Organic Farming in the Tropics and Subtropics

Exemplary Description of 20 Crops

Sesame

These cultivation guidelines have been published by Naturland e.V. with the kind support of the Deutsche Gesellschaft für Technische Zusammenarbeit mbH (GTZ, German Agency for Technical Cooperation) financed by the Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ, Federal Ministry for Development Cooperation). The cultivation recommendations at hand for 20 crops of the tropics and subtropics being of significant importance for the world economy were written by various authors.

Naturland would like mention the following authors and thank them for their contributions:

Franz Augstburger, Jörn Berger, Udo Censkowsky,
Petra Heid, Joachim Milz, Christine Streit.

The cultivation guidelines are available in English, Spanish and German for the following crops:

banana, brazil nut, cashew nut, cocoa, coconut, coffee,
cotton, hibiscus, macadamia, mango, papaya, peanut,
pepper, pineapple, sugar cane, sesame, tea, vanilla.

The cultivation guidelines for Bananas, Mangoes, Pineapples and Pepper were revised in 2001 for the United Nations Conference on Trade and Development (UNCTAD) by Udo Censkowsky and Friederike Höngen.

In 2002 two more guidelines, for rice and date palms, were published in English.

All the authors emphasize, that the cultivation recommendations at hand can just provide general information. They do not substitute technical assistance to the farmers with regard to the location.

All indications, data and results of this cultivation guidelines have been compiled and cross-checked most carefully by the authors. Yet mistakes with regard to the contents cannot be precluded. The indicated legal regulations are based on the state of the year 1999 and are subject to alterations in future. Consequently all information has to be given in exclusion of any obligation or guarantee by Naturland e.V. or the authors. Both Naturland e.V. and authors therefore do not accept any responsibility or liability.

Furthermore the authors kindly call upon for critical remarks, additions and other important information to be forwarded to the address below. The cultivation guidelines will be updated regularly by Naturland e.V.

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We pass our gratitude to Peter Brul of Agro Eco for his helpful comments on the manuscript. Our best thanks are also devoted to all supporters of this publication, in particular Mrs Sybille Groschupf who cleaned up the text from errors in strenuous detail work and did the attractive layout.

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Organic cultivation of sesame

1. Introduction

1.1. Botany

Sesame e *sesame um indicum L.* (*S. orientale L.*) belongs to the double-cotyledon pedaliaceae family. It is an annual plant, which grows either bush-like or upright, depending on variety, to a height of 1-2 m. Its vegetation period is generally around 3-4 months. The oil plant has been grown since the beginning of arable cultivation, and originates from the dry bush savannah of tropical Africa, and spread from there to India and China, where it is still widely cultivated.

The sturdy tap roots, which attain a depth of around 1 m, and the plant's dense network of fibrous roots – which are interwoven with mycorhiza fungi acting in symbiosis – provide a plentiful supply of nutrients and water. The square stem can either have many branches or none at all – depending on the variety. Usually only the middle of the three flowers that form in the leaf axils develop to form between 4 and 10 capsules. The ripe, dry capsules open up to reveal their seeds, nestling along the inner walls, so that they may be carried away by the wind. One thousand corns weigh (TCW) between 2.5-3.2 g. The seeds can be either white, yellow, red, brown or black. The vegetation period is only 80-130 days short. The blossoming and ripening phases take place over several weeks, starting at the bottom of the plant and progressing upwards.

1.2. Varieties and producing countries

The northerly cultivation boundary runs along the 42° parallel. The southerly along the 35° parallel. The main cultivation region lies between the 25° northerly and 25° southerly latitudes. Despite its ideal adaptation to dry sites, sesame can also be raised in humid, tropical and sub tropical regions. The most usually cultivated variety is *S. indicum*. Less prominent varieties include *S. alatum* (tropical Africa) and *S. radiatum* (Africa, Asia, South America).

Since the 50's, varieties have been developed whose capsules are nonscattering, thereby allowing harvesting to be performed mechanically. These are mostly cultivated in the USA and Russia, although they are less resistant to diseases, and also provide a lower yield than varieties whose capsules spring open (List of varieties: see appendix).

Ecological sesame cultivation exists in Peru, Mexico, El Salvador, Nicaragua, India, Sri Lanka, Turkey, Uganda and China.

In the case of organic sesame cultivation in El Salvador, the yield is around 450-520 kg/ha sorted seeds; 350 kg/ha are required to meet production costs there[1]. In Nicaragua, 350-400 kg/ha[2] are harvested on average. Cultivation here is often endangered by the harvest and rainy seasons occurring simultaneously . Organic farmers in Peru can harvest up to 800 kg/ha. The world average for conventional sesame cultivations is around 330 kg/ha.

1.3. Uses and contents

In many of the countries in Africa and Asia, the cultivation of sesame plays hardly any role in cash products, because sesame here is one of the staple, daily foodstuffs. Throughout wide regions of Africa, the cultivation of staple-food crops – including, for example, peanuts – is seen as a woman's chore. The cultivation of cash crops such as, e.g. cotton, is seen as a male duty. Therefore, cultivating sesame as a cash crop is accompanied by changes in cultural and social traditions[3].

In West Africa, the shoots and young leaves of the varieties *S. alatum* and *S. radiatum* are eaten as a vegetable. Sesame seeds are either consumed directly as a highly nutritious foodstuff, or processed by the confectionery and bakery industries. The seed hulls, which are bitter due to their oxalic content, can be removed with the use of steam. Ragouts and soups are often prepared with crushed sesame seeds. Sesame hay, if carefully dried, can be used as fodder.

A large proportion of the world's sesame production goes towards producing edible oil. The plant's oil content lies around 40-60%; protein content ranges between 17-29%. The oil won during the first, cold pressing is one of the costliest produced. The oil is light yellow, does not dry out, and can be used with strong heat. The quality of the oil depends largely in its essential linoleic acid content (35-41% of all the oils). The oil resists oxidative rancidity, due to its anti-oxidants sesamin and sesamolin. The press cakes contain 40-70% protein and also 12% fat, and are an excellent supply of fodder.

Purely white sesame seeds are in just as much demand on conventional as on ecological markets, because of their higher oil content than pigmented varieties. Sesame oil obtained from the second, warm pressing and extraction has a lower quality than cold-pressed. It is generally used in the manufacture of soaps, paint, cosmetics and pharmaceutical products.

[1] AGRODESA (1997): Manual de ajonjolí orgánico. San Salvador.

[2] CLUSA (1995): Producción orgánica de ajonjolí. Serie de documentos técnicos, Managua.

[3] Page, S. (1998): Personal Note

2. Aspects of plant cultivation

2.1. Site requirements

The cotton cultivation zone at the cross-over between the tropics and the sub tropics also provides the best growing conditions for sesame. It lies between the oil palms and soya cultivation regions.

2.1.1. Climate requirements

Warmth

Sesame needs a constant high temperature, the **optimum** range or growth, blossoms and fruit ripeness is **26-30°C**. The minimum temperature for germination is around 12°C, yet even temperatures below 18°C can have a negative effect during germination. Pollination and the formation of capsules is inhibited during heat-wave periods above 40°C. In regions visited by strong, hot winds, the plants only form smaller seeds with a lower oil content. For these reasons, sesame is cultivated in cooler regions as a summer crop, and in warmer climes during the cooler season. Sesame is frost-susceptible. Depending on the climate, sesame can be cultivated at altitudes up to 1600 m. (India 1200 m, Central America 600 m.).

Water

Good harvests can be expected when **rainfall of 300-600 mm** is optimally spread throughout the vegetation period. Optimum distribution means: 35% before the first cusps are formed, 45% during the main blossoming period, 20% during the ripening period and drought, if possible, during harvesting. During each of its development stages, the plant is highly susceptible to water-logging, and can therefore only thrive during moderate rainfall, or when irrigation is carefully controlled in drier regions. Due to its tap roots, the plant is highly resistant to drought, and can provide good harvests even when only stored soil water is available[4].

2.1.2. Soil requirements

A wide range of soils are suitable for sesame cultivation; optimum are well-drained, loose, fertile and sandy alluvial soils that have a pH value between 5.4 and 6.7[5]. Very low pH values have a drastic effect on growth, whereas some varieties can tolerate a pH value up to 8. When irrigated, or during summer rain spells, sesame grows better in sandy than in heavy soils. This is due to its sensitivity to high soil moisture contents. It is not recommended to plant sesame on sloping ground, due to the fact that its **need of weed-free seed beds and its slow rate of early**

[4] ARNON, I. (1972): Crop production in dry regions. Vol.2, Leonard Hill, London.

[5] RAMÍREZ, R. and OVALLES, C. A. (1991): Relación del pH del suelo con el crecimiento, nutrición y producción de semilla del ajonjolí. Oléagineux 46.

development can lead to erosion. Heavy, water-logged soils, as well as soils with high salt contents are not suitable; salt contents which would hardly affect cotton or safflower can already kill off sesame plants[6]. Shallow soils (less than 35 cm) with impermeable subsoils are also unsuitable.

2.1.3. Other factors

Sesame needs long periods of sunshine, and is generally a short-day plant – whereby varieties exist which are unaffected by the length of the day. Sesame is sensitive to strong winds when the main stem is fully grown. Tall varieties should not be planted in regions which have strong winds during the harvesting season (and, if necessary, hedges to protect against the wind should be planted).

2.2. Seeds

2.2.1. Second generation and seed preparation

In order to avoid cross-fertilisation of second generation crops using single-variety seeds, care should be taken to ensure that no other field is being cultivated with other varieties within a 400 m radius. During harvesting, the planting seeds should not be allowed to come into contact with the ground to avoid an infestation of soil borne diseases. The seed shells must remain intact to protect the seeds from infection, and to maintain their ability to germinate.

2.3. Sowing methods

2.3.1. Seedbed preparation

Because the seeds are so small (TCW 2.5-3.2g), and the rate of growth during the early phases is so slow, sesame seeds require a seed bed with firm, fine crumbs and sufficient moisture, in order to ensure their rapid, uniform germination and subsequent growth. The seed bed should be made level and free of weeds by appropriate soil preparation, the previous crop planted and the whole system of crop rotation. This is not intended as a fixed rule, for when machines are not to be used, the following cultivation methods come into play (they are also of interest regarding their protection against erosion):

a) Direct sowing in holes, with stick for support
b) Sowing after narrow strips have been prepared
c) Sowing while ploughing with an ox: a row is sown in the opened furrow from a bottle of seeds with a perforated lid, and then covered over again with a branch.

[6] WEISS, E.A. (1983): Oilseed Crops. Longman, London.

If the field is to be mechanically cultivated, then it should be ploughed to a depth of 20-30 cm (if the soil contains little organic substance, then appropriately shallower), and harrowed 2-3 times afterwards, whereby the weeds should be allowed to grow again between each stage.
Several phases will probably be necessary if the soil is to be worked with animals or manually with a hoe. A wooden beam can be dragged along afterwards as a leveller during the last stage of harrowing. Heavy rainfall can badly affect the germinating seeds, make the finely-crumbed seed bed muddy and flush away the seeds.

2.3.2. Sowing

The optimum depth to sow at is around 1.5-2.5 cm. It is important to sow at an even depth to ensure simultaneous and uniform growth of the crop. In order to ensure that the seeds have access to water, it is far better to use a roller than to sow them deeper – whereby, of course, the seeds should not be damaged in the process.

Manual sowing: Small-hold farmers will often sow by hand. 2-3 weeks after they have been sown, the plants are singled. This method requires 5-10 kg/ha of seeds. Mixing them together with sand, soil, ash or dried, sieved manure or compost will help make growth more uniform, and also save on seeds.

Mechanical sowing: Drilling machines for finer vegetable seeds are best suited, although normal grain-sowing machines can also be used when fine, dry sand of the same grain size is mixed in with the seeds. Drilling seeds need 2.5-3 kg/ha; when mixed crops are sown, only 1.5 kg/ha is required.

Crop density: High yields normally require high densities:

Non-branching varieties:	**Branching varieties:**
250,000-350,000 plants/ha	150,000-200,000 plants/ha
Distance between rows: 30-45 cm	Distance between rows: 50-60 cm
Distance within the rows:7.5 cm	Distance within the rows:10-15 cm

Nevertheless, when planning the crop density, site conditions also need to be taken into consideration. For example, when using dry-land farming, the distance between the rows should be expanded to 75-100 cm, and the distance within the rows to 10-15 cm, each time, depending on the available moisture in the soil.

2.3.1. Singling

In order to achieve an optimum crop density, branching varieties should be singled out to 6-10 cm, or definitely less than 15 cm distance within the rows.

Non-branching varieties:	**Branching varieties:**
Single out to 12-15 plants per meter	Single out to 8-10 plants per meter

Larger distances stimulate branching, even with single stem varieties. This makes harvesting more difficult, without increasing the yield. When the correct amount of seeds are sown, no singling is necessary.

2.4. Diversification strategies

2.4.1. Crop rotation

When cultivating sesame, the following aspects should also be considered when planning the crop rotation:

- Do not cultivate directly following a fallow period (uneven soil, weed proliferation),
- As weed-free seed beds as possible (important when selecting the previous crop),
- Previous crops with few demands on the soil,
- Sesame is also a good preliminary crop (it loosens the soil with its tap roots, and provides a dense network of roots in the upper layer),
- Well-suited as a second crop (short vegetation period, use of water stored in the soil in a similar way to sorgo, as well as being resistant to drought),
- Resistant against root nematodes,
- Keeps the wire worm (larvae of the beetles belonging to the family of *elateridae*) under control in the crop rotation.

Typical crop rotation partners include cotton, grain legumes (peanuts, varieties of beans, soya etc.), maize, dry rice and sorgo.

Examples for **crop rotation in various parts of the world:**

Turkey	Chick peas - wheat (or barley) – sesame
Uganda	Cotton - sesame - maize+beans – fallow
South Brazil	Winter:Second crop: green fertiliser with white lupines/vetch/oats or field beans/sun flowers 1.Summer: Maize 2.Summer: Adzuki beans or soya 3.Summer: Sesame

2.4.2. Mixed crops

With annual crops: Sesame is cultivated in many countries as part of a mixed crop with cotton, maize, sorgo, millet, peanuts, soya or Phaseolus-species. In the case of mixed cultivation with cotton and sesame, each yield is less than it would be if planted alone, although the 'Land Equivalent Ratio = LER' is nevertheless higher. In the process, sesame is placed somewhat under pressure by the taller-growing cotton.

With perennial crops: Cultivation between the rows with young perennial crops is also possible, e.g. cashew (*Anacardium ocidentale*), young forest trees, as well as mixed cultivation with coconut palms. Contour-line planting with pineapples or legume hedges between the strips can help to prevent erosion, and thereby reduce the loss of nutrients, organic substances and of soil acidification – thereby helping to improve the yield.

2.4.3. Bee-keeping

Furnishing bees during the main pollination period can be a simple yet rewarding investment. Sesame's blossom structure facilitates cross-pollination, even though the crop is usually viewed as self-pollinating. The rate of cross-pollination lies between 0.5% and 65%. Experiments by the Central Bee Research Institute in Poona (India) resulted in an increase in yield of 21% for sesame using *Apis c. indica* bees to pollinate. In addition to increasing the yield, cross-pollination also helps to raise quality through a more unified ripening period and an earlier harvesting time[7].

2.5. Supplying nutrients and organic fertilization management

2.5.1. Nutrient requirements

The nutrient content of 1000 kg of sesame seeds is[8]: (Given in kg)

N	P	K
50	6	50

[7] MOHANA RAO, G., SURYANARAYANA, M.C., THAKAR, C.V. (1980): Bees can boost oilseed production. Indian Farming 29 (11), 25-26.

[8] WEISS, E.A. (1983): Oilseed Crops. Longman, London.

The individual plant parts contain at harvesting time[9]: (given in kg/ha)

Plant part	TM	N	P	K
Roots	779	2.84	0.95	4.33
Stems	2846	10.24	7.94	42.98
Leaves	2058	34.98	12.30	16.74
Capsules	4429	71.74	10.63	72.42
Total	**10429**	**119.80**	**31.82**	**136.47**

These values correspond to a very high yield from a conventional plantation of 2200 kg/ha; yet they demonstrate the high content of nutrients in the foliage, that should then be returned to the field as mulch (or well-composted in the case of disease). The nutrient requirements are distributed over the vegetation periods in the following way:

Days after sowing	0-29:	3%
	30-47	10%
	48-81	58%
	82-110	29%

2.5.2. Organic fertilisers

The most important methods of applying fertiliser on organic sesame cultivations are:

- The use of green manure, inclusion of legumes in crop rotation, and
- The use of organic manure and compost manure.

Direct application of fertiliser to sesame is not always necessary; if the soil contains plenty of humus, then fertiliser may already be provided by the previous crop. If fertiliser is to be applied directly, then it is sufficient to do this one month before sowing, as the seed bed is being prepared. When using ripe compost, around 3 t/ha (ca.7 m³/ha) suffice when applied to the seed furrows, or after singling.

The supply of phosphorous can be a limiting factor for high sesame yields. Phosphorous deficiency can be alleviated with rock phosphate and bone meal, which should then be applied before the soil is prepared. The amount and type of phosphate made available to the plants can be improved by the symbiotic relationship with mycorhiza, As this has the effect of increasing the surface area of the root system. By excreting a variety of substances, e.g. phosphatase, it can even make organically bound P available to the plants.

[9] WEISS, E.A. (1983): Oilseed Crops. Longman, London.

Mycorhiza growth can be stimulated by:

- Applying small quantities of phosphate fertilisers[10] on soil poor in phosphate
- Compost fertilising
- The returning of foliage and mulch to the field
- Crop rotation

Small amounts of nitrogen-rich organic fertilisers, such as liquid manure, will stimulate the mineralisation of organic substance. When the plants have reached a height of 20 cm, then 20 kg N/ha can be applied. The supply of potassium is usually not a problem. Calcium and Magnesium are of greater importance, as the plants require large quantities of them, and e.g. can be supplied with magnesium-rich lime (Dolomite).

2.5.3. Leaf fertilisers

Organic foliar spraying can provide a large proportion of the fertilisers necessary, and help balance out deficiencies. They are applied in two lots:

After singling and as blossoming commences.

- Animal liquid manure is diluted 1:5 with water.
- Cattle manure is dissolved in water.
- Plant extracts: green, chopped legume leaves (e.g.: Crotolaria) and other nutrient-rich plant parts (*Lepotea aenstuans*, “Chichicaste”) are left in water fro a few days to ferment.:
- A watery compost extract: the best way is to apply amounts weekly in low concentrations.

2.5.4. Green manure

When utilising green manuring plants, their water requirements must be considered so that sufficient moisture remains available for the main crop. They can fulfil several tasks simultaneously, if managed properly, making cultivation of them worth-while, even when the main reason for planting them is not to harvest them. Some of them are capable of suppressing thick bush growth and 3 m high grasses, leaving behind only a small residue which is easy to work with (alternative to burning down). They create humus in a labour-saving way.

[10] The European Regulation for Organic Agriculture (EEC) 2092/91 as well as the IFOAM Basic Standards do only allow for the use of natural phosphates.

Examples of green manuring plants that have been used in sesame crop rotation systems in Central and South America[11] [12]:

Plant type	Characteristics
Mucuna pruriens Velvet bean	Good for re-cultivation after many years of fallow, with its strong climbing properties. Suppresses weeds, e.g. tall grasses. Dies after seeds have ripened and when frost appears. Foliage and seeds good as fodder. Medium resistance to drought. Vegetation period up to 12 months.
Canavalia ensiformis Jack or giant bean	Drought resistant. Climber or creeper – depending on variety. Good weed suppresser with sufficient water, high resistance to pests and disease.
Dolichos lablab Hyacinth beans	Climber or creeper. Excellent fodder. Only edible after much cooking. Highly adaptable, from arid to humid. Good weed suppresser. Host plant for Phaseolus pests.
Vigna radiata Mungo	Winding and bushy varieties, rapid growth, short vegetation period of 45 days – therefore, good weed suppresser. Resistant to drought and pests. Sown in rows between crop, or spread around 30 kg/ha.
Pueraria phaseoloides Kudzu vine	Strongly sarmentous, flat growing plant with 7 m long stolons, Suitable as bottom crop. Strong growth, good weed suppresser. Good fodder. Only suitable for wet sites.

2.6. Biological methods of plant protection

2.6.1. Diseases and methods of prevention and combating them

Moist conditions are especially conducive to fungi and bacterial growth. In order to prevent this, sites should be chosen which are well-drained, levelled and which have deep, loose soil – in order to avoid water-logging

[11] AGRODESA (1997): Manual de ajonjolí orgánico. San Salvador.
[12] CLUSA (1995): Producción orgánica de ajonjolí. Serie de documentos técnicos, Managua.

Diseases[13]

Fungus germs	Regulation measures
Phytophthora Blight	Crop rotation, use of resistant varieties, use healthy seeds, spray Bordeaux-mixture[14] (3:3:50) 3x at intervals of 7 days against secondary infection and proliferation.
Macrophomina phaseolina and *Rhizoctonia bataticola* (Stem and root rot)	Infection from seeds or soil. Use green manure and encourage nesting of antagonists (ripe compost), use of resistant, or less resistant, varieties (e.g. red shelled varieties).
Fusarium oxysporum (Fusarium Wilt)	Infection from seeds or soil. Non-opening varieties are not as susceptible. If the soil is strongly infected: at least a 5 year pause.
Alternaria (Leaf Spot, leaf fleck)	Infection from seeds, use resistant varieties. Varieties totally covered with hair seem to be resistant. Bordeaux- mixture (0.1%).
Cercospora sesami (White Spot)	Infection from seeds and plant residues in the soil. Burn plant residues. Dress seeds in hot water: 30 min. at 53°C. Use resistant varieties.
Powdery Mildew, 4 germs: a *Oidium erysiphoides* b *Sphaerotheca fuliginea* c *Leveilulla taurica* d *Erysiphe cichoracearum*	Use resistant varieties. Late ripening varieties are less susceptible. Wettable sulphur (0.2%) or use of sulphur dust 20 kg/ha on the 45th and 65th day after sowing.
Corynespora Blight	Dispose of plant residues. Use clean seeds.

[13] Gekürzt nach KOLTE, S. J. (1985): Diseases of annual edible oilseed crops. Vol.2. CRC Press Boca Raton, Florida.

[14] According to the European Regulation for Organic Agriculture (EEC) 2092/91 the use of copper preparations for plant protection (e.g. Bordeaux Mixture) is allowed for a transitional period which will end at the 31st of March 2002. However, any use of copper preparations until 2002 has to be approved by the certification body. In case copper preparations have to be applied it is recommended to use preparations which contain less copper and therefore to reduce the accumulation of copper in soils (e.g. tribasic copper sulphate, copper hydroxide).

Bacterial germs	Regulation measures
Pseudomonas syringae pv. sesami (Bacterial Leaf Spot)	Dress seeds in hot water: 10 min. at 52°C. Transmission by seeds possible for 11 months. Use resistant varieties. Cultivate at low humidity and temperature (change sowing date).
Xanthomonas campestris pv.sesami (Bacterial blight)	Dress seeds in hot water: 10 min. at 52°C. Identify resistance by infecting seedlings. Transmission through the soil, only for 4-6 months, via seeds, for up to 16 months. Also transmitted via field weed *Acanthospermum hisdidum*. Cultivate at low humidity and temperature (change sowing date).
Viruses	**Regulation measures**
Nicotiana 10 virus (Leaf Curl)	Use resistant varieties. Has many host plants e.g.. tobacco, tomato, papaya and is also transmitted by the white fly *Bemisia tabaci.*
P*hyllody* "Mycoplasma-like-organism" (MLO)	Select sowing date at low vector population. Vectors: leafhoppers (Homoptera) *Orosius albicinctus*. Use resistant varieties, which blossom within 40-50 days.

2.6.2. Pests and methods of combating them

Important measures to prevent a massive infestation of pests

- Encourage natural antagonists (e.g. create an eco-system with trees, hedges, mixed crops, avoid slash and burn).
- Crop rotation – which excludes host plants.
- Mixed cultivation to diversify the agroeco-system, This will disorientate some pests and encourage antagonists. Example: In a mixed crop system with sesame and mungo or Phaseolus beans, the beans will be infected by bugs, leaving the sesame capsules relatively untouched[15].
- Sow yellow flowers near to the sesame field, e.g. sunflowers and calendula. The colours will attract pests, which can then be dealt with.
- Remove harvest remains and host plants[16] [17] (also in the vicinity of the field) such as:

a) Common amaranth *Amaranthus retroflexus*
b) Wax bean *Phaseolus ssp*.
c) *Ipomoea spp*.
d) *Bidens pilosa*
e) *Thitonia rotundifolia*

[15] CLUSA (1995): Producción orgánica de ajonjolí. Serie de documentos técnicos, Managua.
[16] AGRODESA (1997): Manual de ajonjolí orgánico. San Salvador.
[17] CLUSA (1995): Producción orgánica de ajonjolí. Serie de documentos técnicos, Managua.

Pest	Regulation measures [18]
Acherontia styx	Plough in after harvesting to control the pupa.
Agrotis spp. (cut worm)	Till weeds early, before harvest. Light traps against moths; preparations made of tobacco[19], derris[20], neem[21], pyrethrum[22].
Antigastra catalaunalia (sesame leaf roll*)*	Plant more resistant varieties.
Asphondyla sesami (sesame-gall-wasp*)*	Collect and disperse of galls.
Bemisia tabaci (White fly)	Extremely polyphagous. Vector for Leaf Curl-Nicotiana 10 Virus. Appears mainly during dry season. Spray preparations made of garlic, tobacco, pyrethrum; Sabadilla *(Schoenocaulon officinale)*.
Cyrtopeltis tenuis	Sucking holes are at risk of infection. Use pyrethrum in emergency.
Diabrotica spp.	Thoroughly work over soil to rid pupa; . Spray preparations made of: *Mammea americana*; garlic+onion+chilli peppers; rhizinus extract; neem.
Diacrisia obliqua	Collect the hairy egg deposit on the underside of leaves.
Estigmene acrea	Use Baculovirus.
Heliothis spp.	Causes a secondary infection. Place light traps next to egg deposits. Spray preparations of: derris elliptica; garlic; neem; pyrethrum; Ryania speciosa.
Myzus persicae	Lice, vector for viruses. Alcoholic extract from neem tree seeds (*Melia azedarach*)

[18] STOLL, G. (1986): Naturgemäßer Pflanzenschutz mit hofeigenen Ressourcen in den Tropen and Subtropen. AGRECOL, Verlag Josef Margraf.
AGRODESA (1997): Manual de ajonjolí orgánico. San Salvador.
CLUSA (1995): Producción orgánica de ajonjolí. Serie de documentos técnicos, Managua.

[19] According to the European Regulation for Organic Agriculture (EEC) 2092/91 the use of tobacco extracts is allowed for a transitional period which will end at the 31st of March 2002. However, any use of tobacco extracts until 2002 has to be approved by the certification body. Furthermore, application is restricted only for tropical and subtropical crops and shall be applied at the beginning of the vegetation period.

[20] Application of Derris (rotenon) has to be approved by the certification body.

[21] According to the European Regulation for Organic Agriculture (EEC) 2092/91 the application of Neem preparations is restricted and only allowed for the production of seed and seedlings. This regulation is discussed controversial. An up-date information is available from your certification body.

[22] The European Regulation for Organic Agriculture 2092/91 as well as the IFOAM Basic Standards do only allow for the use of natural pyrethrins (extract from the flower heads of Chrysanthemum). Synthetical pyrethroids persist in the environment and are forbidden.

Nezara viridula	Increases fungi infection of seeds. Secretion of fungi *Beauveria bassiana*. Neem oil. Spray preparations of 70 g kerosene, 110 g soap and 7,5 l hot water. pyrethrum+sesame oil+derris/tephrosia/tobacco.
Phillophaga	Preparations of an alcohol extract from annona seeds against grubs. Collect/light traps against imago.
Spodoptera spp. *S. exigua* (Lesser cutworm) *S. sunia* *S. frugiperda*	Intensive working of the soil a few weeks before sowing to get rid of eggs and host plants for the larvae: let chickens search for the larvae. Use of *Trichogramma ssp.*, *Bacillus thuringensis* and VPN-virus. light traps against moths; Worm repellent: Branches of the tree *Murraya paniculata* (Philippines). Use Baculo virus. Preparations of neem, pyrethrum, tobacco. Good observation and rapid treatment are important.
Tetranychus urticae (Common red spider mite*)*	Stimulate natural antagonists, Spray preparations made of garlic; neem; soap; cattle liquid manure; flour: 2 cups of fine, white flour + 5-10 l water, mix well, spray infected plants in early morning, pests drop off with crust during the day.

The usage of such wide-range preparations as pyrethrum and neem should be reduced to emergency cases, as useful insects will also be affected. Other methods of control should be tried first. Sabadilla preparations are extremely poisonous to honey bees! Derris and pyrethrum are poisonous to fish, and can cause diseases if they come into contact with unprotected skin.

Baculovirus: A variety of caterpillars are sensitive to this viral disease. Infected caterpillars can easily be detected, they have a white discolouring and seem to be dead. They should be collected and used to prepare a cure. Infection is caused through ingestion. The virus has an incubation time of 1-2 weeks. Spreading the preparation should coincide with the life-cycle of the caterpillars, and must be introduced at the correct time to ensure they have not already damaged the crop too much. This requires careful observation and prognosis[23].

[23] Collect infected caterpillers, finely blend 20 caterpillers/ha, dilute with water and spray among crop. In order to be stored over longer periods, storage forms of the virus can be frozen. To do this, caterpillers killed by the virus are left to rot at room temperature in a bucket of water; the storage form will sink to the bottom as a white layer, while the rest can be tipped away: STOLL, G. (1986) Naturgemäßer Pflanzenschutz mit hofeigenen Ressourcen in den Tropen and Subtropen. AGRECOL, Verlag Josef Margraf

Storage pests

Pest	Cures[24]
Rats	lemon verbena (*Aloysia triphylla*) produces lethal high blood pressure in rats
Tribolium castaneum	Turmeric *Curcuma domestica* and mint *Mentha spicata* as powder or essential oil.
Trogoderma granarium	Storage below 20°C prevents development of larvae, calamus, garlic, neem.

Strong, aromatic plant preparations can have an effect on taste, and should therefore only be used to protect seeds.

2.7. Crop cultivation and maintenance

2.7.1. Crop monitoring

One foundation of the crop control is discerning which pests can affect the plants in which stage of development. Before blossoming commences, these are mainly the leaf-eating caterpillars, during the blossom and capsule development stage, mainly the sucking types of insects. Yet many species also feed off of some bugs parasitically (e.g. predatory bugs). By regularly controlling the crop, disease-carrying and pest insects' nests can be discovered in time before they spread and damage the crop.

2.7.2. Weed management

Young sesame plants only grow very slowly during the first 25 days, due to the small seed size, and are not yet strong enough to compete against weeds. Natural weed resistance sets in when growth rapidly accelerates, after the plants have attained a height of 10 cm. For this reason, the field should be kept as weed-free as possible during the first 20-25 days after being sown, this is usually achieved through 2-3 lots of hand-tillage.

Before sowing: Most of the weeds can already be combated before sowing commences. They are left to grow in the pre-prepared seed beds for 8-10 days (until they have formed 2-3 leaves). Then, the soil should be shallowly worked, only in the uppermost 2-3 cm, e.g. by very lightly harrowing. Care should be taken not to disturb weed seeds lurking in the lower layers, bringing them to the surface, and thus giving them reason to being germination. Shallow harrowing can be carried out 1-3 times before the sowing begins. This intensive working of the soil coupled with

[24] STOLL, G. (1986): Naturgemäßer Pflanzenschutz mit hofeigenen Ressourcen in den Tropen and Subtropen. AGRECOL, Verlag Josef Margraf.

sesame's slow rate of growth means that there is an increased risk of erosion taking place until the plant density is sufficient.

Further measures include:

- Early working in of the weeds and harvest residues from the previous crop,
- The planting of rapidly-growing varieties,
- Setting the distances between plants so that the crop can close ranks quickly and thus compete with the weeds,
- Include plants in the crop rotation that cast strong shadows, or are good ground coverers (e.g. green manure plants). In Turkey, wheat and barley are grown in crop rotation with sesame because of their ability to compete with weeds.

Bottom crop: Ground-covering legumes can be sown between the rows to suppress weed growth, e.g. peanuts, mungo, bonavist bean (*Dolichos Lablab*), *Canavalia ensiformis*.

After sowing: Only hoe very shallowly, in order not to damage the upper nutrient roots.

Manual: Careful preparation of the soil can reduce the amount of tilling necessary (hoe, machete, ripping). Eventually, the number of times needed can be reduced – optimally down to one time when blossoming begins.
The most important weeds in Central America are: *Cyperus rotundus*, *Corchorus aestuans* and *Ipomoea spp*.

Mechanical: Sowing in rows makes mechanical hoeing possible (it also makes manual hoeing easier). The first weed control stage takes place 15 days after sowing, at the same time as singling, the second after another 15 days. Manual hoeing is necessary within the rows.

2.8. Harvesting and post harvest treatment

2.8.1. Time of harvest

Varietal purity will facilitate harvesting as most of the crop ripens at the same time. Two to three harvests may be necessary if ripening times vary. The plants are cut or ripped down at a height of 10-15 cm, and harvested before the capsules are fully ripened, otherwise, huge losses will result as the capsules spring open. The optimum time for harvesting (physiological ripeness) has been reached when:

- The first, lowest capsules turn brown and begin to pop open,
- The stem turns yellow,
- The leaves begin to fall off,
- Blossoming has finished,
- The leaves have turned yellow.

2.8.2. Drying in the field/threshing

Sesame is generally harvested by hand, and then left to dry for the first 2-3 days after cutting in a windrow. The leaves dry out quickly there, making it easier to bundle them into sheaves. The sheaves should be positioned so that the sun can shine down directly onto the capsules. The sheaves should be small (diameter of 15 cm, bottom: 45-80 cm).
In this way, the following can be achieved:

- Drying takes less time
- Better heat and air circulation
- Avoidance of fungi infection because through little moisture
- Easier to turn when being shaken out
- More extensive shaking/threshing, fewer losses

The sheaves should not need to be dried for longer than 15 days.

Shaking out the sheaves and threshing: When the sheaves have dried out fully, they are tipped out onto sturdy cloths or canvases and threshed with sticks. The cloths/canvases should be at least 6 m², to avoid contamination with stones and soil.
In this way, quality and preservability can be retained, and an infection by soil-borne diseases avoided. In some cases, shaking out occurs after 10-12 days, and a second time after another 5 days.
Mechanical harvest is better, as the unripe plants are cut, and then the pre-dried sheaves threshed out. This reduces the amount of seeds lost, and the hay makes better fodder. Most threshing machines with a sheaf pick-up function are suited to the task. Varieties that open are easier to thresh mechanically than those that remain closed, as less force is needed. It is very important to carefully adjust the thresher, as even slight damage to the seeds will adversely effect their germinating capabilities. Well-threshed loads with slight contamination are better than clean, yet broken yields, because sesame is easy to clean[25].

2.8.3. Drying and cleaning seeds

Directly following the harvest, the sesame seeds are sieved of leaves, stems and capsule residues, and then dried out to a moisture content of 6% as rapidly as possible – which can be done on a clean, sun-drenched concrete base. Where the critical 6% cannot be reached only using the sun, artificial methods must be employed. High levels of humidity can cause sesame to take on moisture again and go mouldy; it should therefore only be stored for a short while, or in air-tight containers.

3. Product specifications

3.1. Processing

3.1.1. Post-harvest handling - storage

The storage sacks must be free of insects. Removal of the bitter seed hulls which contain oxalic acid is accomplished with steam treatment. Sesame seeds are not permitted to be treated with methyl bromide or ethylene oxide, and also not irradiated with ionising rays.

3.1.2. Quality requirements

The following is a list of quality characteristics with minimum and maximum values for sesame seeds that are usually required officially or by importers. Different minimum and maximum values can be agreed between importers and exporters, providing these do not clash with official regulations.

Quality characteristics	**Minimum and maximum values**
Taste and smell	Acc. to variety, fresh, not rancid, not stale
Purity	Free of foreign matter, i.e. sand, stones, plant stems, insects etc.
Water content	max. 5-7 %
Residues	
Pesticides	**Not measurable**
Bromide	Not measurable
Ethylene oxide	Not measurable
Heavy metals	
Cadmium (Cd)	max. 0.80 mg/kg
Micro-organisms	
Total number of parts	max. 10.000/g
Yeasts and fungus	max. 500/g
Enterobacteria	max. 10/g
Coliforms	max. 10/g
Escherichia coli	Not measurable
Staphylococcus aureus	max. 100/g
Salmonella	Not measurable in 25 g
Mycotoxins	
Aflatoxin B1	max. 2.0 µg/kg
Total aflatoxins B1, B2, G1, G2	max. 4.0 µg/kg

[25] WEISS, E.A. (1983): Oilseed Crops. Longman, London.

In order that the quality requirements are upheld, and no contamination of the sesame seeds occurs, preparation should take place under clean, hygienic and ideal conditions. The following aspects should be adhered to:

- Equipment (tubs, knives etc.), as well as working and drying surfaces (racks, mats etc.) and preparing and storage rooms, should be cleaned regularly.
- Personnel should be healthy, and have the possibility to wash themselves, or at least their hands (washrooms, toilets) and wear clean, washable overgarments.
- Water used for cleansing purposes must be free from faeces and other contaminants.
- Animals or animal faeces must not come into contact with the product.

3.1.3. Packaging and storage

Information printed on transport packaging

If the sesame seeds are packed into consumer units, the packaging must display details of the following:

- **Product name ('trade name**)

Name of the product e.g.: sesame seeds, shelled from organic cultivation[26]

- **Manufacturer**

Name and address of the manufacturer, importer, exporter or trader, and country of origin

- **Weight**

Details of the total weight in grams

The numbers describing the weight of the contents must be of the following sizes

Weight of contents	Letter size
Less than 50 g	2 mm
More than 50 g to 200 g	3 mm
More than 200 g to 1000 g	4 mm
More than 1000 g	6 mm

- **Best before date**

The 'Best before ...' details must include day, month and year; e.g.. best before 30.11.2001

- **Batch number**

[26] When products from organic farms are being labelled as such, it is necessary to adhere to the requisite government regulations of the importing country. Information concerning this is available from the appropriate certification body. The regulation for organic agriculture (EEC) 2092/91 are applicable to organic products being imported into Europe.

Consumer packages

If the sesame seeds are not to be packaged in bulk containers in the country of origin, but sealed in consumer packages, then this packaging should fulfil the following functions:

- Protect the sesame seeds from loss of aroma and against undesirable smells and tastes from its surroundings (aroma protection).
- Offer sufficient conservation properties, especially against loss or gain of moisture.
- Provide a surface area for advertising and product information.

The following materials can be used as **product packaging:**

- Cardboard boxes or paper bags with/without a transparent window made of polyethylene or polypropylene
- Single-layer plastic bags (polyethylene or polypropylene)

Transport packaging

Some form of transport packaging is required in order to ship the bulk or nuts packed for consumers. In choosing a type of packaging, the following should be heeded:

- Transport packaging made, for example, out of cardboard, should be strong enough to protect the contents against being damaged by outside pressure.
- The packaging should be dimensioned to allow the contents to be held firmly, but not too tightly in place.
- The dimensions should be compatible with standard pallet and container dimensions.

Information printed on transport packaging

The transport packaging should display details of the following:

- Name and address of the manufacturer/packer and country of origin
- Description of the product and its quality class
- Year harvested
- Net weight, number
- Batch number
- Destination, with the trader's/importer's address
- Visible indication of the organic source of the product[27]

Storage

Packaged sesame should be stored in a dark place at low temperatures (below 18°C) and low relative humidity. Under optimum storage conditions, sesame can be stored for up to 1 year.

[27] Organic products must be protected from contamination by non-compliant substances at each stage in the process, i.e. processing, packaging, shipping. Therefore, products originating from a certified organic farm must be recognisably declared as such.

If the organic product is being stored in a single warehouse together with conventional sesame mixing of the different qualities must be avoided. This is best achieved using the following methods:

- Training and informing of warehouse personnel
- Explicit signs in the warehouse (silos, pallets, tanks etc.)
- Colour differentiation (e.g. green for the eco-product)
- Incoming/dispatched goods separately documented (warehouse logbook)

It is prohibited to carry out chemical storage measures (e.g. gassing with methyl bromide) in mixed storage spaces. Wherever possible, storing both organic and conventional products together in the same warehouse should be avoided.

Appendix

Examples of varieties[28]:

Early ripening varieties: “Madhavi”, “B 67”, “Kanak”, “GT 1”, “Tapi”, “TMV 3”, “TMV 5”, “SI 36”, “ES 6”, “ES 43”, “ES 41-3-84” and “IS 234-2-84” (India, Russia, China).

Varieties suitable for dryland farming: “JT 66- 135”, “JT 7”, “Type 4”, “Gujarat Selection 12”, “Type 12” and “Type 13” (India).

Varieties with improved capsules, seeds and oil content: Varieties with multiple capsules include: “Purva 1”, “Patan 64” and “M 32” (India).

Varieties with nonscattering capsules: “S.I.152”, “Delco”, “Rio” and “Palmetto” (USA).

Varieties with large seeds: “Phule Til 1” and “JT 7”.

Varieties with a high oil content: “TMV 5”, “TMV 6” and “Aceiterad”, as well as, generally, the types with white seeds.

High yield varieties: The objective here is to move away from the bushy varieties – which are adapted to low soil fertility and rough weather conditions – and towards the non-branching, single stem varieties which have several capsules on each axil. They allow a higher density to be planted, which leads to higher yields and easier management.

Two Indian varieties are: “Pratap” and “N 32”.

Varieties which are disease and pest resistant: (Lal and Rai; Kolte)

Alternaria leaf spot -resistant: wholly hairy varieties, as well as “SI 948“, “SI-1561”, “1683”, “1737”, “2177”, “2381” and “Rio”.

-tolerant: “Sirogoma”, “Venezuela 51”, “NO 4”, “E 8”, “JT 7”, “JT63-117”, “A-6-5”, “JT-66-276”, “Anand-9”, “JT-62-10”, “VT-43” and Anand 74.

Bacterial blight-resistant: “T-58”.

Bacterial leaf spot -resistant: “Dulce”, “Margo”, “Early Russian” (the latter also against Rasse 2).

India: “Almora local white”, “Punjab 1”, “C23”, “MP 8”, “M3-1”, “EC (4090, 13536, 14538, 20783, 20785 and 20787)”.

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[28] LAL, J.P., and RAI, B. (1991): sesame um: an all-season oilseed crop. Indian Farming 41 (5).
KOLTE, S.J. (1985): Diseases of annual edible oilseed crops. Vol. 2. CRC Press Boca Raton, Florida.
SHARMA, S. M. and REDDY, B. N. (1983): Research on sesamum makes headway. Indian Farming 32 (12).

Venezuela: “Ajimio Atar 55”, “Maporal” and “Morada” (all of African origin) and local variety “A-15-13”.

Bulgaria: “Sadovo 1” and “Sadovo 2”.

Early ripening, white varieties are probably less susceptible as darker ones.

Brown angular spot -resistant: “V-16”.

Capsule-borer-tolerant: “Krishna”, “Soma” and “Tapi” (India).

Charcoal red: red-shelled varieties are less sensitive, including: “Ajinio Attar 55”, “C-50”, “RT-1”, “G-5”, “NP 6” and “M3-1”.

Fusarium wilt: nonscattering varieties are less sensitive. Resistant/less sensitive: “Aceitera”, “Glauca”, “Baco”, “Sirogona”, Tadzhik selections, “Venezuela-25”, “Nebraska 406-3-12”, “119-3” and “2146”.

Leaf- blight -tolerant: “Early Russian”, “Odeskii 539”, “Kubanec 55” and “D 55-23” (Russia), “Dulcek” (USA) and “Vinayak“ (India).

Leaf curl -resistant: “NP-6”, “T 13-3-2”, “65-1/11”, “67-13/2-1” and “Entebbe ex Uganda”.

Phyllody -resistant: “SI- 289”, “951”, “1535”, “2194”, “2201”, “2373”, “2635”, “T-13-3-/2”, “65-1/1-1” and “67-13-1/2-1”.

Barely susceptible: “JT-7”, “JT-276”, “N-32”, “B 67”, “Surya” and “Haryana Til 1”. Of these “B 67” is also Macrophomina-resistant.

Phytophtora-blight -resistant: “71-184-1”, “79-129-2” and “71-145-3” (Venezuela)

Barely susceptible: “N-62-39”, “E 8” and “IV/1/416-2”.

Resistant during germination: “NP 20”, “No.16” and “No.37”.

Resistant when fully grown: “NP 3, 4, 8 and 24” and “T-11”.

Powdery mildew Odium erysiphoides -resistant: “SI-1926”, “194-5”, “SI-1561, 1683, 1737, 2177, 2381 and 2601” and “KRR-2”.

Barely susceptible: generally, the late ripening varieties.

White spot-resistant: “IS 4, 15, 21, 29, 41, 41A, 41B, 128 and 128B”; “ES 150 (H 60-18)” from Morocco, “ES 234” from Mexico and “ES 242” (Precoz) from Venezuela.