one of the most valuable oilseed crops in the World. The food derived from soybeans are generally considered to provide both specific and general health benefits and

being a cheaper source of high quality protein, the crop has potential to alleviate large scale protein malnutrition prevailing in poor sections of society of a country. If the high quality soybean protein is included in daily diet of Indian masses, it can help in mitigating the wide spread energy-protein malnutrition. Already the Government of India as well as private sector has taken initiatives to increase the food use of soybean in the country. Soybean has high demand due to its high protein and oil content. It has been used in fortified foods and in bakery products. The oil is also used in anti-corrosive agents, electrical insulation, hydraulic fluids, printing inks, paints, pesticides, soaps, shampoo, detergents, waterproof cement, etc.

There exists a great potential for improving productivity of this crop in Madhya Pradesh by adoption of the improved technologies advocated for different agro-ecological regions as proved under the frontline demonstrations (FLDs) conducted across the state.

Production problems

The reasons for poor yield of soybean at national levels are (i) inherent poor seed longevity, (ii) poor/excess plant population, (iii) mono-variety cultivation, (iv) delayed sowing, (v) sowing of seed without seed treatment and inoculation, (vi) poor water management practices, (vii) timely unavailability of quality inputs, (viii) imbalanced fertilizer application (ix) no/ little use of organic manures (x) inefficient control of insects and pests, (xi), disproportionate use of water in spraying of pesticides, (xii) mixed sowing of seed with fertilizer, (xiii) shattering losses due to delayed harvesting, (xiv) proneness of soybean to field weathering, (xiv) cumbersome process in availing credits.

Areas of cultivation

Soybean is extensively grown in the State. Major soybean growing districts are Ujjain, Hoshangabad, Mandsour, Dewas, Sagar, Sehore, Sajapur, Dhar, Guna, Rajgarh, Betul, Ratlam, Vidisha, Chhindwara and Raisen,

Climate

Soybean is cultivated in the tropics and sub tropics during monsoon season from June to October. The normal temperature ranging from 15-300C is essential for its germination. The optimum temperature requires for its good growth and yield is 30-350C. The temperature, if it goes below 100 C, there will effect on growth as well as yield. Similarly, if temperature goes above 38¬0C, crop growth is also retarded. Generally, day temperatures around 25°C are congenial for its flowering. It can be grown in areas receiving 600-650 mm railfall. But rainfall at maturity deteriorates the grain quality. Even cloudy weather prolongs vegetative phase. It is generally cultivated at an altitude ranges from 1200 to 2000 m.

Soils

Although, soybean is versatile in respect of soil requirement for remunerative production, a well drained, sandy loam soil to clay with medium available water holding capacity, reasonable depth, comparatively rich in organic carbon and levelled fields with near neutral pH (6.5-7.5) is ideal for harnessing maximum soybean yield.

Varieties

Soybean varieties, which are high yielding and exhibit stable performance across a range of environments, should be selected. The variety must possess resistance against biotic as well as abiotic stresses.

Table 1. Varieties recommended for cultivation

Name of Variety	Year of release	Yield potential (kg/ha)	Oil content (%)	Salient features
JS 95-60	2005	1800-2000	16.60	Maturity 82-88 days, determinate, extra early, lodging and shattering resistance, resistant to stem fly, defoliators, moderately resistant to girdle and blue beetles, resistant/tolerant to root rot, bacterial pustule, RAB+ and TLS++.
Phule Kalyani (DS228)	2005	2400	19.08	Maturity 95-100 days.
TAMS 98-21	2007	2200-2600	18.08	Maturity 95-100 days, moderately resistant to YMV*, bacterial pustule, collar rot anthracnose, pod blight and SMV**.
JS 97-52	2008	2500-3000	17.48	Maturity 100 days, resistance to YMV and collar rot, moderately resistant to Rhizoctonia aerial blight and moderately resistance to insects.
RVS 2001-4	2009	2500	-	Tolerant to major leaf, pod and root diseases, tolerant to girdle beetle and semilooper.
MAUS-158	2009	2260	-	Tolerant to bacterial pustules, Rhizoctonia root rot and aerial blight, collar rot and charcoal rot.
NRC-77	2010	2400	-	Resistant to charcoal rot, Rhizoctonia root rot and moderately resistant to RAB and BP.
MACS-118	2010	2475	-	High oil content, early maturity, resistant to pod shattering and Rhizoctonia aerial blight, bacterial pustules, charcoal rot, stem fly, pod borer, leaf folder, leaf miner and defoliators.
NRC 37	-	3500-4000	-	Semi-determinate.

All the above listed varieties are in seed chain and the seed may be available at National Seed Corporation (NSC), State Seed Corporation, State Agriculture Universities and Cooperative societies of the respective states.

Cropping systems

In addition to sole crop, soybean fits well as relay, mixed, companion or intercrop with other crop(s) appropriate to location and season like pigeonpea, sorghum, maize, sugarcane, cotton, finger millet and plantation crops. This has been found to be highly remunerative and biologically efficient (LER 1.25 to 1.70).

Soybean based cropping systems are not only productive but profitable and energy efficient under various agro-climatic conditions. Monocropping of soybean on same piece of land should be avoided and invariably crop rotation should be followed every 3-4 years for sustainable soybean production.

Cropping sequence

Soybean is a short duration crop mostly grown during kharif. In black soils, after soybean another crop can be grown as sequence crop. The common cropping systems sequence are soybean- bengal gram and soybean–wheat.

Intercropping

Soybean is remunerative and ideal intercrop. The most important intercropping systems are maize + soybean, pigeonpea + soybean, cotton + soybean, sorghum + soybean, groundnut + soybean and sesame + soybean.

Agronomic management

Tillage and seedbed preparation

In soybean, highest yield was recorded with minimum tillage. However, soil preparation for soybean consists of one deep ploughing with mould board plough followed by two horrowings and planking. The soils permit only little water to percolate down to enrich groundwater. The runoff losses are high (25%) which trigger soil loss to an extent of 6 t/ha. High intensity rains, a common phenomenon during kharif in vertisols and associated soils adversely affects crop growth. Thus, a need arises to improve in situ soil and water conservation and at the same time provide proper drainage. Broad bed and furrow or ridge and furrow system have been found satisfactorily to attain these goals on deep vertisols. A very simple technique of making conservation furrows after every 3/6 rows of soybean will facilitate for both to conserve moisture as well drain out excess water from the field.

Sowing time

Timely sowing is very important as soybean is highly photosensitive. Delayed sowing may

result in yield reduction to the extent of 17-39%. Highest soybean grain yield was obtained in June 20th planting and it gradually declined as the planting was delayed till 10th July.

i) For kharif – Middle of June to end of July
ii) For rabi – First week of October to December
iii) For summer – 2nd fort night of January

Seed rate, spacing and plant population

Recommended seed rate is 60-70 kg/ha. The optimum plant population is three lakh plants/ha. It is very important that optimum spacing and plant population is required to harvest optimum yields. Optimum spacing is 30-45 cm row to row and 3-5 cm between plants.

Seed treatment

Seed treatment is very important for attaining higher yields.

i. Fungicidal/Bio-agent: Treat the seed with Thiram 75 WP + Carbendazim 50% WP (2:1) @ 3 g/kg seed or Trichoderma viride @10 gm/kg seed.

ii. Microbial: Treat the seed with Rhizobium culture @ 500 g/75 kg seed + PSB/PSM @ 500 g/75 kg seed.

Table 2. Recommended herbicides for weed control in soybean

S.No	Technical name	Formula-tion	Dose	Method of application
A	**Pre-plant incorporation (PPI)**			
1.	Trifluralin	48 EC	2 l/ha	Make solution in 700-750 litre water and incorporated in soil before sowing
2.	Fluchloralin	45 EC	2.5 l/ha	
B	**Pre-emergence (PE)**			
1.	Metalochlor	50 EC	2 l/ha	Make solution in 700-750 litre water and sprayed
2.	Pendimethalin	30EC-	3.5 l/ha	
C	**Post-emergence (POE)**			
1.	Imazethapyr	10 EC	1 l/ha	Make solution in 700-750 litre water and sprayed15-20 DAS
2.	Quizalofop ethyl	50 EC	1 l/ha	
3.	Chlorimuron ethyl	25 WP	36 g/ha	
4.	Fenaxaprop ethyl	9 EC	1 l/ha	
5.	Quizalofop-p-tefuryl	4.41 EC	1 l/ha	

Manures and fertilizers

Integrated nutrient management involving use of organic manures, residues and inorganic fertilizer is beneficial. Apply farm yard manure @ 10 t/ha before sowing. Always apply fertilizers based on soil analysis. Generally black soils contains high potassium, therefore potassium requirement tends to be very less. The general recommendation of NPKS is 20:60-80:20:20.

Biofertilizers

Unlike other legume crops, requirement of nitrogen is substantially fulfilled from symbiotic nitrogen fixation through Brady rhizobium. The seeds should be inoculated with effective strain of Rhizobium culture @ 5 g/kg seed just before sowing. The extent of nitrogen fixation ranges from 60-160 kg/ha in soybean.

Weed control and Interculture

At least intercultural operations with Guntaka/Danthe/Hoe should be done between 20 to 40 DAS to keep weeds under control. Soybean being a rainy season crop is heavily infested with many grasses as well as broad leaf weeds. Yield loss of soybean may range from 25-70% depending up on intensity and infestation of weeds. The most critical period for the weed interference is initial 15-45 days. Weeds emerging after this period are being suppressed by smothering action of crop. Herbicidal weed control has been found efficient and economical in soybean.

Irrigation management

Irrigate immediately after sowing and provide life saving irrigation on the 3rd day. Further irrigations at intervals of 7-10 and 10-15 days during summer and winter season, respectively may be given depending on soil and weather conditions. Soybean is very sensitive to excess moisture and the crop is affected, if water stagnates in the fields. The crop should not suffer due to water stress from flowering to maturity. To alleviate moisture stress, spray of either Kaolin 3% or liquid Paraffin at 1% on the foliage is recommended.

Plant protection

Insect-pests management

Insect / Pest and Nature of damage	Management
Stem fly *(Melanagromyza sojae)* Yellowish maggots bore the nearest vein of the leaf and reach the stem through petiole and bore down the stem. As a result of severe	• Avoid pre monsoon sowing. • Use optimum seed rate and plant spacing. • Remove and destroy the damaged plant parts.

Insect / Pest and Nature of damage	Management
damage, seedlings and plants wilt and dry.	• Soil application of Phorate granules (15 kg/ha) at the time of sowing prevents early infestation. • Seed treatment with Thiamethoxam (7 g/kg seed) • Spray Chlorantraniliprole (0.3 ml/l) or Indoxacarb (0.6 ml/l) or Thiamethoxam (0.2 g/l) or Triazophos (1.5 ml/l).
Tobacco caterpillar (*Spodoptera litura*) Larvae damages crop by defoliation. Hatched larvae feed gregariously and skeletonise leaves. Mature caterpillars disperse to other leaves / plants and defoliate.	• Collect and destroy plant parts/plants having gregarious stage of caterpillars. • Install sex pheromone trap @ 10 traps/ha for early deduction of the pest. • Spray Sl NPV @ 250 LE/ha or Bacillus thuringiensis var. kurstaki (1 g/l) or Dichlorvos (0.7 ml/l) or Indoxacarb (0.6 ml/l) or Profenofos (2 ml/l) or Chlorantraniliprole (0.3 ml/l) or Quinalphos (2 ml/l), when the population reach 10/m row length.
Green semiloopers (*Chrysodeixis acuta, Gesonia gemma and Diachrysia orichalcea*) Larvae feed voraciously on leaves starting from the edges inwards and leaving behind only midribs and stalks. Damage is maximum in August-September and with excessive loss of foliage.	• Use recommended dose of fertilizers including potash. • Spray Bacillus thuringiensis var. kurstaki (1 g/l) or Dichlorvos (0.7 ml/l) or Indoxacarb (0.6 ml/l) or Profenofos (2 ml/l) or Chlorantraniliprole (0.3 ml/l) or Quinalphos (2 ml/l), when the population exceeds 3-4 larvae/m.
Girdle beetle (*Obereopsis brevis*) Grub feeds and hollows out the inside of the stem. Seedlings and young plants are wilted or dead. On older plants, all or part of the leaves are wilted and brown.	• Remove girdle beetle infested plants / plant parts. • Spray Chlorantraniliprole (0.3 ml/l) or Profenofos (2 ml/l) or Thiacloprid (1.5 ml/l) or Triazophos (1.5 ml/l).

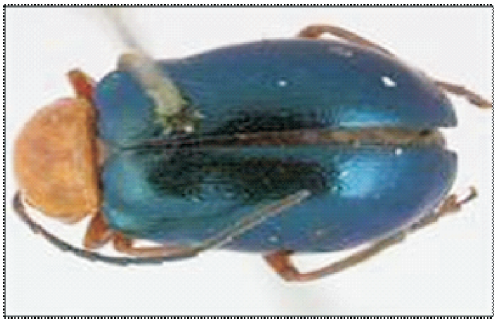
Insect / Pest and Nature of damage	Management
Blue beetle (*Cneorane spp.*) Beetles scarify the cotyledons from either side at seedling stage. Seedlings either killed or their vigour reduced.	• Spray Quinalphos (2 ml/l) or Malathion (2 ml/l) or Triazophos (1.5 ml/l) or Indoxacarb (0.75 g/l) or dust Quinalphos 1.5% (16.6 kg/ha).
Leaf defoliator (*Spodoptera exigua*) Larvae damages crop by defoliation. Hatched larvae feed gregariously and skeletonise leaves. Mature caterpillars disperse to other leaves / plants and defoliate.	• Collect and destroy plant parts/plants having gregarious stage of caterpillars. • Install sex pheromone trap @ 10 traps/ha for early deduction of the pest. • Spray Profenofos (2ml/l) or Chlorantraniliprole (0.3 ml/l) or Dichlorvos (0.7 ml/l) or Quinalphos (2 ml/l) or dust Quinalphos 1.5% (25 kg/ha), when their population is likely to reach 10/m row length.
Bihar hairy caterpillar (*Spilarctia obliqua*) Larvae feed voraciously on the foliage in early stage and defoliate the plant. Larvae also damages flowers and pods.	• Collect and destroy infested plant parts along with larvae. • Spray Bacillus thuringiensis var. kurstaki (1 g/l) or Dichlorvos (0.7 ml/l) or Chlorpyrifos (2 ml/l) or Quinalphos (2 ml/l).
Gram pod borer (*Helicoverpa armigera*) Larvae feed voraciously on the foliage in early stage and defoliate the plant. Larva damages flowers and pods.	• Install pheromone traps at a distance of 50 m @ 10 traps/ha. • Erect bird perches @ 50/ha. • Spray Ha NPV 250 LE/ha or Bacillus thuringiensis var. kurstaki (1g/l) or Indoxacarb (1 g/l) or Chlorpyrifos (2 ml/l) or Quinalphos (2 ml/l).
White fly (*Bemisia tabaci*) Nymphs and adults suck the sap from leaves. The crop present sick appearance with large number of leaves turned pale yellow. The plants remain stunted. Whitefly also transmits mosaic disease.	• Seed treatment with Imidacloprid or Thiamethoxam (5 g/kg seed) • Spray Dimethoate (1.7 ml/l) at the crop age of 35-40 days and repeat after 15 days if needed.

Stem fly

Tobacco caterpillar

Green semilooper

Girdle beetle



Blue beetle

Spodoptera exigua

Bihar hairy caterpillar

Insect pests of soybean

Gram pod borer

Plant protection

Insect-pests management

Diseases and nature of damage	Management
Rust *(Phakopsora pachyrhizi)* Brown pustules appears on the dorsal surface of the leaves in the initial stages, later turns to reddish brown to tan colour. Lesions are generally restricted by veins giving angular appearance. The leaves gradually become yellow and premature defoliation occurs resulting in yield loss.	• Early maturing varieties escapes the infection. • Growing of resistant/tolerant varieties. • Foliar spraying of Mancozeb 0.25 % 3 times effectively reduces infection. • Foliar spraying of Hexaconazole, Propiconazole, Triadimefon and Oxycorboxin (0.1%) 2-3 times at 15 days interval found effective.
Soybean mosaic virus Diseased plants are usually stunted with distorted (puckered, crinkled, ruffled, stunted, narrow) leaves. The parts are often stunted. Flattened or curved and contain fewer and smaller seed. Infected seeds gets mottled. Infected seeds fail to germinate or they produce diseased seedlings.	• Use healthy/certified seeds. • Keep the field free from weeds. • Rogue out infected plants and burn them. • Two foliar sprays of Thiamethoxam 25 WG @ 100 g/ha or Methyl demeton 800 ml/ha at 30 and 45 DAS after sowing to control the vector.
Collar rot / Sclerotial blight *(Sclerotium rolfsii)* Infection usually occurs at or just below the soil surface. Sudden yellowing or wilting of plants is first seen. Light brown lesions, quickly darken, enlarge until the hypocotyl or stem is girdled. Leaves turn brown, dry and often cling to dead stem. Numerous spherical sclerotia form on infected plant material.	• Deep ploughing in summer. • Crop rotation with maize or sorghum. • Destroy infected stubble. • Seed treatment with T. viride @4 g/kg or P. fluorescens @ 10 g/ kg of seed or Carbendazim or Thiram 2 g/kg of seed. • Spot drenching with Carbendazim 1g/l or apply P. fluorescens / T. viride 2.5 kg/ ha with 50 kg FYM.
Charcoal rot, ashy or stem blight or dry root rot *(Macrophomina phaseolina)* Lower leaves become chlorotic and wilting	• Deep ploughing in summer. • Use recommended dose of fertilizer. • Rotate soybean with cereals. • Maintain well drained field

Diseases and nature of damage	Management
and drying are apparent. The diseased tissues generally develop grayish discolouration. The sclerotia look like black powdery mass hence the disease is known as charcoal rot. Blackening and cracking of roots is the most common symptom. The fungus survives in soil and crop debris in dry conditions.	• Destroy infected stubble. • Seed treatment with T. viride @4g/kg or P. fluorescens @ 10g/ kg of seed or carbendazim or thiram 2g/kg of seed. • Spot drenching with carbendazim 1g/ lit or apply P. fluorescens / T. viride 2.5 kg/ha with 50 kg FYM.
Alternaria leaf spot *(Alternaria tenuissima)* Appearance of brown, necrotic spots with concentric rings on foliage, which coalesce and form large necrotic areas. Seed become small and shriveled. Dark, irregular, spreading sunken areas occur on the seed.	• Infected leaves later in the season dry out and drop prematurely. • Use healthy/certified seeds. • Destroy crop residues from fields. • Seed treatment with thiram + carbendazium (2:1) @ 3g/kg seed. • Use Mancozeb or copper fungicide at 2.5g/l or carbendazim 1 g/lit.
Frog eye leaf spot *(Cercospora sojina)* The disease primarily affects foliage, but, stems, pods and seeds may also be infected. Leaf lesions are circular or angular, at first brown then light brown to ash grey with dark margins. When lesions are numerous the leaves wither and drop prematurely. Lesions on pods are circular to elongate, light sunken and reddish brown. Light to dark gray blotches appear on seeds.	• Use healthy or certified seeds. • Rotate soybean with cereals. • Completely remove plant residue by clean ploughing the field soon after harvest. • Seed treatment with Thiram + Carbendazim (2:1) @ 3g/kg seed. • Spray Mancozeb @ 2.5g/lit or Carbendazim 1g/lit.
Cercospora leaf blight, leaf spot and purple seed stain *(Cercospora kikuchii)* Infected leaves appear leathery, dark, reddish purple. Severe infection cause rapid chlorosis and necrosis of leaf tissues, resulting in defoliation. Lesions on petioles and stems are slightly sunken, reddish purple; severe cause defoliation.	• Use healthy/certified seeds. • Previous crop debris should be removed. • Seed treatment with Thiram + Carbendazium (2:1) @ 3g/kg seed. • Use Mancozeb or Copper oxychloride at 2.5 g/l or Carbendazim 1 g/lit.

Diseases and nature of damage	Management
Pod blight *(Colletotrichum truncatum)* The pods turn yellowish green and dry up. Grains become shriveled and mouldy.	• Follow crop rotation. • Use resistant varieties. • Spray Zineb 2-2.5 kg/ha in 500-600ml of water can control the disease.
Bacterial blight *(Pseudomonas syringae pv. glycinea)* Small, angular, translucent, water-soaked, yellow to light brown spots appear on leaves. Young leaves are most infected and are destroyed, stunted and chlorotic. Angular lesions enlarge and merge to produce large, irregular dead areas. Early defoliation of lower leaves may occur. Large, black lesions develop on stems and petioles. Seeds may develop raised or sunken lesions and become shrivelled and discoloured.	• Deep summer poughing. • Use healthy/certified seeds. • Destroy infected crop debris. • Seed treatment with Streptocyclin @ 250 ppm (2.5 g/10 kg seeds). • Application of any copper fungicides @ 2 g/l along with Streptocyclin at the rate of 250 ppm (2.5 g/10 lit water).

Rust

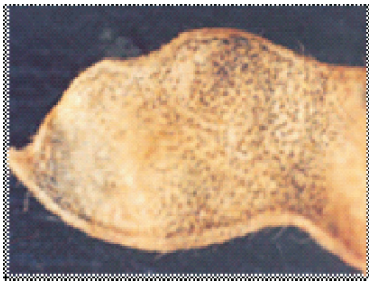
Mosiac virus

Collar rot

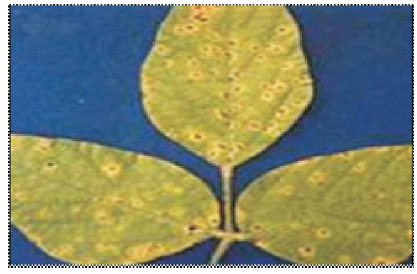
Charcoal rot

Alternaria leaf spot

Frog eye leaf spot



Pod blight



Bacterial blight

Diseases of soybean

Harvesting, threshing and drying

At maturity leaves turn yellow and fall. The seed in the pod is hard and dough. Preferably the crop should be harvested in the morning to avoid losses of shattering. Harvesting is done by uprooting the plants or by cutting with sickle. Threshing should be done by beating with sticks or by bullocks or tractor mounted thresher or by mechanical soybean thresher or by the combine harvester.

The grain should be dried under sun till moisture level reaches to 10-12%. The seed, which is to be used for next season should be stored under low temperature and low humidity conditions.

Performance of improved technologies under real farm situations

The frontline demonstrations conducted in farmers' fields in Madhya Pradesh have indicated the potential of improved technologies in improving the seed yield by 30% with varieties and 29% with whole package. The corresponding additional net returns were ` 12301 and 9325/ ha (Table 3).

Table 3. Performance of improved technologies of soybean in Madhya Pradesh under real farm situations (2011-14)*

Technology	FLD mean yield (kg/ha)		Yield gap-I (%)	Cost of cultivation (Rs./ ha)		Gross returns (Rs./ha)		Additional net returns (Rs./ha)	B:C ratio	
	IT	FP		IT	FP	IT	FP		IT	FP
Whole package	1702	1322	29	15924	12915	46235	35942	9325	2.9	2.8
Improved variety	1731	1335	30	17393	14238	53610	41009	12301	3.2	2.9

* = pooled results for three years

Critical Do's and Don'ts

- Seed should be tested for germination before sowing and adjust the seed rate.
- Fertilizers, should to be applied on the basis of soil analysis.
- Sow the seeds on time (3rd week of June to first week of July).
- In places where labour availability is problem, recommended weedicides should be used at proper time.
- Crop should be harvested just after the pods loose green colour to avoid the losses due to shattering seeds.
- Threshing should be done after 2-3 days with low spread of thresher cylinders and dry the seed for 3-4 days.

RAPESEED MUSTARD

Rapeseed-mustard is one of the major annual edible oilseed crop cultivated in India. The crop contributed 25% of the total oilseed production in India. It ranks second in area next only to soybean in India as well as in the world. It is a major rabi oilseed crop of northern part of the country.

It has been cultivated predominantly in Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, West Bengal, Assam, Gujarat, Bihar, Jammu and Kashmir, Punjab, Chhattisgarh and Uttarakhand. The seeds contain 39 to 44% oil. The oil is used in culinary preparations and salad dressings. The yellow mustard is an excellent emulsifying agent and stabilizer and used in sausage preparations. It stimulates appetite and clears the sinuses.

Rapeseed-mustard does fairly well under low input intensities and low water availability. Hence the crop is an important component in crop diversification programmes and critical for the wellbeing of small holder producers of rainfed regions of the country. A wide gap exists between the potential yield and the yield realized at the farmers' field in rapeseed mustard cultivation. This difference is mainly attributed to a number of biotic and abiotic stresses to which the crop is exposed. For realizing the potential yield of the rapeseed-mustard, it is important that the farmers adopt improved technology which has been developed by research institutions.

Production problems

The average yield of rapeseed-mustard recorded in the farmers' field in the state is below the potential productivity of the crop. The major constraints identified in rapeseed mustard cultivation in the state are:

- Low and erratic rainfall, high temperature at the sowing time
- White rust, Sclerotinia rot and Alternaria blight
- Moisture deficiency at seeding time
- Non-availability of seeds of improved varieties
- Non-adoption of improved varieties
- Imbalanced fertilizer use
- Poor plant protection measures
- Inadequate moisture conservation techniques
- Infestation of insect pest like mustard aphid, sawfly and painted bug
- Late sowing of the crop
- Continuous adoption of fallow-mustard sequence in large area leading to Orobanche and Sclerotinia rot problem.
- Low spread of early maturing varieties of mustard for rainfed situation

Areas of cultivation

The area of mustard found to be concentrated in Morena, Bhind, Gwalior, Mandsour, Shivpuri and Mandla districts. These five districts contributed nearly 85-90% of area and production of mustard in Madhya Pradesh.

Climate

The crop prefers moderate temperature of about 25ºC during growth. However, it can also withstand a temperature of 40ºC for limited period only during vegetative growth.

Soils

Rapeseed and mustard are capable of growing under a wide range of soil types conditions varying from sandy loam to clay loam, but they thrive best on light loam soils. They neither tolerate water logging conditions nor do well on heavy soils. Crop can tolerate moderate salinity reasonably well but a soil having neutral pH is ideal for their proper growth and development.

Varieties and hybrids

The selection of the appropriate variety suited to the growing condition and specific

characteristics of the region is the most important factor in determining the yield and production of the crop. The adoption of improved and suitable variety alone can make significant difference in the crop productivity. The varieties recommended for Madhya Pradesh are given in Table 1.

Table 1. Recommended varieties of rapeseed-mustard for Rajasthan

Variety	Maturity (days)	Oil (%)	Yield (kg/ha)	Situation/ condition
Indian Mustard				
Ashirvad	125-135	31-41	1450-2358	Late sown
Jagannath	125-130	39-40	1700-1800	Timely sown- irrigated
JM-1	125-127	40	2000-2100	Timely sown- irrigated
JM-3	130-132	40	1500-2500	Timely sown- irrigated
NRCHB-101	105-135	35-42	1382-1500	Late sown
Maya	130-134	39-40	2100-2200	Timely sown- irrigated
Narendra Rai	125	39	1300-1400	Irrigated
RGN-73	130-135	40	2000-2100	Irrigated
Swarna Joyati	123-130	39-40	1300-1400	Late sown- irrigated
Vasundra	130-140	38-40	2000-2200	Timely sown- irrigated
Pusa Mustard 27		40-45	1437- 1659	Early sown irrigated conditions and for multiple cropping
Toria				
JT-1	85-87	43	1500-1800	Irrigated

Cropping systems

Rapeseed-mustard crops fit well in various cropping systems, because of its low water requirement (80-240 mm). Cropping sequence with kharif crops such as bajra, urd bean, cluster bean, fodder crops are recommended. Rapeseed & mustard can be profitably intercropped with wheat, potato, barley, lentil and gram. The cropping systems suitable for Madhya Pradesh conditions are given in Table 2 and 3.

Table 2. Rapeseed-mustard based cropping systems

Growing condition	Cropping sequence
Irrigated	*Kharif* fodder – mustard
	Bajra – mustard
Rainfed	Bajra + black gram – mustard
	Pearl millet + cluster bean (as fodder) - mustard
	Fallow – mustard
	Black gram - mustard
	Cluster bean (green manuring) – mustard

Table 3. Rapeseed-mustard based intercropping systems

Intercropping combination	Row ratio	Condition
Wheat + mustard	9:1	Irrigated
Potato + mustard	3:1	Irrigated
Barley + mustard	6:1	Rainfed
Lentil + mustard	6:1	Rainfed
Gram + mustard	3:1	Rainfed

Agronomic management

Tillage and seed bed preparation

Deep ploughing during summer should be done, which helps to destroy pests. Under irrigated condition, first ploughing should be done with soil turning plough followed by 3 to 4 harrowing or ploughing and planking after every ploughing. Pulverize the soil, using cultivator before sowing. Under rainfed condition, disc harrowing should be carried out after effective shower in monsoon to conserve soil moisture. Pulverize the soil, using cultivator before sowing. Apply 25 kg/ha of 1.5 % Quinalphos dust at the time of final ploughing to minimize the problem of soil inhabiting insects.

Pulverizing the soil

Seeding time

It should be ensured that crop is sown when the maximum daytime temperature is not more than 320C, which is essential for proper germination of the seeds. In Rajasthan, under rainfed conditions, Indian mustard can be sown from 15th September to 15th October. The recommended period of sowing for normal sown irrigated crop is the month of October and the late sown crop can be planted as late as first week of November. Toria can be sown up to 7th September and Taramira can be sown from 25th September to 15th October.

Seed rate and spacing

In general, the optimum seed rate is 4-5 kg/ha with a spacing of 45 x 10-15 cm, when Indian mustard is grown under rainfed conditions. In late sown situations, closer inter row spacing of 30 x 20 cm is recommended. In timely sown situations, Indian mustard crop grown under irrigated conditions, 30 x 10-15 cm is recommended.

For Taramira, 30 x 10-15 cm is recommended. A seed rate of 5 kg/ha is to be adopted for Taramira. Line sowing using seed drills gives higher yield when compared to broadcasting of seeds.

Seed treatment

Prophylactic seed treatment is one of the low-cost technologies which can contribute to higher productivity of rapeseed-mustard crop. The recommended chemicals along with dosages for seed treatment are as follows:

Recommended seed treatment of rapeseed-mustard

Fungicide	Dose (g/kg seed)	Disease
Apron SD 35	6.0	White rust and Downy mildew
Carbendazim	2.0 – 2.5	*Sclerotinia stem rot*
Captan or Mancozeb	3.0 – 4.0	Root rot and Wilt

Seed should also to be treated with *Azotobactor* + PSB each @ 250 gm/5kg seed.

Thinning and interculturing

To keep an optimum plant population per unit area and uniform plant growth, thinning operation by removing the extra plants should be done at 15 to 25 days after sowing.

Manure and fertilizers

The requirement of fertilizer varies with the soil type, status of irrigation and species being grown. Keeping in view, the diversity in the nature of soil, cropping sequence and agro-climatic conditions, the application of fertilizers should be done based on regular soil testing,

which can help in determining the exact fertilizer dosage. The general recommendation of fertilizers for Madhya Pradesh is given below.

Table 5. Recommended dosage of fertilizers for rapeseed-mustard

Crop	Irrigated condition (kg/ha)			Rainfed condition		
	N	P	K	N	P	K
Mustard	60-80	30-40	0	30-40	20	0
Taramira	-	-	-	20-40	15	0

Apply half of the recommended dose of N as basal at the time of sowing preferably through drilling at least 5.0 cm below the seeds for proper absorption. The remaining half should be applied by top dressing before the first irrigation and necessarily before flowering. Best nitrogen use efficiency can be obtained by combining soil application with the foliar application of 20 kg N/ha (concentration of urea < 2 %) at 30-35 days after sowing.

Apply full dose of phosphorous (P2O5) as basal application at the time of sowing of irrigated crop. If the soil test values indicate deficiency of potash (K), apply the full dose of potash at the time of sowing under irrigated condition.

Biofertilizers

Nitrogen fixing bacteria (Azotobacter), Phosphate solubilizing bacteria (PSB) and Mycorrhizae are the most commonly used bio-fertilizers which are recommended for rapeseed-mustard. Use of Azotobacter can reduce the nitrogen requirement up to 25-30 kg/ha provided bacterial strain is efficient and soil is rich in organic matter. The PSB and Mycorrhizae are important to increase P uptake and dry matter yield at lower level of applied P.

Sulphur and micronutrient management

Sulphur is important for oilseed crops and it helps in increasing the oil yield and is recommended @ 40 kg/ha for deficient soils under irrigated condition. Sulphur requirement can be met by applying single super phosphate or gypsum.

In soils deficient in boron and zinc, application of boron @ 1 kg/ha and zinc sulphate @ 25 kg/ha is recommended at the time of sowing. Basal application of 20 kg ferrous sulphate/ha with or without organic material is recommended for alkaline-calcareous soils. For rainfed crop, apply full dose of recommended nutrients at the time of sowing. Apply gypsum @ 200 kg/ha as basal dressing if single super phosphate is not used as the source of P.

Weeding and interculture

The critical period of crop-weed competition in rapeseed-mustard has been identified from 15

to 40 days after sowing. An integrated approach combining cultural practices, preventive measures and chemical control should be adopted for ensuring proper control of weeds in the field.

Use weed-free seed, well-decomposed manure, clean machinery/ implements, remove weeds near irrigation ditches and fencerows and restricting livestock movement are the preventive ways of weed management. Tillage, crop rotation, soil solarization, maintenance of optimum plant population, optimum planting date, optimum planting geometry, use of 'live mulches' or smother crops, intercropping, nutrient and water management are the cultural method of weed management.

- Fluchloralin @ 1.0 kg/ha as pre plant incorporation or Pendimethalin @ 1.0 kg/ha as pre-emergence or Isoproturan (75 WP) @ 1.0 kg /ha as per-emergence or post-emergence at 25-30 DAS are recommended.
- Manual and mechanical methods (hand weeding and hoeing) are still the most commonly used methods for weed control in mustard cultivation.
- In Madhya Pradesh two hand weedings; 15-20 DAS and 35-40 DAS are recommended for proper weed control.

Broomrape (Orobanche aegyptiaca)

Orobanche aegyptiaca species of broomrape, a total root parasite is endemic in India and is found in many states including Madhya Pradesh.

Management

- Deep summer ploughing may cause desiccation of the seeds of the parasite and places the seeds below the root zone, which prevents the germination of the parasite. Further, the dry heat exposure may destroy the seeds of the parasite and considerably reduce their viability. However, as the broomrape seeds remain viable in the soil for up to 20 years, deep ploughing may not be effective in the long run.
- Trap crops are the non-host plants that can stimulate the germination of broomrape seeds but they themselves are not parasitized. Some of the trap crops are sorghum, pearl millet, maize, chilli, castor, sesame, niger, soybean, linseed, amaranthus, turmeric, greengram, horsegram, cowpea, redgram, blackgram, lucerne and sunhemp. These trap crops reduces the soil seed bank of the parasite considerably. Taking sorghum or pearl millet as preceding crop of mustard can reduce its infestation.
- Soil solarization by using 0.1 mm thick transparent polyethylene sheet for a period of 40 days during summer effectively controls this weed. Solar heating is achieved by covering pre-irrigated fields with transparent polyethylene sheet. This technique results in heating the covered soil by 8-14°C more than the uncovered soil. This method is however, costly due to the high cost of polyethylene

- Soil fumigation with methyl bromide (350 kg/ha) prior to planting provides effective control of broomrape.

Glyphosate, a foliage-applied, nonselective herbicide, has proved very effective against broomrape without causing any adverse effects on the crop when used as directed spray at very low rates (60-200 g/ha).

Intercultural operations should be done 20-25 das of the crop. Weeding should be done either along with thinning or immediately after thinning. Mechanical weeding using double wheel hand hoe is recommended since manual weeding with traditional Khurpi is time consuming and expensive. Mechanical weeding also improves the aeration of the soil.

Irrigation management

Rapeseed mustard crop requires about 190-400 mm of water. Proper scheduling of irrigation is important to ensure optimum water use efficiency. In Madhya Pradesh, two irrigations are recommended for Indian mustard. These irrigations are to be given at 30-40 DAS and 70-80 DAS. For Taramira, first irrigation is to be given at 45-50 DAS and the second irrigation should be given during the pod filling stage. In areas of limited irrigation or where the quality of irrigation water is low only the first irrigation is advisable.

Crop Protection

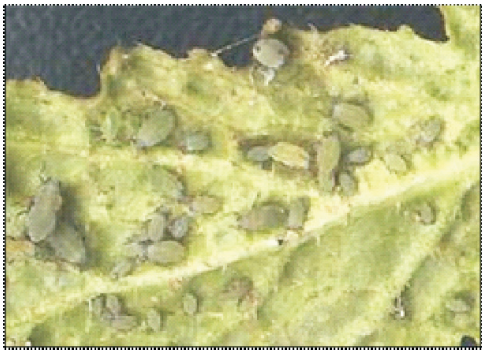
Insect pests and their management

Insect Pests and Nature of damage	Management
Mustard aphid *(Lipaphis erysimi)* Mustard aphid (both nymph and adult) feeds on different parts of the plants (inflorescence, leaf, stem, twig and pods) by sucking the cell sap. In cases of heavy infestation, the entire plant can dry up and lead to seed yield losses. The aphid secretes honeydew, which is responsible to the growth of black fungus called "Sooty Mould" which hinders the photosynthesis in the plant.	• Grow improved and early maturing varieties of Indian mustard (Brassica juncea) as they are fairly tolerant to mustard aphid and have more yield potential than rapeseed (Brassica campestris). • Early sowing of the crop (before 15th October) can help the crop to avoid the infestation by mustard aphid. • Use the recommended fertilizer dose as excess nitrogen application induced crop growth attracts more aphids • Monitor the crop field, especially during the month of December and January, when the chances of infestation and

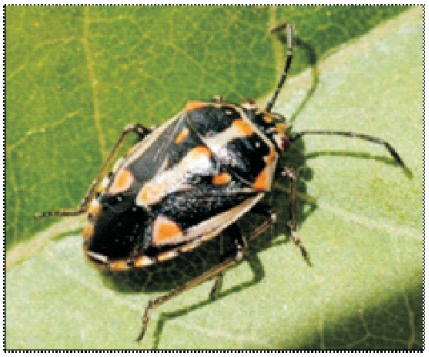
Insect Pests and Nature of damage	Management
	resultant yield losses remain high. Pluck and destroy infested twigs 2-3 times at 10 days interval during this period to prevent the multiplication of aphids. • Apply chemical control when the aphid population reaches the economic threshold level (ETL). Generally, ETL is reached when 26-28 aphids per 10 cm of central shoot is observed in at least 10 per cent of the plant population. • Spray Dimethoate (1.7 ml/l) or Oxydemeton-methyl (1.7 ml/l) or Thiamethoxam (0.1 g/l) or Malathion (1ml/l) or Chlorpyrifos (1 ml/l). Spray in the evening hours to avoid toxicity to insect pollinators.
Painted bug *(Bagrada cruciferarum)* Adults and nymphs suck the cell sap from the leaves, shoot and pods. The infestation in the two-leaf and vegetative stage results in whitening of leaves then wilting leading to complete drying of the tender shoot/plant. The infestation at maturity results in curling of pods and shriveling of grains.	• Clean cultivation by weeding, hoeing and destroying of debris in and around the field. • Apply first irrigation 3-4 WAS of the crop. • Seed treatment with Imidacloprid 70 WS @ 7g/kg of seed. • Spray Imidacloprid (0.2 ml/l) or Dimethoate (1 ml/l) or Dichlorvos (0.7 ml/l) or Malathion (1 ml/l). • Apply Phorate granules (15 kg/ha). If the problem is endemic, apply the chemical before sowing along with the last ploughing. • Harvest the crop at appropriate time (75% pod have golden yellow colour) and thresh as early as possible to avoid the further losses.

Insect Pests and Nature of damage	Management
Mustard sawfly *(Athalia lugens proxima)* The larvae make irregular holes in the leaves. Grown up larva feed from the margin of leaf and in severe infestation the crop looks as grazed by animals.	• Clean cultivation by weeding, hoeing and destroying of debris in and around the field. • Timely irrigation helps in killing the larvae through drowning. • Seed treatment with Imidacloprid 70 WS @ 7 g/kg of seed. • Spray Malathion (1 ml/l) or Dimethoate (1.7 ml/l) or Quinalphos (2 ml/l).
Bihar hairy caterpillar *(Spilarctia obliqua)* The caterpillars remain gregarious underneath leaves in early stages and feed on chlorophyll content from the margin of leaves and make them almost transparent and gradually defoliate the entire plant. Grown up larvae migrate to other plants in the field and feed voraciously leaving only the stem.	• At the initial stages destroy the gregarious phases of caterpillar through hand collection, which is effective and eco-friendly. Collect the infested leaves and dip them in kerosene or insecticide treated solution. • At heavy infestation, spray the crop with Malathion 50 EC @ 2 ml/l. • Dust the border of fields with Quinalphos 1.5% dust to check the spread of larvae.
Pea leaf miner *(Chromatomya horticola)* Maggots mine the leaf and a larger number of silvery zig-zag mines appear due to the feeding on the parenchyma tissues. The heavily infested leaves become yellow and fall down affecting the yield adversely. Its damage is more conspicuous on the older leaves.	• Pluck the infested leaves and bury them to kill the maggots and pupae resting inside. • Spray Dimethoate (1.7 ml/l) or Oxydemeton- methyl (1.7 ml/l).
Diamond back moth *(Plutella xylostella)* Larva makes tunnel and holes in the leaves and feed on the mesophyll.	• Collect and destroy pest infested leaves. • In cases of severe infestation, spray the crop with Malathion (2 ml/l).

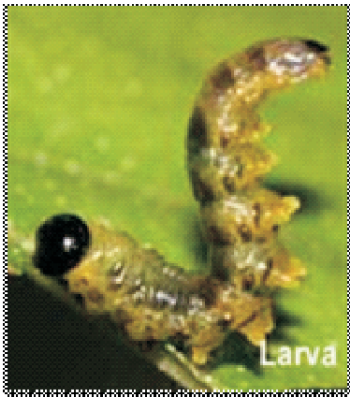
Insect Pests and Nature of damage	Management
Termite *(Odontotermus obesus)* Termites attack the Brassica crops very severely all over the country, especially under rain-fed conditions. Infested plants initially turn yellow and finally dry due to extensive root damage.	• Use only well decomposed farmyard manure. • Destruction of plant debris in and around the fields. • Frequent irrigation helps in reduction of termite infestation. • Application of Chlorpyriphos (4 l/ha) during last ploughing and properly mixing in soil minimizes termite infestation.



Mustard aphid



Painted bug



Mustard sawfly

Bihar hairy caterpillar

Pea leaf miner

Diamond back moth

Insect pests of rapeseed-mustard

Plant protection

Insect-pests management

Diseases and nature of damage	Management
Alternaria blight or leaf spot *(Alternaria brassicae)* The disease is characterized by the formation of prominent, light brown to black round spots with concentric rings of various sizes on leaves, stem and siliquae leading to subsequently blighting and defoliation. At maturity, round to linear black spots appear on siliquae and stem of toria, yellow and brown sarson and brownish black spots with a distinct gray centre on mustard siliqua, which later elongate. The seeds in the siliqua may become small, shriveled and rotten.	• Timely sowing (by the first fortnight of October) of healthy and certified seeds. • Collect and burn the diseased plants debris and remove weeds to minimize the spread. • Spraying of Iprodione or Mancozeb (Dithane M-45) @ 2.5 g/l of water at 15 days interval with a maximum of three sprays, normally at 45, 60 and 75 DAS. • Avoid irrigation at pod formation stage.
White rust *(Albugo candidaAlbugo candida)* Small white or creamy yellow raised pustules, which later coalesce to form patches, are found scattered on the lower surface of the leaves. The part of upper surface corresponding to the lower surface is tan-yellow, which enable recognition of the affected leaves. Affected	• Timely sowing (before 15th October) of healthy and certified seeds from stag head free plants. • Treat the seed with metalaxyl (Apron 35 SD) @ 6 g/ kg seed or Thiram @ 2.5 g/kg seed. • Collect and burn the diseased plants debris including stag heads and remove

Diseases and nature of damage	Management
flowers become malformed, petals become green like sepals and stamens may be transformed to leaf-like club-shaped sterile structures.	weeds to minimize the spread. • Spray the crop (maximum three sprayings) with ridomil MZ 72 WP or mancozeb (Dithane M-45) @ 2.5 g/l of water soon after the disease appearance at 15 days interval. • Avoid irrigation at pod formation stage.
Downy mildew *(Peronospora parasitica)* The disease usually appears 10-15 DAS as small creamy white spots on the leaves in the seedling stage. White downy (cottony) growth of the fungus appears on leaves and spread to stems and stag heads formed by white rust pathogens. Swollen malformed floral parts usually show mixed infection of downy mildew and white rust.	
Powdery mildew *(Erysiphe cruciferarum)* Dirty white, circular powdery patches develop on leaves, stems and pods. As the disease advances, the whole plant looks to be dusted with powder like white talcum. The severely affected plants remain poor in growth and produce less siliquae. Severely diseased siliquae remain small in size, produce seeds, which are small in size and show shriveling. Such siliquae produce few seeds at the base with twisted sterile tips.	• Timely sowing (by the first fortnight of October) and avoid late sowing. • Collect the crop debris of previous season and destroy them. • Spray of Dinocap 1.5 g/l or wettable sulphur 2.5 g/l of water at the incidence of the disease. If required, repeat the spray at 15 days interval.
Sclerotinia rot *(Sclerotinia sclerotiorum)* Symptoms on the stem become visible as elongated water-soaked lesions, which later on are covered by a cottony mycelial growth of the pathogen. When the stem is completely girdled by such lesions, the plant wilts and dries. When the crop is at maturation stage, the affected plants tend to lodge, bringing the	• Collection and burning of the diseased plants along with sclerotia. • Deep ploughing during summer. • Follow crop rotation with non-host crops like wheat, barley and maize • Sowing of healthy seeds free from the sclerotial bodies. • Spray Carbendazim (Bavistin) @ 1.5 g/

Diseases and nature of damage	Management
siliquae in contact with soil. Such plants, though remaining free from stem or aerial infection throughout, show rotting of the siliquae with profuse fungal growth, along with sclerotial bodies just above the soil level. Appearance of the disease in an early stage of crop growth, results in damping-off or the death of whole plant.	1 twice at 50 and 70 DAS will reduce its infestation.
Bacterial rot *(Xanthomonas campestris)* The symptoms are visible when plants are about 60 days old and significant infection occurs in warm and humid weather. At initial stage, dark colour streaks develop on stem from the ground level, which girdle the stem and making it very soft and hollow due to rotting. The lower leaves show midrib cracking, browning of veins and withering. Profuse exudation of yellowish fluid from the affected stem and leaves may also occur.	• Follow 3-4 years crop rotation. • Spray carboxin or copper oxychloride @ 3 g/1. If required, repeat the spray at 15 days interval. • Collection and burning of the diseased plants and their residue.


Alternaria blight


Downy mildew


Powdery mildew


Sclerotinia rot

Diseases of Rapeseed-mustard

Harvesting and threshing

The crop should be harvested when 75% of pods turn to golden yellow in colour. At this stage, majority of seeds are firm when pressed between fingers. The oil content in the seed is the maximum at this stage. Harvesting during the green pod stage reduces the yield and oil content. The crop should preferably be harvested in the morning when the pods are damp

with night dew, which minimizes the shattering losses. For manual harvesting, use a sickle that is light in weight and easy to handle (example: Naveen sickle). After harvesting, the plants are made into bundles and stacked in the sun for 7-8 days before threshing. Threshing should preferably be done by using threshers. Threshing is followed by winnowing, where the seeds are separated from the straw. The seeds should be sun dried for approximately one week to reduce the moisture content. For safe storage, moisture content of seeds should be eight per cent. The grain should be dried under sun till reaches moisture to 10-12% .The seed, which is to be used for next season usually stored under low temperature and low humidity conditions, because of oil, bitterness may develop if stored for long time.

Realizable yield potentials

In Madhya Pradesh, under late sown conditions mustard yield potential is up to 1800 kg/ha. Under irrigated conditions, timely sown crop has high potential to give an yield of 2400 kg/ha. The adoption of improved technologies can enhance both yield and farm income in the State.

Performance of improved technologies of mustard in FLDs

The performance of improved production technologies under real farm situations under varied soil and farming conditions indicate improvement in yield to the extent of 12% with whole package and 13% with management of Sclerotinia disease. The corresponding additional net returns were `6308 and `4091/ha over the farmers' practices (Table 4).

Table 4. Performance of improved technologies of rapeseed mustard in FLD (2011-14)

Technology	FLD average yield (kg/ha)		Yield gap-I (%)	Cost of cultivation (Rs./ ha)		Gross returns (Rs./ha)		Additional net returns (Rs./ha)	B:C ratio	
	IT	FP		IT	FP	IT	FP		IT	FP
Improved variety	1866	1669	12	32162	32015	62561	56107	6308	2.2	1.9
Sclerotinia management	1967	1765	13	32728	30055	66305	59541	4091	2.1	2.0

Critical Do's and Dont's

1. Use recommended varieties for the region
2. Maintain weed free from 15 to 40 days after sowing and timely conrol of Orobanche.
3. When grown under saline conditions, use 25% higher seed rate with closer spacing.
4. Avoid irrigation at pod development stage.

SESAME

Sesame is the oldest oilseed crop its origin is in India. During 2013-2014, sesame was grown on an area of 16.67 lakh ha producing 6.75 lakh t with an yield of 405 kg/ha. Sesame seed contains approximately 50% oil of an excellent quality which is acclaimed for its medicinal qualities besides other commercial uses. Oil is used in a wide range of culinary items, confectionery and in the preparation of pickles and in a wide spectrum of culinary dishes. The crop is mainly cultivated in the states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, West Bengal, Andhra Pradesh, Karnataka and Maharashtra. Sesame being a short duration crop fits well in different cropping sequences. Being extremely sensitive to excess moisture, it is often damaged under water stagnation on heavy soils. The crop requires less fertilizer and is usually not severely damaged by pests. Actually the rabi-summer sown crop results in more than double seed yield than the traditional kharif crop because of less damage due to insect pests. Unfortunately, the crop is cultivated by resource-poor farmers, unable to invest on inputs under rainfed conditions.

Areas of cultivation

Sesame is widely grown in Chhatarpur, Datia, Tikamgarh, Gwalior, Sheopur Kalan, Panna, Shivpuri and Singroli districts of Madhya Pradesh.

Climate

Sesame is grown in almost all the states in large or small areas. It can be cultivated up to the latitude of 1600 m (India 1200 m). Sesame plant needs fairly high temperature during its life

cycle. The crop requires optimum temperature of 25 to 350C. If the temperature is more than 400C with hot winds, the oil content reduces. If the temperature goes beyond 450C or less than 150C there is a severe reduction in yield. The pollen becomes sterile at aberrant temperatures. The crop is very sensitive to excessive water in the field. Stagnation of water for long period in the standing crop will completely affect the crop.

Soils

Sesame can be grown on a wide range of soils, however well drained light to medium textured soils are preferred. It does best on sandy loams with adequate moisture. The optimum pH range is 5.5 to 8.0. Acidic or alkaline soils are not suitable.

Varieties

Sesame is highly sensitive to seasonal variation in terms of day length and temperature. Therefore, varieties recommended for commercial cultivation are location and season specific. Farmers preferred varieties in Madhya Pradesh are JTS-8, Jawahar Til -11, Jawahar Til -12, Jawahar Til -14, TKG-306 and TKG-308. The important characteristics of these varieties are given in the Table 1.

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Table 1. Varieties recommended for the State with salient features

Variety	Year	Seed yield (kg/ha)	Oil content (%)	Days to maturity	Salient characters
JTS-8	2001	650-700	50-53	82-85	White seed, capsules alternate, non-hairy, tolerant to Macrophomina, Alternaria leaf spot and Phytophthora blight.
Jawahar Til-11	2006	650-700	46-50	82-85	Dark brown seed, tolerant to Macrophomina.
TKG-306	2006	700-800	49-52	86-90	White seed, alternate capsule, leaves alternate, flower blue white hairy, capsules medium hairy and tolerant to Phytophthora, phyllody, Cercospora, Macrophomina, powdery mildew, and Alternaria leaf spot.
Jawahar Til –12	2008	700-750	48-52	82-85	White seed, tolerant to Macrophomina.
TKG-308	2008	700-750	46-50	85-90	White seed, tolerant to Phytophthora, Macrophomina, Cercospora, powdery mildew and Alternaria leaf spot.
Jawahar Til -14	2010	700-750	50-53	85-88	Black seed and tolerant to capsule borer.

Cropping systems

Sesame being a short duration crop fits well into a number of sequence and intercropping systems.

Sequence cropping

Sesame is a short duration crop and fits well into a number of multiple cropping systems either as a catch crop or as a sequence crop. Following are some of the common sequences followed in different regions.

- Sesame-wheat
- Cotton-sesame-wheat
- Rice-summer sesame

Intercropping

Yield and monetary returns from sesame are more when it is raised as pure crop rather than as a mixed/intercrop. However, in large parts, sesame is usually raised as a mixed/intercrop. Some of the popular and profitable intercropping systems followed in Madhya Pradesh are:

- Sesame + green gram/black gram (2:2 or 3:3)
- Sesame + soybean (2:1 or 2:2)

Agronomic management

Tillage and seed bed preparation

One or two ploughings followed by harrowing are recommended for pulverization and fine tilth required for good germination and plant stand. Keep the field weed free and perfectly levelled to avoid water logging to which sesame is highly sensitive.

Seed rate

A seed rate of 5 kg/ha is needed to achieve the required plant stand. Wherever seed drill is used, the seed rate may be reduced to 2.5 to 3 kg/ha from 5 kg/ha. For easy interculture and to realize higher yield adopt line sowing.

Sowing time and spacing

Spacing between and within the row depends on the specific variety, plant type and season. The optimum time of sowing and spacing recommended for Madhya Pradesh are given in Table 2.

Table 2. Optimum time of sowing and spacing

Season	Sowing time	Spacing (cm)
Kharif	First week of July	30 x 10-15
Semi-rabi	Late August- early September	30 x 15
Summer	Second to last week of February	30 x 15

Sowing method

In order to facilitate easy seeding and even distribution increase the bulk by mixing the seed with either sand or dry soil or well sieved farmyard manure in 1:20 ratio. Use seed drill or *deshi* plough with suitable attachment for line sowing. The optimum depth for seed placement is 2.5 cm. Avoid deep sowing or placement as it adversely affects germination and plant stand.

Seed treatment

Treat the seed with Thiram @ 2 g/kg + Carbendazim 1 g/kg or *Trichoderma viride* 5 g/kg seed to prevent seed borne diseases. Wherever bacterial leaf spot disease is a problem, soak the seed for 30 minutes in 0.025% solution of Agrimycin-100 prior to seeding.

Manures and Fertilizers

Apply 5 t/ha of well decomposed farm yard manure before last ploughing and incorporate it thoroughly in to the soil. Sesame responds well to inorganic fertilizers. The dose of fertilizers would however, vary depending on the variety, season, soil fertility status, previous crop, rain fall and soil moisture. The optimum doses of N, P and K recommended for Madhya Pradesh are :

Recommended doses of fertilizers

Situation	Recommended dose of N:P:K (kg/ha)	Specific recommendation
Rainfed Summer	40:30:20 60:40:20	Apply zinc sulphate 25 kg/ha once in three years in zinc deficient soils

Apply half the recommended dose of nitrogen and full dose of phosphorus and potash at the time of seeding. The remaining half of nitrogen may be top dressed at flower initiation i.e. 30-35 days after sowing. At the time of top dressing, there should be sufficient soil moisture or irrigate the field as in case of rabi-summer sesame.

Weeding and interculture

The critical crop weed competition period in sesame is up to 40 DAS. The crop is very sensitive to weed competition during the first 20-25 days. Two weedings, one after 15-20 DAS

and second at 30-35 DAS are required to keep the field weed free. For interculture, use hand hoes or bullock drawn blade harrow. Pre-plant incorporation of 1 kg a.i./ha fluchloralin or pre emergence application of 1 kg a.i./ha Pendimethalin followed by one hand weeding and hoeing at 30 days after sowing will effectively check weed growth.

Irrigation management

Sesame rarely receives any irrigation except, when raised during rabi-summer seasons. Protective irrigation will greatly benefit the kharif crop whenever there are prolonged dry spells. For rabi-summer crop give the irrigation, immediately after sowing to improve germination and plant establishment, if soil moisture conditions warrant. The subsequent irrigations may be given at an interval of 12-15 days depending on the soil type, weather conditions and season. For good seed filling and yield, irrigations at flower initiation and capsule formation are essential

Crop protection

Sesame is affected by number of insect pests and diseases at different crop stages. Appropriate control measures should be taken up to reduce yield losses. Major insect pests and diseases, their characteristic symptoms and measures recommended for their management are furnished below.

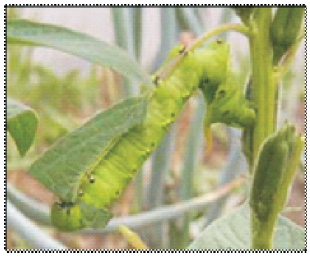
Insect pests and their management

Insect Pests and Nature of damage	Management
Leaf roller and capsule borer or leaf webber *(Antigastra catalaunalis)* In early stage of crop, caterpillars feed on tender leaves and remain inside the leaf web. At flowering, larvae feed inside the flowers and on capsule formation, larvae bore into capsules and feed on developing seeds.	• Crop rotation is very effective in reducing pest population. • Early sown (first week of July) kharif crop is less infested than late sown crop. • Removal of larvae from the leaf webs during the initial stages of plant growth and destroy them. • Inter cropping with cowpea, pigeonpea, pearl millet, mungbean, urdbean and moth bean proved to be more effective than sole crop. • Install 40-50 bird perches/ha. • Spray Quinalphos (2 ml/l) or Profenofos (2 ml/l) or Triazophos (1 ml/l) or Spinosad (0.2 ml/l) or dust Carbaryl (25 kg/ha).

Insect Pests and Nature of damage	Management
Gall fly *(Asphondylia sesami)* Maggots feed inside the floral bud leading to formation of gall like structure which do not develop into flower/capsule. The affected buds wither and drop.	• Clipping of the galls, picking and burning the shed buds may help as prophylatic measure. • Spray Dimethoate (1.7 ml/l) or Quinalphos (2 ml/l) or Dichlorvos (0.7 ml/l) or Imidacloprid (0.3 ml/l) at bud initiation stage.
Bud fly *(Dasynura sesami)* Maggots feed inside the floral bud leading to formation of gall like structure which do not develop into flower/capsule. The affected buds wither and drop. Maggots feed inside the floral bud leading to formation of gall like structure which do not develop into flower/capsule. The affected buds wither and drop.	• Spray Dimethoate (1.7 ml/l) or Quinalphos (2 ml/l) or Dichlorvos (0.7 ml/l) or Imidacloprid (0.25 ml/l).
Sesame leafhopper *(Orosius albicinctus)* Nymphs and adults suck the sap of tender parts of the plants. The jassid of leaf hopper is a serious pest of sesame and is known to transmit phyllody disease.	• Seed treatment with Imidacloprid or Thiamethoxam (5 g/kg of seed). • Spray Dimethoate (1.7 ml/l) or Oxydemeton methyl (2 ml/l) or Dichlorvos (0.7 ml/l) or Imidacloprid (0.3 ml/l).
Hawk moth *(Acherontia styx)* Caterpillars feed on the leaves and defoliates the plant.	• Deep ploughing exposes the pupae for birds. • Collection and destruction of caterpillars. • Dust Phosalone 4% or Malathion 5% dust (25 kg/ha).
Bihar hairy caterpillar *(Spilarctia obliqua)* In the early stages, larvae are gregarious feeders and are concentrated on few plants. Mature caterpillars migrate to other plants and feed voraciously leaving only the stem.	• Destroy egg masses and young larvae during gregarious phase. • Spray NSKE 5% or Azadirachtin 0.03% (5 ml/l) or Dicholrvos (0.7 ml/l) or Profenofos (1 ml/l) or Quinalphos (2ml/l) or Chlorpyriphos (2.5 ml/l) or Triazophos (1.5 ml/l).


Leaf webber


Gall fly


Hawk moth


Bihar hairy caterpillar

Insect pests of sesame

Diseases and their management

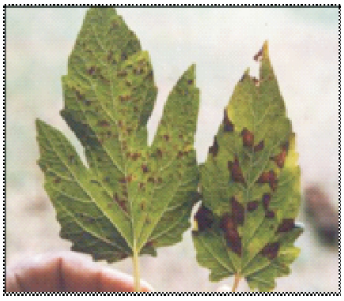
Diseases and nature of damage	Management
Phytophthora blight *(Phytophthora parasitica)* Initially water soaked spots appear on leaves and stem. The spots are brown in beginning, later turn to black. In humid weather severity of disease increases and causes death of plant and give blighted appearance. Disease appears stage: Seedling to flowering stage.	• Deep ploughing in summer Improve drainage two years crop rotation. • Use disease free seed. • Sesame + pearl millet (3:1), intercropping should be followed. • Seed treatment before sowing with Thiram (0.2%) + Carbendazim (0.1%) 3g/kg seed or Apron 35 SD (0.3%) or Ridomil Mz (0.25%) or Trichoderma harzianum or T. viride or Bacillus subtilis (0.5%). • For root/stem infection, 2-3 times drench soil with Kavach (0.25%) or Ridomil Mz (0.25%) at 7 days interval • Spray crop three times with Ridomil Mz (0.25%) or Copper oxychloride (0.25%) alternately at an interval of 10 days from the initiation of disease.
Stem and root rot *(Macrophomina phaseolina* Disease appears on root and stem. The affected plants show wilting. At ground level stem becomes black which extends upward rupturing the stem. Black dots appear on the	• Two years crop rotation . • Deep ploughing in summer. • Use disease free seed. • Follow intercropping sesame + mothbean 1:1or 2:1 ratio.

Diseases and nature of damage	Management
infected stem, which are the pycnidia of the fungus. If wilted plant is uprooted, black coloured roots are observed having sclerotia of the fungus and looks as charcoal is sprinkled on the root. The roots become brittle.	• Treat the seed with T. viride or T. harzianum or Bacillus subtilis (0.5%) or Thiram 75 SD (0.2%) + Carbendazim (0.1%) 3g/kg seed or Thiram 75 SD (0.3%). • Uproot and destroy the infected plants • On appearance of the disease, drench soil with Thiram + Carbendazim (1: 1)
Bacterial blight *(Xanthomonas campestris pv.sesami)* Water soaked; small and irregular spots are formed on the leaves, which later increase in number and turn brown, under favorable conditions, severely infected leaves defoliate. Later, the spots are formed on the twigs, which bear poor capsules. Disease appears stage: Spots appear from 4-leaf stage of the crop and continue till maturity.	• Seed treatment with hot water at 52ºC for 10 minutes, • Steep the seed in Agrimycin-100 (250 ppm) or Streptocycline suspension (0.05%) for 30 minutes. • Foliar spray of Streptocycline (500 ppm) + Copper Oxychloride 0.25% as soon as symptoms are noticed. Continue alternately two more sprays at 15 days interval if necessary.
Bacterial leaf spot *(Pseudomonas syringae pv.sesami)* Small angular light brown to brown spots confined to veins with dark margins. In high humidity and temperature the spots increase and coalesce. The disease may advance along with veins and petiole and defoliation may occur. Disease appears from 4-6 leaf stage of the crop and continue till maturity	• Early planting i.e. immediately after onset of monsoon. • Follow intercropping of sesame + pearl millet (3:1). • Treat the seed with Thiram (0.2%) + Carbendazim (0.1%) 3 g/kg seed. • Three sprays of Indofil M 45 (0.25% + Carbendazim (0.1%) or Topsin M (0.1%) alternatively at 15 days interval.
Cercospora leaf spot *(Cercospora sesami)* Disease appears as small, angular brown leaf spots with gray center and dark margin delimited by veins. In severity of the disease, defoliation occurs. In favorable conditions the	• Treat the seed with Thiram (0.2%) + Carbendazim (0.1%) in 1:1 ratio • Spraying with Indofil M 45 (0.25%) + Carbendazim (0.1%) or Topsin M (0.1%) at 15 days interval when disease appears.

Diseases and nature of damage	Management
disease spreads to leaf petiole, stem and capsules producing linear dark coloured deep seated lesions. Disease appears at 4-6 leaf stage of the crop and continues till maturity.	
Alternaria leaf spot *(Alternaria sesami)* Spots on leaves are brown circular to irregular in shape and often have concentric rings. Disease appears as spots, when the crop is nearly one month old.	
Powdery mildew *(Oidium sp, Sphaerotheca sp., Leveillula sp.)* Small cottony spot appears on the infected leaves, which gradually spread on the lamina. Defoliation of severely infected plant occurs before maturity. Disease appears at 45 days to maturity.	• Early planting i.e. immediately after onset of monsoon. • Follow intercropping system of sesame + pearlmillet (3:1). • Two to three foliar spray of wettable Sulphur (0.2%) or Carbendazim (0.1%) or Tilt (0.1%) or Karathane (0.1%) alternately at 10 days interval.
Phyllody *(Phytoplasma)* All floral parts are transformed into green leafy structures. Infected plant is conspicuous by its stout internodes, abundant abnormal branching which cause top portion to bend down, such plants generally do not bear capsules. Disease appears at vegetative growth and flowering stage.	• Rogue out diseased plants. • Delay in planting of sesame about 3 weeks after onset of monsoon. • Follow intercropping, sesame + pigeon pea (1:1) • Soil application of Phorate 10 kg/ha. • Three sprays of Neem oil (0.5%) or Dimethoate (1.7 ml/l) at 30, 40 and 60 DAS to control the insect vector transmitting the disease.

Phytophthora blight

Stem and root rot



Bacterial blight

Cercospora leaf spot

Powdery mildew

Phyllody

Diseases of sesame

Harvesting, threshing and drying

The best time of harvesting is when the leaves turn yellow and start drooping while the bottom capsules are lemon yellow. Do not postpone harvesting and do not allow the crop to dry completely in the field because such practice leads to losses due to shattering. Usually the crop is threshed by gentle beating of well dried plants with sticks.

Performance of improved technologies in farmers' field through FLDs

Assessment of improved production and protection technologies on rapeseed-mustard under real farm situations through front line demonstrations clearly indicate the benefit in terms of improved yield up to 127% with additional net returns of up to ` 16,375/ha over the farmers practice (Table 3).

Table 3. Performance of improved technologies of sesame in FLDs (2011-14)

Technology	No. of FLD	Average yield (kg/ha)		Increase in IT over FP	Cost of cultivation (Rs./ ha)		Gross net returns (Rs./ha)		Additional net returns (Rs./ha)	B:C ratio	
		IT	FP		IT	FP	IT	FP		IT	FP
Whole package	20	625	275	127	10000	7650	35125	16400	16375	3.7	2.1
Improved variety	10	460	241	91	9600	7450	25825	14140	9535	2.8	1.9
RDF	10	424	233	82	8950	6950	22635	12945	7680	2.6	1.9
Plant protection	10	406	233	75	9300	6900	23165	13550	7215	2.6	2.0

Critical Do's and Don'ts

- Use recommended varieties for the region especially of duration and disease resistance.
- Treat seed with fungicides and Azospirillum + Azotobacter before sowing.
- Control weeds up to 25-35 DAS.
- Protective irrigation during flowering and pod filling period increases yield significantly.
- Harvest at proper time early in the morning.

GROUNDNUT

India is the second largest producer of groundnut after China in the world. Groundnut is the most important oilseed crop in India, and grown in an area of 5.52 m ha with a production of 9.67 m t and productivity of 1750 kg/ha (2013-14). It is an important source of edible oil and vegetable protein. Cultivation of this crop is mostly confined to Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh and West Bengal.

Areas of cultivation

Groundnut is extensively cultivated in Shivpuri, Tikamgarh, Barwani and Chindwara districts of Madhya Pradesh. The other districts where groundnut is grown in the State are Chhatarpur, Betul, Jhabua, Khargaon, Datia, Dhar, Neemach, Khandwa, Mandseur, Seoni, Rajgarh and Sagar.

Climate

Warm and moist conditions are highly congenial for groundnut cultivation. Cool and wet climate delay the germination and seedling emergence, and thus enhance the risk of seed rot and seedling diseases. Optimum temperature for different critical stages ranged from 25 to 35°C.

Soils

Groundnut can be grown on all type of soils such as sandy, sandy loam and heavy black soils. Most suitable soils for groundnut production are well-drained, light-textured, loose sandy-

loam or sandy clay loam soils with good drainage, having reasonable high calcium, pH 5.5 to 7.0 and moderate organic matter. Soils having pH less than 5.5, need to be corrected by furrow application of lime @ 2 t/ha.

Varieties

Selection of suitable variety for the specific situation is important factor in realizing higher seed yield. The recommended varieties for Madhya Pradesh are given in Table 1.

Table 1. High yield recommended varieties for the State

Variety	Year of release	Seed yield (kg/ha)	Oil content (%)	Salient features
JAK-159	2002	1606	51	Early maturity (105-110 days), recommended for kharif season
TPG-41	2004	2008	49	Moderately resistant to rust, bold seeded (HSM > 60 g), high O/L ratio, recommended for kharif
TG-37A	2004	1900	48	Tolerant to collar rot, rust and late leaf spot (LLS), suitable for both kharif and rabi-summer seasons, possess fresh seed dormancy up to 15 days
Vikas (GPBD-4)	2004	1900-2200	49	Resistant to LLS and rust, recommended for kharif
Prutha (Dh-86)	2005	4022	48	Tolerant to LLS and sucking pests, suitable for and rabi-summer seasons
GG-8 (J-53)	2006	1716	46	Moderately tolerant to PBND, collar rot and stem rot
Jawahar groundnut (JGN-23)		2009	1631	49 Tolerant to ELS and LLS, drought tolerant recommended for kharif season
Mallika (ICHG-00440)	2009	2579	48	Resistant to collar rot and PBND, bold seeded (HSM = 73 g), recommended for kharif season
ALG-06-320	2011	3500	49	Recommended for Southern Madhya Pradesh, suitable for rabi-summer

Tillage

Field preparation for groundnut depends on the soil type and onset of monsoon for rainfed crop and the previous crops grown for irrigated crop. The soils are usually ploughed twice with the summer rains or after application of irrigation water for winter/summer sowing followed by two to three harrowings and pulverizing well to obtain a good tilth for optimum germination. Optimum depth of ploughing is 15 -20 cm. Summer ploughing is advantageous to kill weed seeds and hibernating insects and disease organisms by exposing them to the heat of summer. In terrace and flat lands of high rainfall areas, raised beds of 10-15 cm height are to be prepared to avoid water-logging.

Seed treatment

Groundnut pods for seed purpose are shelled either by hand or by using hand decorticator about a week in advance of sowing. The viability of seed will be lost if shelled long before seeding. After and during the shelling split or damaged, shriveled immature and infected seeds should be removed and only well-filled seed should be used for sowing. Treat the seed with mancozeb or carbendazim @ 2-3g/kg kernel to control seed borne diseases. The seed can also be treated with Trichoderma viride @ 10 g/kg seed or it can be applied @ 10 kg/ha as soil application. To prevent the seed damage from soil insects at initial stages, depending upon per cent infestation chloropyriphos @ 12.5-25 ml/kg seed can be used. Spreading and semi-spreading groundnut varieties have fresh seed dormancy, which usually require a resting period of 60-70 days. Dormancy can be broken by exposing seeds to ethrel solution of 250 ppm. Bunch type varieties can be used immediately after harvest for sowing. Further, treat the seed with suitable Rhizobium and PSB cultures.

Sowing time and sowing

Groundnut is mainly grown during kharif and rabi seasons in Madhya Pradesh. Kharif groundnut is sown from June to November and rabi groundnut is grown from November to April. Groundnut is also grown as irrigated crop during January to May/June as summer crop in some parts of Madhya Pradesh. Groundnut is generally sown on flat beds. Some of the improved methods to get higher yield over the conventional method are given below.

1. Criss-cross sowing

Criss-cross method can improve yield by about 18% as compared to conventional sowing by maintaining uniform distribution of seed and optimum number of plants/unit area. The seed rate used in this method is same as in conventional method. In this method, total seed lot is divided into two equal halves; first half of the seed is sown in one direction adopting 30 cm spacing between rows and then the remaining half in the perpendicular direction with the same spacing.

2. Broad-bed and furrow method (BBF)

BBF method is useful in areas having deep Vertisol with high rainfall. This system consists of raised beds of 1.2 m width and 15 cm height with two furrows of 30 cm width on either

side. Each raised bed would accommodate four rows with 30 cm spacing between rows. On an average, 15% higher yield of groundnut has been reported from the medium black soil over the flat bed.

3. Ridge and furrow method

Groundnut is generally sown on flat beds using a seed drill but sowing on either sides of the ridge helps the plants to prevent from come in direct contact with the excess water. Furrows are more advantageous as they increase moisture recharge in the soil by collecting water and simultaneously help in draining away excess water.

Criss-cross sowing

Broad-bed and furrow method

Ridge and furrow method

Hand weeding

Seed rate and spacing

The seed requirement of bunch type groundnut is 100-110 kg/ha and for semi-spreading and spreading varieties is 95-100 kg/ha.

Spacing for bunch type varieties is 30 cm x 10 cm to achieve a plant population of 3.33 lakh/ha. Spreading varities, the most common spacing recommended is 45 cm x 10 cm or 30 cm x 15 cm to achieve a plant population of 2.22 lakh/ha in rabi/summer groundnut.

Cropping systems

Intercropping

The most important cereal intercrops grown with groundnut are bajra, sorghum and maize. The other long duration crops suitable for intercropping with groundnut are red gram, cotton, castor and cassava while short duration crops are sesame, cowpea, green gram and black gram. The important intercropping systems for Madhya Pradesh are groundnut + pearl millet and groundnut + sesame.

Crop sequences

In general, groundnut should be rotated with cereals like pearl millet, sorghum, maize, wheat, rice or other minor millets. This will check the buildup of pests, white grubs, nematodes, soil borne diseases, leaf spots and also maintain soil fertility. In Madhya Pradesh, groundnut–barley/mustard crop sequence is popular sequence in residual soil moisture situations.

Promising crop sequences recommended

Rainfed (Monocropping) two years	Residual moisture (Double cropping in one year)	Irrigated (Double or triple cropping in one year)
Groundnut-pearl millet	Groundnut-barley Groundnut-mustard	Groundnut-wheat-green gram Groundnut-wheat
One year	Groundnut-mustard	

Weed management

Weeds cause much damage to the groundnut crop during the first 35 days of its growth. The most critical period of weed competition is from 3-6 weeks after sowing. The average yield loss due to weeds is about 45%. When once pegging begins (40 DAS), there should not be any disturbance to pegs through manual or mechanical weeding. Important weed floras in the groundnut crop are *Amaranthus viridis* (JangliChaulai), *Boerhaavia diffusa* (Vishakhapra), *Cyperus rotundus* (Motha), *Cyperus esculentus* (Yellownutse), *Cynodon dactylon* (Doob grass), *Digera arvensis* (Laksha), *Convolvulus arvensis* (Hiran)

Anagallis arvensis (Krishnane), *Desmodium trifolium* (Tinpatia), *Commelina benghalensis* (Kaa), *Celosia argentea* (White cock's comb) and *Portulaca oleracea* (Pig weed).

Manures and fertilizers

Integrated nutrient management involving use of organic manures, residues and inorganic fertilizer is beneficial. Apply farm yard manure @ 10 t/ha before sowing. Always apply fertilizers based on soil analysis. Generally black soils contains high potassium, therefore potassium requirement tends to be very less. The general recommendation of NPKS is 20:60-80:20:20.

Promising crop sequences recommended

Herbicide	Dose (kg a.i./ha)	Time of application
Pendimethalin	1.0-2.0	Pre-emergence
Oxyfluorfen	0.25-0.50	-do–
Quizalofop ethyl	0.050	Post-emergence
Imazethapyr	0.050	-do-

Water management

Groundnut crop is mostly cultivated during kharif under rainfed conditions. Irrigated groundnut accounts for over 20% of the total area under the crop in the country and it yields around 4.2 t/ha.

- There is no necessity for irrigation up to 25 days after emergence of groundnut.
- Flowering (20-40 DAS), pod formation, pod development (40-70 DAS) and pod filling and maturation (70-100 DAS) are most sensitive to soil moisture stress.
- An IW/CPE ratio of 1.0 at moisture sensitive stages and 0.6 during other stages leads to high water use efficiency.
- If irrigation water is not limiting, then a total of 8 irrigations are adequate for optimal yield i.e. pre–sowing irrigation followed by irrigation at 25 DAS, 4 irrigations at 10 days interval and final two irrigations at 15 days interval.
- At times of deficit supplies, irrigation at 25 DAS followed by 2 at 15 days interval between 45 and 75 DAS appears to be minimum requirement and it can minimize yield losses due to soil moisture stress. The first irrigation is given at 25 DAS to create moisture stress in the soil which is desirable:

- to get the good root system.
- to reduce excessive vegetative growth.
- encourage the better nodulation
- induce heavy flowering in a single flush (synchronous flowering)

- Depending on soil type, evapo-transpiration and crop duration, water requirement of groundnut ranges between 450 and 650 mm.
- The crop is usually irrigated by check basin method. Border strip is more suitable than other methods. Sprinkler irrigation is ideal for groundnut crop on sandy soils.
- Recently drip irrigation is becoming popular among groundnut growers as it increases crop yield by 25-40% besides better seed quality and saves up to 40-50% irrigation water compared to flood irrigation.

Insect-pests management

Insect / Pest and Nature of damage	Management
Defoliators Groundnut leafminer or Leaf webber *(Aproaerema modicella)* Young larvae mine into the leaves as soon as they hatch. The presence of small brown	**Management of defoliators** • Deep ploughing during April-May to expose the pupae to sunlight and predatory birds. • Set bonfires on community basis on the

Insect / Pest and Nature of damage	Management
blotches on the leaf can be seen. The mines enlarge as the larvae grow. When they become too large and the larvae complete the different instars, emerge out and web the adjacent leaflets together and continuously feed on leaf tissue from inside the webbed leaves. A severely attached field looks likes a burnt appearance.	field bunds from 7-10 pm starting from the next day of the rainy. • Setup the light traps to attract and kill the moths during June-August. • Growing cowpea as trap crop. • Intercrop with castor or red gram in the ratio of 1:11. • Form a deep trench around the field and dust with 5% carbaryl to avoid the migration of larva from one field to the other. • Collection and destruction of egg mass and just emerged larva. • Place the vegetative traps like jatropha or calotropis in and around groundnut fields to attract and kill larva. • Spray NSKE 5% or neem oil (5 ml/l) along with suitable surfactant like nirma powder (1 g/l) or Spray NPV @ 250 LE at third instar stage. • Spray Quinalphos (2 ml/l) or Malathion (1 ml/) or Diflubenzuron (0.75 ml/l) or Phosalone (1.5 ml/l) or Dichlorvos (0.7 ml/l) or Thiodicarb (1.5 g/l).
Tobacco caterpillar (*Spodoptera litura*) In the early stages, larvae are gregarious feeders and damage by scrapping under the surface of the leaves leaving the vein and upper epidermis giving a fabric surface. Late instars larvae feed voraciously on the entire lamina, petioles and sometimes on the tender twigs on the terminal shoot of the plant. In certain cases they feed on the flower and bore the tender groundnut pods.	
Gram pod borer (*elicoverpa armigera*) Larvae are voracious feeders; they feed on flowers and foliage and defoliate the plants.	
Red hairy caterpillars (*Amsacta albistriga* and *A. moorei)* **and** **Bihar hairy caterpillar** *(Spilarctia obliqua*) Young larvae of hairy caterpillars feed gregariously on the under surface of the leaves by scrapping them. The grown up larvae are voracious feeders, defoliate the crop presenting a cattle grazed field. They feed on leaves, flowers and growing points.	

Insect / Pest and Nature of damage	Management
Sucking pests Aphid (*Aphis craccivora*) Aphids congregate on young leaves and young leaf buds sometimes even on flowers and aerial pegs. They desap through a phloem vessels. Under heavy infestation, plant become chloratic and leaves curl.	**Management of sucking pests** • Plating tall crops like bajra (for thrips), maize (for aphid) and cowpea (for jassids) as border to reduce the incidence of sucking pests. • Seed treatment with Imidacloprid @ 2 ml/kg seeds. • Spray Imidacloprid (0.3 ml/l) or Oxydemeton-methyl (1 ml/l) or Acetamiprid (0.3 g/l) or Thiamethoxam (0.3 g/l) or Dimethoate (1.7 ml/l).
Leafhopper/Jassid (*Empoasca kerri*) Nymphs ad adults suck sap from the leaves mainly from under surface. The terminal leaves may wilt if plants are young. Prolonged exposure to jassids results in a 'V' shaped yellowing on the tips of leaflets, which may spread, and the entire leaflet may become yellow.	
Thrips (*Scirtothrips dorsalis, Frankliniella schultzei, Thrips palmi and Caliothrips indicus)* Thrips feed by rasping the upper surface of the leaves, when they are in bud stage, the unfolded leaves thus distorted, condition known as "pouts".	
Root and pod feeders **White grubs** (*Holotrichia consanguinea and H. serrata*) Although the damage to roots starts in the early first instar stage. The maximum damage occurs when the grubs are in the third instar. The attacked plants show varying degrees of wilting, and ultimately die. The roots show a sharp cut which can be distinguished from the	**Management of sucking pests** • Field should be ploughed from the end of April to middle of May to expose the grubs and pupae to sunlight and predatory birds. • Mechanical control by large scale collection and destruction of adults at the time of their mass emergence. • Use of light traps and synthetic

Insect / Pest and Nature of damage	Management
damage by termite where the main root becomes hollow and is filled with soil. Patches of dead plants are seen throughout the field, which later coalesce and produce intensive areas of damage. **Termites** (*Odontotermes obesus and Microtermes obesi*) Termites damage the groundnut plants from seedling stage to maturity. They gnaw and hollow out taproot causing wilting and premature death of plants especially in sandy and red soils.	pheromone traps for monitoring adults. • Early sowing (pre-monsoon, irrigated) of crops should be done to allow roots to get established and evade from white grub attack. • Soil treatment: pre-sowing soil treatment with Phorate granules (25 kg/ha). • Destruction of termatorium and queen termite in and around field • Pre-sowing soil treatment with Phorate granules (25 kg/ha).
Storage pests **Groundnut bruchid** (*Caryedon serratus)* Grubs cause extensive damage to kernels. The heat and moisture generated by a large insect population in storage increases the risk of mould growth, which indirectly spoils the quality through mycotoxin contamination.	• Proper drying of pods • Cleaning of gunny bags and fumigation of godowns before storage using Aluminium phosphide @ 2-3 tablets (5 g/ t of pods) in airtight godowns.

Leafminer or Leaf webber

Tobacco caterpillar

Gram pod borer

Red hairy caterpillars

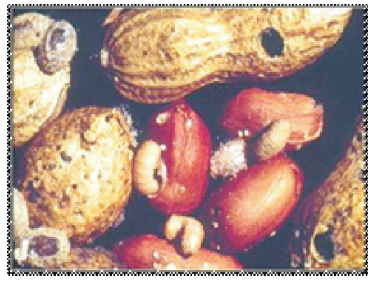
Aphid

Leafhopper/Jassid

Thrips

White grubs

Termite



Groundnut bruchid

Insect pests of groundnut

Diseases and their management

Diseases and nature of damage	Management
Collar rot *(Aspergillus niger)* The fungus present in the soil or adherent on seed surface germinates and attacks the seeds before its germination and causes pre-emergence rotting of seeds. It also causes rotting of hypocotyl, post emergence seedling blight, rapid wilting of entire plant or its branches which are characteristic diagnostic symptoms. Collar region of the affected plants becomes shredded and becomes dark brown covered by mycelia growth and spores.	• Avoid deep sowing (not more than 2 inches). • Crop rotation with wheat and gram, mixed cropping with moth bean. • Soil application of Neem cake or Castor cake @ 500 kg/ha. • Seed treatment with Trichoderma harzianum or T. viride @ 10 g/kg seed and soil application of enriched bio-agents in castor cake or FYM @ 250 kg/ha or Carbendazim 1-2 g/kg seed or Mancozeb 2-3 g/kg seed.
Afla-root / yellow mold *(Aspergillus flavus)* Infected plants generally become stunted and leaf size greatly reduced with symptoms of vein clearing and chlorosis on the leaflets. Such seedlings lack a secondary root system, a condition known as "aflaroot."	• Follow a crop rotation, i.e., cereal-cereal-groundnut. • Sow good quality and disease- free seed. • Avoid damage to the seed testa and deep placement of seed at sowing. • Treat the seed with Thiram or Carbendazim 4 g/kg seed.
Dry root rot *(Macrophomina phaseolina)* The initial lesion girdles the stem, wilting	• Avoid pod and kernel damage. • Avoid closer spacing (30 cm) between rows.

Diseases and nature of damage	Management
follows. The infected stem portion is shredded with the development of sclerotia, becomes black and sooty in appearance. Roots, pegs, and pods also rot and become covered with sclerotia and the infected kernels turn black.	• Seed treatment with *Trichoderma polysporum* or *T. viride* or *T. harzianum* @ 10 g/kg seed or Carbendazim @ 2 g/kg seed or Captafol or Thiram @ 3 g/kg seed reduces the root rot incidence.
Stem rot *(Sclerotium rolfsii)* Initial symptoms are partial or complete wilting of the stem or branches that are in contact with the infected soil. Infection of pegs, pod rot and leaf blight are some of the symptoms of stem rot infected plants. White myceial growths with brown colour sclerotia are visible in the infected plant.	• Deep burial of surface organic matter and crop debris by ploughing it to a depth of 8-10 inches. • Crop rotation with cotton, wheat, maize, jowar, onion and garlic • Seed treatment with T. viride/T. harzianium @ 4 g/kg seed or Captan @ 3 g/kg • Soil application of Castor cake or Neem cake or Mustard cake @ 500 kg/ha or T. viride / T. harzianium
Early leaf spot *(Cercospora arachidicola)* The disease normally occurs 30 days after sowing. Initially minute circular to subcircular chlorotic spots develop on upper surface of leaf, later turn into brown in colour surrounded by yellow halo. Corresponding lower surface of the leaf shows dark brown colour due to abundant sporulation. The lesion may extend to the stem and branches.	• Removal of volunteer groundnut plants, deep burying of crop residues • Intercropping pearl millet or sorghum with groundnut (1:3 or 1:5) • Foliar application of aqueous neem leaf extract (2-5%) or 5% Neem seed kernel extract or Carbendazim (0.05%) + Mancozeb (0.2%) at 2-3 weeks interval, 2 or 3 times from the initiation of the disease effectively reduces the early leaf spot severity.
Late leaf spot *(Phaeoisariopsis personata)* The disease normally occurs on 60 day old crop till harvest. Initially minute chlorotic spots develop on upper surface of leaf, later turn into irregular dark brown spot. Corresponding lower surface of the leaf shows dark brown to black colour due to abundant sporulation.	• Removal of volunteer groundnut plants, deep burying of crop residues • Intercropping pearl millet or sorghum with groundnut (1:3) • Foliar application of aqueous neem leaf extract (2-5%) or 5% Neem seed kernel extract or Carbendazim (0.05%) + Mancozeb (0.2%) at 2-3 weeks interval,

Diseases and nature of damage	Management
Oblong lesions occur on the stem and branches.	2 or 3 times from the initiation of the disease effectively reduces the late leaf spot severity.
Rust *(Puccinia arachidis)* Initially chlorotic spots develop on the upper surface of the leaf. Corresponding lower surface shows orange colored pustules (uredinia). The pustules range from 0.5 to 1.4 mm in diameter. Severely infected leaves turn necrotic and desiccate but remain attached to the plant. The kenels formed in the affected plants are shrivelled and small.	• Destroy volunteer (self sown) groundnut plants • Early sowing (first fortnight of June) to avoid the disease • Intercropping pearl millet or sorghum with groundnut (1:3), • Foliar application of aqueous neem leaf extract (2-5%) or 5% Neem seed kernel extract or Mancozeb or Chlorothalonil @ 0.3%, or Triodimefon @ 250 g/ha reduces disease severity.
Alternaria leaf blight *(Alternaria tenuissima)* Initially blighting starts from apical portions of leaflets, which turn light to dark brown colour 'V' shaped spots. In the later stages of infection, blighted leaves curl inward and become brittle. Adjacent lesions join together, giving the leaf a ragged and blighted appearance.	• Avoid growing of susceptible cultivar: TG 37, TPG 41 and JL 42. • Foliar application of aqueous neem leaf extract (2-5%) or 5% Neem seed kernel extract or Carbendazim (0.05%) + Mancozeb effectively reduce the Alternaria leaf blight.
Peanut bud necrosis *(Peanut bud necrosis virus)* Characteristic symptoms are axillary shoot proliferation, severe leaf deformity and necrosis of the terminal and axillary buds.The pathogen has wide host range and survives on ornamentals (zinnia, cosmos and sunflower), weeds (A. conyzoides, Cassia tora, A. hispidum, D. triflorum) and crop plants (tomato, brinjal, green gram, black gram, beans and pea).	• Growing of tolerant varieties like ICGS 11, ICGS 44, RG 141, ICGS (FDRS) 10, ICGS 37, TAG 24, K 134, DRG 12, JCG 88, ICGS 5, ICGV 86325 and DRG 17. • Closer spacing of 20 or 22.5 x 7.5 or 10 cm and intercropping pearlmillet or sorghum or maize with groundnut (1:3) for reducing movement of thrips are some of the effective management practices for peanut bud necrosis disease.

Diseases and nature of damage	Management
Peanut mottle *(Peanut mottle virus)* Irregular dark green islands on young leaves, mild mottle symptoms visible in transmitted light, inter-veinal depression and upward rolling of leaflet margin are characteristic symptoms of the disease. Infected plants produce only a few pods with small size.	• Observing strict quarantine regulations, control of vector population, sowing trap-crop (cowpea) that attracts aphids, growing of barrier crops, minimizing aphid transmission by manipulating sowing dates of groundnut wherever possible, controlling weed hosts are effective strategies for the peanut mottle disease management.
Peanut clump *(Peanut clump virus)* Young leaves show mosaic mottling and chlorotic ring symptoms. Early infected plants are severely stunted and become dark green. The virus survives and transmitted through Polymyxa graminis and possibly by nematodes.	• Sowing of disease free seeds, weed-free cultivation, soil solarization, crop rotation with pearl millet, soil application of nemagone and temik one week before planting are effective strategies for the peanut clump disease management.

Collar rot

Afla-root / yellow mold

Dry root rot

Stem rot

Early leaf

Late leaf spot

Rust

Diseases of groundnut

Alternaria leaf blight

Peanut bud necrosis

Peanut clump

Harvesting, stripping and drying

Harvesting is done by uprooting the plants along with pods manually or by groundnut digger. After uprooting the plants, follow stack method of drying in such a way to expose pods at either ends with plant mass at the centre. Dry the stacks in field till pods are dried to a moisture of <10% (known by the sound of loose kernels in pods when shaken). Separate the pods from plants manually or by groundnut stripper. After stripping, clean to remove the soil attached to the pods and store in polythene bags (300 guage) in air tight jute bags.

Aflatoxin management

The value of groundnut especially for export is highly dependent on zero aflatoxin content in kernels. Aflatoxin is a fungal toxin gets accumulated during the process of cultivation and storage. Clean cultivation methods from land preparation with summer ploughing, seed treatment, control of moisture and diseases, proper timely harvesting, stripping and storing clean pods below 8°C can prevent aflatoxin accumulation.

Critical practices for groundnut cultivation

- Adopt proper soil and moisture conservation measures as per the land topography and soil depth.
- Summer ploughing to reduce infestation of root grub, aflatoxin, and other pest and disease inoculums beside increased moisture conservation in the profile.
- Use improved varieties recommended for the region especially of disease resistance of bud necrosis and foliar diseases.
- Use healthy, undamaged medium sized seeds for sowing.
- Adopt BBF or paired row planting with a conservation furrow for higher moisture conservation.
- Treat seed with fungicides and Rhizobium before sowing.
- Control weeds up to 45DAS. Final inter cultivation to be done before 45DAS
- Adequate moisture during flowering and pod filling period increases yield significantly.
- Apply dry and fine powdered gypsum at 35-45 DAS near to pod bearing zone.
- Harvest at proper time and moisture, and process under dry conditions for reducing aflatoxin formation.

LINSEED

India is the largest (21.42%) linseed growing country in the World, where it is grown in an area of 3.39 lakh ha, predominantly in the states of Madhya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Bihar, Orissa and Jharkhand. The total production was 1.43 lakh t with an average productivity of 498 kg/ha (2013-14). The productivity of the crop in Madhya Pradesh is 523 kg/ha. Linseed is basically an industrial oilseed crop grown during rabi season. Tolerance to biotic and abiotic stresses is a very important characteristic of this crop. Because of this property, the survival and cultivation of linseed is prevailing in a wide range of tropical, sub-tropical and temperate regions.

Every part of the linseed plant is utilized commercially, either directly or after processing. On a very small scale, the seed is directly used for edible purposes, and about 20% of the total oil produced is used by farmers and remaining 80% goes to industries for the manufacture of paints, varnish, oilcloth, linoleum, pad-ink, printing ink, etc. The oil cake is a good feed for milch cattle. The stem yields fibre of good quality having high strength and durability. The fibre is lustrous and blends very well with wool, silk, cotton, etc. Strong twines, canvas, suiting, shirting and various indispensable products for defense purposes are manufactured from it. The rough, strong linseed fibre can effectively be used for low-cost roofing tiles based on convertible polymers and for fibre-reinforced plastics based on unsaturated polyesters.

Linseed is naturally highly nutritious. It is a source of complete protein (all 8 essential amino acids), linolenic acid (an essential poly unsaturated omega-3 fatty acid), carbohydrates, vitamins and minerals. Linseed is best herbal source of omega-3 and omega-6 fatty acids, cholesterol lowering cardiovascular benefits by affecting prostaglandins and leukotriens related to blood clotting and inflammatory disorder like rheumatoid arthritis. (gama) linolenic acid found in concentrated form in flax seed showed astounding effect in diabetes by normalizing the faulty fatty acid metabolism responsible for diabetics. Linatine an antibiotic found in linseed seed found to cure diseases. Oilcake is good feed for livestock, which makes them immune to certain diseases and improve their digestion.

Areas of cultivation

In Madhya Pradesh, linseed is extensively grown in Balaghat, Chhatarpur, Dindori, Rewa and Seoni districts.

Climate

Linseed is an annual herbaceous plant, grown as a winter crop in warm climate of India. Moderate temperature (21-270C) is ideal during vegetative and reproductive development.

Varieties

Farmers generally grow old varieties, which need to be replaced by new, improved, high yielding and disease resistant varieties. Details about the varieties suitable for different regions and situations are given in Table 1.

Table 1. Recommended varieties and their salient features

Variety	Year of release	Average Seed yield (kg/ha)	Oil content (%)	Salient features
Suyog (SLS-27)	2004	509 (irrigated)	41	White flower, light brown seeded, moderately resistant to rust, powdery mildew and bud fly
Azad Alsi-1 (LMS 9-2K)	2008	1610 (irrigated)	40	Disk shaped violet blue flower, dark brown seed, moderately resistant to bud fly
SLS-67 (Shival)	2010	1252 (irrigated)	40	Dwarf star shaped white flower, early maturity, light brown seed, moderately resistant to powdery mildew and rust
Jawahar Linseed-66 (SLS-66)	2010	1200 (rainfed)	43	-
JLS-73	2011		40	Early maturing variety
Jawahar Linseed-41 (PKDL-41)	2012	1600 (irrigated)	40	Early maturing variety, drought tolerant

Cropping systems

Sole cropping

Seed type as well as double purpose type (seed and fibre) linseed can be grown as sole crop

under irrigated conditions and with adequate fertilization. Double purpose linseed can compete well with other crops in terms of net monetary return, if it is grown as pure crop.

Intercropping

Under rainfed conditions, intercropping of linseed particularly with chickpea, lentil, durum wheat and barley and under irrigated conditions with wheat, potato, rapeseed and mustard needs to be popularized on a priority basis. When linseed is intercropped with chickpea, the incidence of wilt and pod-borer damage in chickpea is reduced and the inherent high risk of chickpea cultivation is minimized.

Paira or Utera cropping

This is one of the best practices for utilizing the residual moisture in rice fields where tillage is difficult. About 25% of the linseed area is under utera cropping. In this practice, linseed is broadcast in the standing rice fields when the rice crop is between flowering and dough stages. Linseed is generally allowed to complete its life cycle under the moisture stress, with inadequate nutrients and plant protection measures, resulting in poor yields.

Agronomic management

Tillage and seed bed preparation

Linseed is often grown on marginal and sub-marginal soils under rainfed conditions. It can be grown successfully on different soils ranging from light to heavy soils. The land should be ploughed 2 to 3 times followed by 2 to 3 harrowings for fine tilth.

Sowing time

Linseed is purely a rabi crop. The sowing time varies widely (October to 15th November), depending upon the availability of soil moisture and water for irrigation (Table 2). Early sowing helps the crop to escape powdery mildew, rust, linseed bud fly.

Spacing and seed rate

The spacing and seed rates recommended for different situations are given in Table 2.

Table 2. Improved varieties and production technologies of linseed in Madhya Pradesh

Condition	Improved varieties	Production technology				Inter-cropping system	Prevalent diseases/pests
		Sowing time	Row spacing (cm)	Seed rate (kg/ha)	Fertilizer N:P (kg/ha)		
Rainfed	Padmini, Kiran, T-397, JLS 9	First fortnight October	25	25-30	30:15	Linseed + Chickpea (3:1)	Wilt, powdery mildew and linseed bud fly

Condition	Improved varieties	Production technology				Inter-cropping system	Prevalent diseases/pests
		Sowing time	Row spacing (cm)	Seed rate (kg/ha)	Fertilizer N:P (kg/ha)		
Utera	R-552	Ist to 3rd week October	Broadcast	35-40	10-20:00	---	
Irrigated	Suyog, JLS-9, J-23 and T-397	Mid Oct.	25	25-30	60-80:30	---	

Note :20-30 kg/ha K2O and 15-30 kg/ha sulphur may also be applied under irrigated condition, if these nutrients are deficient in the soil. DP: Double Purpose

Depth of sowing

Depending upon the soil moisture, the seed should be placed 2-3 cm below the soil. However, shallow sowing is always advantageous, if there is adequate moisture in the soil.

Seed treatment

Seed should be treated with Bavistin @ 1.5 g/kg seed or Thiram @ 3g/kg seed or Topsin-M @ 2.5 g/kg seed to protect the crop from seed-borne diseases and to some extent from soil borne diseases also.

Manures and fertilizer

Linseed responds well to fertilizers. The recommended doses vary from state to state (Table 2). Fertilizers should be applied at the time of sowing. On irrigated lands, half dose of nitrogen with full quantity of phosphorus is applied as a basal dose. The remaining nitrogen is applied with the first irrigation i.e., about 35 days after sowing. An application of 5t FYM/ha can save 25% of inorganic fertilizer.

Irrigation

Yield can be doubled if two irrigations are given, the first at about 35 days after sowing and the second at about 65 days after sowing. However, three irrigations (at about 35, 55 and 75 days after sowing) have proved very effective in increasing the yield.

Weed control

It is necessary to keep the crop free from weeds for the first 35 DAS Application of Isoproturon 75 WP @ 1.0 kg/ha either with or without 2, 4-D (sodium salt) @ 0.50 kg/ha as post-emergence at 35 DAS can control weeds effectively.

Cuscuta

A phanerogamic plant parasite Cascuta is also serious problem. Mechanical separation of Cuscuta seeds from seed lot either by sieve or floating in water, mechanical destruction of Cuscuta vine from infested field; use of weedicide viz., Pendimethylene, Fluchloralin or Paraquat (1-1.5 kg/ha).

Insect-pests management

Insect / Pest and Nature of damage	Management
Linseed bud fly *(Dasyneura lini)* The internal parts of flower bud are eaten by the maggot resulting in un-opening of the bud.	• Deep summer ploughing of the fields exposes the bud fly maggots and crop rotation. • Sow during last week of October to first fortnight of November. • Intercropping with chickpea (3:1) or mustard (5-6:1) reduces bud fly infestation. • Put bamboo pegs @ 40-50/ha for increasing the activity of predatory birds. • Light trap or attractant like jaggery (1 kg/ 75 lit. water) can be used to lure and kill adult flies. • Spray NSKE 5% or Imidacloprid (0.2 ml/ l) or Spinosad (0.3 ml/l).
Gram pod borer *(Helicoverpa armigera)* The caterpillars bore the young capsules and feet on the seeds.	• Timely sowing of linseed. • Spray HaNPV @ 250 LE/ha or Profenofos (1 ml/l) or Spinosad (0.3 ml/l).
Leafminer *(Chromatomyia horticola)* The larvae make tunnels on the leaf.	• Spray Dimethoate (1.7 ml/l) or Oxydemeton- methyl (1.7 ml/l).
Thrips *(Caliothrips indicus)* Nymphs and adults suck the sap from the tender shoots and leaves.	• Spray of Imidacloprid (0.2 ml/l) or spinosad (0.3 ml/l).

Linseed bud fly

Gram pod borer

Leafminer

Thrips

Insect pests of linseed

Diseases and their management

Diseases and nature of damage	Management
Wilt *(Fusarium oxysporum f.sp. lini)* The root system is damaged by the fungus and ultimately the plant dries up.	• Deep summer ploughing. • Follow crop rotation (change of field alternate year for linseed sowing). • Seed treatments with Thiram (3 g/kg seed) or Bavistin (1 g/kg seed) or Topsin M (2.5g/kg seed) or Trichoderma viride or T. harzianum (4 g/kg seed); amendment of Trichoderma (commercial) in soil mixed with FYM (5 t/ha).
Powdery mildew *(Oidium lini)* All the plant parts are covered by white powder like fungus.	• Need based and judicious spray of wettable Sulphur (0.2-0.3%) or Tridemorph (0.05-0.1%) or Dinocap (0.1%).
Alternaria blight *(Alternaria lini and Alternaria linicola)* All the aerial parts of the plants are attacked. The first symptoms are observed on cotyledons as black lesions on the margin just after	• Sowing between 5-10th November. • Seed treatment with Topsin M (2.5g/kg seed) or Iprodione (2 g/kg seed) or Trichoderma harzianum/T.viride (4 g/kg seed).

Diseases and nature of damage	Management
germination. The buds fail to open. The petals and other floral parts become completely covered with fungal growth.	• Need based spray of aqueous neem leaf extract (5%) or Iprodione (0.2%) or Mancozeb (0.25%) on disease initiation at 10-15 days interval.
Rust *(Melampsora lini)* All the plant parts are covered by orange yellow pustules.	• Use clean field and clean seed • Seed treatment with carboxin or oxycarboxin (2 g/kg seed) • Need based spray of Mancozeb (0.25%) or Benomyl (0.1%) or Tridemorph (0.1%) or Indofil M-45 (0.25%) or Calixin (0.05%) at 10-15 days interval.

Wilt

Alternaria blight

Rust

Diseases of linseed

Harvesting and threshing

The crop should be harvested by sickle at ripening, when the stem become woody and capsules turn hard, known when the leaves are dry, the capsules are turned brown and the seeds have become shiny. The harvested crop is dried in the field for 3-4 days to facilitate early recovery of seed. The seeds can be separated from fruiting parts by beating with sticks/wooden clubs on threshing floor or by beating the plants of un-separated fruiting parts to a wooden plank. The seeds will be collected after winnowing the threshed produce.

Yield potential

The yield varies according to the varieties and growing conditions. In general, a yield of 8-10 q/ha from rainfed conditions, 12-15 q/ha with heavier soils and protective irrigation and 16-20 q/ha under irrigated high input management can be expected.

Fibre from dry stalk of linseed/flax

Double purpose linseed varieties are suitable for seed as well as fibre production. A technical plant height (height from root to first branching) more than 50 cm is categorized as double purpose varieties. Fibre from linseed is one of the natural and eco-friendly, has more strength, fineness and durability than many other fibres. It is soft, lustrous and flexible and has high water absorbency and blends very well with wool, cotton, silk, etc. It is being used in the preparation of strong twines, canvas, hosepipe, suiting-shirting and various indispensable products for aero-space and aeronautical and defence purposes. Woody core of stem and short fibre are used as raw pulp for making paper of quality. For obtaining fibre from these varieties involve following steps.

1. Harvest the crop from ground level.
2. Make small bundles of the harvested crop, thresh out the seed and cut the stalk from first branching to separate the unbranched stalk or cut the stalk from first branching and separate the seed portion and stalk to each other thereafter thresh out for seed.
3. Keep out the cut dry stalk separately for its retting.
4. For the retting of stalk, involve following procedure

   (a) Place the stalk bundles in water filled retting tank and leave it for 2-3 days. If stalks are floating put some pressure on it so that stalk fully dip into the water.

   (b) Keep out stalks from tank and wash them about 8-10 times with water thereafter allow it for sundry in open air.
5. Now the stalks are ready for scutching (separating the fibre from retted stalk). The scotching of fibre may be done using either of following procedures.

Manual

1. Take small bundle of retted and dried stalk and beat it by hand mallet (mungri) on plane and hard surface. Owing to this the wooden part of the stalk will split out and resultant to this fibre can be obtained easily.
2. This type of scutching can be done at small scale rightly at farmer's home.

Performance of improved technologies in FLDs

Under real farm situations, the improved technologies showed increase in yield up to 49% as compared to farmers' practices. The yield advantage and economics of improved technologies are given below.

Table 3. Performance of improved technologies of sesame in FLDs (2011-14)

Technology	No. of FLD	Average yield (kg/ha)		(%) Increase	Cost of cultivation (Rs./ ha)		Gross net returns (Rs./ha)		Additional net returns (Rs./ha)	B:C ratio	
		IT	FP		IT	FP	IT	FP		IT	FP
Whole package	67	1285	908	42	13087	10958	42989	30197	10664	3.3	2.8
Improved variety	16	1372	1036	32	13985	11877	47055	34955	9991	3.4	2.9
Recommended dose of fertilizers	4	1886	1285	47	17774	14088	66019	44475	17858	3.7	3.2
Integrated weed management	5	1310	1144	15	13843	13220	49022	40817	7582	3.5	3.1
Integrated pest and disease management	1	1450	1225	18	15383	13608	58000	49000	7225	3.8	3.6
Intercropping	21	1902	1276	49	17425	13638	63012	42866	16359	3.6	3.1

Critical practices for linseed cultivation

- Adopt proper soil and moisture conservation measures.
- Use improved varieties recommended for the region.
- Avoid delayed sowing beyond of October.
- Treat seed with fungicides before sowing.
- Thinning should be done to remove excess seedlings per hill.
- Apply adequate NPK and S as per the soil test.
- Control weeds up to 30-45 DAS by hand weeding and inter-cultivation.
- Seedling, branching, flowering and seed maturation are critical stages for irrigation.

NIGER

Niger is commonly known as ramtil, jagni or jatangi (Hindi). Niger although considered a minor oilseed crop, is important in terms of its 32- 40% content of oil with 18 to 24% protein in the seed. Niger oil is slow drying, used in food, paint, soap, and as an illuminant. 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. The oil is considered good for health. 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. 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.

Areas of cultivation

In Madhya Pradesh, the crop is grown in Dindori, Betul, Chhindwara and Anuppur districts.

Climate

The optimum plant growth in niger is seen when the temperatures range between 20-380C 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.

Varieties

The salient features of the recommended varieties for Madhya Pradesh are given as in Table 1.

Table 1. Recommended varieties of niger

Variety	Year of release	Seed yield (kg/ha)	Oil content (%)	Days to Maturity	Salient features
JNC-6	2001	650-700	37-38	95-100	Shining dark black seed
JNC-1	2002	650-700	38-40	90-100	Black seed
JNS-9	2004	650-700	38-40	95-100	Black seed, tolerant to moisture stress
NRS-96-1	2003	650-700	35-38	90-95	Black seed
BNS-8	2005	600-650	35-38	95-100	Black seed
Jawahar Niger Composite-1	2006	650-700	38-40	90-100	Black seed
BNS-10	2009	650-700	36-38	95-100	Shining black seed, resistant to pests and diseases
BNS-11	2010	600-700		85	Early maturing variety, drought tolerant

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. 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. The common crop sequence followed in Madhya Pradesh is early black gram–niger.

Intercropping

Niger is grown as a mixed crop with various pulses and other crops including millets. However, the seed yield of sole crop is higher than that of mixed/intercropping system. Following intercropping systems have been found remunerative and feasible in Madhya Pradesh.

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

Agronomic management

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

Even though niger is grown in kharif, it can be successfully grown in semi- rabi and late-kharif seasons with limited irrigation. Being exclusively a rainfed crop, niger is grown with the onset of monsoon. The optimum sowing time is third week of July to second week of August.

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.

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.

Depth of sowing

Seed should be sown to 2-3 cm deep depending upon soil type and moisture. Sowing should be done in adequate moisture for better germination.

Spacing

Spacing depends upon soil type and varieties. Row widths vary from 20 to 30 cm depending on soil moisture and amount of fertilizer applied. In low rainfall areas, the wider row-width should be chosen. When strip-cropped, it is often thinned after emergence to 15-20 cm between plants. A spacing of 30 cm x 10 cm is to be followed. Thinning should be done to maintain the required plant population within the rows after two weeks of sowing.

Nutrient management

Fertilizer requirements of niger are ignored and the crop is mostly grown on marginal and sub-marginal lands without manuring or fertilizer application. The crop is expected to benefit from fertilizer applied to suit the major component of intercropping system. It is also expected to grow on the residual fertility from previous crops, with the minimum of added nutrients. However, application of recommended N (10 kg/ha) as basal through urea, seed treatment with PSB 10 g/kg seed enhances seed yield significantly. Phosphorous @ 20 kg/ha and 10 kg N/ha at 35 DAS is recommended. 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.

Irrigation management

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.

Insect-pests management

Insect / Pest and Nature of damage	Management
Niger caterpillar *(Condica conducta)* The caterpillar green with purple markings feeds on leaves and defoliates the plants.	• Proper weeding reduces hiding places. • Spray Quinalphos (2 ml/l) or Dichlorvos (0.7 ml/l) or Profenofos (1 ml/l) or dust with Phosalone 4% or Carbaryl 5% (20-25 kg/ha).

Insect / Pest and Nature of damage	Management
Niger caterpillar *(Condica conducta)* The caterpillar green with purple markings feeds on leaves and defoliates the plants.	• Proper weeding reduces hiding places. • Spray Quinalphos (2 ml/l) or Dichlorvos (0.7 ml/l) or Profenofos (1 ml/l) or dust with Phosalone 4% or Carbaryl 5% (20-25 kg/ha).
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 caterpillar early in the morning and kill them or spray Quinalphos (2 ml/l).
Bihar hairy caterpillar *(Spilarctia obliqua)* The caterpillars remain gregarious underneath leaves in early stages and cause serious loss in yield at third and fourth instar.	• Collection and destruction of egg masses and early instars of caterpillars. • Spray Dicholrvos (0.7 ml/l) or Profenofos (1 ml/l) or Quinalphos (2 ml/l) or Chlorpyriphos (2.5 ml/l) or dust Carbaryl 5% (25 kg/ha).
Surface grasshopper *(Chrotogonus sp.)* Grasshoppers cause damage to the crop to a great extent in its early stage.	• Dusting with Phosalone 4% or Carbaryl 5% (25 kg/ha) can control the pest in early stage.
Aphids *(Uroleucon carthami)* This is one of the important sucking pests of niger during later period of crop growth.	• Spray Dimethoate (1.5 ml/1) or Oxydemeton- methyl (1.7 ml/l) or dust Quinalphos 1.5% (20 kg/ha).
Semilooper *(Plusia orichalcea)* Larva feeds on the leaves and defoliates the plant.	• Spray NSKE 5% or Bacillus thuringiensis var. kurstaki (1g/l) or Dicholrvos (0.7 ml/l) or Profenofos (1 ml/l).
Niger capsule fly *(Dioxyma sarorcula)* Maggot feeds on seed and pulp inside the capitula.	• Install light trap one per ha. • Spray Auinalphos (2 ml/l) or Dichlorvos (0.7 ml/l) or Dimethoate (1.7 ml/l) or Imidacloprid (0.3 ml/l).

Niger caterpillar

Semilooper

Insect pests of niger

Diseases and their management

Diseases and nature of damage	Management
***Cercospora* Leaf spot** 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%)
***Alternaria* Leaf spot** Spots are brown to black with concentric rings.	• Seed treatment with thiram (0.3%). • Spraying with dithane M 45 (0.2%) at 15 days interval.
Powdery mildew 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%) when disease appears..
Stem/Root rot 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.	• Deep ploughing in the summer. • Seed treatment with thiram (0.2%) + bavistin (0.1%) before sowing.

Harvesting and threshing

Proper time of harvesting niger is important for reducing shattering. Seeds are not held firmly in the head and those which ripen first begin to shed their seed before the later heads are mature. Shattering can reduce the yield up to 25%. The crop is harvested when the leaves

dry up and the head turns blackish. Harvesting niger when the buds turn from yellow to brown yellow is the optimum stage. After drying in the sun for about week by stacking on the threshing floor, the crop is threshed by beating with sticks. The crop is also threshed by treading under the feet of bullocks. The threshed produce is winnowed and clean seed is obtained.

Yield potential

The yield varies with the method of cultivation of niger. As a pure crop, 400-500 kg/ha could be obtained although yields up to 1000 kg/ha have been recorded in demonstration plots. As an intercrop, the yield may range from 150 to 300 kg/ha depending on the crop and row ratio. Even with the local varieties of niger, minor alterations to traditional practice can double the yield i.e., planting at optimum period, drilling instead of broadcasting or more efficient weed control.

Storage of seed

Niger seed is attractive to insect and other storage pests and must be protected. After threshing, winnowing is done to clean seed. The seeds are dried in sun for 2-3 days to bring down the moisture to 5%. The seed is stored in gunny bag in houses with good ventilation. Avoid high humidity and moisture inside the storage houses. Seed storage in 200 litre drums fitted with lids and/or the seed dusted with insecticide, have proved most effective.

Performance of improved technologies of niger in FLDs

Niger productivity can be nearly doubled by adopting recommended fertilizer management with additional net returns of ₹4395/ha. The adoption of whole package increased the yield of niger by 86% with additional net returns of ₹ 7041/ha as compared to farmers practice. Simply adoption of improved varieties recommended for the region can increase the yield of niger by 80% as compared to local varieties.

Table 1. Performance of improved technologies of niger under real farm situations (2011-14)

Technology	No. of FLD's	FLD Average yield (kg/ha)		Yild gap-1 (%)	Cost of cultivation (Rs./ ha)		Gross returns (Rs./ha)		Additional net returns (Rs./ha)	B:C ratio	
		IT	FP		IT	FP	IT	FP		IT	FP
Whole package	48	529	284	86	9231	6266	20265	10260	7041	2.2	1.7
Improved variety	25	364	217	80	7234	5184	14647	8963	3634	2.0	1.7
Recommended dose of fertilizers	23	388	201	96	7794	4739	15603	8153	4395	2.0	1.7
Plant protection	14	312	207	52	6273	4240	12451	7892	2293	2.0	1.9

Critical practices for niger cultivation

- Adopt proper soil and moisture conservation measures.
- Use improved varieties recommended for the region. Sow across the slope on contour
- Treat seed with fungicides and Azospirillum + Azotobacter before sowing.
- Thinning should be done to remove excess seedlings per hill.
- Apply adequate NPK and S as per the soil test.
- Control weeds up to 45 DAS by hand weeding and inter-cultivation.
- Avoid delayed harvesting.

CASTOR

India is the leading castor growing country in the world with an area of 13.17 lakh ha and production of 21.77 lakh t. The productivity of castor is 1653 kg/ha (2012-13). Castor seed is the source of castor oil containing 35-58% oil that is rich in triglycerides. The oil, due to unique hydroxyl fatty acid-ricinoleic acid content, is one the important non-edible industrial oils used for a number of products. Castor oil and its derivatives have applications in the manufacturing of soaps, lubricants, hydraulic and brake fluids, paints, dyes, coatings, inks, cold resistant plastics, waxes, polishes, nylon, pharmaceuticals and perfumes. Castor oil is commonly used in medicines as a laxative and to treat skin disorders. Castor cake is an excellent source of organic fertilizer. In eri silk producing areas, leaves are fed to eri silkworms.

In India, castor is mostly confined to Gujarat, Rajasthan and Andhra Pradesh. Although other states like, Karnataka, parts of Madhya Pradesh and Orissa cultivate castor, their contribution to either area or production is limited.

Areas of cultivation

Castor is cultivated in an area of 6000 ha in the state with one of the highest productivity (1667 kg/ha) only after Gujarat (2012-13). Castor crop has high potential for cultivation in Chhindwara, Damor, Mandla, Seoni, Dindori, Betul, Khandwa and Hoshangabad districts.

Climate

Castor grows well in relatively dry and warm regions having a well distributed rainfall of 500-750 mm. In heavy rainfall areas, the crop puts on excessive vegetative growth and assumes a perennial habit. Castor requires a moderately high temperature (200-260C) with low humidity throughout the growing season to produce maximum yields. It can withstand long dry spells as well as heavy rains, but is highly susceptible to water logging.

Soils

Castor can be cultivated on almost all types of well-drained soils. But, it is generally grown on light alluvial soils in the North-Western states. Soils that are not suitable for growing valuable commercial and food crops are often used for growing castor crop.

Seeding time and spacing

The most ideal time to sow kharif castor in drylands is immediately after the receipt of first rains from South West monsoon. In Madhya Pradesh, the suggested optimum seeding time for rainfed castor is first fortnight of July. In rabi season, if there is a provision for supplemental irrigation, the productivity can be significantly increased. September-October and January as ideal periods, respectively for rabi and summer castor cultivation. A plant population of 55,500/ha was found to be optimum for rainfed castor in all regions. The recommended spacing is as follows:

Region	Variety/Hybrid	Spacing (cm)
All castor growing areas (Rainfed)	Early and medium duration variety / hybrid	90 x 30
Irrigated	Hybrids	90/120 x 60

Varieties and hybrids

The selection of the appropriate variety suited to the growing condition and specific characteristics of the region is the most important factor in determining the yield and production of the crop. The list of varieties recommended for Madhya Pradesh under different conditions is given in Table 1.

Cropping systems

Castor is being cultivated as shade crop and intercrop with vegetables and on commercial scale, it is being grown as sole crop under irrigated and rainfed conditions in the state.

Crop sequences

A number of productive and remunerative cereal/legume crop sequences with castor are

Table 1. Recommended hybrids/varieties

S. No.	Hybrid/ variety	Year of notification	Salient feature	Areas of adoptability
1.	DCH-177	2000	Resistant to Fusarium wilt, whitefly, yield : 1550-2130 kg/ha, days to maturity: 90-100, oil content: 49%	All India
2.	DCH-519	2006	Resistant to Fusarium wilt, leaf hoppers, yield: 1740-2130 kg/ha, days to maturity: 105-110, oil content : 49%	Both rainfed and irrigated areas of the country
3.	Jwala (48-1)	2007	Resistant to wilt, capsule borer and tolerant to jassid and Botrytis, yield: 1100-2000 kg/ha, days to maturity: 110-120, oil content: 48%	All India
4.	DCS- 107	2011	Reisistant to wilt and tolerant to leaf hopper, yield : 1700 kg/ha, days to maturity: 100-135, oil content: 49%	All India

identified for different agro-ecological situations either as a regular or contingent measure for enhancing on farm production and income of farmers.

Fertilizer management

Under rainfed conditions, 60:40 N:P/ha is recommended. For irrigated castor in Madhya Pradesh, a basal dose of 40 kg N and 40 kg P205/ha and application of 20 kg N/ha as top dress starting from 90 days after sowing at monthly interval is recommended.

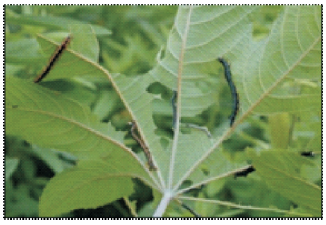
Insect-pests management

Insect / Pest and Nature of damage	Management
Semilooper *(Achaea janata)* Larvae damages crop by defoliation. The neonate larvae nibble the outer tissue of leaf. During second and third instars, larvae damage	• Hand picking and destruction of older larvae during early stages of crop growth to keep defoliation at low level. • Spray Bacillus thuringiensis var. kurstaki (1 g/l) against early instar larvae.

Insect / Pest and Nature of damage	Management
the leaves by making holes while older larvae are voracious feeders which can totally defoliate the plants during outbreaks, leaving only veins, petiole and stem.	• Spray Profenofos (1ml/l) or Malathion (2 ml/l) or Flubendiamide (0.2 ml/l) or Chlorantraniliprole (0.3 ml/l), if more than 25% defoliation is observed. Avoid chemical spray when 1-2 larval parasitoids (Microplitis sp.) are observed per plant.
Tobacco caterpillar *(Spodoptera litura)* Larvae damages crop by defoliation. Newly hatched larvae feed gregariously and skeletonise the leaves giving mesh like appearance which can be easily located from a distance. During heavy infestations, larvae also feed on capsules. Sometimes the larvae bore into the stems causing withering of branches and partial or total death of the plant.	• Collect and destroy egg masses and gregarious stages of the larvae along with damaged leaves. • Install sex pheromone trap @ 10 traps/ha for early deduction of the pest. • Spray Sl NPV @ 250 LE/ha or Profenofos (1 ml/l) or Flubendiamide (0.2 ml/l) or Chlorantraniliprole (0.3 ml/l) or Thiodicarb (1 g/l) or Quinalphos (2ml/l) or Chlorpyrifos (2 ml/l), if defoliation is above 25%.
Capsule borer *(Conogethes punctiferalis)* Larvae bore the capsules and characteristic webbing of capsules along with excreta is seen. When inflorescence is attacked at the time of emergence, it withers and dries away and the terminal shoot also gets killed.	• Good agronomic management with no or less use of insecticides on the crop usually keeps the borer at low level. • Spray Profenofos (2 ml/l) or Indoxacarb (1 ml/l) or Spinosad (0.4 ml/l) or dust the spikes with Quinalphos 1.5% (20 kg/ha), if at least 10% capsules are damaged.
Leafhopper *(Empoasca flavescens)* Nymphs and adults suck sap from plants. Hopper burn symptoms are noticed if infestation is severe. The initial symptom of yellow patches on the margins of leaves is followed by leaf curling. Heavy pest infestations resulting in the loss of vitality, stunted growth and poor formation of capsules.	• Growing triple bloom cultivars like GCH-4, GCH-7, DCH-519 which usually do not express damage symptoms. • Spray Dimethoate (1.7 ml/l) or or Thiamethoxam (0.4 g/l) or Acetamiprid (0.2 g/l). Repeat spray if required after a fortnight.

Insect / Pest and Nature of damage	Management
Thrips *(Retithrips syriacus)* Nymphs and adults suck sap resulting in characteristic wrinkling of plants and withering of developing spikes. Thrips damage is clearly seen on the tender most and not fully opened leaf.	• Varieties resistant to leaf hopper are also usually tolerant to thrips damage. • Spray Dimethoate (1.7 ml/l) or Thiamethoxam (0.4 g/l) or Acetamiprid (0.2 g/l), if damage symptoms appear.
White fly *(Bemisia tabaci)* Nymphs and adults suck the sap causing yellowing and drying of the affected leaves. If the infestation is severe, the vitality of the plant is reduced and its vegetative growth is arrested resulting in shedding of damaged leaves. The insect secrets honey dew and it promotes growth of black sooty mould which interferes with photosynthesis.	• Single and double bloom varieties are relatively resistant to whitefly than triple bloom castor cultivars. • Spray Dimethoate (1.7 ml/l) or Thiamethoxam (0.4 g/l) or Acetamiprid (0.2 g/l) during peak activity of the pest.
Hairy caterpillar *(Euproctis sp.)* Larvae damages crop by defoliation. Hatched larvae feed gregariously and skeletonise leaves. Mature caterpillars disperse to other leaves / plants and defoliate and often capsules get damaged.	• Collect and destroy egg masses and gregarious stages of the larvae along with damaged leaves. • Spray Bacillus thuringiensis var. kurstaki (1 g/l) or Dichlorvos (0.7 ml/l) or Profenofos (2 ml/l) or Quinalphos (2 ml/l), if defoliation is exceeding 25%.
Bihar hairy caterpillar *(Spilarctia obliqua)* Larvae feed voraciously on the foliage in early stage and defoliate the plant. Larvae also damages flowers and pods.	• Collect and destroy infested plant parts along with larvae. • Spray Bacillus thuringiensis var. kurstaki (1 g/l) or Dichlorvos (0.7 ml/l) or Profenofos (2ml/l) or Quinalphos (2 ml/l)), if defoliation is exceeding 25%.
Red hairy caterpillar *(Amsacta albistriga)* Larvae cause damage by defoliation. Often the	• Setting of light traps on community basis with the first monsoon rains to attract the moths and kill them, sowing cucumber along with castor to attract the migrating

Insect / Pest and Nature of damage	Management
larvae feed or destroy the germinating seedling causing death of the plants. Major damage is caused by migrating caterpillars. More destruction to young crop.	caterpillar and facilitate mechanical killing of the larvae by jerking them off into kerosinized water. • Placing the twigs of Ipomoea, Jatropha or Calotropis to attract the migrating caterpillars and kill them mechanically, opening deep furrows around field area and dusting quinalphos 1.5%. • Spray of Dichlorvos (0.7 ml/l) or Profenofos (2ml/l) or Quinalphos (2 ml/l), if defoliation is exceeding 25%.
Serpentine leafminer *(Liriomyza trifolii)* Maggots enter in between the epidermal layers and feed by making characteristic serpentine mines. The damage starts with cotyledonary leaves and moves upward as the plant grows.	• Neem seed kernel extract (5%) and other neem based formulations were found to be effective in reducing the pest population.



Semilooper

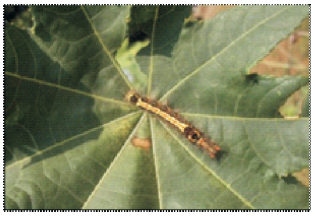
Tobacco caterpillar

Capsule borer

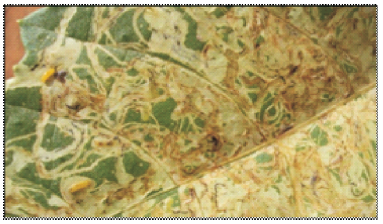
Leafhopper

Thrips

White fly



Euproctis hairy caterpillar



LeafminerWhite fly

Insect pests of castor

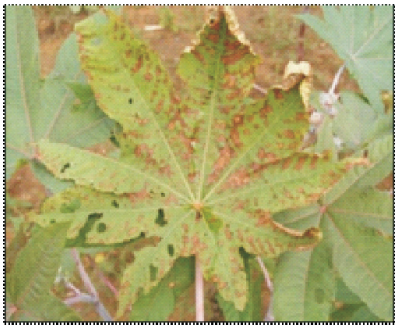
Diseases and their management

Diseases and nature of damage	Management
Seedling Blight *(Phytophthora parasitica)* First appears on both surfaces of cotyledonary leaves of young seedlings as roundish patches of unhealthy dull green colour. The older spots turn yellow, light to dark brown with concentric zones which coalesce to cover almost the entire leaf. The affected leaves shed prematurely.	• Avoid sowing in low lying areas, provide proper field drainage. • Treat the seeds with Thiram or Captan 3g/kg seed. • Spraying of Copper oxychloride 3 g/l two to three times at 10 days interval.
Alternaria blight *(Alternaria ricini)* Severe infection results in death of the young plants due to foliage blight. On adult plants, brown, irregular zonate spots surrounded by yellow halos can be seen. In severe infections, spots coalesce to form bigger patches resulting in premature defoliation of the plant. Immature capsules turn brown to black due to deposition of spore mass on surface, pedicel collapse and capsule hangs down.	• Treat the seeds with Thiram or Captan 3 g/kg seed. • Need based spraying of Mancozeb 0.2%, 2-3 times at 15 days interval.
Fusarium wilt *(Fusarium oxysporum f. sp. ricini.)* Young seedlings exhibit discolouration of	• Grow tolerant and resistant varieties like GCH-4, DCH-332, GCH-5, DCH-177, Jwala. • Avoid water logging.

Diseases and nature of damage	Management
hypocotyl, Symptoms at pre-flowering stage are yellowing, marginal and interveinal necrosis of leaves, senescence of lower leaves in the development of irreversible wilting, bending of the growing apex. Plants infected at flowering, spike formation and spike development stages show sickly appearance, yellowing and marginal necrosis of leaves, leaves shrivel, lower ones drop away leaving only few top leaves followed by irreversible wilting of plants.	• Intercropping of castor with red gram 1:1 ratio. • Crop rotation with millets. • Soil solarization for 6 weeks during peak summer. • Rouging and destruction of diseased plants. • Treat the seeds with Thiram 3 g/kg seed or Carbendazim 2 g/kg seed. Soaking of seeds in fungicidal solution (Carbendazim 1 g/l) for 12 hrs and shade drying before sowing reduces seed borne infection.
Root rot *(Macrophimina phaseolina)* Dark black lesions on the stem near ground level. Tap root shows signs of drying and root bark shreds off easily. Small brown depressed lesions seen on and around nodes. Lesions often unite and girdle the stem causing leaf drop, entire branch and top of the plant withers, drying and death starts from apex and proceed down wards.	• Crop rotation and rouging of infected plants. • Growing tolerant/ resistant cultivars like Jwala. • Maintain sufficient soil moisture through soil moisture conservation practices and irrigate the crop at critical stage. • Treat the seeds with Thiram 3 g/kg seed or Carbendazim 2 g/kg seed.
Gray rot *(Botrytis ricini)* Initial symptoms are small blackish spots on flower from which drops of yellow liquid may exude. Fungal threads which grow from these spots spread the infection and produce.A densely wooly growth on flowers and capsules varying in colour from pale to olive grey. Infected capsules rot, later black sclerotia are produced. Leaves and tender shoots are also infected.	• Use of non-spiny varieties. • Avoid excess irrigation. • Adopt wider spacing of 90 x 60 cm, once affected cut the diseases parts and burn. Provide additional dose of 10kg/ha after cessation of rains. • Spraying of Carbendazim 0.05% or Thiphanate-methyl 0.05% before onset of cyclonic weather based on weather forecast followed by another spray soon after disease appearance.

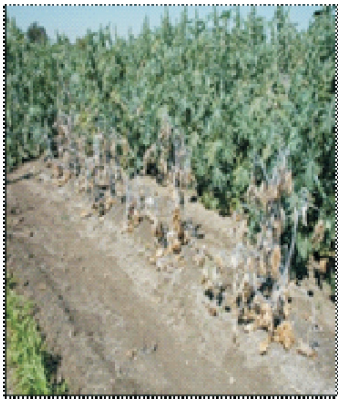
Diseases and nature of damage	Management
Cercospora leaf spot *(Cercospora ricinella)* Minute black or brown spots with pale green margin on both surfaces of leaves. Finally turn brown and to grayish white with a deep brown margin. Black tiny dots like structures are found in the center of the spot.	• Spraying of Copper oxychloride 0.3% or Mancozeb 0.25% two to three times during cropping season in case of severe infection.

Seedling blight



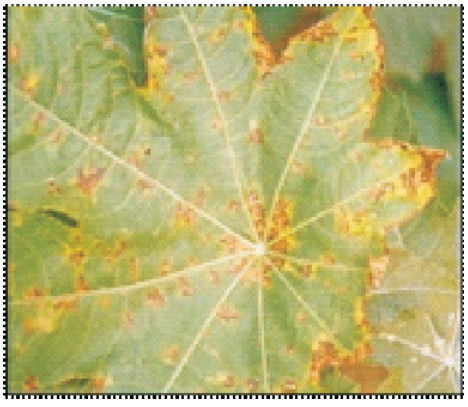
Alternaria blight

Fusarium wilt



Root rot

Gray rot



Cercospora leaf spot

Diseases of castor

Harvesting

Harvesting of castor spikes should be done at right time and early, to avoid capsule dehiscence resulting is loss of produce. Delaying harvesting till all spikes comes to maturity

results in dropping of capsules from early matured spikes. When the capsules turn pale yellow and a few capsules dry up, the spike can be harvested and dried for threshing. Dry the capsules in the sun and thresh manually or by threshers.

Yield potential

On an average about 800 - 1000 kg/ha seed yield is obtained under rainfed conditions and about 1500-2000 kg/ha seed is obtained under irrigated conditions, depending on genotype and growing conditions, very high yields as high as 3 to 4 t/ha has been realised under high input management.

The by-products of castor, castor cake is a nutrient rich manure especially required for managing soil borne diseases and insect pests that has equivalence as that of neem cake.

Performance of improved technologies of castor in FLDs

Improved technologies demonstrated under real farm situations, indicated enhancement in productivity up to 132% with additional returns of Rs. 42,575/ha.

Performance of improved technologies of castor under real farm situations (2011-14)

Technology	No. of FLD's	FLD Average yield (kg/ha)		(%) Increase	Cost of cultivation (Rs./ ha)		Gross returns (Rs./ha)		Additional net returns (Rs./ha)	B:C ratio	
		IT	FP		IT	FP	IT	FP		IT	FP
Whole package	20	2769	1500	85	17464	11417	78870	43225	29598	4.5	3.8
Improved variety	20	2766	1191	132	14855	10165	82980	35715	42575	4.6	2.5

IT = Improved technology; FP = Farmers practice

Critical practices for castor cultivation

- Use recommended varieties for the region especially of duration and disease resistance.
- Treat seed with fungicides and Azospirillum + Azotobacter before sowing.
- Adopt proper wide spacing as per rainfed and irrigated condition and sow the seed by dibbling in moist zone.
- Control weeds up to 45-60DAS.

Annexure-I

Organizations Associated in Agriculture (Oilseeds) Development in Madhya Pradesh

Important websites

Indian Council of Agriculture Research (ICAR), New Delhi : http://www.icar.org.in

Indian Institute of Oilseeds Research (IIOR), Hyderabad: http://www.dor-icar.org.in

Agricultural and Processed Foods Products Export Development Authority (APEDA): http://www.apeda.gov.in

Indian Oilseed and Produce Export Promotion Council (IOPEPC): http://www.iopepc.org

Solvent Extractors Association (SEA): http://www.seaofindia.com

National Mission on Oilseeds and Oil Palm (NMOOP): http://www.nmoop.gov.in

Directorate of Oilseeds Development, Hyderabad: http://www.oilseeds.dacnet.nic.in

Madhya Pradesh Farmers Helpline: 1800 425 3553

National Kisan Call Centre: 1800 180 1551

Farmers' portal: http://farmer.gov.in

Farmer SMS portal: http://www.mkisan.gov.in

Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV)
Jabalpur- 482 004
Madhya Pradesh
E-mail: gkalloo_jnkvv@yahoo.co.in

Rajmata VRS Agricultural University
Gwalior-474002
Madhya Pradesh
E-mail: vcrvskvv@gmail.com

Nanaji Deshmukh Veterinary Science University
Jabalpur-482001
Madhya Pradesh
E-mail: vcnduvs@gmail.com

List of Krishi Vigyan Kendras (KVKs) working on oilseed crops in Madhya Pradesh

Krishi Vagyan Kendra Near Vikram Nagar Railway Station PO. Box No.202, M.L.Nagar Distt. Ujjain - 456 010. Phone No : 0734-2526976	Krishi Vigyan Kendra Raghogarh Naka Aron Distt. Guna-473 101. Phone No : 07545-245360
Krishi Vigyan Kendra Powarkheda Distt. Hoshangabad - 461 110. Phone No : 07574-227297	Krishi Vigyan Kendra Kothi Bagh, Biaora Distt. Rajgarh-465 661. Phone No : 07392-244367
Krishi Vigyan Kendra College of Horticulture Distt. Mandsaur-458 001. Phone No : 07422-220746	Krishi Vigyan Kendra Betul Bazar Distt. Betul-460 004. Phone No : 07141-268201
Krishi Vigyan Kendra, Balgarh Farm PO. Balgarh Distt. Dewas-455 111. Phone No:07272-259139	Krishi Vigyan Kendra Shiksha Samiti, Kalukheda Distt. Ratlam-457 339. Phone No:07414-276314
Krishi Vigyan Kendra Zonal Agriculture Research Station Bamhori, PO. Rajaua Distt. Sagar - 470 002. Phone No : 09954411012	Krishi Vigyan Kendra, Sri Malwa Mahila Vikas Samiti PO. Sirjon Distt. Vidisha - 464 228.
Krishi Vigyan Kendra CRDE, Vill-Sewania Ichhwar Distt. Sehore-462 043. Phone No:07561-275075	Krishi Vigyan Kendra Chandangaon,Distt. Chhindwara-480 001. Phone No:07162-225463
Krishi Vigyan Kendra Girwar Farm Distt. Shajapur-465 001. Phone No:07364-222290	Bbhoj Krishi Vigyan Kendra Near Village Naktara PO.Bankhedi NH-86 Ext., Raisen Sagar Road Distt. Raisen-466 551. Phone No:07482-2647914
Krishi Vigyan Kendra Post Box No.18 Distt. Dhar-454 001.	

Annexure II (a)

Pattern of Assistance for seed component under Mini Mission-I (Oilseeds) of NMOOP during XII Plan

S. No.	Components	Pattern of funding	Rate of Assistance
1	Production of breeder seed	100%	ICAR is the nodal agency for the production of breeder seeds of all crops including oilseeds. No support is proposed for breeder seed production programme under NMOOP during Twelfth Plan period. Only the financial liability of Rs. 12.26 crores approximately on the breeder seed production under ISOPOM up to XI plan has been considered under the NMOOP.
2	Purchase of breeder seed / parental lines (for production of hybrid seed	100%	NMOOP will support purchase of breeder seeds from ICAR/SAUs etc by the States/seed agencies at the full cost of breeder seeds as fixed by the Seeds Division of the Department of Agriculture & Cooperation during Twelfth Plan period.
3	Production of Foundation seed	75-25	Rs1000/quintal for all varieties/hybrids released during last 10 years and Additional assistance of Rs.100/qtl on the varieties/hybrids released in last 5 years. 75% of subsidy amount is meant for farmers and 25% for seed producing agencies for meeting expenditures towards certification & production etc. (SDAs/NSC/SFCI/NAFED/ KRIBHCO/IFFCO/HIL/IFFDC/Central Multi-State Cooperatives such as NCCF
4	Production of certified seed	75-25	-do-
5	Distribution of certified seed	75-25	50% of the cost limited to Rs.1200/quintal for varieties/composites of oilseeds which are not older than 10 years. Hybrids: Assistance for distribution of certified hybrids seeds @ 50% of the cost with a ceiling of Rs.2500/qtls of hybrids, which are not older than 10 years. Subsidized seed distribution only through own outlets/ dealers by Nodal Agencies with a ceiling of 5 ha/farmer.

S. No.	Components	Pattern of funding	Rate of Assistance
6	Distribution of Minikit (Varietal Diversification)	100%	Allocation will be made @ 1 minikit for every 20 ha area each crop @ 100% cost reimbursement. Agencies : NSC/SFCI/NAFED/ KRIBHCO/IFFCO/HIL/IFFDC/Central Multi-State Cooperatives such as NCCF/Identified SSCs.
7	Seed Infrastructure Development	100%	The support for continuation of already approved seed infrastructure projects to States/ Agencies under ISOPOM during Eleventh Plan period will continue. Allocation would be restricted to maximum of 1% of total outlay under the Mini Mission-I on Oilseeds of NMOOP for the entire implementation period during Twelfth Plan period.
8	Variety Specific Targeted Seed Production (VSTSP)	75-25	75% cost of seed production to NSC/SFCI/ selected SSCs/State Government Agencies / ICAR /SAUs and its KVKs farms and International institutions etc in project mode subject to requirement of foundation/ certified seed and availability of breeder/ foundation seeds. **Eligibility :** Varieties/hybrids not older than 5 years.

Annexure II (b)

Pattern of Assistance for Production inputs component under Mini Mission-I (Oilseeds) of NMOOP during XII Plan

S. No.	Components	Pattern of funding	Rate of Assistance
1	Plant Protection Equipments including eco-friendly light trap and Seed Treating Drum.	75-25	For manual sprayers: Knapsack/foot operated sprayers and eco friendly light trap, @ 40% of the cost of procurement subject to a ceiling of Rs. 600/- per equipment (additional 10% assistance to SC / ST / Small / Marginal Farmers / Women, Groups >5 members FPOs and NE States to a ceiling of Rs. 800/- per unit). Seed treating drum with a capacity of 20 kg and 40 kg @ 50% assistance subject to ceiling of Rs. 1750/- and Rs. 2000/- per unit respectively. For Knapsack and power sprayers (capacity below 16 litres) @ 50% of the cost of procurement subject to a ceiling of Rs. 3000/- per unit (additional 10% assistance to SC / ST / Small / Marginal Farmers / Women, Groups >5 members FPOs and NE States to a ceiling of Rs.3800/- per unit). For Knapsack and power sprayers (capacity above 16 litres) @ 40% of the cost of procurement subject to a ceiling of Rs. 8000/- per unit (additional 10% assistance to SC / ST / Small / Marginal Farmers / Women, Groups >5 members FPOs and NE States to a ceiling of Rs. 10000/- per unit).
2	Plant Protection Chemicals	75-25	Need based supply of PP chemicals, insecticides, fungicides, bio-pesticides, weedicides, Bio-agents, micronutrients, biofertilizers etc @ 50% of the cost limited to Rs 500/- ha.
3	Distribution of gypsum/pyrite/ liming/dolomite/ Single Super Phosphate etc.	75-25	50% cost of the material + transportation limited to Rs. 750/- per ha whichever is less. Any source of sulphur notified in FCO including 90% powder (FCO grade) within the cost norms.

S. No.	Components	Pattern of funding	Rate of Assistance
4	Nuclear Polyhedrosis Virus (NPV)	75-25	50% of the cost limited to Rs 500/ha for NPV.
5	Supply of Rhyzobium culture/ Phosphate Solubilising Bacteria (PSB)/ Zinc Solubilising Bacteria (ZSB)/ Azatobactor / Mycorrhiza etc	75-25	Support would be provided to State Department of Agriculture (under AAP) @ 50% of the cost of the culture subject to maximum of Rs. 300 per ha for culture in powder/granules/ liquid forms.
6	Supply of Improved farm implements	75-25	Manually/Bullock drawn implements including Chiseller @ 40% of the cost limited to Rs. 8000/ - per implement (additional 10% assistance to SC / ST/ small/marginal Farmers, Women and NE States to a ceiling of Rs. 0.10 lakh per unit). Tractor driven, farm implements like Rotavator/ Seed Drill/Zero Till Seed Drill/ Multi-Crop Planter/Zero Till Multi-Crop Planter/ Ridge furrow Planter/ Raised bed planter/ Power weeder/ Groundnut digger and Multi crop threshers: @40% of the cost limited to Rs. 50000/- per unit and additional 10% assistance to SC / ST /Small/Marginal Farmers/Women and NE States with a ceiling of Rs. 0.63 lakh per unit.
7	Distribution of Sprinkler Sets	As per NMSA Guidelines	For all categories of sprinkler sets – As per National Mission for Sustainable Agriculture (NMSA).
8	Pipes for carrying water from source to the field	75-25	The support will be provided to the farmers @ 50% of the cost limited to Rs. 25/- per meter with maximum ceiling of 600 meters length and cost of Rs. 15,000/- per farmer for all types of water carrying pipes i.e. PVC, HDPE etc and all sizes as per requirement of farmer. This will be

S. No.	Components	Pattern of funding	Rate of Assistance
			given to the farmers irrespective of condition whether he owns a sprinkler or not, but he should have access to water lifting device.
9	Seed Storage Bins	75-25	The support to farmers through State's Department of Agriculture @ 25% of the cost subject to a maximum of Rs. 1000/- per bin of 1 to 10 qtls capacity. Only one bin per farmer will be provided under MM-I

Annexure II (c)

Pattern of Assistance for Transfer Technology component under Mini Mission-I (Oilseeds) of NMOOP during XII Plan

<table>
<tr><th>S. No.</th><th>Components</th><th>Pattern of funding</th><th>Rate of Assistance</th></tr>
<tr><td>1</td><td>Block demonstrations</td><td>75-25</td><td>Improved package demonstration including Intercropping One demonstration will be allowed to one farmer with a ceiling of one ha under each crop with 50% of the cost of inputs limited to the cost as given
below:-
<table>
<tr><th>Crop</th><th>Rate of Assistance (Rs per ha)</th></tr>
<tr><td>Groundnut</td><td>7500</td></tr>
<tr><td>Soybean</td><td>4500</td></tr>
<tr><td>R & M</td><td>3000</td></tr>
<tr><td>Sunflower</td><td>4000</td></tr>
<tr><td>Sesame/ Safflower/ Castor</td><td>3000</td></tr>
<tr><td>Niger</td><td>3000</td></tr>
<tr><td>Linseed</td><td>3000</td></tr>
</table></td></tr>
<tr><td>2</td><td>Block demonstrations on Polythene Mulch Technology in Groundut.</td><td>75-25</td><td>Package for demonstration on poly-mulch on groundnut in the area/ zone recommended by Directorate of Groundnut Research (ICAR) @ Rs.11500/- per ha (Rs. 7500/- for input cost and Rs.4000/- for poly mulch)</td></tr>
<tr><td>3</td><td>(a) Frontline Demonstrations (b) Frontline demonstrations on Polythene Mulch Technology in Groundnut</td><td>100%</td><td>By ICAR and ICRISAT for mandated crop groundnut.</td></tr>
</table>

<table>
<tr><th>S. No.</th><th>Components</th><th>Pattern of funding</th><th>Rate of Assistance</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><th>Crop</th><th>Rate of Assistance (Rs per ha)</th></tr>
<tr><td>Groundnut</td><td>8500</td></tr>
<tr><td>Soybean</td><td>6000</td></tr>
<tr><td>R & M</td><td>6000</td></tr>
<tr><td>Sunflower</td><td>6000</td></tr>
<tr><td>Sesame/Safflower/niger/ castor/linseed</td><td>5000</td></tr>
<tr><td>poly-mulch on groundnut by ICAR.</td><td>12500</td></tr>
</table>
Maximum of one demonstration will be allowed to one farmer for an area of one hectare under each crop. The size of the FLD plot will be of one ha but not less than 0.4 ha. The assistance will be on pro-rata basis with the reduction of size of demonstration plot.
</td></tr>
<tr><td>4</td><td>Integrated Pest Management (IPM)</td><td>75:25</td><td>Farmers Field School (FFS) would be supported @Rs 26,700/- per FFS including demonstration of bio-agents. Costs include training kits/ material, IPM kits, literature and contingency.</td></tr>
<tr><td>5</td><td>Farmers Training</td><td>75:25</td><td>Rs. 24000/- per training for a batch of 30 farmers for 2 days (@ 400/- per participant per day)</td></tr>
<tr><td>6</td><td>Officers/ Extension workers training (Input dealers included)</td><td></td><td>Rs.36000/- per training for a batch of 20 officers for 2 days. (@ 900/- per participant per day)</td></tr>
<tr><td>7</td><td>Contract Research</td><td>100%</td><td>The TMOP Division has already undertaken few contract research projects through ICAR/ICRISAT etc during the Eleventh Plan period and implemented by the Government of India directly. Funding of these projects will continue during the Twelfth Plan period/ remaining approved period as per the approved budget</td></tr>
</table>

S. No.	Components	Pattern of funding	Rate of Assistance
			through NMOOP. No new contract research projects will be undertaken during Twelfth Plan period.
8	Local Initiatives, Contingency including monitoring & evaluation and Operational costs including Consultant s ervices. Exposure visits of farmers/ Seminar/ Conference/ Tilhan mela etc	100%	The implementing States will be allowed to utilize 1.0 % of their total allocation under MM-I on Oilseeds for contingency expenditure towards monitoring & evaluation and Operational Costs including consultancy. The following activities will be covered under this intervention - 1. Publicity under Mini Mission - I on Oilseeds and Exposure visits (inter and intra state) of farmers and/or officers/Seminar/Conference/ Workshop/Tilhan Mela etc. 2. Contingency: States will be allowed to engage state level consultants/ supporting staff as Technical Support Group (TSG) on contractual basis. Hiring of vehicles/Monitoring of scheme/ attending workshop/meetings etc. Purchase of vehicles will not be allowed. No permanent post will be created under the Mission. 3. Organizing workshop/Seminar/Conference etc by States on oilseed crops & its technologies. Support for use of ICT. 4. Concurrent/Mid Term and end of the Plan period evaluation of Mini-Mission Components by an independent agency. 5. Any other component on increasing production/productivity of oilseeds in state as state specific local initiative, which may be crucial for effective implementation & adoption of best practices in increasing production and productivity of oilseeds under the programme and not covered as an intervention under MM-I with the approval of GOI in their AAPs. The State may include such interventions with subsidy not more than 50% of the cost of the item/services.