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IMPACT OF NEW GENERATION HERBICIDES ON WEED CONTROL EFFICIENCY AND YIELD POTENTIAL OF SPRING MAIZE IN SANDY LOAM SOILS OF PUNJAB

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Abstract

A field experiment was conducted at the Division of Agriculture, Lovely Professional University, Jalandhar, Punjab, India during spring of 2021-2022 in a randomized block design with eight weed treatments and three replications. The lowest weed density and biomass, highest weed control efficiency and maize growth parameters, yield characteristics, kernel, and straw yields were recorded with the post-emergence application of 2, 4-D Na combined with hand weeding at 60 DAS which was statistically at the same level as hand weeding Twice (30 & 60 DAS) followed by (fb) pre-emergence application (PE) of Atrazine with Single hand weeding at 30 DAS. Among the herbicidal treatments, maximum growth and yield attributes, highest monitory returns, (33287₹/ha) and B:C ratio of (1.74), were recorded with treatment of post-emergence application of 2, 4-D Na combined with hand weeding at 60 DAS fb Atrazine with Single hand weeding at 30 DAS.

Keywords: Atrazine; Maize; weed index; yield; economics.

1. Introduction

One of the most significant grains, maize (Zea mays L.), has acquired the rank of commercial crop. With a yield of roughly 23 million tonnes and a productivity of 2.58 t/ha, it is grown on an area of 8.9 million hectares in India (Anonymous 2020). In peri-urban parts of the Indian state, maize is grown all year long for a variety of uses, include grain, forage, fresh ears, sweet corn, baby corn, and popcorn. Punjab is the main growing state in India, an area with a corn crop of 165 thousand hectares with a productivity of 610 thousand tons. Maize productivity in Punjab is about 3697 kg ha^{-1} [1]. Early in the growing season, maize is extremely vulnerable to weed competition. The first 3 to 4 weeks of corn plant growth are often modest, and weed competition and establishment both increase during this time. The 2- to 6-week post-sowing (WAS) period is when weed competition is at its peak in corn, highlighting the significance of keeping a weed-free crop during this crucial time. Between 40% and 60% of maize yields were lost as a result of unchecked weed growth. According on the severity, nature, stages, and length of the weed infestation, spring season maize has significant weed competition, with yield losses ranging from 28 to 100% [5, 3]. A wide-spaced

crop has high weed infestation because of its initial slow growth, especially in the spring. In the soil, weeds remove 30–40% of the provided nutrients. Because weeds consume a sizable amount of the fertiliser applied to the soil, they hinder the effectiveness of fertilizer use by crop plants. The crop cannot utilise the same amounts of growth factors as the weeds do. Several grassy and broad-leaf weeds that can be found in maize field are Cyperus rotundus, Cynodon dactylon, Commelina benghalensis, Chenopodium album, Parthenium hysterophorus, Cannabis sativus, and Sinapis arvensis. These are some of the most dangerous weeds in the world, and they infest maize fields, raising the cost of cultivation because hand weeding is ineffective against them. Higher productivity is said to be a result of managing weeds effectively [5, 9]. Shown that weeds seriously harm maize crops, causing up to 50% of the damage. Unchecked weed development could result in a 90% reduction in corn yield [8]. Infesting fallow land, lowering soil fertility and moisture conditions, and developing a possible threat to succeeding harvests are all difficulties that weeds represent to crop husbandry [4]. Due to the high cost of cultivation, manual or mechanical weeding may not be feasible during the key period of crop weed competition. Chemical weed management utilising pre- and post-emergence herbicides, however, can result in the effective and expense control of weeds during this time [16]. Therefore, the goal of the current work was to ascertain how new generation herbicides affected the effectiveness of weed control and yield potential of spring corn in Punjabi sandy loam soils.

2. MATERIALS AND METHODS

In the springs of 2021 and 2022, furrow-planted maize served as the test subject. The division agriculture research department of Lovely Professional University (LPU), Jalandhar, Punjab, India, has finished a two-year crop cycle. Sand to clay loam with a light grey tint was used for the investigation. The soil has a more open and fertile structure. But humus and NPK levels in the soils are lower. Low Base Exchange capability, pH between 7 and 8, and little organic matter (OM).

2.1 Climatic Conditions during the Cropping Season

Punjab is one of the coolest states in India, with daily high temperatures reaching 30 degrees Celsius. Some months of the year are warm to hot with temperatures constantly above 25 degrees centigrade, occasionally up to 39 degrees. The total number of hours of sunlight refers to the time when the sun is really visible, as shown in (fig.1). That is, without any impediment to visibility caused by clouds, mist, or mountains. Through 8-9 hours per day, May is the lightest month in country portion Punjab. Sunshine houses less in the month of December.

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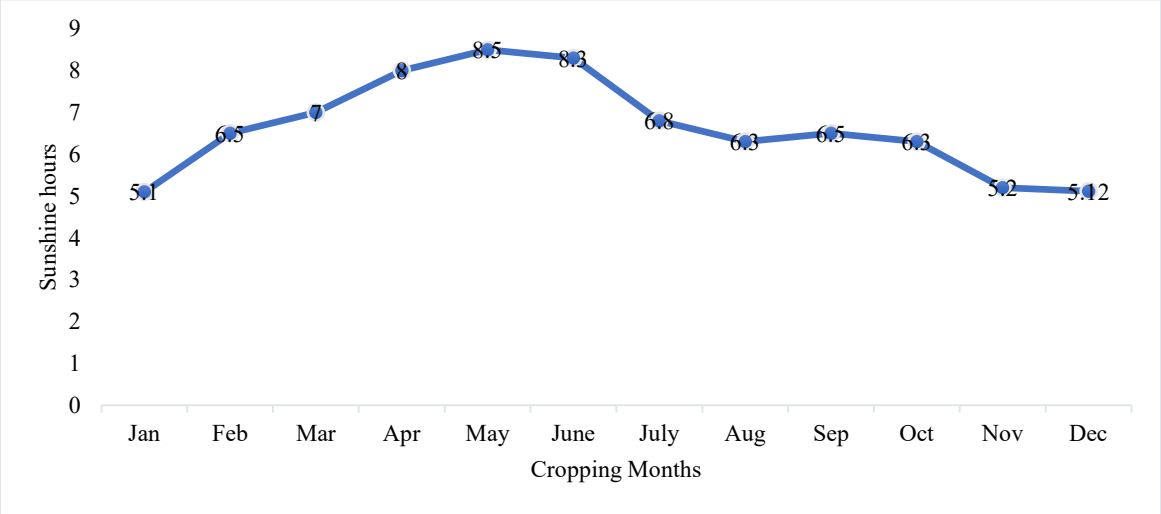

Fig: 1**. Hours of sunshine per day at experimental location**

2.2 Procedures and design of experiments

The present field experiment was conducted during two consecutive spring season (2021-2022) at the research farm Lovely Professional University Punjab, India. To test the performance of five herbicides in maize was evaluated by comparing them to the 'hand weeding' and 'unwedded' treatments as a check to detect the efficiency and cost-effectiveness of herbicide(s). The study deliberated eight treatments such as T_1 = Atrazine (700 g ha^{-1} as pre-emergence), T_2 = Atrazine (500 g ha^{-1} as pre-emergence) + One HW, T_3 = Metribuzin (800 g ha^{-1} as post-emergence), T_4 = Tembotrione (120 g ha^{-1} as post-emergence), T_5 = 2,4-D Na (800 g/ha as post-emergence), T_6 = Topramezone (200 g ha^{-1} as post-emergence), T_7 = Hand weeding Twice (manually weeded twice 30 & 60 DAS), and T_8 = Weedy check (no weed control). The experiment used a randomized block design (RBD) and was repeated three times.

3. RESULTS AND DISCUSSION

3.1 Weed flora

In Maize, seven weed species were observed in two springs (2021–2022). Mixed broad- and narrow-leaved weeds were present, but the field as a whole had a greater preponderance of the former. During the experimental period, more dicot weeds were generally dominant. In the chosen location, the spring season's predominant weed flora in maize crops included of these, two were grasses Commelina benghalensis L. and Cynodon dactylon. Among the sedge (Cyperus rotundus (L.)), and the remaining four were broadleaf weeds (Chenopodium album (L.), Parthenium hysterophorus (L.), Cannabis sativus (L.), and Sinapis arvensis (L.). This outcome is consistent with the findings of [6, 10, 11].

3.2 Impact of herbicides on weeds

Weed-control techniques Compared to the unwedded control, there was a significant decrease in both weed biomass and population ‘Table 1” The sequential application of Post-emergence application of 2, 4-D Na (800 g ha^{-1}) + One HW at 60 DAS weeds fb Atrazine (500 g ha^{-1}) + one HW at 30 DAS produced less weeds and less dry weed matter than the other herbicides evaluated

in the study, although it was comparable to Metribuzin (800 g ha^{-1} Individual years' results generally showed a similar tendency. This may be because both the single (higher dose) and combined herbicidal applications were successful in rapidly decreasing the overall weed population. Parallel outcomes were stated by [2, 4, 16, 13].

It was found that applying pre- and post-emergence herbicides in sequence was preferred to applying purely post-emergence herbicides 'Table 2". The maximal species wise and total weed control efficiency (85.62%) was found with the post-emergence application of 2,4-D Na (800 g ha^{-1}) + 1 HW at 60 DAS fb hand weeding at 30 ND 60 DAS(85.12), [3; 10] and pre-emergence application of Atrazine (500 g ha^{-1}) + 1 HW at 30 DAS shown in 'fig 2". It was caused by the lower weed population and total dry weight of weeds in these treatments due to better control of weeds following the revelation. This indicated the stability of all the post-emergence herbicides utilized in this trial, increasing their efficacy over pre-emergence herbicide application without any phytotoxic side effects that would be harmful. The weed index 'fig 3"indicated that the yield decrease was minimal (4.15 %) with Atrazine (500 g ha^{-1}) + One HW at 30 DAS followed by Metribuzin (800 g ha^{-1}) PE (4.93) and Atrazine (700 g ha^{-1}) (5.84). In comparison to the weedy check, overall weed index was less in all of the treatments. Efficiency of weed control and weed index showed a similar trend during 2021-2022. This outcome is consistent with the findings of [2, 7, 14].

Table.1 Effect of herbicides on species wise and total weed density (no. m^{-2}) at 90 days after sowing of Spring Maize by weed control treatments (pooled data of two years 2021- 2022).

Treatments	Grasses		Sedges	Broadleaf				Total weed density
	C. benghalensis	C. dactylon	C. rotundus	C. album	P. hysterophorus	C. sativus	S. arvensis	
Atrazine (700 g ha^{-1})	1.68 (2.84)	2.48 (6.16)	2.24 (5.06)	1.69 (2.86)	2.00 (4.01)	1.73 (3.00)	1.34 (1.82)	5.07 (25.77)
Atrazine (500 g ha^{-1}) + One HW	1.56* (2.46)	2.50 (6.28)	2.14 (4.58)	1.22 (1.49)	1.25 (1.58)	1.24 (1.55)	1.06 (1.13)	4.36 (19.09)
Metribuzin (800 g ha^{-1})	1.77 (3.16)	2.54 (6.46)	2.22 (4.93)	1.62 (2.63)	1.86 (3.49)	1.57 (2.47)	1.13 (1.29)	4.94 (24.45)
Tembotrione (120 g/ha)	1.62 (2.65)	2.67 (7.15)	3.72 (13.89)	2.74 (7.52)	3.50 (12.27)	3.74 (14.00)	3.70 (13.73)	8.44 (71.29)
2,4-D Na (800 g ha^{-1}) + One HW	1.08 (2.16)	1.51 (2.30)	1.40 (1.96)	1.12 (1.27)	2.24 (5.05)	1.12 (1.26)	1.02 (1.06)	3.93 (15.50)

Topramezone (200 g ha^{-1})	1.65 (2.74)	2.61 (6.85)	2.51 (6.32)	2.32 (5.42)	1.84 (3.40)	2.96 (8.77)	2.61 (6.84)	6.35 (40.36)
HW Twice (30 & 60 DAS)	1.00 (1.00)	2.15 (4.63)	1.45 (2.12)	1.02 (1.06)	1.00 (1.00)	1.14 (1.35)	1.02 (1.05)	3.49 (12.19)
Weedy check	3.57 (12.77)	5.09 (25.94)	4.98 (24.90)	4.79 (22.97)	5.16 (26.66)	5.12 (26.23)	5.28 (27.91)	12.93 (167.39)
SE (m±)	1.14	0.12	0.11	0.14	0.12	0.14	0.14	0.09
CD (p = 0.05)	1.14	0.34	0.32	0.40	0.38	0.42	0.42	0.26

*All values are square root transformed (√x+0.5).

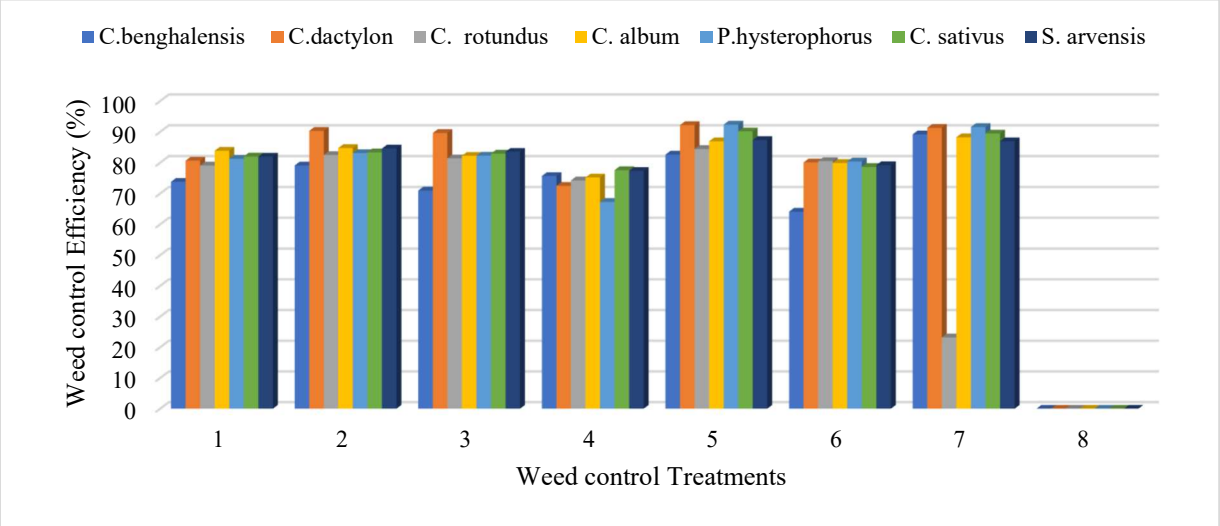

Fig 2. Weed species wise Weed control efficacy (%) (Maize 2021-2022)

Table 2. Influence of herbicides on species wise and total weed control efficiency at 90 days after sowing and WI (%) of Spring Maize by weed control treatments (pooled data of two years 2021 – 2022

Treatments	Grasses		Sedges	Broadleaf				Total weed control efficiency
	C. benghalensis	C .dactylon	C. rotundus	C. album	P. hysterophorus	C. sativus	S. arvensis	
Atrazine (700 g ha^{-1})	73.83	80.69	79.09	83.9	81.30	82.03	81.97	75.87
Atrazine (500 g ha^{-1}) + One HW	79.11	90.34	82.50	84.77	83.13	83.38	84.60	80.8
Metribuzin (800 g ha^{-1})	70.98	89.65	81.42	82.24	82.30	82.96	83.55	78.89
Tembotrione (120 g/ha)	75.69	72.50	74.27	75.22	67.29	77.58	77.36	68.84
2,4-D Na (800 g ha^{-1}) + One HW	82.64	92.20	84.46	86.95	92.36	90.16	87.36	85.62
Topramezone (200 g ha^{-1})	64.13	80.11	80.54	79.94	80.41	78.64	79.21	73.66
HW Twice (30 & 60 DAS)	89.21	91.32	23.21	88.27	91.59	89.49	86.97	85.12
Weedy check	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00

3.3 Effect on crop

The Maximum plant height and 50% tasseling of maize was recorded in post-emergence application of 2, 4-D Na (800 ha^{-1}) + One HW at 60 DAS fb Atrazine (500 ha^{-1}) + One hand weeding at 30 DAS. Maximum number of cobs $plant^{-1}$ (2.32) at harvest were recorded in HW Twice (30 & 60 DAS) which was at par with Topramezone (200 g ha^{-1}) PoE and Atrazine (500 g/ha) + one hand weeding at 30 DAS. Maximum number of kernel rows per cob (16.50) was found in post-emergence application of 2, 4-D Na (800 ha^{-1}) + One HW at 60 DAS fb hand weeding twice (30 & 60 DAS). Maximum weight of grains cob^{-1} (86.22 g) was found post-emergence application of 2, 4-D Na (800 ha^{-1}) + One HW at 60 DAS fb hand weeding twice (30 & 60 DAS). Weedy check showed the lowest yield attribute values. In order to control weeds, both chemical and mechanical methods produced results that were equal to [18, 7,16]

Table 3. Effect of herbicides on growth and yield characters of Spring Maize at 90 DAS by weed control treatments (pooled data of two years 2021-2022).

Treatments	Plant height (cm)	Tasseling (50%)	No. of cobs /plant	No. of kernel rows /cob	Weight of kernel /cob (g)	Seed yield Kg ha^{-1}	Net return (₹ ha^{-1})	WI (%)	B:C ratio
Atrazine (700 g ha^{-1})	173.28	80.27	1.67	14.96	72.75	4338	30355	5.84	1.70
Atrazine (500 g ha^{-1}) + One HW	177.61	84.67	2.13	15.37	80.14	4415	30645	4.15	1.73
Metribuzin (800 g ha^{-1})	175.97	81.86	1.88	15.07	77.71	4380	31284	4.93	1.69
Tembotrione (120 g/ha)	169.95	76.71	1.62	14.48	70.45	4192	28080	9.00	1.65
2,4-D Na (800 g ha^{-1}) + One HW	180.73	87.16	2.60	16.50	86.22	4607	33287	0.00	1.74
Topramezone (200 g ha^{-1})	174.78	80.74	1.71	15.01	75.62	4273	28378	7.25	1.64
HW Twice (30 & 60 DAS)	178.71	84.82	2.32	16.00	82.68	4570	29823	0.79	1.63
Weedy check	166.6	69.21	1.51	13.77	59.81	2536	2623	44.95	1.06
SE (m±)	**0.77**	**0.54**	**0.19**	**0.40**	**0.59**	**96.94**	**-**	**0.47**	**-**
CD (p = 0.05)	**2.35**	**1.63**	**0.57**	**1.22**	**1.78**	**294.01**	**-**	**1.43**	**-**

3.4 Effect of herbicide on yield, yield characteristics of spring corn.

In comparison to the weedy check, maize grain production significantly increased under various weed management methods. Weedy check recorded minimal average seed yield, whereas post-emergence application of 2, 4-D Na (800 ha^{-1}) + One HW at 60 DAS (4607 kg ha^{-1}) fb weeding twice (30 & 60 DAS) (4570 kg ha^{-1}) and Atrazine (500 g ha^{-1}) + one-handed weeding at 30 DAS (4415 kg ha^{-1}) [8]. This provided significantly more grain yield than the other treatments. It may be because post-emergence herbicides were used to manage late-emerging weeds after preemergence spraying had initially been more effective of controlling weeds. Since there was less competition between the crop and the weeds in these treatments, there may have been a larger yield. This may be because nutrients and moisture were more readily available. Significant results were also reported by [15, 13,17].

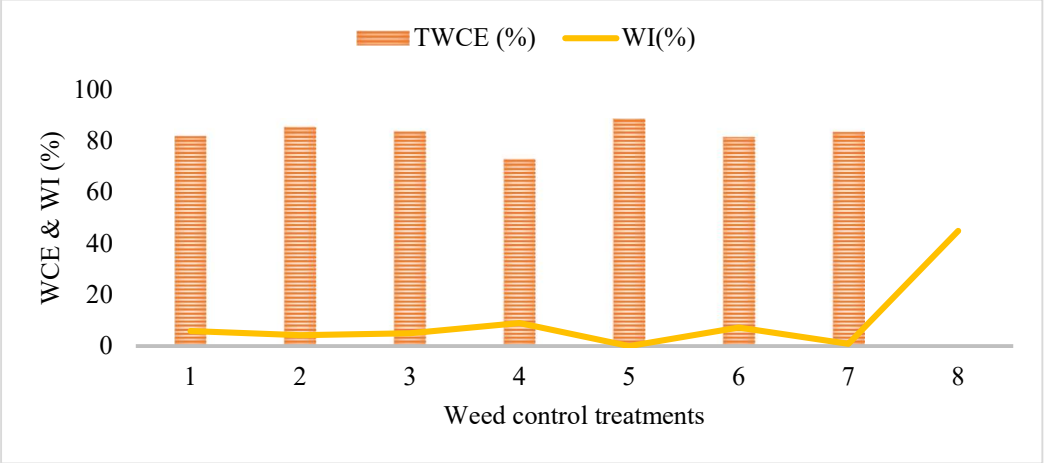

Fig 3. Overall Weed control efficiency and Weed Index (%) Maize (2021-2022)

4. Economic Analysis

Based on average benefit cost ratio, post- emergence application of 2,4-D Na (800 g ha^{-1}) + One HW at 60 DAS (1.74) was strictly followed by Atrazine (500 g ha^{-1}) + one hand weeding at 30 DAS (1.73) and Metribuzin (800 g ha^{-1}) as pre-emergence (1.69). It's possible that these treatments produced good seed yields due to superior weed management. Because of the higher weed population and lower yield, the minimum net cash returns and benefit to cost ratio were under control [12]. Due to higher weed density and lower yield, the gross monetary returns (GMR), net benefit, and B: C ratio were all at their lowest in weedy checks. The greatest cumulative valued of Net Monitory Returns of (₹33287/ha) and B: C value (1.74) was recorded in post- emergence application of 2,4-D Na (800 g ha^{-1}) + One HW at 60 DAS strictly followed by Atrazine (500 g ha^{-1}) + one hand weeding at 30 DAS (1.73). The price of herbicides and the crop's productivity account for the variations in the B: C ratio. Significant results were also reported by [3, 6, and 17].

5. Conclusion

It has been determined after two years of experimentation the post-emergence application of 2,4-D Na (800 g ha^{-1}) + one-handed weeding at 60 DAS fb Atrazine (500 g ha^{-1}) + one-handed weeding at 30 DAS was the most effective. They were the most effective weed treatments, effectively controlling of all groups of weeds and increasing the productivity of spring corn. These treatments can be used for effective weed control in cowpea during labor shortages and without any residual effect on the next crop.

Credit authorship contribution statement

Pratap J Khose: formal analysis, Methodology, Investigation. **Dr. Sandeep Menon:** Supervision, Softwere, Project admistration. **L.S Vyvahare:** Resources, Data curation, validation. **Pawan Thorhate, Kiran Yadav and Bhumi Reddy Divyavani:** Writing-review& editing, Writing-original draft, Supervision.

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