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Research Communication

Efficiency of post-emergence herbicides for enhancing growth and yield of hybrid maize (*Zea mays*) in Kandahar, Afghanistan

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ABSTRACT

A field experiment was conducted at research farm of the Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan, in randomized complete- block (RCBD) design during summer 2017, to evaluate the effect of post-emergence (PoE) herbicides in maize (*Zea mays* L.). Results revealed that sequential application of atrazine @ 1,500 g/ha as pre-emergence followed by (fb) tembotrione @ 120 g/ha as post emergence (PoE) 25 days after sowing (DAS) recorded significantly higher plant height and leaf-area index at 60 and 90 days after sowing (DAS), while dry-matter accumulation and the yield attributes as grains/row, grain/cob and grain weight/cob at harvesting stages. Weed infestation in hybrid maize caused 35.8% yield loss compared to weed-free control. Application of the weed-management treatments increased the maize yield by 35.2% (11.6 – 51.2) over unweeded check. Significantly higher grain yield (6.50 t/ha) was recorded with sequential application of atrazine (1,500 g/ha) as pre-emergence followed by tembotrione (120 g/ha) at 25 DAS, which was at par with pendimethalin (1,000 ml/ha) as pre-emergence followed by atrazine (750 g/ha) + 2,4-D amine (400 g/ha) at 25 DAS as PoE (6.21.3 t/ha) and atrazine (1,500 g/ha) as pre-emergence fb 2,4-D amine (400 g/ha) at 25 DAS (6.12 t/ha). Therefore, the sequential application of pre-and post-emergence herbicides could be opted for enhancing growth and yield and weed control of hybrid maize in Afghanistan and similar ecologies.

Key words: Atrazine, Hybrid maize, Pendimethalin, Tembotrione, Weed management

Maize is the third most important cereal crop in the world after rice and wheat and is grown across a wide range of climates, but mainly in the warmer temperate regions and humid subtropics. In Afghanistan, maize is sown on an area of 0.142 million ha, with average yield of 2.20 t/ha (Government of Afghanistan, 2013–14). The agro-climatic condition of Afghanistan is favourable for maize cultivation in spring and summer seasons. Maize can offer a partial solution to the food shortage of Afghanistan if its present yield level and total production could be raised further. After wheat, maize is important cereal crop of Kandahar and about 20–25% area is grown under maize. There is a significant reduction in maize yield, due to weed infestation, in Afghanistan at farmer's field, and thus weeds are the most important yield-limiting factor in maize. However, the most critical period for crop-weed competition are first 6 weeks after planting of crop, as initial slow growth and wider row spacing of maize, coupled with congenial weather conditions allow luxuriant weed growth which may reduce yield by 28 6° 100% (Dass *et al*., 2012). Farmers spent a lot of money for hand-weeding and many times the labour availability is an issue, which makes maize farming less profitable in this region.

Weed control in maize can be done mechanically because it is grown in wide rows; mechanical cultivation to control weeds growing between the rows is possible and still practiced due to non-availability of post-emergence herbicides. Due to increased cost and non-availability of manual labour for hand-weeding, the alternative technologies based on suitable post-emergence herbicide application are needed. The choice of weed-control measures, therefore, depends largely on its effectiveness and economics. Herbicides not only control the weeds timely and effectively, but also offer great scope for minimizing the cost of weed control. Usage of pre-emergence herbicides assumes

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greater importance in the view of their effectiveness at initial crop stage. However, as the weeds interfere during the grand growth and reproductive period of the crop, use of post-emergence herbicides is also essential for higher yields. Under this situation, managing weeds through pre-emergence and post-emergence herbicides will be an ideal practice for controlling the weeds in view of economics and effectiveness in maize.

In view of the above factors, a research experiment was undertaken to evaluate the efficiency of post-emergence herbicides for the weed management in maize for improving growth and yield attributes at Afghanistan National Agricultural Sciences and Technology University in Kandhar, Afghanistan. The aim of this study was to find out the best post-emergence herbicide for realization of higher productivity of the hybrid maize towards drudgery reduction in crop production.

A field experiment was conducted at the Farm of Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan, (31° 302 263 N, 65° 512 13 E, approximately 1,010 m above sea-level), during the summer season of 2017. The average annual precipitation of this area is between 125 to 300 mm. The soil was sandy clay loam, with *p*H 8.2. The experiment was laid out in randomized complete-block design, having 3 replications with the treatments, viz., T_1, control (weedy check); T_2, weed-free check; T_3, atrazine (1,500 g/ha) as pre-emergence (PE); T_4, atrazine (750 g/ha) + pendimethalin (750 ml/ha) as PE; T_5, atrazine (1,500 g/ha) as PE followed by 2, 4-D amine (400 g/ha) at 25 days after sowing (DAS); T_6, halosulfuron (67 g/ha) at 25 DAS; T_7, atrazine (1,500 g/ha) as PE followed by halosulfuron (90 g/ha) at 25 DAS; T_8, tembotrione (120 g/ha) at 25 DAS; T_9, pendimethalin (1,000 ml/ha) as PE followed by atrazine (750 g/ha) + 2,4-D amine (400 g/ha) at 25 DAS; and T_{10}, atrazine (1,500 g/ha) as PE followed by tembotrione (120 g/ha) at 25 DAS. Other recommended agronomic practices were followed. Growth parameters, yield attributes and yields were recorded using standard procedure for recording these parameters in maize as described by Radheshyam (2018). Observations were taken at 30 days interval from each plot and the leaf area measured by using formula, Leaf area = Leaf length × Leaf breath × 0.75 (Saxena and Singh, 1965). At the final harvesting, central 3 rows from each plot were harvested and yield was recorded. The cobs were separated from the plant and weighted separately; grain yield after shelling was recorded for each plot and expressed in t/ha at 15% moisture content. Data collected were analysed statistically by using analysis of variance (ANOVA) technique and means were compared using least significant difference test at 5% level of significance.

Table 1. Plant height, leaf-area index and dry-matter accumulation of maize as influenced by sequential application of pre-and post-emergence herbicides

Treatment	Plant height (cm)			Leaf area index			Dry-matter accumulation at harvesting (g/plant)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	
$T_{1,}$ Weedy check	43.2	83.4	139.4	0.19	1.70	2.20	158.1
$T_{2,}$ Weed free check	45.3	114.4	172.2	0.24	2.10	3.20	211.4
$T_{3,}$ Atrazine (1,500 g/ha) as pre-emergence (PE)	43.3	90.0	143.9	0.23	2.00	2.80	152.2
$T_{4,}$ Atrazine (750 g/ha) + pendimethalin (750 ml/ha) as PE	43.8	95.9	145.7	0.22	2.00	2.80	160.0
$T_{5,}$ Atrazine (1,500 g/ha) as PE *fb* 2, 4-D amine (400 g/ha) as post-emergence (PoE) at 25 DAS	43.9	101.4	146.6	0.25	1.90	2.70	162.2
$T_{6,}$ Halosulfuron (67 g/ha) as PoE at 25 DAS	42.1	88.9	137.4	0.24	1.80	2.80	159.8
$T_{7,}$ Atrazine (1,500 g/ha) as PE *fb* halosulfuron (67 g/ha) 25 DAS as PoE	43.9	98.2	145.4	0.23	2.10	2.70	187.2
$T_{8,}$ Tembotrione (120 g/ha) as PoE at 25 DAS	42.4	87.4	142.0	0.22	2.10	2.60	172.1
$T_{9,}$ Pendimethalin (1,000 ml/ha) as PE *fb* atrazine (750 g/ha) + 2, 4-D amine (400 g/ha) at 25 DAS as PoE	44.0	104.6	151.4	0.26	2.10	3.00	195.1
$T_{10,}$ Atrazine (1,500 g/ha) as PE *fb* tembotrione (120 g/ha) as PoE at 25 DAS	46.5	114.2	162.9	0.24	2.10	3.00	205.37
SEm±	1.57	6.67	6.10	0.02	0.09	0.13	18.72
CD (P=0.05)	NS	14.02	12.81	NS	0.25	0.43	39.32

DAS, Days after sowing; fb, followed by

Cynadon dactylon (L.) Pers., *Digitaria marginata* (Link) Henrard and *Echinochloa* spp. among grasses; *Cyperus rotundus* L. as sedge and *Amaranthus* spp., *Alhagi maurorum* Medik; syn. A *camelorum* Fisch. and *Convolvulus arvesnsis* L. as broad-leaf weeds were dominant in the experimental field. Higher plant height was noticed at 60, 90 DAS and at harvesting stage in atrazine (1,500 g/ha) as pre-emergence (PE) followed by tembotrione (120 g/ha) at 25 DAS treatment and it was at par with pendimethalin (1,000 ml/ha) as PE followed by atrazine (750 g/ha) + 2, 4-D amine (400 g/ha) at 25 DAS, atrazine (1,500 g/ha) as PE followed by halosulfuron (67 g/ha) at 25 DAS and atrazine (1,500 g/ha) as PE followed by 2, 4-D amine (400 g/ha) at 25 DAS (Table 1).

Significantly higher leaf-area index at 90 DAS was recorded in atrazine (1500 g/ha) as pre-emergence followed by tembotrione (120 g/ha) at 25 DAS, being at par with pendimethalin (1,000 ml/ha) as PE followed by atrazine (750 g/ha) + 2,4-D amine (400 g/ha) at 25 DAS (Table 1). Total dry-matter production in maize differed significantly due to different weed-control treatments. At harvesting stage, atrazine (1,500 g/ha) as PE followed by tembotrione (120 g/ha) at 25 DAS resulted in the maximum total dry-matter production (205.3 g/plant) which was at par with pendimethalin (1,000 ml/ha) as PE followed by atrazine (750 g/ha) + 2, 4-D amine (400 g/ha) at 25 DAS (195.12 g/plant), while the minimum total dry-matter was recorded in the weedy check. The lower dry-matter was due to high weed infestation which led to crop-weed competition as compared to weed-management treatments where crop got good resources in absence of such competition. The improvement in growth and yield components was the result of lower weed competition, which shifted the balance in favour of crop in the utilization of nutrients, moisture, light and space. These results are in conformity with the findings of Chopra and Angris (2008), Sivamurugan *et al*. (2017) and Radheshyam (2018).

Yield and yield components of maize varied significantly among the weed-control treatments (Table 2). The maximum number of grains/row (36.2) was recorded in atrazine (1,500 g/ha) as PE followed by tembotrione (120 g/ha) at 25 DAS, while the lowest (29.9) was noted in the

Table 2. Yield attributes and grain yield of maize as influenced by sequential application of pre-and post-emergence herbicides

	Treatment	Grassy weeds at 50 DAS (No. m^{-2})*	Broad-leaved weeds at 50 DAS (No. m^{-2})*	Grains/ row	Grains/ cob	Grain weight/ cob (g)	Grain yield (t/ha)
T_1	Weedy check	6.53	5.89	29.9	368.9	90.7	4.30
T_2	Weed free check	0.71	0.71	37.0	502.5	137.6	6.70
T_3	Atrazine (1,500 g/ha) as pre-emergence (PE)	4.14	0.88	31.3	408.0	102.4	5.70
T_4	Atrazine (750 g/ha) + pendimethalin (750 ml/ha) as PE	3.31	1.05	33.5	440.1	112.8	5.80
T_5	Atrazine (1,500 g/ha) as PE *fb* 2,4-D amine (400 g/ha) as post-emergence (PoE) at 25 DAS	4.43	0.71	33.3	439.4	113.0	6.10
T_6	Halosulfuron (67 g/ha) as PoE at 25 DAS	4.85	1.77	31.2	403.0	100.2	4.80
T_7	Atrazine (1,500 g/ha) as PE *fb* halosulfuron (67 g/ha) 25 DAS as PoE	5.11	0.71	33.2	434.9	116.1	6.00
T_8	Tembotrione (120 g/ha) as PoE at 25 DAS	4.45	3.03	34.4	455.9	118.4	5.40
T_9	Pendimethalin (1,000 ml/ha) as PE *fb* atrazine (750 g/ha) + 2,4-D amine (400 g/ha) at 25 DAS as PoE	2.96	2.68	35.7	481.1	131.5	6.20
T_{10}	Atrazine (1,500 g/ha) as PE *fb* tembotrione (120 g/ha) as PoE at 25 DAS	2.94	0.88	36.2	499.1	137.0	6.50
	SEm±	0.116	0.124	1.62	38.21	11.77	0.20
	CD (P=0.05)	0.245	0.261	4.30	80.28	24.74	0.42

DAS, Days after sowing and Fb: Followed by.*Transformed values: $\sqrt{X + 0.5}$

weedy check. The highest number of grains/cob (499.1) was recorded from application of atrazine (1,500 g/ha) as PE followed by tembotrione (120 g/ha) at 25 DAS, while the lowest (368.9) from weedy check plot. Grain weight/cob (137.0 g) was the highest in atrazine (1500 g/ha) as PE followed by tembotrione (120 g/ha) at 25 DAS while the lowest (90.7 g) in weedy check. The enhancement in the yield-attributing characters was mainly owing to increased growth parameter that in turn enhanced the sink size in these herbicide treatments. The minimum crop-weed competition throughout of crop-growth period, thus enabling the crop for maximum utilization of nutrients, moisture, light and space, had the influence on growth components and yield components.

Weed infestation in hybrid maize caused yield losses of 35.8%, indicating a good weed pressure in the experimental field used in our study. Significantly higher grain yield (6.50 t/ha) was recorded with sequential application of atrazine @ 1500 g/ha as pre-emergence followed by tembotrione 120 g/ha PoE at 25 DAS, which was at par with pendimethalin (1,000 ml/ha) as pre-emergence followed by atrazine (750 g/ha) + 2, 4-D amine 0.4 kg/ha at 25 DAS as PoE (6.21 t/ha) and atrazine (1500 g/ha) as pre-emergence followed by 2, 4-D amine 400 g/ha at 25 DAS as PoE (6.12 t/ha). The per cent increase in the grain yield of maize with weed-management options such as atrazine (1,500 g/ha) as PE, atrazine (750 g/ha) + pendimethalin (750 ml/ha) as PE, atrazine (1,500 g/ha) as PE followed 2, 4-D amine (400 g/ha) at 25 DAS, halosulfuron (67 g/ha) at 25 DAS, atrazine (1,500 g/ha) as PE followed by halosulfuron (67 g/ha) at 25 DAS, tembotrione (120 g/ha) at 25 DAS, pendimethalin (1,000 ml/ha) as PE followed by atrazine (750 g/ha) + 2, 4-D amine (400 g/ha) at 25 DAS and atrazine (1,500 g/ha) as PE followed by tembotrione (120 g/ha) at 25 DAS over weedy check was 32.6, 34.9, 41.9, 11.6, 39.5, 25.6, 44.2 and 51.2 respectively. The lowest grain yield (4.28 t/ha) was recorded in weedy check as a consequence of greatest removal of nutrients and moisture by weeds and severe crop-weed competition, resulting poor source and sink development with poor yield components. Our results confirm the findings of Singh *et al*. (2015) and Radheshyam (2018).

Application of atrazine @ 1.5 kg/ha pre-emergence fb Tembotrione 120 g/ha PoE at 25 DAS (T_{10}) significantly recorded lower number of grassy weed count while weedy check. There were no broad leaved weeds in T_5, T_7 and T_{10} at 50 DAS. These results are in conformity with Nagalakshmi *et al*. (2006).

Our results indicate that, application of atrazine @ 1,500 g/ha at pre-emergence followed by tembotrione @ 120 g/ha at 25 days after sowing resulted in the highest growth, yield attributes and yield in hybrid maize at Kandhar, Afghanistan. Hence the farmers of Afghanistan and similar agro-ecologies may follow this treatment for weed management in hybrid maize.

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