

Research Application Summary

Effect of selected herbicides on weed management in sorghum production in Kenya

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Abstract

Weed infestation in sorghum (*Sorghum bicolor* L. Moench) forms a major biotic stress that needs to be addressed to achieve adequate grain supply to meet increasing industrial demand for sorghum. The aim of this study was to determine the most effective herbicides for weed management in sorghum. A field experiment was conducted at Egerton University in Njoro, Kenya in 2015. The experiment was carried out in a randomized complete block design (RCBD) with nine experimental units replicated three times. Four pre-emergence herbicides namely Lumax (Mesotrione, Metolachlor, Terbutylazine), Primagram (Atrazine, S - metolachlor), Dual gold (S - Metolachlor) and Sencor (Metribuzin) were tested in the study, in addition to three post-emergence herbicides namely 2,4-D (2,4-D amine salt), Maguguma (Atrazine, S-metolachlor) and Auxio (Bromoxnil, Tembotrione). Positive and negative controls comprised of hand weeding and no weeding. Pre-emergence treatments were applied immediately after sowing while post-emergence treatments were applied 30 days after sowing. Weed density and biomass was determined at 30 and 60 days after sowing. All data were subjected to analysis of variance using SAS version 8.1. Means were separated according to least significant difference (LSD) test whenever the herbicide effects were significant ($P \leq 0.05$). Analysis of variance (ANOVA) revealed significant ($P \leq 0.05$) differences in the effect of the treatments evaluated. Amongst the four pre-emergence herbicides, Sencor (Metribuzin) was the most effective herbicide reducing the weed density by 96% and 95% compared to no weeding and hand weeding, respectively. Thirty days after the application of post emergence treatment, weed densities were reduced by 90%, 80%, 43%, and 26% when 2,4-D, Hand weeding, Maguguma and Auxio were used, respectively. Adoption of Sencor and 2, 4-D in recommended rates will ensure effective weed management and contribute to increased sorghum production to meet the increasing industrial demand.

Key words: Hand weeding, herbicides, Kenya, weeds

Résumé

L'infestation de mauvaises herbes dans le sorgho (*Sorghum bicolor* L. Moench) constitue un stress biotique majeur qui doit être traité pour obtenir un approvisionnement adéquat en céréales pour répondre à la demande industrielle croissante de sorgho. Le but de cette étude était de déterminer les herbicides les plus efficaces pour la lutte contre les mauvaises herbes dans le sorgho. Une expérience sur le terrain a été menée à l'Université d'Egerton à Njoro, au Kenya en 2015. L'expérience a été réalisée dans un plan de bloc complet randomisé (RCBD) avec neuf unités expérimentales répliquées trois

fois. Quatre herbicides de pré-émergence à savoir Lumax (mésotrène, métolachlore, terbutylazine), Primagram (atrazine, S - métolachlore), Dual gold (S - métolachlore) et Sencor (métribuzine) ont été testés dans l'étude, en plus de trois herbicides de post-émergence à savoir 2,4-D (sel de 2,4-D amine), Maguguma (Atrazine, S-métolachlor) et Auxio (Bromoxnil, Tembotrine). Contrôles positifs et négatifs comprenant un désherbage manuel et aucun désherbage. Les traitements de pré-levée ont été appliqués immédiatement après le semis tandis que les traitements de post-levée ont été appliqués 30 jours après le semis. La densité et la biomasse des mauvaises herbes ont été déterminées 30 et 60 jours après le semis. Toutes les données ont été soumises à une analyse de variance en utilisant SAS version 8.1. Les moyennes ont été séparées selon le test de différence la moins significative (LSD) chaque fois que les effets de l'herbicide étaient significatifs ($P < 0,05$). L'analyse de variance (ANOVA) a révélé des différences significatives ($P < 0,05$) dans l'effet des traitements évalués. Parmi les quatre herbicides de pré-levée, Sencor (Metribuzin) était l'herbicide le plus efficace pour réduire la densité des mauvaises herbes de 96% et 95% par rapport à l'absence de désherbage et de désherbage manuel, respectivement. Trente jours après l'application du traitement de post-levée, les densités de mauvaises herbes ont été réduites de 90%, 80%, 43% et 26% lorsque le 2,4-D, le désherbage manuel, le Maguguma et l'Auxio ont été utilisés, respectivement. L'adoption de Sencor et de 2,4-D aux doses recommandées garantira une gestion efficace des mauvaises herbes et contribuera à accroître la production de sorgho pour répondre à la demande industrielle croissante.

Mots clés : Désherbage manuel, herbicides, Kenya, mauvaises herbes

Introduction

Weeds are the major biotic factor responsible for poor yield in sorghum particularly for those farmers who have large holdings. Yield losses due to uncontrolled weeds are in the range of 20 – 80% for sorghum (Pandey *et al.*, 2017) depending on the type of weed flora and weed density. However, there is an increasing demand for sorghum due to its utilization in diverse ways such as food, fodder, beverage, and fuel, among others. For instance, total sorghum consumption in Kenya has been increasing from 2009 to 2013 to about 160 000 tons (FAOSTAT, 2013). These increase in consumption could be attributed to promotion of sorghum as an industrial crop. For example, East African Breweries Limited (EABL) is utilizing sorghum as a raw material for malting in brewing. New sorghum varieties for use in baking and brewing and in biofuel production have also been identified (Kiprotich *et al.*, 2014) and their suitable agro-ecological environments documented. These could contribute to increase in number of farmers venturing into sorghum farming and/or increased production area to meet the increasing demand for industrial sorghum. This therefore demands for documentation of effective and reliable weed control measures for sustainable sorghum production. This is because yield losses from weed competition are greater in sorghum compared to most grain crops where up to 30 to 50 percent yield loss have been reported. The increasing industrial demand for sorghum has led to increase in scale of operation hence necessitating mechanized methods. Herbicide weed control is one of the crucial operations which ensures reduced yield loss occasioned by weeds during early growth period of sorghum where mechanical weeding usually result in delayed weed management (Imoloame, 2017). However, weed control in sorghum through the use of herbicides has received little attention in Kenya, while elsewhere in the world herbicides have shown a promise in weed management. Hence there is a need to change production techniques to suit large scale production so as to meet the demand by reducing losses due to effects of weeds. This study aimed at determining the most effective pre- and post- emergence herbicide in weed management in sorghum for the purpose of contributing to increased sorghum production for industrial uses in Kenya.

Materials and methods

The experiment was carried out at Egerton University (0°23' S, 35°35' E, and 2267 metres above sea level (asl). The area experiences annual mean precipitation of 1000 mm and the annual mean temperature of 15.9°C. The area is situated in agro-ecological zone Low highland 3 (LH 3). The soils are mollic andosols. The study site represents major sorghum growing regions in Kenya but with a rich weed seedbank. Land was disc ploughed and harrowed to a fine tilth prior to planting for better emergence and seedling development. The trial was set up in a randomized complete block design replicated three times. Four pre-emergence and three post-emergence herbicides were tested and each was used at manufacturers recommended rate. Hand weeding and uncontrolled weeding served as positive and negative controls, respectively. Sorghum was sown at a spacing of 60 cm x drill with a seed rate of 8 kg/ha.

Triple Super Phosphate was applied at a rate of 17.2 kg P₂O₅ ha⁻¹ and nitrogen supplied as Calcium Ammonium Nitrate at the rate of 40 kg N ha⁻¹ split into two applications of 20 kg N ha⁻¹ at planting and top dressed with 20 kg N ha⁻¹. At three leaf stage, the crop was thinned to a spacing of 15 cm within rows.

Pre-emergence herbicide application was done immediately after sowing while the post-emergence treatment was done at three leaf growth stage of sorghum (30 days after sowing). Weed density and sampling for weed biomass determination was done before post and after pre-emergence herbicide application. The treatments were applied using flat fan nozzle sprayers. Weed count was done at three - leaf stage of crop (30 days after sowing) followed by a second count one month after post - emergence herbicides application (60 days after sowing). Counting was done using a 1m² quadrat thrown randomly in each plot. The dry biomass of weeds was determined by harvesting above ground growth within the 1 m² quadrat in each plot. The samples were dried in the oven at 60 °C to a constant weight and weight taken. Data were subjected to analysis of variance using SAS version 8.1 and means separated using Least Significant Difference whenever there was significant effect.

Results and discussion

Weed flora. Major weed flora observed in the experimental plots comprised of *Datura stramonium*, *Bidens pilosa*, *Physalis alkekengi*, *Chenopodium album*, *Pennisetum clandestinum*, *Raphanistrum raphanistrum*, *Digitaria scalarum*, *Gallinsoga parviflora*, *Commelina benghalensis*, *Tagetes erecta*, *Anagallis arvensis*, *Oxygonum sinuatum*, *Oxalis latifolia*, *Setaria sphacelata* and *Cyperus rotundas*. Broadleaf weeds namely *Bidens pilosa*, *Gallinsoga parviflora* and *Amaranthus hybridus* were among the predominant weed species in the experiment. Un-weeded sorghum check had high weed densities (Table 1). This was expected given the high relative growth rate and aggressiveness associated with weeds.

Effect of pre- and post-emergence herbicides on weed density. In line with the expectations, the results indicated that use of herbicides significantly reduced the weed density in sorghum compared to the un-weeded check (Table 1). Amongst the four pre-emergence herbicides, Sencor (Metribuzin) was the most effective herbicide reducing the weed density by 96% and 95% compared to no weeding and hand weeding, respectively (Table 1). The effect of Sencor (Metribuzin) and Lumax (S-metolachlor+Atrazine+ Mesotrione) were however comparable 30 days after sowing. On the other hand Primagram (S-Metolachlor+Atrazine) and Dual gold (S-metolachlor) also reduced the weed density. At 60 days

after sowing the effect of these pre-emergence herbicides could still be noted with Sencor (Metribuzin) being the most effective in reducing the weed density of both broad and narrow leaf weeds. These results are in agreement with those of the other researchers (Nanher *et al.*, 2015; Roshdy *et al.*, 2017) who reported reduced weed densities when metribuzin was used in potatoes and maize production, respectively.

Table 1. Effect of selected herbicides on weed density in sorghum

Treatments	Weed density (N/M ²)	
	At 30 days after sowing	At 60 days after sowing
No weeding	2542.7 ^a *	2705.7 ^a
Hand-weeding	2303.2 ^{ab}	251.4 ^{de}
Auxio	1948.2 ^{bc}	1122.7 ^b
2,4-D	1712.1 ^c	83.2 ^e
Maguguma	2192.8 ^{abc}	871.3 ^{bc}
Primagram	378.8.2 ^{cd}	713.4 ^c
Sencor	48.8 ^e	59.1 ^e
Dual Gold	832.3 ^d	591.1 ^{cd}
Lumax	460.4 ^{de}	934.2 ^{bc}
Lsd 0.05	530.31	389.54

*Means with same letter in the column do not differ significantly (P<0.05)

Sencor is absorbed through the plant shoots while they are still underground and kill or injure the shoots before they emerge from the soil. This occurs due to inhibition of the enzyme activity and the disruption of protein synthesis and other subsequent bio-chemical reactions which in turn inhibit the weed growth and few weed species survive the herbicide action. However, Primagram (S-Metolachlor+Atrazine) and Lumax (S-metolachlor+ Atrazine+ Mesotrione) did not have a longer residue effect as shown by increased weed density at 60 days after sowing.

Thirty days after the application of post emergence treatment, weed densities were reduced by 90%, 80%, 43%, and 26% when 2,4-D, Hand weeding, Maguguma and Auxio were used, respectively. However, the unweeded check resulted in increase in weed density by 3%. For the post-emergence herbicide treatment, 2-4-D was most effective in reducing weed density compared to other herbicides. Often 2, 4-D as a synthetic auxin and systemic herbicides is used for controlling broadleaf weeds. It causes unregulated cell and uncontrolled growth leading to damage to chloroplasts, membranes and vascular tissues which finally causes the death of the whole plant (Zahoor *et al.*, 2017).

Effect of pre- and post-emergence treatments on weed biomass in sorghum production. The weed biomass was remarkably influenced by weed control treatments at all stages of observation (Table 2). The results showed that the use of Sencor (Metribuzin) had a significant effect on weed biomass at 30 and 60 days after application. The herbicide reduced weed biomass by 85% and 91.7% compared to no weeding at 30 and 60 days after sowing, respectively. Relative to hand weeding, Sencor reduced weed biomass by 73% and 68% at 30 and 60 days after application, respectively. Primagram, Lumax and Dualgold were not as effective as hand weeding at 30 and 60 days after application.

Table 2. Effect of selected herbicides on weed biomass in sorghum production

Treatment	Weed biomass (days after sowing)	
	30	60
No weeding	1542.7 ^{a^}	1888.7 ^a
Hand weeding	809.0 ^{bc}	323.7 ^d
Primagram	1303.2 ^{ab}	716.4 ^c
Sencor	121.2 ^d	82.09 ^e
Lumax	525.5 ^c	735.9 ^c
Dual Gold	917.2 ^{ab}	945.8 ^b
2,4-D	1004.7 ^{ab}	245.4 ^d
Maguguma	937.1 ^{ab}	858.8 ^{bc}
Auxio	1026.5 ^{ab}	1001.8 ^b
Lsd 0.05	322.16	159.38

*Means with same letter in the column do not differ significantly (P<0.05)

This reflects the ability of Sencor (Metribuzin) in suppressing and preventing germination, survival, growth and competitive ability of weeds (Azadbakht *et al.*, 2017). Metribuzin is a selective triazinone herbicide acting as an inhibitor of photosynthesis, specifically the inhibition of the photosynthetic electron transfer in light reaction stage (Singh *et al.*, 2015).

Amongst post-emergence treatments, 2, 4-D (2, 4-D amine salts) proved more effective in reducing weed growth as indicated by reduced dry weight, compared to other treatments (Table 2). Hand weeding and use of 2, 4-D did not differ significantly (pd>0.05). However, considering the initial weed biomass at the time of application of the treatment, 2, 4-D reduced the weed biomass by 60.7% while hand weeding reduced the biomass by 42.8%. It is documented that 2, 4-D is among the first herbicide compounds that are selectively effective against dicots but not monocots plant species (Andrew *et al.*, 2010). The herbicide effect was manifested by twisted, thickened and elongated leaves and stems which eventually killed the plant. Highest dry weight of weeds was observed under no weeding treatment.

Conclusion

Weeds have competitive ability that allows them to compete for growth resources thus suppress crop growth and development. This study found Sencor (Metribuzin) to be the most effective pre-emergence herbicide in reducing weed density and biomass while 2, 4-D was the most effective post-emergence herbicide for control of weeds in sorghum. The use of the two herbicides could replace hand weeding which is more labour intensive than chemical weed management. Herbicide use also helps to achieve timely intervention within the critical period of weed management and thus ensures minimal crop yield loss attributed to weeds.

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