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EFFECTIVENESS OF REDUCED HERBICIDAL DOSAGE AND INTERCROPPING SPATIAL PATTERN AS A WEED CONTROL OPTION

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ABSTRACT

Weeds are causing daunting challenges to communal farmers in Zimbabwe and the available control options are very expensive to them. A 3 x 5 factorial in a completely randomized block design with three replicates was laid to establish the most effective reduced alachlor dosages rate and maize-sugar beans intercropping spatial pattern in controlling weeds. Alachlor dosage had five levels, which were 100%, 75%, 50% ,25%, and 0% of the full- label application rate, and intercropping spatial pattern had three levels, which were no intercropping, one row of sugar beans between rows of maize, and two rows of sugar beans between rows of maize. Weed density per unit area was obtained at a three week interval from crop emergency, up until week nine. Maize grain yield was also obtained at harvest. The data were analyzed using M-STAT C statistical package for variance at p = 0.05. The results showed that at three weeks after crop emergency, alachlor dosage was statistically significant (p = 0.05) at controlling the weeds. At six weeks after crop emergency, plots without alachlor recorded higher weed densities, as compared to two rows of sugar-beans between two rows of maize. Nine weeks after crop emergency, weed densities were inversely proportional to the amount of the alachlor used; that is it decreased as the dosage approached 100% of the full- label application rate. Both the alachlor dosage and the intercropping had a statically insignificant effect on the maize grain yield. Reduced alachlor dosage rates of 75%, 50%, and 25% of full-label application rates can control weeds effectively for the first three weeks after crop emergency. Maize-sugar-bean intercropping can start to suppress weeds as from six weeks after crop emergency. It can be noted that farmers may reduce alachlor dosage to as low as 25% of the full-label application rate, with two rows of sugar beans between maize rows, as this can be a cheaper option when using this herbicide.

Keywords: Weed; Reduced Alachlor Dosage; Intercropping; Weed Density; Control

INTRODUCTION

Crop production is the major primary source of livelihoods in the communal Zimbabwe. The communal people obtained food and cash from selling their agricultural produce, so they need a good production system that leads to high yields and that will leave the farmers with a surplus to sell. However, the production system is mainly constrained by inadequate plant nutrition, diseases and pests, and weed infestation, among others. Excessive weed infestation has been noted to present a daunting challenge to crop production in the communal farming sector of Zimbabwe (Chivinge, 1984). Weed control in the smallholder farming sector is one of the most labor demanding activities, taking about three weeding cycles per growing season (Chui, Kuhumbwa, & Kusewa., 1997).

A number of weed controlling methods are available in crop production, but their affordability predominantly depends on the characteristics of the farming sector. The Zimbabwean communal farming sector is characterized by financially poor farmers, such as those who cannot afford to use expensive methods in controlling the weeds. They can control weeds by cultural means, such as crop rotation and intercropping, which are more affordable to them than the chemical ones.

Apart from cultural and mechanical means, weeds can be effectively controlled by use of herbicides. Ashton and Monaco (2003) reported that work done in the communal areas, showed that the use of herbicides, combined with tine tillage, is a better and cheaper option for controlling weeds by smallholder farmers. The most common weeds under the experiment showed that they could easily be controlled by the cheapest pre-emergence herbicides, alachlor and atrazine. It was concluded that smallholder farmers who have insufficient labor may benefit immensely from herbicide use. Herbicides increase the capacity of smallholder farmers to deal effectively with weed pressure, especially during the critical weed free period.

The use of reduced herbicide dosages will cost a fraction of full dosages and make them even more affordable to poor farmers who have a limited amount of resources (Mashingaidze & Chivinge, 1995). According to Mulugeta and Stoltenberg (1997), there have not been shown decreases in yields with the use of reduced rates of herbicides. However, studies in the effectiveness of reduced alachlor dosages revealed that due to the reduced strength of the herbicide, the control was highly effective only in the first 21-35 days after crop emergence (Mashingaidze & Chivinge, 1995). The crop was left vulnerable to weed infestation after this period, hence the need for the intergration of this method with other methods if total weed control is to be achieved.

Maize-sugar beans intercropping is the most predominant intercropping system in the eastern, central and southern Africa, while, at the same time, intercropping with many non-competitive short duration legumes, such as sugar beans, smothers the weeds to 60-70%, due to their good canopy coverage (Balasubramaniyan & Palaniappan, 2003). However, an ideal spatial arrangement in this intercropping system, which effectively controls weeds, has yet to be established (Stephen, Murphy, Yussif *et al*., 1996). The aim of this study was to establish the most effective reduced alachlor dosages rate and maize-sugar beans intercropping spatial pattern in controlling weeds that can be cheaper to the smallholder farmer.

METHODOLOGY

Research site

The study was carried out at ARDA-Padeswood Farm in Manicaland Province Zimbabwe. It is in the natural region IIa and has an altitude of 1397 m above sea level, with an annual rainfall varying between 600-1000 mm. The dry hot season runs from mid-September to early November, with peak temperatures in October of about 30^{O}C. The rainy season runs from mid-November to March and is characterized by mid-season dry spells in January. The site is characterized by well-drained, fertile, sandy-loam soils. The major weed species at the site are *Potulaca oleraceae, Amaranthus hybridus, Elusine indica,* and *Datura stramonium.*

Experimental design

A 3x5 factorial experiment was laid out in a randomized complete block design with three replicates. Alachlor dosages had five levels that were 100% (1680g active ingredient), 75% (1260g active ingredient 50% (840g (active ingredient); 5% (420g (active ingredient) and 0% of the full-label application rates. Intercropping spatial patterns had three levels, which were no intercropping (maize Seed Co. variety 513 sole-crop), a single row of sugar beans between the maize rows, and two rows of sugar beans between the maize rows.

Land preparation and planting

The site was ploughed after the first rains, which is typical of the time when smallholder farmers prepare the land for planting. It was disced to obtain a fine soil tilth. The gross plot size was $21.6m^2$ and net plot size was $10.8m^2$. Basal fertilizer was applied at a rate of 300kg per hectare of compound D (Nitrogen: Phosphorus: Potassium, 7:14:7 quantity ratios in a bag, respectively). Alachlor was applied a day after planting as follows:-25% (50mls of alachlor in 10 liters of water); 50% (100mls of alachlor in 10 liters of water); 75% (150mls of alachlor in 10 liters of water); and 100% (full label application rate-200mls of alachlor in 10 liters of water). The application rate was 3.5 liters of commercial product per hectare.

Measurements

Weed counts

Four 50cm X 50cm quadrants were thrown at random and weeds were counted. Weed counting was by species for major weeds, while minor weed species were counted and recorded as others. Weed density was calculated using the formula:

Weed density (number of weeds per square meter) = Number of weeds/area

Maize grain yield

Maize per plot was harvested; sun dried, shelled and weighed (grams). Average yield was then obtained as follows:

Yield (grams) = Sum of harvests per treatment / 3 (plots per each treatment)

Data analysis

Data was analyzed using the M-STAT C computer statistical package. An analysis of variance (ANOVA) was done for the major individual species densities, other weed species densities, total weed densities, and maize grain yield ($p = 0.05$).

RESULTS AND DISCUSSION

Weed densities 3 weeks after crop emergence

Table 1: Effect of Alachlor Dosage and Maize-Sugar Bean Spatial Arrangements on Weed Density - 3 Weeks After Crop Emergence

	Weed densities (weeds/ m^2)					
Treatments	***P.ole***	***A. hyb***	***E. ind***	***D. str***	***Others***	**Total**
Full alachlor rate and 2 rows beans	0.00^a	0.00^a	0.00^a	0.33^a	0.33^b	0.66^a
Full alachlor rate and 1 row beans	0.00^a	0.00^a	0.00^a	1.00^{cd}	0.00^a	1.00^a
Full alachlor rate and sole maize	0.00^a	0.00^a	0.00^a	0.00^a	0.33^b	0.33^a
¾ alachlor rate and 1 rows beans	0.00^a	0.00^a	0.00^a	0.33a	0.33^b	0.66^a
¾ alachlor rate and 2 rows beans	0.00^a	0.00^a	0.00^a	0.33a	0.33^b	0.66^a
¾ alachlor rate and sole maize	0.00^a	0.00^a	0.00^a	0.67^b	0.00^a	0.67^a
½ alachlor rate and 2 rows beans	0.00^a	0.00^a	0.00^a	0.00^a	0.33^b	0.33^a
½ alachlor rate and 1 row beans	0.00^a	0.00^a	0.00^a	0.00^a	0.00^a	0.00^a
½ alachlor rate and sole maize	0.00^a	0.00^a	0.00^a	0.33^{ab}	0.33^b	0.66^a
¼ alachlor rate and 2 rows beans	0.00^a	0.00^a	1.67^b	0.33^{ab}	0.00^a	2.00^b
¼ alachlor rate and 1 row beans	0.00^a	0.00^a	1.67^b	0.33^{ab}	0.67	2.67^b
¼ alachlor rate and sole maize	0.00^a	0.00^a	1.67^b	0.67^{bc}	0.00^a	3.34^b
Grand mean	0.62	0.98	0.66	0.42	0.67	3.42
P value **alachlor dose**	0.000	0.000	0.000	0.075	0.000	0.000
spatial pattern	0.381	NE	NE	0.128	NE	0.628
Interaction	NE	NE	NE	NE	NE	0.338
$LSD_{0.05}$	0.248	0.679	0.572	0.669	0.807	1.153
C.O.V (%)	12.5	8.91	11.33	17.65	16.78	9.32

Means followed by same letters are statistically insignificantly (p = 0.05)

NE means the treatment had no effect

Alachlor dosage had a significant effect (p = 0.05) on *P. oleraceae*, *A. hybridus*, *E. indica*, the other weed species, and the total weed density (table 1). The least weed counts were recorded in treatments with 100%, 75%, and 50%, followed by 25% of the full label application rates of alachlor.

Weed densities 6 weeks after crop emergence

Table 2: Effect of Alachlor Dosage and Maize-Sugar Bean Spatial Arrangement on Weed Density - 6 Weeks After Crop Emergence

	Weed densities (weeds/ m^2)					
Treatments	***P.ole***	***A. hyb***	***E. ind***	***D. str***	***Others***	**Total**
Full alachlor rate and 2 rows beans	0.00[a]	0.00[a]	0.00[a]	1.66[a]	0.33[a]	1.99[a]
Full alachlor rate and 1 row beans	0.00[a]	0.00[a]	0.00[a]	2.00[cd]	0.33[a]	2.33[a]
Full alachlor rate and sole maize	0.00[a]	0.00[a]	0.00[a]	1.00[a]	0.33[a]	1.33[a]
¾ alachlor rate and 2 rows beans	0.00[a]	0.00[a]	0.00[a]	1.33[bc]	0.33[a]	1.66[a]
¾ alachlor rate and 1 rows beans	0.00[a]	0.00[a]	0.00[a]	1.33[bc]	0.67[a]	2.00[ab]
¾ alachlor rate and sole maize	0.00[a]	0.67	0.00[a]	2.67[d]	1.00[ab]	4.34[bc]
½ alachlor rate and 2 rows beans	0.00[a]	1.33	0.00[a]	1.00[ab]	3.00[cd]	5.33[c]
½ alachlor rate and 1 row beans	0.00[a]	2.33[bc]	0.00[a]	2.00[cd]	3.67[cd]	8.00[de]
½ alachlor rate and sole maize	0.00[a]	2.33[bc]	0.00[a]	0.33[a]	5.00[e]	7.66[d]
¼ alachlor rate and 2 rows beans	0.00[a]	2.33[bc]	3.33	2.33[d]	2.00[bc]	9.99[bc]
¼ alachlor rate and 1 row beans	0.00[a]	4.00	4.00	1.00[a]	3.67[cd]	14.67[f]
¼ alachlor rate and sole maize	1.33[b]	5.00	5.00	2.00[cd]	5.00[e]	18.33[g]
Grand mean	0.71	1.70	1.20	1.53	2.84	3.42
P value alachlor dose	0.000	0.000	0.000	0.175	0.000	0.000
spatial pattern	0.381	0.076	0.231	0.712	0.064	0.286
Interaction	0.099	0.273	0.165	0.083	0.332	0.338
$LSD_{0.05}$	0.347	0.549	0.347	0.673	1.123	2.750
C.O.V (%)	12.5	8.91	11.33	17.65	16.78	9.32

Means followed by same letters are statistically insignificantly (p = 0.05)

Plots without the alachlor herbicide had the highest weed densities, followed by the plots in which 25% and 50% of full label rates of alachlor were applied, respectively. Weed densities in treatments with 75% and 100% alachlor dosages were the lowest. Plots in which the maize was grown as a sole crop had the highest weed densities, followed by those in which one row of sugar beans was grown between maize rows. The treatment in which 2 rows of sugar beans were grown between maize rows had the lowest weed counts. There was interaction between alachlor dosages and maize-sugar beans spatial arrangements on total weed densities (p = 0.05) (table 2).

Weed densities 9 weeks after crop emergence

Table 3: Effect of Alachlor Dosage and Maize-Sugar Bean Spatial Arrangement on Weed Density - 9 Weeks After Crop Emergence

			Weed densities		**(weeds /**	**m^2)**
Treatments	***P.ole***	***A. hyb***	***E. ind***	***D. str***	***Others***	**Total**
Full alachlor rate and 2 rows beans	1.00^{b}	0.67^{a}	10.33^{b}	1.66^{a}	2.33^{a}	15.99^{ab}
Full alachlor rate and 1 row beans	2.00^{bc}	1.67^{a}	31.67^{cd}	2.00^{cd}	5.00^{bc}	42.34^{c}
Full alachlor rate and sole maize	3.00^{c}	4.00	8.67^{b}	1.00^{a}	2.33^{a}	19.00^{b}
¾ alachlor rate and 2 rows beans	4.00^{cd}	6.67	9.67^{b}	1.33^{bc}	6.00^{c}	22.67^{b}
¾ alachlor rate and 1 rows beans	0.00^{a}	8.33	3.00^{a}	1.33^{bc}	1.00^{b}	13.66^{a}
¾ alachlor rate and sole maize	1.00^{b}	1.67^{a}	11.00^{b}	2.67^{d}	3.67^{b}	20.01^{b}
½ alachlor rate and 2 rows beans	2.33^{c}	7.33^{b}	35.67^{d}	1.00^{ab}	5.33^{b}	51.66
½ alachlor rate and 1 row beans	3.00^{cd}	5.33	27.00c	2.00^{cd}	3.67^{b}	41.00^{c}
½ alachlor rate and sole maize	5.33	8.33^{b}	11.33^{a}	0.33^{a}	8.00^{d}	33.32^{a}
¼ alachlor rate and 2 rows beans	0.00^{a}	0.00^{a}	3.67^{a}	2.33^{d}	1.00^{a}	7.00^{a}
¼ alachlor rate and 1 row beans	1.33^{b}	2.00^{a}	30.00^{cd}	1.00^{a}	5.33^{bc}	39.67^{b}
¼ alachlor rate and sole maize	3.33^{d}	1.67^{a}	12.33^{b}	2.00^{cd}	6.67^{c}	26.00^{b}
Grand mean	2.64	3.62	15.42	1.53	4.36	27.48
P value **alachlor dose**	0.000	0.064	0.132	0.175	0.000	0.000
spatial pattern	0.381	0.060	0.375	0.712	0.098	0.036
Interaction	0.631	0.978	0.538	0.083	0.556	0.048
LSD$_{0.05}$	1.146	2.159	6.194	0.673	1.359	16.732
C.O.V (%)	13.5	9.21	16.33	17.65	16.78	9.32

Means followed by same letters are statistically insignificantly (p = 0.05)

Highest weed counts were recorded in treatments with a 25% alachlor dosage, followed by those with 50% and 75% herbicide dosages. Low weed densities were found in plots with full label application rates of alachlor. Maize-sugar bean spatial arrangement effects were statistically significant (p= 0.05) on individual weed species, but was significant on total weed density. The lowest weed densities were found in treatments in which two sugar beans rows were planted between the maize rows, followed by the treatments in which one sugar bean row was planted between the maize rows (table 3).

Maize grain yield

Table 4: Effect of alachlor dosage and maize-sugar bean spatial arrangement on maize grain yield

Treatments		**Yield (t/ha)**
Full alachlor rate and 2 rows bean		3.903^{f}
Full alachlor rate and 1 row bean		4.407^{bcde}
Full alachlor rate and sole maize		4.360^{bcde}
¾ alachlor rate and 2 rows beans		4.027^{def}
¾ alachlor rate and 1 row beans		4.267^{bcdef}
¾ alachlor rate and sole maize		4.223^{bcdef}
½ alachlor rate and 2 rows beans		4.113^{cdef}
½ alachlor rate and 1 row beans		4.620^{ab}
½ alachlor rate and sole maize		4.620^{ab}
¼ alachlor rate and 2 rows beans		4.000^{ef}
¼ alachlor rate and 1 row beans		4.917
¼ alachlor rate and sole maize		4.627^{ab}
Grand mean		4.338
P value	**alachlor dose**	0.2619
	spatial pattern	0.0572
	Interaction	NE
LSD$_{0.05}$		0.4393
C.O.V (%)		6.05

Means followed by same letters are statistically insignificantly (p = 0.05)

Both the reduction of alachlor dosage application and the sugar bean- maize intercropping had a statically insignificant (p = 0.05) effect on the maize grain yield (table 4).

The significant effect of alachlor dosage at 3 weeks after crop emergence on *P. oleraceae, A. hybridus, E. indica*, other weed species, and total weed density could be due to the high efficacy of the herbicide. This tallied with Mulugeta and Stolenberg (1997), who postulated that sub-lethal herbicide doses have the ability to control weeds at single or sequential applications due to the action of the small amounts of the active ingredient that is present. According to Ashton and Monaco (2003), reduced alachlor doses control most common weeds and had no effect on *D. stramonium* as it does not fall within the spectrum of weeds controlled by the herbicide (Ross & Lembi, 2004). The insignificant effect of intercropping spatial arrangement on weed density of major species could be attributed to the fact that the intercrop had not yet developed enough canopies to have any effect on weeds growing in the inter-row.

Interaction between reduced alachlor dosage and intercropping spatial arrangement at 6 weeks after crop emergence could be due to the addition of an intercrop or increase in plant population in order to maintain a low weed density. The inverse also proved to be true. Ross and Lembi (2004) owed this to the half-life of the herbicides. They postulated that the half life of alachlor is 21 days and the lower rates resulted in its persistence and, consequently, its effectiveness was lowered proportionally, meaning that its integration or intensification of a suitable weed suppressing strategy, such as intercropping and increasing crop density, becomes necessary.

The higher weed counts recorded in the sole maize crop followed by the single row of sugar beans between the maize rows could be a result of the larger proportion of open spaces than on two rows of sugar beans planted between the maize rows. This is in tandem with Vernon and Parker (1983) who reported that narrower rows between plants, high crop densities, and intercropping may be used as integrated weed management tools. Narrower open spaces between crops have been thought to reduce the amount of light available for weeds located below the crop canopy. This has also been said to increase the leaf area index (LAI), at the same time reducing the photosynthetic photon flux density (PPFD) available below the crop canopy. The weeds are suppressed to the levels that have no economic impact on the crop.

The insignificant effect of alachlor dosage on maize yield could be due to the low application rates of the herbicides used. This is in accordance with Mashingaidze and Chivinge (1995), who stated that rates higher than the labeled rates are the ones that have adverse effects on crop yields rather than sub-lethal dosages. At the same time maize-sugar bean intercropping spatial pattern had no significant effect on maize grain yield. This was in contrast to a research carried out by Stephen *et al*. (1996). Their findings were that narrower spacing increased yield by 10-15% on average principally due to superior sunlight interception. This contradiction can be explained by the differences in the leaf canopy height of the component crops and the maintenance of the inter-row spacing of the maize rows.

CONCLUSIONS AND RECOMMENDATIONS

Reduced alachlor dosage rates of 75%, 50%, and 25% of full label application rates can control weeds effectively for up to 3 weeks after crop emergence. Intercropping can suppress weeds from 6 weeks after crop emergence onwards. Planting two sugar bean rows between maize rows is the most effective spatial arrangement in controlling weeds, followed by planting one sugar-bean row between the maize rows. Smallholder farmers may reduce alachlor dosages to 25% of full label application rate and plant two rows of sugar beans between the maize rows as this could be an affordable option if they want to use alachlor herbicide.

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