Effects of witchweed (*Striga* species) control methods on growth and yield of maize (*Zea mays* L.) in Swaziland

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ABSTRACT

Striga hermonthica and *S. asiatica* are parasitic weeds that reduce yield in cereal crops. Information is scarce on the response of *Striga* to weed control methods in Swaziland. Therefore, a field experiment was conducted in 2006/2007 cropping season, to assess *Striga* control methods in maize. The experimental design was a randomized complete block, using a 4 x 3-factorial arrangement, to assess four maize varieties and three weed control methods. Results showed that Imidazolinone-resistant (IR) maize variety, KB 04 OA10, had a significantly better *Striga* control than other maize varieties. The pre- and post-emergence herbicide mixture of Bladex plus and Bullet was more effective in *Striga* control, and effected sustainable weed control over the selective hand-weeding method. Grain yields were significantly higher with SC 403 + Bladex plus (2236.9 kg ha^{-1}) and using selective hand-weeding than SC 403 + Bladex plus + Bullet (3591.9 kg ha^{-1}); the lowest yield (1279.8 kg ha^{-1}) was from CML-181 combined with hand weeding. Nevertheless, the local maize variety, SC 403, was the highest yielding (3034 kg ha^{-1}), which was 47.4% higher than the best IR-maize variety. IR maize varieties have a potential for reducing *Striga* growth and development, and combined with the use of herbicides, maize yield in *Striga*-infested fields in Swaziland could be improved. Farmers who can afford IR-maize and herbicide technology are encouraged to use Bladex plus in combination with Bullet, for pre-emergence weed control.

Keywords: Maize yield, Maize, *Striga*, Swaziland, Weed control methods, Witchweed.

INTRODUCTION

The witchweeds, *Striga hermonthica* (Del.) Benth. and *S. asiatica* (L.) Kuntze, are parasitic weeds of serious concern in cereal crop production throughout sub-Saharan Africa, especially in those areas with semi-arid and arid conditions (Riches, 2008). Witchweeds cause considerable yield reduction in cereal crops such as maize (*Zea mays* L.), millet (*Pennisetum glaucum* L.), sorghum (*Sorghum bicolor* (L.) Moench.) and dryland rice (*Oryza sativa* L.). They compete with crop plants for the limited production resources in the soil, by growing into the vascular system of the roots of plants, and as a result, deprive the host plant of water and nutrients. Kanampiu (2003) reported that about 40 million hectares of farmland in sub-Saharan Africa were infested with *Striga*.

Witchweed is especially problematic under conditions of low soil fertility, drought stress and poor management practices by farmers (Olakojo, 2004). Kanampiu (2003) observed that the land resource, which could be used in the rotation of fields out of maize, was severely limited in most African countries. *Striga* biological control using "attractive chemicals" in the "push-pull" strategy (Butunyi, 2007) that involved *Striga*, *Desmodium* species, and Napier grass (*Pennisetum purpureum*) in Kenya is worth investigating under Swaziland conditions. *Striga* control using fertilizer technology and herbicides (Kabambe *et al.*, 2007) has been investigated. Supporting the idea that limiting the effects of *Striga* infestation through the incorporation of host-plant resistance or tolerance could be an inexpensive and easy-to-use method by resource-poor farmers, CIMMYT (2004) unveiled a new technology, called Imidazolinone–resistant (IR) maize in Kenya. The IR maize involves the incorporation of herbicide resistance in maize, and seed-dressing the IR maize with the herbicide. The IR maize variety kills any germinating *Striga*, as the parasite makes an effort to attach to the maize plant roots, and also reduces the weed's seed bank by destroying some of the remaining seeds (CIMMYT, 2004). Recommended control methods, based on IR maize in Kenya have not been readily adopted by small-scale farmers probably because of their poor understanding of the life cycle of *Striga*, which must be considered, to effectively manage it. In Swaziland, *Striga* is a serious pest, throughout the Lowveld ecological region where sorghum is a better crop to plant, though farmers still plan maize, despite persistent drought. Typically, farmers hand-weed the *Striga*, and when the infestation overwhelms the farmer, the land is fallowed after harvest. It would be useful to investigate the effects of different control methods on the growth and yield of maize in order to identify the most appropriate method of controlling *Striga*. Therefore, the objective of this investigation was to determine the most effective method of controlling *Striga* spp. and increase the yield of maize in *Striga*-infested farmlands.

MATERIALS AND METHODS

Location and land preparation

The field experiment was conducted during the 2006/2007 cropping season at the Nhlangano Experimental Farm (27° 06'S, 31° 12'E; altitude, 1036 m above sea level; annual rainfall range, 800-1 440 mm; mean temperature range, 11.6°C-23.2°C during the growing season). The soil type at the farm was an M-set Oxisol of the Malkerns series (Murdoch, 1970). Prior to planting, soil sampling (30-cm depth) was carried out, and using standard analytical procedures (Manson *et al.*, 1999; Jones, 1999), soil chemical analysis was done to determine the nutrient status of the soil at the start of the investigation. The land was ploughed using a mouldboard plough, followed by disking with a disk harrow. Based on the soil test results, a basal application of a compound fertilizer, N: P: K [2:3:2 (38)], which also contained 0.5% zinc, was made at the rate of 250 kg ha^{-1} (equivalent of 27.2, 40.7 and 27.2 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively) to all plots. No side dressing with nitrogenous fertilizer was done, because additional nitrogen could have influenced the response of the treatments (Bebawi and Abdelaziz, 1983). Plot sizes were: 9.0 m x 4.5 m, with a 1.0-m distance between treatments and between replicates. Each plot consisted of six maize rows with an inter-row spacing of 0.9 m, and 0.25-m intra-row spacing, giving a plant population of 44,444 plants ha^{-1}.

Maize was hand-planted on 17 October 2006 at a rate of two seeds per station and was thinned to one seedling per planting station 31 days after planting (DAP). Weed control measures were carried out, at planting, and at post-emergence, and once-only selective hand-weeding in the treatment requiring manual weeding. No irrigation was applied, in simulation of the farmers' situation.

Treatments and experimental design

The experiment consisted of 12 treatments (Table 1) and three replicate blocks.

Table 1 Treatment description for the experiment

Treatment code	Combination of maize varieties and weed control methods
1	KB 04 OA10 ; selective hand-weeding at 42 days after planting (DAP)
2	KB 04 OA10 ; Bladex plus + Bullet (pre-emergence)
3	KB 04 OA10 ; Bladex plus (post-emergence; 31 DAP)
4	Ua Kayongo ; selective hand-weeding (42 DAP)
5	Ua Kayongo; Bladex plus + Bullet (pre-emergence)
6	Ua Kayongo; Bladex plus (post-emergence; 31 DAP)
7	CML -181; selective hand-weeding (42 DAP)
8	CML-181; Bladex plus + Bullet (pre-emergence)
9	CML -181 ; Bladex plus (post-emergence; 31 DAP)
10	SC 403; selective hand-weeding (42 DAP)
11	SC 403 + Bladex plus + Bullet (pre-emergence)
12	SC 403 + Bladex plus (post-emergence; 31 DAP)

The four maize varieties used were:

1. KB 04 OA10: IR-open pollinated maize from CIMMYT in Kenya
2. *Ua Kayongo*: IR-maize hybrid from Kenya
3. CML-181: IR-maize hybrid, from Kenya
4. SC 403: a recommended local hybrid,

Three methods of *Striga* control used were:

1. Selective hand weeding of all other weeds except *Striga* species at 42 days after planting (DAP); the low rainfall at the start of the season did not encourage weed growth and earlier weeding was not necessary.
2. Bladex plus (atrazine and cyanazine at 3.0 L ha^{-1}) mixed with Bullet (acetochlor/atrazine/terbuthylazine at 1.0 L ha^{-1}) as a pre-emergence (with respect to weeds and the crop) herbicide
3. Bladex plus (3.0 L ha^{-1}) as a post-emergence (with respect to weeds) herbicide at 31 DAP.

The experiment was a 4 x 3 factorial (4 maize varieties; 3 weed control methods) arranged in a randomized complete block design and each treatment combination was replicated three times. Space constraints in the field did not allow wider inter-plot spaces to further prevent herbicide drift. However, herbicide application was done when there was no wind, and spraying was done close to the target plants to minimize drift. Surface runoff was non-existent, as the soil type readily absorbed fluids, effectively eliminating surface runoff.

Spraying with Ethephon and weed control

The parcel of land where the experiment was located was sprayed (same day, after planting) with Ethephon (2-chloroethylphosphonic acid), using a knapsack sprayer, immediately after planting. The spraying was intended to promote ethylene production, and facilitate early and uniform germination and emergence of *Striga*. The herbicides and rates used were as follows: Bladex plus at (3.0 L ha^{-1}) and Bullet (1.0 L ha^{-1}) mixture, three days after planting, and prior to emergence of the crop; Bladex plus (3.0 L ha^{-1}) herbicide was also applied post-emergence, at 31 DAP, following maize emergence. Selective hand-weeding (using hand hoes) of all weeds except *Striga*, was carried out at 42

DAP, following weed identification in all plots.

Data collection and analysis

Weeds were identified using weed manuals, and weed density in the plots was assessed on 1-6 infestation score within a 100-cm square quadrat (three determinations per plot). The weed assessment was done the same week, just before weeding. The descriptions of the weed scores were: 1 = complete absence of weeds (0%) within the quadrat; 2 = weed coverage of 1-20% of the quadrat; 3 = weed coverage of 21-40% of the quadrat; 4 = weed coverage of 41-60% of the quadrat; 5 = weed coverage of 61-80% of the quadrat; 6 = weed coverage of 81-100% of the quadrat (Ossom, 2007). The same weed scores were used for both *Striga* and other weeds in order to have a common basis for comparison. Five maize plants per plot were sampled for growth analysis at four weekly intervals. Grain yield was assessed at 12.5% moisture content.

Data were subjected to analysis of variance (ANOVA) and if the F-value was significant ($p<0.05$), means were separated using the least significant difference (LSD) test (Steel *et al.*, 1997). The MSTAT-C statistical package (Nissen, 1983) was used in the data analysis.

RESULTS AND DISCUSSION

Soil chemical properties

Soil chemical properties at the start of the investigation were: pH, 5.14; available P, 12.2 mg kg^{-1}; available K, 60 mg kg^{-1}; available Mg, 6.4 mg kg^{-1}; available Ca, 6.4 mg kg^{-1}, and exchangeable acidity, 0.35 cmol kg^{-1}. Thus, the soil pH was below 5.5, and was ideal for most crops under the ecological conditions in Swaziland (Onwueme and Sinha, 1991).

Meteorological data

The mean temperatures and total rainfall during the period of the investigation are shown in Table 2. The total rainfall received during the period of investigation was 602 mm, which was below the 10-year average of 653 mm. The mean monthly temperature range was 14.2-28.7°C. The rainfall distribution was relatively poor, the total rainfall being 8% below the 10-year average, and 63% of that total falling in November and December. The remaining 37% was distributed throughout the rest of the crop growth period. The cropping season of 2006/2007 was a dry year compared to the previous 10-year period (Central Statistical Office, 1998; Swaziland Meteorological Service, 2007), with poor rainfall distribution during the reproductive stage.

Table 2. Meteorological data during the period of the investigation

Month	Mean air temperature (°C)			Rainfall (mm)	10-year average rainfall (mm)
	Maximum	Minimum	Mean		
October 2006	24.8	14.2	19.5	47.7	88.3
November 2006	24.3	14.5	19.4	135.3	107.0
December 2006	25.0	19.1	22.1	280.7	113.0
January 2007	26.5	15.9	21.2	27.5	143.0
February 2007	28.7	16.6	22.7	54.7	120.0
March 2007	26.8	15.3	21.1	56.1	81.7
Means	26.0	15.9	21.0	100.3	108.8
Total				602.0	653.0

Source: Swaziland Meteorological Service, 2007.

Effects of four maize varieties on weeds (excluding *Striga*)

Table 3 lists the weed species encountered in the investigation. That fewer weeds were observed with the pre-emergence herbicide-treated maize than hand-weeding was consistent with the report (Anon., 1985), which noted that a lesser number of weed species resulting from the application of pre-emergence 2,4-D on maize, could lead to higher grain yields than hand-weeded maize.

Considering the interaction between the four maize varieties and three control methods on *Striga* infestation, the maize variety SC 403; selective hand-weeding and CML-181 treated with Bladex plus had the greatest ($p < 0.05$) *Striga* score of 2.4 and 2.4, respectively.

Significant ($p < 0.05$) differences were observed in the effects of four maize varieties on weed infestation (Table 4). The maize variety, SC 403, had a weed score of 1.54 out of 6.00, which was significantly ($p < 0.05$) lower than the weed scores of other maize varieties except KB 04 OA10, which had a weed score of 1.84 out of 6.00. The highest weed score (2.18 out of 6.00) was observed with maize variety, CML-181, which was similar to the other maize varieties, and only significantly ($p < 0.05$) higher than the weed score of variety, SC 403. That SC 403 had a significantly ($p < 0.05$) lower weed infestation than the other maize varieties, could be associated with its vigorous growth at the early vegetative stage, probably causing shading of underlying weeds than the other varieties. The highest weed score, which was observed with maize variety CML-181 might have been a result of slow growth and shorter plants than SC 403, which was a relatively taller variety (Anon., 2001). This result indicated a significantly ($p < 0.05$) higher *Striga* score for the maize varieties, SC 403 with selective hand-weeding, and CML-181 treated with Bladex plus than the Ua Kayongo; Bladex plus mixed with Bullet treatment (1.2), and KB 04 OA10 Bladex plus mixed with Bullet treatment (1.2), which were not significantly different from each other. The low *Striga* density observed on Ua Kayongo, Bladex plus mixed with Bullet treatment might be an indication of the maize variety's efficiency in reducing the density and growth of the parasitic weed. Ua Kayongo maize variety was tolerant to *Striga* and could have suppressed the germination and survival of *Striga* seeds and seedlings (Kanampiu, 2003; CIMMYT, 2004). This, coupled with the herbicide mixture of Bladex plus and Bullet, might have resulted in an effective control of the *Striga*, indicated by reduced *Striga* infestation on the treatment, consistent with earlier studies (CIMMYT, 2004) that concluded that the IR-maize technology suppressed *Striga* germination as well as depleting *Striga* seed bank in infested fields.

Effects of three *Striga* control methods on infestation by other weeds

Selective hand-weeding had a significantly ($p < 0.05$) higher weed infestation (weed score, 3.5) than Bladex plus only (weed score, 1.2), and control method that involved Bladex plus mixed with Bullet (weed score, 1.1), which were not significantly different from each other. The lowest weed score was observed in the treatment involving Bladex plus mixed with Bullet (pre-emergence), which had a weed score of 1.08 out of 6.00. The selective hand-weeding method was not efficient in controlling the other weeds except *Striga* than the management of weeds using the pre- and post-emergence herbicides. This observation agreed with a study by Seubert *et al.* (1988) who reported significant differences in the grain yield and weed population, which was attributed to untimely hand-weeding operations. The smaller number of weed species observed in herbicide-treated maize than in hand-weeding was consistent with a previous report (Anon., 1985), which noted better weed control could be attained with pre-emergence application of 2,4-D herbicide-treated maize than in hand-weeded maize.

This result indicated a significantly ($p < 0.05$) higher *Striga* score for the maize varieties, SC 403 with selective hand-weeding, and CML-181 treated with Bladex plus than the Ua Kayongo; Bladex plus mixed with Bullet treatment (1.2), and KB 04 OA10 Bladex plus mixed with Bullet treatment (1.2), which were not significantly different from each other. The low *Striga* density observed on Ua Kayongo, Bladex plus mixed with Bullet treatment might be an indication of the maize variety's efficiency in reducing the density and growth of the parasitic weed. Ua Kayongo maize variety was tolerant to *Striga* and could have suppressed the germination and survival of *Striga* seeds and seedlings (Kanampiu, 2003; CIMMYT, 2004). This, coupled with the herbicide mixture of Bladex plus and Bullet, might have resulted in an effective control of the *Striga*, indicated by reduced *Striga* infestation on the treatment, consistent with earlier studies (CIMMYT, 2004) that concluded that the IR-maize technology suppressed *Striga* germination as well as depleting *Striga* seed bank in infested fields.

Table 3. Weed species associated with maize varieties and weed control methods under *Striga* infestation at 42 days after planting

Weed species	Common name	Weed treatment number*											
		1	2	3	4	5	6	7	8	9	10	11	12
Amaranthus spinosus L.	Spiny amaranth	+	-	-	+	-	-	+	+	-	+	-	-
Bidens pilosa L.	Common blackjack	-	-	-	-	-	-	-	-	-	+	-	-
Cleome monophylla L.	Spider flower	+	-	-	+	-	-	+	+	+	+	-	-
Commelina benghalensis L.	Benghal wandering Jew	+	-	-	+	-	-	+	-	-	-	-	-
Convolvulus arvensis L.	Field bindweed	+	-	-	+	-	-	+	-	+	+	-	-
Cyperus rotundus L.	Purple nutsedge	-	-	+	-	-	+	-	-	-	-	+	+
Echium plantagineum L.	Purple Echium	+	-	-	+	-	-	+	-	-	-	-	-
Eleusine indica (L.) Gaertn. sub-sp. *africana*	African goosegrass	+	-	-	-	-	-	-	-	+	+	-	+
Galinsoga parviflora Cav.	Gallant soldier	-	-	-	-	-	-	+	-	-	-	-	-
Ipomoea purpurea (L.) Roth.	Morning glory	+	-	-	+	-	-	+	+	+	+	-	-
Leucas martinicensis (Jacq.) R. Br.	Bobbin weed	-	-	-	-	-	-	+	-	-	+	-	-
Nicandra physalodes (L.) Gaertn.	Apple of Peru	+	-	-	-	-	-	+	-	-	+	-	-
Oxalis latifolia H. B. K.	Red garden sorrel	-	-	-	-	-	-	-	-	+	-	-	-
Portulaca oleracea L.	Purslane	-	-	-	+	-	-	+	-	-	-	-	-
Richardia brasiliensis Gomes	Tropical Richardia	+	-	-	-	-	-	+	-	-	-	-	-
Senecio consanguineus	Starvation senecio	-	-	-	-	-	-	+	-	-	-	-	-
Tagetes minuta L.	Mexican marigold	-	-	-	-	-	-	+	-	-	+	-	-

*Treatment codes as described in Table 1;

+, weed species present, -, weed species absent

Effects of *Striga* infestation on maize grain yield

Figure 1 shows the effects of *Striga* infestation on maize yield (kg ha^{-1}) at harvesting. The maize variety SC 403 produced a significantly ($p < 0.05$) higher grain yield (3034 kg ha^{-1}) than all the other maize varieties. The grain yield for the variety CML-181 (1393 kg ha^{-1}) was significantly ($p < 0.05$) lower than all the other varieties except that of maize variety KB 04 OA10 (1927 kg ha^{-1}) with which they were similar. *Ua Kayongo* had the second best grain yield at 2058 kg ha^{-1}, which was however, the same statistically with that of the variety KB 04 OA10. Kayongo' means *Striga* and '*Ua Kayongo*' refers to "Kill the *Striga*" in Luo, a local language of Kenya, and, therefore, '*Ua Kayongo*' could be associated with the control of *Striga*. As could be expected, *Ua Kayongo* had the second best grain yield, second only to SC 403, in agreement with an earlier study (Mbwaga and Massawe, 2001) that observed significant differences in grain yield as a result of variety tolerance or susceptibility to *Striga* infestation. The higher grain yield of SC 403 could be due the wide adaptability of the maize variety to Swaziland conditions and high tolerance to moisture stress, as a result of *Striga* infestation.

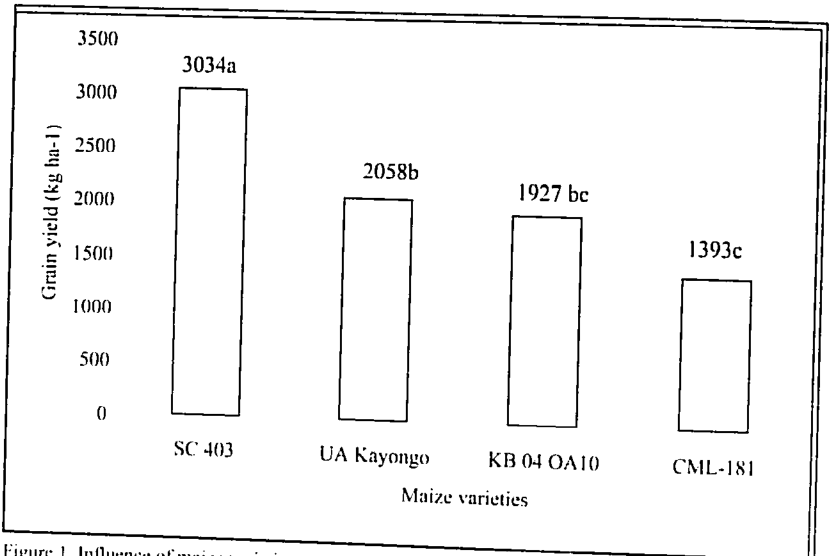

Figure 1. Influence of maize varieties on grain yield (kg ha^{-1}) under *Striga* infestation.

Effects of three *Striga* control methods on maize grain yield

The effects of three Striga control methods on maize grain yield are shown in Figure 2. There were no significant differences in maize yield subjected to the various *Striga* control methods. The maize under *Striga* control method involving the use of Bladex plus mixed with Bullet as a pre-emergence herbicide produced a higher grain yield of 2245 kg ha^{-1} than selective hand-weeding (2213 kg ha^{-1}) and

Table 4. Scores for weed infestation of four maize varieties and three *Striga* control methods at 42 days after planting.

Maize variety (V)	Weed control methods (C)	Interaction (V x C)
KB 04 OA10	Selective hand-weeding	1.57 abc
	Bladex plus; post-emergence	1.23 bc
	Bladex plus + Bullet pre-emergence	1.57 abc
Ua Kayongo	Selective hand-weeding	1.90 abc
	Bladex plus; post-emergence	1.20 c
	Bladex plus + Bullet pre-emergence	2.23 abc
CML-181	Selective hand-weeding	1.90 abc
	Bladex plus; post-emergence	1.67 abc
	Bladex plus + Bullet pre-emergence	2.37 a
SC 403	Selective hand-weeding	2.43 a
	Bladex plus; post-emergence	1.57 abc
	Bladex plus + Bullet pre-emergence	2.33 ab

Numbers followed by the same letter in the same column are not significantly different, according to the LSD test at $p > 0.05$.

Effects of three *Striga* control methods on the DM yield of maize

Table 5 shows that the interaction between four maize varieties and three *Striga* control methods on DM yield was significantly ($p < 0.05$) higher for the maize variety SC 403, selective hand-weeding, which produced 115.0 g per plant at 56 DAP and 229.9 g per plant at 88 DAP, than all the other treatments. The herbicide-treated maize varieties showed rapid increase in DM yield at the early vegetative stage of plant growth, but growth was reduced at 88 DAP, after which DM increased again.

This trend was observed with all the maize varieties treated with the herbicides as a pre- or post-emergence control treatment. This observation could most probably be compared with an earlier observation (CIMMYT, 2004) that the IR-maize varieties, soon after germination and early vegetative stage, could exhibit some symptoms such as yellowing of leaves and slow growth, as the systemic herbicide got absorbed by the growing plant, which was not the case with SC 403, a non-IR-maize variety.

Table 5. Total dry matter yield (g per plant) of four maize varieties and three *Striga* control methods at 56-141 days after planting (DAP)

Maize varieties and weed control methods	Dry matter yield (g per plant)			
	56 DAP	88 DAP	113 DAP	141 DAP
KB 04 OA10 + selective hand weeding	66.59 bc	133.2 bc	214.3 bc	217.5 ab
KB 04 OA10 + Bladex plus + Bullet pre-planting	41.33 c	82.66 c	242.0 abc	243.6 ab
KB 04 OA10 + Bladex plus post-emergence	79.29 b	158.6 b	157.4 bc	162.2 b
Ua Kayongo + selective hand weeding	53.87 bc	107.7 bc	135.7 c	154.5 b
Ua Kayongo +Bladex plus + Bullet	42.44 c	85.00 c	166.1 bc	167.4 b
Ua Kayongo+ Bladex plus	57.99 bc	116.0 bc	357.3 a	362.2 a
CML -181 + hand weeding	40.53 c	81.05 c	190.6 bc	193.0 b
CML-181+ Bladex plus + Bullet	35.28 c	70.56 c	118.2 c	123.8 b
CML -181 + Bladex plus	37.80 c	75.61 c	161.7 bc	169.1 b
SC 403 + selective hand weeding	115.0 a	229.9 a	267.4 ab	274.7 ab
SC 403 + Bladex plus + Bullet	45.97 c	91.95 c	196.5 bc	201.6 b
SC 403 + Bladex plus	58.86 bc	117.7 bc	187.6 bc	190.4 b

Numbers followed by the same letter in the same column are not significantly different, according to the LSD test at $p > 0.05$.

and size to effect considerable competition.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions emerge from the experiment: Variety, KB 04OA10, was effective in suppressing the emergence, growth and development of *Striga*. Bladex plus mixed with Bullet as a pre-emergence herbicide was the most effective in suppressing the emergence, growth and development of other weeds. Ua Kayongo; Bladex plus-Bullet mixture and KB 04 OA10 Bladex plus-Bullet mixture improved efficacy of the treatments and resulted in a significantly ($p < 0.05$) lower incidence (emergence), growth and development of the *Striga*. Bladex plus mixed with Bullet is recommended, for its ability to suppress *Striga*.Based on grain yield, it is recommended that variety SC 403 be planted while research into more *Striga*-tolerant IR-maize varieties continues.

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the Bladex plus treatment had the lowest grain yield (1852 kg ha^{-1}).

The *Striga* control method involving the use of Bladex plus mixed with Bullet as a pre-emergence herbicide had the highest maize grain yield. This is probably an indication of the relative advantage of the mixture over the selective hand-weeding and Bladex plus only in the efficiency of controlling the *Striga*.

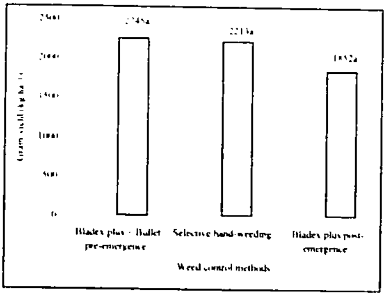

Figure 2. Maize grain yield (kg ha^{-1}) under three *Striga* control methods

The interaction between four maize varieties and three Striga control methods (Table 6) showed variety SC 403 with selective hand-weeding, and SC 403 treated with Bladex plus, mixed with Bullet as a pre-emergence herbicide produced non-significantly different grain yields of 3791.5 and 3591.9 kg ha^{-1}, respectively, but were significantly ($p < 0.05$) higher than all the other varieties, and under various *Striga* control methods.

Variety CML-181 under selective hand-weeding produced a grain yield (1280 kg ha^{-1}) that was significantly ($p < 0.05$) lower than that of SC 403 selective hand-weeding and SC 403 treated with Bladex plus mixed with Bullet, and *Ua Kayongo* treated with Bladex plus yielded 2336.9 kg ha^{-1}. There were no other significant yield differences. Variety SC 403, under selective hand-weeding and SC 403, sprayed with Bladex plus-Bullet mixture, had a similar grain yield but significantly ($p < 0.05$) higher yield than all the other treatments which indicated the relative advantage of the wide adaptability and tolerance to the effects of *Striga* on plant growth and development (Anon., 2001).

Table 6. Seed yield of four maize varieties under three *Striga* control methods

Maize varieties and weed control methods	Grain yield (kg ha^{-1})
KB 04 OA10 + selective hand weeding	2177.7bc
KB 04 OA10 + Bladex plus + Bullet pre-emergence	1695.7bc
KB 04 OA10 + Bladex plus post-emergence	1908.9bc
Ua Kayongo + selective hand weeding	1603.7bc
Ua Kayongo +Bladex plus + Bullet	2233.3bc
Ua Kayongo+ Bladex plus	2336.9b
CML -181 + hand weeding	1279.8c
CML-181+ Bladex plus + Bullet	1457.5bc
CML -181 + Bladex plus	1443.2bc
SC 403 + selective hand weeding	3791.5a
SC 403 + Bladex plus + Bullet	3591.9a
SC 403 + Bladex plus	1718.9bc

Numbers followed by the same letter in the same column are not significantly different, according to the LSD test at $p > 0.05$.

The performance of SC 403 in this investigation could, explain the observation that infestation by *Striga* could have deprived the host plant of assimilates, water and inorganic solutes that were important for vigorous plant growth, development and yield of the host plant. The higher grain yield of SC 403 under selective hand-weeding, might be attributed to multiple-cob characteristics of SC 403 variety, and the ability of this variety to withstand the adverse effects of witchweed infestation and early maturity before the *Striga* had grown in population

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Factors affecting calving percentage in the four different ranching systems practiced by livestock farmers in the southern region of Botswana

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ABSTRACT

Productivity in the livestock industry in Botswana can only prosper, be viable, competitive and remain a major source of income and employment opportunity in the rural areas, if there is an increase in calving percentage through intensive use and efficient management of our land resources and our livestock. Findings from the survey conducted amongst a random sample of 132 livestock farmers on different types of ranches (communal, community, group/syndicate and individual) in the Southern Region of Botswana indicate that various perceptions and needs represent significant constraints in improving the poor management and put emphasis on increasing productivity to acceptable levels with minimum adverse effects on the environment. The incompatibility of increasing productivity to acceptable levels and the resulting ranch types and associated management possibilities with respondent's culturally conditioned needs, is probably the major obstacle.

Keywords: Calving percentage, ranch types, Knowledge, age, education and herd size.

INTRODUCTION

Productivity in the livestock industry in Botswana remains largely undeveloped. It is characterised by extensive farming in communal areas where calving percentage has remained as low as 50% compared to 60% in commercial areas (Ministry of Finance and Development Planning, 1997/98-2002/3).

Calving percentage is a key reproductive trait in the cattle business. For the livestock industry to prosper, be viable, competitive and remain a major source of income and employment opportunity in the rural areas, increased calving percentage is essential (Sigwele & Khupe, 1996).

This study investigates the efficiency criteria, of calving percentage and factors affecting calving percentage, in the context of different ranching systems (individual referring to a ranch owned by an individual farmer; group/syndicate referring to a ranch owned by more than two farmers on partnership base; community referring to a ranch owned by community members; and communal referring to an open grazing accessible to all farmers).

In the promotion of fencing, uncertainty exists concerning the optimum approach that will allow for proper implementation of sound management practices and that are acceptable to and reconcilable with the needs of the communities.

This paper specifically examined: whether age, education, or herd size has any influence on calving percentage; assess livestock farmers' knowledge about the calving percentage of their livestock; whether the knowledge about calving percentage is influenced by ranch type, age, education, or herd size; and whether ranch type (community, communal, individual and group/syndicate ranches) has any influence on calving percentage.