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Meena N
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

M Mohamed Yassin
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

M Mohamed Amanullah
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Correspondence
Meena N
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Effect of spacing and weed management on the energy budgeting in sunflower

Meena N, M Mohamed Yassin and M Mohamed Amanullah

Abstract
A field experiment was carried out at Tamil Nadu Agricultural University, Coimbatore during kharif 2016-17 to investigate the effect of spacing and weed management on the energy use. The experiment consisted of two factors viz. spacing as horizontal factor and weed management as vertical factor. The experiment was laid out in strip plot design replicated thrice. Five horizontal factors as spacing and five vertical factors as weed management practices were adopted. Among the spacing, the treatment S_4 (90cm×20cm) used higher input energy. The treatment *viz*. W_3 (weeding by power weeder twice) among the weed management practice used higher input energy and S_2 (75cm×25cm) gave higher output energy, net energy, energy use efficiency and energy productivity. Among the weed management practices, high output energy, net energy, energy use efficiency and energy productivity were observed with W_4 (hand weeding twice at 15 DAS and 30 DAS). Specific energy was higher with S_4 (90cm×20cm) and W_5 (weedy check).

Keywords: output energy, input energy, net energy, specific energy, energy productivity

Introduction
Fourteen per cent of the world's oil production demands is met by sunflower crop alone. Sunflower ranks fourth among oilseeds next only to soybean, palm oil and canola. It is an important crop as a source of edible oil which has got more of poly unsaturated fatty acids (PUFA). The demand for sunflower oil in India has increased in recent years due to growing health consciousness and high income level. Consumption of sunflower oil in South India is around 70 per cent and the production is only five percent. One of the causes for low yield in sunflower is the weed growth which competes with the crop for nutrients, water, sunlight and space. Wide row spacing and slow initial growth of sunflower provide enough room for weeds to establish and to take advantage of slower initial growth of the crop. Uncontrolled growth of weeds causes enormous loss of nutrients, which in turn reduces the yield of sunflower up to 64%. The combination of herbicides with mechanical weeding could be effective in controlling major weeds. The herbicide controls weeds in rows whereas mechanical weeding removes weeds in between the rows. Energy budgeting which deals with the distribution of energy use by different spacing and weed management practices is studied in this paper.

Materials and Methods
A field experiment was conducted during *Kharif* season of 2016 to study the effect of spacing and weed management in sunflower on the energy use at Tamil Nadu Agricultural university, Coimbatore. The experiment was laid out with strip plot design and replicated thrice. The treatments comprised of five horizontal factors as plant geometry *viz* S_1(60cm×30cm), S_2(75cm×25cm), S_3(75cm×20cm), S_4(90cm×20cm) and S_5(90cm×15cm), five vertical factors as weed management practices *viz.* W_1(Pre- emergence herbicide Pendimethalin at 1kg per ha followed by hand weeding at 30DAS), W_2(Pre- emergence herbicide Pendimethalin at 1kg per ha followed by weeder at 30 DAS), W_3 (weeder weeded twice at 15DAS and 30DAS), W_4(hand weeding twice at 15DAS and 30DAS) and W_5(weedy check). The soil of the experimental field was sandy clay loam in texture. The sunflower hybrid, TNAU Sunflower Hybrid CO2 was used as test crop. Weed management treatments were imposed as per the schedule. The recommended fertilizer dose followed for sunflower was 90:60:60 kg NPK ha^{-1}. Half dose of N and K and full dose of P were applied basally to all the treatments. The remaining N and K were top dressed at 30 DAS. The required data from the experiment were collected and computed using the method suggested by Devasenapathy *et al.* (2009) [1] and

Kalbande and More (2008) [2]. Formulae for computing different energy indices are given here under.

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

$$\text{Specific Energy} = \frac{\text{Energy input (MJ ha}^{-1})}{\text{Grain yield (kg ha}^{-1})}$$

$$\text{Energy Productivity} = \frac{\text{Output (grain+by product(kg ha}^{-1})}{\text{Energy input(MJ ha}^{-1})}$$

$$\text{Net Energy} = \text{Energy output (MJ ha}^{-1}) - \text{Energy input(MJ ha}^{-1})$$

Table I: Effect of spacing and weed management practices on Energy budgeting of sunflower

Treatment	Input energy (MJ ha^{-1})	Output energy (MJ ha^{-1})	net energy (MJ ha^{-1})	Energy Efficiency (%)	Energy productivity	Specific Energy
S_1	17871	85674	67803	4.80	0.30	13.19
S_2	17871	95128	77257	5.32	0.33	11.53
S_3	17868	91972	74104	5.14	0.32	11.80
S_4	18028	75312	57284	4.17	0.26	14.76
S_5	18025	84165	66140	4.67	0.29	13.23
W_1	17706	98637	80930	5.57	0.35	10.22
W_2	18091	94301	76210	5.21	0.33	11.17
W_3	18477	85937	67460	4.65	0.29	12.88
W_4	17717	104070	86354	5.87	0.37	9.70
W_5	17673	49306	31634	2.79	0.17	20.53

Results and Discussion

Among the spacing levels, high input energy was used by S_4 (18028 MJ ha^{-1}) followed by S_5 (18025 MJ ha^{-1}). Weeding by power weeder twice at 15DAS and 30DAS recorded high input energy (18477 MJ ha^{-1}) followed by by Pre- emergence herbicide Pendimethalin at 1kg per ha followed by power weeder weeded at 30DAS (18091MJ ha^{-1}). Output energy (95128MJ ha^{-1}), Net energy (77257MJ ha^{-1}), Energy efficiency (5.32%) and Energy productivity (0.33) were recorded high with S_2 followed by S_3. Hand weeding twice at 15DAS and 30DAS resulted in higher Output energy (104070MJ ha^{-1}), Net energy (86354MJ ha^{-1}), Energy efficiency (5.87%) and Energy productivity (0.37) followed by the Pre- emergence herbicide Pendimethalin at 1kg per ha followed by hand weeding at 30DAS, Pre- Emergence herbicide Pendimethalin at 1kg per ha followed by weeder weeded at 30DAS.

Specific energy was higher with S_4 (14.76) and weedy check (20.53) due to more energy required for production of 1 kg seed yield. Higher output energy, net energy, energy efficiency and energy productivity due to the higher productivity in the treatment and energy value of seed yield was always higher (Ozturn *et al*.,2006)[3]. Out of all the energy used in the experiment, the value of nonrenewable energy (*i.e* chemical and machinery) was recorded higher than the renewable energy inputs (human labour) used in the experiment. Similar results are reported by Mandal *et al*. (2005) [4] and Baskaran (2013) [5]. With regard to energy use efficiently, among the spacing S_2 and S_3. Weed management practices like two time hand weeding at 15DAS and 30DAS, Pre- Emergence herbicide Pendimethalin at 1kg per ha followed by hand weeding at 30DAS, Pre- Emergence herbicide Pendimethalin at 1kg per ha followed by weeder weeded at 30DAS is found to be most remunerative due to its higher energy consumption and energy production.

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