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Effect of intigrated weed management on growth and yield of *kharif* maize (*Zea mays* L.)

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Abstract
A field experiment was conducted during *Kharif* season of 2024 at Crop Research Farm. Department of Agronomy, SHUATS, Prayagraj, (U.P) to determine Integrated Weed Management in *Kharif* Maize (*Zea Mays* L.). The treatments included Paraquat at 2l/ha, Topramezone at 0.109l/ha. Halosulfuron at 67.5g/ha, Mesotrione at 96g/ha, Hand weeding at 20 and 40 DAS and control. The experiment was laid out in a Randomized Block Design with ten treatments each replicated thrice. As a result, Maximum plant height (186.57cm), plant dry weight (117.67g) was recorded with application of Weed free 3 hand weeding at 20, 40,60 DAS, Highest number of grains per row (26.40/row) was recorded with Weed free 3 hand weeding at 20, 40,60 DAS in, higher number of rows per cob (15.73), maximum 100 seed weight (21.67g),Maximum seed yield (4.67t/ha) and stover yield, (7.90) were recorded with the application of Topramezone@0.109l/ha as PoE at 40 DAS fb by Hand weeding (20, 40, DAS), maximum harvest index (45.48), was recorded with the application of Weed free (3hand weeding at 20,40and 60 DAS). the lowest weed density(39.5), The maximum weed control index (90.91%) and weed control efficiency (91.11%) was recorded with the application of Weed free 3 hand weeding at 20, 40,60 DAS, Among the pre and post-emergence herbicides applied alone, post-emergence application of Topramezone@0.109l/ha as PoE at 40 DAS) followed by Hand weeding at 20 and 40 DAS in treatment 4 has the lowest weed density(52.3), the maximum weed control index(84.30%) and weed control efficiency(85.42%) and the lowest weed index(-8.87%).

Keywords: Growth, halosulfuron, maize, mesotrione, paraquat, topramezone, weed, yield

1. Introduction

Maize is the most produced of all the cereals and is grown extensively over the world. As the largest contributor to the world's coarse grain trade, it is regarded as one of the cash crops with the quickest rate of growth in the globe. Maize is preferred staple food for 900 million poor, 120 -140 million poor farm families, and about one-third of all malnourished children globally. With changing global food demands and consumer choices Nowadays, maize is the miracle crop in many nations, particularly developing nations like India. For the Indian people, maize ranks third in importance among food grains, after rice and wheat. Madhya Pradesh, Andhra Pradesh, Karnataka, and Rajasthan contribute more than half of India's total maize production (Murdia *et al*., 2016) [8]. It has gained a prominent position in the farming industry due to its strong productive potential and adaptability to a wide range of environmental conditions. It grows in temperatures between 21 °C and 31 °C. and continue to be nature's most adaptable crop. It accounts for around 36% of the world's food grain production and is grown on an area of roughly 150 M hectares across 160 nations in a variety of soil types, climates, and management techniques with broader plant biodiversity (Anonymous, 2013) [1].

In India, maize is used for food, feed, and fodder. Additionally, it is a source of basic raw materials for a variety of industrial goods, including food sweeteners, alcoholic drinks, biofuel, oil, protein, starch, and cosmetics. It contributes to food (25%), animal feed (12%), poultry feed (49%), starch (12%), brewery (1%) and seed (1%), according to Dass *et al*. The most common cropping system in India among the several maize-based cropping systems is maize-wheat, which is grown on an area of roughly 1.8 million hectares, mostly in rainfed ecologies. About 3% of the national food basket is made up of maize-wheat, the third most significant cropping system after rice-wheat and rice-rice (Kumar *et al*, 2015). One of the most extensively grown crops worldwide, maize helps supply food in the majority of developing countries. Human consumption, animal feed, the manufacturing of corn starch and oil, baby corn, and industrial food processing all directly use it. Both the rabi and kharif seasons are suitable for growing maize. The Ministry of Agriculture & Farmers Welfare, Government of India, provided the secondary statistics on maize area, production, and productivity from 1990-1991 to 2018-19. Descriptive statistics and linear growth rates (Compound Annual Growth Rate) were used to analyze the gathered data. According to the report, maize production and area have been rising. The productivity of maize is drastically increasing due to availability of high yielding varieties of seeds and new technologies in cultivation methods (unjai *et al*. 2021) [20].

Weeds and insects are the main causes lowering maize yields in India. Because they compete with the maize crop for resources, weeds significantly reduce yield. Competition throughout the season decreased maize grain yield by up to 70% (Malviya *et al*). Using herbicides gives crops a competitive edge and a solid start by selectively and economically controlling weeds from the start (Saha, 2003) [16]. It is difficult to eradicate weeds completely using a single weed control strategy. Long-term, consistent pesticide use causes weeds to become resistant, making them challenging to manage. However, a satisfactory degree of weed control can be attained if the several elements of integrated weed management are combined in a systemic manner. It is estimated that weeds cause about 37% of maize yield losses globally (Oerke and Dehne, 2004) [7].

According to the CIBRC, paraquat should only be used as a pre-emergence herbicide on seven crops: rice, tea, apple, cotton, maize, potato, and rubber. The chemical formula for N,N′-dimethyl-4,4′-bipyridinium dichloride (systematic name), commonly referred to as methyl viologen, is [(C6H7N)2]. Cl2. It is categorized as a viologen, which is a family of structurally related redox-active heterocycles. (L. Michaelis, 1922) [11]. There is no discernible difference in selectivity when Topramezone is given to maize during the 2- to 8-leaf development stage, allowing for a flexible treatment window. (Gitsopoulos and others, 2010) [4].

According to Grossmann and Ehrhardt (2007) [5], maize's resistance to topramezone is caused by both a decreased sensitivity of the target site enzyme and a quick conversion of the herbicide to inactive molecules. A post-emergence herbicide containing sulfonylurea, halosulfuron-methyl is used to manage a variety of broad-leaved weeds and sedges (such nutgrass and nutsedge) in a variety of crops, both annual and perennial. Because it inhibits acetohydroxyacid synthase (AHAS, also called acetolactate synthase), it is systemic and selective, limiting the manufacture of important amino acids like valine and isoleucine and so limiting plant growth. The symptoms, which include overall stunting, chlorosis, and necrosis of the growth tips, appear over a period of weeks. Spurge, dandelions, lambs quarters, oxalis, and other prominent annual and perennial weed grasses and broadleaves are usually unaffected. Halosulfuron dosages of 36 gm/acre are advised. Mritunjay Kumar and associates (2018) [19]. Mostly applied to maize crops, mesotrione is a selective herbicide. Inspired by the natural ingredient leptospermone, which is present in the bottlebrush tree Callistemon citrinus, this synthetic compound was created. Per Uttley and Nigel (2011) [21], it prevents the 4-hydroxyphenylpyruvate dioxygenase (HPPD) enzyme from working.

It is systemic, selective, and inhibits acetohydroxyacid synthase (AHAS, also called acetolactate synthase), which limits the production of valine and isoleucine, two important amino acids, and hence limits plant growth. General stunting, chlorosis, and necrosis of the growth tips are among the symptoms, which appear over a period of weeks. Other important broadleaves and annual and perennial weed grasses, including lambsquarters, oxalis, dandelions, and spurge, are usually unaffected. 36 grams of halosulfuron per acre is the recommended dosage. (Kumar, Mritunjay, and others, 2018) [18]. A selective herbicide, mesotrione is mostly applied to maize crops. The natural chemical leptospermone, which is present in the bottlebrush tree Callistemon citrinus, served as the model for this artificial compound. 4-hydroxyphenylpyruvate dioxygenase (HPPD) is inhibited by it (Uttley and Nigel 2011) [21].

2. Materials and Methods

During *Zaid* season 2024, a field experiment was carried out at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). Almost neutral in soil reaction (pH 7.2), sandy loam in texture, organic carbon (0.597%), available N (171.48 kg/ha), available P (37.8 kg/ha), available K (247.1 kg/ha), and electrical conductivity (0.542 dsm-1) were all characteristics of the experimental plot's soil. On July 20, 2024, maize variety P-3305 was planted with a 60 cm × 25 cm spacing and a seed rate of 25 kg ha-1. Ten treatment combinations, including applications of T_1 - Paraquat @ 1/l/ha (7 days before sowing), T_2 - Paraquat @ 1/l/ha (7 days before sowing) followed by Hand weeding (20, 40 DAS), T_3 - Topramezone @ 0.109 l/ha as PoE, T_4 - Tporamezone @ 0.109 l/ha as PoE followed by Hand weeding (20, 40 DAS), T_5 - Halosulfuron @ 67.5 g/ha as PoE, T_6 - Halosulfuron @ 67.5 g/ha as PoE followed by Hand weeding (20, 40 DAS), T_7 - Mesotrione @ 96 g/ha as PE, T_8- Mesotrione @ 96 g/ha as PE followed by Hand weeding (20,40 DAS), T_9 - Weed free (3 hand weeding at 20, 40 and 60 DAS), T_{10}- Weedy check. Ten treatments were used in the Randomized Block Design trial, which was triple-replicated. To plant the seeds, furrows 4-5 cm deep were dug with a manual hoe. The seeds were sown ten days later, and after germination, the spaces were filled with fresh seeds. The distance between plants was maintained at 60 cm by 25 cm by removing seedlings if necessary. Intercultural operations were carried out every 20 to 60 days to reduce weed competition and crop density. Using a backpack power sprayer, 500 L of water per hectare was used to apply the herbicides. The harvest date of the crop was November 2, 2024.

At harvest, observations were made on many growth and yield attribute metrics, including. At 20, 40, 60, 80, and 100 DAS, measurements were made of the following: plant height (cm), dry weight (g), number of cob/plants, number of grain/rows, number of row/cob, seed index (g), seed yield (t/ha), and stover yield (t/ha). Harvest index (%) was also recorded. The observed data of ten treatments were statistically examined using analysis of variance (ANOVA), which is related to randomized block design (Gomez and Gomez, 1984 and Mohan *et al*) [3].

3. Results and Discussion

3.1 Growth Attributes

The data on growth-attributing traits are summarized in Table 1. During the course of the study, it was observed that plant height increased progressively following germination, reaching its peak around 100 days after sowing (DAS). Significantly highest values for plant height (186.57 cm), which was found to be statistically non-significant and maximum dry weight (180.23 g) were recorded with the application of weed free(3 hand weeding at 20,40 and 60 DAS) in (Treatment 9). However, this parameters were found to be statistically at par with the all other treatments except T_1 and $T_{10.}$ This indicates that reduced weed population in the initial stage of crop growth and competition which led good vegetative growth which will result yield also. weeds and crop will germinate simultaneously it is necessary to control the weeds from starting growth period itself so application of herbicides and early hand weeding will help that. But early hand weeding sometimes will disturb the growth of the crop as hand weeding practices are not handled carefully. Similar finding was done that plant dry weight, crop dry matter accumulation were significantly higher in sequential use of pre- a and post-emergence herbicides, resulting in more grain and net return. (Jadhav *et al* 2022) [6]

3.2 Yield Attributes

The data on yield-attributing traits are summarized in Table 1. No significant variation was found in number of cobs per plant. Application of T_3 as PoE, shows higher rows per cob (15.73) and the minimum rows per cob was found in T_7 of (12.13). Number of grains per row was not affected due to various weed management practices. However, maximum Number of grains per row (26.40/row) was recorded with T_9 and the minimum grain T_{10}. 100 seed weight was not affected due to various weed management practices.

However, maximum 100 seed weight (21.67g) was recorded in T_4 and the minimum 100 seed weight (18.00) was recorded in $T_{1.}$However these treatment was found to statistically non-significant.

3.3 Grain Yield (kg/ha)

The data on grain yield is summarized in Table 1. Application of Tporamezone@0.109l/ha as PoE followed by Hand weeding at 20 and 40 DAS(T_4) recorded significantly higher grain yield (4.67t/ha) However, it was found to be statistically at par with application of T_2 (4.18 t/ha) and T_9 (4.29 t/ha) and the minimum yield was recorded in T_{10} (3.07 t/ha). This implies that Grain yield is more due to higher crop growth of maize, foliage, amount of photosynthesis low crop weed competition by application of post-emergence herbicides. yield attributes like cob/plant, row/cob, grain/row, seed index can increase the grain yield of maize. Sequential application of herbicides helps in Effective reduction of mixed weeds and result in better yield. The difference of yield among treatment due to efficacy of herbicides and application mode. Uncontrolled weed control can cause lower production and less quality of produce. The grain yield of maize reduction was due to the heavy weed infestation offered severe competition between crop and weed for growth resources, which resulted in poor partitioning of photosynthates from source to sink and finally reduced the grain yield of maize this result are similar to the Allel Ahmed and Suseela (2012) [2], Ramchandran *et al*. (2012) [14] and Radheshyam *et al*., (2021) [13]

3.4 Stover Yield (kg/ha)

The data on stover yield is summarized in Table 1. Application of Tporamezone@0.109l/ha as PoE followed by Hand weeding at 20, 40, DAS ($T_{4)}$ recorded significantly higher stover yield (8.19 t/ha) and the minimum yield was recorded in T_{10} of (4.85 t/ha). However, it was found that the application of T_1 (6.62 t/ha), T_2 (6.36 t/ha), T_3 (5.88 t/ha), T_5 (7.86 t/ha) and T_6 (7.52 t/ha) are statistically at par with T_4. This implies that Higher crop growth of maize resulted in higher yield and high accumulation of dry matter resulted in high stover yield. Thus, stover yield was significantly influenced by weed management practices. It is recorded that the highest stover yield was obtained with topramezone @ 0.109l/ha followed by hand weeding at 20 and 40 DAS. All these growth parameters resulted in enhanced dry matter production because of maintenance of weed-free environment throughout crop period. Similar results were found by Pratap Singh *et al*. (2018) [19].

3.5 Harvest Index (%)

The data on Harvest index is summarized in Table 1.Harvest index was affected due to various weed management practices. However, maximum harvest index (45.18%) was recorded with the hand weeding of weed-free at 20, 40 feet This could be because, while weed competition was minimal, the crop was better able to move photosynthates to economic sinks. Sanodiya *et al*. previously reported a similar finding of increased harvest index with less weed competition (2013).

3.6 Economics

The data on the economics of different treatments summarized in Table 2. The cost of cultivation of maize ranged from Rs 27660 to Rs 34910 ha-1. The higher cost of cultivation (Rs 34910 ha-1) was noticed with the application Topramezone@0.109l/ha as PoE followed by Hand weeding at 20 and 40 DAS in T_4. The lower cost of cultivation (Rs 22475 ha-1) was recorded with application of Weedy Check in T_{10}. The higher gross return (132665.43 INR/ha) The higher net return (97755.43 INR/ha) was observed with application of Topramezone@0.109l/ha as PoE followed by Hand weeding at 20 and 40 DAS in T_4. Higher B:C ratio (2.99) was observed with application of 3 hand weeding at 20, 40 AND 60 DAS in T_9. this indicates that Weed control is the major challenge in kharif maize. Herbicide application is more commonly used than other treatment due to cost effective, less time taking and efficacy. From the result showed higher yield and economic in treatment with application of Topramezone@0.109l/ha as PoE followed by Hand weeding at 20, 40, DAS, Herbicides not only controls weed it also helps increasing yield through that increases net return. It is reported that the higher B:C ratio was obtained when weed free 3 hand weeding at 20, 40 and 60 DAS The highest net profit was realized from sequential application of T_4 Topramezone@0.109l/ha as PoE followed by Hand weeding at 20, 40, DAS). Similar results were found by Singh (2018) [19] and Rao *et al*., (2016) [15]

Table 1: Effect of integrated weed management in kharif maize *(Zea Mays L.)* on yield attributes and yield of maize.

	Treatments	Plant Height (cm)	Plant Dry Weight (g)	Number			Seed Index (t/ha)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
				Cob per plant	Grain per row	Row per cob				
1.	Paraquat @2l/ha (7 days before sowing)	167.67	162.87	1	21.9	14.0	18.0	3.75	6.62	34.09
2.	Paraquat @2l/ha followed by Hand weeding (20, 40, DAS)	171.73	169.87	1	20.2	12.7	21.0	4.18	6.36	41.18
3.	Topramezone@0.1091/ha as POE	151.40	169.67	1	20.9	15.7	20.7	3.83	5.88	39.66
4.	Topramezone@0.109l/ha as PoE followed by Hand weeding (20, 40, DAS)	163.73	174.73	1	24.3	14.5	21.7	4.67	7.90	36.40
5.	Halosulfuron @ 67.5 g/ha as PoE	159.53	166.33	1	22.3	12.4	21.0	3.83	7.86	34.71
6.	Halosulfuron @ 67.5 g/ha as PoE followed by Hand weeding (20, 40, DAS)	174.07	170.70	1	21.6	14.1	21.0	3.91	7.52	35.66
7.	Mesotrione @ 96 g/ha as PE	153.07	168.33	1	21.2	12.1	21.3	3.87	5.63	39.65
8.	Mesotrione @ 96 g/ha as PE followed by Hand weeding (20, 40, DAS)	164.07	174.67	1	23.2	14.0	19.7	4.03	5.66	43.30
9.	Weed free (3 hand weeding at 20, 40 AND 60 DAS)	186.57	180.23	1	26.4	13.6	18.3	4.29	5.15	45.18
10.	Weedy Check	169.73	151.00	1	19.2	13.9	21.3	3.07	4.85	41.04
	SEm+	11.38	4.78	-	1.36	1.08	1.28	0.19	0.45	2.32
	CD (P=0.05)	-	14.21	-	-	-	-	0.56	1.35	6.88

Table 2: Effect of integrated weed management in kharif maize *(Zea Mays L.)* on economics.

Sr. No.	Treatments	Cost of cultivation (`/ha)	Gross Return (`/ha)	Net Return (`/ha)	B:C Ratio
1.	Paraquat @2l/ha (7 days before sowing)	30140.0	106927.35	76787.35	2.55
2.	Paraquat @2l/ha followed by Hand weeding (20, 40, DAS)	31340.0	117173.68	85833.68	2.74
3.	Topramezone@0.1091/ha as POE	33710.0	107584.67	73874.67	2.19
4.	Topramezone@0.109l/ha as PoE followed by Hand weeding (20, 40, DAS)	34910.0	132665.43	97755.43	2.80
5.	Halosulfuron @ 67.5 g/ha as PoE	30777.8	111497.78	80720.03	2.62
6.	Halosulfuron @ 67.5 g/ha as PoE followed by Hand weeding (20, 40, DAS)	31977.8	112817.78	80840.03	2.53
7.	Mesotrione @ 96 g/ha as PE	28457.9	107908.20	79450.30	2.79
8.	Mesotrione @ 96 g/ha as PE followed by Hand weeding (20, 40, DAS)	29657.9	112068.52	82410.62	2.78
9.	Weed free (3 hand weeding at 20, 40 AND 60 DAS)	29460.0	117634.59	88174.59	2.99
10.	Weedy Check	27660.0	86440.79	58780.79	2.13

4. Conclusion

Based on one year of experimentation, it is concluded that application of Topramezone@0.109l/ha as PoE at 40 DAS followed by Hand weeding at 20, 40, DAS in T $_4$ proved to be the most effective in enhancing seed yield and stover yield and have higher net return suggesting a significant effect of the integrated weed management practices on maize productivity

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Competing Interests

Authors have declared that no competing interests exits.

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