SESAME

TECHNOLOGY FOR MAXIMIZING PRODUCTION

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SESAME

TECHNOLOGY FOR MAXIMIZING PRODUCTION

Sesame (*Sesamum indicum* L.) is the oldest indigenous oilseed crop, with longest history of cultivation in India. Sesame or gingelli is commonly known as til (Hindi, Punjabi, Assamese, Bengali, Marathi), tal (Gujarati), nuvvulu, manchi nuvvulu (Telugu), ellu (Tamil, Malayalam, Kannada), tila/pitratarpana (Sanskrit) and rasi (Odia) in different parts of India. Sesame seed (contain 50% oil, 25% protein and 15% carbohydrate) is used in baking, candy making and other food industries. It is an integral part of rituals, religion and culture. The oil is used in cooking, salad oils and margarine (contains about 40% oleic and 40% linoleic acid). Sesame oil and foods fried in sesame oil have a long shelf life because the oil contains an antioxidant called sesamol. The oil can be used in the manufacture of soaps, paints, perfumes, pharmaceuticals and insecticides. Sesame meal is an excellent high quality protein (40%) feed for poultry and livestock. Sesame seeds are store house of energy and very rich in vitamins E, A, B Complex and minerals viz., calcium, phosphorus, iron, copper, magnesium, zinc and potassium. It is a best substitute for mother's milk especially incase of milk allergies. Sesame seed contains extraordinary quantities of methionine, tryptophan, amino acids with innumerable benefits. The oil is used as the base for Ayurvedic preparations and known as the Queen of oils. Sesame seeds are called as the seed of immortality. Studies showed that lignans found in sesame seed have remarkable antioxidant effect on human body. *Til se dil* or *Til – dil* are the ancient Hindi proverbs in India signifying the importance of sesame for heart. Sesame oil is considered as anticholesterol and highly beneficial for heart ailments. Sesame is energy rich crop, ironically however, grown on energy starved condition.

India ranks first in world with 16.73 Lakh ha area and 6.5 Lakh tonnes production. The average yield of sesame (391 kg/ha) in India is low as compared with other countries in the world. The main reasons for low productivity of sesame are its rainfed cultivation in marginal and submarginal lands under poor management and input starved conditions. However, improved varieties and agro production technologies capable of increasing the productivity levels of sesame are now developed for different agro ecological situations in the country. A well managed crop of sesame can yield 1200-1500 kg/ha under irrigated and 800-1000 kg/ha under rainfed conditions. The crop is grown in almost all parts of the country. The area, production and the productivity of the important states growing sesame during 2012-13 is given in Table 1.

Table 1: Area, Production and Productivity in major states of India (2012-13).

State	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)	State	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Andhra Pradesh	67.0	22.0	328	Madhya Pradesh	314.5	157.1	500

Assam	12.0	7.0	583	Maharashtra	31.0	9.0	290
Bihar	2.5	2.2	873	Odisha	23.1	4.4	191
Chhatisgarh	18.8	5.5	293	Punjab	5.1	1.7	133
Gujarat	133.0	34.0	256	Rajasthan	415.2	122.1	294
Haryana	2.8	1.0	357	Tamilnadu	47.6	20.9	439
Himachal Pradesh	3.0	1.1	357	Uttar Pradesh	345.0	64.0	186
Jammu Kashmir	4.8	2.1	437	Uttarakhand	2.0	1.0	500
Jharkhand	8.0	2.9	356	West Bengal	187.5	176.5	941
Karnatka	40.0	13.0	325	Others	9.9	6.1	616
				All India	**1673.0**	**653.6**	**391**

ANALYSIS OF SESAME SCENARIO: In India sesame is grown practically in all states. However, Rajasthan, Gujarat, West Bengal, Maharashtra, Uttar Pradesh, Madhya Pradesh and Andhra Pradesh are the major sesame growing states. The productivity of sesame is low in India, because the crop is mainly grown in *kharif*. It is significant to note that since 1965-66, the productivity of sesame increased by 128 % and the production increased by 54 % despite a reduction of 32% in area. In 2012-13 maximum area was covered by Rajasthan (415 thousand hectare). The maximum production (176 thousand tonnes) and yield (941 kg/ha) was in West Bengal. Since 1965-66, the production of sesame increased by 192 % in Madhya Pradesh and 4204 % in West Bengal, area increased by 19 % in Gujarat and 2186 % in West Bengal respectively and highest yield increase in Rajasthan in 2012-13.

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

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

State	1965-66	1975-76	1985-86	1995-96	2005-06	2011-12	2012-13*	% Change over 1965-66
Andhra Pradesh	224.20	136.10	152.30	199.40	116.00	72.00	67.0	-70.12
Gujarat	111.30	106.90	126.80	249.70	364.00	247.00	133.0	19.50
Madhya Pradesh	346.50	259.50	233.00	182.50	150.10	294.90	314.5	-9.24
Maharashtra	117.80	171.10	227.30	194.80	107.00	46.00	31.0	-73.68
Rajasthan	630.00	366.90	520.00	329.40	422.10	512.80	415.2	-34.10
Uttar Pradesh	708.00	674.20	278.00	195.60	107.10	345.00	345.0	-51.27
West Bengal	8.20	33.30	74.80	115.30	146.00	182.10	187.5	2186.59
All India	**2480.00**	**2170.00**	**2217.00**	**1825.70**	**1723.20**	**1901.50**	**1673.0**	**-32.54**

***Estimates**

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

State	1965-66	1975-76	1985-86	1995-96	2005-06	2011-12	2012-13*	% Change over 1965-66
Andhra Pradesh	39.00	26.40	30.70	54.10	29.00	20.00	22.0	-43.59

Gujarat	25.70	41.70	19.60	92.40	143.00	117.00	34.0	32.30
Madhya Pradesh	53.70	40.50	46.70	46.40	58.10	154.90	157.1	192.55
Maharashtra	27.20	39.30	49.90	48.60	29.00	15.00	9.0	-66.91
Rajasthan	51.40	64.90	27.00	34.30	62.80	166.30	122.1	137.55
Uttar Pradesh	126.90	86.20	16.80	25.40	27.00	75.00	64	-49.57
West Bengal	4.10	20.70	44.00	90.70	123.10	167.20	176.5	4204.88
All India	**425.00**	**479.50**	**501.00**	**531.10**	**641.10**	**810.30**	**653.6**	**53.79**

*****Estimates

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

State	1965-66	1975-76	1985-86	1995-96	2005-06	2011-12	2012-13*	% Change over 1965-66
Andhra Pradesh	185.00	194.00	202.00	271.00	250.00	278.00	328.00	77.30
Gujarat	231.00	390.00	155.00	370.00	393.00	474.00	256.00	10.82
Madhya Pradesh	155.00	156.00	200.00	254.00	387.00	525.00	500.00	222.58
Maharashtra	231.00	230.00	220.00	249.00	271.00	326.00	290.00	25.54
Rajasthan	82.00	177.00	52.00	104.00	149.00	324.00	294.00	258.54
Uttar Pradesh	179.00	128.00	60.00	130.00	252.00	217.00	186.00	3.91
West Bengal	500.00	622.00	588.00	787.00	843.00	918.00	941.00	88.20
All India	**171.00**	**221.00**	**226.00**	**291.00**	**372.00**	**426.00**	**391.00**	**128.65**

*****Estimates

Source: Directorate of Oil Seeds Development, Himayat Nagar,Hyderabad

CLIMATIC REQUIREMENT: Sesame is grown in almost all the states in large or small areas. It can be cultivated up to the latitude of 1600m (India 1200 m). Sesame plant needs fairly high temperature during its life cycle. Normally the optimum temperature required during its life cycle is between 25-35 ^{0}C. If the temperature is more than 40 ^{0}C with hot winds the oil content reduces. If the temperature goes beyond 45 ^{0}C or less than 15 ^{0}C there is a severe reduction in yield. The pollen become 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. The well distributed rain during *kharif* season results in the good crop. During the last decade drastic changes in the climate have been experienced in the country. Aberrations in weather conditions, irregular and unevenly distributed rainfall have adverse effect on sesame yield. The abiotic stresses consequently will result in the biotic stresses which are difficult to manage. In order to tackle these problems one should evolve appropriate varieties to tolerate abrasive weather conditions. Photo and thermo insensitive varieties, responsive to fertilizer application depending on moisture and resistant varieties to insect pests and diseases are the need of the hour.

VARIETAL REQUIREMENT: Research on sesame is limited for it being considered as a minor crop. Efforts should be intensified to enhance germplasm resources with detailed investigations on wild species. There is a wide range of variability in the germplasm reservoir of sesame. Wild species are rich

sources for resistance to stresses. The wild species possess desirable genes *viz*., resistance to *Antigastra*, powdery mildew, wilt, drought, tolerance to heavy rainfall and more seeds per capsule.

High oil, protein, high sesamin, sesmolin, large seed size, colour, rough and easily removable seed coat with reduced anti nutritional factors are the important characters for breeding. The leaves should be medium to broad at base, narrow lanceolate towards apex with short petiole and high photosynthetic efficiency. Capsules with full seed set, short internodes, determinate growth habit with a uniform, short ripening period and non shattering type suitable for machine harvest can lead to higher yield. An improved harvest index should be stressed, thus reducing unproductive biomass. In sesame, harvest index varies from 15 to 20% and possibilities exist to double with improved plant types. The genotypes with the potential to respond to added inputs should be developed.

Most of the sesame varieties are sensitive to photo and thermo periods, which limits cultivation across seasons and regions. Therefore, breeding for wider adaptation is important. Cultivars having white, bold, high lignans, low free fatty acid, oxalic acid and phytic acid are important for export market. Breeding efforts having a combination of improved and conventional breeding is required for sesame improvement.

IMPROVED 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 generally prefer particular varieties in different regions/states for their popularity on the basis of the desirable traits *viz.,* seed colour, resistance to biotic and abiotic stresses and higher market prices.

Table 3: Statewise farmers preferred varieties

State	Varieties
Gujarat	Guj-Til-1, Guj-Til-2, Guj-Til-3, Guj-Til-4, Guj-Til-10
Madhya Pradesh /Chhattisgarh	TKG-21, TKG-22, TKG-55, JTS-8, TKG-306, TKG-308, PKDS-8, PKDS-11, PKDS-12
Rajasthan	RT-46, RT-54, RT-103, RT-125, RT-127, RT-346, RT-351
Maharashtra	AKT-64 , AKT-101, JLT-408, PKVNT-11, Phule Til.1
Uttar Pradesh	T-78, Sekhar, Pragati, Tarun
Tamil Nadu	Co-1,TSS-6, Paiyur-1, VRI-1, VRI-2, TMV-7
West Bengal	Rama, Savitri, Tilottama (B-67)
Orissa	Nirmala , Prachi, Amrit, Shubhra, Smarak, Usha, Uma, Vinayak
Andhra Pradesh	Varaha, Gautama, Swetha til, Chandana, Hima, Rajeshwari
Kerala	Thilathara, Thilarani, Thilak, Kayamkulam-1
Karnataka	DS-1, DS-5, DSS-9
Punjab	Punjab Til-1, TC-25, TC-289
Bihar	Krishna
Haryana	Haryana Til-1, Haryana Til-2
Himachal Pradesh	Brijeshwari

Improved varieties recommended for different parts of the country for *kharif,* late *kharif, rabi* and summer seasons and their characteristic features are presented in Table 4.

Table 4: Characteristic features of recommended varieties of sesame.

Releasing State/Variety	Year of Release	Seed Yield (kg/ha)	Oil content (%)	Days to maturity	Salient characters
GUJARAT					
Gujarat Til-1	1979	650-700	48-52	86-92	White seed, branching type with smooth green stem, leaf opposite, flower pink colour, multi capsular, capsule opposite on main stem and opposite as well as alternate on secondary branches, moderately resistant to powdery mildew
Gujarat Til-2	1994	750-800	48-52	88-92	White seed, branching type, multi capsular, capsule opposite, hairy, tolerant to macrophomina
Gujarat Til-10	2002	750-800	48-52	88-92	Black seed, profusely branched, single alternate capsule, flower colour pinkish white, resistant to powdery mildew
Gujarat Til-3	2006	750-800	48-52	84-88	White bold seed, medium maturing, single, opposite, broad, oblong capsules
Gujarat Til-4	2010	750-800	48-52	79-83	White seed, early maturing, multicapsule, capsule alternate, glabrous, narrow oblong capsules
RAJASTHAN					
RT-46	1990	700-750	48-50	82-85	White seed, tolerant to alternaria leaf spot
RT-54	1992	700-800	43-46	78-80	Light brown seed, tolerant to leaf blight and alternaria leaf spot
RT-125	1994	700-800	48-50	83-88	White seed, tolerant to macrophomina, alternaria leaf spot and bacterial leaf blight
RT-103	1994	700-800	46-50	83-88	White seed, tolerant to macrophomina and bacterial leaf blight
RT-127	2001	750-850	50-52	82-86	White bold seed, drought hardy, tolerant to macrophomina, bacterial leaf spot and powdery mildew
RT- 346	2009	750-850	49-51	82-86	White seed, capsules non hairy, compact (short internodal distance) medium long and alternate
RT- 351	2010	700-800	48-51	80-85	Tolerant to macrophomina, leaf curl, and cercospora
MAHARASHTRA					
Phule Til.1	1978	600-700	49-51	90-95	White seed, tolerant to macrophomina
N-8	1982	600-650	50-51	120-125	Brown tinge seed, resistant to powdery mildew, tolerant to macrophomina and alternaria leaf spot
Tapi (JLT-7)	1987	600-700	48-52	85-90	White bold seed, tolerant to alternaria leaf spot
Padma (JLT-	199	700-750	48-50	82-86	Light brown seed, tolerant to

26)	1				Alternaria and Cercospora.
AKT-64	1996	700-750	47-48	85-90	White seed, medium tall, tolerant to macrophomina and phytophthora blight
AKT-101	2001	750-800	48-49	88-90	Oxalic acid below 1 % and FFA below 2 %, tolerant to phyllody, macrophomina and bacterial blight
PKV-NT-11	2009	800-850	48-49	88-92	White seed, tolerant to phyllody, macrophomina and bacterial blight,
JLT-408	2010	700-800	51-53	80-85	White bold seed, low FFA content, tolerant to powdery mildew
MADHYA PRADESH/CHHATTISGARH					
Kanchan (JT-7)	1980	600-700	50-53	84-88	White seed, medium size seed
TKG-21 (JT-21)	1993	650-700	52-54	85-90	White seed, tolerant to bacterial leaf spot and alternaria leaf spot
TKG-22	1995	650-700	50-54	82-85	White seed, tolerant to phytophthora blight
TKG-55 (JT-55)	1999	650-700	50-53	82-85	White seed, tolerant to phytophthora blight
JTS-8	2001	650-700	50-53	82-85	White seed, capsules alternate, non hairy; flowers hairy, tolerant to macrophomina, alternaria leaf spot and phytophthora blight
Jawahar Til-11 (PKDS-11-Venkat)	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, macrophomina, cercospora, powdery mildew, and alternaria leaf spot
Jawahar Til – 12 (PKDS-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 (PKDS-8)	2010	700-750	50-53	85-88	Black seed, tolerant to capsule borer
UTTAR PRADESH/UTTARANCHAL					
T-12	1962	650-700	46-50	85-88	White seed, tolerant to phyllody and leaf curl
T-13	1967	600-700	48-52	82-88	White seed, tolerant to lodging
T-78	1995	650-700	46-50	85-90	White seed, tolerant to lodging and leaf curl disease
Sekhar	2001	700-800	50-52	85-90	White seed, tolerant to leaf curl, powdery mildew, macrophomina and phytopthora blight
Pragati (MT-75)	2002	700-750	48-52	85-90	White seed, tolerant to leaf curl, powdery mildew, macrophomina and phytopthora blight,
Tarun	2005	700-800	52-53	90-95	White seed, moderately resistant to diseases
WEST BENGAL					
Tilottama (B-67)	1984	900-1000 (Summer)	42-44	80-85	Blackish brown seed, tolerant to macrophomina
Rama	198	1000-	46-48	85-90	Reddish brown seed, tolerant to

(Imp.Sel.5)	9	1003 (Summer)			macrophomina
SWB-32-10-1 (Savitri)	2008	1100-1400 (Summer)	48-50	84-88	Light brown seed, erect branching type, tolerant to lodging, leaves deep green, flower light pink colour, tetra locular capsules, tolerant to macrophomina
HARYANA					
Haryana Til-1	1978	700-750	48-50	85-90	White seed, early maturing, dark green, long and thick leaves, tolerant to leaf curl
Haryana Til-2	2012	650-750	48-50	85-90	White seed, tolerant to phyllody and leaf curl
ANDHRA PRADESH					
Gauri	1974	650-700	46-48	85-90	Dark brown seed, suitable for early *Kharif and summer*
Madhavi	1978	650-700	46-48	78-82	Light brown seed
Rajeshwari	1988	700-750	48-50	85-90	White seed, tolerant to stem rot and powdery mildew
Varaha (Yel.1)	1993	800-850	50-53	82-85	Dark brown seed, uniform maturity.
Gautama (Yel.2)	1993	750-800	50-52	76-80	Light brown seed, uniform maturity, tolerant to alternaria leaf spot
Swetha Til	1997	750-800	50-52	82-86	White seed, determinate, tolerant to powdery mildew, stem rot, leaf curl and macrophomina
Chandana (JCS-94)	2002	800-850	45-48	84-88	Brown seed, tolerant to bacterial blight
Hima	2006	800-850	48-50	80-85	Shiny white seed, long capsules, early in duration, field tolerant to alternaria leaf spot
ODISHA					
Kanak	1979	600-700	46-48	85-90	Light brown seed, tolerant to lodging
Kalika	1985	600-700	45-48	85-90	Light brown seed, tolerant to macrophomina
Vinayak	1989	600-650	43-46	85-90	Light brown seed, tolerant to alternaria leaf spot
Uma (OMT-11-6-3)	1992	750-850	42-46	75-80	Pale white seed, tolerant to Macrophomina and phyllody
Usha (OMT-11-6-5)	1992	700-750	43-46	85-90	Light brown seed, tolerant to alternaria alternaria leaf spot
Nirmala (OS-Sel-164)	2003	800-900	42-44	80-85	White seed, tolerant to bacterial leaf spot, powdery mildew and alternaria leaf spot
Prachi (ORM-17)	2004	800-900	42-45	85-90	Black seed, tolerant to cercospora, powdery mildew
Amrit [OSC-24(95)2-1-3]	2007	800-900	43-46	82-85	Light brown seed, tolerant to powdery mildew and alternaria leaf spot
Shubhra	2012	800-900	48-52	78-84	White seed, delayed shattering moderately tolerant to macrophomina and alternaria leaf spot
Smarak	2012	800-900	48-52	80-85	Golden yellow bold seed, delayed shattering, Synchronous maturity, tolerant to macrophomina and alternaria leaf spot
TAMIL NADU					
TMV- 3	19	650-700	50-52	80-85	Black seed, suitable for all seasons

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TMV-4	1977	700-850	48-50	85-90	Brown seed, four loculed capsule
TMV-6	1980	700-950	52-54	85-90	Brown seed, tolerant to drought
CO -1	1983	650-750	50-52	85-90	Black seed, tolerant to macrophomina
Paiyur-1	1990	750-850	50-52	85-90	Black seed, four loculed capsule
TSS-6 (SVPR-1)	1991	750-800	50-54	75-80	White seed, four loculed capsule, tolerant to alternaria leaf spot
VRI (SV)-1	1995	600-700	50-52	72-75	Dark brown seed, short, four loculed capsule, early maturing
VRI (SV)-2	2005	700-800	50-53	80-85	Reddish brown seed, glabrous, mixed in phyllotaxy, basal branch habit, profuse branching, tolerant to macrophomina
TMV(SV)-7	2009	800-900	48-50	80-85	Brown seed, tolerant to root rot, high protein content (24.5 %), suitable for value addition
BIHAR/JHARKHAND					
Krishna	1989	700-750	45-48	88-95	Black seed, tolerant to alternaria leaf spot
Jawahar Til-11 (PKDS-11-Venkat)	2006	650-700	46-50	82-85	Dark brown, tolerant to macrophomina
KARNATAKA					
DS-1	1995	400-500	48-50	95-100	White seed, tolerant to bacterial leaf blight
DSS-9	2009	550-600	49-50	85-90	White bold seeded, early maturing
DS-5	2012	600-700	50-52	90-95	White bold seeded, tall 4-5 branched with long capsules, tolerant to bacterial leaf blight
KERALA					
Thilothama	1982	600-650	48-50	85-90	Brown bold seed, multicapsuled, shy branching
Soma	1984	600-650	44-48	85-95	White seed, tolerant to alternaria leaf spot
Surya	1984	600-650	44-48	85-95	Black seed, tolerant to phyllody
Kayamkulam-1	2006	600-650	48-50	80-85	Brownish black seed, moderately branched, with narrow oblong capsule, tolerant to drought
Thilak	2006	600-650	48-50	85-90	Blackish brown seed, highly branched type, suitable for both rice fallow and rabi upland, tolerant to moisture stress
Thilathara	2006	600-650	48-52	84-88	Blackish brown seed, tall, shy branching, resistant to powdery mildew
Thilarani	2006	650-750	46-50	82-86	Dark brown seed, semi tall, compact capsule packing, resistant to powdery mildew
PUNJAB					
Punjab Til-1	1966	650-700	48-52	80-85	White seed
TC-25	1978	700-800	50-52	80-85	White seed

TC-289	1986	700-800	48-52	84-88	White seed, tolerant to macrophomina
Himachal Pradesh					
Brijeshwari (LTK-4)	2001	800-850	48-52	85-90	White bold seed, medium tall with spreading branches

Assam- TKG-21 variety of Madhya Pradesh and Uma variety of Odisha are recommended.

Chhatisgarh- Sekhar variety of Uttar Pradesh and Amrit variety of Odisha are recommended.

Jharkhand- PKDS-11 variety of Madhya Pradesh is recommended.

Jammu and Kashmir- Brijeshwari variety of Himachal Pradesh is recommended.

North Eastern States TKG-21, TKG-22 and TKG-55 varieties of Madhya Pradesh, Tilottama Variety of West Bengal, GT-10 of Gujarat and Uma variety of Odisha are recommended.

- RT-46 and RT-125 are recommended for Punjab, Haryana, and Uttar Pradesh besides Rajasthan state.
- RT-54 and RT-103 are also recommended for Gujarat, Maharashtra and Telangana region of Andhra Pradesh.
- RT-346 is also recommended for Haryana, Punjab, Himachal Pradesh, Gujarat and adjoining areas of western Uttar Pradesh, Maharashtra and Karnataka besides Rajasthan state.
- RT-351 is also recommended for Gujarat, Uttar Pradesh, Maharashtra, Haryana, Punjab and Himachal Pradesh besides Rajasthan state.
- TKG-21, TKG-22 and TKG-55 are also recommended for Eastern UP, Bihar, Odisha, West Bengal and North Eastern states besides Madhya Pradesh state.
- Uma is also recommended for Uttar Pradesh, Bihar, West Bengal and North Eastern States, besides Odisha state.
- Amrit is also recommended for West Bengal besides Odisha state.
- Sekhar is also recommended for Haryana and Bihar besides Uttar Pradesh state.
- PKDS-11 is also recommended for Punjab, Haryana, Uttar Pradesh, Himachal Pradesh and West Bengal besides Madhya Pradesh state.
- JTS-8 is also recommended for Uttar Pradesh, Maharashtra and adjoining parts of Andhra Pradesh besides Madhya Pradesh state.
- TMV-3 is also recommended for Karnataka besides Tamil Nadu state.
- TC-25 is also recommended for Vidarbha region of Maharashtra besides Punjab state.

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

Seed Scenario: The breeder seed production in sesame exceed the indents by 2-3 times. The seed production chain at foundation and certified stages is weak. The seed replacement rate is low exhibiting a range from minimum of 1-2% in Bihar and Madhya Pradesh to a maximum of 10% in Gujarat. The non

availability of quality seed to the farmers at proper time is one of the important reason for low productivity. However, improved varieties and agro production techniques capable of boosting the productivity levels have been developed for different agro ecological situations.

Maintenance of genetic purity: Sesame is highly prone to mechanical mixture due to its very light, small seed and shattering habit. Therefore care has to be taken to avoid mixture at all the stages. Following precautions are to be taken to maintain the genetic purity. Select the field with no preceding crop of Sesame. Use seed from authenticated source after ascertaining genetic purity through grow out test. Restrict selection of only true to the type plants. Renewal of seed should be done at least once in three years. Follow strict rouging at vegetative, flowering and maturity stages. Apply phorate 10G 10kg/ha in and around the seed plot to control seed removal and/or mechanical mixture by the ants, a serious problem at sowing time. The maturity of the capsules is not synchronous in most of the varieties, as a result the earlier capsules start shattering while others are still green. Shattering is the main problem and source of mechanical mixture. In spite of very low seed rate and very high multiplication ratio, the conversion from one to the other stage of seed multiplication is very low. Prolonged exposure to variations in temperature and relative humidity during *kharif* may lead to shrinkage and attack of pathogens. It is sensitive to excessive moisture and highly susceptible to *Phytophthora* and *Macrophomina.* Crop failure due to these reasons is quite frequent. Very small, light seed and shattering of capsules, make the crop prone to mechanical mixture at harvesting, threshing and processing stages. To protect the seed from seed borne pathogens and storage fungi, a protective spray of systemic fungicide like Carbendazim is recommended but not actually practiced. Like other crops, non lifting and delayed lifting of seed is a common problem of breeder seed production process.

Presently two seed production systems are operating. The formal system is being operated through public sector agencies like NSC, SFCI, SSC's, SAUs and oil federations *etc.* The seed multiplication ratio in this system is extremely poor. The main advantage of this system is that the identity, genetic purity, quality and source of the seed is known to the farmers. The informal system includes multiplication of varieties by private growers or individual farmers and sharing the seed by the farmers. The seed of most of sesame varieties under cultivation is being produced and supplied through this system. The main disadvantage of this system is that the identity, genetic purity, quality and source of the seed is not authenticated. However, the seed produced through this system is less expensive and easily available to the farmers. The existing formal system of seed production had been hardly sufficient to cope up with the seed requirement. The minor crops like sesame receive least priority of seed producing agencies and therefore the production of quality seed for the farmers in these crops is pathetic. The possibility of improving the supply of quality seed through the formal system in near future appears not to be so bright. Therefore in these crops, alternative systems of seed supply may prove worthy for fulfillment of the requirement.

Both, the formal and informal systems of seed supply, have their own limitations. To overcome the limitations of the prevalent informal system and the existing formal seed supply system, the seed production can be undertaken by the research institutes and distributed through farmer fairs/field days/sale counters. The direct supply is quite feasible and will be rather more effective in view of the specific advantages. This system has been quite successful to bring the maximum area under quality seed of improved varieties in Gujarat where total area has been occupied by Gujarat Til-1 and Gujarat Til-2 and average productivity of the state has gone to 600 kg/ha. Another option to augment the seed supply in sesame is seed village concept. The institutes can choose a single variety to grow in one ha plot which will easily produce 8-10 q seed sufficient to cover the area of about 250 to 300 ha in one village with the single variety. The seed village should grow one and the only one variety. The local or other varieties should not be grown in seed village. Clubbing together the programme of demonstrations and seed village will prove synergistic for the improvement of seed replacement rate.

The improved production technologies recommended for different sesame growing areas in the country are as follows.

GROWING SEASONS: Sesame is grown in all the crop growing seasons *viz*, *kharif,* late *kharif, rabi* and summer. It is grown in more than one season in some part and in different seasons in other parts of the country (Table 5).

Table 5: Sesame growing seasons in India.

Season	Planting time	Harvesting time	Situation	Area (%)	Name of states
Rainy (*kharif*)	June-July	Oct.- Nov.	Rainfed	70	Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Andhra Pradesh, Maharashtra, Odisha, Tamil Nadu and Karnataka
Late *Kharif*	Aug. - Sept.	Dec. - Jan.	Rainfed	10	Andhra Pradesh, Gujarat, Madhya Pradesh and Maharashtra
Winter (*rabi*)	Oct. - Nov.	Feb. - March	Irrigated	Rare	Tamil Nadu, Andhra Pradesh and Odisha
Summer	Jan. - March	April - June	Irrigated	20	West Bengal, Odisha, Gujarat, Andhra Pradesh, Tamil Nadu and Kerala
Pre *Kharif*	Apr - May	July	Rainfed	10	Karnataka , Andhra Pradesh

Normally, the crop is grown in plains but it also comes up successfully up to 1200 m above mean sea level. For maximum yield, sesame requires fairly high temperatures (25-35^{o}C) and evenly distributed rainfall during its growth period.

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.

CROPPING SYSTEM

Sequence cropping: Sesame is a short duration crop and fits well into a number of multiple cropping systems either as a catch crop or a sequence crop. Following are some of the common sequences followed in different regions (Table 6).

Table 6: Sequence cropping with sesame.

State	Crop sequence
Andhra Pradesh	Rice-Groundnut-Sesame, Sesame-Horse gram, Finger millet/Sorghum/Horse gram (Early)-Sesame, Sesame- Upland Rice
Bihar	Early Rice -Potato-Summer Sesame/Green gram *Kharif* Sesame-Maize/Pigeon pea/Rabi gram Wheat-Summer Sesame/ Green gram
Gujarat	Sesame-Wheat/Mustard
Karnataka	Sesame-Horse gram/Chickpea
Madhya Pradesh	Sesame-Wheat ,Cotton-Sesame-Wheat, Rice-Summer Sesame
Maharashtra	Sesame (Early)-Rabi Sorghum/Safflower/Gram Cotton-Summer Sesame (For Vidharbha Region)
Odisha	Rice/Potato-Sesame, *kharif* Sesame-Maize/Pigeon pea/ Rabi gram
Rajasthan	Sesame-Wheat/Green gram/Barley/Mustard Sesame-Pearlmillet/Green gram/Clusterbean/Mothbean
Tamil Nadu	Rice/Groundnut-Sesame, Sesame- Green gram, Sesame-Rabi Sorghum, Groundnut-Black gram-Sesame, Sesame-Green gram, Cowpea-Sesame
Uttar Pradesh	Sesame (Early)-Gram/Rapeseed-Mustard/Lentil/Pea
West Bengal	Potato-Sesame , Rice - Sesame

Inter cropping: Profitable intercropping systems recommended for different states are given in Table 7.

Table 7: Inter cropping systems for different states.

State	Intercropping system
Gujarat	Sesame+Groundnut / Black gram (3:3) Sesame+Pearl millet / Cotton (3:1)
Karnataka	Sesame+Groundnut (1:4)
Madhya Pradesh	Sesame+Green gram / Black gram (2:2 or 3:3) Sesame+Soybean (2:1 or 2:2)
Maharastra	Sesame+Pearl millet / Black gram (3:1), Sesame+Pigeonpea(4:2) Sesame+Green gram(3:3), Sesame+Soybean (2:1), Sesame+Cotton (3:1) (For Vidharbha Region)
Odisha	Sesame+Green gram /Black gram (2:2) Pigeonpea+Sesame (2:2) (In *kharif*)
Rajasthan	Sesame+Green gram(4:2) / Moth bean (1:1)
Tamil Nadu	Sesame+Green gram / Black gram (3:3) Sesame+Pigeonpea(3:1), Sesame+Groundnut (2:4)
Uttar Pradesh	Sesame+Green gram (1:1), Sesame+ Pigeon pea(3:1)
West Bengal	Sesame+Groundnut (1:3 or 2:2)

AGRONOMIC MANAGEMENT

Land 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 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 seeding as it adversely affects germination and plant stand.

Optimum time of sowing and spacing: Indian agro climate is so variable that sesame is sown and harvested through out the year in all the months in one or the other part of the country. Spacing between and within the row depends on the specific variety, plant type and season. The optimum time of sowing and spacing recommended for different states/ regions are given in Table 8.

Table 8: Optimum time of sowing and spacing in different states/ regions.

State	Season	Sowing time	Spacing (cm)
Andhra Pradesh			
Coastal	*Kharif*	Second fortnight of May	30 x 15
	Summer	Second fortnight of January	30 x 15
Telangana	*Kharif*	Second fortnight of July	30 x 10-15
Gujarat	*Kharif*	Last week of June to second fortnight of July	60 x 15
	Semi-*rabi*	Mid September	60 x 15
	Summer	Second fortnight of February	30 x 10
Madhya Pradesh/ Chhattisgarh	*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
Maharashtra	*Kharif*	Second fortnight of June to First week of July	30 x 15
	Semi-*rabi*		30 x 15
	Summer	Early September	45 x 15
Vidharbha Region	*Kharif*	February	30 x 10
	Semi-*rabi*	Last week of June to first fortnight of July	30 x 10
	Summer	First fortnight of September	30 x 10
		Last week of January to first week of February	
Rajasthan	*Kharif*	First fortnight of July	30 x 15 or 45 x 10
Odisha	*Kharif*	June-July	30 x 10-15
	Rabi	September-October	30 x 10-15
	Summer	February	30 x 10-15
Uttar Pradesh/ Uttaranchal	*Kharif*	Second fortnight of July	30-45 x 15
Bihar/ Jharkhand	*Kharif*	July	30 x 15

West Bengal	*Kharif* *Rabi* Summer	End of May-first week of June September-October February-March	30 x 15 30 x 15 30 x 15
Tamil Nadu	*Kharif* *Rabi* Summer	Second fortnight of May to Second fortnight of June November-December Second fortnight of January to March	30 x 30 30 x 30 30 x 30
Karnataka North South	*Kharif* Pre *Kharif*	June-July April-May	30 x 15 30 x 15
Assam	*Kharif*	July-August	30 x 10-15
Punjab/Haryana	*Kharif*	Second fortnight of July	30 x 10-15
Kerala	*Kharif* Summer	August December	30 x 10-15 30 x 15

Seed Treatment: For the prevention of seed borne diseases, use treated seed with Thiram 2 g/kg + Carbendazim 1 g/kg or *Trichoderma viride* 5 g/kg seed. 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: For improving soil physical conditions and to obtain higher yield, apply about 5 tonnes/ha of well decomposed farm yard manure before the 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 different regions/situations are given in Table 9.

Table 9: Recommended doses of fertilizers for different states.

State/ Situation	Recommended dose of N:P:K (kg/ha)	Specific recommendation
Andhra Pradesh Coastal region Telangana region	 40:40:20 30:30:20	 -
Gujarat *Kharif* Semi-*rabi* Summer	 50:25:40 25:12.5:0 50:25:0	 Apply sulphur 15-20 kg/ha - -
Madhya Pradesh/ Chhattisgarh Rainfed Summer	 40:30:20 60:40:20	 Apply zinc sulphate 25 kg/ha once in three years in zinc deficient soils
Maharashtra Vidharbha Region	50:0:0 40:50:0 25:25:0	Half N at 3 weeks after sowing and remaining half 6 weeks there after. For AKT-64 variety For other varieties -Half N at sowing and remaining half dose 30 DAS -20 kg Zn and S/ha each at sowing if soils are deficient
Rajasthan Heavy soils	 40:20:0	 Apply Gypsum 250 kg /ha

Light soils	40:25:0	
Odisha Irrigated Rainfed	 40:20:20 30:15:15	 - -
Tamil Nadu Irrigated Rainfed	 35:23:23 23:13:13	 Apply full dose of N, P and K as basal Seed may be treated with 600 g *Azospirillum*
Uttar Pradesh/ Uttaranchal	20:10:00	-
Haryana	30:00:00	-
Bihar/ Jharkhand	40:40:00	-
West Bengal Irrigated Rainfed	 50:25:25 25:13:13	 No fertilizer if sown after potato.
Assam	30:30:20	Entire as basal
Kerala	30:15:30	N may be applied 75% as basal + 25 % as foliar 2% urea, 30-35 days after sowing
Karnataka	37.5:25:25	Half N + full P and K as basal Remaining half N at 30-35 DAS

Wherever specific mention has not been made, 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 days of sowing and other at 30-35 days after sowing are required to keep the field weed free and for moisture and nutrients available to the crop. For interculture, use hand hoes or bullock drawn blade harrow. Preplant incorporation of 1 kg a.i./ha fluchloralin or pre emergence application of 1 kg a.i./ha Pendimethalin effectively check weed growth. One hand weeding and hoeing at 30 days after sowing may be followed.

Irrigation: Except, when raised during *rabi*-summer seasons, sesame rarely receives any irrigation. Nevertheless, protective irrigation will greatly benefit the *kharif* crop also 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: A number of insect pests and diseases may damage sesame 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 in Table 10 and 11.

Table 10: Important insect pests of sesame and their integrated management.

Insect pest	Nature of damage	Stage when crop is damaged	Period of insect activity	Integrated management
Leaf roller and capsule borer (*Antigastra catalaunalis* Dup.)	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.	The first attack of the pest starts when the crop is 2-3 weeks old.	July to September	• Early sown *kharif* crop is less infested than late sown crop • Use tolerant varieties *viz*; RT-46, RT-54, RT-103, RT-125, Usha, Swetha Til, Tapi, Pragati, TMV-3, Shekhar, Tarun, Amrit, Gujarat Til-3, TKG-306, Hima, PKV-NT-11, TKG-55, TKG-21, TKG-22 and JTS-8 • Removal of larvae from the leaf webs during the initial stages of plant growth and destroy them • Intercropping with black gram, green gram, moth bean, pearl millet, pigeon pea and cowpea proved to be more effective than sole crop • Crop rotation is effective in reducing pest population. • Birds readily eat the caterpillars and help to check when they are numerous, 40-50 bird perches are required for one hectare • For effective control of the sesame pest particularly at early stage, apply phorate 10G 10 kg/ha as basal application • Release of Larval parasite *Bracon hebator*, *Bracon geichi* Ashm • Spray NSKE 5 g/l • Seed treatment with imidachloprid 70 WS 7.5 g/kg seed or thiamethoxam 25 WG 5 g/kg seed and one or two foliar sprays of NSKE 5 g/l or neem oil 5 ml/l or neem gold 0.3% or Spinosad 45 SC 0.15 ml/l. or prophenophos 50 EC 2ml/l is found effective against major insect pests of sesame • Two sprays of Chloropyriphos 20 EC 1.5 ml/l or Quinalphos 25 EC 1.5 ml/l or Triazophos 40 EC 1 ml/l at 30 and 45 days after sowing • Economic threshold level of *Antigastra catalaunalis* is 10 per cent plant infestation level
Gall fly *(Asphondylia sesami* Folt.)	Maggots feed inside the floral bud leading to formation of gall like structure which do not develop into flower/ capsule. The affected buds	At the time of bud initiation	September to November	• Clipping of the galls, picking and burning the shed buds may help as prophylactic measure • Use tolerant varieties like RT-46, Swetha Til, RT-103, OMT-26, Swetha Til, RT-127, Hima and RT-125 • Spray NSKE 5 g/l • Spray crop at bud initiation stage with any one of the following insecticides dimethoate 1.5 ml/l or Quinalphos 25 EC 1.5 ml/l or Dichlorvos 76 EC 1 ml/l or

	wither and drop.			Triazophos 40 EC 1 ml/l or Imidacloprid 17.8% SL 0.25 ml/l
Bud fly (*Dasynura sesami* G&P)	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.	At the time of bud initiation	September to October	• Use tolerant varieties like MT-75 and Shekhar • Management as in the case of gall fly
Sesame leaf hoppers (*Orosius albicinctus* Dist.)	Nymph and adults suck the sap of tender parts of the plants. The jassid or leaf hopper is a serious pest of sesame and is known to transmit phyllody disease.	From vegetative to capsule stage	July to end of September	• Seed treatment with imidachloprid 70 WS 7.5 g/kg seed or thiamethoxam 25 WG 5 g/kg seed protects the crop from all sucking pests for about a month • Intercrop with Redgram • Remove and destroy infected plants • Use Predator : *Brumus sutugalis* (Early instar nymphs) • Spray NSKE 5 g/l • Spray Dimethoate 30 EC 1.5 ml/l or Imidacloprid 17.8% SL 0.25ml/l or Acetamaprid 0.3 g/l or Thiamethoxam 0.25 g/l or Thiochloprid 1 ml/l
Hawk moth (*Acherontia styx* W.)	Caterpillars feed on the leaves and defoliates the plant.	Throughout the crop.	August to October	• Deep ploughing exposes the pupae for birds • Collection and destruction of caterpillars • Use bioagents *Trichogramma spp*. (Egg. Parasite) or *Apanteles achorantiae* (larval parasite) • Spray NSKE 5 g/l • Two sprayings of Quinalphos 25 EC 1.5 ml/l or Chloropyriphos 20 EC 2 ml/l • Two rounds of dusting with phosalone 4% or malathion 5% dust 25 kg/ha, first at 30 DAS and second at 45 DAS
Bihar Hairy caterpillar (*Spilosoma 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	Starting from vegetative stage till maturity.	August to October	• After harvesting of *kharif* crop, field should ploughed to expose larvae and pupae for bird predation • Avoid pre monsoon sowing • Use optimum seed rate and adequate plant spacing should be followed • Use tolerant varieties like Tilotama and Rama • Destroy egg masses and young larvae during gregarious phase • Install one light trap/ha to catch the adults • Use bird perches 40-50/ha • Use *Trichogramma evanesuns* or *T.*

	the stem.			*minutam* or *T. riely* or *Apanteles oblique Welkinson* as egg parasite • Use *Bacillus thuringiensis* var. Kurstaki as larval parasite • Spray NSKE 5 g/l • Two sprayings of any one of the following insecticides Chloropyriphos 20 EC 1.5 ml/l or Triophos 40 EC 1 ml/l or Quinalphos 25 EC 1.5 ml/l or Acephate 75% SP 1.5 g/l or Indoxacarb 15.8 EC 0.5 ml/l first at 30 DAS (days after sowing) and second at 45 DAS

Table 11: Important sesame diseases and their management.

Disease	Symptoms	Stage of crop when disease appears	Management
Phytophthora blight (*Phytophthora parasitica Sesami*)	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.	Seedling to flowering stage.	• Deep ploughing in summer • Improve drainage • Two years crop rotation • Use disease free seed • Sesame + pearlmillet (3:1), Intercropping, should be followed • Use tolerant varieties *viz*. TKG-21, TKG-22, TKG-55, JTS-8, AKT-64 • 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 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	Seedling to maturity.	• Two years crop rotation • Deep ploughing in summer • Use disease free seed • Follow intercropping sesame + mothbean 1:1 or 2:1 ratio • Use tolerant varieties *viz*. RT-46, RT-54, RT-103, RT-125, RT-127, TKG-55, JTS-8, MT-75, Nirmala • 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) at 7 days interval

	sprinkled on the root. The roots become brittle.		• Irrigate field to avoid stress condition
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.	Spots appear from 4-leaf stage of the crop and continue till maturity.	• Seed treatment with hot water at 52 ºC 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 alongwith veins and petiole and defoliation may occur.	From 4-6 leaf stage of crop and continue till maturity.	• As in bacterial blight
Cercospora leaf spot (*Cercospora sesami)*	Disease appears as small, angular brown leaf spots of 3mm diameter with gray center and dark margin delimited by veins. In severity of the disease, defoliation occurs. In favorable conditions the disease spreads to leaf petiole, stem and capsules producing linear dark coloured deep seated lesions.	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%) 3g/kg seed • Use tolerant variety TKG-21 • Three sprays of Indofil M 45 (0.25%) + Carbendazim (0.1%) or Topsin M (0.1%) alternately at 15 days interval
Alternaria leaf spot (*Alternaria sesami)*	Spots on leaves are brown circular to irregular in shape and often have concentric rings.	Spots appears when the crop is nearly one month old.	• Use tolerant varieties *viz*. TC-25, RT-46, RT-54, JTS-8, Sekhar, Usha, TSS-6, Nirmala, RT-125 • 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

Powdery mildew (*Oidium* sp, *Sphaerotheca* sp., *Leveillul*a sp.)	Small cottony spot appears on the infected leaves, which gradually spread on the lamina. Defoliation of severely infected plant occurs before maturity.	45 days to maturity.	• Early planting i.e. immediately after onset of monsoon • Follow intercropping system of Sesame + Pearlmillet (3:1) • Use tolerant varieties *viz*. Swetha, RT-127, MT-75 • 2 to 3 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 but if capsules are formed on lower portion of plant they do not yield quality seed.	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) • Use tolerant varieties *viz*. JT-21, Swetha, Rama, Sekhar • Soil application of Phorate 10 kg/ha • Three sprays of neem oil (0.5%) at 30, 40 and 60 days after sowing or Three sprays of Dimethoate (0.3%) alternately at 30, 40 and 60 days after sowing

IPM PACKAGE: Pest resistant variety + seed treatment with Carbendazim 50 wp (0.2%) or Carbendazim (0.1%) + Thiram (0.2%) or *Trichoderma viride* (0.5%) + two sprays of Azadirachtin (0.5%) or Indofil M 45 (0.25%) + Quinalphos (0.05%) at 30-40 and 45-55 days after sowing. Intercropping with Green gram/pigeon pea/Black gram minimizes the incidence of leaf roller, gall fly and major diseases.

HARVESTING AND THRESHING: 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 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.

ECONOMICS OF CULTIVATION

With the adoption of improved technology, on an average, the seed yield of 508 kg/ha, gross returns of Rs. 35245/ha, additional net return of Rs. 8458 /ha and the benefit cost ratio of 2.11 can be obtained. The seed yield and economics of sesame cultivation in major sesame growing states are given in Table 12.

Table 12: Economics of improved technology under real farm situations (FLD's).

S. No.	State	Rainfed/ Irrigated	Seed yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Additional net returns (Rs./ha)	Benefit cost ratio
1	Rajasthan	R	451	12555	38335	5219	3.04
2	Uttar Pradesh	R	360	10764	28080	9007	2.61

3	Maharashtra	R	654	15015	44040	9969	2.93
4	Bihar	R	393	10035	23568	8235	2.34
5	Kerala	I	610	36175	48800	11190	1.34
6	Jharkhand	R	684	12000	34200	9400	2.85
7	Haryana	R	326	16890	26080	2624	1.54
8	Punjab	R	576	15735	43200	15699	2.75
9	Karnatka	R	515	20645	30900	4780	1.49
10	**India**		**508**	**16646**	**35245**	**8458**	**2.11**

CROP DEVELOPMENT PROGRAMME: The country ranks first in area (1700 thousand ha) under sesame and earned Rs. 2880 crore through sesame export. In the recent past, the international demand and market for sesame has witnessed substantial growth. It is grown in all seasons of the year and being a short duration crop, fits well in to various cropping systems.

To promote sesame as summer crop where protective irrigation is available: During summer season the potential of sesame is about 1 tonne/ha (double of *kharif* season). It is less infested, during summer by diseases, insects and weeds. Cultivation should be encouraged in summer in the states *viz*., West Bengal, Orissa, Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu.

Timely availability of quality seed of improved varieties: Unfortunately quality seed of high yielding varieties to the farmers is not available. Improvement in the seed chain is needed so that foundation and certified seed are produced in larger quantities. Replacement of old local varieties has to be ensured for improvement in production.

Improvement in crop husbandry: Sesame is generally cultivated during *Kharif* on marginal lands, with negligible inputs. It is often attacked by diseases, insects and infested by weeds. The farmers do not adopt line sowing and plant protection. The improved production technology would increase productivity considerably. Sustainability in production can be achieved, with adoption of long term measures. Seed chain, which is very poor at foundation and certified stages need to be improved. Need based use of major and micro nutrients based on soil test values should be encouraged.

There is a vast realizable yield reservoir available with the existing level of technologies. Hence, quick and effective transfer of technology through the following is the need of the hour. (a). Frontline demonstrations (b). On farm research (c). Training to the extension personnel (d). State agricultural officers and farmers (e). Seed village adoption (total production technology in integrated manner).

The oilseed economy has been transformed during the few decades owing to several governmental policies and the positive response by the farmers and the line departments. We have a network of organizations committed to the oilseeds research, development and related aspects. The research pertaining to the socio economic aspects has by and large been done sporadically and in isolation. It is therefore, necessary to take up systematic research on these aspects. Assessment of improved technologies and their sustainability from the socio economic point of view, methodologies

for assessment of sustainability, total factor productivity, performance of regulated markets, trading, consumer preferences and demand analysis need to be studied.

It is drought tolerant, requiring 1/4 the water for corn, 1/3 the water for sorghum and 1/2 the water for cotton. Approximately 80-90 percent of sesame grown in the country is dry land and 10-20 percent has supplemental irrigation. It uses common farming practices, including no till practices, and standard farming and handling equipment. The sesame plant conditions, the soil and reduces cotton root rot and root knot nematodes, thus lowering the risk and increasing the yield on subsequent cotton crop.

Export and Import: International demand for sesame is increasing continuously every year due to its increasing applications. India is the largest exporter of Sesame seed in the World accounting for a share of 23%. The total global exports of Sesame seed were at a level of 1.31 million tonnes during 2012-13(Source: Oil World 2013). China is the largest importer of sesame seed followed by Japan. Most of the importers who supply ingredient distributors and oil processors only want to purchase scientifically treated, properly cleaned, washed, dried, color sorted size graded and impurity free seeds packed according to international standards. Usually, only seed meeting there criteria may be exported from a producing country. India earned the foreign exchange of Rs. 2880 crores by export of sesame seed. The export demand is in increasing trend promising a bright future for export potential. The pesticide residue free, white seeded sesame is preferred in foreign countries market. Sesame export has witnessed a constant increase from 218.97 thousand tonnes (2001-02) to 299.52 thousand tonnes (2012-13).

Table 13: Year-wise Export status of Sesame (India)

Year	Sesame seed	
	Quantity('000 tonnes)	Value (Rs. in crores)
2001-02	218.97	562.23
2002-03	118.31	372.89
2003-04	189.11	708.90
2004-05	168.28	708.95
2005-06	199.81	746.60
2006-07	233.34	939.58
2007-08	317.01	1642.29
2008-09	196.98	1494.26
2009-10	215.73	1494.10
2010-11	398.44	2307.52
2011-12	389.15	2641.66
2012-13	299.52	2881.54

Source: - Director General of Commercial Intelligence & Statistics, Ministry of Commerce, Kolkata

SWOT Analysis: Sesame with high export potential (40 % of world natural; 60 % of hulled), Irreversible increase in demand and growth of international trade is the strength; Poor transfer of

recommended technology, energy rich crop grown in energy starved conditions are the weaknesses; Very low seed rate, very high seed multiplication ratio, short duration crop, fits well into various cropping systems and best contingent crop to manage drought situations are opportunities; High pesticide residue, high FFA, low lignans, high anti nutritional factors and shifting of better areas with irrigation to low risky crops like soybean and upland rice are the threats. Sudan, China, Korea and Thailand are international competitors.

Diversified Uses: Sesame seeds are the oldest condiment and because of nutty flavour used in cooking recipes. They are the main ingredient in tahini (*Tahini* is one of the main ingredients in famous middle eastern dip, hummus). Natural sesame seeds are largely served in bakery products such as bread, bread sticks, cookies, candies, pasta, vegetables and curry dishes. Sesame flour, an edible, creamy and light brown powder obtained from seed has high protein, high levels of methionine and tryptophan and 10% to 12% oil. Sesame meal is excellent feed for poultry and livestock. Among edible oils, sesame has the highest antioxidant content. According to Hindu legends and beliefs, til oil represent a symbol of immortality and is considered the most auspicious oil next to ghee. Tamil medicine holds that gargling with sesame oil after brushing one's teeth will reduce gum disease and mouth ulcers while eliminating plaque. Sesame oil is used as a solvent, oleaginous vehicle for drugs, skin softener and used in the manufacture of margarine and soap. Sesame seeds are rich in quality vitamins and minerals. They are very good sources of B-complex vitamins such as niacin, folic acid, thiamin (vitamin B_1), pyridoxine (vitamin B_6) and riboflavin and also contain dietary fiber and monounsaturated fats. The mono unsaturated fatty acid oleic acid, which comprises 40-50% fatty acids, helps to lower LDL or bad cholesterol and increases HDL or good cholesterol in the blood. Calcium, iron, manganese, zinc, magnesium, selenium**,** and copper are specially concentrated in sesame seed. Many of these minerals have a vital role in bone mineralization, red blood cell production, enzyme synthesis, hormone production, as well as regulation of cardiac and skeletal muscle activities. Sesame seed contain three times more calcium than a comparable measure of milk. In addition to these, sesame seeds also contain health benefiting compounds such as sesamol and sesaminol. Sesame is used to prepare perfumes. Several pharmaceutical uses have been identified from sesame. Myristic acid is used as an ingredient in cosmetics. Sesame flower extract possesses tumor inhibiting effect. Chlorosesamone obtained from roots of sesame has antifungal activity. Its oil and seed are sources for some phytonutrients such as omega-6 fatty acids, flavonoid phenolic antioxidants, vitamins and dietary fiber with anticancer as well as health promoting properties.

Exploitable Yield Reservoir: The impact of improved sesame production technologies under real farm situations indicated that there is a huge gap between actual and attainable yield, which be harnessed through adoption of improved technologies. An attempt has been made to estimate the extent of yield reservoir through adoption of technologies. For this purpose, the whole package demonstrations of

three years (2010-11, 2011-12 and 2012-13) conducted in Maharashtra (35), Tamilnadu (44), Uttar Pradesh (91), Karnataka (25), Rajasthan (53) and India (248) were considered (Table 14). The yield Gap-I (between IT and FP) was ranging from 23.5% in Rajasthan to 72.1 % in Uttar Pradesh. The national sesame production could be increased to 1145.4 thousand tonnes from 785.6 thousand tonnes, if the yield gap was bridged. Similarly, the yield gap-II (between IT and state average productivity) was ranging from 5.9 % in Karnataka to 775.1 % in Uttar Pradesh. The national sesame production could be increased to 2097.6 thousand tonnes from 1145.4 thousand tonnes by bridging the yield gap-II. This situation warrants a need to effectively transfer the improved sesame production technologies among the sesame growers, so that the huge exploitable yield reservoir be harnessed.

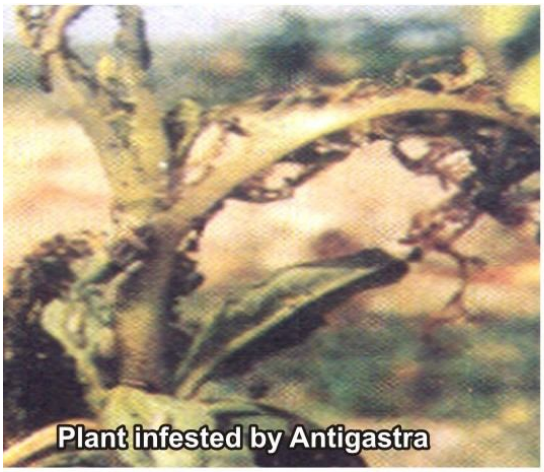
Table 14: Exploitable yield reservoir in sesame

State	No. Of Demons.	FLD'S Average Yield (kg/ha)		Yield gap-I (%)	Average yield (kg/ha)	Yield gap-II (%)	Average Production ('000 tonnes)	Expected production ('000 tonnes)	
		IT	FP					EP-I	EP-II
Maharashtra	35	1199.7	927.3	29.4	324.3	269.9	14.7	19.0	54.3
Tamilnadu	44	1385.3	891.3	55.4	526.0	163.4	24.2	37.7	63.8
Uttar Pradesh	91	1747.3	1015.3	72.1	199.7	775.1	68.3	117.6	598.0
Karnataka	25	498.0	390.7	27.5	470.3	5.9	31.7	40.4	33.5
Rajasthan	53	714.3	578.3	23.5	342.0	108.9	170.5	210.6	356.2
All India	248	1108.9	760.6	45.8	415.3	167.0	785.6	1145.4	2097.6

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

Tips to obtain higher yield:

- Use good quality seed of recommended variety.
- Sow at appropriate time with proper spacing and maintain population by thinning
- Select well leveled field and provide good drainage. Prepare a fine seed bed free from clods.
- Apply recommended dose of fertilizers at appropriate time and foliar spray of 2 % urea, DAP at flowering and capsule development stage.
- Keep the field weed free, particularly up to 40 days after sowing.
- Apply irrigation at critical stages for *rabi*-summer crop and provide protective irrigation wherever possible during *kharif*.
- Treat the seed with fungicide/bactericide as recommended.
- Adopt need based plant protection measures against insect pests and diseases.

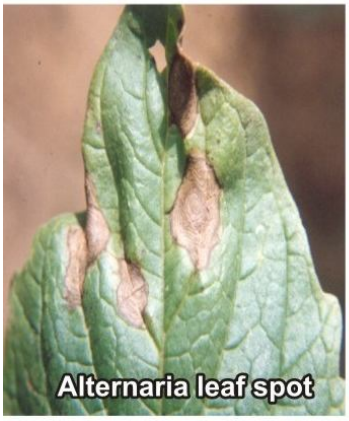

Plant infested by Antigastra

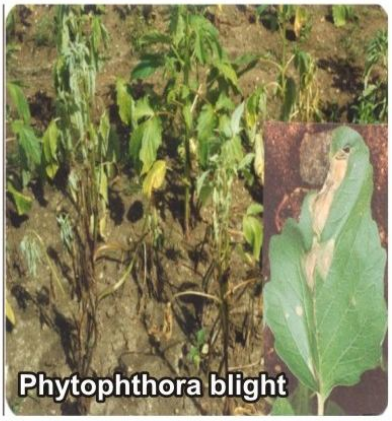

Different life stages of Antigastra


Til hawk moth


Bihar hairy caterpillar

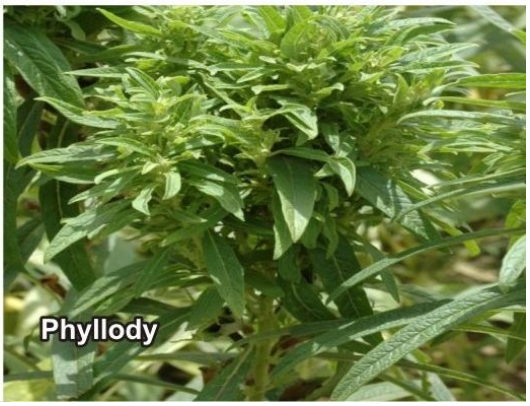

Macrophomina stem/root rot

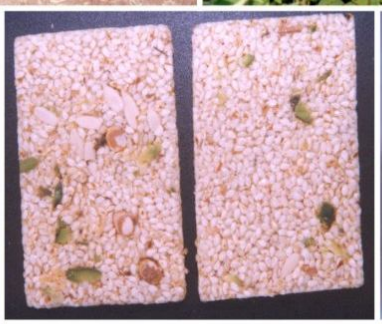

Alternaria leaf spot

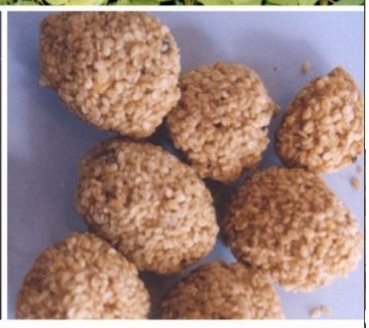

Phytophthora blight


Bacterial leaf spot


Powdery mildew


Phyllody





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