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Performance and economical evaluation of different weed management practices on yield of summer sesame (*Sesamum indicum* L.)

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Abstract
A field experiment was conducted during two consecutive summer of 2020 and 2021 to investigation "Performance and economical evaluation of different weed management practices on yield of summer sesame (*Sesamum indicum* L.)" at agricultural farm of Krishi Vigyan Kendra, Durg-II (Chhattisgarh). The experiment treatments were include W_1: Weedy check, W_2: Hand weeding at 20 and 40 DAS, W_3: Pendimethaline 30 EC @ 1 kg *ai* ha^{-1} as PE, W_4: Quizalofop ethyl 5 EC @ 40 g *ai* ha^{-1} at 20 DAS, W_5: Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS, W_6: Imazethapyr 10 SL @ 75 g *ai* ha^{-1} at 25 DAS and W_7: Weed free check. Among different weed management treatments, weed free check (W_7) recorded statistically lower density of total weeds during 2020 and 2021 than rest of the treatments at all the stages of observation. Second best treatment was W_2; two hand weedings at 20 and 40 DAS. Among all the herbicidal treatments, application of Propaquizafop recorded lower density of total weeds during both the years. The highest seed yield and stover yield was recorded in Weed free check, which was found at par with hand weeding at 20 and 40 DAS during both experimental year. Among all the herbicides, Propaquizafop and Quizalofop ethyl, recorded maximum yield, while Pendimethalin produced lower sesame yield. Highest cost of cultivation and gross return were found with the weed free check (W_7), followed by W_2; Hand weeding at 20 and 40 DAS, whereas maximum net return and benefit: cost ratio was observed in W_5 that is application of Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS. Minimum cost of cultivation, gross return, net return and benefit: cost ratio was associated with W_1 (weedy check).

Keywords: Weeds, *Sesamum indicum* L., propaquizafop, quizalofop, hand weeding

Introduction
Sesame (*Sesamum indicum* L.) is one of the important oilseed crops in Indian agriculture, adorned as queen of oilseeds. India is the world's second largest edible oil consumer after China, meeting more than half of its annual requirement through imports (Babu and Hedge, 2011) [3], therefore there is need to boost oilseeds production in India. Among all oilseeds, sesame costs maximum in terms of export i.e. Rs. 3583.46 crore (groundnut- Rs. 3212.06 crore and niger- Rs. 113.61 crore) (Anonymous, 2014) [2]. The potential yield of sesame (2000 kg ha^{-1}) is much higher than actual yield, as much damage occurs by pests and diseases, insufficient weed control and lack of nutrients (Mkamilo and Bedigian, 2007) [8].

Weeds are serious pest damages for the most crops caused by competition on light, nutrients, moisture and space, and this lead to enormous reduction in crop yield (Lahmod and Alsadaawi, 2012) [7]. Lack of proper weed management is one of the main constraints for poor yields of sesame. The severity of yield loss depends upon the type of weed flora and time of weed infestation in a given agro-climatic conditions. The yield loss due to uncontrolled weed growth in sesame has been reported as high as 50 per cent (Dungarwal *et al*., 2003) [5]. Simultaneous emergence and rapid growth of weeds leads to weed competition for moisture, light, space and nutrients. The period from 15 to 30 DAS is the most critical period of crop weed competition in sesame. Though the conventional methods of weed control are very much effective, but due to high wages and non- availability of labour during critical weeding season, use of herbicides could be more time saving, economical and efficient to check early crop-weed competition.

Keeping above fact in view, with the specific object that to find out the effect of different weed management practices on growth, yield and weed dynamics in summer sesame, a field investigation entitled "Performance and economical evaluation of different weed management practices on yield of summer sesame (*Sesamum indicum* L.)" was under taken during summer

seasons of 2020 and 2021 at agricultural farm of Krishi Vigyan Kendra, Pahanda (A), Durg (Chhattisgarh).

Methodology

The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatments comprised W_1: Weedy check, W_2: Hand weeding at 20 and 40 DAS, W_3: Pendimethaline 30 EC @ 1 kg *ai* ha^{-1} as PE, W_4: Quizalofop ethyl 5 EC @ 40 g *ai* ha^{-1} at 20 DAS, W_5: Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS, W6: Imazethapyr 10 SL @ 75 g *ai* ha^{-1} at 25 DAS and W_7: Weed free check.

Sesame variety TKG-308 was taken as test crop. Seeds were sown manually in summer season in the experiment during 2020 and 2021, adopting a spacing of 30 cm x 10 cm with uniform recommended dose of fertilizers (60 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1}). All the herbicides were applied with manually operated knapsack sprayer fitted with flat-fan nozzle at spray volume of 500 l ha^{-1}. Weed density and dry matter were recorded at 45, 60 and 75 DAS with the help of 1 x 1 m quadrate by throwing randomly at three places in each plot. Weeds were removed and counted species wise.Observations were recorded for different characters and mean values were subjected to analysis. The combined analysis of two years revealed that the year effect was non-significant, and the mean data of two years were analyzed. The statistical analysis of data was done using OPSTAT Software.

Results and discussion

Species wise weed composition

The dominant weed species in the experimental field of sesame at 45, 60 and 75 DAS included grassy weeds like, *Cynodon dactylon*, *Digitaria sanguinalis*, *Eleusine indica*, *Echinochloa colonum* and *Dactyloctenium aegyptium* and broad leaved weeds like *Alternanthra sessilis*, *Trianthema portulacastrum*, *Phyllanthus niruri*, *Commelina benghalensis* and *Parthenium hysterophorus* (Figure-1).

Effect on weeds

Total weed density

Total weed density (Table-1) differed significantly due to weed management practices at all the growth stages. Among the different weed management treatments, weed free check (W_7) recorded statistically lower density of total weeds (2.27, 2.26, 2.62 m^{-2} during 2020 and 2.69, 2.69, 2.83 m^{-2} during 2021) than rest of the treatments at 45, 60 and 75 DAS. Second best treatment was W_2; two hand weedings at 20 and 40 DAS. Among all the herbicidal treatments, application of Propaquizafop recorded lower density of total weeds (5.64, 5.56, 5.64 m^{-2} during 2020 and 5.37, 5.58, 5.71 m^{-2} during 2021). However, all the weed management measures reduced the total weed density significantly over weedy check at all stages of crop growth.

Relative weed density

The influences of different weed management practices on the relative density of grasses and broad leaved weeds were studied (Table -1). The relative density of grasses was decreasing in all the treatments as the number of days increased, whereas density of BLWs increased with advancement of crop stage. W_1; weedy check and W_3; application of Pendimethalin, showed almost similar density of weed flora at the later stage of observations. Among treatments of herbicide application, density of broad- leaved weed was found higher in W_5; Propaquizafop and W_4; Quizalofop.

Weed dry weight

Weed dry weight differed significantly at all the stages of growth due to various weed management treatments at 45, 60 and 75 DAS stages during both the years. Dry matter of weeds was increased with the advancement of crop stages (Table-1). Weedy check (W_1) showed higher weed dry weight (6.27, 7.47, 8.73 and 8.94, 6.73, 7.56 g m^{-2} during 2020 and 2021), followed by W_3; Pendimethalin 30 EC @1 kg *ai* ha^{-1}(6.02, 6.31, 6.54 and 5.56, 5.79, 6.24 g m^{-2}) at all the stages of observations during 2020 and 2021. However, weed free check (W_7) treatment showed lower dry matter of weeds in both the years (2.11, 2.30, 2.75 and 2.55, 3.05, 3.20 g m^{-2}).

Effect on crop yield

Seed yield

Seed yield (Table-2) was influenced by treatments of weed management practices were statistically found significant. The highest seed yield (752.00 and 830 kg ha^{-1}) was recorded in W_7; Weed free check, which was at par with W_2; hand weeding at 20 and 40 DAS (721.33 kg ha^{-1} in 2020 and 800.00 kg ha^{-1} in 2021), followed by W_5; propaquizaofop (662.00 kg ha^{-1} in 2020 and 758.33 kg ha^{-1} in 2021) and W_4; quizalofop ethyl (640.33 kg ha^{-1} in 2020 and 733.67 kg ha^{-1} in 2021), while the lowest seed yield was achieved by W_1; weedy check (268.00 kg ha^{-1} in 2020 and 366.67 kg ha^{-1} in 2021). Narkhede *et al*. (2000) [9] observed that two hand weeding and hoeing in sesame significantly gave higher seed yield than rest of the integrated weed management practices. This might be due to prolonged weed free crop growth produced higher number of capsules plant^{-1}, seeds capsule^{-1} and 1000 seed weight that leads to higher seed yield. Serogy (1992) [10], Zewdie (1996) [12], Shamna and Mishra (1997) [11], Narkhede *et al.* (2000) [9] and Amare *et al.* (2009) [1] reported a higher seed yield in sesame under prolonged weed free conditions after crop emergence.

Stover yield (kg ha^{-1})

Results depicted in table-2 on stover yield were influenced by treatments of weed management practices and were found statistically significant. The highest stover yield (1068.33 and 1287.67 kg ha^{-1}) was recorded in W_7; Weed free check, which was at par with W_2; hand weeding at 20 and 40 DAS (1044.00 kg ha^{-1} in 2020 and 1261.00 kg ha^{-1} in 2021), followed by W_5; propaquizafop (961.33 kg ha^{-1} in 2020 and 1202.67 kg ha^{-1} in 2021) and W_4; quizalofop ethyl (978.00 kg ha^{-1} in 2020 and 1160.00 kg ha^{-1} in 2021), while the lowest stover yield was achieved by W_1; weedy check (849.00 kg ha^{-1} in 2020 and 1025.33 kg ha^{-1} in 2021).This might be due to effective control of all the categories of weeds during the critical stage might have increased the plant height and produced more number of leaves and branches plant^{-1}, which resulted in increased dry matter production leads to better vegetative growth thus increased stover yield. These results are in agreement with those of Gnanavel and Anbhazhagan (2006) [6] and Dhaka *et al.* (2013) [4].

Effect on economics

Gross monetary return (Rs. ha^{-1})

The highest gross return (Rs.90240.00 and 99600.00 ha^{-1}) was

obtained from the treatment W_7 (weed free check) during 2020 and 2021 followed by W_2; two hand weedings (Rs.86560.00 and 96000.00 ha^{-1}). Lowest gross return (Rs. 32160.00 and 44000.00 ha^{-1}) was obtained from treatment W_1 (weedy check) due to reduced seed yield as a result of heavy weed competition. The highest yield was obtained from W_7 treatment which is responsible for fetching the more gross return from this treatment (Table-3).

Net monetary return (Rs. ha^{-1})

Net return varied in different weed control treatments (Table 4.60). The highest net return (Rs.60579.00 and 71550.00 ha^{-1}) was obtained from the treatment W_5; Propaquizafop during 2020 and 2021, respectively, while the lowest net return (Rs.14317.00 and 26157.00 ha^{-1}) was achieved from W_1; weedy check (Table-3).

Benefit: Cost ratio

Benefit cost ratio was varied in different weed management treatments. Propaquizafop treated plots (W_5) gave the highest BCR (4.09 and 4.65) than the other treatments. It might be due to ratio of net return and cost of production was obtained higher from this treatment. However W_1 gave the lowest (1.80 and 2.47) B: C Ratio (Table-3).

Table 1: Effect of different weed management practices on weed dynamics at 75 DAS of summer sesame

Treatments	Total weed density m^{-2}			Relative density of m^{-2}						Weed dry weight g m^{-2}		
				Narrow leaved weeds			Broad leaved weeds					
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
W_1	9.41 (87.70)	8.88 (76.86)	9.12 (82.28)	55.28	58.10	56.69	44.72	41.90	43.31	8.73 (75.42)	7.56 (56.27)	8.17 (65.85)
W_2	4.25 (17.10)	4.10 (15.83)	4.17 (16.47)	49.95	45.94	47.94	50.05	54.06	52.06	4.21 (16.76)	4.12 (16.00)	4.16 (16.38)
W_3	7.21 (51.03)	7.07 (49.10)	7.14 (50.07)	58.07	56.00	57.03	41.93	44.00	42.97	6.54 (41.85)	6.24 (37.97)	6.39 (39.91)
W_4	5.84 (33.13)	5.77 (32.30)	5.80 (32.72)	38.53	36.33	37.43	61.47	63.67	62.57	5.55 (29.82)	5.38 (28.03)	5.47 (28.93)
W_5	5.64 (30.77)	5.71 (31.60)	5.67 (31.18)	38.91	36.61	37.76	61.09	63.39	62.24	5.26 (26.77)	5.26 (26.73)	5.26 (26.75)
W_6	6.56 (42.10)	6.32 (38.97)	6.44 (40.53)	52.28	50.66	51.47	47.72	49.34	48.53	6.30 (38.73)	5.90 (33.87)	6.10 (36.30)
W_7	2.62 (5.93)	2.83 (7.03)	2.73 (6.48)	37.97	49.35	43.66	62.03	50.65	56.34	2.75 (6.65)	3.20 (9.30)	2.99 (7.97)
S.Em ±	1.60	0.46	0.84	3.57	1.21	2.10	3.57	1.21	2.10	1.39	0.67	0.76
C D (P = 0.05)	4.98	1.42	2.62	11.11	3.76	6.54	11.11	3.75	6.54	4.33	2.08	2.37

Figures in parenthesis indicate square root transformed $\sqrt{X + 0.5}$ values.

Where,

W_1: Weedy check,

W_2: Hand weeding at 20 and 40 DAS

W_3: Application of Pendimethaline 30 EC @ 1 kg *ai* ha^{-1} as pre-emergence

W_4: Application of Quizalofop ethyl 5 EC @ 40 g *ai*ha^{-1} at 20 DAS

W_5: Application of Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS

W_6: Application of Imazethapyr 10 SL @ 75 g *ai* ha^{-1} at 25 DAS

W_7: Weed free check

Table 2: Effect of different weed management practices on yield and yield attributes of summer sesame

Treatments	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2020	2021	Mean	2020	2021	Mean
W_1	268.00	366.67	317.33	849.00	1,025.33	937.17
W_2	721.33	800.00	760.67	1044.00	1,261.00	1152.50
W_3	352.67	440.00	396.33	924.00	1,040.00	982.00
W_4	640.33	733.67	687.00	978.00	1,160.00	1069.00
W_5	662.00	758.33	710.17	961.33	1,202.67	1082.00
W_6	623.33	723.33	673.33	945.33	1,183.33	1064.33
W_7	752.00	830.00	791.00	1068.33	1,287.67	1178.00
S.Em ±	17.58	16.84	12.18	17.44	28.656	14.94
C D (P = 0.05)	54.75	52.46	37.94	54.33	89.276	46.56

Where,

W_1: Weedy check,

W_2: Hand weeding at 20 and 40 DAS

W_3: Application of Pendimethaline 30 EC @ 1 kg *ai* ha^{-1} as pre-emergence

W_4: Application of Quizalofop ethyl 5 EC @ 40 g *ai*ha^{-1} at 20 DAS

W_5: Application of Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS

W_6: Application of Imazethapyr 10 SL @ 75 g *ai* ha^{-1} at 25 DAS

W_7: Weed free check

Table 3: Effect of different weed management practices on economics of summer sesame

Treatments	Cost of cultivation Rs. ha^{-1}			Gross monetary return Rs. ha^{-1}			Net monetary return Rs. ha^{-1}			Benefit :Cost Ratio		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
W_1	17843	17843	17843	32160	44000	38080	14317	26157	20237	1.80	2.47	2.13
W_2	26203	26203	26203	86560	96000	91280	60357	69797	65077	3.30	3.66	3.48
W_3	19829	19829	19829	42320	52800	47560	22491	32971	27731	2.13	2.66	2.40
W_4	19444	19444	19444	76840	88040	82440	57396	68596	62996	3.95	4.53	4.24
W_5	19581	19581	19581	80160	91000	85580	60579	71550	65999	4.09	4.65	4.37
W_6	19669	19669	19669	74800	86800	80800	55131	67131	61131	3.80	4.41	4.11
W_7	34563	34563	34563	90240	99600	94920	55677	65037	60357	2.61	2.88	2.75

Where,
W_1: Weedy check
W_2: Hand weeding at 20 and 40 DAS
W_3: Application of Pendimethaline 30 EC @ 1 kg *ai* ha^{-1} as pre-emergence
W_4: Application of Quizalofop ethyl 5 EC @ 40 g *ai*ha^{-1} at 20 DAS
W_5: Application of Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS
W_6: Application of Imazethapyr 10 SL @ 75 g *ai* ha^{-1} at 25 DAS
W_7: Weed free check

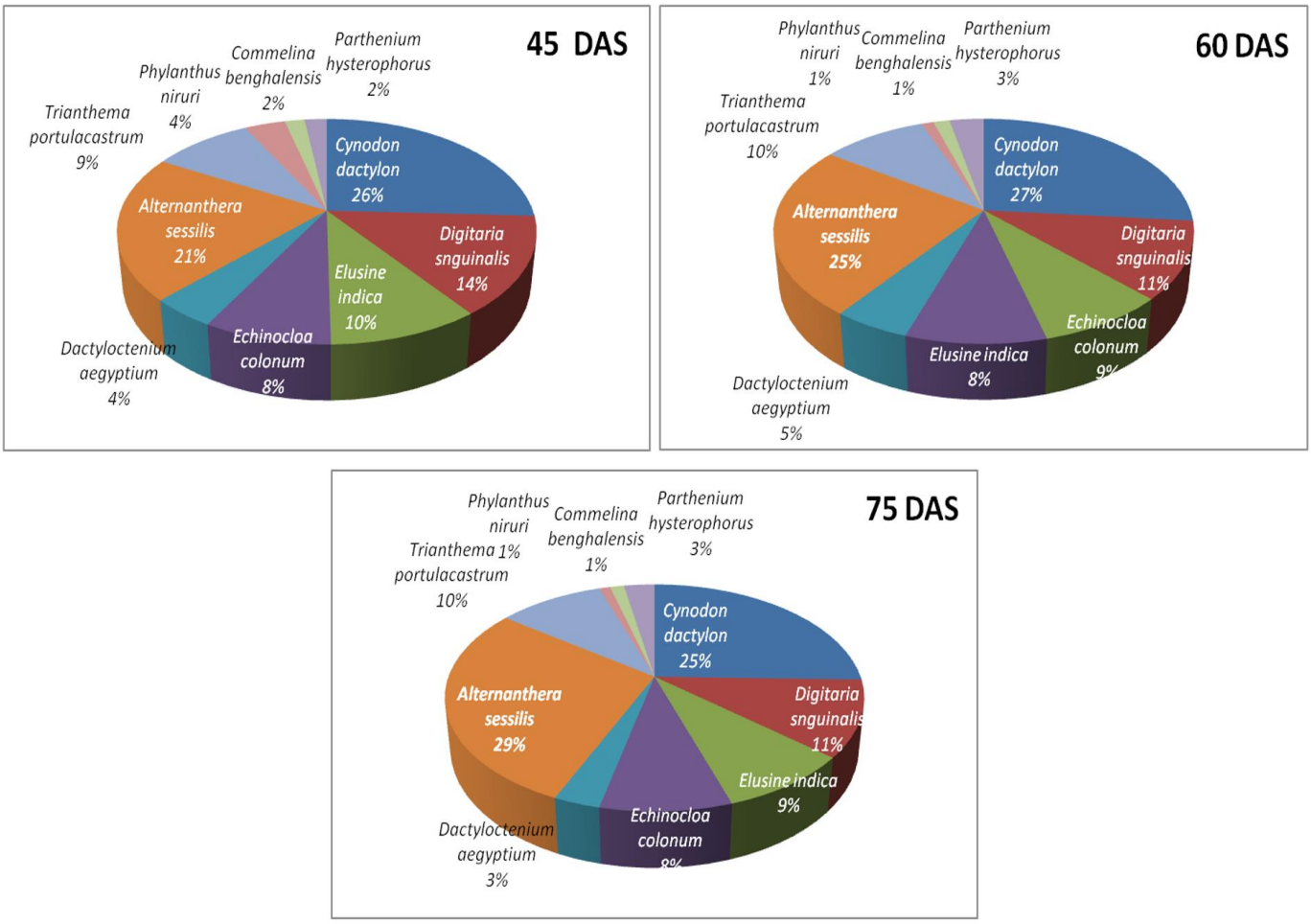

Fig 1: Species wise weed compositions at different stages of sesame under weedy check

Conclusion

In experiment, the lowest density of grasses and broad-leaved weeds were recorded under W_7; weed free check, followed by W_2; two hand weeding at 20 and 40 DAS, while the highest density of both types of weed was recorded with weedy check (W_1). Weedy check (W_1) showed higher weed dry weight, followed by W_3; Pendimethalin 30 EC @1 kg *ai* ha^{-1} at all the stages of observations during 2020 and 2021. However, weed free check (W_7) treatment showed lower dry matter of weeds in both the years. Maximum weed control efficiency was found under W_7; Weed free check during both the years, followed by W_2; two hand weedings. Application of Pendimethaline 30 EC @ 1 kg *ai* ha^{-1} as PE was found inferior than the others as it recorded lower weed control efficiency. Minimum weed index was found under two hand weeding (W_2), followed by application of Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1}, whereas maximum weed index was estimated with weedy check (W_1).

Seed yield and stover yield was observed maximum in W_7 (Weed free check) which was found statistically similar with W_2 (Hand weeding at 20 and 40 DAS).While the lowest was recorded under W_1; weedy check.

Highest cost of cultivation and gross return were found with the weed free check (W_7), followed by W_2; Hand weeding at 20 and 40 DAS, whereas maximum net return and benefit: cost ratio was observed in W_5 that is application of Propaquizafop 10 EC @ 50-100 g *ai* ha^{-1} at 20 DAS. Minimum cost of cultivation, gross return, net return and benefit: cost ratio was associated with W_1 (weedy check).

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