International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 144-147

Received: 11-05-2019
Accepted: 15-06-2019

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Effect of chemical weed management practices on economics of irrigated sesame cultivation in western zone of Tamil Nadu

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Abstract
A field experiment was conducted at Agricultural College and Research Institute, Coimbatore during December, 2018 to March, 2019 to study the effect of chemical weed management practices on economics of irrigated sesame. The field experiment was laid out in randomized block design with eleven treatments and replicated thrice. Total cost of cultivation, gross return, net return and benefit cost ratio were computed for each treatment. Cost of production of sesame crop was highly influenced by the weed management options due to high infestation of weeds and increased labour cost. On the basis of field experimentation, it can be concluded that, integrating herbicide and hand weeding provided the highest net profit due to increased yield at a relatively low cost. Results revealed that pre-emergence application of pendimethalin @ 750g/ha with one hand weeding at 30 DAS recorded significantly higher gross and net return, compared to other treatments which also resulted to high benefit cost ratio. In addition to that, PE pendimethalin 38.7 CS @ 0.65 kg a.i./ha+ HW at 30 DAS (T_2), EPoE imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha + HW at 40 DAS (T_9) and PE oxyfluorfen 23.5 EC @ 200 g a.i./ha+ HW at 30DAS (T_3) recorded higher net return and benefit cost ratio than twice hand weeding even though lower yield is recorded compared to twice hand weeding.

Keywords: Chemical weed management, sesame, economics, BCR

Introduction
Sesame (*Sesamum indicum* L.) is one of the foremost conventional oilseed crop cultivated in almost every tropical, subtropical, Asian and African nations (Iwo *et al*., 2002) [1]. Sesame oil contains the significant amount of polyunsaturated fatty acids, because of the quality of sesame oil it has a poetic label such as "Queen of Oilseeds". India ranks first in the area and second in sesame production by contributing 29.8 per cent and 25.8 per cent of the world area and production, respectively, and the largest (40 per cent) sesame exporter in the world. In India, sesame is grown in an average area of 17.46 lakh ha with a production of 8.28 lakh tonnes per year and average productivity of sesame was 413 kg/ha (Anonymous, 2017) [2]. In Tamil Nadu it is cultivated in an area of approximately 0.56 lakh ha with the production of 0.35 lakh tonnes and average productivity of 621 kg/ha. West Bengal marked as highest productivity region with an average yield of 951 kg/ha in India.

Weeds are one of the major threats to the crop cultivation. Weeds are competing with the crop for different growth factors such as nutrient, moisture, light and space which ultimately affect the crop by reducing the economic yield. Therefore, it is necessary to focus more on weeding out the unwanted than on any other activity related to increasing agricultural production. Weed infestation is one of the biggest problems with low sesame productivity. Mizan *et al.*, (2009) [3] found a critical period of weed competition between 15 and 30 days after the emergence of seedling in sesame crop. NPK depletion of nutrients may also be increased due to more weed density in sesame field (Bhadauria *et al*., 2012) [4]. Therefore during the critical period, the crop is to be maintained as weed free condition in order to realize maximum yield and also higher net return of sesame.

Weeds can be effectively managed by preventive, cultural, mechanical, chemical and biological methods. Though the manual weeding is effective and eco-friendly, yet they are expensive, tedious, time consuming and non-availability of laboures in time lead to the search for alternative methods. An alternative weed control could be an important way to increase the yield of sesame by reducing the initial investment costs and maintaining the integrity of the environment. Chemical weed management is more favourable and effective as they are quick

in action, selective in nature, cost effective, time saving, labour saving and efficient approach to weed control at an early stage of crop-weed competition. Returns from crop cultivation are essential not only for the survival of the farmers but also to facilitate reinvestment in agriculture. If the flow of income from crop cultivation is not regular and inadequate, farmers may not be able to repay their debts which would lead to increased indebtedness (Reddy and Mishra, 2009; Deshpande and Arora, 2010) [5, 9].

To search the answers to the above questions, the study has focused on the following objectives are to find out the effect of chemical weed management on cost of production, net returns of sesame, in order to estimate the profitability and to find out the most economic and profitable chemical weed management option for sesame crop.

Materials and Methods

The study was conducted in Coimbatore district which is situated in western region of Tamil Nadu during the period from December, 2018 to March, 2019 at Agricultural College and Research Institute, Coimbatore. It is located at 11ºN latitude and 77ºE longitude and at an altitude of 426.7 meters above the Mean Sea Level (MSL).

The experiment consisted of eleven treatments *viz.* T_1 - PE Pendimethalin 30 EC @ 0.75 kg a.i./ha+ HW at 30 DAS, T_2 - PE Pendimethalin 38.7 CS @ 0.65 kg a.i./ha+ HW at 30 DAS, T_3 - PE Oxyfluorfen 23.5 EC @ 200 g a.i./ha+ HW at 30DAS, T_4 - EPoE Quizalofop ethyl 5 EC @ 40 g a.i./ha+ HW at 40 DAS, T_5 - EPoE Imazethapyr 10 SL @ 75 g a.i./ha + HW at 40 DAS, T_6 - EPoE Quizalofop ethyl 5 EC @ 40 g a.i./ha + Imazethapyr 10 SL @ 75 g a.i./ha, T_7 - EPoE Imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha, T_8 - EPoE Quizalofop ethyl 5 EC @ 40 g a.i./ha+ Imazethapyr 10 SL @ 75 g a.i./ha + HW at 40 DAS, T_9 - EPoE Imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha + HW at 40 DAS, T_{10} - Hand weeding at 20 and 40 DAS and T_{11}- Unweeded control with three replications and laid out in randomized block design.

The certified sesame seed of VRI 2 was used @ 5 kg/ha. Because of its smaller size the recommended quantity of seeds was taken and it was mixed with four times of its volume of dry sand for easy sowing. Sowing was taken by adopting recommended square spacing of 30 cm between rows and 30 cm between plants to a depth of 3 cm. A week after sowing, gap filling was done. Thinning was done at 12 days after sowing (DAS) & 20 DAS in order to maintain the optimum plant population. Urea, single super phosphate and murate of potash fertilizers were used to meet out the fertilizer requirement of sesame crop based on the recommended NPK dose @ 25:23:23 kg/ha. As basal half of N and full P and K fertilizers were applied through broadcasting. Remaining N was applied at the time of flowering stage as split dose.

Hand weeding treatments were imposed as per the technical treatment schedule and were done at 20, 30 and 40 DAS as per the respective treatment. All the herbicides were given as per the treatment schedule. All pre emergence herbicides were applied on 3 DAS and all the early post emergence herbicides were applied on 14 DAS. The recommended herbicide dose was mixed with water at the rate of 500 liters/ha and sprayed uniformly over the soil using hand operated knapsack sprayer fitted with deflector nozzle. Irrigation was given immediately after herbicide spray.

Economics: Total cost of cultivation, gross return, net return and benefit cost ratio were computed for each treatment.

Cost of cultivation: It includes operational costs, material costs and other costs in crop production. The expenditure incurred from sowing to harvest was worked out and expressed in □/ha. The prevailing market rate for inputs, produce and the wages paid to the labours at Tamil Nadu Agricultural University were used to work out the economics. For other costs like land revenue and interest on working capital are fixed as □1000.

Gross return: The gross return for each treatment was calculated using the yield of seed and haulm for sesame based on prevailing market price and expressed in □/ha.

Gross return = Yield × price of produce

Net return: Net return was worked out for all treatments by subtracting the cost of cultivation from gross return as detailed and expressed in □/ha.

Net return (□/ha) = Gross return (□/ha) – Cost of cultivation (□/ha)

Benefit cost ratio (BCR): Using the formula below, the benefit cost ratio was calculated.

$$\text{Benefit cost ratio} = \frac{\text{Gross return (□/ha)}}{\text{Total cost of cultivation (□/ha)}}$$

Results and Discussion

Cost of cultivation of sesame in western zone of Tamil Nadu is presented in Table 1. To cultivate sesame crop in one-hectare area, an amount of □46,251 is required in western zone of Tamil Nadu. It is evident from the Table 1, twice hand weeding contributes 31.13 per cent share of cost of production of sesame in western zone of Tamil Nadu. Adewale Osipitan *et al.*, (2018) [7] also reported that cost of weed control was substantially influences the total variable cost of cowpea cultivation.

The influence of chemical weed management options on total cost of cultivation, grain yield, gross return, net return and benefit cost ratio of sesame is presented in Table 2.

Results of the study revealed that, twice hand weeding treatment without chemical registered with the highest cost of cultivation of □ 46,251 and it was clearly indicated that twice hand weeding is expensive due to higher labour cost. Use of herbicides was cheaper and effective in controlling the weeds and reducing total energy required for sesame cultivation. Similar findings were also reported by Srinivasan and Chaudhary (1993) [8]. A single input of hand weeding resulted in higher cost of weed control than the input of herbicide for weed control.

Table 1: Cost of cultivation sesame in western zone of Tamil Nadu

Sl. No.	Abstracts	Cost of cultivation (□/ha)	Per cent share
I	Field Preparation	6175	13.35
II	Integrated Nutrient Management (Manures & Fertilizer)	5046	10.91
III	Seeds and Sowing	4970	10.75
IV	Weed Management (Twice hand weeding)	14400	31.13

V	Irrigation	3600	7.78
VI	Integrated Pest Management	1340	2.90
VII	Harvesting	9720	21.02
VIII	Operational cost & Transport of inputs and produce	1000	2.16
	Total cost	46251	100.00

Table 2: Effect of chemical weed management on economics of sesame cultivation

Treatments	Cost of cultivation (□/ha)	Cost of weed management (□/ha)	Total cost of cultivation (□/ha)	Yield (kg/ha)	Gross return (□/ha)	Net return (□/ha)	BCR
T_1 - PE Pendimethalin 30 EC @ 0.75 kg a.i./ha+ HW at 30 DAS	31851	9020	40871	843	58987	18115	1.44
T_2 - PE Pendimethalin 38.7 CS @ 0.65 kg a.i./ha+ HW at 30 DAS	31851	9432	41283	777	54367	13083	1.32
T_3 - PE Oxyfluorfen 23.5 EC @ 200 g a.i./ha+ HW at 30DAS	31851	10011	41862	758	53083	11221	1.27
T_4 - EPoE Quizalofop ethyl 5 EC @ 40 g a.i./ha+ HW at 40 DAS	31851	9568	41419	613	42933	1514	1.04
T_5 - EPoE Imazethapyr 10 SL @ 75 g a.i./ha + HW at 40 DAS	31851	9098	40949	325	22750	-18199	0.56
T_6 - EPoE Quizalofop ethyl 5 EC @ 40 g a.i./ha + Imazethapyr 10 SL @ 75 g a.i./ha	31851	3546	35397	278	19483	-15913	0.55
T_7 - EPoE Imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha	31851	1360	33211	508	35583	2372	1.07
T_8 - EPoE Quizalofop ethyl 5 EC @ 40 g a.i./ha+ Imazethapyr 10 SL @ 75 g a.i./ha + HW at 40 DAS	31851	10746	42597	285	19950	-22647	0.47
T_9 - EPoE Imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha + HW at 40 DAS	31851	8560	40411	743	52033	11622	1.29
T_{10} - Hand weeding at 20 and 40 DAS	31851	14400	46251	812	56817	10565	1.23
T_{11}- Unweeded control	31851		31851	385	26950	-4901	0.85

In the treatments, wherever herbicide is combined with one hand weeding registered less cost incurred for weed management due to the reduction of one hand weeding and the less cost incurred for chemical and application charges. It revealed that cost incurred for application herbicide during early stages of crop growth by skipping one hand weeding is lesser. This finding is confirmed other reports that, the use of herbicide for weed control is less expensive than hand weeding Oerke, 2006 [9]; Patil *et al.*, 2014 [10]; Selvakumar *et al.*, 2018 [11].

With respect to gross return, application of pendimethalin 30 EC @ 0.75 kg a.i./ha as pre emergence followed by one hand weeding on 30 DAS registered higher gross return and it was followed by twice hand weeding. However, early post-emergence application of imazethapyr 10 SL @ 75 g a.i/ha alone or along with any other combination as tank mixture registered lower gross return than the unweeded check. It's due to the phytotoxicity of imazethapyr 10 SL @ 75 g a.i./ha in sesame. Mruthul *et al*., (2015) [12] also reported that application of imazethapyr 10 SL @ 75 g a.i./ha in sesame having phytotoxicity and it reduced the gross return than the unweedy check.

The experimental results clearly indicated that, it was more profitable to control weeds in sesame using any of the weed management methods than allowing the weeds on the plots. Application of pendimethalin 30 EC @ 0.75 kg a.i./ha as pre-emergence followed by one hand weeding at 30 DAS registered higher net return and it was followed by PE pendimethalin 38.7 CS @ 0.65 kg a.i./ha+ HW at 30 DAS (T_2), EPoE Imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha + HW at 40 DAS (T_9), PE Oxyfluorfen 23.5 EC @ 200 g a.i./ha+ HW at 30DAS (T_3) and hand weeding at 20 and 30 DAS.

When comparing gross return and net return, it's clearly indicated that even though twice hand weeding recorded higher gross return than treatments like (T_2), (T_9) and (T_3) it's not accounted as profit output due to higher cost incurred for hand weeding than the herbicide application. This was because of increasing the frequency of weed removal by hand did not guarantee the highest yield (Adigun *et al*., 2014), but rather increased the cost of weed control. Integrating herbicide and hand weeding provided the highest net profit due to increased yield at a relatively less cost. The findings are similar to that of Kumar and Singh (2017) [13] and Adewale Osipitan *et al.,* (2018) [7] in which integrated weed management treatments gave higher gross and net returns, compared to non-integrated approach.

All herbicide treatments except imazethapyr 10 SL @ 75 g a.i./ha alone and combination with other chemicals registered higher benefit cost ratio over weedy check. The highest benefit cost ratio (BCR) was obtained by application of pendimethalin 30 EC @ 0.75 kg a.i./ha as pre emergence followed by one hand weeding at 30 DAS might be due to higher grain yield in this treatment compared to other treatments. It was followed by PE pendimethalin 38.7 CS @ 0.65 kg a.i./ha+ HW at 30 DAS (T_2), EPoE imazythapyr 35 a.e. + imazamox 35 a.e. @ 30 g a.e./ha + HW at 40 DAS (T_9), PE oxyfluorfen 23.5 EC @ 200 g a.i./ha+ HW at 30 DAS (T_3) and then twice hand weeding. The lower BCR was obtained in hand weeding treatment was mainly because of higher labour cost involved in hand weeding. Therefore, the higher cost involved in manual weeding was not compensated by the additional grain yield obtained in hand weeding leads to lower BCR.

Conclusion

Cost of production of sesame crop was highly influenced by the weed management options due to high infestation of weeds and increased labour cost. On the basis of field experimentation, it can be concluded that, integrating herbicide and hand weeding provided the highest net profit due to increased yield at a relatively low cost.

Highest gross return, net return and benefit cost ratio were obtained with the application of pendimethalin 30 EC @ 0.75 kg a.i./ha as pre emergence followed by one hand weeding at 30 DAS. In addition to that, PE pendimethalin 38.7 CS @ 0.65 kg a.i./ha+ HW at 30 DAS (T_2), EPoE imazythapyr 35 a.e. + Imazamox 35 a.e. @ 30 g a.e./ha + HW at 40 DAS (T_9) and PE oxyfluorfen 23.5 EC @ 200 g a.i./ha+ HW at 30DAS (T_3) recorded higher net return and benefit cost ratio than twice hand weeding even though lower yield was recorded compared to twice hand weeding.

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