Technical Bulletin

Organic Sesame Production

K A Gopinath, B Venkateswarlu, S Venkateswarlu,
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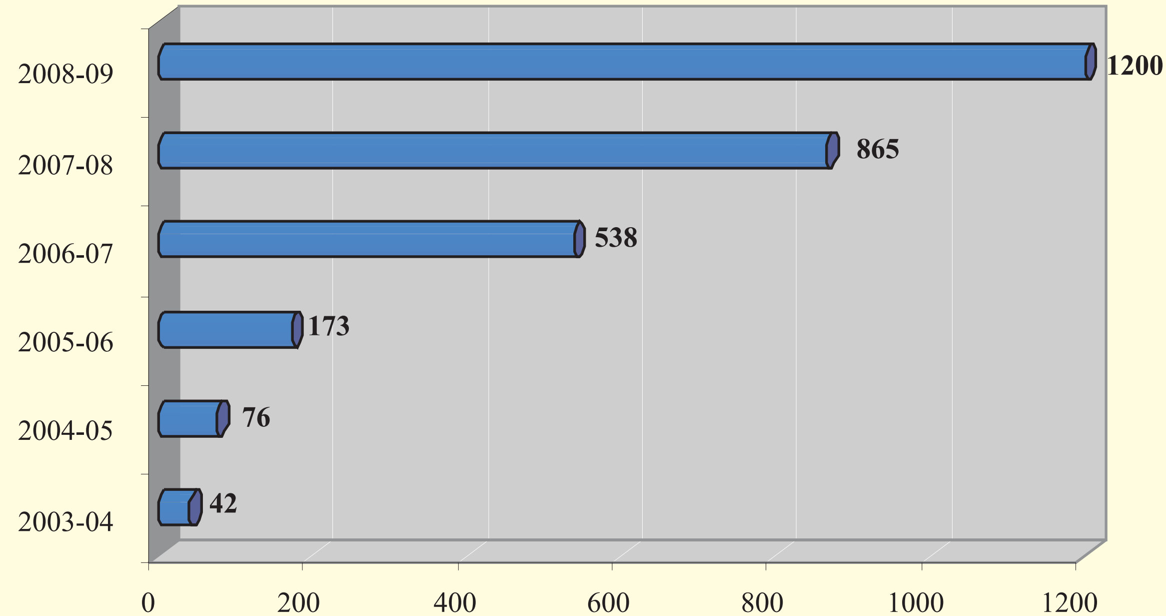

Growth of area under certified organic management (000' Ha) in India

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CONTENTS

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FOREWORD

Exclusive organic farming is possible only in niche areas and commodities where there are clear opportunities for realizing higher premiums through exports and where there is a strong justification for replacing chemical inputs with organic or bio-inputs. Several expert reviews in the country pointed out that rainfed areas are ideally suitable for organic farming in view of the existing low use of chemical inputs and less drastic yield declines when farms are converted from chemical to organic management. Extensive data is available on the export potential of various commodities grown organically, particularly in rainfed areas, but farmers, small entrepreneurs and NGOs are trying to grow these commodities through trial and error approach. No systematic and well-defined research program has been initiated so far that could back up such efforts.

Sesame (Sesamum indicum L.) is an important oilseed crop grown in the states of Gujarat, Rajasthan, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Chhattisgarh. It is grown mostly under rainfed conditions during kharif but rabi and summer crop is supported with irrigation. India ranks first in area (29%) and production (26%) of sesame in the world. Sesame seeds are rich source of food, nutrition, edible oil, health care and bio-medicines. International demand and export of sesame are steadily increasing. India's share in world's exports of hulled sesame is around 60%. India exports about 2.5 lakh tonnes of seed valued at Rs.1000 crore. Since it is essentially used in food and medicine in developed countries, the importers are insisting for certified organic produce.

Globally sesamum is exported in the form of seed. Seed with uniform size, lustrous, white, bold, sweet, free from flash, low free fatty acids (<2%), and free from pesticide residues is preferred in the global markets. However, scattered production with varied management practices is resulting in seed of non homogenous quality. The solution lies in identifying appropriate production zones, standardization of production technlogies and adoption of organic production methods through contract farming to produce the desirable product.

With this in view, a field experiment was initiated at the Research Farm of Central Research Institute for Dryland Agriculture, Hyderabad to evaluate the feasibility of organic sesame production under rainfed conditions and to assess the impact of organic management on sesame quality and soil properties. The present bulletin is the result of five years of research work (2005-2009) on organic sesame production. In addition to the research results, the bulletin contains some general standards for organic production. I hope the publication would be of immense use to researchers, teachers, extension workers and farmers interested in organic farming.

B. Venkateswarlu

Organic Sesame Production

Introduction

The rainfed agro-ecosystem in India covers arid, semi-arid and sub humid zones which represents more than 70% of the geographical area. Fifty eight per cent of the 142 million ha cultivated area is rainfed. Unlike irrigated areas, where homogenous, high intensive cropping systems are common, rainfed farming systems are more diverse and heterogenous. Livestock farming plays an important role in farmer's livelihood. Historically, rainfed farmers followed a low intensive sustainable farming system with excellent integration of crops-trees-pastures and livestock (Venkateswarlu, 2008).

The vast majority of rainfed farmers in remote areas still practice low external input or no external input farming which is well integrated with livestock, particularly small ruminants. Based on several surveys and reports, it is estimated that up to 30% of the rainfed farmers in many remote areas of the country do not use chemical fertilizers and pesticides. Thus, many resource poor farmers are practicing organic farming by default. The Government of India task force on organic farming and several other reviewers has identified rainfed areas and regions in north east as more suitable for organic farming in view of the low input use (GOI, 2001; Dwivedi, 2005; Ramesh et al., 2005).

Rainfed areas are reported to have relative advantage to go for organic farming primarily due to i) low level of input use, ii) shorter conversion period and iii) smaller yield reductions compared to irrigated areas, but no one can suggest any large scale conversion in view of several limitations particularly availability of organic inputs in required quantities (Venkateswarlu, 2008). The inherent advantages of rainfed areas should be capitalized by encouraging organic farming in highly selected areas and commodities with edapho-climatic and price advantages.

Sesame (Sesamum indicum L.) is an important oilseed crop cultivated mostly by small and marginal farmers in the states of Gujarat, Rajasthan, Madhya Pradesh, Tamil Nadu, Orissa, Andhra Pradesh and Chhattisgarh. It is cultivated in an area of about 1.85 million ha with a production of 0.65 million tones and productivity of about 350 kg/ha. Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which it is known as 'the queen of oils'. Due to the presence of potent antioxidants, sesame seeds are called as 'the seeds of immortality'. The seeds are also very good source of dietary proteins with fine quality amino acids that are essential for growth, especially in children. Sesame seeds also contain many health benefiting compounds such as sesamol (3, 4-methylene-dioxyphenol), sesaminol, furyl-methanthiol, guajacol (2-methoxyphenol), phenylethanthiol and furaneol, vinylguacol and decadienal. Sesamol and sesaminol are phenolic anti-oxidants which protect biological system from the harmful effects of free radicals. The seeds are rich sources of many essential minerals. Calcium, iron, manganese, zinc, magnesium, selenium and copper are especially concentrated in sesame seeds. With the growing health consciousness, the international demand and export of sesame are continuously increasing. It has emerged as a valuable export crop, earning more than Rs. 1000 crores from the export of 2.5 lakh tonnes of sesame seed (Duhoon et al., 2004). Since it is mostly used in food and medicine in developed countries, of late pesticide residues are becoming major problem in the promotion of sesame exports. Therefore, organically produced sesame will suit to the tailor-made requirements of the buyers and will get premium in both the national and international markets. In recent years, many farmers have switched over to certified organic sesame production with the support of the State Government. For example, the Government of Gujarat has undertaken a model organic sesame cultivation project in Surendranagar district involving around 200 farmers. Similarly, there are already a growing number of farmers involved in organic sesame production, particularly in the dryland areas of Western Rajasthan.

Organic certification

The term 'organic' in organic agriculture is a labelling term that denotes products that have been produced in accordance with certain standards during food production, handling, processing and marketing stages, and certified by a duly constituted certification body or authority. The organic label is therefore a process claim rather than a product claim. In order to enter the lucrative markets for organic produce, it is not only necessary for organic growers to abide by the stipulated norms and regulations of organic farming but they also require a certification from an established certification agency (Appendix III) before the produce can be sold as 'organic'.

While third-party certification is an essential component to world trade, there are downsides to the system. The inherent expense and paperwork required in a multi-level system discourages most small organic producers from being certified at all. In an attempt to alleviate this problem, a number of alternative methods to guarantee the organic integrity of products have been developed for small domestic producers including group certification based on internal control system (ICS) and participatory guarantee system (PGS). PGS is a process in which people in similar situations (in this case small holder producers) assess, inspect and verify the production practices of each other and collectively declare the entire holding of the group as 'organic' (Yadav, 2010). These alternative certification systems are becoming more popular as certification costs are low, involve minimal paper work and regionally appropriate than third-party certification agencies.

Standards for organic sesame production

Organic produce gets recognition and price premium in market, only if it meets the required standards and is certified. India has evolved National Standards for Organic Production (NSOP, 2006) which has been adopted in the country. These standards are in conformity with the international standards such as EU, Codex and IFOAM. The following organic management practices should be followed (as per NSOP) for achieving higher productivity and quality of sesame.

1. Requirement of conversion or transition period

Among the requirements for organic agricultural production, the conversion period from conventional to organic farming is of particular significance. The conversion period is basically the time between the start of organic management and the certification of crops or animal husbandry as organic. Plant products produced can be certified when the national standards requirements have been met during a conversion period of at least two years before sowing for annual crops. However, the certification authority has the discretion of extending or reducing the duration of the conversion period depending on past use of the land and the ecological situation. It is not necessary to convert the whole farm or holding. However, the certification programme shall ensure that the organic and conventional parts of the farm are separate, clearly distinguished and inspectable.

2. Diversity in crop production

Organic farming should contribute beneficially to the ecosystem. Crop diversification is essential for maintenance of soil health while minimizing nutrient losses and to reduce pressure from insect-pests, weeds and diseases. Diversity in crop production is achieved by a combination of a versatile crop rotation with legumes/cereals and intercropping. Sesame + green gram (3:3) and sesame + cluster bean (3:3) intercropping systems minimize the incidence of leaf roller/capsule borer and bud fly.

3. Growing season

Proper time of sowing is a must for getting higher yield. Sesame requires fairly hot conditions and a temperature of 25-27^{0} C encourages rapid germination, initial growth and flower formation. It is cultivated as kharif (sowing in June-July) crop in north India but in south India it is cultivated during all seasons [kharif (May-June), late kharif (July-August), rabi (November-December) and spring (January-February)].

4. Soils

Sesame can be grown in many soil types but thrives best on well-drained, medium textured fertile soils. Soils with a neutral reaction are preferred, although the crop will grow in soils having a pH in the range of 5.5 to 8.0. Heavy, water-logged soils, as well as soils with high salt contents are not suitable. Shallow soils (less than 35 cm) with impermeable sub-soils are also unsuitable.

5. Field preparation

Sesame requires well pulverized seedbed with fine tilth for good germination and establishment of desired plant stand. After the harvest of the preceding crops, the field should be ploughed once (off-season or summer ploughing of 15-20 cm deep) and left exposed to sunlight. This helps in soil and moisture conservation particularly in drylands, and control of insect-pests, weeds and diseases. The soil is brought to fine tilth by ploughing the field 2-3 times followed by harrowing and planking. For a rabi crop, 2-3 harrowings followed by leveling is enough. A level field improves water use efficiency, helps in weed control and allows the rapid removal of excess water. To prevent contamination, all equipment/implements used in organic crop production must be free of non-organic crops and prohibited materials. Equipment/implements used for both organic and non-organic farming must be cleaned and flushed prior to use on organic fields or crops.

6. Choice of varieties

Choice of variety is more critical in organic situations than for conventional production system where problems can be solved at a later stage by application of pesticides or mineral fertilizers. Level of resistance to diseases and insect pests must be a criterion while selecting the variety (Table 1). Yield, quality, and market acceptability also have to be considered while selecting crop varieties. There are two types of varieties, black-seeded and white-seeded. In India, most of the work in sesame is mostly concentrated on white-seeded varieties. Many high yielding varieties have been released by All India Coordinated Sesame

Improvement Project, which are capable of yielding 500-1000 kg/ha in different growing conditions (Hegde and Sudhakara Babu 2002). Certified organic seed should be used for sowing. However, when organic seed is not available, chemically untreated conventional seed may be used.

Table 1. List of important varieties recommended for different states

Variety (season)	Region	Level of resistance or tolerance to pests		
		Resistant	Moderately resistant	tolerant
JTS-8 (kharif)	Madhya Pradesh, Uttar Pradesh, Andhra Pradesh, Karnataka, Rajasthan, Gujarat and Maharashtra	Phytophthora blight, Alternaria leaf spot	Phyllody	-
AKT-64 (kharif)	Maharashtra	-	Phyllody	Macrophomina stem/root rot, Phytophthora blight
AKT-101 (rabi)	Maharashtra	-	Phyllody, Macrophomina stem/root rot, Bacterial blight	-
Pragati (kharif)	Uttar Pradesh, Haryana and Rajasthan	Phyllody, Leaf curl, Powdery mildew	Leaf curl, blight, Macrophomina stem/root rot, Capsule borer	-
Nirmala (kharif)	Coastal region	Bacterial leaf spot, Powdery mildew	Stem/root rot, Alternaria leaf spot	Phyllody, Wilt
Chandan (kharif)	Andhra Pradesh	-	-	Phyllody, Bacterial blight
VRI(SV)-2 (kharif/rabi)	Tamil Nadu	Phyllody, Root rot	-	-
Hima (kharif/rabi)	Andhra Pradesh	-	-	Capsule borer, Phyllody, Alternaria leaf spot

7. Seeds and sowing

Sesame is grown as broadcast as well as line sowing. A seed rate of 5-7 kg is required for sowing one hectare. The seed rate in mixed or intercropping depends on the proportion of area occupied by sesame in the system. Treat the seed before sowing with *Azotobacter* and *Trichoderma*. Phosphate solubilizing bacterial (PSB) culture should also be used for seed treatment for better availability of soil phosphorus. Each of these cultures should be used at the rate of 5-10 g/kg seed. Seed priming with soaking of seeds with water for 12 hrs followed by drying before sowing improves the crop establishment. Spacing depends on growth habit of the variety, season and growing conditions. The seeds should be sown in lines 30-40 cm apart with the help of a desi plough/ tractor-operated seeder with a plant to plant distance of 12-15 cm. As the seeds are very small in size, they should be mixed with 2-3 kg fine sand or soil/kg seed to ensure uniform distribution of seed in soil. The depth of sowing should not be more than 2-3 cm.

8. Nutrient management

Biodegradable material of microbial, plant or animal origin produced on organic farms should form the basis of the fertilisation programme. Non-synthetic mineral fertilisers and brought in fertilisers of biological origin should be regarded as supplementary and not a replacement for nutrient recycling. Organic standards minimize or eliminate use of synthetic or manufactured inputs and encourage maximum use of local natural resources. The certification programme shall lay down restrictions for the use of inputs such as mineral potassium, magnesium fertilizers, trace elements and manures with a relatively high heavy metal content and, or unwanted substances, e.g. basic slag, rock phosphate and sewage sludge. Manures containing human excreta shall not be used on vegetation for human consumption. There are a number of organic sources of nutrition and among them green manuring, composting, biofertilizers, vermicompost and biodynamics are important. A list of products, as per NSOP, for fertilizing and soil conditioning is given in Appendix I.

9. Pest management

Pest control strategies under organic farming are largely preventive rather than reactive. The balance of cropped and uncropped areas, crop species, variety, temporal and spatial pattern of the crop rotation seek to maintain a diverse population of pests and their natural enemies and disrupt the life cycle of pest species. Use of certified seed of resistant varieties, intercropping and crop rotation, summer ploughing, timely sowing, removal of infected plants, keeping field borders free of weeds etc will help reduce certain insect-pests and diseases (Prabhakar, 2005). A list of products, as per NSOP, for plant pest and disease control is given in Appendix II.

9.1 Diseases

There are a number of fungal, bacterial, mycoplasma and viral diseases responsible for reduction of sesame yields. Among them, bacterial blight, alternaria leaf spot, stem and root rot, powdery mildew and phyllody are major diseases of the crop. A successful approach for disease management under organic farming could be the integration of two or more of the following approaches:

- Cultural practices such as deep summer ploughing, clean cultivation, phyto-sanitation and timely sowing
- Intercropping and mixed cropping
- Use of resistant varieties
- Treat the seeds with talk-based formulations of *Pseudomonas flurescens* and *Trichoderma harzianum* or *T. viridae* each @ 10g/kg seed
- The bio-agent formulations can be used for enriching the FYM by applying 2 kg of *Pseudomonas flurescens* or *Trichoderma harzianum* and 50 kg of neem or pongamia cake to one tonne of FYM. This should be left for 15 days under the shade and then apply uniformly in the field

- A number of bio-agents such as *Trichoderma* spp., *Pseudomonas* spp., *Paecilomyces* spp. and *Aspergillus* spp. etc. can be used for the management of soil pathogens
- Spray *Pseudomonas flurescens* 2% 2-3 times to induce disease resistance and control of foliar diseases

9.2 Insect-pests

Sesame is infested by as many as 29 insect-pests belonging to 8 species which are potential pests of the crop. Among them, the leaf roller/capsule borer is the key pest of the crop. The insect-pests could be controlled by using the following methods:

- Biocontrol agents such as spiders, damselflies, dragonflies, meadow grasshoppers, coccinellids, *Apanteles* sp., *Tetrastichus* sp., *Telenomus* sp., *Trichogramma* sp., etc. should be encouraged
- Cultivation of green gram or black gram along the outer periphery of the sesame crop
- Sesame + green gram (3:3) and sesame + cluster bean (3:3) intercropping systems minimize the incidence of leaf roller/ capsule borer and bud fly
- Spray neem seed powder extract 4% or neem oil (3-4%) or pongamia soap (1%) at 20-25 days after sowing and repeat 2-3 times at 15 days interval for managing sucking pests
- Spray Bacillus thuringiensis (BT) @ 1 kg a.i./ha for control of leaf eating caterpillars
- Spray NPV @ 250 LE/ha at flower initiation stage and repeat 2-3 times at weekly intervals to reduce the capsule borer incidence
- Erect pheromone traps @ 20/acre at flowering stage to trap shoot- and capsule-borers
- Spray of garlic buds + red pepper (1:1) @ 5 g/liter or neem leaf extract in cow urine (250 g neem leaf/liter cow urine kept for 10-15 days) @ 30 ml/liter or cow butter milk @ 40 ml/liter (10-15 days old) are found effective and economical

9.3 Weeds

Weed management is one of the main concerns in organic agriculture. Crop:weed interactions and weed community dynamics can be greatly influenced due to use of organic manures (major source of incoming viable weed seeds) in organic farming systems. Generally, all aspects of arable crop production play an important role in systems approach to weed problems. Within organic systems, total exclusion of weeds from cropped areas is rarely necessary and weed control can be targeted effectively to key crop growth periods (Stockdale et al., 2000). The slow initial growth of sesame seedlings makes them poor competitors to quick-growing weeds. Therefore, the crop is very sensitive to weed competition during the first 20-25 days. A weed-free seedbed is the most important, since cultivation of sesame seedlings is difficult as the fine fibrous roots are easily damaged. It is essential to have a minimum of two weedings, one after 15 days of sowing and another 15-20 days thereafter. Row crops can be weeded with any inter-row tillage implement such as bullock-drawn blade harrow, rotary or finger weeders and wheel-hoe provided they are set to work as shallow as possible (Hegde and Sudhakara Babu 2002). Planting in narrow rows can assist reducing late weed growth due to shading effect. Other approaches proposed for an effective weed management under organic farming are:

- Use of crop seed free from weed seeds. The first rule for weed prevention and the first step of any good weed management programme is the purchase and planting of clean seed.
- Good crop husbandry practices (tillage, crop diversification, intercropping, planting geometry etc) contribute considerably to weed control with little extra cost
- Use of thoroughly decomposed compost and other organic manures
- Mulching the soil surface can physically suppress weed seedling emergence

10. Soil and water conservation

All attempts should be made to prevent contamination from outside and within the farm. Soil and water resources should be handled in a sustainable manner to avoid erosion, salinization, excess and improper use of water and pollution of surface and ground water. Clearing of land through the means of burning organic matter, e.g. slash-and-burn, straw burning should be restricted to the minimum. The clearing of forest for agriculture is also prohibited.

11. Harvesting and threshing

Sesame is usually ready for harvest in 80-150 days after sowing, generally in 100-110 days, but some cultivars mature in 70-80 days. Sesame should be harvested when the leaves turn yellow and start dropping, while most of the capsules are still greenish. Capsules ripen irregularly from the lower stem upward, the topmost often being only half matured at harvesting. If the harvesting is delayed, there is loss in yield due to bursting and shattering of capsules. The plants are cut with sickles or uprooted. The harvested plants are carried to threshing yard and stacked for a week. Once the plants are dried, threshing is done manually. The seeds are cleaned by sieving and winnowing, dried in sun to bring down the moisture content to <10%.

12. 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 (Anon, 2002).

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
Microorganisms	
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

Research on organic sesame production at CRIDA

A field experiment was conducted during the rainy season of 2005-2009 to assess the yield and quality of sesame, and soil properties under organic vis-à-vis conventional production systems. The experiment was laid out in 3 blocks i.e. control, organic and conventional with a 5 meter buffer zone between the blocks with pearl millet as the barrier crop. Sesame (var. 'Swetha Til') was sown at a seeding rate of 6.5 kg/ha and a row spacing of 30 cm. The crop was sown during second fortnight of June to first fortnight of July depending upon the onset of monsoon in each year.

The two treatments i.e. conventional (chemical) and organic were designed based on the available data and package of practices evolved for the crop and using permitted inputs in case of organic treatment. The conventional system included application of recommended dose of chemical fertilizers (40:26.5:33.3 kg NPK/ha) and recommended pest management module viz. seed treatment with thiram 3 g/kg seed; spray of dimethoate 2 ml/l water for control of thrips/red spider mites; dimethoate/chlorpyriphos 2 ml/l for podfly; monochrotophos 1.6 ml/l for pod borer; COC 3 g/l for stem/root rot, mancozeb 1 g/l for Alternaria leaf spot, removal of plants for phyllody and sulfur dust 3 g/l for control of powdery mildew.

Conventional management

Organic management

The organic system included application of FYM 3.7 t/ha + neem cake 900 kg/ha + ash 75 kg/ha + bone meal 75 kg/ha + elemental sulfur (ELS) 20 kg/ha + PSB 5 kg/ha (soil application) + Azotobactor 5 kg/ha, and pest management with *Trichoderma* (0.4%) seed treatment + neem oil spray thrice at 15, 30 and 45 DAS, and Azadirachtin (0.03%) spray at 30 DAS. The organic manures were applied two weeks before sowing and chemical fertilizers were applied at the time of sowing. Two hand weedings were carried out at 20 and 40 days after sowing in all the plots.

Productivity of sesame

The seed yields were higher under conventional farming than under organic farming and control in all the years (Fig. 1). During the initial three years, organic sesame yield was about 20% less compared to conventional farming. However, in the fourth and fifth year, the seed yield reduction under organic farming was 7.7 and 7%, respectively compared with conventional farming indicating that the yield levels under organic farming may further improve over the years. Lower seed yields in the plots under organic management may have been associated with the less

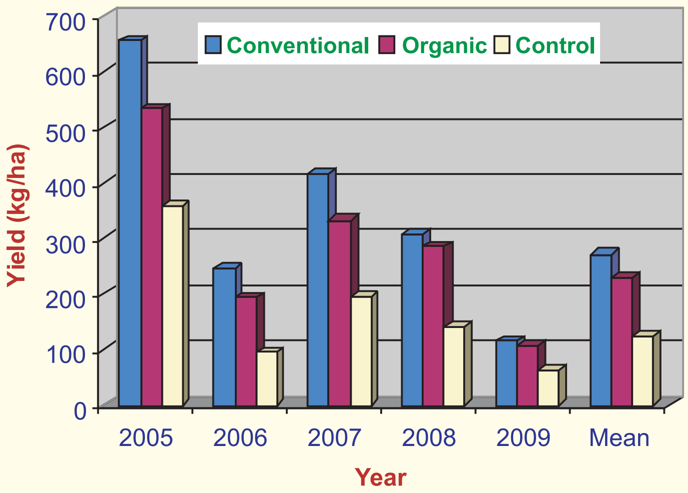

Figure 1. Yield of sesame (kg/ha) under different production systems over five years

readily available nutrients in the initial years of transition as nutrient cycling processes in first-year organic systems change from inorganic N fertilization to organic amendments (Harris et al., 1994; Reider et al., 2000) and slower release rates of organic materials (Liebhardt et al., 1989; MacRae et al., 1993). In 2006 and 2009, the seed yields were drastically reduced in all the treatments due to prolonged dry spells during the crop season (CRIDA, 2009).

Quality of sesame oil

Sesame is an important oilseed crop having an ideal balance of different fatty acids present in its oil and is practically free from any undesirable constituent making it traditionally suitable oil for frying as well as table purpose. The oil (%) content in sesame seeds was marginally lower in all the treatments in 2009 compared with 2008 (Fig. 2). This may be due to prolonged dry spells during the crop season resulting in shriveled seeds and poor oil content. Organically grown sesame seeds had marginally higher oil (%) content compared with conventional and control treatments in both the years.

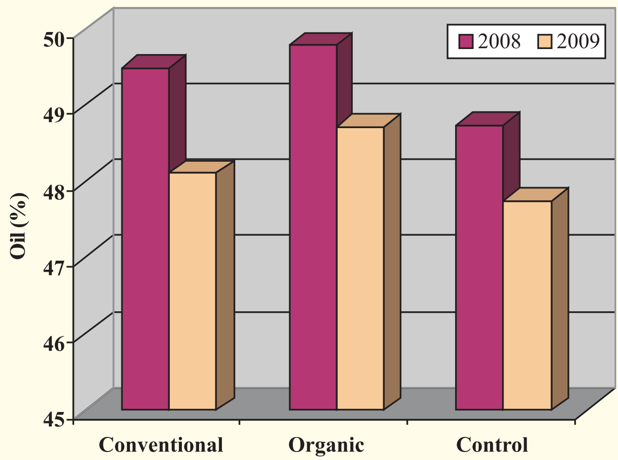

Figure 2. Oil content of sesame grown under different production systems

Fatty acid composition of any edible oil governs its chemical and nutritional properties and hence ultimately responsible for its end use. Sesame oil has around 15 % saturated fatty acids (palmitic + stearic) and 85% unsaturated fatty acids (oleic + linoleic). The oil is rich in mono-unsaturated fatty acid (MUFA) 'oleic acid' (also known as omega-9 fatty acid) which constitutes over 40% of total fatty acids. Oleic acid helps to lower LDL (low density lipoprorein) or "bad cholesterol" and increase HDL (high density lipoprotein) or "good cholesterol" in the blood. Linoleic acid, a polyunsaturated fatty acid (PUFA) also known as omega-6 fatty acid, is an essential fatty acid which constitutes over 40 % of total fatty acids. Omega-6 fatty acids have been shown to be beneficial in the reduction of cholesterol levels. The oleic:linoleic ratio is around 1 which provides a good shelf life to the oil making it suitable medium for cooking.

The oil extracted from seeds obtained under conventional, organic and control treatments were analyzed for fatty acid composition by Gas Liquid Chromatography. No significant variation was observed in the fatty acid composition across different treatments over different years (Table 2).

Table 2. Effect of treatments on fatty acid composition of sesame oil

Treatment	Palmitic acid		Stearic acid		Oleic acid (MUFA)		Linoleic acid (PUFA)	
	2008	2009	2008	2009	2008	2009	2008	2009
Conventional	10.36	9.67	4.37	4.98	41.28	41.15	43.98	44.10
Organic	10.25	9.40	5.12	4.80	41.29	41.10	43.12	44.60
Control	9.67	9.70	5.46	5.06	41.10	42.00	43.76	43.19

Soil fertility

Results of the analysis of the soil samples collected after the harvest of sesame at the end of fifth year are presented in Table 3. Organic cultivation of sesame resulted in the buildup of organic carbon content (0.71%) in soils as compared to conventional

(0.63%) and control (0.53%) treatments. The available P and K contents were also higher in the plots under organic management than those under conventional and control treatments.

Table 3. Soil properties under different production systems after five years of experimentation

Soil property	Production system			Initial value
	Conventional	Organic	Control	
pH	6.72	6.64	6.11	6.07
Organic C (%)	0.63	0.71	0.53	0.64
Available P (kg/ha)	29.5	30.7	28.3	28.9
Available K (kg/ha)	228.0	245.0	216.0	225.0
DTPA-Zn (ppm)	0.60	0.67	0.58	0.62
DTPA-Cu (ppm)	0.65	0.72	0.61	0.77
DTPA-Mn (ppm)	13.1	14.4	9.6	56.1
DTPA-Fe (ppm)	26.05	27.65	24.58	35.6
Dehydrogenase (µg TPF/g/h)	12.31	14.79	9.69	-
SMBC* (µg/g)	249.08	460.96	74.26	-

*Soil microbial biomass carbon

Addition of potash-rich ash for meeting the nutritional requirement of organic sesame might have resulted in higher available K contents in organic plots. Similarly, organically managed plots had higher levels of DTPA-extractable micronutrients (Zn, Cu, Mn and Fe) than other treatments. Information on soil microorganisms and their activity are very important for assessing soil quality and productivity. Studies of enzyme activities provide information on the biochemical processes occurring in soil. There is growing evidence that soil biological parameters may be potential and sensitive indicators of soil ecological conditions and soil management. The activity of the dehydrogenase (DHA) is considered an indicator of the oxidative metabolism in soils and thus of the microbiological activity because it is linked to viable celss. Soil DHA reflects the total range of oxidative activity of soil microflora and, consequently it may be a good indicator of microbiological activity in the soil (Skujins, 1976). The soil microbial properties such as dehydrogenase activity and soil microbial biomass carbon were higher in the plots under organic management than other treatments.

Nutrient loss

The runoff water contained considerable amount of K and small quantities (less than 1 ppm) of P and micronutrients (Table 4). In general, the loss of P and K was high from plots under conventional production system as compared with organic and control plots. However, the runoff water from organic production system had higher contents of Fe, Cu and Mn than from other treatments.

Table 4. Nutrient loss through runoff water under different production systems

Production system	Nutrients (ppm)					
	P	K	Zn	Fe	Cu	Mn
Conventional	0.11	14.71	Traces	0.22	0.003	0.320
Organic	0.09	14.22	Traces	0.57	0.004	0.359
Control	0.05	13.33	Traces	0.13	0.002	Traces

Incidence of insect-pests and diseases

The pod borer incidence was high with a pest population index (PPI) of 1.5 under organic farming compared with conventional farming (PPI of 0.2) and control (0.2). However, incidence of phyllody, bacterial leaf spot and aphids were similar across the treatments (Fig. 3). The population of natural enemies like coccinellids was comparatively higher under organic management.

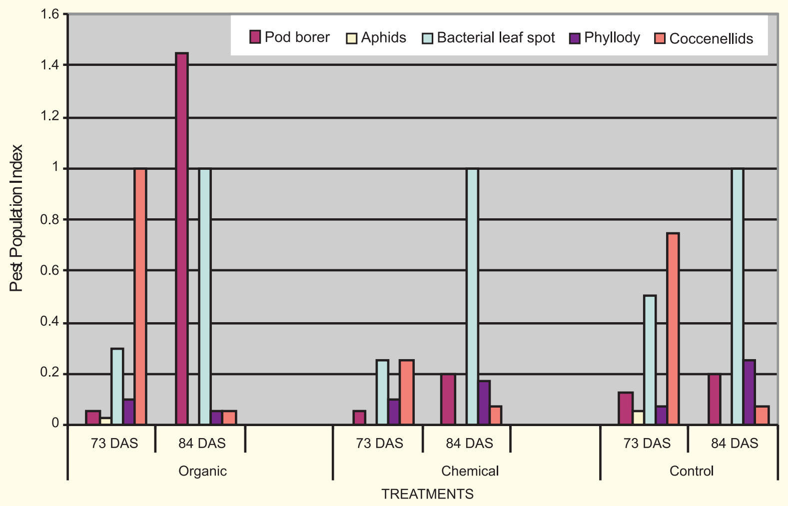

Figure 3. Incidence of insect-pests and diseases in sesame under different treatments

Economics of organic sesame production

Economic analysis was based on the prevailing cost of input/ operations and price of produce. The yield data for three years (2005, 2007 and 2008) was considered for economic analysis since low rainfall coupled with prolonged dry spells during the crop season in 2006 and 2009 drastically reduced sesame yields in all the treatments. Economic evaluation of organic sesame cultivation was also done by assuming different price premiums (0-40%) for the produce to assess whether sesame can be profitably grown under organic farming conditions in comparison with conventional practice. The cost of cultivation of sesame was Rs. 10800 and 14050 per hectare under conventional and organic farming, respectively. Higher cost of cultivation under organic management was mainly due to more input costs particularly for purchase of neem cake and bone meal. The net return from organic sesame was about 60% less compared with conventional management (Fig. 4). Furthermore, the reduction in net return from organic management was 46, 29 and 13% at 10, 20 and 30% price premium, respectively compared with conventional management. However, at 40% price premium for organic sesame the net returns from organic sesame was comparable with that of conventional sesame. Therefore, at least 40% price premium for organic sesame may be required to offset the higher cost of cultivation and low yields under organic production system compared with conventional production system particularly during initial years.

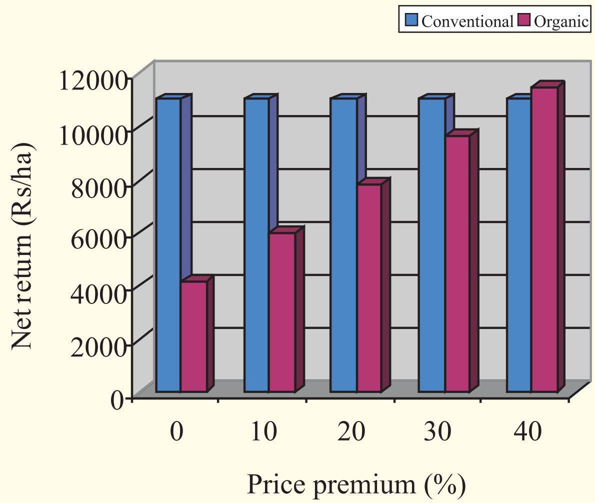

Figure 4. Net return at different price premiums for organic sesame

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Appendix I

Products for Fertilizing and Soil Conditioning

In organic agriculture the maintenance of soil fertility may be achieved through the recycling of organic material whose nutrients are made available to crops through the action of soil micro-organisms and bacteria.

Many of these inputs are restricted for use in organic production. In this appendix "restricted" means that the conditions and the procedure for use shall be set by the certification programme. Factors such as contamination, risk of nutritional imbalances and depletion of natural resources shall be taken into consideration.

Type of input	Status
Matter Produced on an Organic Farm Unit	
• Farmyard & poultry manure, slurry, urine	Permitted
• Crop residues and green manure	Permitted
• Straw and other mulches	Permitted
Matter Produced Outside the Organic Farm Unit	
• Blood meal, meat meal, bone meal and feather meal without Preservatives	Restricted
• Compost made from any carbon based residues (animal excrement including poultry)	Restricted
• Farmyard manure, slurry, urine	Restricted (preferably after control fermentation and / or appropriate dilution) "factory" farming sources not permitted.

Type of input	Status
• Fish and fish products without preservatives	Restricted
• Guano	Restricted
• Human excrement	Not allowed
• By-products from the food and textile industries of biodegradable material of microbial, plant or animal origin without any synthetic additives	Restricted
• Peat without synthetic additives (prohibited for soil conditioning)	Permitted
• Sawdust, wood shavings, wood provided it comes from untreated wood	Restricted
• Seaweed and seaweed products obtained by physical processes, extraction with water or aqueous acid and/or alkaline solution	Restricted
• Sewage sludge and urban composts from separated sources which are monitored for contamination	Restricted
• Straw	Restricted
• Vermicasts	Restricted
• Animal charcol	Restricted
• Compost from organic household reference	Restricted
• Compost from plant residues	Permitted
• By products from oil palm, coconut and cocoa	Restricted
• By products of industries processing ingredients from organic agriculture	Restricted

Type of input	Status
Minerals	
• Basic slag	Restricted
• Calcareous and magnesium rock	Restricted
• Calcified seaweed	Permitted
• Calcium chloride	Permitted
• Calcium carbonate of network origin (chalk, limestone, gypsum and phosphate chalk)	Permitted
• Mineral potassium with low chlorine content (e.g. sulphate of potash, kainite, sylvinite)	Restricted
• Natural phosphates (e.g. Rock phosphates)	Restricted
• Sodium chloride	Permitted
• Trace elements (baron, In, Fe, Mn, molybolerum, Zn)	Restricted
• Wood ash from untreated wood	Restricted
• Potassium sulphate	Restricted
• Magnesium sulphate (Epson salt)	Permitted
• Gypsum (calcium sulphate)	Permitted
• Aluminum calcium phosphate	Restricted
• Sulphur	Restricted
• Clay (bentonite, perlite, zeolite)	Permitted
Microbiological Preparations	
• Bacterial preparations (biofertilizers)	Permitted
• Biodynamic preparations	Permitted
• Plant preparations and botanical extracts	Permitted
• Vermiculite	Permitted
• Peat	Permitted

Appendix II

Products for Plant Pest and Disease Control

Certain products are allowed for use in organic agriculture for the control of pests and diseases in plant production. Many of these products are restricted for use in organic production. Such products should only be used when absolutely necessary and should be chosen taking the environmental impact into consideration.

In this appendix "restricted" means that the conditions and the procedure for use shall be set by the certification programme.

Type of input	Status
Substances from plant and animal origin	
Azadirachta indica [neem preparations (neem oil)]	Restricted
Preparation of rotenone from *Derris elliptica, Lonchocarpus, Thephrosia spp.*	Restricted
Gelatine	Permitted
Propolis	Restricted
Plant based extracts (e.g. neem, garlic, pongamia, etc.)	Permitted
Preparation on basis of pyrethrins extracted from *Chrysanthemum cinerariaefolium,* containing possibly a synergist *pyrethrum cinerafolium*	Restricted
Preparation from *Quassia amara*	Restricted
Release of parasite predators of insect pests	Restricted
Preparation from *Ryania* species	Restricted
Tobacco tea	Not allowed
Lecithin	Restricted
Casein	Permitted

Type of input	Status
Sea weeds, sea weed meal, sea weed extracts, sea salt and salty water	Restricted
Extract from mushroom (Shiitake fungus)	Permitted
Extract from *Chlorella*	Permitted
Fermented product from *Aspergillus*	Restricted
Natural acids (vinegar)	Restricted
Minerals	
Chloride of lime/soda	Restricted
Clay (e.g. bentonite, perlite, vermiculite, zeolite)	Permitted
Copper salts / inorganic salts (Bordeaux mix, copper hydroxide, copper oxychloride) used as a fungicide, maximum **8 kg per ha per year** depending upon the crop and under the supervision of inspection and certification agency	Restricted
Mineral powders (stone meal, silicates)	Not allowed
Diatomaceous earth	Restricted
Light mineral oils	Restricted
Permanganate of potash	Restricted
Lime sulphur (calcium polysulphide)	Restricted
Silicates (sodium silicate, quartz)	Restricted
Sodium bicarbonate	Permitted
Sulphur (as a fungicide, acaricide, repellent)	Restricted
Microorganisms / Biocontrol agents	
Viral preparations (e.g., Granulosis viruses, Nuclear polyhydrosis viruses etc.).	Permitted
Fungal preparations (e.g., *Trichoderma* species etc.)	Permitted

Type of input	Status
Bacterial preparations (e.g., *Bacillus* species etc.)	Permitted
Parasites, predators and sterilized insects.	Permitted
Others	
Carbon dioxide and nitrogen gas	Restricted
Soft soap (potassium soap)	Permitted
Ethyl alcohol	Not allowed
Homeopathic and Ayurvedic preparations	Permitted
Herbal and biodynamic preparations	Permitted
Traps	
Physical methods (e.g., chromatic traps, mechanical traps, light traps, sticky traps and pheromones)	Permitted
Mulches, nets	Permitted

Appendix III

Accreditation and Certification Agencies in India

Accreditation means Registration by the National Accreditation Body for certifying organic farms, products and processes as per the National Standards for Organic Products and as per the guidelines of the National Accreditation Policy and Programme for organic products. The National Steering Committee for National Programme for Organic Production (NPOP) members are drawn from Ministry of Commerce and Industry, Ministry of Agriculture, Agricultural and Processed Food Products Export Development Authority (APEDA), Coffee Board, Spices Board and Tea Board and other government and private organizations associated with the organic movement. The National Steering Committee would also function as the National Accreditation Body (NAB).

As per the national accreditation policy under the NPOP being implemented by the Government of India through the Ministry of Commerce, all the certifying agencies operating in the country have to obtain accreditation from NAB.

List of Accredited Certification Bodies under NPOP

Sr. No	Name of the Certification Agency	Contact Person & Address	Scope of Accredi-tation	Certification Mark
1	**Bureau Veritas Certification India Pvt. Ltd., Mumbai**	**Contact Person:** Mr. R. K. Sharma, Director **Address:** Marwah Centre, 6th Floor, Opp. Ansa Industrial Estate Krishanlal Marwah Marg, Off Saki-Vihar Road, Andheri (East), Mumbai-400 072 (Maharashtra) Tel. : 022-66956300, 56956311; Fax : 022-66956302/10 Email : scsinfo@in.bureauveritas.com	NPOP USDA NOP	Organic Farming BUREAU VERITAS Certification

Sr. No	Name of the Certification Agency	Contact Person & Address	Scope of Accredi-tation	Certification Mark
2	**ECOCERT India Pvt. Ltd., Aurangabad**	**Contact Person:** Dr. Selvam Daniel, Country Representative **Address:** Sector-3, S-6/3 & 4, Gut No. 102, Hindustan Awas Ltd. Walmi-Waluj Rd, Nakshatrawadi Aurangabad-431 002 (Maharashtra) Tel. : 0240-2377120, 2376949; Fax No.: 0240-2376866 Email: ecocert@sancharnet.in	NPOP USDA NOP	ECO CERT®
3	**IMO Control Pvt. Ltd.**	**Contact Person:** Mr. Umesh Chandrasekhar, Director **Address:** No. 3627, 1st Floor, 7th Cross, 13th ' G ' Main, H.A.L. 2nd Stage, Bangalore-560 008. Tel. : +91-80-25285883, 25201546, 25215780; Fax: 0091-80-25272185 Email: imoind@vsnl.com	NPOP USDA NOP	control IMO
4	**Indian Organic Certification Agency (INDOCERT)**	**Contact Person:** Mr. Mathew Sebastian, Executive Director **Address:** Thottumugham, P.O. Aluva-683 105, Cochin (Kerala) Telefax: 0484-2630908-09/2620943 Email: info@indocert.org	NPOP USDA NOP	INDOCERT®
5	**Lacon Quality Certification Pvt. Ltd., Thiruvalla (Kerala)**	**Contact Person:** Mr. Bobby Issac, Director **Address:** Chenathra, Theepany, Thiruvalla - 689 101 (Kerala) Tel. 0469 2606447; Fax: 0469 2631902 Email: info@laconindia.com	NPOP USDA NOP	lacon QUALITY

Sr. No	Name of the Certification Agency	Contact Person & Address	Scope of Accredi-tation	Certification Mark
6	**Natural Organic Certification Agency (NOCA), Pune**	**Contact Person:** Mr. Sanjay Deshmukh, Chief Executive Officer **Address:** Row House Banglow No-2, E-10 Bldg. Sun Empire, Survey No. 7, 9 (Part), Vadgaon- Budruk, Sinhgad Road, Pune-411051 Mobile : 9822006586 / 9822148609 Tel. : +91-20-65218063; Fax : +91-20-25457869 E-mail: nocaindia@gmail.com	NPOP USDA NOP	
7	**OneCert Asia Agri Certification Pvt. Ltd., Jaipur**	**Contact Person:** Mr. Sandeep Bhargava, Chief Executive Officer **Address:** Plot No. 8, Pratap Nagar Colony, (Near glass factory & Gopalpura bypass), Tonk Road, Jaipur - 302017 (Rajasthan) Telefax No: 0141-2701882 Email: info@onecertasia.in	NPOP USDA NOP	
8	**SGS India Pvt. Ltd.**	**Contact Person:** Dr. Manish Pande, Head-Food Services **Address:** 250 Udyog Vihar, Phase - IV, Gurgaon - 122 015 (Haryana) Tel. : +91-124-2399990; Mobile No: +91-9871794640 Fax No.: +91-124-2399764 Email: manish.pande@sgs.com	NPOP USDA NOP	

Sr. No	Name of the Certification Agency	Contact Person & Address	Scope of Accredi-tation	Certification Mark
9	**Control Union Certifications, Mumbai**	**Contact Person:** Mr. Dirk Teichert, Managing Director **Address:** "Summer Ville", 8th Floor; 33rd - 14th Road Junction Off Linking Road, Khar (West) Mumbai - 400052 (Maharasthra) Tel. : 022-67255396/97/98/99; Fax: 022-67255394/95 Email: cuc@controlunion.in cucindia@controlunion.com controlunion@vsnl.com	NPOP USDA NOP	
10	**Uttarakhand State Organic Certification Agency (USOCA)**	**Contact Person:** Sh. Chandan Singh Mehra, Director **Address:** 12/II Vasant Vihar, Dehradun-248 006, (Uttarakhand) Tel: 0135-2760861; Fax:0135-2760734 Email: uss_opca@rediffmail.com ua_usoca@yahoo.co.in	NPOP USDA NOP	
11	**APOF Organic Certification Agency (AOCA)**	**Contact Person :** Mr. K. Dorairaj, Chief Operating Officer **Address:** 126, 1st Floor, Govindappa Road, Off D.V.G. Road, Gandhi Bazar, Bangalore-560 004 (Karnataka) Tel: +91-80-26677275, 41203848 Mobile: 09342349255 / 09886019021 Email: aocabangalore@yahoo.co.in	NPOP	
12	**Rajasthan Organic Certification Agency (ROCA)**	**Contact Person:** Mr. Yashpal Mahawat, Director **Address:** 3rd Floor, Pant Krishi Bhawan, Janpath, Jaipur 302 005 (Rajasthan) Tel. No.: 0141-2227104, Tele Fax: 0141-2227456 Email: rocajpr.cb@gmail.com	NPOP	

Sr. No	Name of the Certification Agency	Contact Person & Address	Scope of Accredi-tation	Certification Mark
13	**Vedic Organic Certification Agency**	**Contact Person:** Dr. (Mrs.) M.Usha, Managing Director **Address:** Plot No. 55, Ushodaya Enclave, Mythrinagar, Miyanagar, Hyderabad - 500 050 Mobile : 09290450666, Tel. : 040-65276784 Fax: 040-23045338 Email: voca_org@yahoo.com; usha_preetham@yahoo.co.in	NPOP	
14	**ISCOP (Indian Society for Certification of Organic Products)**	**Contact Person:** Prof: Dr.K.K.Krishnamurthi, President **Address:** Rasi building, 162/163, Ponnaiyarajapuram Coimbatore - 641 001, Tamil Nadu Mob. No.: 094432 43119 Tel. : 0422-2544199; 0422-6586060 E-mail: iscop_cbe@yahoo.in; profdrkkk@yahoo.com	NPOP	
15	**Food Cert India Pvt. Ltd**	**Contact person:** Mr. Srihari Kotela, Director **Address:** Quality House, H. No. 8- 2- 601/P/6, Road No. 10, Banjara Hills, Panchavati Cly, Hyderabad-500 034 Tel. No.: +91- 40-23301618, 23301554, 23301582 Fax: +91-40-23301583 Email: foodcert@foodcert.in	NPOP	
16	**Aditi Organic Certifications Pvt. Ltd**	**Contact person:** Narayana Upadhyaya, Director **Address:** Aditi Organic Certifications Pvt. Ltd. No. 531/A, Priya Chambers, Dr. Rajkumar Road, Rajajinagar, 1st Block, Bangalore - 560010 Tel.: +91-80-32537879; Fax: +91-80-23373083 Mobile: +91-9845064286 Email: aditiorganic@gmail.com	NPOP NOP (w.e.f 1-6-2010)	

Sr. No	Name of the Certification Agency	Contact Person & Address	Scope of Accredi-tation	Certification Mark
17	**Chhattisgarh Certification Society, India (CGCERT), Raipur**	**Contact person:** Shri A.K. Singh (IFS), Chief Executive Officer **Address:** A-25, VIP Estate, Khamhardih, Shankar Nagar, Raipur-492007, Chhattisgarh Telefax: +91-771-2283249. Email: cgcert@gmail.com	NPOP	
18	**Tamil Nadu Organic Certification Department (TNOCD), Coimbatore**	**Contact person:** Shri A. Karmugilan, Director (Organic Certification) **Address:** 1424 A, Thadagam Road, Coimbatore-641013, Tamil Nadu (India) Tel.: +91-422-2405080, Fax: +91-422-2457554. Email: tnocd@yahoo.co.in	NPOP	
19	**Intertek India Pvt. Ltd.**	**Contact Person:** Mr. Ashis Gaur, Head - Certification (Food Services) **Address:** E-20, Block B-1, Mohan Cooperative Industrial Estate, Mathura Road, New Delhi-110 044 Ph : +91-11-4159 5420/ +91 9899461610 Fax : +91-11-4159 5475 E-mail : ashish.gaur@intertek.com	NPOP	
20	**TUV India Pvt. Ltd.**	**Contact Person:** Mr. Anil Rairikar, Managing Director **Address:** 801, Raheja Plaaza - 1, L.B.S. Marg, Ghatkopar (West) Mumbai - 400 086 (Maharashtra) Ph : 022-66477000; Fax : 022-66477009 Email : mumbai@tuv-nord.com Website : www.tuvindia.co.in	NPOP	

Source : Accredited inspection and certification agencies. Accessed at http://apeda.com/apedawebsite/organic/NPOP_certification_bodies.doc on 25 November, 2010.

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