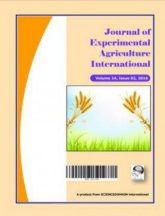

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Comparative Study of Herbicides for Pre-Emergence Weed Control in Maize (*Zea mays* L.) in Derived Savanna of Nigeria

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: To evaluate and compare the efficiency of candidate herbicides and increase the latitude of herbicides for pre-emergence weed control in maize.
Study Design: Randomized Complete Block Design, with three replicates was used in the study.
Place and Duration of the Study: Candidate herbicides were obtained Rainbow Nig. Limited for evaluation. The study was carried out between June – September, 2014 and 2015 at Ibadan (0.7.38N; 003.84E) and Ilora (07.81N; 003.82E) research stations of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Ibadan.
Methodology: Weed flora composition was taken with 1sqm quadrat placed randomly before land preparation. Acetochlor 500 g/L, Acetochlor 900 g/L, Metholachlor 720 g and Ametryn 80 WP were applied randomly at three rates of active ingredient (a.i) at maize sowing, while Atrazine (reference), weed-free and weedy check were the control. Agronomic and weed data were taken, analysed and means separated using Duncans Multiple Range Test (DMRT) at p≤ 0.05.
Results: Result showed that weed flora composition before land preparation was dominated by annual weeds {broadleaves (80%) and grass (20%)}. At 6 weeks after sowing (WAS), weed flora composition comprised of 8% spiderwort, 8% sedge, 25% grass weeds and 59% broadleaf weed

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species. Weed flora dynamics after treatments application might have been influenced by types of herbicides, herbicidal activities and previous cultural practices. Herbicides application resultantly increased plant height (50%) and grain yield (46 - 60%) relative to plant height in weedy check at both locations. These might have accrued from minimal weed interference hence, high weed control efficiency (WCE) recorded in herbicides applied (WCE ≥80%) and significant reduction in cumulative weed dry matter of about 80%.

Conclusion: Herbicides applied significantly reduced weed growth and enhanced maize grain yield. Notwithstanding, investigation of the benefit cost ratio and the environmental impact assessment of herbicides applied are imperative for sustainability of maize production and agro-ecology.

Keywords: Pre-emergence; herbicides; weed control efficiency; weed flora composition; maize seed yield and derived savanna.

1. INTRODUCTION

The infusion of modern technology in chemical weed management is imperative in combating weed problems, increasing crop yield and enhancing food security. Maize (*Zea mays*) is a major food crop in Nigeria and the world at large. It is widely cultivated in almost all the ecological zone. According to estimation, 75% of the total production of maize is used as food by the farming community and the remaining finds its way in starch manufacturing industry, poultry feed and grain sales. As one of the stable food crops, the yield of maize is very crucial for the survival of teeming population of Nigeria citizens.

However, maize yield is widely affected by weed competition. The reduction in yield due to weed resulted from competition for light, water, nutrition and other potential yield limiting factors [1]. Early weed infestation reduced maize leave area [2], reduce photosynthesis [3] and impact negatively on green ear yield and grain yield by 60% and 80 - 90% respectively [4].

Manual weed control is a problem particularly large farm holdings because of acute shortage of labour, Hence, hand weeding or mechanical weeding operation are usually left all together. The efficacy of herbicides for weed control was reported by [5]. Herbicides are effective and cheaper in locations with scarce labour for farm operations [6]. Corn yield respond positively when weeds were controlled by herbicides [7]. Maximum weed competition in maize occurs within the period of 2 – 6 WAS. Hence, early weed control was suggested in field crops. The study was conducted to generate data and determine the efficacies of some formulations in order to increase the frontier of herbicides available for pre-emergence weed control in maize, to reduce the cost of weed control, enhance profitability in maize production among farmers and agro-chemical companies.

2. MATERIALS AND METHODS

The weed flora compositions at the experimental site were identified using the Handbook of West African weeds [8] before conventional tillage was done in both locations of the study and during data collection after herbicide application. The site was ploughed and harrowed before planting in June in Ilora (07.81N; 003.82E) and Ibadan (0.7.38N; 003.84E). The plots were marked out into 3 x 3 m and maize planting was done with the spacing of 75 x 25 cm (1plant/stand). Maize variety SUWAM I obtained from the Institute of Agricultural Research and Training (IAR&T) Ibadan was planted. NPK (20:10:10) fertilizer was applied at the rate of 200 kg/ha at 5 WAS. Four herbicides were evaluated at three rates of active ingredient (a.i) each, along with weedy check, weed-free control and Atrazine (Reference). Herbicide rates were randomly assigned to different plots immediately after planting maize. These were replicated three times and arranged in Randomized Complete Block Design (RCBD). Maize agronomic traits and weed growth data were measured at specified times. Data were analyzed with statistical analysis System [9] at 5% level of probability (P≤ 0.05) and means were separated with Duncans Multiple Range Test (DMRT). The list of the herbicides and rates were given below.

List of Herbicides and Rates Applied:

Acetochlor-900 g at 1.80 kg a.i/ha
Acetochlor-900 at 2.25 kg a.i/ha
Acetochlor-900 g at 2.70 kg a.i/ha
Metholachlor-720 g at 2.88 kg a.i/ha
Metholachlor-720 g at 3.60 kg a.i/ha
Metholachlor-720 g at 4.32 kg a.i/ha

Ametryn-80 WP at 3 kg/ha
Ametryn -80 WP at 4 kg/ha
Ametryn-80 WP at 5 kg/ha
Acetochlor-500 g at 1.50 kg a.i/ha
Acetochlor-500 g at 1.75 kg a.i/ha
Acetochlor-500 g at 2.0 kg a.i/ha
Atrazine (Reference)
Weed-free control
Weedy check/control

3. RESULTS AND DISCUSSION

Table 1 shows the pool of weed flora composition of the experimental site before land preparation. This was composed of about 39% grass and 61% broadleaves. The weed species were annuals, from different plant families. Previous cropping activities and fallow period of three years might have influenced the weed richness in the sites. Fallow lands are occupied by few dominant weed species. Prolonged fallow period may influence weed flora dynamics and a shift occur from annual to a few perennials weed species. In Table 2, weed flora composition contained 8% spiderwort, 8% sedge, 25% grass weeds and 59% broadleaf weed species. Table 3 showed the weed richness at 6 WAS in Ibadan. Broadleaf weeds were 66.7%, grass weed was 16.7%, sedge was 16.7% and spiderwort was 8.3%.

The weed flora composition 6 WAS at both locations evidently showed the dynamism of weed composition. *Hackelochloa granularis* and *cyperus rotundus* were recorded in all the treated plots in Ilora. The dominance of *Hachelochloa granuluris* and *Cyperus rotundus* in Ilora*; and Panicum maximum* in Ibadan (Table 3) mirrored ineffectiveness of herbicides on their propagules, consequently their ascendency was exhibited through substitution of annual weed species that succumbed to herbicide treatments. High occurrence of *Mitracarpus villosus* ($^{10}/_{15}$ Ilora; $^{11}/_{15}$ Ibadan - out of 15 treated plots) and *Desmodium scorpurus* ($^{11}/_{15}$ Ilora; $^{9}/_{15}$ Ibadan) in both locations; *Tithonia diversifolia* ($^{11}/_{15}$) and *Cynodon dactylon* ($^{9}/_{15}$) might also show the limitations of spectrum of activities of herbicides and the numerical impact of the aforementioned weeds in the study area. In Ibadan, *Panicum maximum* was found in all the treated plots at 6 WAT, though in scattered faction, and the overall weed richness in Ibadan might reflect the limitation of herbicides to corm grass control and negative impact on weed control efficiency. Sparsely disperse weed flora composition in Ilora (Table 2) might have been influenced by previous agronomic practices [10] weed species dominance during the fallow period, efficacy of herbicides and geographical effect [11]. Weed flora dynamics after treatments application might have been influenced by the difference in herbicidal activities and previous cultural practices. According to, factors such as the type of herbicide, application rate, climatic conditions following application, as well as a number of soil factors can affect the activity of soil-applied herbicides evaluated in the study [12].

Table 1. Weed flora composition of experimental sites before land preparation at Ibadan and Ilora

Family	Weed species	Morphology	Life cycle	Ibadan	Ilora
Poaceae	*Panicum maximum*	G	P	*	*
"	*Hackelochloa granularis*	"	"	-	*
Asteraceae	*Tithonia diversifolia*	B	A	*	*
"	*Tridax procumbens*	B	A	*	*
"	*Aspillia africana*	B	A	*	*
"	*Agerantum conyzoides*	B	A	*	*
Leguminosae-Mimosoideae	*Mimosa invisa*	B	A	*	*
Leguminosae-Papilinoideae	*Crotalaria retusa*	B	A	*	*
"	*Desmodium scorpiurus*	B	A	-	*
Lamiaceae	*Hyptis suaveolens*	B	A	-	*
Rubiaceae	*Mitracarpus villosus*	B	A	*	*
Verbenaceae	*Stachytarpheta cayennesis*	B	A	*	-
"	*Stachytarpheta jamaicensis*	B	A	*	-

*P – Perennial, A- annual, G- grass, B- broadleaf, * - presence of weed species*

Table 2. Weed spectrum and prevalence after pre-emergence herbicide application in Maize at 6WAS at Ilora

Family	Weed Spp	Morph.	Life cycle	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
Poaceae	*Hackelochloa granularis*	G	A/P	a	b	b	b	a	b	a	b	b	b	b	a	b	b	a
Cyperaceae	*Cyperus rotundus*	S	A/P	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b
Rubiaceae	*Mitracarpus villosus*	B	A/P	b	b	b	-	b	b	b	b	b	b	-	-	b	-	-
Leguminosae-Papilinoideae	*Desmodium scorpiurus*	B		b	b	b	-	b	b	-	-	b	b	-	b	b	b	b
Poaceae	*Panicum maximum*	G	A	-	b	-	-	-	-	-	-	-	b	b	-	-	-	-
“	*Cynodon dactylon*	G	A	b	b	-	-	b	b	b	-	b	-	b	b	-	-	b
Asteraceae	*Tridax procumbens*	B	A	-	-	-	-	b	-	b	-	-	-	-	-	-	-	-
“	*Tithonia diversifolia*	B	A	-	b	b	b	b	-	b	b	b	b	b	-	b	-	b
“	*Acanthospermum hispidium*			-	-	-	-	-	-	-	-	b	-	-	-	-	-	b
Malvaceae	*Sida acuta*	B	A/P	-	b	b	b	-	-	-	-	-	-	-	-	-	-	-
Commelinaceae	*Commelina bengalensis*	Sp	P	-	-	-	-	-	b	-	b	-	-	-	-	-	-	-
Lamiaceae	*Hyptis suaveolens*	B	A	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-

Legend: a – Major weed , b – Minor weed, B- broadleaf, G- grass, Sp- Spiderwort, S – Sedge, P- Perennial, A – Annual, A/P – annual/perennial, T_1 – Acetochlor 900 g – 1.80 kg a.i/ha, T_2 – Metholachlor 720 g - 3.60 kg a.i/ha, T_3 – Ametryn – 80 WP 4 kg/ha, T_4 – Acetochlor 900 – 2.25 kg ai/ha, T_5 – Weedy check, T_6 – Acetochlor 500 g – 1.75 kg ai/ha, T_7 – Weedfree, T_8 - Acetochlor 500 g – 1.50 kg ai/ha, T_9 – Metholachlor 720 g – 2.88 kg ai/ha, T_{10} – Atrazine – (Reference), T_{11} – Acetochlor 500 g – 2.0 kg ai/ha, T_{12} – Ametryn – 80 WP 3 kg/ha, T_{13} – Acetochlor 900 g – 2.70 kg ai/ha T_{14} – Ametryn – 80 WP 5 kg/ha and T_{15} – Metholachlor 720 g – 4.32 kg ai/ha

Table 3. Weed spectrum after pre-emergence herbicide application in maize at 6WAS in Ibadan

Family	Weed spp.	Morpholorgy	Life cycle	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}
Asteraceae	*Tithonia diversifolia*	B	A	a	-	-	a	-	b	-	b	-	-	b	b	b	-	b
Leguminosae-Mimosoideae	*Mimosa invisa*	B	P	a	-	-	-	-	b	-	b	-	-	-	-	b	-	-
Rubiaceae	*Mitracarpus villosus*	B	A	b	a	-	b	b	b	-	-	a	-	b	b	b	b	b
Poaceae	*Panicum maximum*	G	A	a	b	a	a	a	a	b	a	b	a	b	a	b	b	b
Leguminosae-Papilinoideae	*Crotateria retusa*	B	A	-	b	-	-	-	-	-	-	b	-	b	-	b	-	b
“	*Desmodium scorpiurus*	B	P	-	b	b	b	b	-	-	b	b	-	b	-	b	b	-
Cyperaceae	*Cyperus rotundus*	S	A/P	b	b	-	-	-	-	-	-	-	b	-	-	-	-	-
Commelinaceae	*Commelina bengalensia*	SP	P	-		-	a	b	-	b	-	-	-	b	b	-	-	b
Poaceae	*Elusine indica*	G	A	-	-	-	-	-	--	b	-	-	b	-	b	-	-	-
Convolvulaceae	*Ipomea triloba*	B	A	-	b	-	-	-	-	-	b	-	-	-	-	-	-	-
	Acanthespernum hispiudum	B		-	-	-	-	b	b	-	-	-	-	-	-	-	-	-
Rubiaceae	*Oldenlandia corymbosa*	B		-	-	-	-	b	-	-	-	-	-	-	-	-	-	-
Cyperaceae	*Cyperus esculenta*	S	A	-	-	b	-	-	-	-	-	b	-	-	-	-	b	-

Legend: a – Major weed , b – Minor weed, B- broadleaf, G- grass, Sp- Spiderwort, S – Sedge, P- Perennial, A – Annual, A/P – annual/perennial, T_1 – Acetochlor 900 g – 1.80 kg a.i/ha, T_2 – Metholachlor 720 g - 3.60 kg a.i/ha, T_3 – Ametryn – 80 WP 4kg/ha, T_4 – Acetochlor 900 – 2.25 kg ai/ha, T_5 – Weedy check, T_6 – Acetochlor 500 g – 1.75 kg ai/ha, T_7 – Weedfree, T_8 - Acetochlor 500 g – 1.50 kg ai/ha, T_9 – Metholachlor 720 g – 2.88 kg ai/ha, T_{10} – Atrazine – (Reference), T_{11} – Acetochlor 500 g – 2.0 kg ai/ha, T_{12} – Ametryn – 80 WP 3 kg/ha, T_{13} – Acetochlor 900 g – 2.70 kg ai/ha T_{14} – Ametryn – 80 WP 5kg/ha and T_{15} – Metholachlor 720 g – 4.32 kg ai/ha

The effects of weed interference and herbicides efficacy was evident in disparities in plant height at 10 WAP in both locations (Figs. 1 and 2). At Ilora, the tallest plant was recorded in plots treated with Acetochlor-500 g (1.75 kg ai/ha), this was comparable with plant heights in other plots except weedy check that had the shortest plants. This was due to the critical weed competition with maize plants in the weedy check plots. Similar trend was recorded in Ibadan in weedy check plots that had about 50% reduction in plant height compared with the tallest plant in weed-free plots. Crop-weed interaction becomes critical in crop plant at early stage of weed competition [1]. Evidently, herbicides treated plots had taller maize plants relative to untreated weedy plots. Maize plant height increased by about 60% at both locations compared with the average height from weedy check and other plots (Figs. 1 and 2). Consequently, weed control efficiencies were higher in weed-free plots and herbicides treated plots than in weed check plots (Figs. 3 and 4). This may be traced to the cumulative effects of weed growth and dry matter accumulation in each plot as expressed in Fig. 5. Weed dry weight was about six times in weedy check compared to the average from other treated plots. Thus, herbicides evaluated in the study significantly reduced weed dry matter by about 80% in Ilora and slightly lower in Ibadan. This might be due to the richer weed flora composition in Ibadan. Notwithstanding, herbicide treated plots had taller plants, better weed control efficiency and more grain yield (Figs. 6 and 7).

Chemical weed control is better alternative because it is cheaper, faster and gives better weed control [5]. Chemical weed control gave better results and attractive return than hoe weeding in wheat and sweet potatoes fields infested with weeds [13,14]. In places with scarce and high cost of labour for farm operations, chemical weed control will remain appropriate for timely weed management [15]. The efficiency and profitability of herbicides over hoe-weeding was also reported to be higher [6]. Similarity in weed control efficiency of the herbicides evaluated may call for benefit cost ratio analysis of the study. This is appropriate for selection and recommendation of herbicides for maximum profitability in maize production.

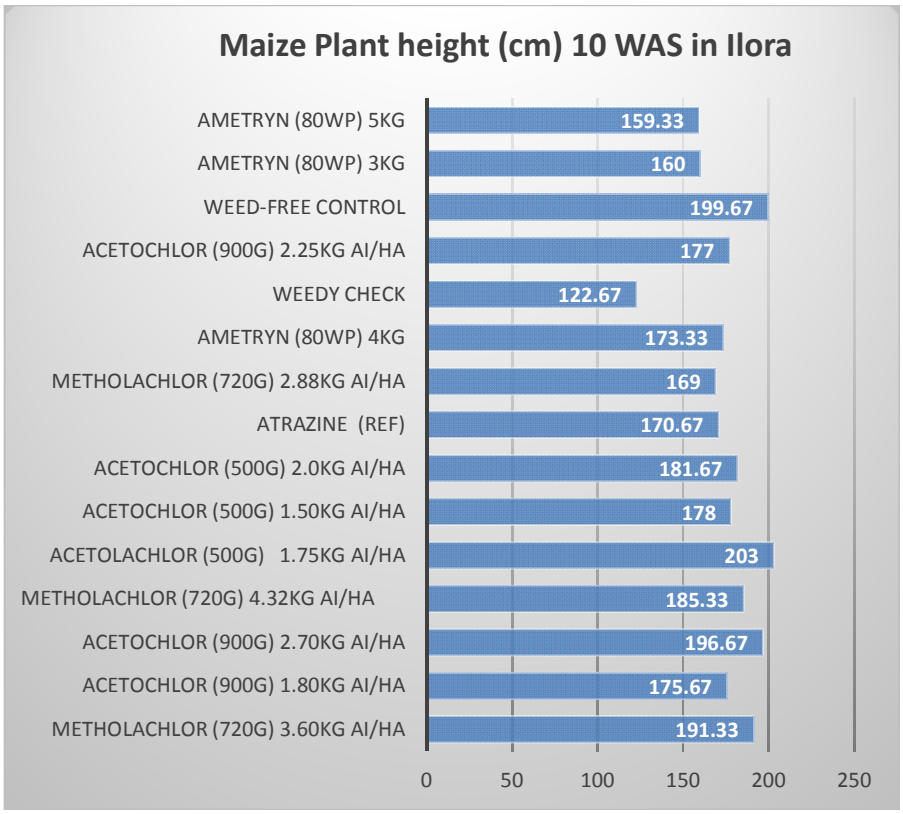

Fig. 1. Effects of herbicides on plant height (cm) at 10 WAS in Ilora

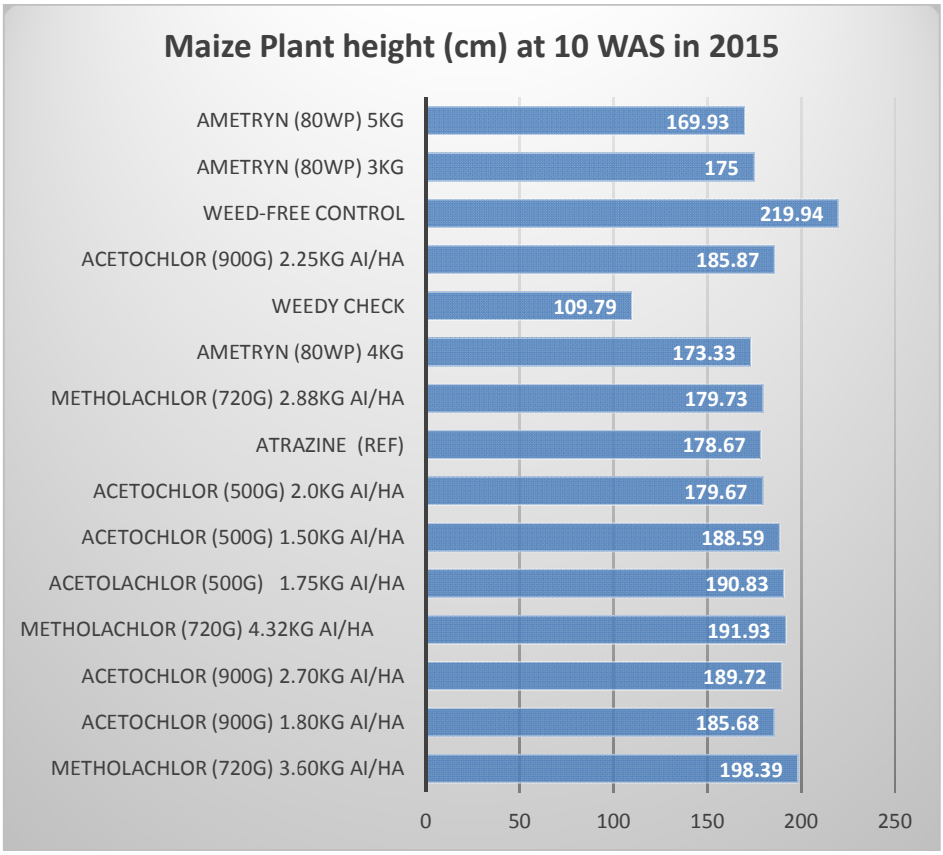

Fig. 2. Effects of herbicides on plant height (cm) at 10 WAS in Ibadan

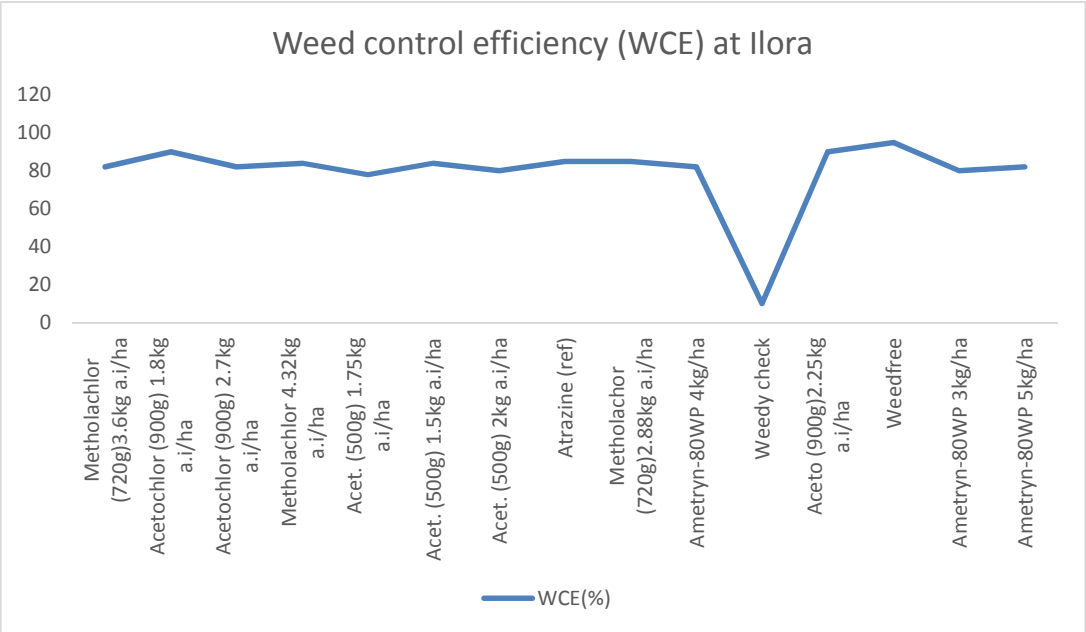

Fig. 3. Weed control efficiencies of the herbicides applied at Ilora

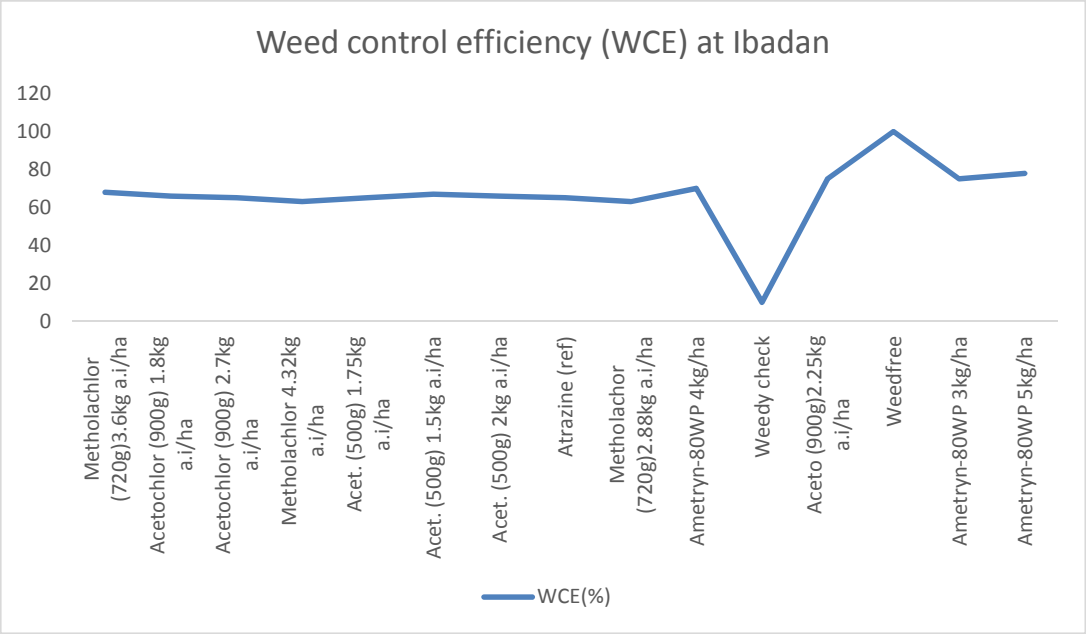

Fig. 4. Weed control efficiencies of herbicides applied at Ibadan

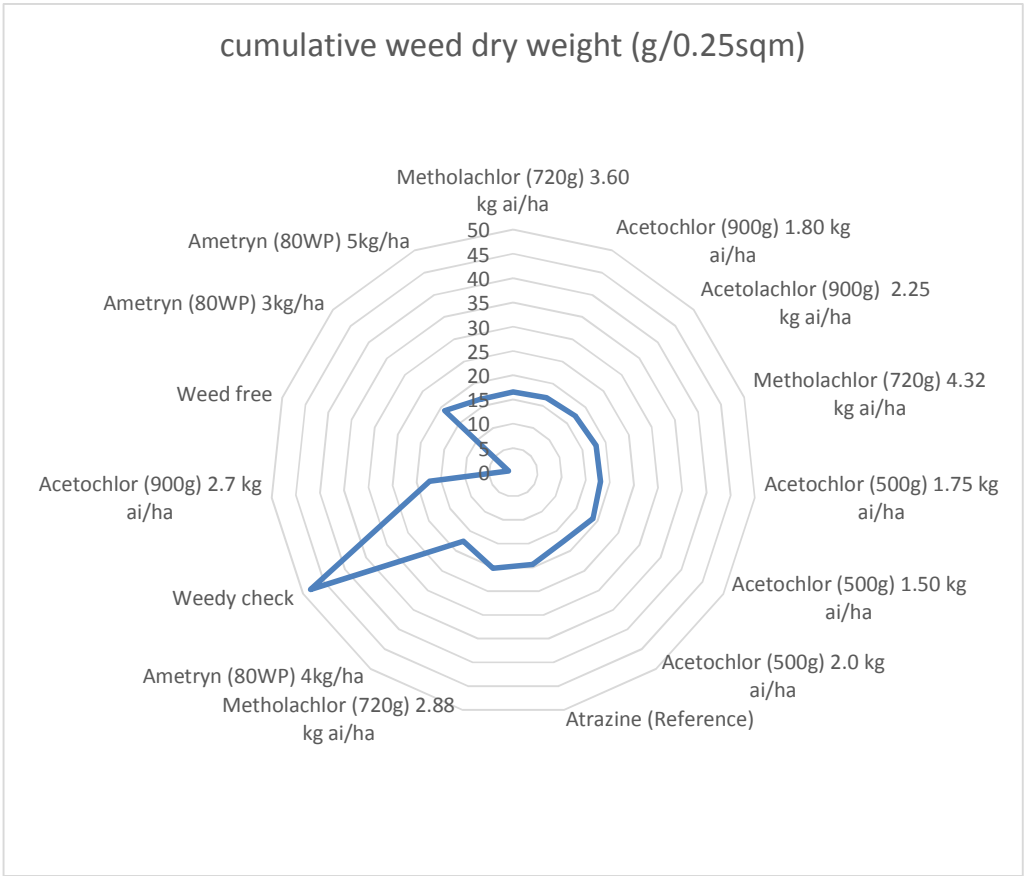

Fig. 5. Cumulative weed dry weight at 6 WAS at both locations

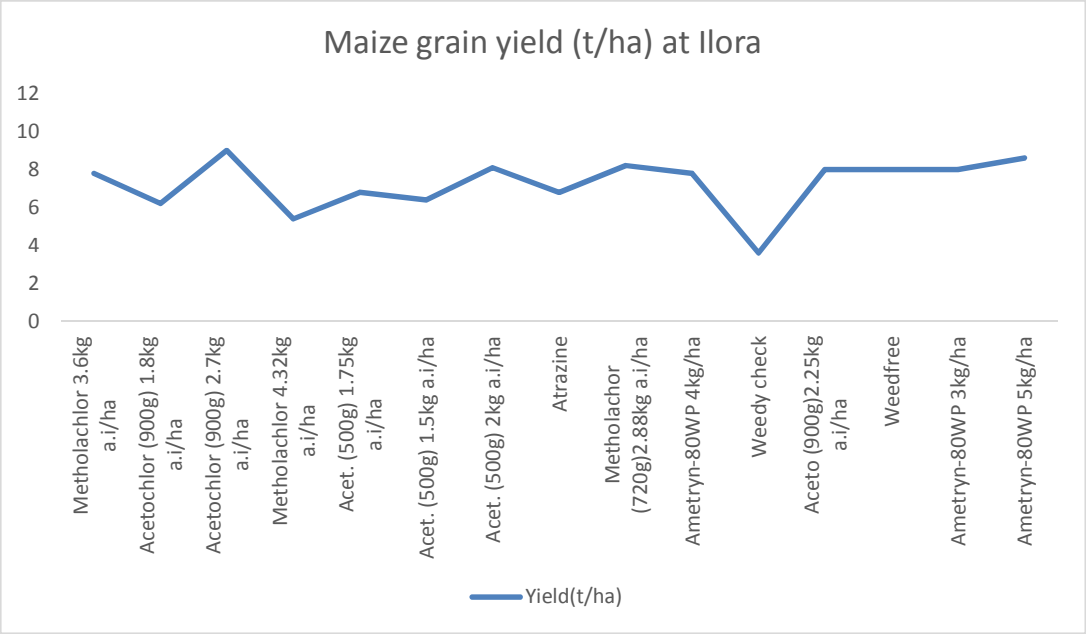

Fig. 6. Effects of pre-emergence weed control on grain yield at Ilora

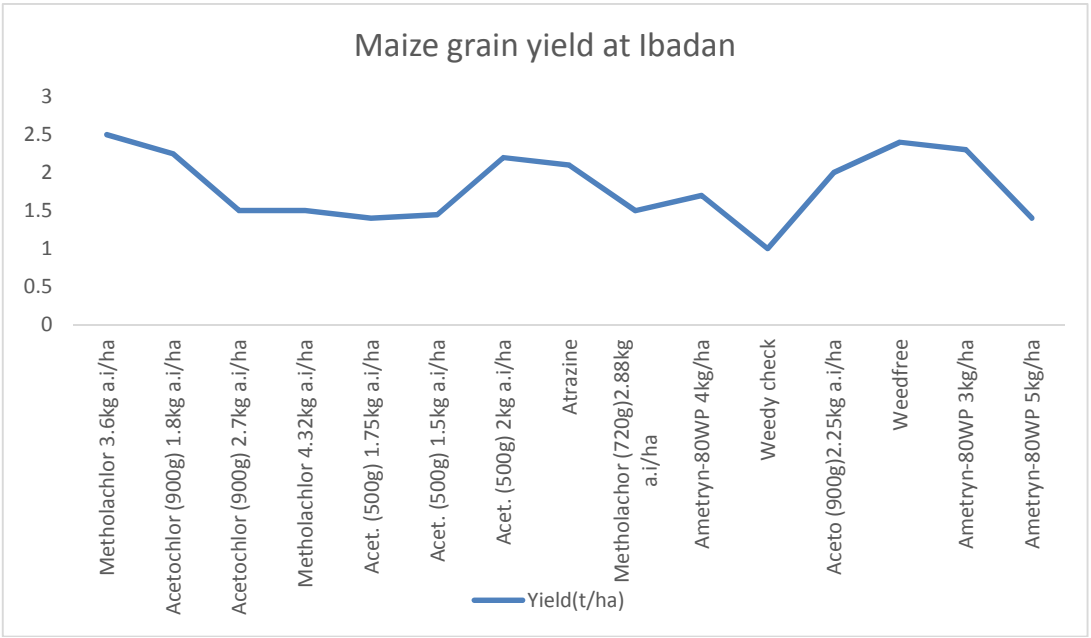

Fig. 7. Effects of pre-emergence weed control on grain yield in Ibadan

The use of Acetochlor, (2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6- methylphenyl)-acetamide) as a pre-emergence herbicide to control annual grass weeds such as barnyardgrass, crabgrass and fall panicum, and certain broadleaf weeds, as well as yellow nutsedge in maize is well documented [16,17] and evidently suppressed weeds in this study. This is similar in effect with other herbicides evaluated in the study. Notwithstanding, it comparative advantage of this herbicide as one of the most widely used herbicides in maize in the USA due to its better biodegradability and relatively small cancer-causing effect [18,19],

need to be ascertained in other herbicides aside the economic return in maize production when applied.

4. CONCLUSION

Chemical weed control remains a timely and suitable intervention option for weed suppression especially where labour is of limited supply for manual weeding. Herbicides investigated reduced weed growth by 80% and increased grain yield by about 50% on the average at both locations. Investigation of the economic and environmental impacts of these herbicides is imperative for optimum profitability and environmental safety.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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