Integrated Weed Management of mustard crop *(Brassica juncea* L.*)* under mid-hill region of Himachal Pradesh

ABSTRACT

Aim: To study on Integrated Weed Management of mustard crop *(Brassica juncea* L.*)* under mid-hill region of Himachal Pradesh.

Study design: The field experiment was conducted in randomized block design (RBD).

Place and duration of study: A field experiment was carried out during 2022-2023 with the concept of integrated weed management at Abhilashi University Chail chowk Mandi (H.P.).

Methodology: eight treatment**s** were evaluated in randomized block design with three replications. T_1-Oxadiargyl 0.90 kg a.i.ha^{-1} (pre-emergence), T_2-Oxadiargyl0.90kgai. ha^{-1}(pre-emergence)+ twohandweedingat30and60DAS,T_3-Pendimethalin1.5 kga.i.ha^{-1} (pre-emergence)T_4-Pendimethalin0.75kga.i.ha^{-1}(pre-emergence)+onehandweedingat30DAS,T_5-Oxadiargyl0.90kga.i.ha^{-1}(pre-emergence)fbIPU0.75kga.iha^{-1}(postemergence),T_6-Pendimethalin0.75kga.iha^{-1}(pre-emergence)fbIPU0.75kga.iha^{-1}(post-emergence),T_7-Twohandweeding at30and 60DAS, T_8-Weedycheck.

Result: The investigation found that the most effective ways to control weeds are by keeping the area completely T_2-Oxadiargyl0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS, which involved keeping the area weed-free, was found to be the most successful in terms of achieving the lowest weed density and highest weed control efficiency.

Conclusion: Based on the results, it can be concluded that integrated weed management practices T_2-Oxadiargyl0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS, treatment is the most effective option for managing weeds in mustard crop.

Key words: mustard, weed population, weed control efficiency and weed control

1. INTRODUCTION

Mustard (*Brassica juncea* L.) is one of the major *rabi* oilseed crops of India. It is also known as Rai or Laha. India is one of the largest producers of mustard in the world. The term "mustard" refers to two species of the *Brassica* family that are strikingly similar to one another. Brown mustard, also known as Indian, Oriental, or *Sinapi's alba* L. and yellow mustard*, Brassica hirita*L*.* India is one of the largest producers of mustard in the world. Mustard is a cool-season, annual specialty cash crop with a shortened growth season that is often grown in rotation with small grains. The historical origin and current habitat of mustard are the temperate zones of Europe. India's contribution in the world production is 11.00 per cent with forth position in the world, next to China, Canada and Germany.

Among numerous constraints of mustard production technology, weed infestation is one of the major causes of low productivity **(**Singh et al. 2013**)**. Competition by weeds at initial stages is a major limiting factor to its productivity. Approximately, 15- 30% yield reduction is caused by weeds in mustard crop **(**Mishra et al. 2016**)**. Weed management is essential at initial stage of crop to avoid crop weed completion. The most critical period of this crop is varying according to agro-climatic condition varieties nature of weed and density of weed etc**..** Weeds can be controlled by several methods. Continuous use of the same method leads to build up of tolerant weeds to particular methods. Therefore, it is necessary to combine to other methods of weed control. Due to continuous use of same herbicide with same mode of action weeds become tolerant or resistant to those specific herbicides. Weeds compete with crop plants for water, light, space, and nutrients. Therefore, timely and appropriate weed control greatly increases the crop yield and thus nutrient use efficiency. The most common weeds that grow in rapeseed mustard are *Avena ludoviciana, Phalaris minor, Chenopodium album, Rumex dentatus, Anagallis arvensis, Convolvulus arvensis, Melilotus indica and Cirsium arvensis* (Singh and Kumar, 2020). The critical period of crop weed competition in mustard is 15-40 DAS and weeds cause about 25-50 % of yield loss (Yadav et al. 2017) depending on weed flora, intensity and stage of the crop.

Farmers have adopted herbicides for weed control because the chemicals can increase the profit, weed control efficiency, production flexibility and reduce time a labour requirement for weed management but this needs experimental testing. However, the continuous use of chemicals is detrimental to human and environmental health. The consequences generated by herbicide applications include declines in weed biomass, weed biodiversity, and soil quality (Jiang et al.2016, Robinson et al. 2002,Yu et al. 2015). Additionally, these practices foster the development and evolution of herbicides resistant weed species (Pieterse et al. 2010) and favor an insurgence of soil sickness Polverigiani et al. 2018**)**. Therefore, various herbicide mechanisms of action, especially using a mix of herbicides in the same tank, or practicing rotating herbicides from season to seasons, have been advocated to overcome the spread of herbicide resistant weeds (Beckie et al. 2006). The most common herbicidal weed control measure recommended in Indian mustard is the pre-emergence application of pendimethalin. Under situations when weeds are not taken care completely by pre-emergence application of herbicides, post-emergence herbicides may have an added economic advantage over super imposition of hand weeding. Therefore, it is imperative to find out an alternative weed management strategy for achieving season long weed control in Indian mustard.

2. MATERIAL AND METHODS

research project was conducted during the Rabi season of 2022-2023 at the Research Farm of the School of Agriculture, Abhilashi University Mandi (H.P.), India. The experimental farm is located at 30°32'N latitude and 74°53'E longitude, with an elevation of 1391 m above mean sea level. The soil has a slightly acidic reaction with a pH of 5.65, an electrical conductivity of 0.29, and organic carbon of 0.73. The available nitrogen is low (234.98), while the available phosphorus (13.67) and potassium (203.31) are medium. The net plot size was 3.4 m × 1.2 m, and the gross plot size was 3.7 m × 1.5 m. The observation was recorded at 30, 60, and 90 DAS and at harvest on weed parameters [viz., narrow and broadleaf weeds, including the number of weeds (No. m^2), weed dry matter accumulation (g/m^2), weed control efficiency (%), and weed index]. The mustard varietygold medal was sown manually in rows with a spacing of 15 cm and a seed rate of 100 kg ha-^{1}. The experimental design was a randomised block design (RBD) with seven treatments and three replications. The treatments, T_1-Oxadiargyl @ 0.90 kg a.i.ha^{-1} (pre-emergence), T_2-Oxadiargyl @ 0.90 kga.i. ha^{-1} (pre-emergence) + two hand weeding at 30 and 60 DAS, T_3-Pendimethalin @ 1.5 kga.i.ha^{-1} (pre-emergence), T_4-Pendimethalin @ 0.75 kga.i. ha^{-1} (pre - emergence) + one hand weeding at 30 DAS, T_5-Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence)fbIPU @ 0.75kga.i.ha^{-1}(postemergence), T_6-Pendimethalin @ 0.75 kg a.i.ha^{-1} (pre-emergence) fb IPU @ 0.75 kga.i.ha^{-1} (post- emergence), T_7-Two hand weeding at 30 and 60 DAS and T_8-Weedy check.In each experimental plot, an area of 1 m2 was fixed, and the number of weeds was recorded at 30, 60, and 90 DAS. The weed samples were sun-dried for three days and then oven-dried at 70 °C to ensure a consistent weight. Pendimethalin,Oxadiargyl, and isopoturonwere applied according to their respective treatments. No weed management was performed in the T_2Oxadiargyl 0.90 kg ha^{-1} (pre-emergence) + two hand weeding at 30 and 60 DAS

3. RESULT AND DISCUSSION

3.1 Weed studies

The weed flora observed in the experimental field was collected, identified and categorized into narrow-leaf and broad-leaf weeds. During the investigation in the experimental plots, several major weed species were observed included narrow-leaf weeds such as *Echinochloacrusgalli, Phalaris minor, Cynodondactylon, Cyprus rotandus*and broad leaf weeds such *as Parthenium hysterophorus., Anagallis arvensis L, Rumex spp. and Raphanus raphanistrum.*

1Narrow leaf weed density

The density of narrow leaf weeds was measured at 30, 60, 90 days after sowing (DAS), and at the harvest of the crop growth period. The results are presented in Table .1 and illustrated in Fig .1. The data showed that the density of narrow leaf weeds was significantly influenced by the weed control methods at all stages of crop growth.

The data regarding density of narrow leaf weeds at 30, 60, 90 DAS and at harvest revealed that there was fewer weed density under treatment T_2 (Oxadiargyl @ 0.90 kg a.i. ha^{-1} (pre-emergence) +two hand weeding at 30 and 60 DAS) since the weeds were being control timely as they appear by herbicides and hand weeding. This treatment was managed with lowest weed density throughout the growing period; hence it recorded (25.13, 18.66, 10.60 and 5.30 m^{-2}) weeds density over the other treatments. Among the rest of the treatments, T_7 (Twohandweeding at30and 60DAS) recorded the lowest weed density (26.11, 18.91, 16.45 &11.80 m^{-2}) followed by T_4 Pendimethalin @ 0.75kg a.i.ha^{-1}(pre-emergence)+onehandweedingat30DAS and T_5 Oxadiargyl @0.90kga.i.ha^{-1}(pre-emergence)fbIPU @ 0.75kg a.i ha(postemergence). It was observed that the weed density was decrease continuously with the aging of the crop. The highest weed density at 30, 60, 90 DAS and at harvest (37.05, 26.12, 16.45 and 11.80 m^{-2}) was found in treatment T_8 (weedy check). This could to be due to the broad-spectrum activity of herbicides, which works effectively on both narrow and broad-leaf weeds Singh et al. (2011). The reduction in weed density in hand weeding was due to periodic disturbances of the soil by removing the weeds with the help of hand tools. The application of herbicides also substantially reduces weed density. Similar result was found by Pandey et al. (2007) and Singh et al. (2008).

4.1.2 Broad leaf weed density

Density of broadleaf weed were recorded at 30,60,90 DAS and at harvest of crop growth period and presented in Table 2. illustrated in Fig .2. As per result indicated that the density of broad leaf weeds was significantly affected by weed control methods at all the stages of crop growth.

The data on the density of broadleaf weeds was recorded at 30, 60, 90 DAS, and at harvest. It was observed that there was less weed density under treatment T_2 (Oxadiargyl @ 0.90 kg a.i. ha^{-1} pre-emergence, +two hand weeding at 30 and 60 DAS) as the weeds were being controlled timely by herbicides and hand weeding. This treatment consistently maintained the lowest weed density throughout the growing period, recording 35.63, 25.56, 16.13, and 7.10 m^{-2} weed density over the other treatments. Among the other treatments, T_7 (Two hand weedings at 30 and 60 DAS) recorded the second lowest weed density at 36.60, 26.12, 16.90, and 7.66 m^{-2}, followed by T_4(Pendimethalin @ 0.75 kga.i. ha^{-1} pre-emergence + one hand weeding at 30 DAS) and T_5 (Oxadiargyl @ 0.90 kg ha^{-1} pre-emergence followed by IPU @ 0.75 kga.i.ha^{-1} post-emergence). It was observed that weed density decreased continuously as the crop aged. The highest weed density at 30, 60, 90 DAS, and at harvest (43.70, 36.61, 26.91, and 16.44 m^{-2}) was found in treatment T_8 (weedy check).

There are various effective herbicides (among which we have use Oxadiargyl and pendimethalin) available to manage narrow leaf and broadleaf weeds in mustard. Although some weeds may die as a result of higher weeds and the crop canopy's shade impact, herbicides should only be used as an additional tool, never as a cure. However, the regular application of any kind of control method, chemical or mechanical often results in a change in the weed population towards a species that is more challenging to eradicate. This finding has been reported by Sharma and Jain (2002). The use of herbicides significantly decreases weed density. Similar findings were reported Bazaya et al. (2004).

Table 1 Effect of integrated weed management practices on narrow leaf weed density (m^{-2}) in mustard crop

Sr. No.	Treatment	30DAS	60DAS	90DAS	At harvest
T_1	Oxadiargyl0.90kgha^{-1}(pre-emergence)	5.8 (33.10)	5.0 (24.90)	4.0 (15.21)	3.4 (10.90)
T_2	Oxadiargyl0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS	5.1 (25.13)	4.4 (18.66)	3.4 (10.60)	2.5 (5.30)
T_3	Pendimethalin1.5 kgha^{-1} (pre-emergence)	5.6 (31.11)	4.9 (23.25)	3.9 (14.81)	3.2 (9.40)
T_4	Pendimethalin0.75kgha^{-1}(pre-emergence)+onehandweedingat30DAS	5.3 (27.50)	4.4 (19.20)	3.7 (13.40)	2.6 (6.20)
T_5	Oxadiargyl0.90kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(postemergence)	5.4 (28.91)	4.6 (20.21)	3.8 (13.51)	2.8 (7.00)
T_6	Pendimethalin0.75kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(post-emergence)	5.4 (29.10)	4.7 (21.80)	3.8 (13.95)	2.9 (7.90)
T_7	Twohandweeding at30and 60DAS	5.2 (26.11)	4.4 (18.91)	3.5 (11.83)	2.6 (5.90)
T_8	Weedycheck	6.1 (37.05)	5.2 (26.12)	4.1 (16.45)	3.5 (11.8)
CD at 5 %		*0.004*	*0.011*	*0.015*	*0.002*
Sem±		*0.001*	*0.004*	*0.005*	*0.001*

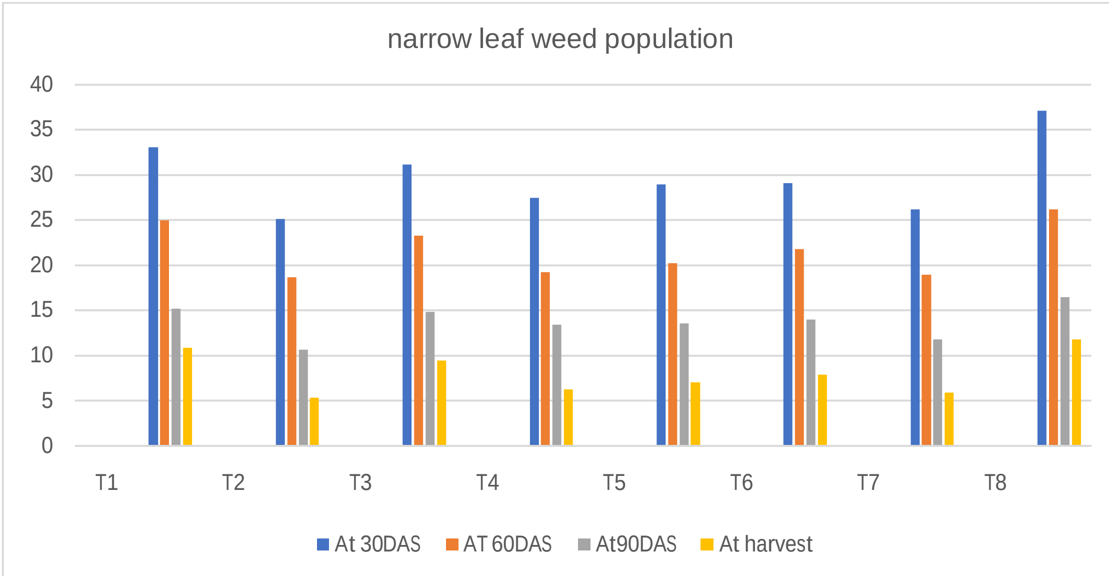

Fig.- .1: Effect of integrated weed management practices on narrow leaf weed density (m^{-2}) in mustard crop

4.1.3 Total weed density (m^{-2})

The total weed densitywas recorded at 30,60,90 DAS and at harvest of crop growth period and presented in Table 3. and illustrated in Fig .3. As per result indicated that the total weed density was significantly affected by weed control methods at all the stages of crop growth.

The total weed density 30, 60, 90 DAS and at harvest was revealed that there were less weed density under treatment T_2 (Oxadiargyl @ 0.90 kg a.i.ha^{-1} (pre-emergence) +two hand weeding at 30 and 60 DAS) since the weeds were being control timely as they appear by herbicides and hand weeding. This treatment was managed with lowest weed density throughout the growing period; hence it recorded (60.76, 44.22, 26.73, 12.40) weeds density over the other treatments. Among the rest of the treatments, T_7 (Twohandweeding at30and 60DAS) recorded the lowest weed density (62.71, 45.03, 28.73, and 13.56 m^{-2})followed by T_4 Pendimethalin @ 0.75kga.i.ha^{-1}(pre-emergence)+onehandweedingat30DAS and T_5 Oxadiargyl0.90kgha^{-1}(pre-emergence)fbIPU @ 0.75kga.i.ha^{-1}(postemergence). It was observed that the weed density was decrease continuously with the aging of the crop. The highest weed density at 30, 60, 90 DAS and at harvest 80.75, 62.73, 43.36 and 28.24 (m^{-2}) was found in treatment T_8 (weedy check).

Table 2 Effect of integrated weed management practices on broad leaf weed population in mustard crop

Sr. no.	Treatments	30 DAS	60 DAS	90 DAS	At harvest
T_1	Oxadiargyl0.90kgha^{-1}(pre-emergence)	6.4 (40.74)	5.7 (32.26)	4.8 (22.20)	3.7 (12.93)
T_2	Oxadiargyl0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS	6.0 (35.63)	5.1 (25.56)	4.1 (16.13)	2.8 (7.10)
T_3	Pendimethalin1.5 kgha^{-1} (pre-emergence)	6.4 (40.15)	5.6 (30.43)	4.4 (19.16)	3.5 (11.54)
T_4	Pendimethalin0.75kgha^{-1}(pre-emergence)+onehandweedingat30DAS	6.2 (37.63)	5.2 (26.81)	4.2 (17.10)	3.0 (8.16)
T_5	Oxadiargyl0.90kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(postemergence)	6.2 (38.64)	5.3 (27.56)	4.3 (17.53)	3.2 (9.36)
T_6	Pendimethalin0.75kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(post-emergence)	6.3 (39.66)	5.4 (28.31)	4.4 (18.81)	3.4 (10.89)
T_7	Twohandweeding at30and 60DAS	6.1 (36.60)	5.2 (26.12)	4.2 (16.90)	2.9 (7.66)
T_8	Weedycheck	6.6 (43.70)	6.1 (36.61)	5.2 (26.91)	4..1 (16.44)
	CD at 5 %	*0.046*	*0.005*	*0.005*	*0.007*
	Sem±	*0.015*	*0.001*	*0.002*	*0.002*

Pre-emergence application of Pendimethalin @ 1.0 kg/ha reduced the weed density which might be due to effective control of grassy and broad leaf weeds (Singh et al. 2020). Among the integrated weed management treatments, pendimethalin 750 g/ha PE fb one HW was effective against grassy, broad-leaved and sedge weeds Pendimethalin inhibits cell division and cell elongation in the root and shoot meristem resulted by inhibition of growth being absorbed through hypocotyls or shoot growth resulted in death of the germinated seedling. Integrated weed management is an effective tool for weed control in mustard, which have also been observed by Mukherjee (2014). Several authors reported that the reduction of weed density, weed dry matter and weed index due to application of pendimethalin (Patel et al., 2013, Kour et al., 2014 and Jangir et al., 2017).

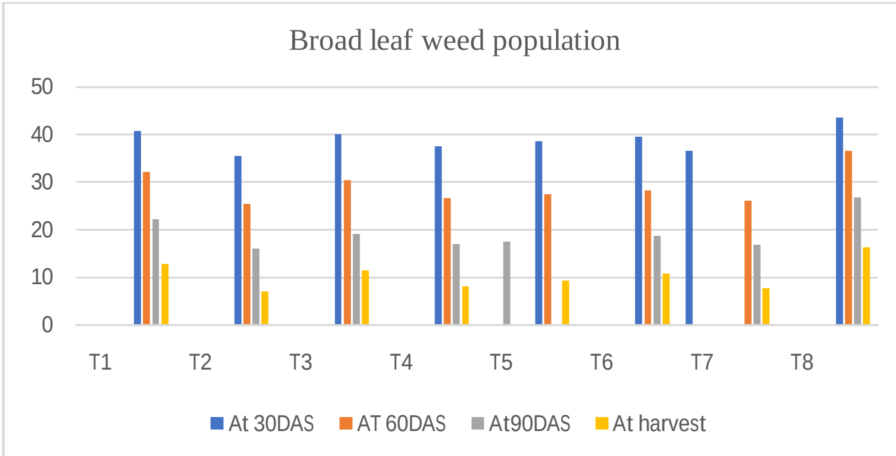

Fig.- .2: Effect of integrated weed management practices on broad leaf weed density (m^{-2}) in mustard crop

Table .3 Effect of Integrated weed management practices on mustard crop on total weed density (m^{-2}) in mustard crop

Treatment		30DAS	60 DAS	90 DAS	At harvest
T_1	Oxadiargyl0.90kgha^{-1}(pre-emergence)	8.6 (73.84)	7.6 (57.16)	6.1 (37.41)	4.9 (23.73)
T_2	Oxadiargyl0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS	7.8 (60.76)	6.7 (44.22)	5.2 (26.73)	3.6 (12.40)
T_3	Pendimethalin1.5 kgha^{-1} (pre-emergence)	8.5 (71.26)	7.3 (53.68)	5.9 (33.97)	4.6 (20.94)
T_4	Pendimethalin0.75kgha^{-1}(pre-emergence)+onehandweedingat30DAS	8.1 (65.13)	6.8 (46.01)	5.6 (30.50)	3.9 (14.36)
T_5	Oxadiargyl0.90kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(postemergence)	8.2 (67.55)	6.9 (47.77)	5.6 (31.04)	4.1 (16.36)
T_6	Pendimethalin0.75kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(post-emergence)	8.3 (68.76)	7.1 (50.11)	5.8 (32.76)	4.4 (18.79)
T_7	Twohandweeding at30and 60DAS	7.9 (62.71)	6.7 (45.03)	5.4 (28.73)	3.8 (13.56)
T_8	Weedycheck	9.0 (80.75)	7.9 (62.73)	6.6 (43.36)	5.4 (28.24)
F	*CD at 5 %*	0.034	0.039	0.014	0.011
i	*Sem±*	0.011	0.013	0.004	0.004

g.- .3: Effect of Integrated weed management practices on total weed density (m^2) in mustard crop

4.1.4 weed dry matter accumulation (gm^{-2})

The dry matter accumulation of total weed density (narrow and broad-leaved weeds) was recorded throughout the growing period and represented in Table .4 and illustrated in Fig .4. The perusal of data revealed that the various weed management treatments was significantly influenced the weed dry matter of the crop at all growth stages of mustard crop. The observations on total weed dry matter recorded in gm^{-2} was reported during the experiment, at all the growth stage, the treatment T_8 (weedy check). has the highest weed dry matter (6.80, 8.25, 12.80 and 13.95 gm^{-2}) which closely followed by treatment T_1Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence). Whereas, the minimum weed density and weed dry matter were noted under treatment T_2 (Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence)+ twohandweedingat30and60DAS) However, all the herbicidal treatment as well as other treatment were significantly superior in reducing total dry matter of weed over weedy check.

The reduction in total weed dry matter in these treatments was primarily due to the effective control of all monocots, dicots and sedges at early stages and as a consequence recorded lower total weed density at all growth stages. The results confirm with the findings of Bhadauria et al. (2012) This could be attributed to re-emergence and more accumulation of biomass in the weeds as they grew bigger with time. As the density of weeds decreases, their dry weight also decreases. The similar results finding by Jangir et al. (2017).

	Treatment	At 30 DAS	AT 60 DAS	At 90 DAS	At harvest
T_1	Oxadiargyl0.90kgha^{-1}(pre-emergence)	2.6 (5.91)	2.9 (7.66)	3.5 (11.52)	3.6 (12.02)
T_2	Oxadiargyl0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS	2.3 (4.73)	2.6 (5.81)	2.6 (5.81)	2.7 (6.64)
T_3	Pendimethalin1.5 kgha^{-1} (pre-emergence)	2.5 (5.63)	2.8 (7.13)	2.9 (7.66)	3.1 (8.76)
T_4	Pendimethalin0.75kgha^{-1}(pre-emergence)+onehandweedingat30DAS	2..4 (5.21)	2.7 (6.29)	2.7 (6.76)	2.8 (7.31)
T_5	Oxadiargyl0.90kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(postemergence)	2.5 (5.32)	2.7 (6.56)	2.8 (7.09)	2.9 (7.84)
T_6	Pendimethalin0.75kgha^{-1}(pre-emergence)fbIPU0.75kg/ha(post-emergence)	2.5 (5.46)	2.8 (6.94)	2.8 (7.32)	3.0 (8.46)
T_7	Twohandweeding at30and 60DAS	2.4 (5.02)	2.6 (6.11)	2.7 (6.32)	2.8 (7.12)
T_8	Weedycheck	2.7 (6.80)	3.0 (8.25)	3.7 (12.80)	3.8 (13.95)
	CD at 5 %	0.01	0.011	0.007	0.003

	Sem±	0.003	0.003	0.002	0.001

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ble 4 Effect of integrated weed management practices on weed dry matter accumulation (gm^{-2}) in mustard crop.

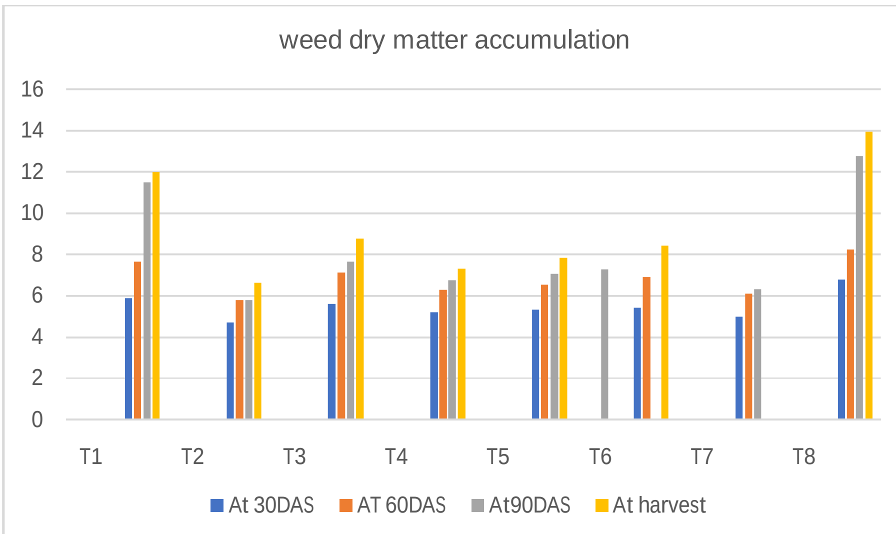

Fig.- 4: Effect of integrated weed management practices on weed dry matter accumulation (gm^{-2}) of mustard crop

4.1.5 Weed control efficiency (WCE) (%)

The weed control efficiency on the basis of dry matter accumulation of weeds was worked out in different treatments at the time of harvest. The data regarding WCE have been present in Table .5 and illustrated in Fig .5. As per result indicated that the weed control methods were significantly affected the weed control efficiency. For both narrow and broad leaf weed, the maximum WCE was recorded with treatment T_2 (Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence)+ two handweedingat30and60DAS) (52.40%) followed by treatment T_7 (Two hand weeding at 30 DAS and 60 DAS) which gave the next best next value ranged 48.49 per cent. The lowest weed control efficiency was observed under treatment T_8 (weedy check) because no measure has been taken to control weed during the experiment

Oxadiargyl, pendimethalin, Isoproturon, herbicides used to control only grassy weeds and in the experimental field density of grassy weeds was comparatively less as compared to broadleaved weeds. Thus, this was a main reason of lower WCE with this treatment over rest of the herbicidal treatments. Overall, the pendimethalin was found more effective to control the both types of weeds which resulted in higher WCE. It was because of the effective control of broadleaved and grassy weeds due to pendimethalin during both the years. These findings are in close conformity with those reported by Patel et al. 2013. Thus, both these treatments provided the crop better environment for luxuriant growth and later on, the crop itself acted as smoother crop and curbed the growth of weeds beneath the crop coverage. These results were also supported by Bamboriya et al., (2016), Chauhan et al., (2005) and Degra et al., (2011).

4.1.6 Weed Index (%)

The data pertaining to the weed index (%) under various weed management practices furnished in Table- 5 and illustrated in Fig.- .5. The analysis of data indicated that the weed index (%) was significantly influenced by different weed management practices. Among different treatments, the minimum weed index (0.00 %) was recorded under treatment T_8 (Weed check), whereas, the highest weed index (32.49 %) was observed under treatment T_2 (Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence)+ twohandweedingat30and60 DAS) in the present field investigation.

The crops faced increased stress as a result of uncontrolled weed growth, leading to lower yields. Chemical treatments that reduced the weed index were found more effective in suppressing weeds, providing better conditions for crop growth and ultimately increasing grain yields compared to weedy check treatments. Similar results were found (Patel et al., 2013)

Table 5 Effect of integrated weed management practices on weed control efficiency (%) and weed index (%) of mustard crop

	Treatments	Weed control efficiency	Weed Index
T_1	Oxadiargyl @ 0.90kgha^{-1}(pre-emergence)	13.83	21.48
T_2	Oxadiargyl @ 0.90kgha^{-1}(pre-emergence)+ twohandweedingat30and60DAS	52.40	0.00
T_3	Pendimethalin @ 1.5 kgha^{-1} (pre-emergence)	37.20	27.22
T_4	Pendimethalin @ 0.75kgha^{-1}(pre-emergence)+onehandweedingat30DAS	47.59	16.33
T_5	Oxadiargyl @ 0.90kgha^{-1}(pre-emergence)fbIPU @ 0.75kg/ha(postemergence)	43.79	12.32
T_6	Pendimethalin @0.75kgha^{-1}(pre-emergence)fbIPU @ 0.75kg/ha(post-emergence)	39.35	10.02
T_7	Twohandweeding at30and 60DAS	48.96	1.89
T_8	Weedycheck	0.00	32.49
	CD at 5 %	*0.064*	*0.058*
	Sem±	*0.021*	*0.019*

CONCLUSION

On the basis of findings of field experiment, it can be concluded that the application of Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence)+ twohandweedingat30and60DAS (T_2) revealed significantly minimum density of narrow weeds (m^{-2}), broad leaf weeds (m^{-2}), maximize the weed control efficiency (%) of mustard crop and minimized the weed index (%) in mustard crop during field investigation and it was followed by treatment T_7 [Twohandweeding at30and 60DAS] for the same parameters. However, the maximum density of narrow weeds (m^{-2}), broad leaf weeds (m^{-2}) and total weeds (m^{-2}), dry matter accumulation (g m^{-2}) of weeds, minimum weed control efficiency at all growth stages of mustard crop and maximum weed index in mustard crop were observed under weedy check treatment (T_8).

Among various weed management practices treatment T_2 [Oxadiargyl @ 0.90kga.i.ha^{-1}(pre-emergence)+ twohandweedingat30and60DAS] recorded the highest values of growth parameters *viz.,* Plant height (cm), number of branches (plant^{-1}) and dry matter accumulation (g m^{-2}), yield attributes like Number of seed siliquae^{-1}, and yields *i.e.,* Grain yield kg ha^{-1}, straw yield kg ha^{-1}and biological yield kg ha^{-1}] of mustard crop which was statistically at par with treatment T_7 [Twohandweeding at30and 60DAS]. While, the days to 50 % flowering, days to taken mature, effective plant population (No. m^{-2}), number of siliquae, test weight (g) and harvesting index (%) of mustard crop were found non-significant. However, treatment T_8 (Weedy check) recorded the minimum values of growth parameters, yield attributes characters and yield of mustard crop during field study.

The maximum cost of cultivation (₹ ha^{-1}), gross returns (₹ ha^{-1}), net returns (₹ ha^{-1}) and Net return per rupees invested of mustard crop were noted with the application of Oxadiargyl0.90kga.i.ha^{-1}(pre-emergence)+ twohandweedingat30and60DAS (T_2), While, the minimum cost of cultivation (₹ ha^{-1}), gross returns (₹ ha^{-1}), net returns (₹ ha^{-1}) and Net return per rupees invested of mustard crop was found under weedy check treatment (T_8) from the current field study.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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