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Productivity and profitability of Indian mustard (*Brassica juncea* L.) as influenced by soil solarization and weed management practices

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Abstract

A field experiment was conducted at Dr. BSKKV, Dapoli, Maharashtra during 2020-21 (*rabi* season) to find out the efficient weed control measure through soil solarization in Indian mustard (*Brassica juncea* L.). The results revealed that significantly maximum growths, yield parameters, plant height (175 cm), number of branches plant^{-1} (5.2), number of siliquae plant^{-1} (161), siliquae weight plant^{-1} (9.34 g), siliquae length (4.36 cm), number of seeds siliquae $^{-1}$ (12.85), seed weight plant^{-1} (10.36 g), test weight (2.81 g), seed yield (11.14 q ha^{-1}), stover yield (26.47 q ha^{-1}) and harvest index (25.58 %) were noticed under soil solarization treatment along with transparent polythene except weed count and weed dry matter which was significantly low in soil solarization with black polythene. The maximum values of most of growth and yield parameters and weed control efficiency were recorded in weed free check followed by pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1}, post-emergence application of quizalofop-ethyl 10 % EC @ 45 g ha^{-1}, and weedy check. Though, weed free check without soil solarization was found the most profitable.

Keywords: *Indian mustard, profitability, productivity, solarization, weed control efficiency*

Introduction

Weeds are one of the major barriers which is responsible for low productivity of Indian mustard (*Brassica juncea* L.). Weeds are unwanted plants and these are also known as silent robbers of plant nutrient, soil moisture, solar energy and space which would be otherwise available for main crop (Gage and Schwartz-Lazaro, 2019). The total loss of agriculture produce in India is due to weeds 45 %, insects 30 %, diseases 20 % and other pests 5 % (Rao, 2000). The reduction in crop yield has a direct correlation with weed competition. Thus, it is important to control weeds in time to avoid unproductive use of growth factors to enable the crop plant to express fully by utilizing these factors meant for them. Herbicides are effective against narrow range of weed species (Mukherjee and Singh, 2005). A limited number of herbicides have been tested against the weeds in mustard. These herbicides are applied as pre-emergence and can control weeds up to limited period. The activity of these herbicides is either reduced or they become ineffective for second flush of weeds. Introduction of post-emergence applied herbicides may prove a boon for effective weed control in growing stage of mustard crop. During recent period a number of broad-spectrum herbicides have been launched which are capable of reducing competition for a longer period of time. The efficacy and selectivity of these herbicides are yet to be explored in mustard. On the other hand, soil solarization in combination with herbicides application is very effective for controlling weed infestation. Soil solarization is a non-chemical, hydrothermal method of soil disinfection in which soil captures radiant energy of sunlight under transparent and black polythene to create unfavorable conditions for weeds, insects and soil borne plant pathogens (Gill and Garg, 2014). Soil solarization improves the soil structure and increase the availability of nitrogen and other essential plant nutrients (Elmore *et al.*, 1997) which leads to increase plant growth and reduce weed population and requirement of fertilizers. With this background the present study was undertaken to study the effect of soil solarization and weed management practices on productivity and profitability of Indian mustard.

Materials and Methods

The experiment was conducted during the *Rabi* 2020-21 at College of Agriculture, Dr. BSKKV, Dapoli, Ratnagiri, Maharashtra. The experiment was laid out in split plot design with 12 treatment combinations and three replications. Main plot includes three treatments of soil solarization (30 days) *viz.*, (S_1) soil solarization with black polythene, (S_2) soil solarization with transparent polythene and (S_3) control (without solarization) and sub plot treatments comprised of four weed management measures *viz.*, (W_1) pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1}, (W_2) post-emergence application of quizalofop-ethyl 10 % EC @ 45 g ha^{-1}, (W_3) weed free check (20 and 40 DAS) and (W_4) weedy check. Soil solarization was done for 30 days with the help of black and transparent polythene. After 30 days, polythene was removed manually and field was made ready for sowing. Seeds of mustard (variety: Varuna) was collected from Department of Agronomy, College of Agriculture, Dapoli. Spacing between row to row was 30 cm and 15 cm for plant to plant was maintained during sowing. Seed rate required was @ 5.00 kg ha^{-1}. Recommended dose of fertilizer 90:45:00 of $N:P_2O_5:K_2O$, out of which 50 % N and 100 % $P_2O_5:K_2O$ was applied at the time of sowing and remaining 50 % N was applied at 30 DAS. The herbicide oxadiargyl and quizalofop-ethyl was applied as pre-emergence and post-emergence as per treatments. Hand weeding was performed as per treatments. In the net plot intensity of weeds was calculated by quantitative method. For this purpose, quadrant having 0.5 x 0.5 m^{-2} was put randomly in net plot. The weeds present in the quadrant were counted. After sun drying samples were dried again in oven at 60-70^oC for 3-4 days and weight was recorded immediately after removing from oven. The weed control efficiency was calculated on the basis of reduction of dry weight of weeds from the given treatments in comparison with the weed weight in the unweeded treatment (Mani *et al*. 1973). The weed index is the reduction in crop yield due to presence of weeds in comparison with weed free check (Gill and Kumar, 1969).

Yield attributes were recorded randomly from selected five plants from each plot at harvesting stages *viz*. number of seeds per siliquae, number of siliquae e per plant, weight of seeds per plant, length of siliquae and 1000-seeds weight (g). The crop was harvested from each net plot and carefully recorded the grain yield and calculated by multiplying net plot size and converted on hectare basis as q ha^{-1}. At harvest, stover and grain yields were recorded and these plant components were further used for chemical analysis. Harvest index was calculated by dividing economic yield (seed yield) with biological yield (total produce). The experimental data was analyzed by DBSKKVSTAT software and used guideline as given by Panse and Sukhatme (1985).

Results and Discussion

Effect on Weeds

The dominant weed flora observed during the experiment was presented in Table 1. Data from Table 2 revealed that, the total number of weeds and dry matter accumulation of weeds was significantly lower in treatment soil solarization with transparent polythene followed by soil solarization with black polythene. Soil solarization treatments were more prominent in suppressing growth of weeds mainly broad leaves weeds which resulted in reducing total number of weeds and dry matter accumulation of weeds over rest of the weed management measures. Similar findings were reported by Golzardi *et al.* (2014).

Table 1: Dominant weeds flora observed in the mustard crop

Botanical Name	Family	Common Name
Celosia argentea L.	Amaranthaceae	Kurdu/Kombada
Cleome viscose L.	Cleomaceae	Pivali tilvan
Cardiospermum halicacabum L.	Sapindaceae	Kanphuti/kapalphodi
Tinospora glabra L.	Menispermaceae	Gulvel

Weed management measures resulted in reducing the weed density of broad leaves weeds. Least total number of weeds and dry matter accumulation of weeds were recorded under the weed free check. Similar findings were reported by Kumar *et al*. (2015) and Gupta *et al*. (2017). Among chemical weed management measures, pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1} recorded least total number of weeds and dry matter accumulation of weeds. This treatment showed the superiority in suppressing the density and dry weight of weeds which were significantly lower than rest of the weed management measures during the year of study. The results are in confirmation with the results reported by Singh *et al*. (2017). To judge the effectiveness of herbicides weed index is an ideal parameter. Higher value of weed index resulted in reduction of crop yield due to presence of high weed density. Pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1} recorded lower weed index value (6.33 %) followed by post-emergence application of quizalofop-ethyl 10 % EC @ 45 g ha^{-1} with weed index value (10.28 %) while weedy check treatment reported highest weed index value (20.22 %). Weed free check recorded highest weed control efficiency value of 95.89 %, 83.79 % and 63.99 % at 30, 60 DAS and at harvest. This result resembles the findings of Kumar *et al.* (2015). Among chemical treatments, highest weed control efficiency was recorded in treatment pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1} i.e. 44.58 %, 27.17 % and 32.99 % followed by post-emergence application of quizalofop-ethyl 10 % EC @ 45 g ha^{-1} with weed control efficiency i.e. 28.53 %, 18.89 % and 21.51 % at 30, 60 DAS and at harvest.

Figure in parenthesis indicates square root transformation ($\sqrt{x + o.5}$)

Table 2: Total weed count and dry matter and WCE and as influenced by different treatments

Treatment	Total weed count (m^2)						Dry matter of weed (g m^{-2})		
	30 DAS	WCE (%)	60 DAS	WCE (%)	At harvest	WCE (%)	30 DAS	60 DAS	At harvest
Solarization (30 days)									
S_1	10.75 (3.09)	-	21.25 (4.46)	-	14.50 (3.78)	-	1.27 (1.35)	2.93 (1.84)	2.30 (1.69)
S_2	8.75 (2.77)	-	18.50 (4.14)	-	14.08 (3.77)	-	1.04 (1.29)	2.84 (1.82)	2.25 (1.66)
S_3	13.42 (3.49)	-	28.25 (5.19)	-	18.42 (4.29)	-	1.93 (1.54)	3.26 (1.91)	2.74 (1.78)
SEm±	- (0.07)	-	- (0.04)	-	- (0.05)	-	- (0.04)	- (0.02)	- (0.02)
CD at 5%	- (0.29)	-	- (0.15)	-	- (0.18)	-	- (0.16)	- (0.06)	- (0.09)
Weed management measures									
W_1	10.53 (3.29)	44.58	24.44 (4.71)	27.17	15.00 (3.87)	32.49	1.16 (1.27)	2.45 (1.70)	2.21 (1.64)
W_2	13.58 (3.74)	28.53	27.22 (5.49)	18.89	17.44 (4.26)	21.51	1.25 (1.31)	3.00 (1.86)	2.34 (1.67)
W_3	0.78 (1.06)	95.89	5.44 (2.37)	83.79	8.00 (2.89)	63.99	0.91 (1.14)	1.71 (1.48)	1.75 (1.49)
W_4	19.00 (4.38)	-	33.56 (5.82)	-	22.22 (4.75)	-	2.33 (1.67)	4.88 (2.31)	3.43 (1.92)
SEm±	- (0.08)	-	- (0.15)	-	- (0.11)	-	- (0.07)	- (0.06)	- (0.06)
C. D.at 5%	- (0.28)	-	- (0.52)	-	- (0.40)	-	- (0.23)	- (0.22)	- (0.20)
Interaction									
SEm±	- (0.24)	-	- (0.30)	-	- (0.32)	-	- (0.15)	- (0.16)	- (0.11)
CD at 5%	- (0.74)	-	- (0.93)	-	- (0.98)	-	- (0.46)	- (0.49)	- (0.35)

Growth and yield attributes

The treatment soil solarization with transparent polythene recorded significant increase in growth parameters *viz*., plant height, and number of branches plant^{-1} ultimately reflected in maximum yield attributing characters (*viz*., number of seeds siliqua^{-1}, siliqua length, number of siliquae plant^{-1}, siliquae weight plant^{-1}, seed weight plant^{-1} and 1000 seed weight), but at par with soil solarization with black polythene. However, 1000 seed weight did not differ significantly (Table 3). The present results are in consonance with Khan *et al*. (2012) and Subrahmaniyan *et al*. (2008). Weed free check recorded significantly

Table 3: Growth and yield attributing characters of mustard at harvest

Treatment	Plant height (cm)	Number of branches plant^{-1}	Number of seeds siliqua^{-1}	Siliqua length (cm)	Number of siliquae plant^{-1}	Siliquae weight (g plant^{-1})	Seed weight (g plant^{-1})	1000 seeds weight (g)
Solarization (30 days)								
S_1	174	5.2	12.48	4.31	157.9	9.09	9.86	2.79
S_2	175	5.2	12.85	4.36	161.4	9.34	10.36	2.81
S_3	173	5.1	11.14	3.97	140.1	7.08	7.62	2.76
S.Em±	0.2	0.02	0.24	0.08	4.2	0.22	0.46	0.07
CD at 5%	0.8	0.08	0.96	0.31	16.4	0.87	1.82	NS
Weed management measures								
W_1	175	5.2	12.68	4.20	154.0	8.60	9.30	2.88
W_2	173	5.1	12.21	4.16	153.2	8.26	9.26	2.73
W_3	178	5.4	13.13	4.62	166.4	9.52	10.54	2.89
W_4	17	5.0	10.61	3.64	138.9	7.64	8.03	2.65
SEm±	0.3	0.02	0.46	0.14	3.9	0.11	0.45	0.08
CD at 5%	1.1	0.06	1.58	0.48	13.5	0.39	1.56	NS
Interaction								
SEm±	0.7	0.07	1.00	0.36	13.4	0.85	1.48	0.23
CD at 5%	2.0	0.23	NS	NS	41.3	2.63	NS	NS

maximum plat height, number of branches per plant, seeds siliqua^{-1}, siliqua length, number of siliquae plant^{-1}, siliquae weight plant^{-1} and seed weight plant^{-1}, which was significantly superior over weedy check and was at par with the pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1} and post–emergence application of quizalofop-ethyl 10 % EC @ 45 g ha^{-1}.

Grain and stover yields

Data presented in Table 4 revealed that soil solarization with transparent polythene reported significantly higher grain yield (11.14 q ha^{-1}) stover yield (26.47 q ha^{-1}) followed by treatment soil solarization with black polythene and control (without solarization) in descending order. Among the treatments weed free check recorded significantly higher grain yield (10.83 q ha^{-1}) and straw yield (25.82 q ha^{-1}) while pre-emergence application of oxadiargyl 80% WP @ 100 g ha^{-1} and post-emergence application of quizalofop-ethyl 10 % EC @ 45 g ha^{-1} was found at par with each other and significantly superior over other treatments. Significantly lowest grain yield (8.64 q ha^{-1}) and stover yield (23.69 q ha^{-1}) was recorded in weedy Check. The increase in yield might be due to maximum growth and yield attributing characters of crop which ultimately resulted in maximum yield of seed and straw. The present results are in agreement with the results reported by Singh *et al*. (2004), Khan *et al*. (2012),Tekale *et al*. (2005), Mankar *et al*. (2016) and Choudhary *et al*. (2021).

Table 4: Yield and economics of mustard under soil solarization and weed management practices

Treatment	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)	Weed index (%)
Solarization (30 days)				
S_1	10.28	24.64	29.40	-
S_2	11.14	26.47	29.58	-
S_3	8.09	22.89	26.14	-
SEm±	0.12	0.47	0.23	-
CD at 5%	0.46	1.84	0.91	-
Weed management measures				
W_1	10.15	24.68	29.13	6.33
W_2	9.72	24.46	28.37	10.28
W_3	10.83	25.82	29.40	-
W_4	8.64	23.69	26.59	20.22
SEm±	0.15	0.32	0.59	-
CD at 5%	0.53	1.12	NS	-
Interaction effect				
SEm±	0.37	1.18	1.43	-
CD at 5%	1.15	3.64	4.42	-
General mean	9.84	24.66	28.37	-

Economics

On the basis of economic analysis, data presented in Table 5 revealed that, the higher cost of cultivation (56919 Rs ha^{-1}) was recorded under soil solarization with transparent polythene combined with weed free check (S_2W_3). The highest gross monetary returns (67667 Rs ha^{-1}) were gained by the soil solarization with transparent polythene combined with weed free check (S_2W_3). The higher net returns (17791 Rs ha^{-1}) were obtained in treatment control (without solarization) combined with weed free check (S_3W_3). The highest B: C ratio (1.57) was obtained when mustard was treated with control (without solarization) combined with weed free check (S_3W_3). This might be due to higher cost of soil solarization (Tekale *et al*. 2005).

Table 5: Economics of the treatment combinations of mustard

Treatment	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net return (Rs ha^{-1})	B : C ratio
S_1W_1	55248	57344	2096	1.04
S_1W_2	55188	56594	1406	1.03
S_1W_3	56509	65208	8698	1.15
S_1W_4	53710	51165	-2544	0.95
S_2W_1	56588	65387	8799	1.16
S_2W_2	55849	60560	4711	1.08
S_2W_3	56919	67666	10747	1.19
S_2W_4	54921	55677	756	1.01
S_3W_1	31089	47997	16907	1.54
S_3W_2	30986	46983	15997	1.52
$S3W_3$	31208	48999	17791	1.57
S_3W_4	29817	40654	10837	1.36

Conclusion

The soil solarization with transparent polythene recorded the higher yield attributing characters and seed yield of mustard followed by soil solarization with black polythene. Weed free check recorded higher yield attributing characters, seed yield and stover yield of mustard followed by pre-emergence application of oxadiargyl 80 % WP @ 100 g ha^{-1}. Though, weed free check without soil solarization was found the most profitable.

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