ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

# JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 7 (3): 229-236, 2008
ISSN 1812-5379


# Performance of Maize (*Zea mays* L.) and Soya Bean [*Glycine max* (L.) Merrill] Cultivars of Varying Growth Habit in Intercrop in Sub-Humid Environments of Zimbabwe

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**Abstract:** The objective of this study was to intensify soybean and maize production in smallholder production systems, where land is a limiting resource. Performance during growth and final yield in intercrop was evaluated for cultivars with different growth habits. Field experiments were undertaken at two sites, in two seasons (2002/03 and 2003/04) to evaluate the response of two soybeans (Storm-a determinate and Solitaire-an indeterminate cultivar) to intercropping with three maize cultivars (a semi-erectophile SC513, a planophile PAN413 and AC31; a dwarf cultivar). Treatments were laid in a Randomised Complete Block Design (RCBD) with three replications. Intercropping significantly increased Leaf Area Index (LAI), resulted in greater yields and income per unit land area than sole crops. In 2002/03, maize and soya bean cultivars did not significantly affect Land Equivalent Ratio (LER). However, the maize cultivar by soya bean cultivar interaction significantly ($p<0.01$) affected LER. Maize cultivar SC513 resulted in the highest LER with Storm but the lowest with Solitaire. It was concluded that SC513, a semi-erectophile intercropped with a determinate soya bean Storm cultivar might optimise yields without significant maize yield reduction.

**Key words:** Growth habit, intercropping, land equivalent ratio, maize, soybeans

## INTRODUCTION

About 70% of Zimbabwe is covered with sandy soils derived from granite (Mugwira and Murwira, 1997). The sandy soils are low in nitrogen (N), phosphorus (P), sulphur (S) and exchange capacity due to low clay and organic matter contents. Studies with cattle manure have indicated that manure alone generally produced low crop yields and needed supplementation with inorganic fertilisers, particularly N for optimum yields (Zingore *et al*., 2007). Rotations of maize (*Zea mays* L.) and groundnuts (*Arachis hypogea* L.) has been one of the most common legume/cereal crop sequence on smallholder farms in sub-humid parts of Zimbabwe (Waddington and Karigwindi, 2001; Mashingaidze, 2004). However, both the area planted to groundnut and yields declined due to poor seed quality, late planting and low population densities, lack of fertiliser use and high labour requirement for production (Waddington and Karigwindi, 2001). Rotations with legumes, use of green manure crops and multipurpose perennial legumes have been investigated as alternatives to maintain soil fertility (Murata and Hikwa, 1998; Waddington *et al*., 1998). Soybeans (*Glycine max* (L.) Merrill) are a relatively new crop that has been promoted amongst smallholder (SH) farmers. Soybean is a known potent nitrogen fixer (Musiyiwa *et al*., 2005; Zengeni *et al*., 2006). The formation of a Soybean Promotion Taskforce has led to the successful adoption of the crop amongst SH farmers in Zimbabwe (Rusike *et al*., 2000; Kasasa *et al*., 1998).

Legumes, such as cowpea (*Vigna unguiculata* L. Walp.), groundnut (*Arachis hypogea* L.), bambarra-groundnut (*Vigna subterranean* L.) and beans (*Phaseolus vulgaris* L.) are usually grown in intercrops by SH farmers (Musambasi *et al*., 2002; Mashingaidze, 2004). These are intercropped with maize, sorghum (*Sorghum bicolor* L.) or pearl millet (*Pennisetum americunum* (L.) Leeke) (Chivasa *et al*., 1998; Musambasi *et al*., 2002). Soybean/maize intercropping among SH farmers who rely on rainfall is relatively unknown. Smallholder soybean production has been very low, because of the belief that the crop was not suited for smallholder production, which lacks irrigation facilities. Soybean is a profitable crop worldwide because of the virtually unrivalled protein content (40%) and high quality edible oil (20%) (Takamuhambwa *et al*., 2001; Giller, 2002).

With limited land resources on many SH farms; intercropping soybean and maize may result in increased

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productivity. Biological productivity is enhanced in intercrops when component crops complement each other in their use of resources over time and space (Willey, 1979; Hauggaard-Nielsen and Jensen, 2001). It is important for farmers to be knowledgeable on which cultivars of different crop species to select to enhance complementarity. Farmers do not select species suitable for intercropping, some randomly intercrop while others plant within cereal rows (Mabika and Mariga, 1996). Most of the improved soybean cultivars available on the market were developed under mono-cropping conditions, their performance when intercropped with maize need to be evaluated.

Many researchers have stressed the need for identification of suitable genotypes in intercropping. Best cultivars for mono-cropping might not be the most suitable for mixed cropping due to the changes in the microclimate within crop mixtures (Hauggaard-Nielsen and Jensen, 2001; O'Leary and Smith, 1999, 2004). Ideally use of legumes in mixtures should be preceded by evaluations of their suitability and compatibility.

Complementarity has been observed with respect to light interception in inter crops. Improved radiation efficiency (RUE) of field pea (*Pisum sativum* L.) and canola (*Brassica napus* L.) stems resulted in intercrops of field pea and canola out-yielding their pure stands (Soetedjo *et al*., 1998). Cereals with leaves inclined to the vertical (erectophiles) allow more light into the canopy, which may be efficiently intercepted by legumes with leaves inclined to the horizontal (planophiles) leading to increased productivity per unit area in intercrop (Squire, 1990).

Adeniyan and Ayoola (2006) reported that maturity time and growth habit of component crops were important determinants of productivity in maize/soybean intercrops. They recommended an early maturing erect soybean cultivar for intercropping with maize. Olufajo (1995) reported that soybean yielded 12% better when intercropped with a semi-dwarf sorghum compared with a tall sorghum. The aim of this study was to evaluate the responses of soybean (*Glycine max* L.) cultivars with a determinate and indeterminate growth habit to intercropping with erectophile, planophile or dwarf maize (*Zea mays* L.) cultivars.

## MATERIALS AND METHODS

**Location:** Field trials were carried out in the Chinyika (32° 05' and 32° 44' E and 18° 00' and 18° 20' S) during the 2002/2003 and 2003/2004 seasons. In the first season the trials were carried out at Ruzawe and Pfekedza in the second season they were carried out at Tsindi and Mhlanga. An experiment was also carried out at Thornpark (31° E and 17° 30' S) during the 2002/03. Chinyika and Thornpark represent semi-humid environments at altitudes of 1300 m above sea level (masl) to 1500 masl with mean annual rainfall of 700-800 mm. The soils in Chinyika are derived from granite rock and are sandy, light textured and of fair agricultural potential while those at Thornpark Farm are classified as Chromic Luvisols using the FAO classification (Nyamapfene, 1991).

**Treatments and experimental design:** Two soya bean cultivars, Storm, a determinate cultivar and Solitaire, an indeterminate soya bean cultivar were evaluated in intercrop with three maize cultivars with differing leaf architecture. The maize cultivars were: SC513 is a medium season hybrid with semi-erectophile leaves maturing in 140 days, PAN413 is an early maturity hybrid with planophile leaves maturing in 130 days and AC31 is a dwarf hybrid with planophile leaves maturing in 135 days at an altitude of 1350 masl. At each site, the experiment comprised eleven treatments, sole maize and soya bean crops and all the different cultivar combinations in intercrop. Treatments were laid in a Randomised Complete Block Design (RCBD) with three replications at each site.

Gross plot size was 6×4.5 m and net plot 4.8×0.9 m. Soya bean density was 100,000 plants ha$^{-1}$ and that of maize 37,000 plants ha$^{-1}$ in both sole and intercrop. Initial fertilizer compound L (5% N: 14% K: 4.4% P, 8% S, 0.25% B) was applied by banding at planting using a rate of 150 kg ha$^{-1}$. In both sole and intercrop maize, two seeds were sown in furrows 0.9 m apart at intervals of 0.3 m and covered using hand-hoes. In intercrops, soybean seed was planted along the maize rows and the furrows covered using hand-hoes. In sole soybean, seed was planted along furrows 0.45 m apart and then covered using hoes. Maize plants were thinned to one plant per station and soybean to the desired population of 100 000 plants ha$^{-1}$ at three weeks after emergence. Ammonium nitrate (34.5% N) was applied at the rate of 250 kg ha$^{-1}$ as a side dressing six weeks after crop emergence in all plots except sole soybean. In Chinyika land preparation was done by ox-drawn plough and at Thornpark using a tractor-drawn plough. Weeds were controlled at three and seven weeks after planting using hand-hoes.

Photosynthetically Active Radiation (PAR) (μmol/m$^2$/sec) was measured at 12 weeks after crop emergence (WACE) in the sole and intercrops using a PAR meter (Syke Instruments Ltd). PAR was measured above the maize crop canopy in sole and intercrop, at the maize cob height level, above soybean canopy in sole and intercrop and at ground level. Leaf area of maize and soybean was measured at 4, 6, 8, 12 and 14 WACE by destructively sampling six plants from border rows at each sampling date. Leaf area was read using a leaf area meter (Area measurement system, Delta-T devices, Burwell, Cambridge, UK). Measurements of leaf area and PAR were taken at Thornpark Farm only during the 2002/2003 season. Yield (kg $ha^{-1}$) was also measured, the Land Equivalent Ration (LER) was used to assess the productivity of intercrops. LER is defined as the relative land area under sole crops that is required to produce yields achieved by intercropping. LERs were calculated using the following equation:

$$LER = Y_{ij}/Y_{ii} + Y_{ji}/Y_{jj} \quad (1)$$

where, $Y_{ii}$ and $Y_{jj}$ are monocrop yields of the component crops i and j and $Y_{ij}$ and $Y_{ji}$ are the intercrop yields of i and j, respectively (Ofori and Stern, 1987). Maize prices used for calculating the gross income were based on the Grain Marketing Board (GMB) 2003 producer prices of USD 0.23 $kg^{-1}$ while soya bean prices were based on Olivine Industries 2003 producer prices of USD 0.46 $kg^{-1}$. The exchange rate used was ZWD 1300 to 1 USD.

**Data analyses and presentation:** The measured variables (PAR, yields of maize and soya bean, LER and income data) were analyzed by ANOVA using the MSTATC (Freed, 1991) statistical package. Mean separations were done using the Least Significant Difference (LSD) method. Leaf Area Index (LAI) was calculated as a ratio of leaf area to land area for each crop component at the five periods of measurement. Leaf area indices were subjected to analysis of variance using crop cultivar, cropping systems and time of measurement as factors; separate analyses were done for maize and soya bean. PAR was analyzed using maize cultivar, soya bean cultivar and position of measurement as factors. Sole crop data was analyzed separately from intercrop data. This way, the interaction of maize cultivars and soya bean cultivars with different growth habits could be assessed as PAR penetrated to the bottom of the canopy. Across site analyses were done on soya bean and maize grain yield, land equivalent ratios and income data. Unless otherwise stated, 'significant' refers to a threshold of p = 0.05.

## RESULTS

**Rainfall:** In the 2002/03 season, Thornpark farm received a total of 845 mm while Chinyika received 556 mm. Also in the 2002/03 season most of the rain was received in the months of January and February. The total amount of rainfall received at Chinyika in the 2002/03 season was 491 and 593 mm in the 2003/04 season (Fig. 1).

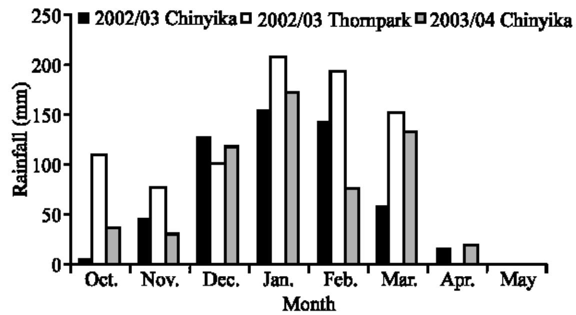


Fig. 1: Monthly rainfall at Chinyika and Thornpark Farm during the 2002/03 and 2003/04 seasons

### Leaf area indices

**Maize LAI:** Leaf area indices in maize were not significantly affected by cropping system and maize cultivar at all the measurement periods. Interactions between maize cultivar, cropping system and time of measurement were also not significant with respect to LAI in maize. However, time of measurement significantly ($p<0.01$) affected LAI were the trend was for LAI to increase with increase in WACE as expected. The LAI at 4, 6, 8, 12 and 14 WACE were 0.8, 1.2, 3.3, 4.1 and 2.6, respectively.

**Soya bean LAI:** Soya bean cultivar, cropping system and time of measurement significantly ($p<0.05$) affected LAI in soya beans. Storm had greater LAI values than Solitaire. For example, at 12 and 14 WACE, Storm had LAI values of 2.3 and 1.7 while Solitaire had 1.9 and 1.3, respectively. The only interaction that was significant ($p<0.01$) was between cropping system and the time of measurement. For older plants, there was a greater difference in LAI values between the sole soya bean crop and intercropped soya bean compared to younger plants. Soya bean intercropped with PAN 413 also tended to have higher LAI values compared to intercropping with AC 31 and SC 513 (Fig. 2).

**Total LAI:** Intercropping significantly increased the total LAI compared to sole crops of either maize or soya bean. For example, PAN 413 intercropped with either storm or sotilaire had greater leaf area indices compared to sole crops of PAN 413, Storm or Solitaire (Fig. 3). The intercrop of PAN 413 with Storm or Solitaire had the highest LAI of 6.1 followed by a sole crop of Storm with a LAI of 4.5 at 12 WACE (Fig. 3).

### PAR

**Intercrop PAR:** Neither maize cultivar nor soybean cultivar significantly affected PAR measurements. The interaction between maize and soya bean cultivars was also not significant. However, PAR measurements were

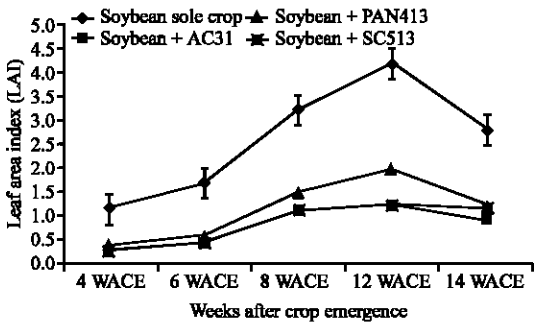


Fig. 2: Leaf area indices of soya bean grown as a sole crop and intercropped with AC31, SC513 and PAN413 at different times of measurement. Data shown is for Thornpark Farm during the 2003/2004 season. Error bars represent the $LSD_{(0.05)}$

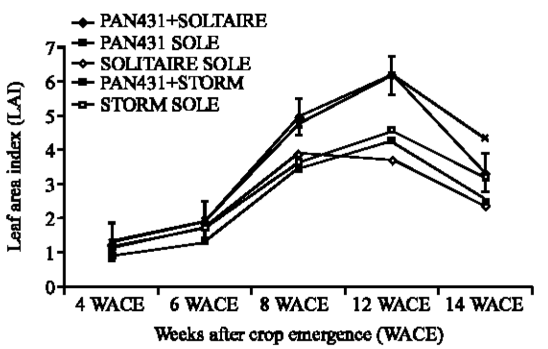


Fig. 3: Total leaf area indices in different cropping systems (sole crops of PAN 413, solitaire and storm compared with intercrops of PAN 413 + Storm and PAN 413 + Solitaire). Data shown is for Thornpark Farm during the 2003/2004 season. Error bars represent the $LSD_{(0.05)}$

significantly ($p<0.001$) affected by position of measurement. PAR tended to decrease as measurements moved to the bottom of the canopy. However, there were no significant differences in PAR recorded at the maize cob height and at the top of the soya bean canopy (Table 1).

**Sole crop PAR:** Maize cultivar and soya bean cultivar did not significantly affect PAR absorption by the canopy. The general trend was for PAR to be reduced as it was measured down the crop canopy (Table 1).

### Grain yield

**2002/03 season maize yields:** All factors; site, maize cultivar and cropping system significantly ($p<0.01$) affected maize yields. However, maize cultivar by cropping system interaction was the only significant ($p<0.01$)

Table 1: Photosynthetically active radiation (μmol/m²/sec) penetration into an intercrop canopy of soya bean and maize (across maize and soya bean cultivars) at 12WACE in the 2003/04 season

| Variables | Above maize | Cob height | above soya bean | Ground level | $LSD_{(0.05)}$ | CV |
|---|---|---|---|---|---|---|
| Intercrop | 94.7 | 56.80 | 59.6 | 1.4 | 10.5 | 29.8 |
| Sole maize | 99.5 | 66.81 | - | 9.7 | 9.04 | 14.6 |
| Sole soya bean | - | - | 93.5 | 3.0 | 3.41 | 29.8 |

WACE: Weeks after Crop Emergence, LSD: Least Significant Difference, CV: Coefficient of Variation

Table 2: Maize yields (kg ha$^{-1}$) in the 2002/03 and 2003/04 seasons in monocrop or intercropped with soya bean cultivars. Means across sites presented

| Maize yields | Sole | With storm | With solitaire |
|---|---|---|---|
| **2002/03** | | | |
| AC 31 | 1962 | 1624 | 1760 |
| PAN 413 | 2835 | 2591 | 2337 |
| SC 513 | 3246 | 2848 | 1765 |
| $LSD_{(0.05)}$ | 582.8 | | |
| CV | 26.4 | | |
| **2003/04** | | | |
| AC 31 | 2303 | 2519 | 2499 |
| PAN 413 | 2837 | 2365 | 2553 |
| SC 513 | 2555 | 2353 | 2755 |
| $LSD_{(0.05)}$ | 378 | | |
| CV | 12.7 | | |

interaction. Thornpark Farm had the highest yield of 3 551 kg ha$^{-1}$ followed by 1,691 and 1,747 kg ha$^{-1}$ for Pfekedza and Ruzawe farms, respectively. Cultivar SC513 was the best yielding under sole cropping, however, it had the greatest yield reduction when intercropped with Solitaire (Table 2).

**2003/04 season maize yields:** Site, cultivar and soya bean intercropping did not significantly affect yields. All interactions were not significant (Table 2).

**2002/03 season soya bean yields:** All factors; site, soya bean cultivar and cropping system significantly ($p<0.0.1$) affected soya bean yields. However, soya bean cultivar by cropping system interaction was the only significant ($p<0.01$) interaction. Thornpark Farm had the highest yields of 923 kg ha$^{-1}$ followed by 734 and 683 kg ha$^{-1}$ for Pfekedza and Ruzawe farms respectively. Sole cropping yielded higher than intercropping. However, Storm yielded better than Solitaire when intercropped, the yield difference was greater when intercropped with SC513 (Table 3).

**2003/04 season soya bean yields:** Site and intercropping significantly affected yields. Soya bean cultivar had no significant effect on yields. The interaction between soya bean cultivar and intercropping was not significant. A soya bean yield of 531 kg ha$^{-1}$ was recorded at Tsindi farm while 976 kg ha$^{-1}$ was recorded at Mhlanga farm. Intercropping soya beans with maize severely affected soya bean yields (Table 3).

Table 3: Soya bean yields (kg $ha^{-1}$) in the 2002/03 and 2003/04 seasons in monocrop or intercropped with maize cultivars. Means across sites presented

| Variables | Sole | AC31 | PAN413 | SC513 |
|---|---|---|---|---|
| **2002/03** | | | | |
| Storm | 1307 | 677 | 587 | 940 |
| Solitaire | 1038 | 584 | 531 | 575 |
| $LSD_{(0.05)}$ | 582.8 | | | |
| CV | 17.2 | | | |
| **2003/04** | | | | |
| Storm | 1272 | 683 | 450 | 782 |
| Solitaire | 1246 | 605 | 493 | 497 |
| $LSD_{(0.05)}$ | 239.0 | | | |
| CV | 26.8 | | | |

Table 4: Partial and total LERs for the different cultivar combinations in the 2002/03 season. Means across sites are presented

| Cultivars | AC31 | PAN413 | SC513 |
|---|---|---|---|
| **2002/03 maize PLER** | | | |
| Storm | 0.859 | 0.883 | 0.878 |
| Solitaire | 0.884 | 0.813 | 0.548 |
| $LSD_{(0.05)}$ | 0.1632 | | |
| CV | 20.9 | | |
| **2002/03 soya bean PLER** | | | |
| Storm | 0.516 | 0.447 | 0.697 |
| Solitaire | 0.571 | 0.512 | 0.603 |
| $LSD_{(0.05)}$ | 0.1515 | | |
| CV | 25.2 | | |
| **2002/03 LER** | | | |
| Storm | 1.376 | 1.331 | 1.575 |
| Solitaire | 1.455 | 1.325 | 1.151 |
| $LSD_{(0.05)}$ | 0.2081 | | |
| CV | 15.8 | | |

PLER: Partial Land Equivalent Ratio; LER: Land Equivalent ratio

## Land Equivalent Ratio (LER)

**2002/03 Maize partial LER (PLER):** Site, maize and soya bean cultivars all significantly ($p<0.05$) affected maize PLER. The maize cultivar by soya bean cultivar interaction was the only significant ($p<0.05$) interaction to affect maize PLER. The maize PLER was highest at Ruzawe (0.82) followed by Thornpark (0.808) and Pfekedza (0.805). When SC513 was intercropped with Solitaire the maize PLER was the lowest compared with other treatment combinations (Table 4).

**2002/03 Soya bean partial LER (PLER):** Maize cultivar was the only factor that significantly ($p<0.05$) affected Soya bean PLER. All interactions were not significant. Intercropping with PAN 413 resulted in lower soya bean PLER compared with AC31 and SC513 (Table 4).

**2002/03 total LER:** Site, maize and soya bean cultivars did not significantly affect LER. However, the maize cultivar by soya bean cultivar interaction significantly ($p<0.01$) affected LER. Maize cultivar SC513 resulted in the highest LER with Storm but the lowest with Solitaire (Table 4).

**2003/04 total LER:** In the second season site and soya bean cultivar did not significantly affect the partial and total LER. Maize cultivar significantly ($p<0.01$) affected maize PLER, were PAN 413 had the lowest maize PLER (Table 5). All the interactions were also not significant. However, all the total LERs for the various treatments were above one (Table 5).

Table 5: Partial and total LERs for the different cultivar combinations in the 2003/04 season. Means across sites are presented

| Cultivars | AC31 | PAN413 | SC513 |
|---|---|---|---|
| **2003/04 maize PLER** | | | |
| Storm | 1.097 | 0.865 | 0.925 |
| Solitaire | 1.087 | 0.897 | 1.079 |
| $LSD_{(0.05)}$ | 0.1762 | | |
| CV | 14.8 | | |
| **2003/04 soya bean PLER** | | | |
| Storm | 0.528 | 0.321 | 0.625 |
| Solitaire | 0.506 | 0.411 | 0.487 |
| $LSD_{(0.05)}$ | 0.1698 | | |
| CV | 13.2 | | |
| **2003/04 LER** | | | |
| Storm | 1.625 | 1.186 | 1.550 |
| Solitaire | 1.593 | 1.309 | 1.566 |
| $LSD_{(0.05)}$ | 0.2593 | | |
| CV | 18.1 | | |

Table 6: Income in United States Dollars (USD) from the different cropping systems in 2002/03 and 2003/04 seasons. Means across sites are presented

| Cropping | 2002/03 USD | 2003/04 USD |
|---|---|---|
| PAN413+Solitaire | 784 | 817 |
| AC31+Storm | 687 | 897 |
| SC513+Storm | 1091 | 904 |
| PAN413+Storm | 869 | 753 |
| Solitaire sole | 479 | 575 |
| SC513 sole | 767 | 590 |
| SC513+Solitaire | 654 | 865 |
| PAN413 sole | 654 | 655 |
| AC31+Solitaire | 676 | 856 |
| AC31 sole | 453 | 532 |
| Storm sole | 603 | 587 |
| $LSD_{(0.05)}$ | 121.9 | 119.5 |
| CV | 9.1 | 14.1 |

## Income

**2002/03 season:** Income was significantly ($p<0.001$) affected by site and the cropping system. Thornpark farm had a superior income of USD 980 $ha^{-1}$ followed by Pfekeza and Ruzawe farmers with USD 559 $ha^{-1}$ and USD 571 $ha^{-1}$, respectively. Intercropping consistently gave higher incomes compared to sole crops. The intercrop of SC 513 and Storm gave the highest income (Table 6).

**2003/04 season:** The same trend as in the 2002/03 season was observed where income was significantly ($p<0.01$) affected by site and the cropping system. Mhlanga farm had a superior income of USD 764 $ha^{-1}$ followed by Pfekeza farm with USD 696 $ha^{-1}$ and USD 251 $ha^{-1}$, respectively. Intercropping consistently gave higher incomes compared to sole crops (Table 6).

## DISCUSSION

Intercrop systems had greater LAI values compared to monocrop systems, suggesting that intercrops may be more efficient in light interception. This was confirmed by PAR measurements, which revealed that only 1.5% of the light received at the top of the canopy was reaching the ground in intercrops. Maize and soya bean monocropping allowed 9.7 and 3.2% of PAR at the top of the canopy to reach the ground. This is in agreement with other studies that have reported improved light use efficiency in intercrop systems. Awal *et al.* (2006) reported that a maize/peanut intercropping system would help to increase production through the efficient utilisation of solar energy. The additional solar energy used by the intercrop canopy may have led to improved crop production and thus greater economic yield.

Soya beans intercropped with maize did not significantly affect maize LAI or leaf area development. Maize intercropped with soya bean cultivars reduced soya bean LAI signifying the dominance of maize over the soya bean (Fig. 2). This implies that the maize was the dominant component in the intercrop. In the intercrop, soya bean received about 63% of available PAR, with most of the PAR absorbed by maize, which towered over the soya bean.

Leaf inclination, or leaf angle, will determine the amount of light penetrating to lower sections of the canopy (Squire, 1990) and this is directly proportional to the amount of photosynthates manufactured hence the yield obtained. Erectophile plants allow more available PAR to penetrate deep into the canopy (Gardner *et al.*, 1995). In this study there was no evidence that the erectophile maize cultivar (SC 513) allowed more available PAR to penetrate to the ground. This may be due to the fact that measurements were not taken continuously during the growth of the crop. Also in limiting moisture environments erectophiles are known to sag their leaf (due to lack of turgidity) and assume a more planophile leaf angle. The rainfall received at Chinyika in the 2002/03 was below the long-term average. In spite of this, intercropping with the erectophile SC513 gave consistently greater soya bean yields in both seasons when intercropped with the determinate soya bean cultivar Storm (Table 3).

In some instances, maize yields were enhanced with soya bean intercropping as evidenced by PLER>1 (Table 5). A possible explanation for this may be that nitrogen was transferred from the nitrogen fixing soybean to the maize during crop development. Brophy and Heichel (1989) reported that soybean released 10.4% of symbiotically fixed plant N into the root zone over its growth period. Martin *et al.* (1991) also reported that the elevated yields and protein levels observed in maize and soybean intercrops may be a consequence of nitrogen transfer from soybean to maize. Cultivars, which minimize intercrop competition and maximize complementarity effects are suitable for intercropping.

Storm performed better than Solitaire in 2002/2003 and this can be due to the fact that Solitaire is an indeterminate cultivar and due to the poorly distributed rainfall experienced in that season, some of the flower flushes coincided with a dry spell during end of February to March so that there was poor pod formation and filling. Storm, a determinate cultivar had a single flush of flowers that coincided with a wet spell and utilised this moisture to achieve good pod formation. In determinate crops, once flowering commences, vegetative growth ceases and assimilates are directed to flowering and fruiting parts whilst in indeterminate crops, vegetative growth continues even after flowering and there is competition for assimilates. Crop production under dry conditions is successful if the flowering stage coincides with a wet spell. Soya bean plants are less sensitive to drought during the main period of vegetative growth than during flowering and fruiting. The plants are very sensitive to water stress at the time of flower bud differentiation and during flowering (Onwueme and Sinha, 1991).

Intercropping resulted in greater income per unit land area than sole cops. The combination of SC 513 and Storm consistently gave grater incomes in both seasons. This may be attributed to increased biological productivity in the intercrop system. Farmers may therefore realize better incomes with intercropping. Maize/soya bean intercropping increases incomes obtained by smallholder farmers in sub-humid tropics such as Chinyika, in Zimbawe.


## ACKNOWLEDGMENTS

We thank the Rockefeller Foundation for financing this research through Grant No. 2002 FS 121 to the University of Zimbabwe under its Forum program. We also thank farmers who participated in this study.


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