UPRIGHT VARIETIES OUT-YIELD CLIMBING COWPEA VARIETIES AND LEAF STRIPPING AND DETASSELLING ENHANCES PRODUCTIVITY OF MAIZE/COWPEA INTERCROPS

A. B. Mashingaidze[1] and R. D. Katsaruware[2]
[1]Umutara Polytechnic, Nyagatare, Rwanda
[2] Crop Science Department, University of Zimbabwe, Mount Pleasant, Harare, Zimbabwe
E-mail abmash@yahoo.com

Abstract
An experiment to test the effect of cowpea architecture (two varieties with upright and bushy architecture and two with climbing architecture); three cropping systems (sole maize, sole cowpea and maize cowpea intercrop) and a maize leaf stripping/ detasselling treatment at anthesis (leaf stripped and detasselled, intact maize) on maize and cowpea grain yield and weed density and biomass at University of Zimbabwe Farm in the 2005/2006 season. Cowpea grain yield for the upright varieties was 2.5- 4 times higher than for the climbing varieties in maize cowpea intercrops. Cowpea vegetative biomass had a significant (P<0.01) but opposite trend with the climbing varieties having 1.46-1.62 more vegetative biomass at end of season than the upright varieties. Leaf-stripping and detasselling, averaged across the cowpea varieties, significantly increased cowpea grain yield by 5.46%, 1000 grain weight by 11.7%, number of grains per pod (11%) and number of pods per plant (17%). Upright cowpea varieties planted as sole crops suffered significantly less yield reduction (19.5%-36.6%) when intercropped with maize than one of the climbing varieties, R ex-Mbare (68.5%). Leaf stripping and detasselling in the maize bean intercrops increased maize grain yield by 12% compared to intact maize. The climbing cowpea varieties proved to be more competitive against maize, causing greater maize grain yield reduction (66%-67.7%) in maize cowpea intercrops than the upright cowpea varieties (29%-43%). Weed biomass was reduced by 46% in the intercropped treatments compared to the cowpea monocrop treatments. The results of the study show that new upright cowpea varieties are more adapted to be grown with maize in an intercrop than the traditional trailing and climbing cowpea varieties as they produced 2.5-4 times more cowpea grain and reduced maize grain yield by 24%-38% less than that caused by the trailing and climbing varieties.

Key words: Crop architecture, maize, cowpea, intercropping, leaf stripping, detasselling

1.0 Introduction

Cowpea is a widely grown legume that is commonly intercropped with maize in Southern Africa (Giller et al., 1993). Maize and cowpeas complement each other in the diet. Maize is a ready source of carbohydrates while cowpea is a rich source of proteins with 22-30% protein (Ledbetter, 2005). With the growing problem of malnutrition, which is evident in developing countries, a diet containing cowpeas is a possible way of alleviating protein deficiency.

Intercropping has remained popular in smallholder agriculture in Africa despite the emphasis on modern "green revolution" technologies such as monocropping, mechanization and use of pesticides by local research and extension (Richards, 1983). Various socio-economic and environmental reasons have been advanced to explain the widespread cereal-legume and cereal-cucurbit practices in semi-arid areas of Africa. These include the minimization of risk (Ruthenberg, 1980; Richards, 1983; Tafera and Tana, 2002), higher net economic returns (Richards, 1983), diversification of food supply (4) and more efficient use of environmental resources such as light, mineral nutrients and water (Richards, 1983; Ofori and Stern, 1987; Tafera and Tana, 2002). In addition intercrops have the potential to suppress weed germination, growth and seed production (Zimdahl, 1999) thereby reducing the number of times smallholder farmers hoe weed their crops to attain maximum yield (Mashingaidze, *et al*., 2000). Maize cowpea intercropping is widely practiced by smallholder farmers in Zimbabwe (Mariga, 1990); however there are currently no recommendations as to the complimentarity between maize and specific cowpea varieties with regards to productivity of the maize cowpea intercrops. Traditional varieties of cowpeas have a trailing and climbing architecture and these varieties have evolved under intercropping in smallholder farming systems in Southern Africa. New upright and bushy varieties of cowpeas are currently being promoted (Black Eyed Bean BEB and CBC_3) for production as monocrops by smallholder farmers in Southern Africa. Despite the recommendations that these varieties are best produced under monocropping conditions, farmers frequently intercrop these new upright cowpea varieties with maize. It is therefore necessary to investigate the adaptability of these new upright cowpea varieties to intercropping in comparison to the traditional climbing varieties.

Although intercropping has largely been shown to be advantageous in terms of greater efficiency of land utilization, yield of the dominated minor crop, grown under the canopy of the dominant cereal crop has always been low. Ofori and Stern (1987) reviewed 40 papers on cereal legume intercropping and found that the legume component crop yield declined an average of 52% and that of the cereal by 11% of their respective monocrop yields. Interception of most of the incoming Photosythetically Active Radiation (PAR) by the dominant cereal crop reduces dry matter production in the dominated legume crop reducing its grain yield. Any intervention, such as detasselling and leaf stripping, that increases the quantity of PAR intercepted by the minor crop in an intercrop, has potential to increase minor crop yield. In addition detasselling and leaf stripping can have a positive effect on dry matter allocation to the maize ear and therefore maize grain yield. Detasselling increases PAR interception by maize leaves (Hunter et al., 1969; Duncan *et al*., 1967) and removes apical dominance imposed by the tassel over the growth and development of the maize ear (Mostert and Marais, 1982; Subedi, 1996). Mashingaidze et al. (2004) found that the removal of 4-6 lowest leaves in maize at anthesis increased maize grain yield and attributed the maize grain yield increases to reduced transpiration during critical water stress sensitive stages of anthesis and grain-filling. Crookstone and Hicks (1988) found that positive yield response to defoliation was associated with low-end of the season available water. Shimada et al. (1992) found that grain yield of soybean was reduced by defoliation only under well watered conditions but was not affected defoliation in water restricted plants. We therefore hypothesized that leaf stripping and detasselling would enhance maize cowpea intercrop productivity allowing more PAR to reach the cowpeas in the maize under storey and by directly influencing dry matter accumulation in the maize ear.

The objectives of this study were therefore to determine the adaptability of upright and bushy cowpea varieties (Black Eyed Bean BEB, CBC_3) and climbing and trailing cowpeas varieties (Local Landrace and Red ex Mbare) for intercropping with intact maize and maize modified by detasselling and leaf stripping from two points of view (a) productivity of the component crops and (b) the ability of each maize cowpea cultivar combination to suppress weeds.

2.0 Materials and Methods

The experiment was carried out at the University of Zimbabwe Farm, 14 km north-west of the city of Harare in Zimbabwe in the 2005/2006 season. The experiment was set up as a 4*3*2 factorial in a randomized block design. The first factor was the cowpea variety with four levels, two upright and bushy varieties (Black Eyed Bean (BEB), CBC_3) and two trailing and climbing varieties (Local Landrace and Red ex Mbare). The second factor was cropping system with three levels; sole cowpea, sole maize and maize-cowpea intercrop. The third factor is leaf stripping and detasseling treatments that was imposed on treatments with maize only (a commercial hybrid SC 637); (a) four bottom leaves of maize stripped (leaf stripping) and the tassel removed (detasselled), (b) the maize left intact (unstripped and tasselled). Each treatment was replicated three times and plot size was 4.5×6m.

The land was ploughed and disc harrowed in November before planting in December 2005. Maize was planted at 90 cm (between-rows) and 30 cm (in-row) spacing to attain a plant density of 37 000 plant ha^{-1}. Cowpeas were planted at 45 cm (between rows) and 20 cm (in-row) spacing to attain a density of 111 000 plants ha^{-1}. In the maize cowpea intercrops, the maize spatial arrangement and density was maintained and cowpeas were planted in the middle of each maize row, ultimately attaining 90 cm × 20 cm spacing and 55 000 plants ha^{-1}. A basal fertilizer dressing of 150 kg ha^{-1} of compound D (7%N, 14%P_2O_5, 8%K_2O) and single super phosphate (19% P_2O_5) was banded into planting furrows before seeding for maize and cowpeas, respectively. Maize was top-dressed with 150 kg ha^{-1} Ammonium Nitrate (34.5% N) at 5 weeks after emergence (WAE) in the sole crops and intercrops.

Leaf stripping and detasselling was carried out at 50% silking (when 50% of the maize plants have produced silks). Four lowest leaves that were green were pulled and detached at the junction of the stem and the leaf sheath. Detasselling was done by pulling the tassel stalk upwards until the tassel popped out of the funnel, without damaging any sub-tassel leaves.

Weed density and biomass were measured at 6 WAE and at maize physiological maturity. Three 30cm × 30cm quadrants were randomly thrown into each plot, weeds were counted, cut at ground level, put into brown paper bags and dried at 80°C for 48 hours and then weighed. Weed density was square root transformed (Steel and Torrie, 1984) before analysis of variance (ANOVA). The yield and yield components of cowpeas were determined at cowpea physiological maturity when the pods were brown and the beans rattled within the pods. A random sample of five plants was selected and number of pods per plant, number of beans per pod, 1000-grain weight and biomass of cowpea plants was measured. Cowpea yield was measured from a 4m×3.6m net plot and moisture content was determined using a moisture meter and grain yield standardized to 11% moisture content (mc) before statistical analysis. Maize 1000 grain weight and grain yield was measured after harvesting cobs from a 4m×3.6m net plot, measuring grain moisture content and standardizing to 12.5% mc.

ANOVA was carried out on all data and where significant treatment effects were detected at $P<0.05$, means were separated using the least significant difference (lsd). Intercrop productivity was analyzed using Land Equivalent Ratios (Mead and Willey, 1980).

3.0 Results

3.1 Cowpea Grain Yield and Yield Components in Maize-Cowpea Intercrop

Cowpea cultivar ($P < 0.01$) and leaf stripping and detasselling of the maize ($P < 0.05$) significantly affected cowpea yield components and grain yield. Number of pods per plant, grains per pod and grain weight significantly and progressively increased from Red ex Mbare, Local Landrace, and BEB and was highest in CBC_3. The test weight (1000 grain weight,) an indicator of the size of grain and the extent of grain filling, was significantly higher in the variety BEB than in CBC_3 and the Red ex Mbare cultivars. There was no significant difference in 1000 grain weight between BEB and the Local Landrace (Table I).

Cowpea residual vegetative biomass harvested at the end of the season had an opposite trend to all the grain yield parameters. Vegetative biomass of the Local Landrace and Red ex Mbare, the climbing cultivars was 33.7%-38% higher than for CBC_3 and BEB, the improved upright types of cowpeas (Table I).

Leaf stripping and detasselling of maize in a maize-cowpea intercrop significantly ($P < 0.05$) influenced cowpea grain yield components (number of pods per plant, grains per pod, 1000 grain weight and grain yield and did not affect ($P > 0.05$) cowpea biomass Leaf stripping and detasselling maize at anthesis in a maize-cowpea intercrop resulted in a 14.65%, 10.51% and 5.18% increase in number of pods per plant, 1000 grain mass and cowpea grain yield, respectively, when compared to cowpeas grown under intact maize (Table II).

3.2 Maize Grain Yield and 1000-Grain Weight in the Intercrop and Monocrop

Leaf stripping and detasselling maize in a maize-cowpea intercrop ($P < 0.05$) significantly affected the size of maize grains as well as the grain yield. Maize yield and 1000 grain weight increased by 12% and 11.7% respectively in leaf stripped and detasselled maize compared to intact maize averaged across cowpea cultivars. Significantly higher grain yield (10.6%) and 1000 grain weight (9.6%) were recorded in leaf stripped and detasselled maize than in intact maize averaged across the cowpea varieties and cropping system treatments (Table III).

Cowpea cultivar in a maize-cowpea intercrop had a highly significant effect on maize grain yield ($P < 0.01$). Maize intercropped with the upright cowpea cultivars (BEB and CBC_3) had 16.1%-29.8% higher grain yield than maize intercropped with the trailing Local landrace and Red ex Mbare (Table IV).

Monocropped maize had significantly higher grain yield than intercropped maize (Table IV). Intercropping maize with CBC_3, BEB, Local landrace and Red ex Mbare caused 29.15%, 43.05%, 66.13%, and 67.66% maize grain yield reductions respectively when compared to sole maize. Although the test weight of monocrop maize was highest, it did not significantly differ with the test weights attained when the maize was intercropped with all the four cowpea cultivars (Table IV).

3.3 Weed Density and Biomass

Cropping system had a highly significant effect ($P < 0.01$) on weed density and biomass at 6 WAE and at maize physiological maturity. More (47%) numbers and greater (37%) biomass of weeds were recorded in the maize cowpea intercrop than in the sole cowpeas, early in the season, at 6 WAE. The opposite was true at maize physiological maturity, with twice as many and 87% greater weed biomass being recorded in the sole cowpea crops than the maize cowpea intercrops (Table V).

3.4 Productivity of Maize-Cowpea Intercrops

The productivity of maize-cowpea intercropping system with leaf stripping and detasselling was assessed through comparisons of Land Equivalent Ratios (LER) of the treatment combinations. The partial LERs for maize in a maize-cowpea intercrop was calculated based on unstripped intact sole maize (Table VI). Leaf stripping and detasselling conferred an 11% yield advantage over intact maize in sole maize. The LER when cowpeas were intercropped with intact maize was 1.54, 1.4, 1.34 and 1.17 for BEB, CBC_3, L. Landrace and R. ex-Mbare and when intercropped with leaf stripped and detasselled maize was 1.61, 1.63, 1.5 and 1.17, respectively, indicating gains in the efficiency of land use when maize was leaf stripped and detasselled and intercropped with upright cowpea varieties (BEB and CBC_3) and the trailing and climbing L. Landrace. Generally higher LERs were recorded with intercrops when maize was leafstripped and detasselled. The highest LER (1.63) was produced by maize-CBC_3 intercrop with maize leafstripped and detasselled (Table VI).

4.0 Discussion

The climbing cowpea varieties in this study allocated a greater proportion of their total dry matter to vegetative plant parts and less to grain yield when compared to upright cowpea varieties. This strategy enabled the these varieties to climb and entwine maize stalks up to the tassel, however pod formation and grain development in these varieties seemed to be very sensitive to photon flux density of PAR as the little yield they produced was observed to be confined to the tips of the vines that were exposed to full PAR at the top of the canopy, the rest of the shaded bean plant did not carry grain. Our results also show that the climbing varieties did not fare any better under monocrop conditions, climbing varieties produced grain yield that was 0.31-0.42 of the upright varieties grain yield (Table VI).They displayed a high propensity to allocate dry matter to vegetative materials (leaves, stems and petioles) under monocrop conditions. It was also apparent that the commercial plant densities that we used for cowpeas were too high for the climbing varieties, we observed that smallholder farmers use lower (half of the plant density that we used) when planting climbing varieties in both monocropping and intercropping situations. Excessive mutual shading reduced the grain yield of these climbing varieties when planted as sole crops, given the sensitivity of grain yield of these climbing varieties to photon flux density that we observed in the intercrops. Maize suffered 16.1-29.8% greater yield loss when intercropped with climbing cowpea varieties than when intercropped with upright cowpea varieties (Table IV) showing that the climbing varieties were more competitive against maize in the intercrops. When climbing varieties entwine the maize plant, their foliage causes partial shading of the maize canopy, reducing photosynthetic production and maize grain yield. Upright cowpea varieties on the other hand occupy the under-storey of the maize canopy and exert less influence on the total PAR intercepted by the maize plant compared to climbing varieties. The apparent high sensitivity to low PAR conditions in the canopy and the greater levels of competitiveness for PAR against maize displayed by the climbing cowpea varieties indicates less adaptability of the climbing cowpea varieties to intercropping when compared to upright varieties, our results suggest.

In this study, leaf stripping and detasselling of the maize consistently increased maize grain yield and 1000 grain mass by 11-12% in intercropped and sole maize. Increases in maize grain yield due to detasselling have been attributed to increased radiation interception by maize leaves as a result of removal of the “tassel shading effect” and/or the removal of the apical dominance effect (Mostert and Marais, 1982; Subedi, 1996). Barbieri *et al*., 2000 and Andrade et al., 2002 observed that increased radiation penetration into the maize canopy during the critical three week period bracketing anthesis resulted in increases in kernel number and kernel weight, as observed in this study on leaf stripping and detasselling. In previous research Mashingaidze *et al*., (2004) it was established that removal of bottom 4-6 leaves at 50% silking (leaf stripping) significantly increased maize grain yield and we attributed the maize grain yield increases to the removal of senescing leaves which if they remain on the plant would transpire and subject the plants to water deficits during critical moisture stress sensitive stages of anthesis and grain filling. Crookstone and Hicks (1988) provided evidence that partial defoliation of the maize plant conserved water in the plant and alleviated the yield reducing effects of drought stress in dry seasons but had no effects on grain yield in wet seasons. Leaf stripped, detasselled and leaf stripped and detasselled maize achieved significantly higher rates of ear growth rate when compared to intact maize, however the combined effect of leaf stripping and detasselling was not higher than that of detasselling or leaf stripping on their own, indicating that the two interventions affected the same process, but were not additive (Mashingaidze *et al*., 2004). Our results also show that leaf stripping and detasselling benefited cowpea grain yield components and total grain yield as a result of increased PAR penetration into the lower echelons of the canopy occupied by the cowpeas. The effects of leaf stripping and detasselling on maize and cowpea grain yield resulted in the higher efficiencies of land use as measured by LER that were recorded in leaf stripped and detasselled treatments than intact ones, in this study (Table VI). These results show that leaf stripping and detasselling is a technological intervention that has potential be deployed by smallholder farmers to increase the productivity of intercrops by increasing both maize grain yield and minor crop yield.

The results of this study show that sole cowpea crops suppressed weeds more than the maize cowpea intercrops early in the season but the trend was reversed late in the season when the maize cowpea intercrops reduced weed density and biomass more than the sole cowpea crops. These results suggest that the maize cowpea intercrop is more effective in suppressing late weeds than the sole cowpea crops. These results are similar to what has been observed by (10).

5.0 Conclusions

In conclusion the results of this study indicate that the new upright cowpea varieties are adaptable to be intercropped with maize as they produced more cowpea grain yield and competed less with the maize (caused less reduction in maize grain yield in maize cowpea intercrops) than the climbing varieties; leaf stripping and detasselling has potential to increase intercrop productivity by increasing the maize and the cowpea grain yield and maize cowpea intercrops can reduce emergence and growth of (late) weeds.

References

Andrade, F. H., Calviño, P., Cirilo, A. and Barbieri, P. (2002). Yield responses to narrow rows depend on increased radiation interception. *Agronomy Journal,* **94**, pp 975-980.

Barbieri, P. A., Sainz Roza, H. R., Andrade F. H. and Echeverria H. E. (2000). Row spacing effects at different levels of nitrogen availability in maize. *Agronomy Journal,* **92**, pp 283-288.

Crookstone K. R. and Hicks D. R. (1988). Effect of early defoliation on maize growth and yield: An eleven year perspective. *Crop Science*, **28**, pp 371-373.

Duncan, W. G., Williams, W. A. and Loomis, R. S. (1967). Tassels and the productivity of maize. *Crop Science,* **7**, pp 37-39.

Francis C. A. (1985). Intercropping: Competition and yield advantage. In R. Shibles (Ed*.), World Soybean Research Conference III.* Westview Press, Boulder, Colorado, pp1017-1024.

Giller K. E., McDonagh, J. F. and Cavendish, G. (1993). Can biological nitrogen fixation sustain agricultural production in the tropics? In J.K. Syers and D. L. Rimmer (Ed.), *Soil Science and Sustainable Land Management.* C.A.B. International, Wallingford. pp 173-192.

Hunter R. B., Daynard T. B., Hume D. H., Tanner J. W., Curtis J. D. and Kannenberg L. W. (1969). Effects of tassel removal on grain yield of corn (*Zea mays* L.) *Crop Science,* **9**, pp 405-406.

Ledbetter K.(2005). Cowpeas could add sustainability to cropping systems. Agnews, Texas a & M University System Agriculture Program http//newsagnews.tamu.edu/dailynews/stories/SOIL/Oct0405a.htm

Mariga, I. K. (1990). Effect of cowpea planting date and density on the performance of maize-cowpea intercrop. *Zimbabwe Journal of Agricultural Research,* **28**, pp 125-131.

Mashingaidze, A. B**.**, Hupenyu, A. and Nyakand, C. (2006). Leaf stripping and detasselling increases maize cob growth rate and grain yield. Combined Cogress, University of KwaZulu Natal, 23-26 January, 2006.

Mashingaidze, A. B., Nyakanda C., Chivinge O. A., Mwashaireni A.and Dube K. W. (2000). Influence of maize-pumpkin live mulch on weed dynamics and maize yield. *African Plant Protection* 6(1):57-63.

Mashingaidze, A. B., van der Werf W, Lotz L. A. P., Kropff M. J., Mudita, I. and C. Nyakanda 2004. Leaf stripping and detasselling increases maize grain yield. *Tropical Resources Management Papers,* **57**, pp 15-30.

Mead, R. and Willey, R. W. (1980). The concept of a 'land equivalent ratio' and advantages in yields from intercropping. *Experimental Agriculture,* **16**, pp 217-228.

Moster, A. J. and Marais, J. N. (1982). The effects of detasselling on the yield of irrigated maize. *Crop Production/Gewasproduksie* XI: pp 163-167.

Norman, D. W., Simmons, E. B. and Hays, H. M. (1982). Farming systems in the Nigerian Savannah: Research and strategies for development. Westview Press, Boulder, Colorado.

Ofori, F. and Stern W. R. (1987). Cereal-legume intercropping systems. *Advances in Agronomy*, **41**, pp 41-87.

Richards, P. (1983). Ecological change and politics of African land use. *African Studies Review,* **26**, pp 1-72.

Ruthenberg, H. (1980). Farming systems in the Tropics. Oxford Press, Oxford.

Shimada, S., Kokobun, M. and Shibata, H. (1992). Effect of water supply and defoliation on photosynthesis, transipiration and yield of soybean. *Japanese Journal of Crop Science* **61**(2), pp 264-270.

Steel, R. G. D. and Torrie, J. H. (1984). Principles and Procedures of Statistics. 2nd Edition. MacGraw-Hill, New York.

Subedi, K. P. (1996). Effect of leaf stripping, detasselling and topping of maize on maize and relay intercropped finger millet. *Experimental Agriculture,* **32**: 57-61.

Tafera, T. and Tana, T. (2002). Agronomic performance of sorghum and groundnut cultivars in sole and intercrop cultivation under semi-arid conditions. *Journal of Agronomy and Crop Science,* **188**, pp 212-218.

Willey, R.W. (1990). Resource use in intercropping systems. *Agriculture and Water Management* **17**, pp 215-231.

Zimdahl, R. L. (1999). Fundamentals of weed science. Academic Press, San Diego.

Table 1: Effect of cowpea cultivar on grain yield and yield components of cowpeas in maize-cowpea intercrops

Cultivar	# of pods plant $^{-1}$	# of grains pod $^{-1}$	1000 grain weight (g)	Grain yield kg ha^{-1}	Plant biomass kg ha^{-1}
BEB	3.00c[1]	9.2c	184.77c	119.21c	88.79a
CBC_3	3.33d	11.0d	147.27b	135.07d	85.80a
Local Landrace	2.23b	6.9b	170.24c	47.02b	129.56b
Red ex Mbare	1.13a	1.63a	88.94a	34.20a	140.21b
P-value	0.000	0.000	0.000	0.000	0.010
Sed	0.12	0.50	6.71	2.19	16.58
Lsd $_{0.05}$	0.26	1.07	14.35	4.71	35.49

[1]Means followed by the same letter in a column are not significantly different at P<0.05

Table 2: Effect of leaf stripping and detasselling maize on cowpea grain yield and yield components in maize-cowpea intercrops

Leaf stripping and detasseling	# of pods plant^{-1}	# of grains pod^{-1}	1000 grain weight g	grain yield kg ha^{-1}	plant biomass kg ha^{-1}
Leaf strip detass	2.62b[1]	7.58b	156.00b	86.11b	122.59
Intact maize	2.23a	6.82a	139.60a	81.65a	99.59
P-value	0.001	0.047	0.004	0.013	0.07
Sed	0.09	0.35	4.74	1.55	11.73
$LSD_{0.05}$	0.18	0.75	10.14	3.33	NS

[1]Means followed by the same letter in a column are not significantly different at P<0.05

Table 3: Effect of leaf stripping and detasselling on maize grain yield in the maize cowpea intercrop and averaged across intercrop and monocrop treatments

	Maize cowpea intercrops		Averaged across monocrop and intercrop treatments	
Treatment	1000 grain grams	Grain yield tons ha^{-1}	1000 grain grams	Grain yield tons ha^{-1}
Leaf strip detass	536.32b[1]	5.17b	538.02b	5.67b
Intact maize	473.56a	4.60a	486.45a	5.07a
P value	0.043	0.028	0.038	0.000
Sed	28.27	0.23	23.05	0.19
$Lsd_{0.05}$	60.50	0.50	48.40	0.41

[1]Means followed by the same letter in a column are not significantly different at P<0.05

Table 4: Effect of cowpea variety on maize grain yield and test weight and comparisons of monocropped maize grain yield and test weight to maize in maize-cowpea intercrops

cowpea cultivar	1000 grain weight (g)	Grain Yield (tonnes ha^{-1})
BEB	441.45	5.11b
CBC_3	544.58	5.66c
Local Landrace	503.23	4.40a
Red ex Mbare	530.48	4.36a
Maize monocrop	541.43	7.31d
P-value	0.060	0.000
Sed	36.44	0.12
$LSD_{0.05}$	NS	0.252

Table 5: Effect of cropping system on weed density and biomass at 6 WAE and at maize physiological maturity 17 WAE

Cropping System	6 weeks after emergence: weed density number m^{-2}	6 weeks after emergence: weed biomass grams m^{-2}	At maize physiological maturity: weed density number m^{-2}	At maize physiological maturity: weed biomass grams m^{-2}
Sole cowpea	13.40a[1]	4.72a	13.76b	2.69b
Maize-cowpea	19.75b	6.48b	6.78a	1.44a
P value	0.001	0.000	0.000	0.001
Sed	1.46	0.32	0.69	0.30
$Lsd_{0.05}$	3.12	0.68	1.48	0.63

[1]Means followed by the same letter in a column are not significantly different at P<0.05

Table 6: Land Equivalent Ratio (LER) analysis of treatment combinations in a maize- cowpea intercropping experiment

Treatment	maize grain yield t ha^{-1}	pLER[1] maize	cowpea grain yield kg ha^{-1}	pLER cowpea	LER
Sole maize					
Intact	6.94	1	_	_	1
Leafstripped and detasselled	7.68	1.11	_	_	1.11
Maize- cowpea intercrop					
Leaf strip and detass & BEB	5.35	0.77	118.98	0.84	1.61
Intact &BEB	4.88	0.70	119.44	0.84	1.54
Leaf strip and detass & CBC_3	6.11	0.88	140.05	0.75	1.63
Intact &CBC_3	5.20	0.71	130.09	0.69	1.4
Leaf strip and detass & L.landrace	4.70	0.68	49.24	0.82	1.5
Intact and L.landrace	4.10	0.88	44.81	0.74	1.62
Leaf strip and detass & ex, Mbare	4.51	0.65	36.16	0.52	1.17
Intact and ex, Mbare	4.23	0.61	32.25	0.56	1.17
Sole cowpea					
BEB	_	_	142.49	1	1
CBC3	_	_	187.27	1	1
Local landrace	_	_	59.61	1	1
Red ex Mbare	_	_	57.64	1	1

pLER[1] = partial Land Equivalent Ratio