# Effect of organic and inorganic nutrient management on productivity, cost economics and energy use efficiency in sesame


## Abstract

Field experiments were carried out to assess the soil physicochemical properties, yield, quality, energy use and profit analysis of sesame and under organic *vis-à-vis* conventional production systems for three consecutive seasons. The soil organic C, available N, P, K and micronutrients recorded a slight rise in the organic production system over three seasons. The mean total energy input expended in the production of sesame using organic inputs was much lower (3,586.9 MJ ha$^{-1}$) compared to that with inorganic fertilizers (5,156.3 MJ ha$^{-1}$). Manures/Fertilizers and diesel inputs dominated the total energy inputs for both the production systems. However, the energy output obtained was higher in the inorganic production system (12,000 MJ) than in organic production system (9,375 MJ). The cost of cultivation of sesame was Rs. 12807 ha$^{-1}$ and Rs. 16413 ha$^{-1}$ under inorganic and organic farming, respectively. Organic sesame yield was about 22 per cent less compared to inorganic production system. 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 inorganic production system especially during initial years. Renewable energy input utilization was higher (66 %) in organic than in inorganic production systems (13%). Energy efficiency and productivity was higher in organic than inorganic sesame production system by 12 per cent and 10 per cent, respectively. Since, the organic production system is more energy efficient and it is recommended that sesame production under organic farming should be encouraged for environmental and economic sustainability.


**Key words:** Sesame. Organic farming, Soil properties, Yield, Economics, Energy efficiency


## Introduction

"Sesamum (*Sesamum indicum* L.) is one of the oldest and most traditional oilseed crops, valued for its high quality seed oil. Seeds of sesame is a rich source of protein and edible oil which is 20 per cent and 50 per cent, respectively and also contain a high amount of saturated fatty acids (47% oleic acid and 39% linolenic acid) and due to presence of some natural antioxidants such as sesamoline, sesamin and sesamol, sesame oil has very good stability" (Moazzami *et al*. 2006). "Sesame oil is a known dietary source having high nutraceutical value" (Gauthaman and Mohamed saleem, 2009). "The oil of sesame is used for cooking, baking, candy making, soaps and as alternative medicine" (Kafiriti and Deckers, 2001). "The sesame oil cake is a very good for cattle feed since it contains 32 per cent crude protein of high biological value" (Alam *et al.*, 2007). "Sesame is drought resistant crop, which can be easily grown under rainfed conditions. India is the world's leading producer of sesame with largest cultivated area of about 1.79 m ha (45% of the world cultivation area) and the total production is 8.02 lakh tones with the productivity of 448 kg $ha^{-1}$. In India sesame is cultivated in the states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu and Orissa and Karnataka. In Andhra Pradesh, it is cultivated in an area of 0.61 lakh hectares with a production of 0.2 lakh tonnes and productivity of 321 kg $ha^{-1}$" (Anonymous, 2017). "The modernization of agriculture resulted into the extensive use of chemical fertilizers, indiscriminate use of pesticides, development of pesticide/herbicide resistance, pesticide residue in produce and disruption and degradation of agro-ecosystems. Excessive use of agro-chemicals increases pollution, decreases soil productivity and leads to nutrient imbalance" (Verma *et al.*, 2020).

"Organic farming, which is considered alternative agriculture, provides quality and safe products and benefits the environment (Willer and Lernoud, 2019) because, in organic farming, the use of chemical fertilizers and artificial pesticides is prohibited". "Organic agriculture is one of the fastest growing sectors of agricultural production. In this regard, soil remediation with green manure, animal manure, compost, and pest control with natural methods (biological extracts) are the main operations" (Suddhiyam *et al.*, 2009; Atkinson and Christine, 2019). "Organic fertilizers have also been reported to greatly improve water holding capacity, soil aeration, soil structure, nutrient retention and microbial activity" (Anonymous, 2007). "Popularizing use of organics to reduce the dependence on chemical fertilizers and to contribute to pollution free environment is the greatest need of the hour. 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). Therefore, it is essential to investigate the prospect of increasing sesame production and export through organic cultivation. One of the most important management areas for organic crops is nutrient control. Therefore, there is a need for study on techniques for enhancing soil fertility in organic farming systems, particularly in the early years. Therefore, this experiment was conducted to investigate the soil physicochemical properties as well as soil nutrient status, sesame yield, quality, energy use and profit analysis under organic vis-à-vis inorganic production systems.

**Materials and Methods**

A field study was carried out at Agricultural Research Station, Yellamanchili in Visakhapatnam district of Andhra Pradesh, India during *rabi* 2016-17, *kharif* 2017-18 and *rabi* 2017-18. The site is located at 17.5701° N latitude and 82.8499° E longitude with an altitude of 23.0 m above mean sea level. The experiment was laid out in 2 blocks *i.e.* organic and inorganic with a buffer zone between the blocks. The two treatments *i.e.* inorganic 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 inorganic system included application of recommended dose of chemical fertilizers (40:20:20 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 2.5 ml L$^{-1}$ for pod-fly; monochrotophos 1.6 ml L$^{-1}$ for pod borer; copper oxychloride 3 ml L$^{-1}$ for stem/root rot, mancozeb 3 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 seed treatment with *Trichoderma viridae* @ 10 g kg$^{-1}$ seed, basal application of 10 t ha$^{-1}$ FYM + *Trichoderma viridae* (2 kg 20 kg$^{-1}$ FYM) + Azospirillum (2 kg 100 kg$^{-1}$ FYM); Top dressing of Neem cake at 20 & 40 DAS @ 100 kg acre$^{-1}$ in each split, Application of Jeevamrut (3 %) @ 30 & 50 DAS, and pest management with *Trichoderma* (0.4%) seed treatment and neem oil spray @ 5 ml L$^{-1}$ thrice at 15, 30 and 45 DAS. The average nutrient contents of organic amendments used in the experiment are given in Table 1.

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

| Organic amendment | N | P | K |
|---|---|---|---|
| FYM | 0.5 | 0.2 | 0.5 |
| Neem cake | 3.0 | 0.5 | 0.7 |

Sesame cv. YLM-66 was sown @ 5 Kg seeds/ha with a spacing of 30 cm between the rows and 10 cm between the plants. Thinning of and gap filling was done 7 days after sowing. 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. Recommended doses of 40 kg N + 20 kg $P_20_5$ + 20 kg $K_2O$/ha was given through urea (46% N), single super phosphate (16% $P_20_5$) and muriate of potash (60% $K_20$) to the sesame crop. Half of the total nitrogen was applied at the time of sowing and rest of nitrogen was top dressed at 30 days after sowing. Full dose of $P_2O_5$ and $K_2O$ was given at the time of sowing. Recommended agronomic practices and plant protection measures were followed to maintain a good crop. Observations on growth, yield attributes and seed yield were recorded at the time of harvest. Soil samples were collected from the surface layer (0- 15 cm) of all the plots before treatment applications and immediately after sesame harvest in both the years. Soil analysis was done as per standard procedures to estimate the impact of organic management on different physicochemical properties of soil. Seed oil content (%) was determined by using Soxhlet method and seed protein content was determined by using Khejdal method (% protein = %

nitrogen in seed × 6.25). Seed oil yield (kg $ha^{-1}$) and protein yield (kg $ha^{-1}$) were calculated by multiplying oil and protein percentage with seed yield per ha. Economics of sesame cultivation, as influenced by organic and inorganic 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 inorganic practice.

The energy equivalent of inputs and output of sesame production using organic and inorganic production systems were derived from the following sources (Table 2).

**Table 2. Energy equivalent of inputs and output in agricultural production**

| Variables | Unit | Energy equivalent (MJ $unit^{-1}$) | References |
|---|---|---|---|
| Labour | (h) | 01.96 | Erdal *et al*., 2007; Akpinar *et al*., 2009 |
| Machinery | (h) | 62.70 | Erdal *et al*., 2007; Akpinar *et al*., 2009 |
| Pesticides | (Lt) | 10.00 | Abubakar and Ahmed, 2010 |
| Manure | (kg) | 0.30 | Hatirli *et al*., 2006; Erdal *et al*., 2007 |
| Diesel oil | (Lt) | 56.31 | Erdal *et al*., 2007; Akpinar *et al*., 2009 |
| Sesame seed | (kg) | 15.2 | Akpinar *et al*., 2009 |
| Sesame yield | (kg) | 25.0 | Akpinar *et al*., 2009 |
| Fertilizer | | | |
| N | (kg) | 66.14 | Hatirli *et al.* (2006); Erdal *et al.* (2007) |
| P | (kg) | 12.44 | |
| K | (kg) | 11.5 | |

According to Hatirli *et al*. (2006) and Erdal *et al*. (2007), the energy equivalent of a unit of elemental N, P and K was 66.14, 12.44 and 11.5 MJ $kg^{-1}$, respectively.

Energy use efficiency and energy productivity were estimated as follows:

$$\text{Energy efficiency} = \frac{\text{Energy output (MJ ha}^{-1}\text{)}}{\text{Energy inputs (MJ ha}^{-1}\text{)}}$$

$$\text{Energy productivity} = \frac{\text{Output of sesame (kg ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}}$$

## Results and Discussion

The data regarding growth, yield attributes and yield of sesame are presented in Table 3. The higher plant height ( 112 cm) , maximum number of branches plant$^{-1}$ (4.8), number of capsules per plant ( 97.4) and test weight (3.0 g ) was recorded under inorganic farming than under organic farming during three consecutive seasons of experimentation. This might be due to the quick release and increased availability of nutrients as compared to organic sources of nutrients. Similar results were also obtained by Verma *et al*. (2013); Deshmukh M R and Duhoon S S (2008); Imayavaramban *et al*. (2002).

**Yield of sesame**

The seed yields were higher under inorganic farming (530 kg ha$^{-1}$, 324 kg ha$^{-1}$ and 586 kg ha$^{-1}$, respectively) than under organic farming (420 kg ha$^{-1}$, 262 kg ha$^{-1}$ and 443 kg ha$^{-1}$, respectively during *rabi* 2016-17, *kharif* 2017-18 and *rabi* 2017-18, respectively) in three consecutive seasons (Fig. 1). Organic mean sesame yield (375 kg ha$^{-}$) was about 22 % less compared to inorganic farming (480 kg ha$^{-1}$). "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). The organic mean sesame stover yields are on average 15 % lower than inorganic yield (table 3). However, Duhoon *et al.* (2004) reported that yield levels under organic farming may further improve over the years in sesame.

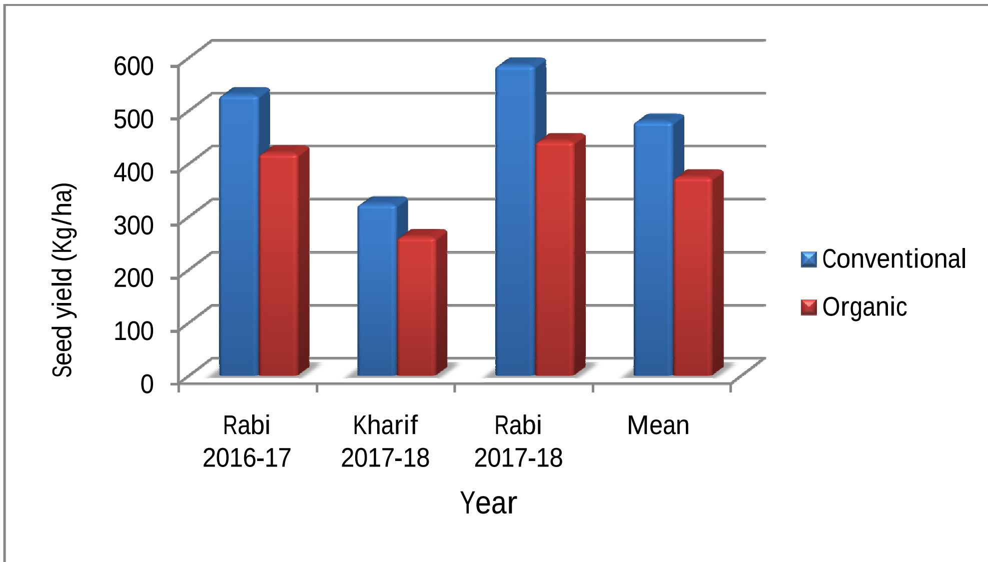


**Fig. 1: Yield of sesame under different productionsystems**

## Quality of sesame oil

The oil (%), oil yield (kg/ha) and protein content of sesame under inorganic and organic farming are presented in Table 4. Organically grown sesame seeds had marginally higher oil content (47.1 % ) compared with inorganic treatment ( 46.1) in three consecutive seasons (Fig. 2). The protein content (%) in sesamum was also found slightly higher under organic farming ( 23.3 %) compared to inorganic management system (22.1%). The results corroborate the findings of Thiruppathi *et al*., (2001) Ghosh *et al*., (2013) and Verma *et al*., (2012).

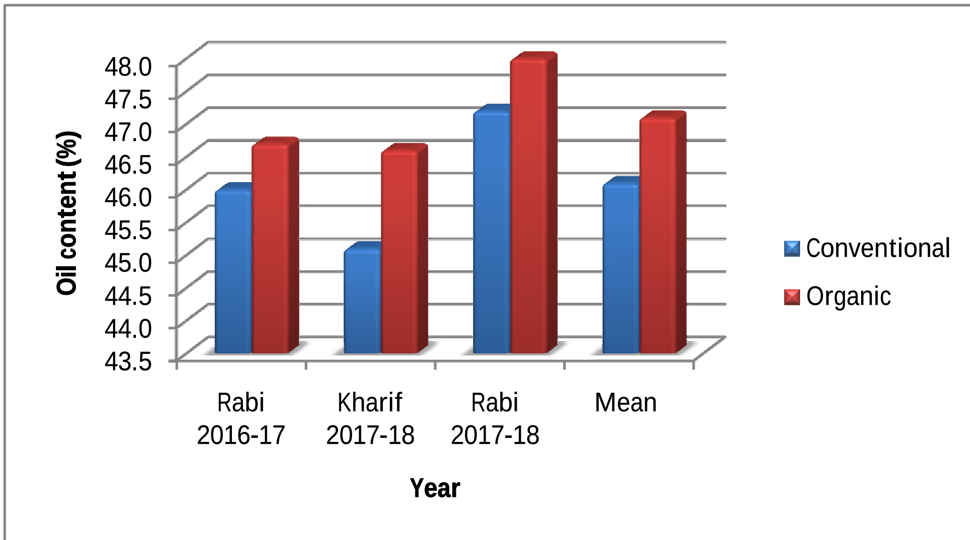


**Fig. 2 : Oil content (%) of sesame grown under different production systems**

## Soil fertility

Organic cultivation of sesame resulted in the buildup of soil organic C (0.34 %) as compared to inorganic (0.25%) treatment (Table 5). "Soil organic C levels may increase linearly with the amount of organic matter input depending on soil type, climate, management, and the capacity of a soil to store organic matter" (Carter, 2002; Clark *et al*., 1998). The available N, P and K contents were also higher under organic management than those under inorganic treatment. Similarly, organically managed plots had higher levels of DTPA- extractable micronutrients (Zn, Cu, Mn and Fe) than inorganic treatments. These results are in line of the findings of Gopinath *et al.* (2011), Deshmukh *et al.* (2002).

## Economics

The cost of cultivation of sesame was Rs. 12807 and Rs. 16413 per hectare under inorganic and organic farming, respectively. Higher cost of cultivation under organic management was mainly due to more input costs particularly for purchase of neem cake. The net return from organic sesame was about 47 % less compared with inorganic production system (Fig. 3). Furthermore, the reduction in net return from organic management was 35, 23 and 12% at 10, 20 and 30% price premium, respectively compared with inorganic management. However, at 40% price premium for organic sesame the net returns from organic sesame was comparable with that of inorganic 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 inorganic production system particularly during initial years.

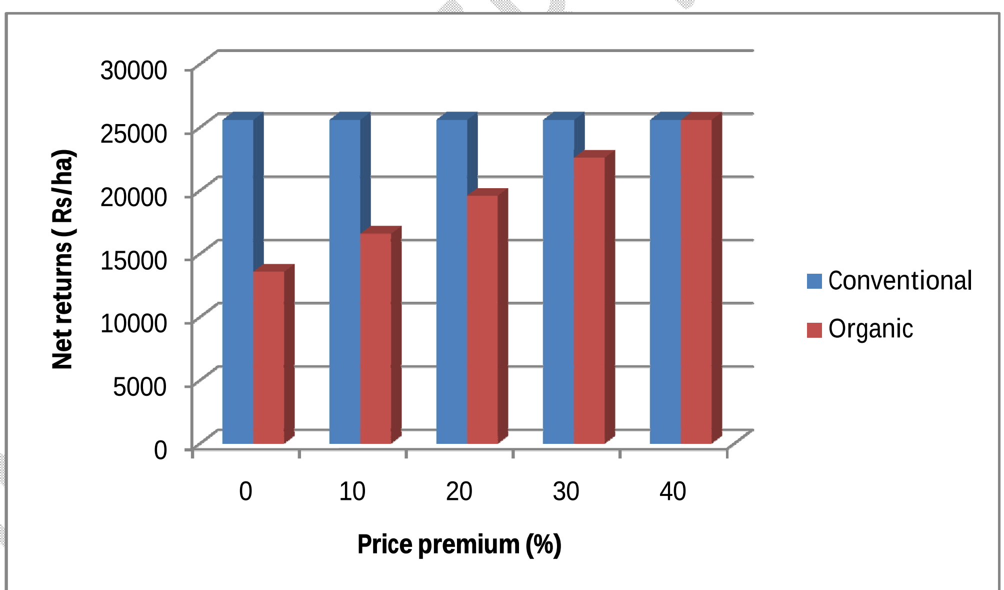


**Fig. 3: Net return at different price premiums for organic sesame**

## Energy inputs and outputs for sesame production

The total energy expenditure, energy use efficiency & productivity of sesame under organic and inorganic production system are shown in Tables 7 and 8. A total of 3,586.9 MJ of energy input was used in production per hectare for organic sesame, against 5,156.3 MJ for the inorganic system. This shows that energy input required in production of sesame under inorganic production system is higher by 30 % than under organic farming. Manures/fertilizers and diesel constituted major sources of energy inputs for both production systems (organic and inorganic) as they contributed 46, 28, and 60, 22 % of total energy inputs, respectively.

The amount of labour energy input used for routine practices (seed planting, fertiliser application, spraying of pesticides and weeding), accounted for the dominant share (36 and 31%) in the total labour energy input used in organic and in inorganic production systems, respectively.

Energy output of sesame production per hectare under organic and inorganic production systems were 9,375 and 12,000 MJ, respectively. This shows an increase of 28 % over energy output from organic sesame production system.

The energy output/input ratio (energy efficiency) for sesame production per hectare under organic farming was 2.6, against 2.3 for inorganic sesame. Energy productivities were 0.10 and 0.09 kg MJ $ha^{-1}$ of sesame production under organic and inorganic production system. This implies that sesame production under organic farming is more energy efficient (12%) and productive (10 %) than under inorganic production system. Higher energy efficiency of sesame grown under organic farming was also reported by Mendoza (2002).

**Energy input in form of renewable and non-renewable.**

The total energy input in form of direct, indirect, renewable and non- renewable used in production of sesame under organic and inorganic production system were shown in Table 9. The direct energy sources were human and diesel oil; while indirect sources of energy were machinery, manure, pesticides, NPK and sesame seed. Human, manure and sesame seed were sources of renewable energy, while machinery, pesticides, NPK and diesel oil constituted non-renewable sources of energy used in production of sesame in the study. Table 9 shows that the sesame production under organic farming consumed 46 % of direct energy, against 33% for inorganic fertilized sesame. The renewable energy utilization was higher (66%) under organic sesame than those of inorganic production systems (13%). That is, inorganic sesame production system used more (87%) of non renewable energy. This agrees with the findings of Umar and Ibrahim (2012).

## Conclusion

The yield of sesame under organic management decreased by 22% when compared to inorganic production under rainfed circumstances, according to the study. However, organic management enhanced soil characteristics in terms of accessible nutrients and soil organic C. Sesame production using organic fertilizer is more efficient (2.6) and productive (0.10 kg MJ) in terms of energy utilization than inorganic production systems (2.3 and 0.09 kg MJ, respectively). To make up for the greater cultivation costs and lower yields under the organic production system compared to the inorganic production method, particularly in the early years, it may be necessary to charge at least a 40% premium for organic sesame.

Conference disclaimer:

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**Table 3: Growth and yield of sesame as affected by different production systems**

| Treatment | Plant height (cm) | | | | No. of branches / Plant | | | | No. of capsules / Plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean |
| Inorganic | 96.3 | 139.4 | 99.5 | **111.7** | 4.75 | 4.85 | 4.81 | **4.80** | 96.8 | 95.1 | 100.2 | **97.4** |
| Organic | 93.1 | 135.2 | 96.1 | **108.1** | 4.55 | 4.65 | 4.77 | **4.66** | 83.5 | 86.4 | 86.5 | **85.5** |

| Treatment | Test weight (g) | | | | Seed yield (Kg/ha) | | | | Stover yield (Kg/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean |
| Inorganic | 3.0 | 2.6 | 3.4 | **3.0** | 530 | 324 | 586 | **480** | 1773 | 1841 | 1864 | **1826** |
| Organic | 2.1 | 2.0 | 2.4 | **2.2** | 420 | 262 | 443 | **375** | 1448 | 1499 | 1636 | **1528** |

**Table 4: Oil content (%) and Protein content (%) of sesame as affected by different production systems**

| Treatment | Oil content (%) | | | | Oil yield (Kg/ha) | | | | Protein content (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean |
| Inorganic | 46.0 | 45.1 | 47.2 | **46.1** | 244 | 146 | 277 | **222** | 22.2 | 22.0 | 22.0 | **22.1** |
| Organic | 46.7 | 46.6 | 48.0 | **47.1** | 196 | 122 | 213 | **177** | 23.1 | 23.2 | 23.6 | **23.3** |

**Table 5 : Soil properties under different production systems after two years of experimentation**

| S.No | Soil property | Inorganic | Organic | Initial value | Method |
|---|---|---|---|---|---|
| **1.** | pH | 7.67 | 7.59 | 7.45 | Glass electrode method (Jackson, 1973) |
| **2.** | Organic C (%) | 0.25 | 0.34 | 0.24 | Walkley and Black modified Method (Walkley and Black, 1934) |
| **3.** | Available N (kg $ha^{-1}$) | 178.5 | 225.0 | 175.4 | Alkaline permanganate method (Subbiah and Asija, 1956) |
| **4.** | Available P (kg $ha^{-1}$) | 29.2 | 32.6 | 28.5 | Olsen's method (Olsen *et al.*, 1954) |
| **5.** | Available K (kg $ha^{-1}$) | 96.5 | 108.5 | 92.5 | Neutral normal ammonium acetate |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | method (Muhr *et al.*, 1965) |
| **6.** | DTPA-Zn (ppm) | 0.54 | 0.61 | 0.56 | DTPA extractable method (Lindsay and Norvell, 1978) |
| **7.** | DTPA-Cu (ppm) | 0.17 | 0.22 | 0.20 | |
| **8.** | DTPA-Mn (ppm) | 6.0 | 6.8 | 10.2 | |
| **9.** | DTPA-Fe (ppm) | 17.2 | 18.5 | 20.2 | |

**Table 6: Economics of sesame as affected by different production systems**

| **Treatment** | **Gross returns (Rs./ha)** | | | | **Cost of cultivation (Rs./ha)** | | | | **Net returns (Rs./ha)** | | | | **BC Ratio** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean * | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean | Rabi 2016-17 | Kharif 2017-18 | Rabi 2017-18 | Mean |
| Inorganic* | 42400 | 25920 | 46880 | **38400** | 13090 | 15710 | 13180 | **12807** | 29310 | 13770 | 33700 | **25593** | 2.23 | 1.13 | 2.55 | **1.97** |
| Organic* | 33600 | 20960 | 35440 | **30000** | 16710 | 12150 | 16820 | **16413** | 16890 | 5250 | 18620 | **13587** | 1.01 | 0.33 | 1.11 | **0.82** |
| Organic** | 47040 | 29344 | 49616 | **42000** | 16710 | 15710 | 16820 | **16413** | 30330 | 13634 | 32796 | **25587** | 1.82 | 0.87 | 1.95 | **1.54** |

***** Calculated as per price of sesame: ` Rs. 80 $kg^{-1}$

**At 40 % premium price of sesamum: Rs. 112 $kg^{-1}$

**TABLE 7. Energy input and output for Sesame production under organic farming**

| **Variable** | **Qty $ha^{-1}$** | **Energy equivalent (MJ)** | **%** |
|---|---|---|---|
| **Labour (h)** | | | |
| Land preparation and sowing | 96 | 188.2 | 29 |
| Cultural practices | 120 | 235.2 | 36 |
| Harvesting | 66 | 129.4 | 20 |
| Threshing and bagging | 48 | 94.1 | 15 |
| **Total labour input** | 330 | 646.8 | 100 (18) |
| **Machinery (h)** | | | |
| Tillage | 2.8 | 175.6 | 5 |

| | | | |
|---|---|---|---|
| Organic inputs ( manure) (kg) | 5500 | 1650.0 | 46 |
| Pesticides (lt) | 2.5 | 25.0 | 0.7 |
| Diesel (lt) | 18 | 1013.6 | 28 |
| Sesame seed (kg) | 5 | 76.0 | 2.1 |
| Total energy input (MJ) | | 3586.9 | 100 |
| Yield (kg) | 375 | 9375.0 | |
| Energy output/input ratio | | 2.6 | |
| Energy productivity (kg MJ) | | 0.10 | |

Figure in parenthesis represents percentage share of total labour energy input in the total energy input

**Table 8. Energy input and output for sesame production under inorganic production system**

| Variable | Qty ha-1 | Energy equivalent (MJ) | % |
|---|---|---|---|
| **Human labour (hr)** | | | |
| Land preparation and sowing | 78 | 152.9 | 26 |
| Cultural practices | 96 | 182.3 | 31 |
| Harvesting | 72 | 135.2 | 23 |
| Threshing and bagging | 54 | 113.7 | 19 |
| Total labour input | 300 | 584.1 | 100.0 (11.0) |
| **Machinery (hr)** | | | |
| Tillage | 3 | 175.6 | 3.0 |
| **Inorganic fertilizer** | | | |
| N | 40 | 2645.6 | 51 |
| P | 20 | 248.8 | 4.8 |
| K | 20 | 230 | 4 |
| Pesticides (lt) | 7 | 70 | 1.4 |
| Diesel (lt) | 20 | 1126.2 | 22 |

| | | | |
|---|---|---|---|
| Sesame seed (kg) | 5 | 76 | 1.5 |
| Total energy input (MJ) | | 5,156.3 | 100 |
| Yield (kg) | 480 | 12000.0 | |
| Energy output/input ratio | | 2.3 | |
| Energy productivity (kg MJ) | | 0.09 | |

Figure in parenthesis represents percentage share of total labour energy input in the total energy input

**Table 9. Energy input per hectare in sesame production in organic and inorganic production systems**

| Farm type | Total energy (MJ $ha^{-1}$) | Direct[D] | Indirect[I] | Renewable[R] | Non renewable[N] |
|---|---|---|---|---|---|
| Organic | 3586.9 | 1660.4 (46) | 1926.6 (54) | 2372.8 (66 ) | 1214.1 (34) |
| Inorganic | 5156.3 | 1710.3 ( 33) | 3446.0 (67) | 660.1 (13) | 4496.2 (87) |

[D] = include human and diesel oil ; [I] = include machinery, manure, pesticides, NPK and seed;
[R] = include human, manure and seed [N] = include machinery, pesticides, NPK and diesel oil
Figure in parenthesis represents percentage share of total energy input

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