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Bio-efficacy of propaquizafop herbicide against weeds in sesame (*Sesamum indicum* L.)

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ABSTRACT

A field investigation was carried out for two consecutive **kharif** seasons during 2013 and 2014 at the Research Farm, College of Agriculture, RVSKVV, Gwalior, Madhya Pradesh to study the bio-efficacy of propaquizafop for the control of narrow-leaved weeds in sesame. Experiment consisted of eight treatments viz.,T_1 (Propaquizafop 10% EC @ 50 g a.i./ha PoE), T_2 (Propaquizafop 10% EC @ 62.5 g a. i./ha PoE), T_3 (Propaquizafop 10% EC @ 100 g a. i./ha PoE), T_4 (Propaquizafop 10% EC @ 125 g a. i./ha PoE), T_5 (Quizalofop-p-ethyl 5% EC @ 50 g a. i./ha PoE), T_6 (Fenoxaprop-p-ethyl 9% w/w EC @ 100 g a. i./ha PoE), T_7 (Two hand weedings at 20 and 40 DAS) and T_8 (Weedy check). The experiment was laid out in randomized block design (R. B. D.) with three replications. Propaquizafop and other two herbicides viz., quizalofop-p-ethyl and fenoxaprop-p-ethylwere applied at 2-3 leaf stage of weeds. Among the herbicidal treatments, propaquizafop @ 125 g a. i./ha gave lowest narrow-leaved weed density as well as their dry weight at 75 DAS stage on pooled basis, however, these herbicides were not found effective against broad-leaved weeds. These were observed statistically at par with all the doses of propaquizafop tried under investigation. The highest sesame grain yield (718 kg/ha), oil yield (348 kg/ha),harvest index (18.11%) and net income (₹47339) were recorded with execution of two hand weedings at 20 and 40 DAS (T_7) over rest of the weed control treatments followed by propaquizafop application @ 50 g a. i./ha (T_1). Propaquizafop applied at its higher dose (@125 g a. i./ha) gave excellent control of narrow-leaved weeds but this could not turn into yield due to phytotoxicity caused by it on the crop.

Key words : Bio-efficacy, grain yield, herbicides, sesame, weed density, weed index

INTRODUCTION

Sesame (*Sesamum indicum* L.), popularly known as *til, tilli, gingelly,* etc., is important oilseed crop and belongs to the family Pedaliaceae. It is one of the important edible oilseeds cultivated in India.

It is grown in **kharif** season in Madhya Pradesh during which it faces severe competitional stress from weeds and any other categories of agricultural pests like insects, nematodes, diseases, rodents, etc. For total loss of an agricultural produce from various pests in India, weeds account for 45%, insects 30%, diseases 20% and other pests 5% (Subramanian *et al.*, 1997). Further, it has also been observed that narrow-leaved weeds infest the **kharif** crop severally than broad-leaved weeds in Gird Agro-climatic region of Madhya Pradesh. Such observations were also recorded by Pinto and Fleck (1990) in soybean [*Glycine max* (L.) Merr.] crop, where 31-50% yield reduction by grassy-weeds was recorded. Studies revealed that in India the losses caused by weeds could be in some cases as high as 70-80%. The yield of this crop is also affected by continuous rain water stagnation and diseases. But these problems could be minimized by better soil

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management with adequate drainage, timely sowing and by growing disease resistant variety. Farmers have to be vigilant right from the sowing to at least knee-high stage of the crop to overcome the hazards posed by weeds on the crop.

Severe weed competition is one of the major constraints in lower productivity of sesame. The competitional stress of weeds on crop for nutrients, water, light and space is responsible for poor yield of sesame. Prevalence of high temperature with high relative humidity and frequent rainfall during the crop season coupled with slow plant growth particularly during early crop growth stages favour luxuriant weed growth since seedling emergence which causes about 50-75% reduction in seed yield of sesame (Dungarwal *et al.,* 2003). The period from 15-30 DAS is the most critical period of crop-weed competition in sesame (Venkatakrishan and Gnanamurthy, 1998). Therefore, it is essential to control weeds during the initial growth period.

Though the conventional methods of weed control are very much effective but due to high wages and non-availability of labourers during the critical weeding season (15-30 DAS) and incessant protracted rains, use of post-emergence herbicides could be more time saving, economical and efficient to check early crop-weed competition.

MATERIALS AND METHODS

The field experiment was conducted at the Agronomy Research Farm, College of Agriculture, Gwalior during the **kharif** seasons of the years 2013 and 2014 to evaluate bio-efficacy of propaquizafop for the control of narrow-leaved weeds in sesame. The maximum and minimum temperature during growing period remained as 35.7^{0}C and 20.6^{0}C during 2013 and 37.6^{0}C and 16.5^{0}C during 2014, respectively. The total rainfall received during the rainy season of 2013 and 2014 from June to October was 871.0 and 508.2 mm, respectively. The topography of the field was uniform with proper drainage. The soil of the experimental field was sandy clay loam (60.10% sand, 17.90% silt and 22.00% clay), neutral in reaction (pH 7.5). The soil waslow in organic carbon (0.39%), available nitrogen (180 kg/ha) and medium in available phosphorus (14 kg/ ha) and available potassium (235.2 kg/ha).

The experiment was conducted in randomized block design with three replications and eight treatments. The treatments of weed control included propaquizafop 10% EC (PoE) @ 50 g a. i./ha (T_1), propaquizafop 10% EC (PoE) @ 62.5 g a. i./ha (T_2), propaquizafop 10% EC (PoE) @ 100 g a. i./ha (T_3), propaquizafop 10% EC (PoE) @ 125 g a. i./ha (T_4), quizalofop-p-ethyl 5% EC (PoE) @ 50 g a. i./ha (T_5), fenoxaprop-p-ethyl 9% EC (PoE) @ 100 g a. i./ ha (T_6), two hand weedings at 20 and 40 DAS (T_7) and weedy check (T_8). The herbicides were applied at 20 DAS stage of the crop during 2-3 leaf stage of weeds by using battery operated knap-sack sprayer pump fitted with flat-fan nozzle using water volume of 500 litres per hectare. The seed was treated with carbendazim @ 2 g/kg seed. The sesamevariety 'TKG 22' was sown in planting geometry 30 x 10 cm, behind the hand plough with a seed rate of 5 kg/ha keeping 3-4 cm depth in first and third week of July in 2013 and 2014, respectively. The recommended package of practices was followed to raise the crop. The crop was harvested on 18 and 22 September during 2013 and 2014, respectively. Observations on species-wise densities and dry weight of weeds were recorded at 75 DAS of the crop. Data pertaining to density of narrow-leaved, broad-leaved and total weeds were subjected to square-root and log transformation prior to statistical analysis to draw valid conclusions.

RESULTS AND DISCUSSION

Effect on Weeds

The major weed flora in the experimental field comprised narrow-leaved viz., *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers., *Echinochloa colona* L., *Digitaria longiflora* L. and *Dactylactenium aegyptium* L., etc., and broad-leaved viz., *Parthenium hysterophorus, Commelina benghalensis*, *Alternanthera sessilis, Digera arvensis* and *Celosia argentia* etc.

All weed control treatments significantly reduced the population and dry weight of all narrow-leaved weeds over weedy check (2.01/ m^2 and 111.00 g/m^2, respectively). The significantly lower population (0.97/m^2) and dry weight (3.33 g/m^2) of all narrow-leaved weeds were recorded under treatment T_7 (Two hand weedings at 20 and 40 DAS) over rest of the weed control treatments. The next effective treatment was T_4 (1.42/m^2 and 9.83 g/m^2, respectively) followed by T_3 (1.48/m^2 and 10.50 g/m^2, respectively), which was statistically at par with treatments T_6 (1.50/m^2 and 11.00 g/m^2, respectively).The population and dry weight of all broad-leaved weeds were not reduced significantly by all herbicidal weed control treatments except treatment T_7 (Two hand weedings at 20 and 40 DAS) and gave at par population and dry weight of all broad-leaved weeds with weedy check (1.38/m^2 and 45.33 g/m^2, respectively).

The propaquizafop was not found effective at any dose of application against the broad-leaved weeds. Significantly lowest population and dry weight of all broad-leaved weeds (0.55/m^2 and 5.83 g/m^2, respectively) were noted (Tables 1 and 2) under treatment T_7 (Two hand weedings at 20 and 40 DAS). Similar results were also obtained by Kushwah and Vyas (2006) and Bhadauria *et al.* (2012).

Effect on Crop

All weed control treatments significantly increased the grain yield (kg/ha) and harvest index (%) over weedy check (T_8). The significantly higher grain yield/ha (718 kg) and harvest index (18.11%) were recorded under treatment T_7 (Two hand weedings at 20 and 40 DAS) over rest of the weed control treatments. The next effective treatment was propaquizafop @ 50 g a. i./ha (517 kg/ha and 15.71%, respectively) followed by quizalojop-p-ethyl @ 50 g a. i./ha (495 kg/ha and 15.33%, respectively) and both the treatments were statistically at par with each other (Table 5 and Fig. 1). All these weed control treatments resulted in 74.68 to 208.15% increase in grain yield/ha over weedy check. The unchecked weeds of weedy check plot reduced the grain yield by 67.55%, when compared to grain yield/ha of treatment T_7 (Two hand weedings at 20 and 40 DAS). The increase in yield under different weed control treatments may also be attributed to proper increased availability of congenial micro-environment created by all the weed control treatments to crop for growth and its development. However, almost weed free condition enabled the crop plants to grow vigorously and produced more grain yield/ha and harvest index. The superiority of all weed control treatments over weedy check under increasing grain yield (kg/ha) and harvest index (%) also corroborate the findings of Shete *et al.* (2008) and Benke *et al.* (2012).

Weed Index

Weed index may be termed as the competition index. It indicates the reduction in yield due to weed competition and is represented in percentage yield reduction due to weeds. The treatment T_7 (Two hand weedings at 20 and 40 DAS) recorded lowest weed index (0.00%), whereas in herbicidal treatments, it was recorded lowest in treatment of propaquizafop @ 50 g a. i./ha (27.96%). This might be due to effective control of weeds, which enhance the yield of crop (Table 5 and Fig. 1). Treatments T_5 (31.04%), T_2 (32.47%), T_6 (39.85%), T_3 (40.48%) and T_4 (43.30%) were next in order. Highest weed index was observed under weedy check (67.51%), it may be due to increase in the density, growth and dry matter of weeds. Such findings were also obtained by Kumar *et al.* (2008).

Phytotoxic Effect

The application of propaquizafop @ 125 g a. i./ha, propaquizafop @ 100 g a. i./ha and fenoxaprop-p-ethyl @ 100 g a. i./ha was found more effective for control of weeds over rest of the herbicidal weed control treatments but had phytotoxic effects (Tables 3 and 4) on growth of sesame, viz. chlorosis and AC-Case inhibitor (Inhibition of fatty acid synthesis presumably blocks the production of phospholipids used in building new membranes required for cell growth), respectively, resulting in significantly reduced growth and yield attributes and subsequently significant decrease in yield (Tables 3 and 4). These views were also earlier confirmed by Nadeem *et al.* (2009).

Qualitative Studies

The oil content in grain differed

Table 1. Effect of weed control practices on species-wise narrow-leaf weed population/m^2 and dry weight (g/m^2) at 75 DAS in sesame (Pooled data of two years)

Symbols	Treatments	*C. dactylon*	*C. rotundus*	*D. aegyptium*	*D. longiflora*	*E. colona*	Total narrow-leaf weed population	Total narrow-leaf weed dry weight
T_1	Propaquizafop 10% EC (PoE) @ 50 g a. i./ha	2.47 (6.00)	3.69 (13.72)	1.41 (6.39)	2.49 (6.11)	2.56 (6.39)	1.57 (38.61)	14.78
T_2	Propaquizafop 10% EC (PoE) @ 62.5 g a. i./ha	2.29 (5.17)	3.88 (15.33)	1.36 (6.00)	2.23 (5.06)	2.26 (5.11)	1.55 (36.67)	13.00
T_3	Propaquizafop 10% EC (PoE) @ 100 g a. i./ha	2.19 (4.56)	3.64 (13.45)	1.16 (3.94)	2.17 (4.39)	2.08 (4.00)	1.48 (30.33)	10.50
T_4	Propaquizafop 10% EC (PoE) @ 125 g a. i./ha	1.84 (3.06)	3.54 (12.78)	1.15 (3.56)	2.04 (3.72)	1.94 (3.39)	1.42 (26.50)	9.83
T_5	Quizalofop-p-ethyl 5% EC (PoE) @ 50 g a. i./ha	2.56 (6.56)	3.82 (14.72)	1.47 (6.78)	2.34 (5.61)	2.53 (6.33)	1.58 (40.00)	15.33
T_6	Fenoxaprop-p-ethyl 9% EC (PoE) @ 100 g a. i./ha	2.10 (4.28)	3.67 (13.61)	1.41 (5.00)	2.15 (4.33)	2.26 (4.78)	1.50 (32.00)	11.00
T_7	Two hand weedings at 20 and 40 DAS	1.46 (2.00)	1.74 (3.28)	0.77 (1.67)	1.33 (1.50)	1.34 (1.56)	0.97 (10.00)	3.33
T_8	Weedy check	5.21 (26.67)	4.60 (21.28)	2.69 (19.78)	4.09 (16.61)	4.38 (18.78)	2.01 (103.11)	111.00
S. Em±		0.09	0.08	0.05	0.06	0.07	0.01	0.42
C. D. (P=0.05)		0.27	0.22	0.16	0.16	0.20	0.04	1.21
Transformation		√x+0.5	√x	√x+0.5 & Log (x)	√x+0.5	√x+0.5	Log (x)	-

Table 2. Effect of weed control practices on species-wise broad-leaf weed population/m^2 and dry weight (g/m^2) at 75 DAS in sesame (Pooled data of two years)

Symb.	Treatments	*D. arvensis*	*C. benghalensis*	*C. argentia*	*A. sessilis*	*P. hysterophorus*	Total broad-leaf weed population	Total broad-leaf weed dry weight
T_1	Propaquizafop 10% EC (PoE) @ 50 g a. i./ha	2.88 (8.33)	2.44 (5.50)	2.08 (4.50)	1.84 (3.00)	1.46 (1.67)	1.36 (23.00)	42.00
T_2	Propaquizafop 10% EC (PoE) @ 62.5 g a. i./ha	2.92 (8.67)	2.47 (5.67)	2.05 (4.67)	1.90 (3.17)	1.40 (1.50)	1.37 (23.67)	40.39
T_3	Propaquizafop 10% EC (PoE) @ 100 g a. i./ha	2.88 (8.33)	2.44 (5.50)	2.14 (4.67)	1.94 (3.33)	1.46 (1.67)	1.37 (23.50)	38.33
T_4	Propaquizafop 10% EC (PoE) @ 125 g a. i./ha	2.75 (8.00)	2.40 (5.33)	2.07 (4.33)	1.88 (3.17)	1.35 (1.50)	1.34 (22.33)	37.83
T_5	Quizalofop-p-ethyl 5% EC (PoE) @ 50 g a. i./ha	2.88 (8.33)	2.44 (5.50)	2.11 (4.50)	1.94 (3.33)	1.39 (1.50)	1.36 (23.17)	43.28
T_6	Fenoxaprop-p-ethyl 9% EC (PoE) @ 100 g a. i./ha	2.85 (8.17)	2.42 (5.50)	2.06 (4.33)	1.88 (3.17)	1.46 (1.67)	1.35 (22.83)	39.44
T_7	Two hand weedings at 20 and 40 DAS	1.07 (1.17)	1.11 (0.83)	1.00 (1.00)	0.88 (0.33)	0.88 (0.33)	0.55 (3.67)	5.83
T_8	Weedy check	2.93 (8.67)	2.47 (5.83)	2.13 (4.67)	1.90 (3.17)	1.48 (1.83)	1.38 (24.17)	45.33
S. Em±		0.06	0.06	0.07	0.06	0.05	0.01	1.22
C. D. (P=0.05)		0.18	0.16	0.20	0.17	0.13	0.03	3.53
Transformation		√x	√x+0.5	√x	√x+0.5	√x+0.5	Log (x)	-

Table 3. Observations for the specific parameters like chlorosis, necrosis, wilting, scorching, hyponasty and epinasty should be noted by using following scale

Score	Phytotoxicity (%)	Score	Phytotoxicity (%)
0	No phytotoxicity	6	51-60
1	0-10	7	61-70
2	11-20	8	71-80
3	21-30	9	81-90
4	31-40	10	91-100
5	41-50	-	-

Table 4. Phytotoxicity symptoms on 10-point scale at 1, 3, 5, 7 and 10 days after application of different post-emergence herbicides

Treatment	Chlorosis					Necrosis					Wilting					Scorching					Hyponasty					Epinasty				
	Days of observations																													
	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10
T_1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	0	1	2	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3	0	2	3	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4	0	3	4	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

significantly among various weed control treatmentsand it varied from 45.67 to 48.41. All the weed control treatments produced significantly higher oil yield over weedy check. The significantly higher oil content (48.41%) and oil yield/ha (348 kg) were recorded under treatment T_7 (Two hand weedings at 20 and 40 DAS). The next effective treatment was T_1 (47.10% and 244 kg/ha, respectively) followed by T_2 (46.94% and 228 kg/ha, respectively) and both the treatments were statistically at par with each other (Table 5 and Fig. 1). All these weed control treatments resulted in 73.83 to 225.23% increase in oil yield over weedy check.

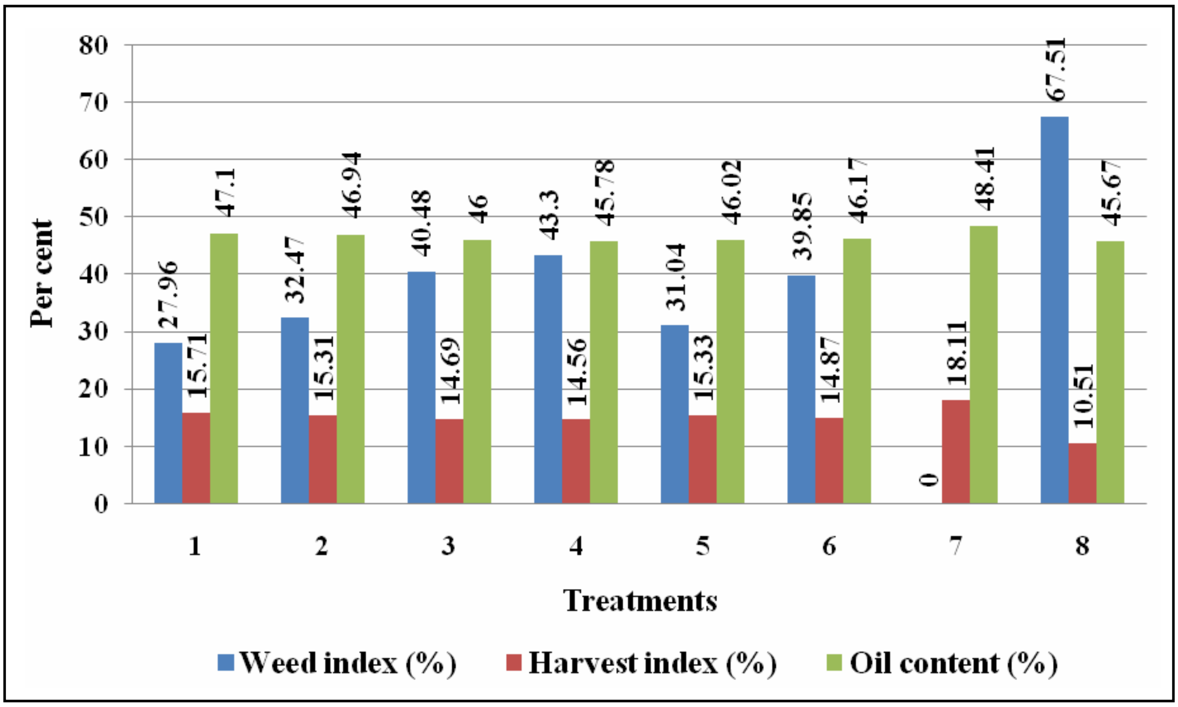

Fig. 1. Effect of weed control practices on weed index (%), harvest index (%) and oil content (%) in sesame (Pooled data of two years).

Table 5. Effect of weed control practices on yield, quality parameters and economics in sesame (Pooled data of two years)

Symb.	Treatments	Grain yield/ha (kg)	Stalk yield/ha (kg)	Weed index (%)	Harvest index (%)	Oil content (%)	Oil yield/ha (kg)	Total cost of cultivation (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)
T_1	Propaquizafop 10% EC (PoE) @ 50 g a. i./ha	517	2785	27.96	15.71	47.10	244	19836	53095	33259
T_2	Propaquizafop 10% EC (PoE) @ 62.5 g a. i./ha	485	2691	32.47	15.31	46.94	228	20064	49814	29751
T_3	Propaquizafop 10% EC (PoE) @ 100 g a. i./ha	427	2476	40.48	14.69	46.00	196	20746	43954	23208
T_4	Propaquizafop 10% EC (PoE) @ 125 g a. i./ha	407	2413	43.30	14.56	45.78	186	21201	41904	20703
T_5	Quizalofop-p-ethyl 5% EC (PoE) @ 50 g a. i./ha	495	2722	31.04	15.33	46.02	227	20447	50852	30405
T_6	Fenoxaprop-p-ethyl 9% EC (PoE) @ 100 g a. i./ha	432	2479	39.85	14.87	46.17	200	20779	44408	23629
T_7	Two hand weedings at 20 and 40 DAS	718	3243	-	18.11	48.41	348	26054	73393	47339
T_8	Weedy check	233	1972	67.51	10.51	45.67	107	18494	24303	5809
S. Em±		0.36	21.72	-	-	0.36	6.12	-	-	-
C. D. (P=0.05)		1.05	62.92	-	-	1.04	17.72	-	-	-

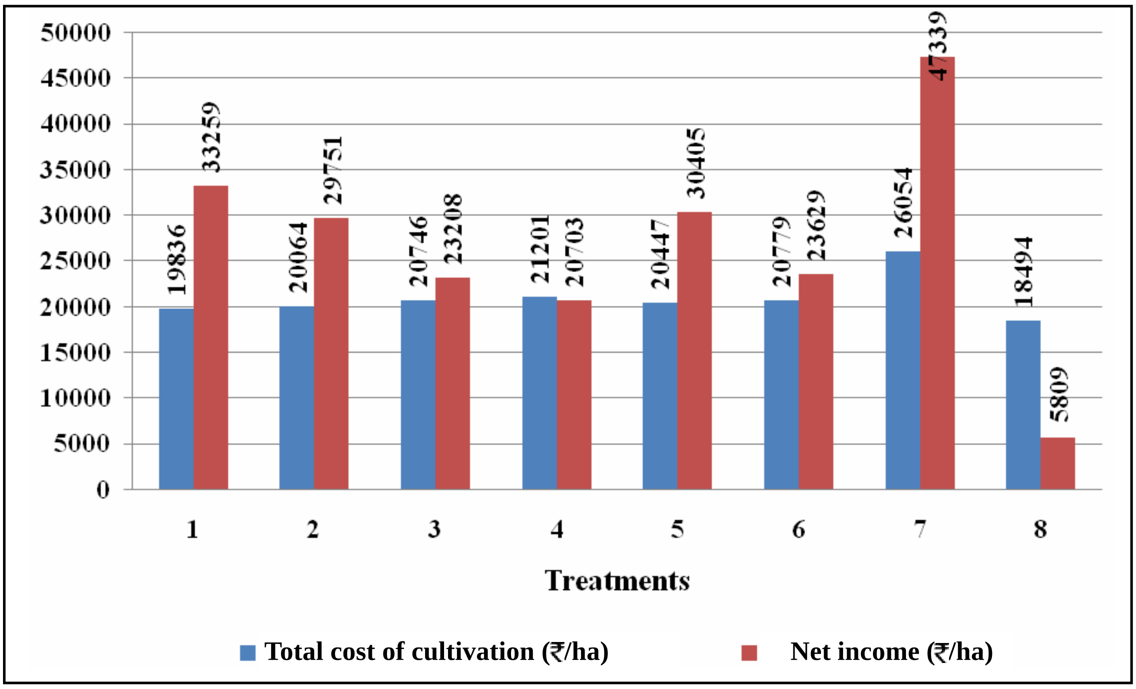

Fig. 2. Effect of weed control practices on total cost of cultivation (Rs./ha) and net income (Rs./ha) in sesame (Pooled data of two years).

The unchecked weeds of weedy check plot reduced the oil yield by 69.25%, when compared to oil yield/ha of treatment T_7 (Two hand weedings at 20 and 40 DAS). Such findings were also reported by Patel *et al.* (2011).

Economic Analysis of the Treatments

The choice of any weed control method ultimately depends on economics and efficiency in controlling weeds.

The highest total cost of cultivation (₹26,054/ha) was incurred under treatment T_7 (Two hand weedings at 20 and 40 DAS) followed by treatment T_4 (₹210201/ha). All the weed control treatments gave higher net income over weedy check (₹ 5809/ha). The highest net income of ₹47339/ha was obtained under treatment T_7 (Two hand weedings at 20 and 40 DAS), which was 714.93% higher than weedy check. The treatments T_1 (₹ 33259/ha), T_5 (₹30405/ha), T_2 (₹29751/ha), T_6 (₹23629/ha), T_3 (₹23208/ha) and T_4 (₹20703/ha) were next in order (Table 5 and Fig. 2). Under all weed control treatments, net income was found low due to abnormal weather conditions in crop growth period. Such findings were confirmed by the results of Vijayalaxmi *et al.* (2012).

CONCLUSION

The significantly lower population (0.97/m^2) and dry weight (3.33 g/m^2) of all narrow-leaved weeds were recorded under treatment T_7 (Two hand weedings at 20 and 40 DAS) over rest of the weed control treatments. The next effective treatment was T_4 (1.42/m^2 and 9.83 g/m^2, respectively). The significantly higher grain yield/ha (718 kg) and harvest index (18.11%) were recorded under treatment T_7 (Two hand weedings at 20 and 40 DAS) over rest of the weed control treatments. The next effective treatment was propaquizafop @ 50 g a. i./ha (517 kg/ha and 15.71%, respectively). All the weed control treatments gave higher net income over weedy check (₹ 5809/ha). The highest net income of ₹47339/ha was obtained under treatment T_7 (Two hand weedings at 20 and 40 DAS), which was 714.93% higher than weedy check.

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