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Research Article

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Efficiency of post-emergence herbicide for enhancing yield attributes, yield, and economics of hybrid maize (*Zea mays* L.)

Noor Mohammad Kakar[1], Sayed Yuonus Amini[2] and Mohibullah Samim[3]
[1]ANASTU, Kandahar, Afghanistan
[2]ICAR-IIMR, Pusa Campus, New Delhi
[3]Division of Agronomy, IARI, Pusa Campus, New Delhi
[4]IASRI, Pusa Campus, New Delhi
Corresponding author e-mail: noormohammad.kakar@yahoo.com
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ABSTRACT
An experiment was conducted at the research farm of National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan in a randomized complete block (RCBD) during the summer season of 2017 to evaluate the effect of post-emergence herbicides in maize. The experiment consisted of ten treatments and was replicated thrice. Among the weed control treatments, sequential application of atrazine @ 1.5 kg/ha pre-emergence followed by tembotrione 120 g/ha as PoE at 25 DAS recorded significantly higher grain row^{-1} (36.18), the number of grain cob^{-1} (502.48), and Grain weight cob^{-1} (137.63 g). Significantly higher grain and stover yield (6.7 and 11.6 t ha^{-1}) were recorded in weed-free check plot which is on par with (T_{10}) atrazine @ 1.5 kg/ha pre-emergence fb tembotrione 120 g /ha PoE at 25 DAS (6.5 and 11.4 t ha^{-1}) and (T_9) pendimethalin (1000 ml/ha) pre-emergence fb atrazine (750 g/ha) + 2,4-D Amine 0.4 kg /ha at 25 DAS as PoE (6.2 and 11.0 t ha^{-1}). The benefit-cost ratio was higher (1.57) in the sequential application of Atrazine 1.5 kg/ha fb 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE, which was on par with Pendimethalin (1000 ml/ha) pre-emergence fb Atrazine (750 g/ha) + 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE and (T_7) Atrazine @ 1.5 kg/ha pre-emergence fb Halosulfuron67 g/ha 25 DAS.
Keywords: B: C ratio, Economics, Harvest Index, Post-emergence herbicide, weed management, yield.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. In Afghanistan, it is cultivated over an area of 0.142 million hectares with a production of 0.312 million tones and productivity is 2200kg/ha which is less than half of the global productivity (Afghanistan Statistical Yearbook, 2013-14). The agro-climatic condition of Afghanistan is favorable for maize cultivation in the spring and summer seasons. Maize can offer a partial solution to the food shortage of Afghanistan if its present yield level and total production if further raised. Maize can contribute significantly in this respect because of its higher productivity per unit area.

Among them, weed management plays a significant role in enhancing crop yield. Generally, weeds reduce crop yields and increasing the cost of cultivation due to competition of resources with maize crops. Management of weeds is considered to be an important factor for achieving higher productivity as weed problem is more severe during continuous rains in the early stages of maize growth which cannot be controlled by traditional and cultural practices alone due to too much wetness.

Initial slow growth of maize is more sensitive to weed competition during its early growth period. Wider row spacing of the crop provides enough opportunity for the weeds to emerge and offer severe competition. Even with a light infestation of weeds under an ideal situation, the weeds should be controlled throughout the crop-growing season. However, the most critical period for crop weed competition is the first six weeks after planting of the crop because of initial slow growth and wider row spacing of maize, coupled with congenial weather conditions allow luxuriant weed growth which may reduce yield by 28-100% (Pandey *et al*., 1999; Dass*et al*., 2012). Herbicidal weed control seems to be a competitive and promising way to control weeds at the initial stages of crop growth. As the weeds interfere during the harvesting of the crop, post-emergence at about 25-35 DAS may help in avoiding the problem of weeds at later stages. Under this situation, managing weed through pre-emergence and post-emergence herbicides will be an ideal means for controlling the weeds because of economics and effectiveness in maize. The selection of proper herbicides is essential for successful weed management in all crop production systems. The choice of weed control measures, therefore, depends largely on its effectiveness and economics.

After wheat, maize crop plays an important role in the food security of Afghanistan. About 20-25 percent, the area is grown under maize and farmer does not use herbicides. Due to weed, infestation there is a drastic reduction in yield levels. Farmers spent a lot of money on labor for weed management but many times the labor availability is scarce. Considering all the above factors into account a research experiment was undertaken to evaluate the efficiency of post-emergence herbicides on the weed management, growth, and yield attributes of hybrid maize at the research farm of ANASTU, Kandhar, Afghanistan. The key aim of this study is to find out the best post-emergence herbicide for the realization of higher productivity and profitability from hybrid maize.

MATERIALS AND METHODS

A field experiment was conducted in the Farm of Afghanistan National Agriculture Science and Technology University (ANASTU), Kandahar, Afghanistan, (310 30′ 26″ N, 650 51′ 1″ E) approximately 1010 m above sea level, during the summer season of 2015. The average annual precipitation of this area is between 125 to 300 mm. The soil of the experimental site was sandy clay loam with 8.2 pH. The experiment was laid out in randomized complete block (RCBD), having three replications with the following treatments *viz*., T_1- Control (weedy check), T_2- Weed-free, T_3- Atrazine @ 1.5 kg /ha pre-emergence, T_4- Atrazine (750 g /ha) + pendimethalin (750 ml/ha) pre-emergence, T_5- Atrazine (1.5 kg /ha) followed by (fb) 2,4-D Amine 0.4 kg /ha at 25 DAS as PoE, T_6- Halosulfuron 67 g /ha at 25 DAS, T_7- Atrazine @ 1.5 kg /ha pre-emergence fb halosulfuron 90 g/ha 25 DAS, T_8- Tembotrione @ 120 g/ha PoE at 25 DAS, T_9- Pendimethalin (1000 ml/ha) pre emergence fb atrazine (750 g /ha) + 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE and T_{10}- Atrazine @ 1.5 kg/ha pre-emergence fb tembotrione 120 g/ha PoE at 25 DAS. Others recommended agronomic practices were uniformly followed throughout the study. All yield attributes and yield were recorded using standard procedure. At the final harvest, central three rows from each plot were harvested to record observations on yield. The cobs were separated from the plant cleaned, dried, and weighed separately; the grain yield of each plot was adjusted at 15% moisture content and was expressed in t/ha. All the collected data were analyzed statistically by ANOVA and means were compared using LSD at a 5% level of significance.

RESULTS AND DISCUSSION

Yield attributes

Post-emergence herbicides significantly influenced the number of grain row^{-1}, number of grain cob$^{-1,}$ and grain weight cob^{-1}. The greatest value of grain per row (36.18), number of grain cob^{-1} (502.48), and Grain weight cob^{-1} (137.63 g) were recorded from (T_{10}) Atrazine @ 1.5 kg/ha pre-emergence fb Tembotrione 120 g/haPoE at 25 DAS, while the lowest value was recorded from weedy check plot. There was no significant difference between the treatments for cobs plant^{-1}, Grain rows cob^{-1}, 1000-grains weight, and shelling percentage. However, (T_2) weed-free check plot recorded a higher number of cobs per plant (1.59) and highest shelling percentage (80.98) while, 1000-grains weight-Grain rows cob^{-1}were recorded from (T_{10}) Atrazine @ 1.5 kg/ha pre-emergence fb Tembotrione 120 g/haPoE at 25 DAS, and the lowest value was recorded from the weedy check. The improvement in growth and yield components was a consequence of lower weed competition, which shifted the balance in favor of crops in the utilization of nutrients, moisture, light, and space. These results conform with the finding of Saini and Angris (1998) and Chopra and Angris (2008).

Yield

Higher grain and Stover yield (6.7 and 11.6 t ha^{-1}) were recorded in a weed-free check plot which is on par with (T_{10}) atrazine @ 1.5 kg/ha pre-emergence fb tembotrione 120 g /ha PoE at 25 DAS (6.5 and 11.4 t ha^{-1}) and (T_9) pendimethalin (1000 ml/ha) pre-emergence fb atrazine (750 g/ha) + 2,4-D Amine 0.4 kg /ha at 25 DAS as PoE (6.2 and 11.0 t ha^{-1}). The lowest grain and Stover yield (4.3 and 8.2 t ha^{-1}) were noticed in weedy check as a consequence of the greatest removal of nutrients and moisture by weeds and severe crop weed competition resulting in poor source and sink development with poor yield components. The results conform with the finding by Singh *et al*. (2015).

Harvest index (%)

Harvest index did not differ significantly due to the application of post-emergence herbicides. Harvest index ranged between 36.49 in weed-free check plot and 34.28 in weedy check.

Economics

Among the weed control treatments, highest net income (Af. 39,592 ha^{-1}) was recorded in (T_{10}) Atrazine @ 1.5 kg/ha pre-emergence fb Tembotrione 120 g/haPoE at 25 DAS which was on par with (T_9) Pendemathalin (1000 ml/ha) pre-emergence fb Atrazine (750 g/ha) + 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE followed by (T_5) sequential application of Atrazine (1.5 kg/ha) fb 2,4-D Amine 0.4 kg/ha at 25 DAS as PoE. This was due to the higher gross income recorded in these treatments as a consequence of the higher economic and biological yield of maize. Whereas weedy check recorded lower net income (Af. 9,369 ha^{-1}). This was due to the lower grain yield of maize in these treatments. These results conform with Sreenivas and Sathyanarayan (1994).

The benefit-cost ratio was higher (1.57) in the sequential application of Atrazine 1.5 kg/ha fb 2, 4-D Amine 0.4 kg/ha at 25 DAS as PoE, which was on par with Pendimethalin (1000 ml/ha) pre-emergence fb Atrazine (750 g/ha) + 2, 4-D Amine 0.4 kg/ha at 25 DAS as PoE and (T_7) Atrazine @ 1.5 kg/ha pre-emergence fb Halosulfuron67 g/ha 25 DAS. This was mainly due to higher economic yield, net returns, and lower cost of cultivation. The lower B: C was recorded in the weedy check. It was due to lower gross income because of the lower economic yield of maize. Although weed-free conditions had higher growth and yield still Atrazine @ 1.5 kg/ha pre-emergence fb Tembotrione 120 g/haPoE at 25 DAS (T_{10}) recorded higher net returns, it is due to the higher cost of cultivation for weed-free conditions.

Table 1. Yield attributes of maize as influenced by sequential application of post-emergence herbicides

Tr.No.	Treatments	Cobs plant^{-1}	Grainrows cob^{-1}	Grains row^{-1}	Grainscob^{-1}	Grain weight cob^{-1}(g)	1000-grains weight (g)	Shelling (%)
T_1	Weedy check	1.29	12.33	29.87^{c}	368.90^{c}	90.66^{d}	245	74.78
T_2	Weed free check	1.59	13.57	36.98^{a}	502.48^{a}	137.63^{a}	273.13	80.98
T_3	Atrazine (1500 g/ha) as pre-emergence (PE)	1.45	13.05	31.27^{bc}	408.02^{bc}	102.38^{cd}	251.07	77.13
T_4	Atrazine (750 g/ha) + pendimethalin (750 ml/ha) as PE	1.5	13.12	33.51^{ab}	440.14^{abc}	112.78^{bcd}	253.5	78.72
T_5	Atrazine (1500 g/ha) as PE *fb* 2,4-D amine (400 g/ha) as post-emergence (PoE) at 25 DAS	1.4	13.20	33.28^{bc}	439.43^{abc}	113.03^{abcd}	255.93	79.2
T_6	Halosulfuron (67 g/ha) as PoE at 25 DAS	1.34	12.93	31.19^{bc}	402.95^{bc}	100.23^{cd}	247.87	75.53
T_7	Atrazine (1500 g/ha) as PE *fb*halosulfuron (67 g/ha) 25 DAS as PoE	1.41	13.07	33.23^{ab}	434.89^{abc}	116.12^{abc}	266.93	78.43
T_8	Tembotrione (120 g/ha) as PoE at 25 DAS	1.55	13.22	34.43^{ab}	455.87^{ab}	118.43^{abc}	256.07	79.39
T_9	Pendimethalin (1000 ml/ha) as PE *fb* atrazine (750 g/ha) + 2,4-D amine (400 g/ha) at 25 DAS as PoE	1.57	13.48	35.68^{ab}	481.13^{ab}	131.49^{ab}	271.03	80.34
T_{10}	Atrazine (1500 g/ha) as PE *fb*tembotrione (120 g/ha) as PoE at 25 DAS	1.57	13.77	36.18^{ab}	499.12^{a}	136.97^{ab}	274.2	80.7
	SEm (±)	0.188	0.69	1.62	38.213	11.773	11.282	2.338
	LSD (P=0.05)	NS	NS	4.3	80.282	24.735	NS	NS

Table 2. Effect of post-emergence herbicides on yield and economics of maize.

Tr. No.	Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)	Cost of cultivation (Af ha^{-1})	Gross returns (Af ha^{-1})	Net returns (Af ha^{-1})	B:C
T_1	Weedy check	4.3^{cd}	8.2^{c}	34.28	63,000^{d}	72,369^{cd}	9,369^{d}	1.15^{bc}
T_2	Weed-free check	6.7^{a}	11.6^{a}	36.49	82,100^{a}	109,433^{a}	27,333^{b}	1.33^{ab}
T_3	Atrazine (1500 g/ha) as pre-emergence (PE)	5.7^{bc}	10.5^{bc}	35.09	64,900^{c}	98,764^{b}	33,864^{ab}	1.52^{a}
T_4	Atrazine (750 g/ha) + pendimethalin (750 ml/ha) as PE	5.8^{bc}	10.7^{bc}	35.25	64,900^{c}	100,139^{ab}	35,239^{ab}	1.54^{a}
T_5	Atrazine (1500 g/ha) as PE *fb* 2,4-D amine (400 g/ha) as post-emergence (PoE) at 25 DAS	6.1^{b}	10.9^{bc}	36.05	66,300^{b}	104,068^{ab}	37,768^{ab}	1.57^{a}
T_6	Halosulfuron (67 g/ha) as PoE at 25 DAS	4.8^{c}	8.6^{bc}	35.88	64,900^{c}	83,503^{c}	18,603^{c}	1.29^{ab}
T_7	Atrazine (1500 g/ha) as PE *fb*halosulfuron (67 g/ha) 25 DAS as PoE	6.0^{b}	10.6^{b}	36.17	66,300^{b}	102,330^{ab}	36,030^{ab}	1.54^{a}
T_8	Tembotrione (120 g/ha) as PoE at 25 DAS	5.4^{c}	9.5b^{c}	36.48	64,900^{c}	82,100^{c}	17,200^{c}	1.27^{ab}
T_9	Pendimethalin (1000 ml/ha) as PE *fb* atrazine (750 g/ha) + 2,4-D amine (400 g/ha) at 25 DAS as PoE	6.2^{b}	11.0^{ab}	36.17	66,300^{b}	104,111^{ab}	37,811^{ab}	1.57^{a}
T_{10}	Atrazine (1500 g/ha) as PE *fb*tembotrione (120 g/ha) as PoE at 25 DAS	6.5^{ab}	11.4^{ab}	36.38	66,300^{b}	105,892^{ab}	39,592^{a}	1.60^{a}
	SEm (±)	0.20	0.83	1.15	-	6,203	2,445.3	0.240
	LSD (P=0.05)	0.42	3.83	NS	-	19,001	9,445.7	0.505

CONCLUSION

Based on the study it may be concluded that weeds associated with hybrid maize may be effectively managed and resulted in the highest growth & grain yield by application of atrazine @ 1.5 kg/ha pre-emergence fb tembotrione 120 g/ha PoE at 25 DAS in Kandahar ecological conditions. This treatment can be best utilized for weed management in hybrid maize by the farmers of Afghanistan.

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