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Effect of Organic Management on Agronomic and Economic Performance of Sesame and on Soil Properties

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ABSTRACT: 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. During the initial three years, organic sesame yield was about 20% less compared to conventional farming. However, in the fourth and fifth year, the grain yield reduction under organic farming was 7.7 and 7%, respectively compared with conventional farming. However, the soil organic C, P, K, micronutrients, dehydrogenase activity and soil microbial biomass carbon were higher in the plots under farming. The incidence of major insect-pests and diseases were similar under both organic and conventional farming except that the pod borer incidence was high in organic sesame. The cost of cultivation of sesame was ₹ 10800 and 14050 ha^{-1} under conventional and organic farming, respectively. 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.

Key words: Organic farming, sesame, productivity, economics

Organic agriculture is one of the fastest growing sectors of agricultural production. The Government of India task force on organic farming and several other reviewers have identified rainfed areas as more suitable for organic farming in view of the low use of external inputs. 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 (Venkateswarlu, 2008). 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 M ha with a production of 0.65 million tons and productivity of about 350 kg ha^{-1}. 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. Hence, it is necessary to explore the possibility of enhancing the productivity and export of sesame through organic farming. Nutrient management is one of the most critical management areas for organic growers. Because synthetic inputs (i.e. chemical fertilizers and pesticides) are disallowed in organic crop production, there is need for research on organically approved soil amendments and methods for improving soil fertility in organic farming systems, particularly during initial years. Hence, a field experiment was conducted to assess the yield and quality of sesame, and soil properties under organic vis-à-vis conventional production.

Materials and Methods

A field experiment was conducted at Gunegal Research Farm of the Institute during the rainy season of 2005-2009. 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. The runoff from the plots was directed to the end of each block to assess the effect of different treatments on nutrient loss through runoff. The two treatments i.e. conventional 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^{-1}) and recommended pest management module viz. seed treatment with thiram 3 g kg^{-1} seed; spray of dimethoate 2 ml L^{-1} water for control of thrips/red spider mites; chlorpyriphos 2 ml L^{-1} for pod-fly; monochrotophos 1.6 ml L^{-1} for pod borer; COC 3 g L^{-1} for stem/root rot, mancozeb 1 g L^{-1} for *Alternaria* leaf spot, removal of plants for phyllody and sulfur dust 3 g L^{-1} for control of powdery mildew. The organic system included application of FYM 3.7 t ha^{-1} + neem cake 900 kg ha^{-1} + ash 75 kg ha^{-1} + bone meal 75 kg ha^{-1} + elemental sulphur (ELS) 20 kg ha^{-1} + PSB 5 kg ha^{-1} (soil application) + *Azotobactor* 5 kg ha^{-1}, 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 average nutrient contents of organic amendments used in the experiment are given in Table 1.

Sesame (cv. Swetha) was sown during second fortnight of June to first fortnight of July depending upon the onset of monsoon in each year, as per recommended seed rate and spacing. The organic manures were applied 2-3 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. The crop received a total of 850 mm rainfall during the crop season in 2005, 357 mm in 2006, 573 mm in 2007, 337 mm in 2008 and 384 mm in 2009. The rainfall was low with prolonged dry spells during 2006 and 2009.

Table 1 : Nutrient contents (%) of organic amendments used in the experiment

Organic amendment	N	P	K
Farmyard manure	0.65	0.34	0.58
Neem cake	4.25	1.10	1.37
Bone meal	3.00	21.24	-
Ash	0.20	0.17	2.28

Soil samples were collected from the surface layer (0-15 cm) of all the plots before treatment applications and immediately after sesame harvest in 2009. Soil analysis was done as per standard procedures to estimate the impact of organic management on different chemical and biological properties of soil. Economics of sesame cultivation, as influenced by organic and conventional management, were calculated based on the prevailing cost of input/operations and price of produce. 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.

Results and Discussion

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.

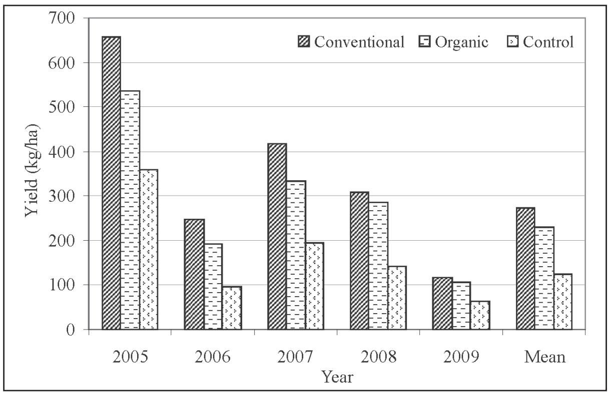

Fig. 1: Yield of sesame under different production systems across five years

Lower seed yields in the plots under organic management may have been associated with the less 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 (Reider *et al*., 2000) and slower release rates of organic materials (Liebhardt *et al*., 1989; MacRae *et al*., 1993). On contrary, Duhoon *et al*. (2004) recorded similar grain yields of sesame under organic and conventional farming. 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

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.

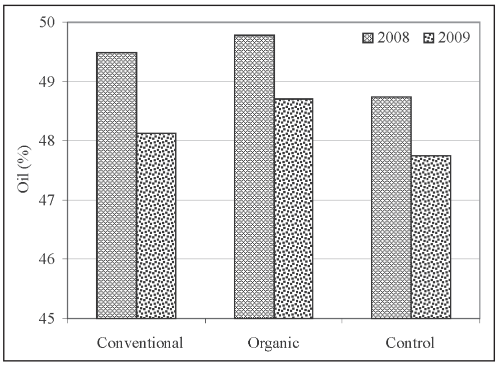

Fig. 2 : Oil content of sesame grown under different production systems

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

Organic cultivation of sesame resulted in the buildup of soil organic C (0.71%) as compared to conventional (0.63%) and control (0.53%) treatments (Table 3). Depending on soil type, climate, management, and the capacity of a soil to store organic matter, soil organic C levels may increase linearly with the amount of organic matter input (Carter, 2002). During the conversion years from conventional to organic farming systems, soils show a very slow but important increase in soil organic matter (Clark *et al*., 1998).

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^{-1})	29.5	30.7	28.3	28.9
Available K (kg ha^{-1})	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^{-1} h^{-1})	12.31	14.79	9.69	-
SMBC* (µg g^{-1})	249.08	460.96	74.26	-

*Soil microbial biomass carbon

The available P and K contents were also higher in the plots under organic management than those under conventional and control treatments. 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. There is growing evidence that soil biological parameters may be potential and sensitive indicators of soil ecological conditions and soil management. The soil microbial properties such as dehydrogenase activity and soil microbial biomass carbon were higher in the plots under organic management than other treatments. Gopinath *et al.* (2009) also reported beneficial effects of organic management on soil microbial properties.

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. The population of natural enemies like coccinellids was comparatively higher under organic management.

Economics

The cost of cultivation of sesame was ₹ 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. 3).

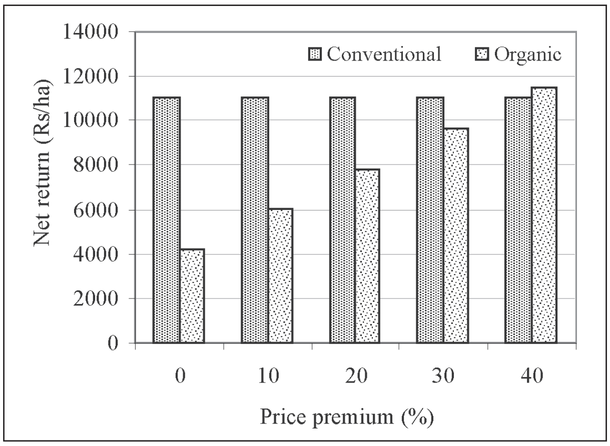

Fig. 3: Net return at different price premiums for organic sesame

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.

Conclusions

The comparison of organic and conventional production of sesame under rainfed conditions revealed that there was 16.6% reduction in sesame yield under organic management. However, organic management improved soil properties in terms of soil organic C, available nutrients and microbial activities. 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.

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