
Research Article

Effects of weed management on agronomic performance and productivity of hybrid maize (*Zea mays* L.)

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Article history:

Submitted 20 January 2021

Accepted 03 May 2021

Published 25 June 2021

Keywords:

Dry matter accumulation

Hybrid maize

Kernel yield

Leaf area

Pre-and post-emergence

herbicide

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Abstract

The yield loss as a result of weed infestation is a major problem in maize fields. Hence, this research meant to examine the impacts of weed chemical control on maize growth and yield. The design of experiment was randomized complete block, and comprised 10 treatments viz., T₁ (Control, weedy check), T₂ (Weed free), T₃ (Atrazine 1.5 kg ha⁻¹ pre-emergence), T₄ (Atrazine 750 g ha⁻¹ + Pendimethalin 750 ml ha⁻¹ pre-emergence), T₅ (Atrazine 1.5 kg ha⁻¹ followed by 2,4-D amine 0.4 kg ha⁻¹ at 25 days after sowing as Post-emergence), T₆ (Halosulfuron 67 g ha⁻¹ at 25 DAS), T₇ (Atrazine 1.5 kg ha⁻¹ pre-emergence followed by Halosulfuron 90 g ha⁻¹ 25 days after sowing), T₈ (Tembotrione 120 g ha⁻¹ Post-emergence at 25 days after sowing), T₉ (Pendimethalin 1000 ml ha⁻¹ pre-rise fb Atrazine 750 g ha⁻¹ + 2,4-D amine 0.4 kg ha⁻¹ at 25 days after sowing as Post-emergence) and T₁₀ (Atrazine 1.5 kg ha⁻¹ pre-emergence followed by Tembotrione 120 g ha⁻¹ Post-emergence at 25 days after sowing) with 3 replicates. The results showed that among other treatments, T₁₀ recorded highest number of kernels per row (36.18), number of kernel cob⁻¹ (499.12) and kernel weight cob⁻¹ (136.97 g). A higher plant height (172.19 cm), leaf area (396.6 cm² plant⁻¹), dry matter accumulation (211.37 g plant⁻¹), kernel yield (6.7 t ha⁻¹) and stover yield (11.6 t ha⁻¹) were found with weed free check plot which is on par with T₁₀ treatment which brought about a higher value of plant height (162.93 cm), dry weight accumulation (205.7 g plant⁻¹), leaf area (384.3 cm² plant⁻¹), kernel yield (6.5 t ha⁻¹) and stover yield (11.4 t ha⁻¹). In the meantime, T₉ treatment reasonably increased kernel yield (6.2 t ha⁻¹) and stover yield (11.0 t ha⁻¹). It shows that application of herbicides as pre-emergence followed by post-emergence, such as T₁₀ treatment could be a good method for weed control in maize fields.

Introduction

Maize (*Zea mays* L.) is the most flexible emerging crop having more extensive versatility under fluctuated agro-climatic conditions. It

ranks third after wheat and rice among the cereal crops. Maize is utilized for food, forage, drug and industrial purposes. It has extraordinary significance especially in developing

How to cite:

Wiqar, B., Noori, M. S., & Amini, S. Y. (2021). Effects of weed management on agronomic performance and productivity of hybrid maize (*Zea mays* L.). *Journal of Agriculture and Applied Biology*, 2(2): 70 - 75. doi: 10.11594/jaab.02.02.01

countries where populace is quickly increasing (Khan et al., 2020). Maize can provide crude material for the industry, where it is largely utilized for the production of corn starch, corn oil, dextrose, corn syrup, wax, corn flakes, beautifying agents, alcohol and tanning material (Arain, 2012).

Weeds mostly interfere with field crops and build up significant competition for moisture, light and minerals. To prevent these hurtful impacts, there are distinctive control measures among which, the most important is weed management (Pena-Asin et al., 2013). Weed infestation negatively influences maize yield due to competition with crops for moisture, space, light and nutrients, and accordingly affects the growth and development of field crops (Patel et al., 2013).

Other than decreasing the yield, weeds additionally influence the quality of kernels, because weed seeds and chaffs are mixed with seed lots during crop harvest (Khan et al., 2020). Crops are very sensitive to weed infestation in first 6 weeks after sowing. At this time, crop growth is slow and a wider spacing of maize, combined with suitable whether conditions which enhance weed growth that can decrease maize yield by 28-100% (Dass et al., 2012).

Herbicides are inexpensive and dynamic strategy for weed control in maize. Utilization of herbicide is simpler and efficient method than other different strategies. Application of herbicides in maize field enhance plant performance and productivity, which is assumed as an indispensable technique of weed management and can be considered as a substitute for hand weeding (Absy, 2019).

The pre-emergence utilization of herbicides such as Atrazine can greatly reduce the emergence and biomass of weeds (Khan et al., 2012). Utilization of herbicides after the germination of field crops and weeds is referred to as post-emergence herbicides. Post-emergence herbicides can be sprayed or applied on the canopy of weed in the field of maize by utilizing the sprayer tool (Hossain et al., 2019).

A mixture of 2 or 3 herbicides provides better weed control as compared to application of only one herbicide. In such condition the

possibility of plant injury will be negligible with any mixture of herbicides under normal growing conditions (Janak and Grichar, 2016). Weed control at the critical stage by common technique is sometimes troublesome because of the unsuitable climate conditions and at the pinnacle time of worker demand. Subsequently, weed control by using chemical herbicides has gotten more importance because of shortage of workers at the time of peak growing season, and lower cost of weed control by applying herbicides (Sarker et al., 2021).

Maize can offer a partial solution to the food shortage of Afghanistan, if its present yield level and total production raised in the further. Weed competition is one of the main stress factors in maize growing areas, which decreases the crop yield. In Afghanistan, farmers spent a lot of money on labor for weed management, but many times the labor availability is scarce, which in turn results in drastic reduction of maize yield due to weed infestation. Little importance is given to the herbicide application in maize growing fields bringing about a tremendous increment of weed population. Hence, the current field experiment was carried out to ascertain the impacts of weed control using pre and post-emergence herbicides on agronomic performance and productivity of hybrid maize.

Materials and methods

A high yielding maize hybrid (CS-200) was selected for this study. This hybrid variety is well-known as a successful variety which has greater adaptability to wider agro-ecological area and grows well at altitudes ranging from 1650 to 2800 m.a.s.l. and annual precipitation of 300 to 1500 mm year⁻¹. The research was carried out in the research farm of National Agriculture Science and Technology University of Afghanistan during growing season 2015. The average annual precipitation of this area is between 125 to 300 mm. The soil texture was sandy clay loam with 8.2 pH. The experiment was designed in a randomized complete blocks (RCBD), with 3 replicates consisting 10 treatments viz., T₁ (Control, weedy check), T₂ (Weed free), T₃ (Atrazine 1.5 kg ha⁻¹ pre-emergence), T₄ (Atrazine 750 g ha⁻¹ + Pendimethalin 750 ml ha⁻¹ pre-emergence), T₅ (Atrazine 1.5 kg ha⁻¹

followed by 2,4-D amine 0.4 kg ha⁻¹ at 25 days after sowing as post-emergence), T₆ (Halosulfuron 67 g ha⁻¹ at 25 DAS), T₇ (Atrazine 1.5 kg ha⁻¹ pre-emergence followed by Halosulfuron 90 g ha⁻¹ 25 DAS), T₈ (Tembotrione 120 g ha⁻¹ PoE at 25 DAS), T₉ (Pendimethalin 1000 ml ha⁻¹ pre-emergence followed by Atrazine 750 g ha⁻¹ + 2,4-D amine 0.4 kg ha⁻¹ at 25 DAS post-emergence) and T₁₀ (Atrazine 1.5 kg ha⁻¹ pre-emergence followed by Tembotrione 120 g ha⁻¹ post-emergence at 25 days after sowing).

Maize plant height was measured from three randomly selected tagged plants. The height from the soil surface to the apical branch at harvest time was considered for measurements. First leaf area was measured in three plants by taking the area of all green leaves, then the area of single leaf was calculated by multiplication of leaf length and maximum breadth by correction factors 0.75 and expressed as leaf area cm² plant⁻¹. Dry matter accumulation of plants was measured at harvest time by taking three plants at random from each plots. Leaves and stems were dried in the sun and afterward in the electric oven at 70 ± 5°C for 48 hours to attain a constant weight. After drying, the samples were weighted as dry weight accumulation and expressed as g plant⁻¹.

Yield components and yield were recorded utilizing standard methods. At the harvest time, central three lines from each plot were collected to record observations on yield. The cobs were sun dried and later shelled and winnowed in the air to obtain clean kernels, then kernels were weighted separately, and the moisture content of kernel was reduced to 15 % and kernel yield was expressed in t ha⁻¹.

The data analyses were carried out by using the SPSS software (version 22). Analysis of variance was conducted to examine the impacts of the main factor (weed management) on the agronomic performance and productivity of

hybrid maize. Less Significant Difference (LSD) was used to estimate the least significant range between means at the probability level of 0.05.

Results and discussion

Growth parameters

Statistical analysis of data showed that growth parameters of maize were significantly affected by weed chemical control (Table 1). Application of T₁₀ treatment significantly enhanced plant height (218 cm) at harvest time, which was on par with T₉ (209 cm). Weedy check (T₁) recorded significantly lowest plant height. Leaf area was significantly higher (396.6 cm² plant⁻¹) with weed free chick (T₂). While, T₁₀ and T₉ treatments also produced the same value of leaf area statistically. Among the different treatments, the lower leaf area was noted in weedy check (T₁). This reduction in leaf area might be because of weed competition for nutrient uptake which resulted in crop failure to utilize the resources and the crop growth was affected due to this phenomenon. A larger leaf area contributes to a higher yield in maize as it helps in a larger leaf surface for the utilization of more solar energy which enhances photosynthesis. Imoloame (2017) also found that application of herbicides increased the leaf area compared to weedy check. Dry matter accumulation was enhanced by chemical weed control and T₁₀ treatment recorded a higher dry matter accumulation (205.26 g plant⁻¹) at harvest time, which was on par with T₉ (195.12 g plant⁻¹). However, T₁ treatment recorded the lowest dry matter accumulation (158.13 g plant⁻¹) at final harvest, which was comparable to T₃ treatment (152.23 g plant⁻¹). A similar result was also observed by Gul et al. (2011) that effective weed control through different herbicides resulted in a higher dry matter production which in turn enhances biological yield.

Table 1. Effect of weed management on growth parameters of hybrid maize

Treatments	Plant height (cm)	Leaf area (cm ² plant ⁻¹)	Dry matter accumulation (g plant ⁻¹)
T ₁	139.44 ^{cd}	297.00 ^{cd}	158.13 ^{bc}
T ₂	172.19 ^a	396.60 ^a	211.37 ^a
T ₃	143.89 ^{cd}	344.81 ^b	152.23 ^c
T ₄	145.67 ^{cd}	327.20 ^{bc}	160.00 ^{bc}
T ₅	146.58 ^{cd}	344.63 ^b	162.20 ^{bc}
T ₆	137.44 ^d	333.12 ^{bc}	159.80 ^{bc}
T ₇	145.44 ^{cd}	314.21 ^{cd}	187.23 ^{abc}
T ₈	142.00 ^{cd}	307.30 ^{cd}	172.13 ^{abc}
T ₉	151.43 ^{bc}	384.32 ^{ab}	195.12 ^{ab}
T ₁₀	162.93 ^{ab}	383.11 ^{ab}	205.27 ^a
SEm(±)	6.10	8.30	18.72
LSD (p=0.05)	12.18	24.40	39.21

Note: The average number followed by the same letter in the same column is not significantly different at the 5% test.

Yield components

Yield components such as number of kernel row⁻¹, number of kernel cob⁻¹ and kernel weight cob⁻¹ was significantly affected by application of herbicides before germination and after the emergence of maize plants (Table 2). The highest number of kernel row⁻¹ (36.18), number of kernel cob⁻¹ (499.48) and kernel weight cob⁻¹ (136.97.63 g) were recorded with T₁₀ treatment, while the lowest value was recorded from weedy check plot (T₁). The difference between the treatments for 1000-kernels weight was nonsignificant. While, a higher value of 1000-kernels weight was obtained from T₁₀ treatment. However, weedy check (T₁) recorded the lowest value of 1000-kernel weight.

Application of Herbicides can significantly control weeds in maize field and therefore, affects the yield components (Khan et al., 2016). The increase in growth and yield components of maize can be a result of lower weed rivalry, which changed the balance for the benefit of maize plant in nutrient uptake, and utilization of light, moisture, and available space (Patel et al., 2013). The same result was reported by Chopra and Angiras (2008) who found that among the different weed control techniques herbicide application significantly reduced the weed density, which in turn resulted in the significant increase in all the yield components of maize over weedy check.

Table 2. Effect of weed management on yield component of hybrid maize

Treatments	Number of kernels row ⁻¹	Number of kernels cob ⁻¹	Kernel weight cob ⁻¹ (g)	1000-kernels weight (g)
T ₁	29.87 ^c	368.90 ^c	90.66 ^d	245.00
T ₂	36.98 ^a	502.48 ^a	137.63 ^a	273.13
T ₃	31.27 ^{bc}	408.02 ^{bc}	102.38 ^{cd}	251.07
T ₄	33.51 ^{ab}	440.14 ^{abc}	112.78 ^{bcd}	253.51
T ₅	33.28 ^{bc}	439.43 ^{abc}	113.03 ^{abcd}	255.93
T ₆	31.19 ^{bc}	402.95 ^{bc}	100.23 ^{cd}	247.87
T ₇	33.23 ^{ab}	434.89 ^{abc}	116.12 ^{abc}	266.93
T ₈	34.43 ^{ab}	455.87 ^{ab}	118.43 ^{abc}	256.07
T ₉	35.68 ^{ab}	481.13 ^{ab}	131.49 ^{ab}	271.03
T ₁₀	36.18 ^{ab}	499.12 ^a	136.97 ^{ab}	274.20
SEm(±)	1.62	38.213	11.773	11.282
LSD (p=0.05)	4.30	80.282	24.735	NS

Note: The average number followed by the same letter in the same column is not significantly different at the 5% test level, NS: not significant at 0.05.

Kernel and stover yield

Weed management by using pre and post-emergence herbicides significantly enhanced kernel and stover yield of hybrid maize (Table 3). Higher kernel yield (6.7 t ha^{-1}) and stover yield (11.6 t ha^{-1}) were found with weed free check plot which is comparable to T_{10} and T_9 treatments. The lowest kernel yield (4.3 t ha^{-1}) and stover yield (8.2 t ha^{-1}) were observed with weedy check. The low yield of maize in weedy check may be because of removal of mineral nutrient and moisture by weeds and serious competition between weed and crop causing weak source and sink development. Weed infestation accounts for 66% reduction in maize yield in weedy control compared to the average kernel yield (Amosun et al., 2015). While, 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. Herbicides prevents weed germination and provides an environment for the crop which is free of competition (Ali et al., 2011). This outcome is similar to Robert and Zenon (2014) findings who reported that application of herbicide in mixture form provided satisfactory suppression of weed infestation and resulted in a higher kernel yield in maize. The same results were reported by Imoloame (2017) who revealed that application of herbicide mixtures can significantly control weed infestation and hence can increase kernel yield of maize compared to T_1 (weedy check). The kernel yield in our study (6.51 t ha^{-1}) was higher than Khan et al. (2020) research which has resulted in 4.63 t ha^{-1} .

Table 3. Effect of weed management on kernel yield, stover yield and harvest index of hybrid maize

Treatments	Kernel yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
T_1	4.30 ^{cd}	8.22 ^c	34.28
T_2	6.70 ^a	11.61 ^a	36.49
T_3	5.71 ^{bc}	10.50 ^{bc}	35.09
T_4	5.80 ^{bc}	10.71 ^{bc}	35.25
T_5	6.11 ^b	10.90 ^{bc}	36.05
T_6	4.82 ^c	8.62 ^{bc}	35.88
T_7	6.03 ^b	10.60 ^b	36.17
T_8	5.41 ^c	9.50 ^{bc}	36.48
T_9	6.23 ^b	11.03 ^{ab}	36.17
T_{10}	6.51 ^{ab}	11.42 ^{ab}	36.38
SEm($\pm$)	0.20	0.83	1.15
LSD ($p=0.05$)	0.42	3.83	NS

Note: The average number followed by the same letter in the same column is not significantly different at the 5% test level, NS: not significant at 0.05.

Conclusion

Weed infestation is a big challenge in maize growing areas. Therefore, the current research was carried out to find the best weed management method and effective combination of herbicides. The result of this experiment shows that application of Atrazine 1.5 kg ha^{-1} before germination of maize plants followed by directed spray of Tembotrione 120 g ha^{-1} at 25 days after sowing as a post-emergence minimized the yield loss which caused by weed infestation, and can be adopted for best

agronomic performance, minimum loss and reasonable kernel yield of hybrid maize.

Authors declaration

Authors declare that there is no conflict of interest. BW (senior teaching assistant in Agronomy department): Designed the experiment procedure, collected the data and arranged the first draft of this study. MSN (Associate professor of Agronomy): Assisted in designing the study, performed statistical analysis of data, revised the first draft minutely and elaborated the final manuscript for publication.

While, SYA (senior teaching assistant in Agronomy department) helped in data collection. All authors read the manuscript and approved the final version.

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