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Effect of Integrated Weed Management on Weed Dynamics in Spring Maize

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ABSTRACT: Maize (*Zea mays* L.) is a versatile cereal crop farmed in a variety of environments and geographical areas for human nourishment, livestock feed and fodder, and industrial raw materials. Weeds are the major problem which causes 30-40 percent of the applied nutrients lost and 40-45% decreased crop yield. Chemical application leads to create herbicide resistant weed biotype. Integrated weed management is best option to manage weeds properly. Keeping in view, experiment was layout in RBD with 12 treatments and replicated thrice. Among all the treatments, the lowest weed density and its dry matter (DM) and highest weed control efficiency (WCE) was found in T_2 (weed free upto harvest), followed by T_3 (two hoeing at 15 and 30 DAS) which was statistically at par with T_{12} (CCRIJAF nail weeder at 6 and 20 DAE) and T_{11} (Residue mulch and hand pulling of weeds at 25 DAS). Among chemical methods, layby application of atrazine after 20 to 25 DAS (T_4) recorded lower WD, weed DM and higher WCE which was statistically similar with T_5 (layby application of pendimethalin), T9 (atrazine + tembotrione), T_8 (atrazine + halosulfuron) but statistically differed with Single dose applications of post-emergence herbicides like topramezone, tembotrione and halosulfuron.

Keywords: WCE, weed density, dry matter, tembotrione, halosulfuron, hand pulling, crop residue.

INTRODUCTION

Maize (*Zea mays* L.) is a major cereal crop farmed in a variety of environments and geographical areas for human nourishment, livestock feed and fodder, and industrial raw materials. It is grown in India on an area of 8.9 m ha with a production of roughly 23 m t and a yield of 2.58 t ha^{-1}. It is capable of harnessing solar energy more efficiently than some other cereal crops (Deewan *et al*., 2017; Kumawat *et al*., 2021).

With the advance of the monsoon, wider row spacing and crop sowing create a favorable environment for the weed growth. It not only helps the weeds absorb more nutrients than the crop by providing above and below ground competition for light, space, CO_2 and moisture. The maize fields are infested with almost all forms of weeds, including grasses, BLWs, and sedges during all the seasons. The amount of nutrients lost varies between 30 and 40 percent of the applied nutrients (Mundra *et al.,* 2002). Maximum crop weed competition in maize crops occurs two to six weeks after sowing (Sandhu and Gill 1973). If weeding is not done during this time, yield characteristics may be irrevocably harmed. So, it is generally known that, the first 30 days following sowing were crucial for weed competition in maize (Krishnamurthy *et al*., 1981). According to Pandey *et al.* (2001), weeds are a substantially negative element for agricultural productivity, which are responsible for a significant loss of crop yield (28-100%).

Weeding by hand is inconvenient, time-consuming, and costly. However, in light of these facts, it is required to evaluate integrated weed management approaches incorporating manual methods, hoeing, mulching, and low herbicide rates that can provide broad spectrum weed control in maize while minimizing residual toxicity in subsequent crops at a low cost (Pandey and Ved-Prakash 2002; Meyyappan and Kathiresan 2005). Keeping these points in view an experiment was conducted to know the effect of integrated weed management on weed density and their dry matter accumulation and WCE in maize.

MATERIAL AND METHOD

Experimental site. The experiment was conducted at the fields of Lovely Professional University Farm, Jalandhar (Punjab) during spring season of 2022. This field is situated at 310 22′31.81 North Latitude and 750 23′03.02 East longitude, with an average elevation and with 252m MSL.

Experimental field comes under Trans-Gangetic plains region dominating with alluvial soil. Winters being cool, summers being hot and a period of distinctive rains. This area has an annual precipitation of 703.0 mm. Even though the winters are cold, the temperature never goes below zero degrees even during the peak cold months i.e. December to January and lowest temperature ranges between 4-10°C. The peak temperature in the summer ranges between 45°C to 48°C during mid of May to mid of June which occurs rarely and the normal temperature during summer remains between 35°C to 45°C.

Treatment details. The experiment was arranged with Randomized Block Design (RBD) with 12 treatments and replicated thrice *viz*., T1:Control (weedy check), T2: Weed free check (full duration), T3: Weed free upto DAS (2 hoeing at 15 and 30 DAS),T4: Lay by application of Atrazine (0.75 kg a.i/ha) after one hoeing at 15 to 20 DAS, T5: Lay by application of Pendimethalin (0.75 kg a.i/ha) after one hoeing at 15 to 20 DAS,T6:Halosulfuron @ 67.5 g ha^{-1} at 2-3 leaf stage, T7:Tembotrione@120 g ha^{-1} at 2-3 leaf stage, T8: Atrazine (0.75 kg a.i/ha) as pre-emergence + Halosulfuron @67.5 g ha^{-1}at 25DAS, T9: Atrazine (0.75 kg a.i/ha) as pre-emergence + Tembotrione @ 120 g ha^{-1}at 25 DAS, T10: Maize + rice crop residue as mulch and hand pulling of weeds at 25DAS, T11:Topramezone (25.2 g ha^{-1}) as post emergence application and T12: CRIJAF nail weeder at 6 days after emergence and 20 days after emergence.

Maize variety PMH-10 was obtained from Punjab Agricultural University, Ludhiana. Sowing was done at a depth of 5 to 6 cm with spacing of 60 × 20 cm. Recommended dose of fertilizer (120: 60: 40 NPK kg/ha) wasapplied.50 percent of nitrogen and full dose of phosphorus and potassium were applied at the time of sowing and remaining 50% of nitrogen was applied in two splits, one at knee high stage and other at tasseling stage. Crop sowing was done on 12th Feb 2022 and harvested on 2nd June 2022.

Statistical analysis. Data on weed parameters in maize with different treatments was analyzed by using `statistical design randomized block design (Gomez and Gomez, 1984). The value of "F" was worked out and compared with the value of table "F" at 5 per cent level of significance. Original values are square root transformed and the original values are mentioned in parenthesis. The values of S.Em+ and CV percent along with critical difference values were also calculated for all parameters.

RESULTS AND DISCUSSION

Weed flora. Diversity of weeds were observed in experimental field, which were divided into sub groups *i.e.,* narrow leaf and broad leaf weed (Table 1). The dominant weed floras are listed below with their common name, botanical name and family. Among them *Cynodon dactylon, Cyperus rotundus, Dactyloctenium aegyptium* and *Chenopodium album* are dominant spp. According to Sharma *et al*. (2018) predominant weeds were *Cynodon doctylon, Cyperus rotundus, Ludwigia parviflora* and *Fimbristylis miliacea in* Bihar. Kumar *et al*. (2015) noticed that, the dominant weeds live together with maize are *Brachiaria ramosa, Sorghum halepense, Digitaria sanguinalis, Echinochloa colonum, Setaria glauca, Panicum spp., Cynodon dactylon, Eleusine indica, Digitari asetigera, Leptochloa chinensis* and *Digitaria ciliaris.* Mixed weed flora, consisting of *Echinocloa colonum, Portulaca oleraceae, Echinocloacrusgalli, Digera arvensis, Trianthema portulacastrum, Commelina benghalensis and Phyllanthus niruri*are dominant weed flora in Rajasthan (Chalka and Nepalia 2006).

Table 1: Different weed floras found in the experimental field.

Sr. No.	Botanical name	Common name	Family
A.	**Narrow leaf weed**		
1.	*Cynodon dactylon*	Bermuda grass, Doob, Hariali	*Poaceae*
2.	*Cyperus rotundus*	Purple nutsedge	*Cyperaceae*
3.	*Cyperus esculentus*	Yellow nutsedge	*Cyperaceae*
4.	*Digitaria sanguinalis*	Crabgrass	*Poaceae*
5.	*Setaria glauca*	Green foxtail	*Poaceae*
6.	*Dactyloctenium aegyptium*	Crowfoot grass	*Poaceae*
7.	*Agrostis gigantea*	Black bent	*Poaceae*
B.	**Broad leaf weed**		
8.	*Parthenium hysterophorus*	Congress grass	*Partheniaceae*
9.	*Chenopodium album*	Bathua	*Amaranthaceae*
10.	*Amaranthus viridis*	Amaranthus	*Amaranthaceae*
11.	*Phyllanthus niruri*	Hazar dana	*Phyllanthaceae*
12.	*Commelina beghalensis*	Creeping dayflower	*Commelinaceae*
13.	*Euphorbia hirta*	Hairy Spurge,Asthma Weed	*Euphorbiaceae*
14.	*Trianthema portulacastrum*	Giant pigweed	*Aizoaceae*

Weed Density. All the weed control treatments significantly reduced weed population at 30, 60, 90 DAS and at maturity as compared to that in weedy check plots (Table 2). Weed free was found to be very effective in reducing the weed density and their growth. The lowest total density of weeds was observed in weed free up to harvest at 30, 60, 90 DAS and at maturity followed by weed free by two hoeing at 15 and 30 DAS CRIJAF nail weeder @ 6 and 20 days after emergence and Maize + rice residue as mulch and hand pulling of weeds at 25 DAS are superior over chemical control methods at 30 DAS (7.12 to 7.78 no.) same trend was followed in rest of the periods. Among the chemical control methods, lay by application of atrazine (0.75 $kgha^{-1}$) as PE after one hoeing at 15 to 20 DAS was seen a smaller number of total weed population at all the stage of crop growth followed by lay by application of pendimethalin (0.75 $kgha^{-1}$) as pre-emergence herbicide after one hoeing at 15 to 20 DAS. Better result was record in combination application of herbicide i.e. pre-emergence atrazine (0.75 $kgha^{-1}$) at 25 DAS + tembotrione (120 gha^{-1}) + than the combination application pre emergence atrazine (0.75 $kgha^{-1}$) + halosulfuron (67.5$kgha^{-1}$) + at 25 DAS (9.10 to 9.98 no.) but both are statistically similar with layby application atrazine and pendimethalin. However, the individually used post emergence herbicides *i.e.* topramezon (25.2 gha^{-1}), tembotrione (120 gha^{-1}) at 2-3 leaf stage and halosulfuron (67.5$kgha^{-1}$) at 2-3 leaf stage was seen higher weed density after weedy up to harvest. Lower weed density was observed in these treatments due to PE application of atrazine hoeing at 20 to 25 DAS which might have effectively controled BLW, grasses and sedges at early stage of crop growth and later POE application of tembotrione and halosulfuron have controlled the late germinated BLW and grasses as compared to other treatment combinations. Similar results were also revealed by Arunkumar *et al*. (2019); Satyendra *et al.* (2018); Vikram *et al.* (2017).

Table 2: Effect of integrated weed management on weed density (no.) in spring maize during 2022.

Treatment	Weed density (no.)			
	30 DAS	60 DAS	90 DAS	at maturity
T1 Control (weedy check)	4.47 (19.00)	5.26 (26.67)	6.15 (36.83)	6.20 (37.50)
T2 Weed free (full duration)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T3 Weed free (2 hoeing at 15 and 30 DAS)	2.85 (7.12)	2.16 (3.67)	1.77 (2.12)	1.76 (2.09)
T4 Lay by application of Atrazine (0.75 kg a.i/ha) after one hoeing at 15 to 20 DAS	3.18 (9.10)	2.55 (5.50)	2.35 (4.50)	2.17 (3.71)
T5 Lay by application of Pendimethalin (0.75kg a.i/ha) after one hoeing at 15 to 20 DAS	3.22 (9.38)	2.59 (5.70)	2.42 (4.83)	2.22 (3.95)
T6 Halosulfuron @ 67.5 g/ha at 2-3 leaf stage	3.90 (14.20)	3.15 (8.94)	2.90 (7.40)	2.66 (6.05)
T7 Tembotrione @120 g/ha at 2-3 leaf stage	3.81 (13.49)	3.09 (8.58)	2.77 (6.70)	2.51 (5.29)
T8 Atrazine (0.75 kg a.i/ha) as pre-emergence + Halosulfuron @ 67.5 g/ha at 25DAS	3.31 (9.98)	2.66 (6.10)	2.59 (5.70)	2.42 (4.86)
T9 Atrazine (0.75 kg a.i/ha) as pre-emergence + Tembotrione @ 120 g/ha at 25 DAS	3.23 (9.43)	2.60 (5.77)	2.45 (5.01)	2.26 (4.09)
T10 Maize + rice crop residue as mulch and hand pulling of weeds at 25 DAS	2.96 (7.78)	2.24 (4.02)	2.03 (3.11)	1.96 (2.83)
T11 Topramezone (25.2 g/ha) as post emergence application	3.80 (13.45)	3.05 (8.30)	2.76 (6.63)	1.18 (2.27)
T12 CRIJAF nail weeder at 6 days after emergence and 20 days after emergence	2.86 (7.17)	2.17 (3.70)	1.81 (2.26)	1.81 (2.27)
SE(m)±	0.02	0.01	0.02	0.02
CD (p=0.05)	0.06	0.04	0.06	0.06

*Original data in parenthesis subjected to square root transformation($\sqrt{X+1}$)

Weed dry matter. In general, weed dry matter was higher due to higher weed population. During the crop growth season, the dry matter of weeds at 30, 60, 90 and 120 DAS was significantly differed in all the weed control treatments over the weedy check (Table 3). At 30 days after sowing, the lowest weed dry matter was recorded in weed free plot followed by two hoeing operation, CRIJAF nail weeder and residue mulching (37.73 to 49.33 g m^{-2}). The same trend is followed at 60, 90 and 120 DAS. But among the herbicide application layby application of atrazine after one hoeing at 15 to 20 DAS (58.47 g m^{-2}) is better performer and layby application of pendimethalin after one hoeing at 15 to 20 DAS, Atrazine + Tembotrione and Atrazine + halosulfuron are statistically similar (55.60 to 69.10 g m^{-2}). The lowest weed population and dry matter found in two hoeing followed by other mechanical method I could be attributed to effectively control of grassy and non-grassy weeds by hoeing at predetermined intervals which resulted in reduction of dry matter production by weeds. These findings are correlated with Arunkumar *et al.* (2019); Sharma (2015); Nagalakshmi (2002).

Table 3: Effect of integrated weed management on total dry weight of weeds (g m^{-2}) in spring maize during 2022.

Treatment	Total dry weight of weeds (g m^{-2})			
	30 DAS	60 DAS	90 DAS	at maturity
T1 Control (weedy check)	10.22 (103.47)	10.75 (114.57)	12.84 (163.83)	12.85 (164.10)
T2 Weed free (full duration)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T3 Weed free (2 hoeing at 15 and 30 DAS)	6.22 (37.73)	4.75 (21.57)	2.27 (4.15)	2.05 (3.21)
T4 Lay by application of Atrazine (0.75 kg a.i/ha) after one hoeing at 15 to 20 DAS	7.52 (55.60)	6.03 (35.40)	2.67 (6.13)	2.59 (5.72)
T5 Lay by application of Pendimethalin (0.75kg a.i/ha) after one hoeing at 15 to 20 DAS	7.71 (58.47)	6.09 (36.12)	2.71 (6.35)	2.67 (6.12)
T6 Halosulfuron @ 67.5 g/ha at 2-3 leaf stage	9.81 (95.27)	7.47 (54.80)	5.42 (28.40)	5.14 (25.40)
T7 Tembotrione @120 g/ha at 2-3 leaf stage	8.90 (78.20)	7.11 (49.50)	4.43 (18.60)	4.64 (20.51)
T8 Atrazine (0.75 kg a.i/ha) as pre-emergence + Halosulfuron @ 67.5 g/ha at 25DAS	8.39 (69.10)	6.52 (41.50)	2.98 (7.86)	2.99 (7.96)
T9 Atrazine (0.75 kg a.i/ha) as pre-emergence + Tembotrione @ 120 g/ha at 25 DAS	7.82 (60.10)	6.23 (37.80)	2.82 (6.96)	2.75 (6.57)
T10 Maize + rice crop residue as mulch and hand pulling of weeds at 25 DAS	7.09 (49.33)	5.39 (28.07)	2.51 (5.28)	2.50 (5.24)
T11 Topramezone (25.2 g/ha) as post emergence application	8.67 (74.20)	7.04 (48.60)	4.00 (15.03)	4.02 (15.15)
T12 CRIJAF nail weeder at 6 days after emergence and 20 days after emergence	6.36 (39.46)	5.05 (24.48)	2.30 (4.30)	2.21 (3.86)
SE(m)±	0.05	0.05	0.02	0.03
CD (p=0.05)	0.13	0.15	0.07	0.09

*Original data in parenthesis subjected to square root transformation ($\sqrt{X+1}$)

Weed control Efficiency. Effect of integrated weed management on weed control efficiency is statistically differed with each other at 30, 60, 90 DAS and at harvest during 2022 (Fig. 1). Among all the weed control treatments the maximum weed control efficiency was recorded in weed free up to harvest of the crop showed superior over the other treatments. Two hoeing operations at 15 and 30 DAS by CRIJAF nail weeder operation carried plot and in maize + rice straw mulching plot performed well and statistically similar with each other. Among the herbicidal application treatments, the maximum weed control efficiency was recorded in lay by application of atrazine (0.75 kgha^{-1}) after one hoeing at 15 and 20 DAS followed by lay by application of pendimethalin (0.75 kgha^{-1}) after one hoeing at 15 and 20 DAS which are statistically similar with pre-emergence atrazine (0.75 kgha^{-1}) + tembotrione (120gmha^{-1}) and pre-emergence atrazine (0.75 kgha^{-1}) + halosulfuron (67.5kgha^{-1}). Performance of post emergence application of topramezone, tembotrione and halosulfuron was low. Plots kept weed free throughout the season were achieved 100% WCE. Similarly, mechanical management of weeds by hoeing, CRIJAF nail weeder and residue mulch performed superior than the herbicide application. Due to continuous application of herbicides on the same field decreases the weed controlling capacity. Similarly, Kumar *et al.* (2015) also noticed that, early post-emergence application of atrazine @ 0.25 kg/ha to 1.5 kg/ha have controlled the weeds superiorly with WCE (36- 76%). This may be due to reduction of weed dry weight as a result of broad spectrum weed control and elimination of weeds competition within crop weed compition period in these treatments. These results are also in harmony with the results of Nazreen and Subramanyam (2017); Parul *et al.* (2017); Vikram *et al.* (2017).

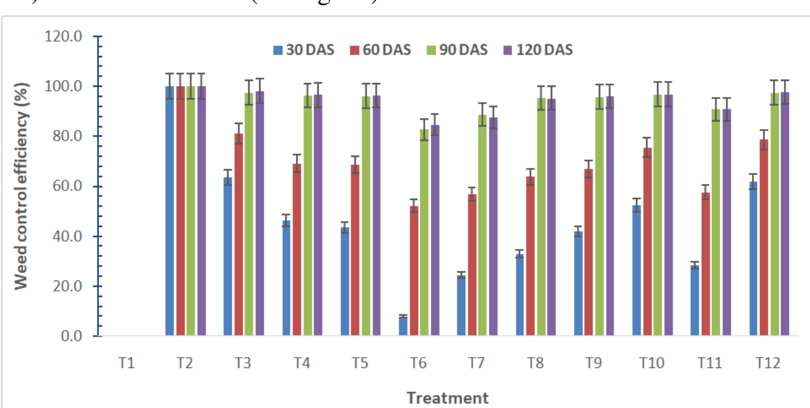

Fig. 1. Effect of integrated weed management on weed control efficiency (%) in spring maize during 2022.

CONCLUSION

Effect of different weed management methods significantly differed with respect to weed dynamics in spring maize. Weed free up to maturity of the crop showed superior control with recording the lowest weed population, and WD and higher WCE when compared to other weed management methods. Keeping the plot weed free by two hoeing at 15 and 30 DAS has recorded better weed control and was statistically similar with other mechanical methods like CRIJAF weeder at 6 and 20 DAE of crop and maize + rice crop residue mulch. Among chemical methods, lay by application atrazine was better than layby application of pendimethalin and atrazine (PE) + tembotrione (POE) but statistically similar with each other. Single dose of POE herbicides showed less control over weeds. Whereas, the highest WD and its DM and lowest WCE was found in weedy check.

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Conflicts of Interest. None.

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