TITLE

ADAPTABILITY OF SOYBEAN (*Glycine max* (L). Merr) VARIETIES TO INTERCROPPING UNDER LEAF STRIPPED AND DETASSELLED MAIZE (*Zea mays* L.)

BY

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN CROP SCIENCE

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OCTOBER 2007

ABSTRACT

Intercropping of maize (*Zea mays* L.) and soybean (*Glycine max* (L). Merr) is becoming a common practice among smallholder farmers but soybean is sensitive to shading resulting in yield decline. A research study to evaluate the adaptability of soybean varieties to intercropping under leaf stripped and detasselled maize was conducted at the University of Zimbabwe Farm (Thornpark Farm) during the 2006 /2007 rainy season. The experiment was laid out as a 3 x 3 x 2 factorial with controls in a Randomized Complete Block Design. The three factors were; cropping system (sole maize, maize-soybean intercrop, sole soybean), soybean variety (Storm, Solitaire and Magoye) leaf stripping and detasselling (intact maize, four bottom leaves removed and tassel removed). In the intercrop, two soybean rows were planted between maize rows. Leaf stripping and detasselling was done at 50% silking. Weed counts were taken at 6 and 9 weeks after crop emergence (WACE) and at physiological maturity. Yield and yield components were determined at harvesting. There were significant differences ($P < 0.05$) in the performance of the soybean varieties, Storm had the highest yield (1770 kg/ha) which was not significantly different from Solitaire (1496 kg /ha), but Magoye gave the lowest yield (837 kg/ha), which was different from either Storm or Solitaire. There was a significant difference in performance of soybean varieties under different cropping systems ($P < 0.05$). The soybean varieties performed better as sole crop (1838 kg/ha) than under intercropping (maize (intact)-soybean: 868 kg/ha), maize (leaf stripped and detasselled: 950 kg/ha). Leaf stripping and detasselling and cropping system had no significant effect on 1000-grain weight and grain yield of maize. The Land Equivalent Ratio (LER) values of the various intercropping systems were all greater than 1 indicating the advantages of intercropping. Cropping system, soybean variety and leaf stripping and detasselling had no significant effect on total weed biomass at 6 and 9 WACE but had significant effect on total weed biomass at physiological maturity. Results suggest that intercropping reduces the yield of soybean but there is an advantage of intercropping since the LER values were greater than 1.The soybean crop can be considered as a bonus crop from which a farmer can reap additional financial and nutritional benefits as well as residual soil fertility. The stripped leaves from the maize can be fed to livestock. Magoye is not adaptable to intercropping.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisors Ms I. Mudita and Dr A. B Mashingaidze for their contributions during the course of the study, Mr. D. Icishahayo for assisting me with statistical analysis, my family and friends for their moral and financial support. Above all l would like to thank God for his grace in seeing me through this project.

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CHAPTER ONE

1.0 INTRODUCTION

Intercropping is the growing of two or more crop species simultaneously in the same field during a growing season (Ofori and Stern, 1987). It is mainly practiced by smallholder farmers in Southern Africa. Surveys conducted in 1992-1993 in Chinyika Resettlement Area reported that 42% of the farmers in that area practiced intercropping (Munguri, 1996). The most preferred combination is the cereal-legume intercrops. Cereal staple crops such as maize, sorghum and millets are intercropped with legumes such as cowpea, groundnuts and beans. The promotion of soybean production by the National Soybean Taskforce saw the introduction of soybean as a component crop in maize-legume intercrop systems in Zimbabwe.

Soybean has multiple benefits, which include improved human nutrition, cash generation and biological nitrogen fixation. It possesses a very high nutritional value; it contains 20% oil, 40% high quality protein (as against 7% rice, 12% wheat, 10% maize 20-25% other pulses). Soybean protein is rich in the valuable amino acid lysine (5%) in which most cereals are deficient. It also contains a good amount of minerals, salts and vitamins (Singh, 1983). Intercropping maize and soybean will increase diversity. Other benefits of intercropping include minimization of risk, higher net economic returns, more efficient use of environmental resources such as nutrients, light and water as well as improved soil fertility through addition of nitrogen by fixation and excretion from the component legume (Ofori and Stern, 1987).

Weed suppression has often been found to be greater in intercrops compared to sole crops. Intercropping has the ability to suppress weeds better than a sole crop (Akobundu, 1980). This is likely through rapid canopy closure in the intercropping system as the foliage of component crops overlap to shade the emerging weed seedlings and also a more competitive community of crop plants either in space or time provided by the intercrop compared to the sole crops.

Although intercropping has shown to be advantageous it may lead to reduction in yield of one or more component crops due to adverse competitive effects. Usually the cereal component with relatively higher growth rate, height advantage and a more extensive rooting system is favoured in the competition with the associated legume. The greater yield loss of the minor crop is mainly because of reduced Photosynthetically Active Radiation (PAR) reaching the lower parts of the intercrop canopy, occupied by the minor legume. Intensity and quality of solar radiation intercepted by the canopy are important determinants of yield components and hence yield of soybean since it is sensitive to shading. Light levels during the late flowering to midpod formation stages of growth have been found to be more critical than during vegetative and late reproductive periods in determining the yield of soybean. Any interventions that lead to increased amount of PAR interception by the minor crop has potential to increase the yield of the minor crop and increase productivity of the intercropping system (Mashingaidze, 2004). Nitrogen fixation by the legume is dependent on amount of PAR intercepted by the soybean foliage. This is because the energy required for nitrogen fixation is derived from photosynthesis, which depends on light (Wahua and Miller, 1978). Intercropping has potential to reduce nitrogen fixation by the legume as a result of shading from the cereal. Interventions that will increase PAR penetration into the canopy and therefore photosynthesis has potential to increase nitrogen fixation.

Leaf stripping and detasselling have the potential of improving the penetration of incoming PAR into the canopy to the benefit of the understorey crop. Leaf stripping is the removal of the lower leaves in the canopy late in the season when the leaves are becoming senescent in maize. It has potential of increasing net dry matter accumulation in the plant by removing leaves that are becoming net importers of assimilates instead of net contributors to the plant assimilate supply during grain formation and filling stages of the maize. Removal of these senescent leaves will also increase light penetration to the under storey crop.

Detasselling which is the removal of the tassel also increase light penetration into the canopy, since shortly after pollen shedding the tassels becomes an obstruction to light penetration into the foliage of the canopy below (Edje, 1983). The tassel is an active sink that competes for assimilates with the developing cob therefore its removal will result in more energy and assimilates being channelled to the maize cob. Leaf stripping and detasselling has the potential to increase yields of maize and soybean as well as increasing nitrogen fixation through increasing the amount of PAR penetration into the foliage. The indeterminate variety of soybean, which continues to grow and make maximum utilization of resources when the maize is senescing, is expected to benefit more from this intervention.

Leaf stripping and detasselling have been found to increase the yield of pumpkins in the under storey of maize crop by increasing the amount of PAR reaching the pumpkins during the reproductive stages but this was not so for beans (Mashingaidze, 2004). There is no work that has been done on leaf stripping and detasselling in soybean intercrops. This study aims at determining the suitability of three soybean varieties (Storm, Solitaire and Magoye) to intercropping with leaf stripped and detasselled maize and the effects of leaf stripping and detaselling maize on weed biomass in the maize-soybean intercropping systems.

1.1 Objectives

1. To investigate adaptability of three soybean varieties (Storm, Solitaire, Magoye) for intercropping with leaf stripped and detasselled maize.
2. To determine the effect of leaf stripping and detasselling of maize at anthesis on maize grain yield and productivity of the maize-soybean intercrop.
3. To investigate the effect of leaf stripping and detasselling maize on weed biomass in a maize-soybean intercropping system

1.2 Hypotheses

1. The indeterminate soybean varieties i.e. Solitaire and Magoye will perform better in the intercrop than the determinate variety Storm as they will exploit resources (radiation, moisture, soil nutrients) in the late season when the maize is senescing
2. Leaf stripping and detasselling maize increases maize yield by increasing the dry matter allocated to the developing cob and soybean grain yield through increased radiation penetration into the canopy increasing overall intercrop productivity as measured through LER, the indeterminate soybean varieties will derive more benefit from this intervention
3. Maize-soybean intercrops will reduce weed emergence and growth more than either of the sole component crops.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Intercropping

Intercropping is the growing of two or more crops simultaneously on the same piece of land (Ofori and Stern, 1987). Crop intensification is in both time and space dimensions and there is intercrop competition during all or part of crop life cycle (Andrews and Kassam, 1977). The crops are not necessarily sown at exactly the same time and their harvest time may be different, but are usually simultaneous for a significant part of their growing periods (Willey, 1979). A high degree of interaction between plant species is expected in intercropping system. For best success, the plants to be intercropped must be judiciously selected to reduce intercrop competition. It is best if the crops fill different niches so they can better use resources in the production environment (e.g. include annuals and perennials, shallow and deep rooted plants, legumes and non-legumes) combinations, which represent complementary associations (Acquaah, 2002).

Intercropping has long been recognized as a very common practice throughout the developing tropics especially among resource limited farmers. Cereal-legume combinations are the most common. In Zimbabwe, cereals such as maize, sorghum, millets are intercropped with legumes such as cowpea, beans, groundnuts, soybean as well as cucurbits (pumpkin, squash, gourd and cucumber).

2.1.1 Benefits of Intercropping

The success of intercropping is based on maximizing complementarity and minimizing competition. In intercropping systems there is enhancement of high yields because component crops differ in their way of using growth resources and are able to complement each other (Willey, 1979). Higher yields are obtained due to better use of environmental resources (light, water and nutrients), better weeds, and disease and insect pest control. Better control of weeds is possible where intercropping provides a more competitive community of crop plants either in space or time than sole cropping. Intercrops may be more effective than sole crops in capturing resources from weeds, resulting in reduced weed growth or they could suppress weeds through allelopathy (Liebman and Dyck, 1993). There is also rapid canopy closure in intercropping system as the foliage of the component crops overlap to shade the emerging weed seedlings.

A better soil cover by intercrops protects the soil from erosion. This is because intercrops generally produce a denser continuous canopy cover that reduces raindrop impact on the soil and also reduces the erosive power of wind through strong binding effect of the dense root system. The intercrop may also offer physical support for climbing species. Intercropping provides damage insurance against risk of crop failure of individual species (Francis and Sanders, 1978) and also results in greater gross economic return.

2.1.2 Limitations of Intercropping

Intercropping may lead to reduction in yield of one or more of component crops due to adverse competitive effects (Willey, 1979). Competition is defined as the situation in which two or more plants growing together in the same area seek the same growth factor, which is below their combined demands. Competition between component crops for growth limiting factors is regulated by basic morpho-physiological differences and agronomic factors such as proportion of crops in the mixture, fertilizer applications and relative sowing time. Where component crops are arranged in definite rows the degree of competition is determined by the relative growth rates, growth duration and proximity of roots of the different crops. In cereal-legume intercrops, the cereal component with relatively higher growth rate, height advantage and a more extensive rooting system is favoured in the competition with associated legume. A review by Ofori and Stern, (1987) of 40 published papers showed that the yield of the legume component declined on average by about 52% of the sole crop yield whereas the cereal yield was reduced by only 11%. Thus a general observation is that yields of the legume components are significantly depressed by cereal components in intercropping. The greater yield reduction in the legume companion crop when intercropped with a cereal is attributed to reduced photosynthetically active radiation (PAR) that reaches the lower parts of the maize canopy occupied by the legume crop.

Another limitation of intercropping is often thought to be difficulties concerned with practical management of intercropping especially where there is a high degree of mechanization or where the component crops have different requirements for fertilizer and pesticides (Willey, 1979). These difficulties are typically associated with more developed agriculture as would be found in large scale farms in Zimbabwe.

2.2 Weeds and Intercrops

One of the benefits that have been attributed to intercropping is its ability to suppress weeds better than sole crop (Akobundu, 1980; Enyi, 1973). This is because of the more complete ground cover provided by crop canopy in intercropping systems. Greater weed biomass was measured in sole groundnuts compared to maize-groundnut intra- and inter-row intercrops (Nyakanda, Mashingaidze, Kurambwa, 1995). This was attributed to greater and earlier ground cover in the intercrops compared to the groundnut monocrop. Maize combined with a fast growing prostrate and vining crop such as pumpkins was more efficient in suppressing weeds than groundnuts and bambara nuts (Mashingaidze and Chivinge, 1998).

In order for intercrops to be effective in controlling weeds they must be able to utilize space more effectively than a sole crop. This effectiveness in space utilization depends on crop type, growth habit, seedling vigor, inherent competitiveness of the crop, spatial arrangement of the crop, severity of intercrop competition, moisture and fertility status of the soil and efficiency in resource allocation and utilization by both weeds and crops.

2.3 Effects of Shading on Soybean Yield and N-fixation

Environmental conditions prevailing during the growth periods, especially intensity and quality of solar radiation intercepted by the canopy are important determinants of yield components and hence the yield of soybean (Mathew, Herbert, Shuhuan, Rautenkranz and Litchfield, 2000). Hardman and Brun (1971) proposed that the yield of soybean is controlled by the availability of photosynthates during post-flowering stage of development. Schou, Jeffers and Streeter, (1978) observed that light levels during late flowering to mid pod formation stages of growth are critical than during the vegetative and late reproductive periods in determining the yield of soybean. Pod abortion caused by lack of photosynthate supply late in the growing period is a major factor-limiting yield of soybean. In an experiment by Jiang and Egli (1993), shade imposed from first flower to early pod fill reduced flower production and increased flower and pod abscission, resulting in reduced pod number and yield. Canopy photosynthesis during flowering and pod set has been found to be an important determinant of seeds m-^{2}, and that the impact of shading on seed m^{-2} depends on duration of shading. Therefore pod number per plant is the most important component responsible for differences in soybean yield. Shading (49-20% of ambient light) has been found to result in lengthening of internodes and increased lodging in soybean plants which results in yield reduction. Light enrichment has been found to increase pod number per plant (Mathew et al., 2000). Shading by the cereal reduces both seed yield and the N-fixation potential of the companion legume (Wahua and Miller, 1978). The energy for nitrogen fixation is derived from photosynthesis, which depends on light. Studies by Wahua and Miller (1978) showed that the nodule activity (TNA) of soybean intercropped with tall sorghum variety was reduced by about 99%. This was due to reduction in all components of nodule activity (CAN): number of nodules per plant 77%, weight per nodule 50% and specific nodule activity (SNA) 96%. In another experiment where sorghum was intercropped with groundnut, partial defoliation of sorghum increased the amount of light for the associated legume and enhanced N-fixation.

2.4 Manipulation of Plant Architecture to Influence Productivity of Intercrops

Canopy architecture describes the space occupation by the plants above the ground (Ross, 1981). The amount of light intercepted by the component crop in an intercrop system depends on the geometry of the crop and foliage architecture. Development of a crop canopy that encourages sufficient light utilization is a major means of enhancing the productivity and efficiency of intercrops. This can be achieved through physical means and selection of plant varieties that promote efficient use of light.

Physical modification of crop canopies can be achieved through leaf stripping and detasselling. Leaf stripping is the removal of lower leaves from the maize plant at anthesis or post- anthesis (Subedi, 1996). Photosynthesis occurs in the leaf and the leaf is the source of photoassimilates from which partitioning occurs to the sink that are proximal to this source and which shows the highest sink demand. In maize upper leaves export principally to the shoot apex. The ear is located in the middle of the stem and almost all assimilates produced are from leaves or sheaths nears the ear (Gardner, Pearce and Mitchell, 1985). During grain filling the upper leaves distribute about 85% of their assimilates to the ear. Lower leaves contribute to root growth, stem and leaf maintenance as well as to ear weight. A fully expanded leaf under conducive environmental conditions for photosynthesis may export 60-80% of the total assimilates it produces to other parts of the plant. With time the leaves undergo senescence and in grasses this begins at the lower older leaves and progresses up the plant. As the leaf senesce it may fail to support its own energy requirements because of a net reduction in net photosynthesis and shading. Contribution of assimilates from bottom leaves decline progressively with senescence (Gardner *et al*., 1985) and possibly become net importer of assimilate from other parts of the plant in competition with the developing maize embryos and grain filling. In studies done by Mudita (2000), Tembani (2002) and Mashingaidze (2004) showed that leaf stripping results in increased maize yield. Leaf stripping also resulted in doubling of percentage incoming PAR reaching the pumpkin foliage from 10% to 20% and eventually increased pumpkin fruit yield (Mashingaidze, 2004).

Detasselling is the removal of the male inflorescence (tassel) in maize soon after its emergence. In the vegetative phase maize leaves are the primary interceptors of radiation but on initiation of the reproductive phase, the tassel establishes a layer of light intercepting substance above the foliage canopy (William, Looms, Duncan, Dovert and Nunez, 1968). The function of the tassel is to shed pollen a few days after its emergence near the end of the vegetative phase. After this the tassel structure remains on the plant and will be an obstruction to free penetration of light into the foliage canopy below. From work by Mashingaidze (2004) detasselling resulted in 5% increase in the amount of PAR reaching the pumpkin foliage. The tassel is also a strong competitive sink for assimilates high in plant nutrients. Detasselling results in yield increases as more energy and assimilates are channelled to the maize cob resulting in less barren and larger cobs (Edje, 1983). The tassel is the centre for the production of indole-acetic acid (IAA) a hormone that mediates the partitioning of photoassimilates in favour of the apex over the other sinks. Removal of the tassel will reduce apical dominance effect on maize. Overally leaf stripping and detasselling will improve the penetration of PAR into the canopy to the benefit of the dominated minor crop and dominant cereal.

2.5 Land Equivalent Ratio (LER)

Land equivalent ratio (LER) is the ratio of the area needed under sole cropping to the one under intercropping to give equal amounts of yield at the same management level. As an index of combined yield, LER provides a quantitative evaluation of the yield advantage due to intercropping (Willey, 1979). Although component crops may give varying yields, the estimate of relative yields with sole crops at optimum or recommended densities as references gives comparable scales for both component crops allowing comparisons of various crop combinations (Ofori and Stern, 1987). Chetty and Reddy (1984) proposed that LER could be used either as an index of biological efficiency to evaluate the effects of various agronomic variables for example fertility levels, densities, comparison of cultivar performance and relative time of sowing on an intercrop system in a locality or as an index of productivity across geographic locations to compare a variety of intercrop systems.

Willey (1979) suggested that LER can be used for any set of intercropping treatments and that the partial LER values give an indication of the relative competitive abilities of component crops. Species with higher partial LERs are considered to be more competitive for growth limiting factors than the species with lower partial LERs. The disadvantage of LER is that it is based on land area only and does not take into account the duration of component crops. However, crop production is a function of both temporal and spatial effects because land occupancy by a given intercrop system is frequently of longer duration than sole crops (Ofori and Stern, 1987).

LER is calculated as; LER= $\frac{Yij}{Yii} + \frac{Yji}{Yjj}$

Where;

Y - yield per unit area

Yii - sole crop yield of crop i

Yjj - sole crop yield of crop j

Yij - intercrop yield of i when grown in association with crop j

Yji - intercrop yield j when grown in association with crop i

Result interpretation: If

LER=1 - no difference in yield between intercropping and monocropping

LER<1 - yield disadvantage in intercropping compared to monocropping

LER>1 - yield advantage in intercropping compared to monocropping

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Research Site

The studies were carried out at Thornpark Farm in the 2006/07 season, which lies in Mazowe district in Mashonaland Central Province of Zimbabwe. Thornpark Farm lies at $31^{o}10^{"}$ East and 18^{o} $25^{"}$ South. The farm is in a reliable cropping area with 576 rainy pentads being recorded over a 30-year period. This compares with 600-647 pentads in the best cropping areas in Zimbabwe. The farm is in Natural Farming Region IIa, which is in an area of high agricultural potential. Annual average rainfall ranges from 444mm to 1270mm. The mean annual temperature is 19^{o}C (Kwela, 1998).

The highest point on the farm is 1480 metres above sea level (masl) with a fall of 60 metres to the lowest point. The arable lands are flat with slopes of 2% or less. The farm consists of deep to moderately deep well drained granular clay soils derived from epidiorite with some intrusions of banded ironstone. Soil colour changes from red in the well-drained areas to grey and black in the vleis. The soils at the farm are classified in Zimbabwe as Harare 5E.2 [Tyoic or Kandic Rhodulstulf (U.S.D.A) Taxonomy]. The soils are described as Chronic Luvisols using the F.A.O classification (Nyamapfene, 1991)

3.2 Trial Management

3.2.1 Description of varieties used in the experiment

SC513

SC513 is a white dent early maturing maize hybrid, which takes about 130 days to reach physiological maturity. It has good tolerance to Grey Leaf Spot. SC513 has a relatively high yield potential of 4 to 8 t/ha. It has a relatively high ear placement and is slightly susceptible to root lodging when planted at high population. SC513 has semi-erectophile leaf architecture (Seed Co, 2002).

Storm

Storm is a short determinate soybean variety, which can grow up to 79 cm in height. It is resistant to most leaf diseases but susceptible to Soybean Rust (*Phakospora pachyrhizi*). Storm has good agronomic characteristics such as short stature, good pod clearance, good lodging resistance and a long shatter-free period (Seed-Co, 2002). The variety is suitable to all areas of the country. In the lowveld (altitude 400 to 800 masl) the variety takes 115 days to 95% maturity, in the middleveld and the highveld it takes 120 and 125 days to 95% maturity respectively (Seed Co, 2001).

Solitaire

Solitaire is an indeterminate variety which can grow up to 95 cm in height and is suitable in middleveld (800 to 1200 masl) where it takes 120 days to 95% maturity and in the highveld (over 1200 masl) where it takes 125 days to 95% maturity (Seed Co, 2001).

Magoye

Magoye is a tall indeterminate and hay type variety. The variety is late maturing taking over 150 days to maturity and hence does well in areas of high rainfall potential. It is a promiscuously nodulating variety that can nodulate with natural strains of *Rhizobium* which occur in soil.

3.2.2 Field Operations

The land was disc ploughed and disc harrowed to a fine tilth. Plots measuring 4.5 x 5.4 m were marked just before planting. Pathways measuring 1.5 m were left between the plots Planting was done on the 19th of December 2006. Planting furrows 0.9 m apart were opened using hoes and a basal fertiliser Compound D (8%N, 14%P_2O_5, 7%K_2O) was applied in the furrows at 300 kg ha^{-1}. The maize was planted at a spacing of 0.9 m x 0.3 m and two maize pips were planted per station. Thinning to one plant per station was done at 3 weeks after crop emergence (WACE). The maize was top dressed with ammonium nitrate (34.5%N) at a rate of 250 kg ha^{-1} at 5 WACE. Maize stalk borer (*Busceola fusca*) was controlled using Dipterex at 6WACE. Management practices were the same for both the maize monocrop and the maize-soybean intercrop.

Leaf stripping and detasselling was carried out at 50% silking (when 50% of the maize plants had produced silks). This procedure was carried out by pulling and detaching four lowest leaves that were green from the junction of the stem and the sheath, at 50% silking (anthesis). Detasselling was done by pulling the tassel stalk upwards until the tassel emerged out of the funnel, without damaging any sub-tassel leaves.

The soybean crop was planted in furrows 0.45 m apart in the monocrop. Two soybean rows were planted between two rows of maize spaced at 0.3 m apart and 0.3 m from the maize row. The soybean was inoculated using *Rhizobium* dribbled in the furrows and covered using hoes. Soybean was thinned to 0.07 m at 3 WACE. Irrigation was used to supplement rainfall.

3.3 Experimental Design and Treatments

The experiment was set up as a 3 x 3 x 2 factorial with controls in a randomised complete block design to test the effect of soybean variety, leaf stripping and detasselling and cropping system on total yield and yield components of maize and soybean and weed density and biomass. Factor one was soybean variety with three levels (Storm, Solitaire, Magoye). Factor two was cropping system with three levels (sole maize, maize-soybean intercrop and sole soybean). Factor three was leaf stripping and detasselling with two levels (four bottom leaves removed and tassel removed, maize intact). This resulted in eleven treatment combinations that were randomly assigned to plots. All plots were weeded at 3, 6 and 9 WACE. Leaf stripping and detasselling was done as per treatment at 50% anthesis

Table 3.1: Treatment combinations of soybean variety, cropping system and leaf stripping and detasselling

Treatment number	Treatment details
1	Sole Storm
2	Sole Solitaire
3	Sole Magoye
4	Sole maize intact
5	Sole maize leaf stripped and detasselled
6	Storm-maize intercrop- maize intact
7	Storm-maize intercrop-maize leaf stripped and detasselled
8	Solitaire-maize intercrop-maize intact
9	Solitaire-maize intercrop-maize leaf stripped and detasselled
10	Magoye-maize intercrop-maize intact
11	Magoye-maize intercrop-maize leaf stripped and detasselled

3.4 Measurements

3.4.1 Maize yield

Maize was harvested from a net plot of 8.91 m^2. The grain moisture content was determined using a moisture meter and grain yield adjusted to 12% moisture content using the following formula.

$$\textbf{Adjusted yield} = \textbf{Measured yield} \ \frac{\textbf{(100- sample moisture content)}}{\textbf{(100- standard moisture content)}}$$

3.4.2 Soybean yield

The soybean was hand harvested when both the pods and stems were dry from a net plot of 8.91 m^2. The soybean grain moisture was determined using a moisture meter. The grain yield was adjusted to 11% moisture content using the same formula as used for maize.

3.4.3 Yield components

A sample of five randomly selected soybean plants in the net plot was used to determine yield components and these were pods plant^{-1}, seeds plant^{-1} and thousand-grain weight. For maize 1000-grain weight was determined.

3.4.4 Weed density and biomass

Weed density and biomass measurements were done at 6, 9 WACE and at physiological maturity. A 30 cm x 30 cm quadrant was randomly thrown in each plot three times and weeds within the quadrants counted. Weeds were uprooted, shaken off the soil and placed in khaki paper bags then dried at 80^{o}C for 48 hours and weighed to obtain the biomass, which was expressed in g m^{-1}. Weed density was also expressed on a square meter basis.

3.5 Data Analysis

Analysis of variance was carried out using Genstat 6.1 statistical package. Where treatment means were significantly different, mean separation was done using least significance difference ($LSD_{0.05}$). All weed count data was square root transformed and the weed biomass log (X) transformed before analysis of variance. An analysis of total weed biomass and density over time was also carried out. Intercrop productivity was assessed by calculating Land Equivalent Ratios (LER) from component crop yields (Mead and Willey, 1980).

CHAPTER FOUR

4.0 RESULTS

4.1 Rainfall received at Thornpark Farm during 2006/07 cropping season

Figure 4.1 shows the total rainfall received at Thornpark Farm between September 2006 and May 2007 and its distribution. The total rainfall received was about 540 mm, and was poorly distributed and the length of the season rather short.

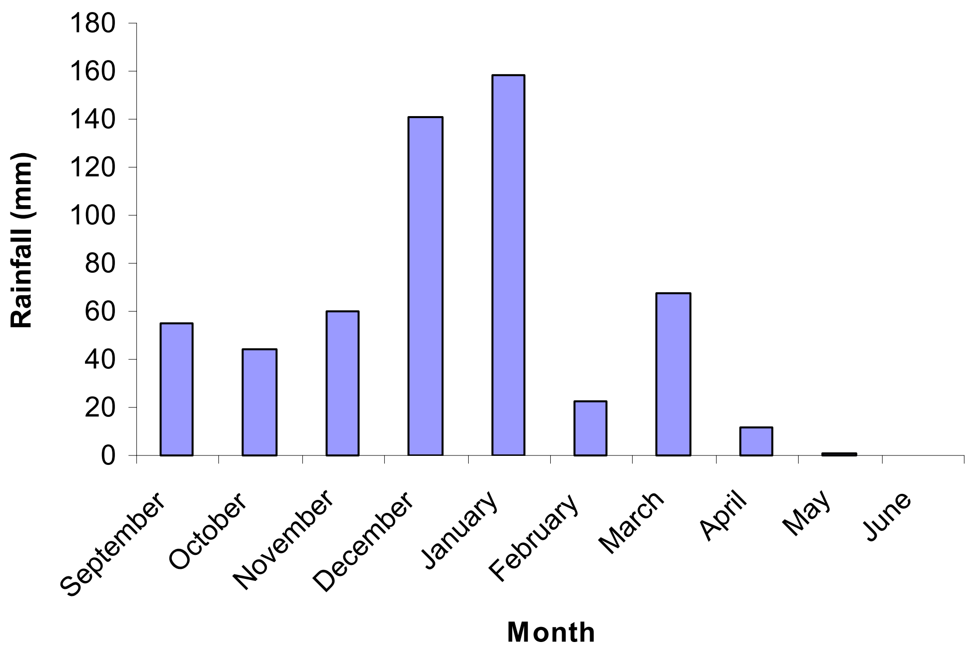

Figure 4. 1:Monthly rainfall (mm) for Thornpark Farm in 2006/07 season

4.2 Effects of soybean variety on grain yield and yield components of soybean

There were significant differences in number of pods per plant ($P < 0.001$), number of grains per plant ($P = 0.015$), 1000-grain weight ($P < 0.001$) as well as grain yield ($P < 0.001$) of soybean varieties. Magoye had the highest number of pods per plant and number of grains per plant and was significantly different from storm and solitaire. Storm and solitaire had similar number of pods per plant and number of grains per plant. There were significant differences in 1000-grain weight, an indicator of size of grain and extent of grain filling across the varieties. Solitaire had the highest 1000-grain weight (209.7g) followed by Storm (166.3g) then Magoye (123.6g) (Table 4.1).

Table 4.1: Effects of soybean variety on grain yield and yield components of soybean

Variety	No of pod/plant	No of grain/plant	1000grain weight (g)	Grain yield (Kg ha^{-1})
Storm	18.5^a	38.2^a	166.3^b	1770^b
Solitaire	18.2^a	34.5^a	209.7^c	1496^b
Magoye	28.9^b	52.9^b	123.6^a	837^a
P value	<0.001	0.015	<0.001	<0.001
$LSD_{0.05}$	5.35	12.62	14.94	325.4
CV (%)	29	35.80	10.60	28.20

Means followed by the same letter in a column are not significantly different at $P \leq 0.05$

There were significant differences in grain yield of the different soybean varieties. Magoye had the lowest grain yield (837 kg ha^{-1}), which was significantly different from Storm (1770 kg ha^{-1}) and Solitaire (1496 kg ha^{-1}). There were no significant differences between Storm and Solitaire.

4.3: Effects of cropping systems on soybean grain yield and yield components in maize-soybean intercrops

Cropping system had no significant effect on number of grains per plant and 1000-grain weight of soybean. However, cropping system had significant effect on the number of pods per plant ($P < 0.05$). Sole soybean had the highest pod numbers per plant compared to soybean intercropped with either leaf stripped and detasselled maize or intact maize. There were no significant differences in pod numbers between soybean in leaf stripped and detasselled maize and intact maize. Cropping system had significant effect on the grain yield of soybean ($P < 0.05$). Sole soybean had the highest yield of 2062 kg ha^{-1} which was significantly different from the yield in either soybean intercropped with leaf stripped and detasselled maize or intact maize with mean yields of 1066kgha^{-1} and 975kgha^{-1} respectively (Table 4.2).

Table 4.2: Effects of cropping systems on soybean grain yield and yield components in maize-soybean intercrops

Cropping system	No of pod/plant	No of grain/plant	1000grain weight (g)	Grain yield (Kg ha^{-1})
Sole soybean	25.8^{b}	46.3	162	2062^{b}
Maize-soybean (Intact)	19.4^{a}	40	165.2	975^{a}
Maize-soybean (Lsdetass)	20.4^{a}	46	172.4	1066^{a}
P value	0.047	0.468	0.352	<0.001
$LSD_{0.05}$	5.35	NS	NS	325.4
CV (%)	29	35.80	10.60	28.20

Means followed by the same letter in a column are not significantly different at $P \leq 0.05$
Lsdetass - Leaf stripped and detasselled
NS - Not significant
Grain yield in leaf stripped and detasselled maize was the same as in intact maize.

4.4: Effects of cropping system, soybean variety and leaf stripping and detasselling on the soybean grain yield and yield components of soybean

There were significant differences in the number of pods per plant (P = 0.003), 1000-grain weight (P < 0.001) and the grain yield (P < 0.001) of soybean due to the different treatments. The pure stands of soybean had higher number pods per plant compared to those of soybean intercropped with either leaf stripped and detasselled or intact maize. Magoye had the highest number of pods per plant with a mean of 33.6 in the sole and 28.5 where it was intercropped with intact maize and 24.7 in leaf stripped and detasselled maize. Sole storm had the highest number of pods per plant followed by where it was intercropped with maize leaf stripped and detasselled and then maize intact. For solitaire the highest pod number was in treatment with sole solitaire but for solitaire intercropped with either leaf stripped and detasselled maize or intact maize the number of pods per plant were the same (Table 4.3). There were no significant differences in the number of grains per plant across the different treatments (P>0.05). There were significant differences in 1000-grain weight across the three soybean varieties. Magoye had the lowest 1000-grain weight as a pure stand as well as when intercropped with either leaf stripped and detasselled or intact maize. Solitaire had the highest 1000-grain weight 227.8g and Solitaire intercropped with leaf stripped and detasselled maize was significantly different from the sole solitaire and solitaire intercropped with intact maize.

There were significant differences in the grain yield of soybean due to variety and cropping system. The pure stands had higher yields compared to the intercrops. For example sole Magoye (1457 kg ha^{-1}), Magoye-maize intact (602 kg ha^{-1}) and Magoye-maize leaf stripped and detasselled (452kg ha^{-1}). There were no significant differences in the grain yield of Storm and Solitaire in the intercrops. Magoye had the lowest grain yield (1457 kg ha^{-1}) in the pure stand when compared with Storm (2583 kg ha^{-1}) and Solitaire (2147 kg ha^{-1}) as pure stands as well as when it was intercropped with either leaf stripped and detasselled or intact maize (Table 4.3).

Table 4.3: Effects of cropping system, soybean variety and leaf stripping and detasselling on the soybean grain yield and yield components of soybean

Treatment	No of pod/plant	No of grain/plant	1000grain weight (g)	Grain yield (Kg)
Sole Storm	24.5b^{cd}	48.6	165.1^{b}	2583^{d}
Sole Solitaire	19.4^{abc}	33.8	200.1^{c}	2147^{d}
Sole Magoye	33.6^{d}	56.5	120.8^{a}	1457^{c}
Storm-maize (Intact)	12.2^{a}	27.2	164.7^{b}	1263^{c}
Storm-maize (Lsdetass)	19^{b}	38.9	169.1^{b}	1464^{c}
Solitaire-maize (Intact)	17.6^{a}	36.8	201.3^{c}	1059^{bc}
Solitaire-maize (Lsdetass)	17.7^{a}	33.1	227.8^{d}	1283^{c}
Magoye-maize (Intact)	28.5^{cd}	56.1	129.7^{a}	602^{ab}
Magoye-maize (Lsdetass))	24.7^{bcd}	46	120.4^{a}	452^{a}
P value	0.003	0.101	<0.001	<0.001
$LSD_{0.05}$	9.27	NS	25.88	563.6
CV (%)	29	35.8	10.6	28.2

Means followed by the same letter in a column are not significantly different at $P \leq 0.05$
Lsdetass - Leaf stripped and detasselled
NS - Not significant

4.5: Effects of cropping system on 1000-grain weight and grain yield of maize

Cropping system had no significant effect on 1000-grain weight and grain yield ($P > 0.05$) of maize (Table 4.4).

Table 4. 4: Effects of cropping on 1000-grain weight and grain yield of maize

Cropping system	1000grain weight (g)	Grain yield (Kg)
Sole maize	327.2	5769
Maize-Storm	314.6	4983
Maize -Solitaire	302	5199
Maize-Magoye	314.7	5431
P value	0.424	0.24
$LSD_{0.05}$	NS	NS
CV (%)	9.40	14.50

Means followed by the same letter in a column are not significantly different at $P \leq 0.05$
NS - Not significant

4.6: Effects of leaf stripping and detasselling on 1000-grain weight and grain yield of maize

There were no significant differences in 1000-grain weight ($P > 0.05$) and the grain yield ($P > 0.05$) of maize due to leaf stripping and detasselling (Table 4.5).

Table 4. 5: Effects of leaf stripping and detasselling on 1000-grain weight and grain yield of maize

Leaf stripping and detasselling	1000grain weight (g)	Grain yield (Kg)
Intact maize	312.3	5519
Leaf stripped and detasselled Maize	316.9	5172
P value	0.665	0.219
$LSD_{0.05}$	NS	NS
CV (%)	9.40	14.50

Means followed by the same letter in a column are not significantly different at $P \leq 0.05$
NS - Not significant

Table 4.6: Effects of cropping system, soybean variety and leaf stripping and detasselling on 1000-grain weight and yield of maize

Treatment	1000grain weight (g)	Grain yield (Kg)
Sole maize intact	337.8	6302
Sole maize Lsdetass	316.7	5236
Maize-Storm (Intact)	314.3	4847
Maize- Storm (Lsdetass)	314.8	5120
Maize-Solitaire (Intact)	298.1	5118
Maize-Solitaire (Lsdetass)	305.9	5281
Maize-Magoye (Intact)	317.5	5809
Maize-Magoye (Lsdetass))	311	5053
P value	0.754	0.216
$LSD_{0.05}$	NS	NS
CV (%)	9.4	14.5

Means followed by the same letter in a column are not significantly different at P≤0.05
Lsdetass - Leaf stripped and detasselled
NS - Not significant

4.7: Effects of cropping system, soybean variety and leaf stripping and detasselling on 1000-grain weight and yield of maize

1000-grain weight and grain yield of maize was not significantly influenced by cropping system and leaf stripping and detasselling (P>0.05).

4.8: Productivity of maize-soybean intercrops

The productivity of maize-soybean intercropping system with leaf stripping and detasselling was assessed through comparisons of Land Equivalent Ratios of the treatment combinations (Table 4.7).

Table 4.7: Land Equivalent Ratio (LER) analysis of treatment combinations in a maize-soybean intercropping experiment

Treatment	Maize Yield kg/ha	Maize Partial LER	Soybean Yield kg/ha	Soybean Partial LER	LER
Sole maize intact	6302	1.00	-	-	1.00
Sole maize leaf stripped and detasselled	5236	0.8308	-	-	0.8308
Maize-Storm (intact)	4847	0.7691	1263	0.489	1.2581
Maize-Storm (leaf stripped and detasselled	5120	0.8124	1464	0.5668	1.3792
Maize-Solitaire (intact)	5118	0.8121	1059	0.4932	1.3053
Maize- Solitaire (leaf stripped and detasselled	5281	0.838	1283	0.5976	1.4356
Maize- Magoye (intact)	5809	0.9218	602	0.4132	1.335
Maize- Magoye (leaf stripped and detasselled)	5053	0.8018	452	0.3102	1.112
Sole Storm	-	-	2583	1.00	1.00
Sole Solitaire	-	-	2147	1.00	1.00
Sole Magoye	-	-	1457	1.00	1.00

Lsdetass - leaf stripped and detasselled

The partial LERs for maize in a maize soybean intercrop were based on unstripped intact sole maize. The partial LERs for both maize and soybean were all less than 1.00. However, the LERs for the various maize/ soybean intercrops were all greater than 1.00 and thus better than the sole crops. Partial LER values for soybean were generally lower than the partial LERs for maize. Generally the leaf stripped and detasselled treatments had slightly higher LER values for both Storm and Solitaire compared to the intercrops with intact maize except for Magoye-maize intercrops. Solitaire-maize (maize leaf stripped and detasselled) had the highest LER, 1.456 followed by Storm-maize (maize leaf stripped and detasselled) with an LER value of 1.379 (Table 4.7). The lowest LER was obtained in treatment with sole maize leaf stripped and detasselled with LER value of 0.8308.

4.9: Effects of cropping system, soybean variety and leaf stripping and detasselling on total weed density

There were no significant differences P > 0.05 in the total number of weeds at 6 and 9 WACE as well as at physiological maturity.

Table 4.8: Effects of cropping system, soybean variety and leaf stripping and detasselling on total weed density

Treatment	6 WACE	9 WACE	Physiological maturity
Sole Storm	15.88	7.5	7.12
Sole Solitaire	14.69	8.94	5.56
Sole Magoye	14.67	8.43	5.7
Sole maize intact	10.49	8.63	6.73
Sole maize leaf stripped and detasselled	15.6	9.38	6.92
Maize-Storm (intact)	15.27	7.43	6.75
Maize-Storm (leaf stripped and detasselled	18.09	8.43	7.6
Maize-Solitaire (intact)	15.62	9.03	5.69
Maize- Solitaire (leaf stripped and detasselled	12.58	8.15	5.85
Maize- Magoye (intact)	18.38	8.0	5.86
Maize- Magoye (leaf stripped and detasselled)	14.64	7.56	4.85
P value	0.198	0.095	0.796
$LSD_{0.05}$	NS	NS	NS
CV (%)	24.20	11.40	34.20

Means followed by the same letter in a column are not significantly different at P≤0.05
Lsdetass -Leaf stripped and detasselled
NS -Not significant

There was a decrease in the total densities of weeds from 6 WACE to physiological maturity (Figure 4.2).

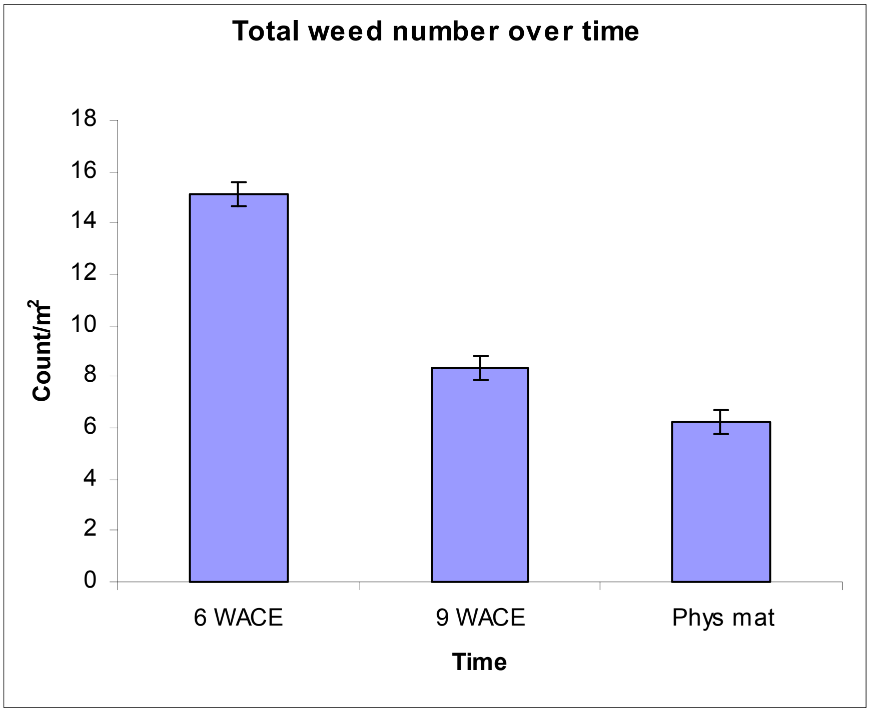

Figure 4. 2: Total weed density with time

4.10: Effects of cropping, soybean variety and leaf stripping and detasselling on total weed biomass

There were no significant differences in the total weed biomass at 6 and 9 WACE ($P > 0.05$) but at physiological maturity the total weed biomass differed across the treatments $P<0.05$.

Table 4.9: Effects of cropping system, soybean variety and leaf stripping and detasselling on total weed biomass

Treatment	6 WACE	9 WACE	Physiological maturity
Sole Storm	0.846	0.953	0.523[c]
Sole Solitaire	0.854	0.857	0.611[c]
Sole Magoye	0.799	0.825	0.305[a]
Sole maize intact	1.106	0.950	0.331[ab]
Sole maize leaf stripped and detasselled	0.865	1.043	0.618[c]
Maize-Storm (intact)	0.738	1.225	0.424[bc]
Maize-Storm (leaf stripped and detasselled	0.887	1.023	0.590[c]
Maize-Solitaire (intact)	0.872	0.776	0.396[ab]
Maize- Solitaire (leaf stripped and detasselled	0.897	1.274	0.304[a]
Maize- Magoye (intact)	0.984	0.958	0.568[c]
Maize- Magoye (leaf stripped and detasselled)	0.784	0.862	0.345[ab]
P value	0.954	0.542	0.029
$LSD_{0.05}$	NS	NS	NS
CV (%)	38.1	34.0	35.9

Means followed by the same letter in a column are not significantly different at P≤0.05
Lsdetass stands for leaf stripped and detasselled

The highest biomass was obtained in sole solitaire 0.611g and it was not significantly different from sole Storm but was significantly different from sole Magoye, sole maize intact, maize-Solitaire (intact), maize-Solitaire (leaf stripped and detasselled) and Magoye leaf stripped and detasselled). The lowest weed biomass was obtained in maize-solitaire intercrop (leaf stripped and detasselled).

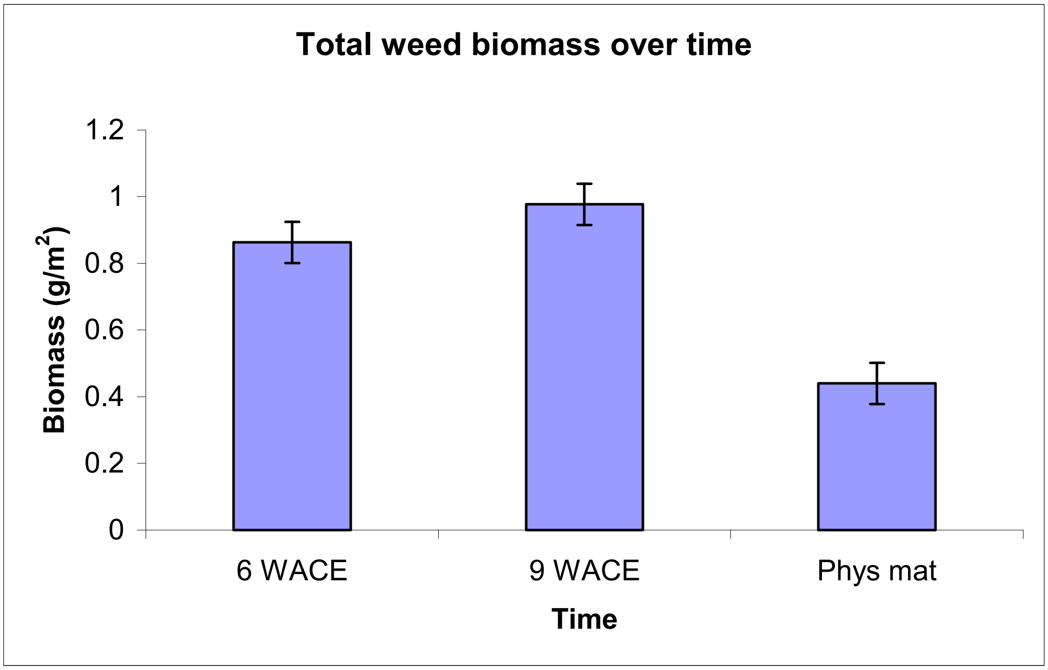

Figure 4. 3: Total weed biomass with time

Generally there was a drop in the total weed biomass from 6 WACE to physiological maturity but there was an increase in total weed biomass at 9 WACE

CHAPTER FIVE

5.0 DISCUSSION

5.1 Soybean yield components and grain yield

Grain yield components for Storm, Solitaire and Magoye were relatively higher in the monocrops compared to the intercrops probably due to a higher degree of interspecific competition in the intercrops and also as a result of the shading effect imposed by the tall maize plants. The intensity and quality of solar radiation intercepted by the canopy are important determinants of yield components and hence yield of soybean (Jomol, Stephe, Shuhuan, Andreas and Gerald, 2000). Since the amount of PAR reaching the soybean in the intercrops is reduced it implies that photosynthesis is also reduced. Hardman and Brun (1971) proposed that the yield of soybean is controlled by the availability of photosynthates so if the availability of photosynthates is reduced the yield will eventually be reduced.

Magoye of the three varieties used in the experiment suffered the greatest depression in yield. This may be due to the combined effects of the short rainy season experienced, shading as well as lodging. From the results (Table 4.3) Magoye had the highest number of pods per plant and number of grains per plant but it had the least 1000- grain weight and grain yield, this maybe because the pods that had set had no grain and the grain that had formed did not complete the grain filling process. Most of the Magoye seeds were shrivelled. This can be attributed to the fact that Magoye is a long season variety and because the rainy season was rather short (Figure 3.1) it did not reach full maturity. Storm and Solitaire had the same higher number of pods per plant and grains per plant.

Leaf stripping and detasselling had no effect on soybean yield and its yield components, which agree with results, obtained by Mashingaidze, (2004) on leaf stripping and detasselling and maize-bean intercrop. This may be because the light increases were not substantial enough to cause significant yield increases in soybean.

Magoye was more likely to have exhibited greater yield benefits from leaf stripping and detasselling if it had not lodged since it continues to grow and make full use of the PAR penetrating the understorey.

5.2 Maize yield

From the results the yields of maize in the sole crops were similar to those in the intercrops. There were neither yield gains nor yield decline. The results of this study also agree with the findings of Chandel, Singh and Saxena, (1987) and Mudita (2002). The yield of maize was not affected by intercropping but soybean yield was reduced by 55% to 60% (Chandel, Singh and Saxena 1987). Mutungamiri, (1999), also concluded that intercropping has no negative impact if maize population is not reduced below 37 000 plants/ha. In intercrops usually the cereal has a competitive advantage since they are tall and benefits from maximum PAR reaching the foliage and hence they may not experience yield declines. In other studies done yield declines of 11% by Ofori and Stern (1987), 15% decline by Silwana and Lucas (2002) 12-22% declines by Mashingaidze (2004).

Maize in the pure stands and in intercrops yielded equally the same. The fact that there was no yield increase in maize yields as a result of intercropping with soybean indicates that it is unlikely that soybean can provide a nitrogen advantage to associated crops within an intercropping system in the same season. Giller (2001), reported that there is little evidence for direct transfer of significant amounts of nitrogen between roots of legumes and cereals in mixture. The nitrogen advantage would benefit the proceeding crop after harvesting the legume (Mpepereki and Giller, 1998).

There was no reduction in maize yield due to intercropping which is probably because of lack of competition between the maize and soybean. The two crops extracted nutrients from different zones in the soil profile since they have different rooting depths so competition for nutrients could have been minimal or non-existent. The plant densities were not high enough to result in competition between the maize and soybean.

There was no yield increases as a result of leaf stripping and detasselling. This is maybe because the maize did not fully benefit from this intervention as a result of the poor season that was experienced in the 2006/07 growing season. Previous studies have shown that leaf stripping and detasselling results in increased maize grain yield as photo-assimilates limited supply of water will also limit the rate of photosynthesis and the amount of photo-assimilates channelled to the grain.

5.3 Productivity of maize-soybean intercropping system

The results of the LER analysis showed that leaf stripping and detasselling is capable of increasing productivity of intercropping systems as shown by higher LERs in treatments where the maize was leaf stripped and detasselled compared to treatments with tasselled and unstripped (intact) maize. This increase can be attributed to increased PAR reaching the understorey soybean crop.

There was no reduction in maize grain yield on intercropping which is contrary to findings by Ofori and Stern (1987), who reported an average decline in yield of cereal component by 11% of sole maize crop yield, Silwana and Lucas (2002) recorded 15% yield decrease in the maize crop. Mashingaidze (2004) recorded 12-22% reductions in maize yield.

There was a reduction in the soybean yield with intercropping. Yield reduction of about 40 -69% were obtained in these studies this agrees with findings by Ofori and Stern in a survey of 40 published papers in which they reported an average yield decline of 52% of the legume component crop. In an experiment by Wahua and Miller, 1978 soybean yields were reduced by 75% when intercropped with tall sorghum. This yield reduction can be attributed to competition from the cereal component. The cereal crop has a competitive advantage over the legume as it is taller and has relatively higher growth rates. Azam-Ali (1995), reported that the tallest species in an intercrop benefits by having foliage in a layer above its competitors where light intensities are at their highest and where it cannot experience interspecific shading. The cereal and in this case maize thus shades the soybean crop and probably the amount of PAR intercepted by the soybean crop was less compared to that received by the maize component and therefore yield reductions in the soybean tended to be greater than those in the maize in intercrops if they are any reductions. These yield decreases in soybean are acceptable to farmers since in intercrops they prioritise the major crop in this case maize. They consider the grain yield from the minor crop to be a bonus from which they reap additional financial and nutritional benefits (Mariga 1990; Mutungamiri, Mariga and Chivinge, 2001).

Intercropping gave higher total yields per unit are than sole cropping. This can be attributed to temporal and spatial complementarity of component crops, which allows for better use of light, water and other resources. From the results an additional hectarage ranging from 0.1 to 0.4 ha would be required under sole cropping to attain the yields obtained in the intercrop.

5.4 Weed density and biomass

Cropping system, soybean variety and leaf stripping and detasselling had no significant effect on the total weed densities at 6 and 9 WACE as well as at physiological maturity. Generally there was a decrease in total weed density over time. This decrease in the densities of weeds with time can be attributed to higher levels of shading and the attenuation of spectral composition of incoming radiation into far-red-rich light that is inhibitory to weed germination as proposed by Radosevich, Holt and Ghersa (1992). Weed numbers were higher at 6 WACE compared to 9 WACE and physiological maturity because the weeds were benefiting from maximum PAR reaching the ground so most of the weeds germinated and their growth rates were relatively higher. As the maize and soybean developed full canopy the intensity of shading on the weeds increased resulting in few weeds germinating. However, there were no differences between monocrops and intercrops.

There were no significant differences in weed biomass at 6 and 9 WACE but there were significant differences at physiological maturity due to cropping system, soybean variety and leaf stripping and detasselling. Sole Storm and sole Solitaire had higher weed biomass compared to sole Magoye. This can be attributed to increased light penetration to the ground as the sole Storm and Solitaire would have lost their foliage resulting in increased growth rate and biomass accumulation by the weeds. Magoye is long seasoned and it retains foliage for a longer period thus shades the weeds for prolonged periods thus lower weed biomass. Generally there was a decrease in weed biomass from 6 WACE to physiological maturity but there was a slight increase in biomass at 9 WACE, which can be due to increase in rainfall around that March which resulted in increased growth rate of the weeds.

The increase in radiation in the canopy as a result of detasselling and leaf stripping did not increase weed density because leaf stripping and detasselling was only done at 50% silking which is late in the season and most weeds germinate at the beginning of the season together with the crops. There were slight increases in weed biomass in treatments that had leaf stripped and detasselled maize which can be attributed to increased light penetration to the weeds.

The effects of intercropping on weeds in this experiment did was not clear because the season in terms of rainfall was not good, the amount of rainfall that was received was little such that the growth of the plants was slow. Magoye and Solitaire lodged which also resulted in variations.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- From the study it can be concluded that soybean variety had a significant effect on number of pods and seeds per plant. Magoye had higher number of pods and seeds per plant.
- Soybean variety had significant effect on 1000-grain weight of soybean. Solitaire had the highest 1000- grain weight and Magoye had the least.
- Leaf stripping and detasselling had no significant effect on maize and soybean grain yield.
- Magoye is not adaptable to intercropping either with leaf stripped and detasselled maize or intact maize.
- Intercropping increases total yield per given piece of land and resulted in higher LER.
- Cropping system, soybean variety and leaf stripping and detasselling had no significant effect on total weed density at 6 and 9 WACE as well as at physiological maturity.
- Cropping system, soybean variety and leaf stripping and detaselling had no significant effect on total weed biomass at 6 and 9 WACE but had significant effect at physiological maturity.

6.2 Recommendations

- Leaf stripping and detasselling is recommended to farmers since there are other extra benefits that can be accrued from this technology besides grain yield for example the stripped leaves from the maize can be fed to livestock.

Future research

- Measuring PAR at different levels of crop canopy in intercrop so as to quantify changes in radiation and its effect on grain yield and weed density and biomass as a result of leaf stripping and detasselling.
- This study should be repeated applying a fertilizer high in potassium, which is essential for lignification and thus strengthening the stem of the soybean especially magoye which is prone to lodging.
- There is need for further work with magoye under irrigation since it requires a long growing season.
- Reducing legume population so as to reduce competition.
- Early planting to utilize the length of the growing season.
- There is need to do farmer evaluation of leaf stripping and detasselling.

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APPENDICES

Appendix 1: Analysis of variance for number of soybean pods/plants

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block stratum	3	151.62	50.54	1.25	
svar	2	889.62	444.81	11.02	<.001
Cs	2	281.75	140.87	3.49	0.047
svar.cs	4	187.76	46.94	1.16	0.352
Residual	24	968.39	40.35		
Total	35	2479.13			

Appendix 2: Analysis of variance for number of soybean seeds/plant

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	386.9	129.0	0.57	
svar	2	2251.3	1125.7	4.99	0.015
lsdetass	2	352.9	176.5	0.78	0.468
svar.lsdetass	4	882.8	220.7	0.98	0.437
Residual	24	5409.9	225.4		
Total	35	9284.0			

Appendix 3: Analysis of variance for 1000-grain weight soybean

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	1420.2	473.4	1.51	
svar	2	44464.1	22232.0	70.69	<.001
lsdetass	2	686.1	343.1	1.09	0.352
svar.lsdetass	4	1552.2	388.1	1.23	0.323
Residual	24	7548.4	314.5		
Total	35	55671.1			

Appendix 4: Analysis of variance for soybean grain yield

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	1979310.	659770.	4.42	
svar	2	5523474.	2761737.	18.52	<.001
lsdetass	2	8736553.	4368276.	29.29	<.001
svar.lsdetass	4	305964.	76491.	0.51	0.727
Residual	24	3579102.	149129.		
Total	35	20124403.			

Appendix 5: Analysis of variance for the different treatments on 1000-grain weight soybean

Source	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	1420.2	473.4	1.	
Treatment	8	46702.4	5837.8	18.56	<.001
Residual	24	7548.4	314.5		
Total	35	55671.1			

Appendix 6: Analysis of variance for the different treatments on number of pods/ plant

Source	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	151.62	50.54	1.25	
Treatment	8	1359.12	169.89	4.21	0.003
Residual	24	968.39	40.35		
Total	35	2479.13			

Appendix 7: Analysis of variance for the different treatments on number of seeds / plant soybean

Source	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	386.9	129.0	0.57	
Treatment	8	3487.1	435.9	1.93	0.101
Residual	24	5409.9	225.4		
Total	35	9284.0			

Appendix 8: Analysis of variance for the different treatments on soybean grain yield

Source	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	1979310.	659770.	4.42	
Treatment	8	14565991.	1820749.	12.21	<.001
Residual	24	3579102.	149129.		
Total	35	20124403.			

Appendix 9: Analsis of variance for maize grain yield

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	10599072.	3533024.	5.91	
CS	3	2713414.	904471.	1.51	0.240
Lsdetass	1	960916.	960916.	1.61	0.219
CS.Lsdetass	3	2661596.	887199.	1.48	0.248
Residual	21	12552336.	597730.		
Total	31	29487335.			

Appendix 10: Analysis of variance for 1000- grain weight maize

Source of variation	d.f.	S.S.	M.S.	V.R.	F pr.
Block	3	6226.5	2075.5	2.38	
CS	3	2551.1	850.4	0.97	0.424
Lsdetass	1	168.8	168.8	0.19	0.665
CS.Lsdetass	3	906.9	302.3	0.35	0.792
Residual	21	18334.8	873.1		
Total	31	28188.2			

Appendix 11: Analysis of variance for maize grain yield across treatments

Source	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	10599072.	3533024.	5.91	
Treatment	7	6335927.	905132.	1.51	0.216
Residual	21	12552336.	597730.		
Total	31	29487335.			

Appendix 12: Analysis of variance for 1000-grain weight maize across treatments

Source	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	6226.5	2075.5	2.38	
Treatment	7	3626.9	518.1	0.59	0.754
Residual	21	18334.8	873.1		
Total	31	28188.2			

Appendix 13: Analysis of variance for total weed counts at 6 WACE

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr
Block	3	4.06	1.35	0.10	
Treatment	10	196.30	19.63	1.47	0.198
Residual	30	399.96	13.33		
Total	43	600			

Appendix 14: Analysis of variance for total weed counts at 9 WACE

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr
Block	3	2.7930	0.9310	1.02	
Treatment	10	16.7915	1.6791	1.85	0.095
Residual	30	27.3017	0.9101		
Total	43	46.8862			

Appendix 15: Analysis of variance for total weed counts at physiological maturity

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr
Block	3	26.603	8.868	1.95	
Treatment	10	27.595	2.759	0.61	0.796
Residual	30	136.576	4.553		
Total	43	190.773			

Appendix 16: Combined analysis for weed density over time

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block stratum	3	24.267	8.089	0.95	
Block.Subject stratum					
Treatment	10	89.155	8.915	1.05	0.430
Residual	30	255.169	8.506	1.77	
Block.Subject.Time stratum					
d.f. correction factor 0.7753					
Time	2	1877.424	938.712	194.91	<.001
Time.Treatment	20	151.535	7.577	1.57	0.113
Residual	66	317.864	4.816		
Total	131	2715.415			

Appendix 17: Analysis of variance for total weed biomass at 6 WACE

Source	D.F.(m.v.)	S.S.	M.S.	V.R.	F pr.
Block	3	0.0988	0.0329	0.30	
Treatment	10	0.4005	0.0401	0.36	0.953
Residual	26(4)	2.8900	0.1112		
Total	39(4)	3.2861			

Appendix 18: Analysis of variance for total weed biomass at 9 WACE

Source of variation	D.F.	S.S.	M.S.	V.R.	F pr.
Block	3	0.6268	0.2089	1.89	
Treatment	10	0.9974	0.0997	0.90	0.542
Residual	30	3.3142	0.1105		
Total	43	4.9384			

Appendix 19: Analysis of variance for total weed count at physiological maturity

Source	D.F.(m.v.)	S.S.	M.S.	V.R.	F pr.
Block	3	0.26073	0.08691	3.25	
Treatment	10	0.65543	0.06554	2.45	0.029
Residual	29(1)	0.77540	0.02674		
Total	42(1)	1.68543			

Appendix 20: Combined analysis for weed biomass over time

Source of variation	D.F.(m.v.)	S.S.	M.S.	V.R.	F pr.
Block stratum	3	0.38143	0.12714	1.24	
Block.Subject stratum					
Treatment	10	0.67512	0.06751	0.66	0.751
Residual	30	3.06609	0.10220	1.23	
Block.Subject.Time stratum					
d.f. correction factor 0.9255					
Time	2	7.03259	3.51630	42.15	<.001
Time.Treatment	20	1.49967	0.07498	0.90	0.584
Residual	61(5)	5.08864	0.08342		
Total	126(5)	16.33580			