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Influence of organic and inorganic herbicides on weed growth in maize (*Zea mays* L.)

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Abstract
The field experiment was conducted at Research farm of Department of Agronomy, Lovely Professional University, Phagwara, Punjab during *kharif* season of 2022-2023 to find out the effective weed control treatment in maize. The experiment consisted of ten treatments and three replications *viz.* T_1 weedy check (control), T_2 weed free, T_3 Acetic acid (10%), T_4 Acetic acid (20%), T_5 Eucalyptus Aqueous Extract 25%, T_6 Pendimethalin 35% EC, T_7 Atrazine 50% WP, T_8 Pendimethalin 35% EC + Atrazine 50 WP, T_9 Tembotrione 34.4% SC and T_{10} Tembotrione 34.4% SC+ Atrazine 50% WP. Among the herbicide treatments, application of T_{10} Tembotrione 34.4% SC+ Atrazine 50% WP effectively reduced the weed density as well as weed dry matter accumulation species wise (*Echinochloa colona, Cyperus rotundus, Digera arvensis, Digitaria sanguinalis, Parthenium hysterophorus, Phyllanthus niruri*) and total weed dry matter production. Weed control efficiency also higher in same treatment after T_2 (weed free) plot. In terms of controlling the weeds inorganic herbicide treatments quite effective as compared to organic treatments.

Keywords: Acetic acid, dry matter, eucalyptus aqueous extract, weed control efficiency

Introduction
Maize (*Zea mays*) was first cultivated around 9000 years ago in Mexico, and Later, it expanded throughout the America. In general, maize is a cereal grain. Maize (*Zea mays*) is the major crop in the world after rice and wheat. It is grown as a food crop in northern India. It is mostly grown as a kharif crop in India. It is known as queen of cereals in India. The area under maize cultivation in India is around 9.2 million ha during the year 2018-19. Oil, starch, calories, proteins, fibre, and vitamins are all abundant in maize grain. It is eaten raw, roasted, boiled, or prepared like a vegetable by humans. Maize leaves and stalks can be fed to animals raw or turned into silage or hay for long-term use. Male portions (placed on the apex of the plant) and on the same plant female portions (found in the mid or above-mid region of the stem called ear) are produced separately. Maize is also used in the manufacturing of biofuel, pigments, plastic, and fibre. Dent corn, flint corn, pod corn, flour corn, sweet corn, and other types of maize can be classified based on grain properties and applications popcorn, waxy corn, and amylomaize [1]. Maize is commonly sown in the *kharif* or *spring*. Weeds in maize field will reduce the yield by competing with crop for space, light, and nutrients. Weed infestation is one of the biggest restrictions to maize production in India, as well as one of the plant biotic stressors.

Weeds grow faster than the crop in this highly competitive environment in the same set of growth conditions. Weeds, or undesirable plants, are more adaptable and prolific than other plants. By infesting other crop fields, they can increase their growth rate, compete for growth elements such as water and nutrients, and diminish crop production Up to 40% of the world's population the threat of weeds has an impact on maize yield. Weed infestations have been observed in large numbers. Because of the weeds, the yield will be reduced by up to 35% to 80% among other biotic stressors, are the most important of this harvest (Oerke and Dehne, 2004). Generally speaking, Weeds have the biggest potential for loss (37%) and are the most difficult to eradicate. Fungal loss potential is larger than that of insect pests (18%). bacterial pathogens (16%), and viruses (2%), according to [2].

However, heavy infestation by grassy and broad-leaved weeds and sedges may be a major constraint upon maize production. Herbicides have a wide range of side effects, from skin rashes to death. Intentional or unintentional direct consumption, as well as inappropriate nutrition, can all lead to an attack pathway. Residual activity: An herbicide is said to have low residual activity if it is neutralised quickly after application (within a few weeks or months) - this is usually due to rainfall or soil reactions an organic herbicide, according to this definition, is one that can be used in a certified organic farming operation. They are often used in conjunction with cultural and mechanical weed control strategies and may be less effective than synthetic herbicides depending on the application. It inhibits surface growth but not subsurface development, necessitating respraying to treat perennial regrowth. Organic farmers have a distinct advantage over conventional farmers. Excellent products for controlling insects and plant pathogens, allowing for the creation of new, more effective pesticides One of their most pressing needs is weed management equipment. Furthermore, the appeal of "greener" technologies has begun to grow to have an impact on traditional agriculture. Herbicides that are ideal are intended to be non-toxic to plants, effective at controlling weeds, affordable, and have no detrimental influence on the environment. Organic herbicides are non-toxic and biodegradable. soil microorganisms as a carbon source in the soil Spreading acetic acid will allow it to enter the soil surface. Microorganisms will quickly degrade it has no biological accumulating potential or cross-contamination [3].

Materials and Methods

The experiment was conducted at the Research Farm of Department of Agronomy, Lovely Professional University, Phagwara, Punjab in *kharif* 2022. The study area is in Chaheru village of Kapurthala district, which lies in the northern plain zone between 31.26° N, 75.70°E. The design used for this experiment is 'Randomized Block Design' with 3 replications and 10 treatments *viz* weedy check (control), weed free Acetic acid (10%), Acetic acid (20%), Eucalyptus Aqueous Extract 25%, Pendimethalin 35% EC, Atrazine 50% WP, Pendimethalin 35% EC + Atrazine 50 WP, Tembotrione 34.4% SC and Tembotrione 34.4% SC+ Atrazine 50% WP. Syngenta TA 5084 variety was sown on 13th June, 2022 at seed rate of 20 kg per hectare, with spacing 60 X 20 cm. The fertilizer application was done as per the package and practices of Punjab Agricultural University. Six irrigations were applied after sowing, four-leaf stage, knee height stage, tasselling stage, skilling stage and dough stage.

Spp by weed count at monthly interval

Species wise Weed count was taken from each plot by using quadrant of 50X50 cm^2 at regular intervals of 30, 60, 90 DAS at harvest. Quadrant was thrown randomly in each plot.

Spp by weed dry weight at monthly interval

Species wise weeds were collected and kept in brown bags and placed in hot air oven at 70 °C till constant weight is achieved. After constant weight is achieved weeds are taken out and their dry weight was taken at regular intervals (30, 60, 90 DAS and at harvest).

Total weed count and total dry weight at monthly interval:

Total weed count is taken by adding all the weeds and total dry weight is taken by adding all the dry weights of weeds at regular intervals of 30, 60,90 DAS at harvest.

Weed control efficiency (%)

Weed control efficiency (WCE) denotes the magnitude of weed reduction due to weed control treatment. It was worked out by using the formula suggested by [4] and expressed in percentage.

$$WCE\ (\%) = \frac{\text{Dry weight of weeds in control plot} - \text{Dry weight of weeds in treated plots}}{\text{Dry weight of weeds in treated plots}} X\ 100$$

Weed index (%)

Weed index is defined as the magnitude yield reduction due to presence of weeds in comparison with weed free check [5].

$$WI\ (\%) = \frac{\text{Yield from weed free plot} - \text{Yield from treated plots}}{\text{Yield from weed free plot}}\ X\ 100$$

Results and Discussion

Weed parameters

The effect of various inorganic and organic treatments on weed parameters were significantly effective.

Species wise Weed count

Data presented in the Table 1 indicated that the species wise weed count of all the weeds species (*Echinochloa colona, Cyperus rotundus, Digera arvensis, Digitaria sanguinalis, Parthenium hysterophorus, Phyllanthus niruri*) were significantly low in the T_2 (weed free plots) followed by the inorganically treated plots like T_{10} (Tembotrione 34.4% SC+ Atrazine 50% WP), T_8 (Pendimethalin 35% EC + Atrazine 50 WP), T_9 (Tembotrione 34.4% SC). A significant higher weed count was recorded in T_1 (control plot). Similar results were reported by [6].

Species wise Weed dry matter

Table 2 revealed that species wise weed dry matter accumulation of species (*Echinochloa colona, Cyperus rotundus, Digera arvensis, Digitaria sanguinalis, Parthenium hysterophorus, Phyllanthus niruri*) were significantly low in the T_2 (weed free plots) followed by the inorganically treated plots like T_{10} (Tembotrione 34.4% SC+ Atrazine 50% WP), T_9 (Tembotrione 34.4% SC), T_8 (Pendimethalin 35% EC + Atrazine 50 WP) as compared to organic treated plots. A significant higher weed count was recorded in T_1 (control plot) [7]. Also found similar results.

Table 1: Effect of inorganic and organic treatments on Species wise Weed count

S. No.	Treatments	Species wise Weed count at 60 DAS					
		Digitaria sanguinalis	*Cyperus rotundus*	*Digera arvensis*	*Echinochloa colona*	Other weeds	Total weeds
1	Control	4.3** (18.7)*	5.3 (26.7)	4.3 (18.7)	6.6 (42.7)	1.9 (4.0)	16.4 (270.1)
2	Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
3	Acetic acid (10%) (Pre plant incorporation)	2.9 (9.3)	4.6 (22.7).	3.9 (18.7)	3.7 (13.3)	3.5 (12.0)	16.0 (255.3)
4	Acetic acid (20%) (Pre plant incorporation)	2.0 (4)	4.5 (20.0)	3.9 (14.7)	6.4 (41.3)	2.1 (4.0)	14.5 (210.9)
5	Eucalyptus Aqueous Extract 25% (Pre-emergence)	1.8 (5.3)	1.0 (0.0)	3.8 (13.3)	5.6 (33.3)	1.7 (2.7)	13.9 (192.4)
6	Pendimethalin 35% EC (Pre-emergence)	1.3 (9.3)	3.8 (17.3)	3.6 (12.0)	1.0 (0.0)	1.8 (2.7)	13.2 (173.9)
7	Atrazine 50% WP (Pre-emergence)	1.4 (1.3)	3.5 (14.7)	2.5 (5.3)	2.5 (6.7)	1.7 (2.7)	13.0 (170.2)
8	Pendimethalin 35% EC + Atrazine 50 WP (Pre-emergence)	1.0 (0.0)	3.4 (13.3)	2.3 (5.3)	1.9 (4.0)	1.0 (0.0)	8.4 (70.3)
9	Tembotrione 34.4% SC (Post-emergence)	1.0 (0.0)	1.4 (1.3)	1.4 (1.3)	1.0 (0.0)	1.0 (0.0)	9.5 (88.8)
10	Tembotrione 34.4% SC+ Atrazine 50% WP (Post-emergence)	1.0 (0.0)	2.5 (14.7)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	7.4 (55.5)
SE (m) ±		0.6	1.0	0.6	0.6	0.5	0.7
LSD+P=0.05)		1.8	2.9	1.9	1.8	NS	2.1

*Values given in paranthesis are the mean of original values, **Data subjected to $\sqrt{(X+1)}$ square root transformation

Table 2: Effect of inorganic and organic treatments on Species wise Weed dry matter

S. No.	Treatments	Species wise Weed dry matter at 60 DAS							
		Digitaria sanguinalis	*Cyperus rotundus*	*Digera arvensis*	*Echinochloa colona*	Other weeds	Total weeds	Weed control efficiency	Weed index
1	Control	5.5** (30.0)*	5.1 (27.6)	7.5 (59.3)	12.8 (162.8)	2.2 (4.1)	16.5 (270.6)	0.0	49.0
2	Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	93.9	0.0
3	Acetic acid (10%) (Pre plant incorporation)	2.4 (8.4)	5.0 (24.0)	7.4 (53.7)	12.7 (161.2)	1.8 (2.3)	15.5 (238.7)	10.6	33.9
4	Acetic acid (20%) (Pre plant incorporation)	2.5 (10.1)	3.8 (14.0)	6.9 (47.3)	9.8 (112.9)	1.8 (2.6)	14.7 (215.0)	5.9	27.7
5	Eucalyptus Aqueous Extract 25% (Pre-emergence)	2.5 (9.3)	1.0 (0.0)	6.9 (63.7)	5.4 (28.5)	1.7 (2.8)	14.2 (200.8)	14.1	67.2
6	Pendimethalin 35% EC (Pre-emergence)	3.7 (13.5)	3.5 (14.5)	6.3 (38.8)	1.0 (0.0)	1.5 (1.6)	10.4 (106.8)	36.8	13.4
7	Atrazine 50% WP (Pre-emergence)	1.7 (2.9)	2.9 (9.9)	5.1 (28.0)	3.2 (13.3)	1.5 (1.6)	10.2 (103.5)	37.8	11.3
8	Pendimethalin 35% EC + Atrazine 50 WP (Pre-emergence)	1.0 (0.0)	1.1 (0.3)	1.7 (2.7)	2.6 (11.2)	1.0 (0.0)	6.7 (44.8)	59.1	0.8
9	Tembotrione 34.4% SC (Post-emergence)	1.0 (0.0)	3.1 (11.1)	2.7 (7.0)	1.0 (0.0)	2.1 (4.0)	5.1 (25.0)	69.1	10.4
10	Tembotrione 34.4% SC+ Atrazine 50% WP (Post-emergence)	1.0 (0.0)	2.4 (4.7)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	2.4 (4.7)	85.5	1.9
SE (m) ±		0.9	0.8	1.2	1.2	0.4	0.5		
LSD+P=0.05)		2.7	2.4	3.5	3.5	NS	1.5		

*Values given in parentheses are the mean of original values, **Data subjected to $\sqrt{(X+1)}$ square root transformation

Total weed count and total dry weight at monthly interval:
Weed count and dry weight of total weeds was significantly lower in the weed free plot during all stages of observation in the experiment plot. Plots treated with Pendimethalin 35% EC + Atrazine 50 WP (pre-emergence), Tembotrione 34.4% SC (post-emergence), and Tembotrione 34.4% SC+ Atrazine 50% WP (post-emergence) were statistically comparable to superior treatments at all observational stages. During all stages of observation, there was a significantly higher total weed count and dry weight was recorded in the weedy plot.

Weed control efficiency
Weed control efficiency was significantly higher in T_2 (weed free plot) (93.9%). How ever among various inorganic and organic treatments, T_{10} (Tembotrione 34.4% SC+ Atrazine 50% WP) (85.5%), T_9 (Tembotrione 34.4% SC) (69.1%), T_8 (Pendimethalin 35% EC + Atrazine 50 WP) (59.1%) were statistically alike with superior treatment. Lowest weed control efficiency was recorded in T_1 (control plot) (0.0%) [7]. Also found similar results.

Weed index
Data presented in Table 2 indicated that the Weed index was significantly lower in the weed free plot during observation in the experiment plot. Plots treated with Pendimethalin 35% EC + Atrazine 50 WP (pre-emergence), Tembotrione 34.4% SC (post-emergence), and Tembotrione 34.4% SC+ Atrazine 50% WP (post-emergence) were statistically alike to superior treatments at observational stages. During observation, there was a significantly higher Weed index was recorded in the weedy plot [8] found similar results.

Conclusion
From the above findings, it is concluded that the pre-emergence application of Pendimethalin 35% EC + Atrazine 50 WP and Post-emergence application of Tembotrione 34.4% SC + Atrazine 50% WP was most effective in controlling weeds in maize than the organic treatments. Weed index was lowest in Pendimethalin 35% EC + Atrazine 50 WP (0.8). Highest weed control efficiency was recorded in Tembotrione 34.4% SC + Atrazine 50% WP (85.5). In comparison to organic and inorganic weed control treatments, inorganically weed control treatments in maize were performed better than the organic weed control treatments *viz* Acetic acid (10%), Acetic acid (20%), Eucalyptus Aqueous Extract 25% in terms of controlling the population of total weeds. Inorganic herbicides are often more

efficient than organic herbicides in controlling total weeds because they contain highly concentrated, synthetic chemicals that are specifically designed to target and kill weeds.

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