CHAPTER 1

1. GENERAL INTRODUCTION

Maize is one of the most important cereal crops, which serves as a staple food for many people in the Limpopo Province. The witch weed (*Striga asiatica*) is a parasitic weed that plagues cereal crops including maize and sorghum. This weed competes for water and nutrients as a root parasite, literally sucking the life out of the crop on which it germinates. In doing so, maize growth is stunted (Sallah and Afribeh, 1998) and yields are generally reduced. In the semi-arid areas of sub-Saharan Africa the problem of striga is so bad that some farmers have been forced to abandon their arable land. Striga does most of its damage to its host through phytotoxins before the weed emerges from the soil. Above ground the crop withers, and grain production is reduced. Striga infestation is a consequence of monocropping of cereals, which host the parasite, and declining soil fertility, which weakens the host plant to striga attack. As a result of these cropping practices, striga- infested areas have gathered very high levels of long-lived striga seeds in the soil with some breaking dormancy each season when stimulated by crop exudates. Kanampiu and Friesen (2004) reported that yield losses due to striga damage range between 20-80% to complete yield loss. Striga is considered an indicator for poor soil fertility (Kanampiu and Friesen, 2004).

Striga infests an estimated two-thirds of the 73 million hectares devoted to cereal crops in Africa, resulting in crop losses of up to 70% among subsistence farmers (Jesse, 2005; Kanampiu and Friesen, 2004). Striga accounts for an estimated 4.1 million tonnes in lost cereal yields each year, and is considered by many experts to be the greatest obstacle to food production in Africa, particularly the Sahel region (Watson et al., 1998). In Western Kenya an estimated 75 000ha of land (80% of farmland) are infested with striga. Every year striga damage to crops accounts for an estimated US$7 billion in yield loss in sub-Saharan Africa, and affects the welfare and livelihood of over 100 million people (Kanampiu and Friesen, 2004).

There are several methods that are used or have been tried to control Striga infestation in maize. Crop rotation of a cereal with legumes such as soybean can be a highly effective means of reducing the amount of striga seeds in the soil (Berner et al., 1997) but this practice may not be viable in the smallholder sector of South Africa where land holdings are small and farmers always require their staple maize. Intercropping cereal with cowpea in the same row gave the highest yield in Cameroon and in Ethiopia (Mbwaga et al., 2001). Intercropping with legumes also improves soil fertility through fixation of atmospheric nitrogen. Addition of nitrogen to the soil is generally considered to alleviate the effects of striga and to lower the amount of striga supported by the host. The effectiveness of cereal/legume intercropping to influence striga germination depends on the effectiveness of the produced stimulants/inhibitors, root development, fertility improvement, shading effect and its compatibility to striga species because the response of striga to management options is specific (Mbwaga et al.,2001).

Chivinge et al. (2001) conducted an on-farm experiment in Zimbabwe between 1996 and 1998 with the objective of determining the effectiveness of cowpea cultivars: IT93K-8-45-5-1-5, B301, IT82D-849, IT90K-76 and Kavara (local check) in the management of striga. All the cowpea cultivars reduced striga emergence by at least 40% with IT82D-849 exhibiting the highest percentage reduction. Intercropping cowpea cultivars with maize resulted in maize yield increases of 650-860% during the 1996/97 season with yields of 3.8-4.8 t ha^{-1}. These yield increases, however, were higher than those obtained during the subsequent 1997/98 season.

Hoe weeding remains the most common method of weed control among smallholders Limpopo. Development of striga resistant varieties from susceptible species has been attempted in a number of crops including sorghum, maize, cowpeas, rice and millet (Mloza-Banda and Kabambe, 1997). The effectiveness of striga resistance of local maize varieties needs to be tested in places such as Mopani and Vhembe where striga is most problematic. This may be a viable option since there are many early maturing cultivars suitable for these marginal rainfall areas.

Olupot et al. (1999) conducted series of experiments with the objective to develop an integrated management strategy for striga under Ugandan conditions. Treatments consisted of two levels of nitrogen and two weedings. These were applied either singly or in various combinations on two sorghum varieties (local/susceptible cultivar and an improved/tolerant variety- Seredo). The results showed that a combination of tolerant variety, nitrogen applied at the rate of 80kgN/ha and the two hand weedings was superior to other treatments. The lowest striga count and the highest sorghum grain yield were achieved in this treatment. Ordinary hoe weeding (twice) followed by spot spraying of striga with gramoxone every ten to fourteen days showed higher yields than ordinary hoe weeding (twice) alone or hoe weeding coupled with hand pulling. Hand pulling for witch weed may be much more difficult and expensive because plants are small, less conspicuous and may be much more numerous (Mloza-Banda and Kabambe, 1997).

There is a need to test the effectiveness of different agronomic practices in Limpopo Province to assist farmers to control striga in their maize fields. These practices can increase maize production. Farmers in Limpopo Province are controlling striga by hoe weeding only. Smallholder farmers are not aware of other methods, which can be used to control striga.

The objectives of this study were: 1) to test the effect of hand hoeing, hand hoeing and application of inorganic fertilizer (N), and hand hoeing maize intercropped with cowpea on striga emergence and growth, and maize yield in dry land maize and 2) to evaluate the response of maize cultivar on maize striga infestation.

CHAPTER 2

2. Literature review

2.1 Striga management

2.1.1 Intercropping

The roots of several legumes are known to induce suicidal germination of striga seeds, and this feature has become incorporated into striga suppression strategies involving cereal-legume rotation or intercropping. *Silverleaf desmodium* is particularly effective in suppressing striga and has been incorporated into a biological control system known as push and pull. In push-pull, desmodium neutralizes striga (Woomer, 2004). Intercropping cereal with cowpea in the same row gave the highest yield in Cameroon and in Ethiopia (Mbwaga et al., 2001). Intercropping with legumes also improves soil fertility through fixation of atmospheric nitrogen. Addition of nitrogen to the soil is generally considered to alleviate the effects of striga and to lower the amount of striga supported by the host. The effectiveness of cereal/legume intercropping to influence striga germination depends on the effectiveness of the produced stimulants/inhibitors, root development, fertility improvement, shading effect and its compatibility to striga species (Mbwaga et al., 2001). Mixed cropping of cereals and cowpea has been observed to reduce striga infestation significantly (Khan et al., 2002). This is thought to be due to the soil cover of cowpea creating unfavorable conditions for striga germination (Mbwaga et al., 2001; Musambasi et al., 2002). Intercropping maize and beans in the same hole had the highest grain yield, which was 78.6 % above the yield of pure maize stands due to the fact that beans is able to fix nitrogen which will improve maize yield (Odhiambo and Ariga, 2001).

2.1.2 Crop rotation

Crop rotation is the easiest control measure of striga control to implement because it requires only commitment and planning (Shank, 2002). Crop rotation or intercropping with trap or catch crops can reduce the number of witch weed seeds in the soil. For heavily infested fields, trap crops can accelerate the depletion of the reservoir of striga seed in the soil (Mloza-Banda and Kabambe, 1997). Crop rotation of a cereal with legumes such as soybean can be a highly effective means of reducing the amount of striga seeds in the soil. To ensure effectiveness of the rotation crop, the cultivars which are most effective in stimulating striga must be included. A more desirable option is the use of leguminous non-host crops, which stimulate striga germination, but do not support its growth. These non-hosts can significantly deplete the soil seed bank by inducing suicidal germination of striga (Berner et al., 1997).

Rotating the infested maize or sorghum areas to wheat/barley, pulses, or groundnuts are viable and effective options in Ethiopia. A season of non-host cropping allows for a large portion of the striga seeds to deteriorate into non-viability. Seriously infested areas should be rotated to non-host crops for two years followed by closely supervised weeding. In Ethiopia two years of cropping to a non-host was reported to reduce striga infestation by 50% (Shank, 2002). In Sahel the results of a four year experiment in bush fields indicated that one season cowpea in 1998, had a positive effect on subsequent millet grain yields, soil organic carbon and nitrogen, and reduced striga infestation. The increase in yields due to millet-cowpea rotation was 37% in 1999 compared to 3-5 years continuous millet cropping (Samake, 2003).

2.1.3 Weeding/Sanitation

Although weeding the small Striga plants is a tedious task and may not increase the yield of already infected plants, it is necessary to prevent seed production and reinfestation of the soil. Weeding must begin at the first sign of flowering because pod formation and seed setting will soon follow. New shoots may sprout out below the soil from infected plants requiring a second weeding before crop maturity (Shank, 2002). Hoe weeding remains the most common method of weed control in Malawi. Farmers will normally weed twice, the second time is through the banking operation where the soil is pulled-up the ridge. Inconsistent results have been obtained in Malawi on the effectiveness of hoe-weeding for striga control (Mloza-Banda and Kabambe,1997). Sanitation consists of taking care to note infested areas and to isolate them. Wind, rainwater, ploughing, and soil on tools or root crops can spread seeds in the soil. Seedpods on striga plants attached to maize or sorghum plants pulled for forage will infest manure and feeding areas. It is suggested that a striga disposal pit be constructed to prevent seed maturation of green or drying plants that are pulled (Shank, 2002). If striga has formed flowers and matured, farmers should dig a hole about 70 cm deep, burn the plant and bury them (Woomer, 2004).

2.1.4 Genetic Resistance

Varietal resistance to striga infestation in maize and sorghum has long been recognized but only recently have attempts been made to utilize it. Basically, the resistant varieties were low yielding and not desirable in other agronomic characteristics. Recent efforts to utilize resistance in breeding and improvement programs have met with limited success. A number of resistant lines of maize have been identified by the Institute of Tropical Agriculture (IITA) in Nigeria and the International Wheat and Maize Improvement Center (CIMMYT) in Tanzania but have not been tested in Ethiopia (Shank, 2002).

More than 80 resistant sorghum lines have been selected by the International Center for Research in the Semi-Arid Tropics (ICRISAT) in India. Of these, three selections made by the Ethiopian Institute of Agriculture Research at Nazreth have performed well in research trials and are currently being verified in large scale tests. Seed of these varieties is available for adaptation testing in striga infested areas. Care must be taken in distinguishing resistance from tolerance since good yielding tolerant varieties will allow Striga growth and seed production, thus increasing soil contamination (Shank, 2002).

Development of resistant varieties has been attempted in a number of crops including sorghum, maize, cowpeas, rice and millet. Resistance in sorghum materials has been confirmed for *S.asiatica* in Southern Africa and has been incorporated into breeding materials. One of the major problems though is that resistance to striga has been associated with low grain yield and poor grain quality. At IITA, some maize lines with partial tolerance and/or resistance to *S.hermonthica* and *S.asiatica* were identified and hybrids developed with resistance or tolerance are commercially available in East and Southern Africa (Mloza-Banda and Kabambe, 1997).

Development of resistant maize genotypes is further complicated by the existence of biotypes and the presence of three different and economically important striga species in Africa that infest maize and the potential buildup of the parasite where tolerant maize lines are used. Additional research is needed to confirm the role of some genotypic traits of the crop along with other host-parasite interactions and their contribution to striga resistance (Mloza-Banda and Kabambe, 1997). Hiriray, Higretay and Korokora are Ethiopian maize varieties that are resistant due to their early maturing characters, which is an escape mechanism against the infestation of striga (Kidane et al., 2004).

2.1.5 Soil Fertility

It has been noted in western countries that host plant shading can restrict striga growth when generous soil fertilizer is applied (Table 2.1.5.1). In areas of high rainfall, factors such as high plant populations, recommended fertility levels, and good weed control encourage lush crop growth and shading in spite of striga parasitism. This is not feasible in moisture stressed areas since high fertilizer applications would burn up the crop should normal soil moisture restrictions occur. However, it appears that several small applications of fertilizer adjusted to the level of available soil moisture could raise crop yields and shading in favorable rainfall years (Shank, 2002).

Table 2.1.5.1. Effect of soil fertility level on striga growth and plant characters of 4 maize hybrids in Nigeria

NPK % recommended	No of Striga plants/m of row	No of Striga seed capsules/plant	Maize plant height(cm) Res/Sus	Grain Yield kg/plant
0	150	12	102/53	10
30	102	54	103/65	17
50	85	33	124/75	13
100	23	6	146/119	36

(Shank, 2002)

Farina et al. (1985) conducted long-term fertilizer trials using nitrate and ammonium N sources at 60, 120 and 180 kg/ha and found that N significantly reduced the incidence of *S. asiatica* on maize in South Africa. Esilaba et al. 2000 reported that striga emergence was minimized with the application of 120kg N/ha. Mumera and Below (1993) and Esilaba et al. (2000) reported that Striga infestation declines with increasing N availability and the impact depends on the severity of the infestation. Aflakpui et al. (1997) reported that to reduce the population of Striga in maize, it is essential to apply a minimum of 90kg N/ha fertilizer and it must be applied early.

2.1.6 Mulches

In Tsholotsho, Zimbabwe, mulches were applied at 2t/ha at 4 weeks after maize planting. Mulches from *Collophospermum mopane, Acacia karoo and Acacia nilotica* reduced the incidence of *S.asiatica* and delayed its emergence and flowering. Mulch from *C.mopane* was the most effective in suppressing the weed between the 4th and 5th weeks after its application. *A. karoo* increased the number of days to emergence from 47 days to 68 days while that from *C. mopane* and *A.nilotica* increased the number to 58 days. Mulches from *A. nilotica*, *A. karoo* and *C. mopane* increased the number of days to flowering from 75 to 108, 125 and 100, respectively. It is recommended that farmers mulch their fields at different times, depending on the mulch being used in order to suppress weed emergence and flowering throughout the season (Chanyowedza and Chivinge, 1999). The requirement of large amounts of mulch, however, limits the usefulness of this approach.

2.1.7 Chemical control

A number of chemical control measures that have been practiced in the western hemisphere are not practical or are too risky for several reasons. Soil sterilization by means of stimulating striga seed germination with non-host plants (cotton or soybeans) or chemical stimulants (Strigol and ethylene) is not practical in developing countries because of cost and the resulting delay in planting the food crop in areas where the season length is already limited by moisture (Shank, 2002). Preemergence herbicides against striga, such as oxyfluorfen and dinitroaniline compounds, form a barrier in the top few centimetres of the soil and kill striga as it emerges (Berner et al., 1997). Since Striga is a broadleaf plant, preplant herbicides such as Atrazine, Goal, and Flex show some effect though not efficient enough to be justified (Shank, 2002). Post-emergence use of 2,4-D is effective when sprayed on the striga leaves. Though low in cost, this herbicide is quite volatile and drift to nearby sensitive broadleaf crops (legumes, pepper and tomato) and could be devastating. Also, maize and sorghum are vulnerable to stalk twisting and lodging if 2,4-D is sprayed into the leaf whorl. Spraying should only be done after users have been trained and cautioned to these hazards. Experimentally, anti-transpirant type herbicides applied only to the base of the row of sorghum-striga or maize-striga were very effective (Shank, 2002). Herbicides such as trifluralin and pendimethalin, have been effective against *S. asiatica* when incorporated shallowly in a layer above the cereal seed by inhibiting shoot growth of the parasite (Mloza-Banda and Kabambe, 1997). Traore et al. (2001) reported that use of herbicides is more cost effective than mechanical weeding and it enhanced striga control. Use of 2,4-D cannot work in the smallholder sector in SA where maize is often intercropped with cowpea, cucumber and melons, and herbicide technology has largely not yet been introduced to these farmers.

2.1.8 Biological control

Fusarium fungus that is found at low levels under normal conditions in some African soils can be applied by coating cereal seeds first with Arabic gum and then with dry fungal powder. It is a seed technology rather than herbicide technology. The advantage with this approach is that fusarium can colonize the soil and lie in wait for striga. When striga attacks the crops, it is killed by the fusarium (Eberlee, 2000). Researchers at McGill Biopesticides Research Laboratory discovered a fungus (*Fusarium oxysporum*) in the soil in Mali that can suppress the weed’s growth (Watson et al., 1998). In a pilot study, the fungus was grown on sorghum straw, and then spread on farmers’ fields at sowing time. It is not toxic to humans or to cereal crops and attacks striga at an early growth stage, resulting in dramatically increased sorghum yields. In 1994 at Samaya in Mali, there was delayed emergence of striga in all inoculum treated plots, achieving reduction in striga emergence from 53% to 90% in treated plots and increase in sorghum yields of 100%. In 1995 at Kolokani in Mali there was reduction in striga emergence of 75% and increase in sorghum yield of 19%. In 1996 at Cinzana in Mali there were reductions in striga emergence of 54% and increase in sorghum yields of 23%. Lastly in Sikasso, in Mali, there was reduction in striga emergence of 84% (Watson et al., 1998).

2.1.9 Integrated striga management

A series of experiments were conducted with the objective of developing an integrated management strategy for striga (witch weed) under Ugandan conditions (Olupot et al., 1999). The first of these experiments was carried out during the first rains (March – July 1999). Treatments consisted of two levels of nitrogen and two weedings. These were applied either singly or in various combinations on two sorghum varieties (local/susceptible cultivar and an improved/tolerant variety- Seredo). The results showed that a combination of tolerant variety, nitrogen applied at the rate of 80kgN/ha and two hand weedings was superior to other treatments. The lowest striga count and the highest sorghum grain yield were achieved in this treatment (Olupot et al., 1999). Ordinary hoe weeding (twice) followed by spot spraying of striga with gramoxone every ten to fourteen days showed higher yields than ordinary hoe weeding (twice) alone or hoe weeding coupled with hand pulling. However, the use of herbicides poses challenges of accurate calibration of sprayers and use of correct dosages. Hand pulling for witchweed may be much more difficult and expensive because plants are individually small, less conspicuous and may be much more numerous (Mloza-Banda and Kabambe, 1997). Generally, no single method provides an acceptable level of control. An integrated striga management strategy is required and would be strengthened by the use of natural enemies as biological control agents (Abbasher et al., 1998).

CHAPTER 3

EFFECT OF WEED CONTROL METHOD ON STRIGA NUMBERS, MAIZE GRAIN YIELD AND YIELD COMPONENTS

3.1 INTRODUCTION

The witchweed (*Striga asiatica*) is a parasitic weed that plagues cereal crops including maize. This weed competes for water and nutrients as a root parasite, literally sucking the life out of the crop on which it germinates. In doing so, crop growth is stunted (Sallah and Afribeh, 1998) and yields are generally reduced. Generally striga is considered an indicator for poor soil fertility (Kanampiu and Friesen, 2004). Kanampiu and Friesen (2004) reported that yield losses due to striga damage ranged between 20-80%.

Addition of nitrogen to the soil is generally considered to alleviate the effects of striga and to lower the amount of striga supported by the host (Mbwaga et al., 2001). Chivinge et al. (2001) reported that cowpea cultivars reduced striga emergence by 40%. The effectiveness of cereal/legume intercropping to influence striga germination depends on the effectiveness of the produced stimulant/inhibitors, root development, fertility improvement, shading effect and its compatibility to striga species because the response of striga to management options is specific (Mbwaga et al.,2001).

There is a need to test the effectiveness of different agronomic practices in Limpopo Province to assist farmers to control striga in their maize fields. These practices can have a major effect on maize production, as it is known that the farmers in Limpopo Province are controlling striga by hoe weeding only. Smallholder farmers are not familiar with other methods, which can be used to control striga. These agronomic practices have been successfully tried in other countries. The effectiveness of striga resistance of local maize varieties needs to be tested in Districts such as Mopani and Vhembe where striga is most problematic. This may be a viable option since there are many early maturing cultivars suitable for these marginal rainfall areas. It is necessary to test the effectiveness of selected agronomic practices on controlling striga in maize and for farmers to evaluate them since subsistence farmers can only afford inexpensive control measures. Smallholder farmers in South Africa almost wholly intercrop their maize with legumes. It may, therefore, be necessary to test the interaction of maize cultivar with a legume on control of striga, among other treatments.

This study is aimed at improving maize productivity and household food security by enhancing management of striga using selected agronomic practices. The main objective of the study is to investigate the effectiveness of selected agronomic practices on striga control in dry land maize in Limpopo Province and the farmer's reaction to their performance. Specific objectives of the study are: 1) to test the effect of hand hoeing, hand hoeing and application of inorganic fertilizer (N), and hand hoeing maize intercropped with cowpea on striga emergence and growth, and maize yield in dry land, 2) to evaluate the effect of maize cultivar to maize response to striga infestation and 3) to evaluate the interaction between maize cultivar and agronomic practices in suppressing striga and maize yield.

3.2 MATERIALS AND METHOD

3.2.1 Study area

The experiment was done at Mafarana village (Mopani District) near Tzaneen where striga is a serious problem. The study was conducted on three fields, belonging to Mrs. Shingwenyana, Mr. Nyathi and Mr. Mushwana, which were selected on the criterion of having high natural striga infestation.

3.2.2 Experimental design and treatments

The experiment was carried out under a 2X3 factorial arrangement in a Randomized Complete Block Design (RCBD) with four replications. The trial was planted between the 14th and 16th December 2006. The experiment consisted of two treatment factors; (i) two maize cultivars i.e. Zm 1421(V_1) and Zm 423(V_2) which are early maturing and drought resistant open pollinated cultivars; (ii) three agronomic practices: hand hoeing alone (M_1), hand hoeing plus inorganic fertilization using lime ammonium nitrate (LAN-28%N) at the rate of 56kg/ha (M_2), and hand hoeing plus inter-row intercropping of maize with cowpea (M_3). Cowpea cultivar Bechuana White was used for the intercropping treatment. Hand hoeing alone was the control factor.

3.2.3 Trial management

Inter-row spacing was 90cm and in-row spacing was 50cm for maize (giving a population of 22 220 plants per hectare). Hand weeding was done at 33 days after planting (DAP) and 105 DAP. The cowpea was sprayed with dimethoate 40 EC for pest control as necessary.

3.2.4 Data collection

Gross plot size was 21.6m^2 (4 rows X 90cm X 6m) and Net plot size was 10.8 m^2 (2 central rows X 90cm X 6m). Data were collected from 10.8 m^2 area leaving the other two rows as borders. Striga counts were done at 61, 83 and 105 days after planting (DAP). The yield of cowpea was not taken because excessive rain caused serious flower drop and pods were insect damaged. The farmers in that area also prefer to grow cowpeas for their leaves, which they use as vegetable. The following data were collected:

1. Date of first emergence of striga
2. Number of striga plants in the row at 61, 83 and 105 DAP.
3. Number of maize plants per plot at physiological maturity (PM)
4. Number of ears per plot
5. Date of physiological maturity (PM) of maize
6. Unshelled weight per plot
7. Maize grain yield per plot

3.2.5 Data analysis

Data were analyzed using SPSS to compute analysis of variance (ANOVA) across all locations. Treatment means were compared using the Least Significant Difference (LSD), $P<0.05$. Striga counts were analysed after logarithmic transformation of data [log (counts + 1)]. Correlation analysis between striga numbers and maize yield was done.

3.3 RESULTS AND DISCUSSION

3.3.1 Effect of weed control method on striga numbers

The results indicated that the effect of the method of weed control on the number of striga plants was significant at the 5% level of significance at all locations except at Mushwana's where at 105 days after planting (DAP) there was no significant effect (Appendix 5.1-5.7). At 63 DAP striga plants were only found at Shingwenyana's where the field was highly infested with striga and the numbers were lower compared to other counting days because the maize crop was still small and at Mushwana and Nyathi's fields striga plant emergence was delayed (Table 3.1). The interaction effect between variety and weed control method was not significant on striga numbers in all fields. At The striga numbers were significantly different among all locations at 5% level of significance.

Table 3.1: Effect of weed control method on striga numbers (Log transformed) at Shingwenyana, Mushwana and Nyathi's Fields

	Striga number						
	Shingwenyana			Mushwana		Nyathi	
Weed control method	68DAP	83DAP	105DAP	83DAP	105DAP	83DAP	105DAP
Hand hoeing	0.954ab	1.582a	1.117a	1.065a	0.554	0.954a	0.206b
Hand hoeing+ inorganic fertilizer	0.544b	0.843b	0.690b	0.185b	0.247	0.544b	0.172b
Hand hoeing + intercropping	1.173b	1.607a	0.966c	0.975a	0.345	1.174a	0.794a
LSD (p=0.05)	0.543	0.396	0.063	0.426	0.543	0.543	0.213
CV%	40.5	20.0	31.0	49.0	78.0	40.5	34.0

Note: Means in the same column followed by the same letter are not significantly different: LSD = least significance difference
CV = Coefficient of variation
DAP = Days after planting

At 83 DAP the striga counts were high across all locations because this is the most productive stage of maize and that's the time when striga will be causing a lot of harm to the maize crop (Table 3.1). At Shingwenyana's field the number of striga was low at 68 DAP and the number was high at 83 DAP but, at 105 DAP the striga counts came down. This would have been caused by heavy rainfalls between 86 and 101 DAP. After heavy rains most of the striga plants became dry. Olupot et al. (1988) reported that high moisture in the soil delays striga emergence.

3.3.1.1. Hand hoeing

In most of the plots hand hoeing had the highest number of striga except at Shingwenyana's field where the highest number of striga was under hand hoeing plus intercropping (Figure 3.1). Under hand hoeing the numbers of striga plants ranged from 0.954 at 68 DAP, 1.582 at 83 DAP and 1.117 at 105 DAP.

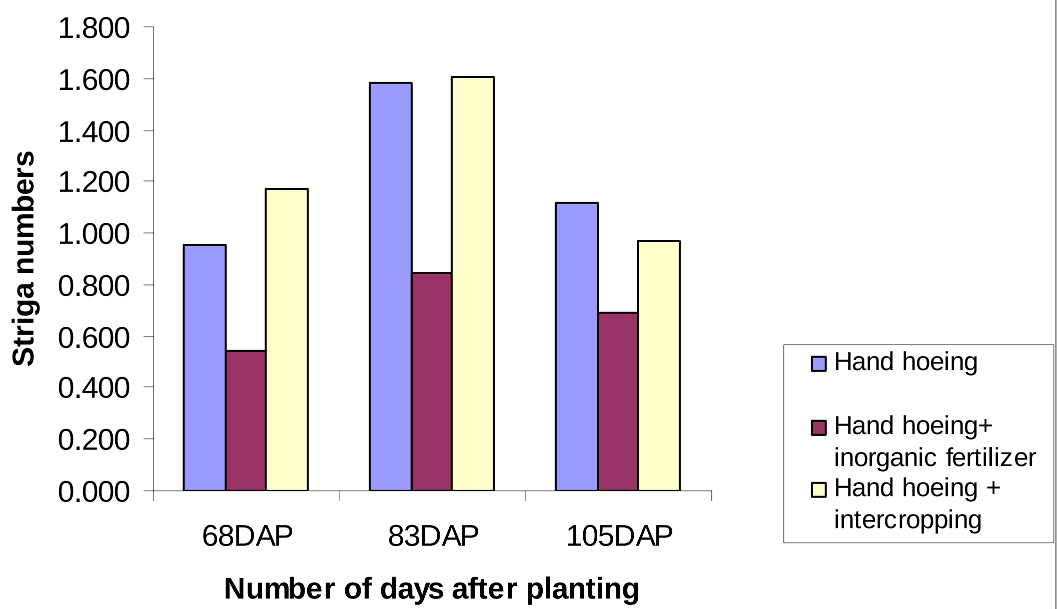

Figure 3.1 Striga numbers (log transformed) 68, 83, and 105 days after planting at Shingwenyana's field following three agronomic practices

At Mushwana’s field the striga numbers were not very high compared to Shingwenyana’s field (Figure 3.2). Under hand hoeing the numbers of striga plants ranged from 1.065 at 83 DAP and 0.544 at 105 DAP (Figure 3.2). At Nyathi’s field under hand hoeing the numbers of striga plants ranged from 0.954 at 83 DAP and 0.206 at 105 DAP (Figure 3.3).

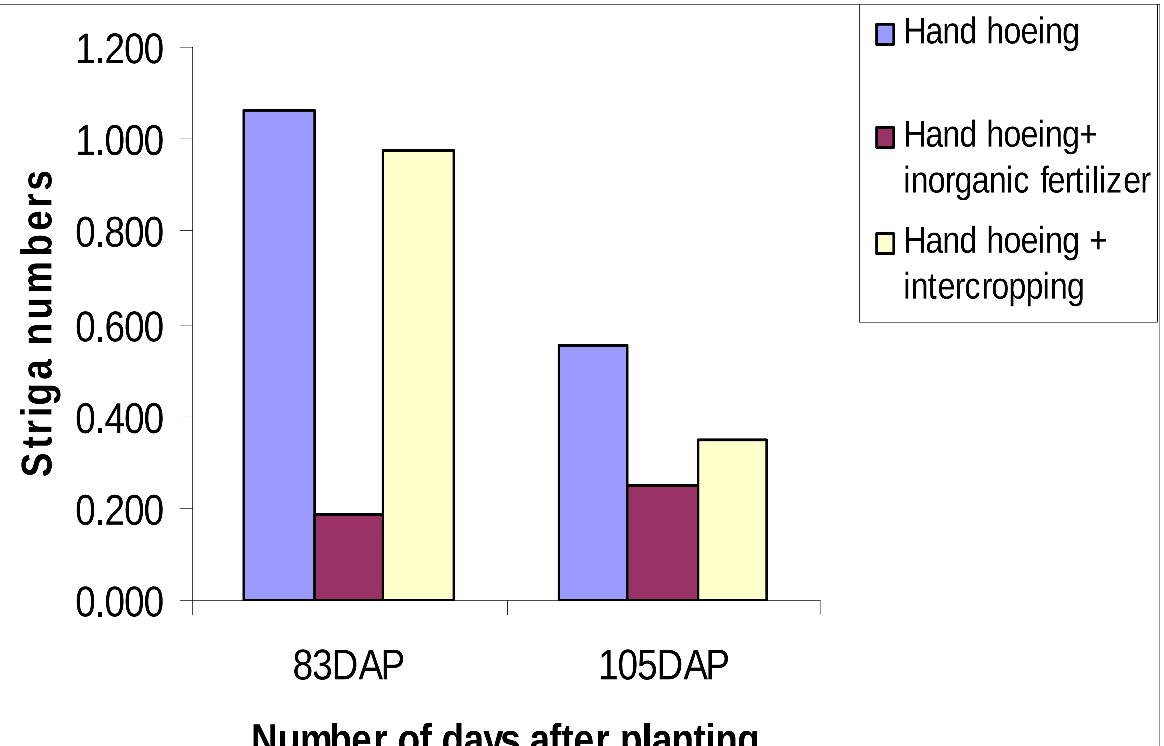

Figure 3.2 Striga numbers at 83 and 105 days after planting at Mushwana's field following the three agronomic practices

3.3.1.2 Hand hoeing plus inorganic fertilizer

At Shingwenyana’s field the numbers of striga plants under hand hoeing plus inorganic fertilizer ranged from 0.544 at 68 DAP, 0.843 at 83 DAP and 0.690 at 105 DAP (Figure 3.1). At Mushwana’s field the number of striga plants at the same treatment ranged from 0.185 at 83 DAP and 0.247 at 105 DAP (Figure 3.2). At Nyathi’s field the number of striga plants in this treatment ranged from

0.544 at 83 DAP and 0.172 at 105 DAP (Figure 3.3). The number of striga plants was reduced under hand hoeing plus inorganic fertilizer application compared to hand hoeing alone and hand hoeing plus intercropping at all the three sites. This could be due to the fact that inorganic fertilizer resulted in vigorous maize plants which resulted in shading of striga plants suppressing its growth and reducing damage to the maize crop. Aflakpui et al. (1997) reported that to reduce the population of Striga in maize, it is essential to apply N fertilizer early. Farina et al. (1985) conducted long-term fertilizer trials using nitrate and ammonium N sources at 60, 120 and 180 kg/ha and found that N significantly reduced the incidence of *S. asiatica* on maize in South Africa. Olupot et al. (1999) reported that lowest striga emergence was recorded in a combination of nitrogen application and two weedings. Elisaba et al. (2000) also supported that improving nitrogen status of the soil help suppress striga.

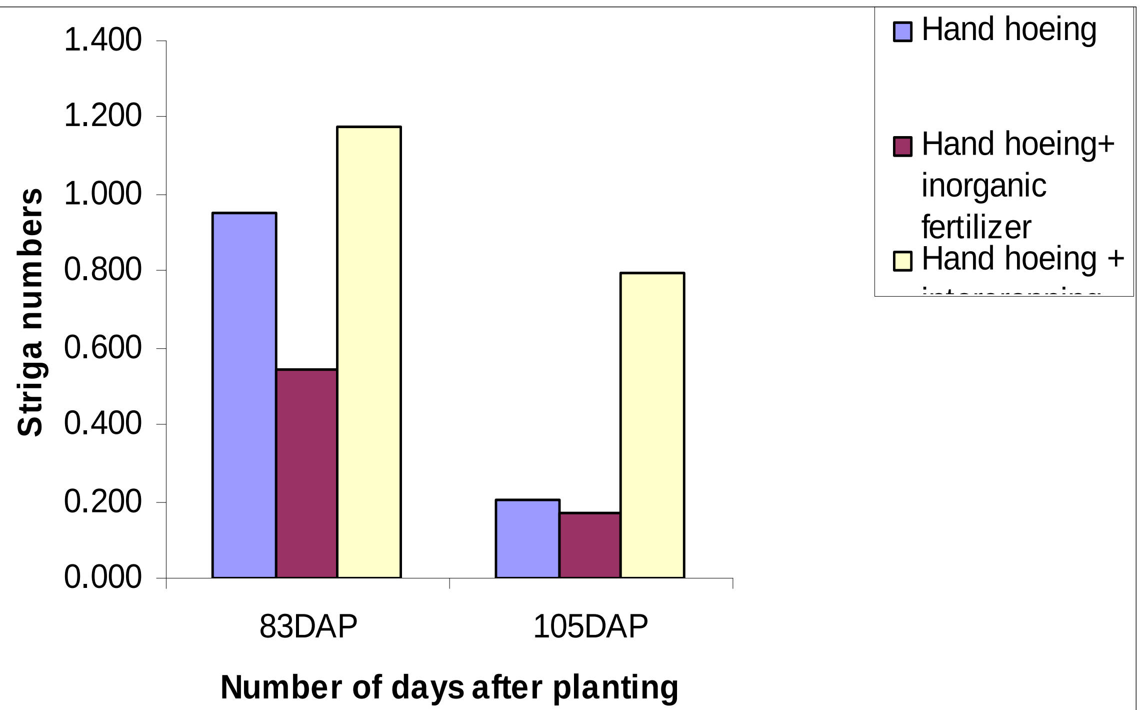

Figure 3.3 Striga numbers at 83 and 105 days after planting at Nyathi's field following the three agronomic practices

3.3.1.3 Hand hoeing plus intercropping with cowpea

At Shingwentans's field the number of striga plants under hand hoeing plus intercropping ranged from 1.173 at 68 DAP, 1.607 at 83 DAP and 0.966 at 105 DAP (Figure 3.1). In Mushwana's field the number of striga plants in this treatment ranged from 0.975 at 83 DAP and 0.345 at 105 DAP (Figure 3.2). At Nyathi's field the number of striga plants in this treatment ranged from 1.174 at 83 DAP and 0.794 at105 DAP (Figure 3.3).

3.3.1.4 General discussion – Weed control effect on striga number

Striga numbers under hand hoeing alone and hand hoeing plus intercropping with cowpea were statistically similar at Shingwenyana (68 DAP and 83 DAP) and Mushwana (83 DAP) and at Nyathi (83 DAP). This has been caused by the inefficiency of the cowpea cultivar to suppress striga plants. The inefficiency of cowpeas to suppress striga might have been caused by the fact that second pest control was not done on cowpeas due to heavy rains which resulted in cowpea being damage by pests. Elsewhere, mixed cropping of cereals and cowpea has been observed to reduce striga infestation significantly (Khan et al., 2002). Musambasi et al. (2002) reported that maize/cowpea intercrop supported less striga plant/m^2 than sole maize. Mbwaga et al. (2000) also supported the fact that intercropping cereals and cowpea has been observed to reduce striga infestation significantly.

3.3.1.5 Effect of maize variety on striga numbers

There was a significant difference of striga numbers among varieties of maize at Nyathi's field at 105 DAP (Figure 3.4). In hand hoed, striga numbers were 0.075 for Zm 1421 and 0.489 for Zm 423. Plots that were hand hoed plus inorganic fertilizer application striga numbers were 0.075 for Zm 1421 and 0.270 for Zm 423 and finally hand hoed plus intercropped plots with maize and cowpeas had striga numbers of 0.739 for 1421 and 0.850 for ZM 423. The results suggest that maize varieties used in this study had little potential to influence striga numbers.

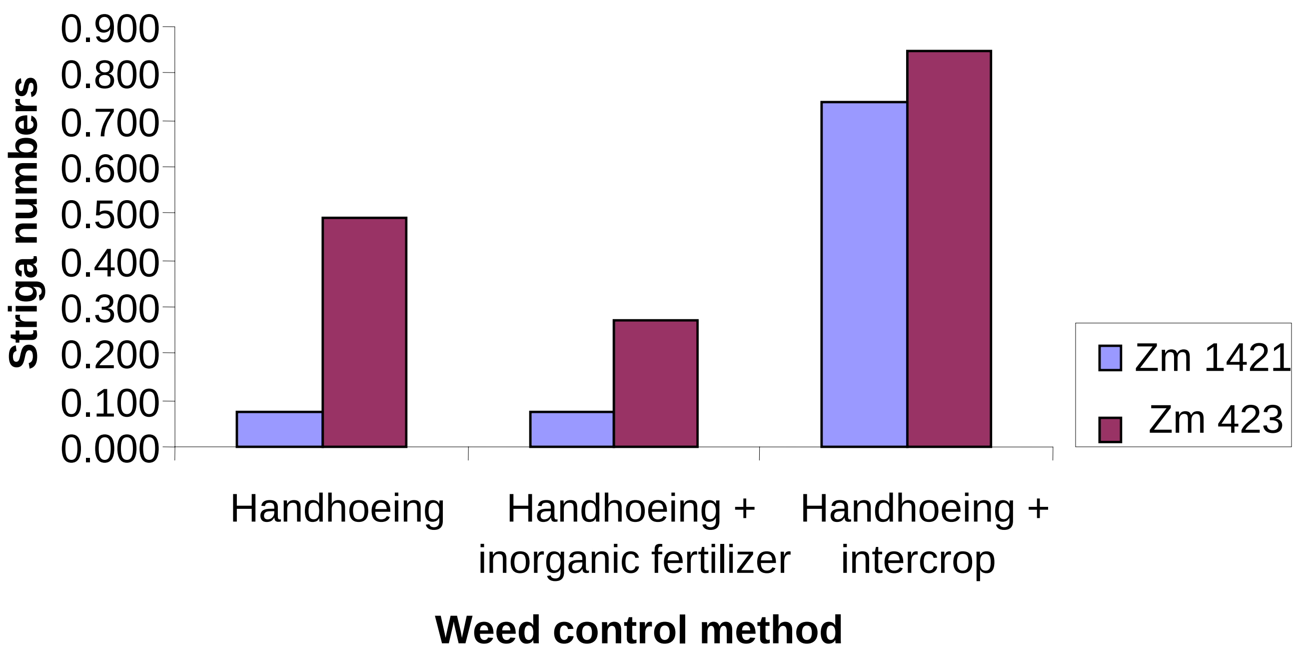

Figure 3.4 Effect of weed control method on striga numbers on maize varieties at Nyathi's field at 105 DAP

3.3.2 Effect of weed control method on maize grain yield

At Shingwenyana's field the results indicated that effect of weed control methods on grain yield was significant (Appendix 5.8) and this is where the striga numbers were the highest than at Mushwana (Appendix 5.9) and Nyathi's fields (Appendix 5.10). The highest yield was 3928 kg/ha under hand hoeing plus intercropping the lowest being 2219 kg/ha under hand hoeing at Shingwenyana's field. At Mushwana and Nyathi's fields the effect of weed control methods on grain yield was not significant, which implies that the higher striga numbers in hand hoeing alone and intercropped plot did not have any effect on yield. The lack of response can be that there was competition between cowpea and maize or that the cowpea variety used did not suppress striga growth. Nyathi's field had the lowest yield of 1226kg/ha from 3928 kg/ha at Shingwenyana's field (Table 3.2). Shingwenyana's field had the highest striga pressure. The results in Table 3.2 only show significant superiority of the hand hoeing plus intercropping over the other methods at this field.

Table 3.2: Effect of weed control method on maize grain yield

	Grain yield in kg/ha			
Weed control method	Shingwenyama	Mushwana	Nyathi	All Locations
Hand hoeing	2219b	3292	1226	2380
Hand hoeing+ inorganic fertilizer	2248b	3416	1253	2505
Hand hoeing + intercropping	3928a	3665	1978	2557
LSD (p=0.05)	1365	NS	NS	NS
CV%	36	17	46	39

Note: Means in the same column followed by the same letter are not significantly different. LSD = Least significance difference, CV = coefficient of variation, NS = not significant.

Hand hoeing plus intercropping had the highest striga numbers and the highest yield at Shingwenyana's field. This combination cannot be easily explained. Chivinge et al. (2001) reported that intercropping cowpea cultivars with maize resulted in maize yield increases of 650-860% during the 1996/97 season with yields of 3.8-4.8 tha^{-1}. These yield increases, however, were higher than those obtained during the subsequent seasons of 1997/98. Musambasi et al (2001) supported that intercropping maize with legumes results in higher yield. Carson (1988) reported that the yield of a crop is rarely improved by hand weeding of striga alone.

3.3.3 The effect of weed control method on yield components of maize

3.3.3.1 Shelling %

At all fields the effect of weed control method on shelling % was not significant at 5% level of significance (Table 3.3). At Shingwenyana's field hand hoed plot had the lowest shelling % and under hand hoed plus nitrogen fertilized plot and hand hoed plus intercropped with cowpea the shelling % was the same. At Mushwana's field hand hoed plot had the lowest shelling %, then followed hand hoed plus nitrogen fertilized plot and the highest was hand hoed plus intercropped with cowpea. At Nyathi's field hand hoed plot had the lowest shelling %, then followed hand hoed plus intercropped with cowpea plot and the highest being under hand hoed plus nitrogen fertilized plot.

At Shingwenyana's (Appendix 5.11) field there was a strong interaction between maize varieties and weed control method especially at hand hoeing whereas at Mushwana (Appendix 5.13) and Nyathi's (Appendix 5.12) fields there was no interaction between maize varieties and weed control method (Figure 3.5). At Shingwenyana's field Zm 1421 had the highest shelling % under hand hoed plus nitrogen fertilized plot whereas Zm 423 had the highest shelling % under hand hoed plot. At Mushwana's field Zm 1421 had the highest shelling % under hand hoed plus intercropped with cowpea whereas Zm 423 had the highest shelling % under hand hoed plus nitrogen fertilized plot. At Nyathi's field both Zm 1421 and Zm 423 had the highest shelling % under hand hoed plus nitrogen fertilized plot. These indicate that the varietal difference for shelling % was influenced by weed control method at Shingwenyana's field.

3.3.3.2 Number of plants per plot

The effect of weed control method on the number of plants was only found significant at Mushwana's field (Appendix 5.16) and for Shingwenyana (Appendix 5.14) and Nyathi's (Appendix 5.15) fields there was no significant influence. At Mushwana's field the number of plants per plot under hand hoeing is 27.88 which were statistically similar to hand hoeing plus intercropping with cowpeas which is 27.75 and these were different from hand hoeing plus inorganic fertilizer application which is 34.63. Mushwana's field was the field which had the highest number of plants per plot ranging from 27.75 to 34.63 (Table 3.3).

3.3.3.3 Hundred seed weight

The effect of weed control method on hundred seed weight was not significant at 5% level of significance (Appendix 5.20-5.22). At Shingwenyana's field the highest weight was under hand hoed plus intercropped with cowpea plot (29.25g), then followed by hand hoed plus nitrogen fertilized plot (28.25g) and the lowest under hand hoed plot (26.25g). At Muswana's field the highest weight was under hand hoed plot (30.75g), then followed hand hoed plus intercropped with cowpea plot (30.50g) and the lowest under hand hoed plus nitrogen fertilized plot (30.25g). At Nyathi's field the highest weight was under hand hoed plus nitrogen fertilized plot (28.25g), then followed hand hoed plus intercropped with cowpea plot (26.25) and finally hand hoed plot (25.50g).

3.3.3.4 Number of cobs per plant

The effect of weed control method on number of cobs per plant was not significant at 5% level of significance (Figure 3.6). The effect of weed control method was significant among maize varieties at Shingwenyana (Appendix 5.17) and Mushwana's (Appendix 5.19) fields and at Nyathi's field (appendix 5.18) the effect was non significant. At Shingwenyana's and Mushwana's fields Zm 423 had the highest cobs per plant across all weed control methods and Zm 1421 having the lower number. At Nyathi's field it was the same except under hand hoed plus intercropped with cowpea plot. This means that Zm 423 has the ability to tolerate stress a little bit than Zm 1421.

3.3.3.5 Lodging %

The effect of weed control method on lodging % was not significant at 5% level of significance at all fields (Appendix 5.23-5.25). At all fields hand hoed plots had the highest lodging %. This can be influenced by the fact that the crops were weak due to poor soil fertility. At Shingwenyana and Nyathi's fields the second one was hand hoed plus intercropped with cowpea plot and this can be due to competition among maize and cowpea plants and the lowest lodging % being under hand hoed plus nitrogen fertilized plot this has been influenced by the availability of nutrients to the maize plant. The lodging has also been influenced by pests and also by heavy rains.

Table 3.3: Effect of weed control methods on yield components of maize at Shingwenyana, Mushwana and Nyathi

	Shingwenyana					Mushwana					Nyathi				
Weed control method	**SP**	**NP**	**HW**	**NC**	**LP**	**SP**	**NP**	**HW**	**NC**	**LP**	**SP**	**NP**	**HW**	**NC**	**LP**
Hand hoeing	82.84	30.87	26.25	0.77	42.02	83.85	27.88b	30.75	0.85	32.31	80.74	30.87	25.50	0.80	50.37
Hand hoeing + inorganic	83.70	33.25	28.25	0.81	29.45	84.28	34.63a	30.25	0.93	24.86	82.80	31.62	28.25	0.66	39.17
Hand hoeing + intercropping	83.70	30.63	29.25	0.79	31.92	84.63	27.75b	30.50	0.94	23.40	81.25	31.25	26.25	0.72	39.87
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	5.23	NS	NS	NS	NS	NS	NS	NS	NS
CV%	1.4	12.6	11.4	17.4	34.0	2.3	11.5	4.5	17.8	50.0	2.6	18.0	12.0	17.5	36.0

SP = shelling percentage, NP=number of plants per plot, HW=100 seed weight, NC=number of cobs per plant, LP=lodging percent
Note: LSD = Least significance difference
CV = Coefficient of variation
NS = Not significant

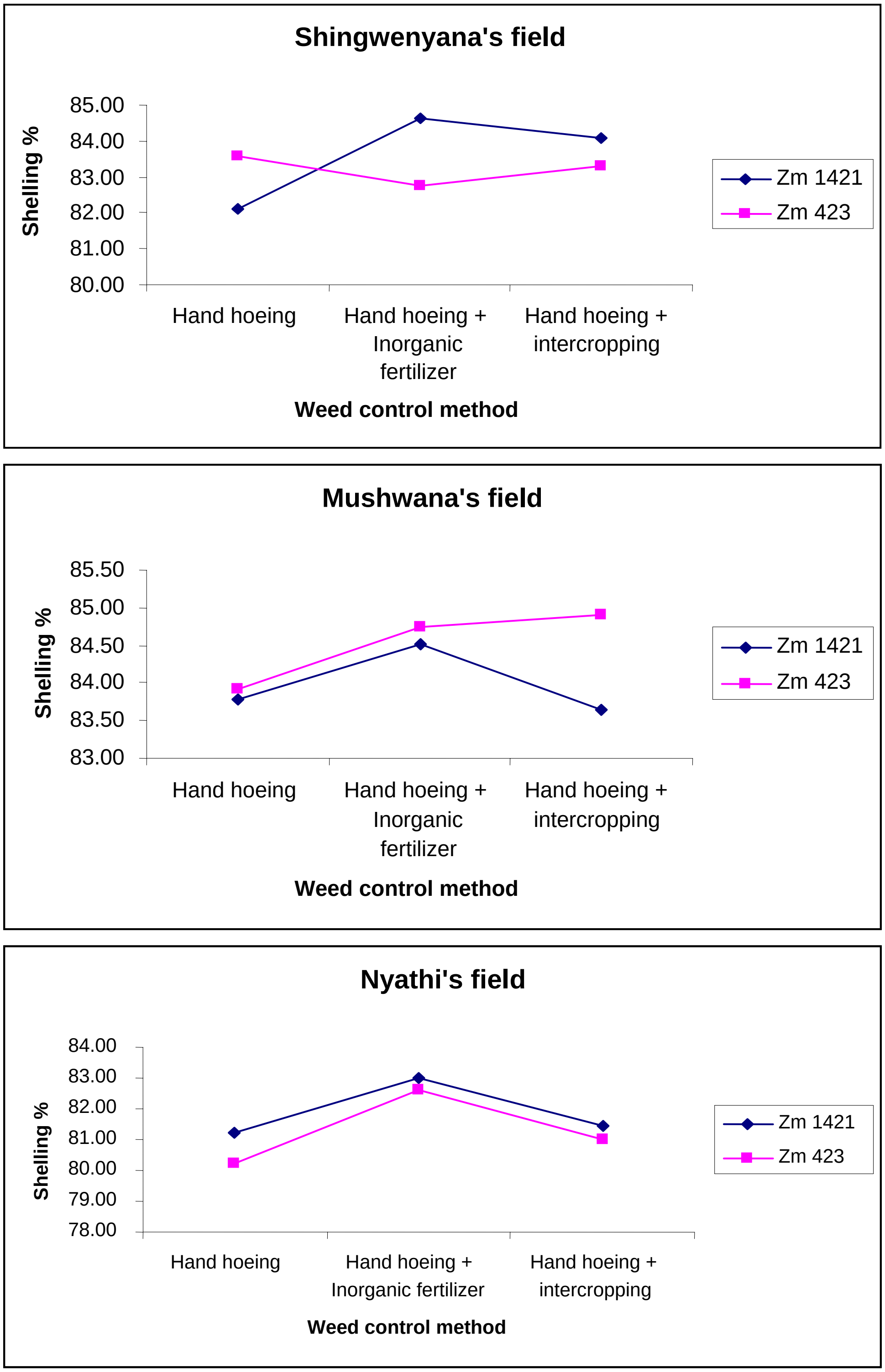

Figure 3.5 Interaction between Maize varieties and weed control method on shelling % of maize for Mafarana fields.

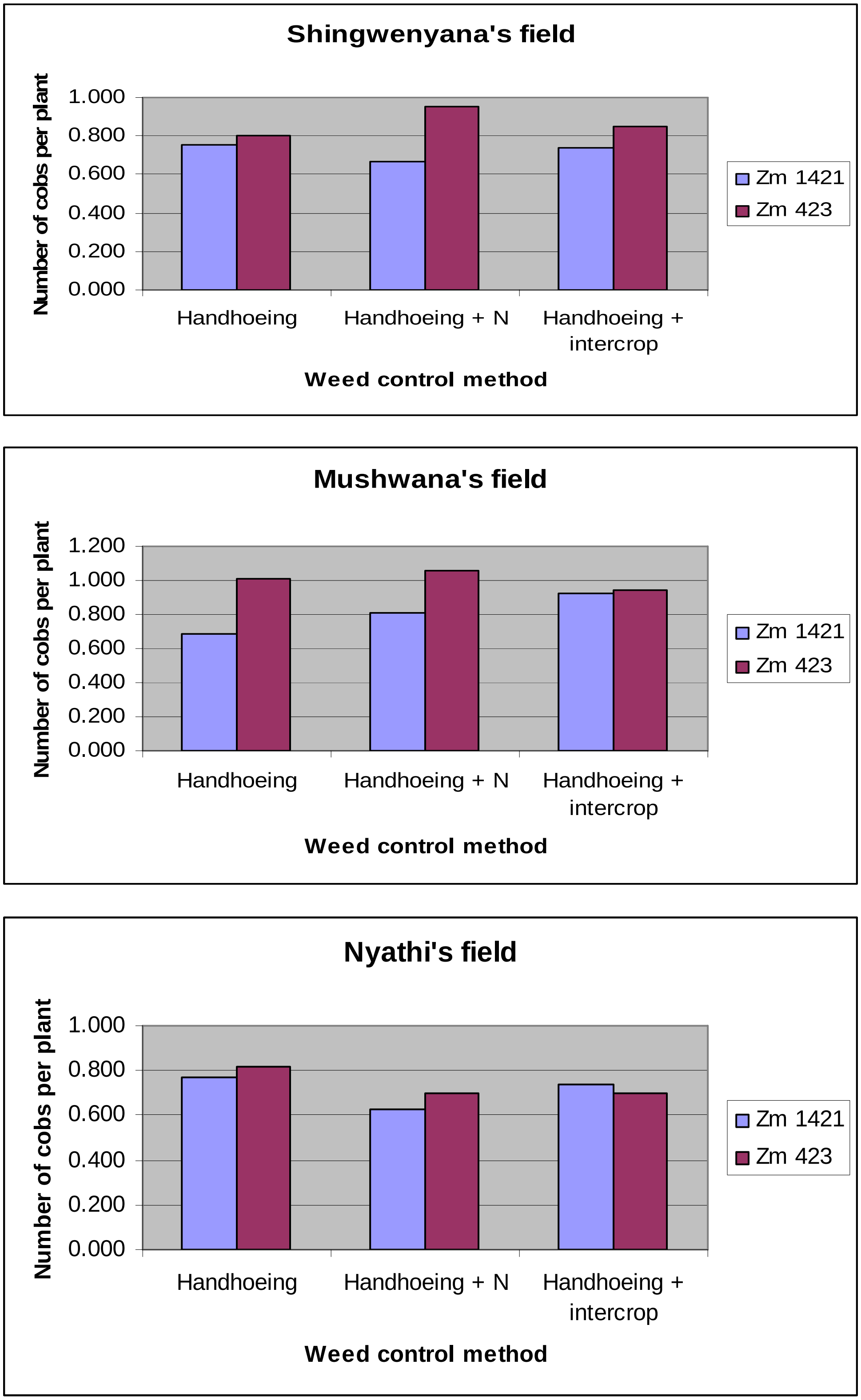

Figure 3.6 Effect of weed control method on the number of cobs per plant among maize varieties for Mafarana fields

3.4 CONCLUSION

After the study the following conclusions were made:

i) Intercropping maize with cowpea was effective in suppressing striga emergence and achieved the highest maize yield, particularly under high striga pressure.

ii) Maize varieties differed considerably in their support for striga numbers.

iii)Hand hoeing plus inorganic fertilizer had the lowest striga numbers, for the well-to-do farmers, timely and adequate application of N must be encouraged.

3.5 RECOMMENDATIONS

i) Future studies must utilize cowpea varieties that have already been evaluated for suppression of striga in maize.

ii) Future studies must also evaluate maize varieties for striga tolerance or resistance for effective striga control as it will be compatible with low cost inputs requirements for small scale farmers.

iii) Wherever possible, future studies must have higher number of replication to improve the precision level.

iv) For well-to-do farmers, timely and adequate application of N must be encouraged.

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5. APPENDICES

Appendix 5.1 Analysis of variance for number of striga plants at Shingwenyana as influenced by variety and weed control methods at 68 DAP

Source	Sum of squares	df	Mean squares	F	5%
rep	0.80	3	0.27	2.02	3.29
Variety	0.28	1	0.28	2.16	4.54
Co.method	1.63	2	0.82	6.20*	3.68
Variety* Co.method	0.01	2	0.01	0.06	3.68
Error	1.97	15	0.13		
Total	4.70	23			

Appendix 5.2 Analysis of variance for number of striga plants at Shingwenyana as influenced by variety and weed control methods at 83 DAP

Source	Sum of squares	df	Mean squares	F	5%	1%
rep	4.74	3	1.58	22.89**	3.29	5.42
Variety	0.21	1	0.21	3.01	4.54	8.68
Co.method	3.01	2	1.51	21.81**	3.68	6.36
Variety* Co.method	0.04	2	0.02	0.32	3.68	6.36
Error	1.04	15	0.07			
Total	9.05	23				

** = significant at 1% level

Appendix 5.3 Analysis of variance for number of striga plants at Nyathi as influenced by variety and weed control methods at 83 DAP

Source	Sum of squares	df	Mean squares	F	5%
Replication	0.80	3	0.27	2.02	3.29
Variety	0.28	1	0.28	2.16	4.54
Co.method	1.63	2	0.82	6.20*	3.68
Variety* Co.method	0.01	2	0.01	0.06	3.68
Error	1.97	15	0.13		
Total	4.70	23			

* = significant at 5% level.

Appendix 5.4 Analysis of variance for number of striga plants at Mushwana as influenced by variety and weed control methods at 83 DAP

Source	Sum of squares	df	Mean squares	F	5%	1%
rep	0.16	3	0.05	0.41	3.29	5.42
Variety	0.44	1	0.44	3.43	4.54	8.68
Co.method	3.75	2	1.88	14.76**	3.68	6.36
Variety* Co.method	0.10	2	0.05	0.38	3.68	6.36
Error	1.91	15	0.13			
Total	6.35	23				

** = significant at 1% level.

Appendix 5.5 Analysis of variance for number of striga plants at Shingwenyana as influenced by variety and weed control methods at 105 DAP

Source	Sum of squares	df	Mean squares	F	5%
rep	0.71	3	0.24	2.83	3.29
Variety	0.16	1	0.16	1.86	4.54
Co.method	0.75	2	0.38	4.49*	3.68
Variety* Co.method	0.03	2	0.01	0.16	3.68
Error	1.26	15	0.08		
Total	2.90	23			

* = significant at 5% level.

Appendix 5.6 Analysis of variance for number of striga plants at Nyathi as influenced by variety and weed control methods at 105 DAP

Source	Sum of squares	df	Mean squares	F	5%	1%
Rep	0.06	3	0.02	1.00	3.29	5.42
Variety	0.35	1	0.35	16.51**	4.54	8.68
Co.method	1.76	2	0.88	42.17**	3.68	6.36
Variety* Co.method	0.10	2	0.05	2.32	3.68	6.36
Error	0.31	15	0.02			
Total	2.58	23				

** = significant at 1% level.

Appendix 5.7 Analysis of variance for number of striga plants at Mushwana as influenced by variety and weed control methods at 105 DAP

Source	Sum of squares	df	Mean squares	F	5%
rep	0.45	3	0.15	1.89	3.29
Variety	0.04	1	0.04	0.46	4.54
Co.method	0.52	2	0.26	3.27	3.68
Variety* Co.method	0.02	2	0.01	0.14	3.68
Error	1.20	15	0.08		
Total	2.23	23			

Appendix 5.8 Analysis of variance for maize grain yield at Shingwenyana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	7.84	3	2.61	3.18	0.05
variety	0.20	1	0.20	0.24	0.63
co.method	3.37	2	1.68	2.05	0.16
variety * co.method	4.02	2	2.01	2.45	0.12
Error	12.32	15	0.82		
Total	27.74	23			

Appendix 5.9 Analysis of variance for maize grain yield at Nyathi as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	0.34	3	0.11	0.24	0.87
variety	0.03	1	0.03	0.06	0.82
co.method	2.91	2	1.45	3.09	0.08
variety * co.method	0.77	2	0.39	0.82	0.46
Error	7.06	15	0.47		
Total	11.10	23			

Appendix 5.10 Analysis of variance for maize grain yield at Mushwana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	37.00	3	12.33	36.22**	0.00
variety	0.11	1	0.11	0.33	0.57
co.method	0.58	2	0.29	0.85	0.45
variety * co.method	0.74	2	0.37	1.08	0.36
Error	5.11	15	0.34		
Total	43.53	23			

** = significant at 1% level

Appendix 5.11 Analysis of variance for shelling % at Shingwenyana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	13.62	3	4.54	3.35*	0.05
variety	0.88	1	0.88	0.65	0.43
co.method	3.89	2	1.95	1.44	0.27
variety * co.method	11.97	2	5.99	4.42*	0.03
Error	20.33	15	1.36		
Total	50.70	23			

* = significant at 5% level.

Appendix 5.12 Analysis of variance for shelling % at Nyathi as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	4.75	3	1.58	0.35	0.79
variety	2.20	1	2.20	0.48	0.50
co.method	18.31	2	9.15	2.00	0.17
variety * co.method	0.46	2	0.23	0.05	0.95
Error	68.81	15	4.59		
Total	94.53	23			

Appendix 5.13 Analysis of variance for shelling % at Mushwana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	48.56	3	16.19	4.32*	0.02
variety	1.73	1	1.73	0.46	0.51
co.method	2.43	2	1.22	0.33	0.73
variety * co.method	1.61	2	0.80	0.21	0.81
Error	56.14	15	3.74		
Total	110.47	23			

* = significant at 5% level.

Appendix 5.14 Analysis of variance for number of plants at Shingwenyana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	36.83	3	12.28	0.78	0.52
variety	0.17	1	0.17	0.01	0.92
co.method	33.58	2	16.79	1.07	0.37
variety * co.method	11.58	2	5.79	0.37	0.70
Error	235.67	15	15.71		
Total	317.83	23			

Appendix 5.15 Analysis of variance for number of plants at Nyathi as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	86.83	3	28.94	0.93	0.45
variety	4.17	1	4.17	0.13	0.72
co.method	2.25	2	1.13	0.04	0.96
variety * co.method	17.58	2	8.79	0.28	0.76
Error	467.67	15	31.18		
Total	578.50	23			

Appendix 5.16 Analysis of variance for number of plants at Mushwana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	11.17	3	3.72	0.31	0.82
variety	32.67	1	32.67	2.71	0.12
co.method	247.58	2	123.79	10.27**	0.00
variety * co.method	23.58	2	11.79	0.98	0.40
Error	180.83	15	12.06		
Total	495.83	23			

** = Significant at 1% level.

Appendix 5.17 Analysis of variance for number of cobs per plant at Shingwenyana as influenced by variety and weed control methods

Source	Sum of squares	df	Mean squares	F	5%
rep	0.063	3	0.02	1.11	4.54
Variety	0.131	1	0.13	6.89*	3.68
Co.method	0.005	2	0.00	0.16	3.68
Variety* Co.method	0.06	2	0.03	1.58	3.29
Error	0.292	15	0.02		
Total	0.551	23			

* = Significant at 5% level.

Appendix 5.18 Analysis of variance for number of cobs per plant at Nyathi as influenced by variety and weed control methods

Source	Sum of squares	df	Mean squares	F	5%
rep	0.232	3	0.08	4.81*	4.54
Variety	0.004	1	0.00	0.25	3.68
Co.method	0.071	2	0.04	2.188	3.68
Variety* Co.method	0.014	2	0.01	0.437	3.29
Error	0.245	15	0.02		
Total	0.566	23			

* = Significant at 5% level.

Appendix 5.19 Analysis of variance for number of cobs per plant at Mushwana as influenced by variety and weed control methods

Source	Sum of squares	df	Mean squares	F	5%	1%
rep	0.028	3	0.01	0.35	4.54	5.42
Variety	0.227	1	0.23	8.73**	3.68	8.68
Co.method	0.040	2	0.02	0.77	3.68	6.36
Variety* Co.method	0.102	2	0.05	1.96	3.29	6.36
Error	0.387	15	0.03			
Total	0.784	23				

** = significant at 1% level.

Appendix 5.20 Analysis of variance for hundred seed weight at Shingwenyana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	25.83	3	8.61	0.85	0.49
variety	4.17	1	4.17	0.41	0.53
co.method	37.33	2	18.67	1.85	0.19
variety * co.method	49.33	2	24.67	2.45	0.12
Error	151.17	15	10.08		
Total	267.83	23			

Appendix 5.21 Analysis of variance for hundred seed weight at Nyathi as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	2.67	3	0.89	0.09	0.97
variety	10.67	1	10.67	1.04	0.32
co.method	32.33	2	16.17	1.58	0.24
variety * co.method	14.33	2	7.17	0.70	0.51
Error	153.33	15	10.22		
Total	213.33	23			

Appendix 5.22 Analysis of variance for hundred seed weight at Mushwana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	227.33	3	75.78	39.65**	0.00
variety	0.00	1	0.00	0.00	1.00
co.method	1.00	2	0.50	0.26	0.77
variety * co.method	1.00	2	0.50	0.26	0.77
Error	28.67	15	1.91		
Total	258.00	23			

** = Significant at 1% level.

Appendix 5.23 Analysis of variance for lodging % at Shingwenyana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	242.41	3	80.80	0.59	0.63
variety	251.29	1	251.29	1.83	0.20
co.method	709.24	2	354.62	2.58	0.11
variety * co.method	766.70	2	383.35	2.79	0.09
Error	2063.86	15	137.59		
Total	4033.50	23			

Appendix 5.24 Analysis of variance for lodging % at Nyathi as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	792.98	3	264.33	1.09	0.38
variety	436.65	1	436.65	1.80	0.20
co.method	629.72	2	314.86	1.30	0.30
variety * co.method	291.66	2	145.83	0.60	0.56
Error	3631.79	15	242.12		
Total	5782.80	23			

Appendix 5.25 Analysis of variance for lodging % at Mushwana as influenced by variety and weed control methods

Source	Sum of Squares	df	Mean Square	F	Sig.
rep	2953.95	3	984.65	5.51**	0.01
variety	244.80	1	244.80	1.37	0.26
co.method	364.99	2	182.49	1.02	0.38
variety * co.method	852.06	2	426.03	2.39	0.13
Error	2678.98	15	178.60		
Total					

** = Significant at 1% level.