MAIZE-COWPEA INTERCROPPING AND WEED SUPPRESSION IN LEAF STRIPPED AND DETASSELLED MAIZE IN ZIMBABWE

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ABSTRACT

A study was conducted to evaluate the suitability of cowpea (Vigna anguiculata) varieties for maize-cowpea intercropping in leaf stripped and detasselled maize at the University of Zimbabwe Farm during the 2005/6 cropping season. A Randomized Complete Block Design (RCBD 4*3*2 factorial experimental design was adopted. Three factors that included cowpea variety, cropping system and detasselling/leaf stripping were used for the design. Trailing and climbing varieties invested more dry matter to vegetative growth than the new upright bushy cultivars that invested most of their dry matter in grain yield. Leafstripping and detasselling significantly increased cowpea grain and maize yields. Sole cowpea grain yield was significantly higher than grain yield from their respective intercrops. Weed density significantly (P<0.01) decreased at 6 weeks after crop emergence (WACE and at maize physiological maturity (PM), and biomass decreased at 6 (WACE) and maize (PM) respectively. Weed density was reduced in the intercrops when maize was intercropped with CBC3, BEB and L. Landrace. In contrast R.ex-Mbare was not effective in suppressing weeds when intercropped with maize. Leafstripping and detasselling maize at anthesis can be used by smallholder farmers to increase the productivity of maize and cowpea.

KEYWORDS

intercropping adaptability weed suppression productivity leafstripped detasselled.
INTRODUCTION
In Zimbabwe’s smallholder sector, maize is commonly intercropped with legumes like cowpea (*Vigna anguiculata*) and curcubits that include low densities of pumpkins (*Curcubita maxima*), groundnut (*Arachis hypogea*) and cucumber (*Cucumis sativa*) (Mariga, 1990). Among these combinations cowpea is widely intercropped with maize not only in Zimbabwe but in Southern Africa. Besides their compatibility in the field, these two crops complement each other in human diets as a ready source of carbohydrates (Galinat, 1992) and proteins with 22-30% protein. However, these crops continue to be grown in traditional formats with limited scientifically established cultural practices that would exploit interactions between the two crops for maximizing yield and weed suppression.

Intercropping is an important agricultural technique that improves diversification of food supply (Francis, 1985) and ensures high economic returns (Norman, Simmons and Hays, 1982). It also suppresses weeds particularly when short statured, bushy cowpea varieties are used (Zimdahl, 1999). These varieties have the potential to intercept incident radiation reaching the soil surface (Liebman, 1988). Cowpea cultivars with a prostrate, vining and dense crop canopy also act as live mulch, suppressing weed germination and growth (Mashingaidze, 2004). Thus, reducing the frequency of weeding the maize crop and the labour costs involved (Akobundu, 1993).

Intercropping results in efficiency of land utilization and improved yields (Mashingaidze (2004). However, the maize yield was observed to be depressed by 12-22% when intercropped with a legume (*ibid*). This is mainly due to competition for water and nutrients yield by the minor crop (Liebman and Dyck, 1993). Yields decline for the legume crop are due to reduced Photosynthetic Active Radiation (PAR) reaching the lower parts of the intercrop canopy (Subedi, 1996). A second reason advanced is due to the early maturity of the minor crop that does not allow it to benefit from increased PAR penetration towards the end of the growing season when the dominant cereal senesces (Mashingaidze, 2004).

The architectures of climbing cowpea varieties yield well maize intercropped. They have greater vertical separation of the leaves that probably improve the radiation interception of the climber in intercropping (Trenbath and Angus, 1975) and depend on the cultivar, spatial arrangement and foliage architecture of the component crops (Subedi, 1996). Cowpea varieties with an upright and semi-determinate structure are potentially less competitive for light resource. In contrast traditional cowpea varieties are more vigorous and active competitors for light. This characteristic is attributed to perennial intercropping (Iwaki, 1959, Williams, 1964 Kumura, 1968). They have reduced rates of dark respiration, lowered root to shoot ratio and greater leaf area to leaf weight ratio which increase their chances for survival and increased yields of the intercrops if enhanced with architecture modification. Maize crop architecture modifications are achieved through leaf stripping (removal of lower leaves of maize plants) and detasselling at anthesis (the removal of male inflorescence of a maize plant (Mashingaidze, 2004). High yields of maize are achieved by a smaller proportion of barren plants in the detasselled treatments than intact plants (Chinwuba, Grogan and Zuber, 1961), diversion of energy normally expended in pollen production to grain production and increases in PAR penetration in the maize canopy (Mashingaidze, 2004).

The aim of this study was therefore to determine the suitability of commonly grown cowpeas varieties (BEB, CBC3, and L. Landrace and Red ex-Mbare) for intercropping with intact maize and maize modified by detasselling and leaf stripping.
METHOD AND MATERIALS

Site location and description
The experiment was carried out at the University of Zimbabwe Farm during the 2005/6 cropping season fifteen kilometers north of Harare. Altitude on the farm varies from highest point of 1480 metres to the lowest of 60 metres. The arable lands are flat with slopes of 2% or less. The farm is in Natural Region 2a (Vincent and Thomas, 1960) and is a reliable cropping area with annual rainfall ranging between 444 mm and 1270 mm. The mean annual temperature is 19C with risk of frosts between late May and early August. The farm has deep to moderately deep well drained granular, red clay soils derived from epidiorite rocks with some intrusions of ironstone.

Treatment description and Experimental Design
The experiment was set up as a 4*3*2 factorial in a Randomized Complete Block Design (RCBD) with four factors; variety, cropping systems, Leafstripping and detasselling. The BEB, CBC3, Local Landrace and Red ex-Mbare cowpea varieties were used for the experiment. The cropping systems used in the experiment were sole cowpea, sole maize and maize-cowpea intercrops. A commercial late maturity hybrid maize seed, SC637 was used and Leaf stripped/detasselled treatment was done at 50% silking. The gross plot size was 4.56 m, that is total area planted and the net plot size was 3.6×4m (the net size of the land excluding the border effects for the measurement of yields).

Plots were marked, disc ploughed and harrowed to a fine tilth just before planting on the16th of December, 2005. Planting furrows were opened using hoes at 90 cm interrow and 30 cm within row spacing for the sole maize plots and 45 cm and 20 cm respectively for the sole cowpeas plots. Cropping density in intercrops for cowpea was 156 or 55 555 plants ha⁻¹ and 311 for sole cow pea plots or 111 000 plants ha⁻¹. Maize was planted at a density of 37 000 plants ha⁻¹ in all the treatments. Compound D (7%N, 14%P₂O₅, 8%K₂O) was applied into furrows before seeding maize at 150 kg ha⁻¹. Super sulphate SSP (19% P₂O₅, 5 %S) was dribbled into cowpea planting furrows a and 150 kg ha⁻¹. Two maize seeds were dropped per hole and were thinned to one plant per planting station at two WACE. Cowpea was overseeded and later thinned to 20 cm between plants at three WACE in both the intercrop and the monocrop.

Maize was top dressed with 150 kg ha⁻¹ Ammonium Nitrate (34.5%N) at five WACE and nothing was applied to the sole cowpeas. At 5 and 8 WACE, carbaryl (85%WP) was sprayed into the maize funnel at 20 g/10l of water to control maize stalk borer (Busseola fusca). Dimethoate® (40%EC) was also sprayed at 5 WACE to control leaf eaters at 83 ml ha⁻¹. Benomyl and Copper Oxychloride® (85%WP) were sprayed at 50 g/10l of water to control Ascochyta blight in cowpea during flowering. The crops were hoe weeded twice, at 3 and 8 WACE. Leaf stripping and detasselling was done at 50% silking. Weed density and biomass measurements were done at six WACE and at physiological maturity (PM) through use of randomly thrown quadrants measuring 30 30 cm into the net plot. Weeds were cut at ground level, put into brown paper bags and were dried at 80C for 48 hours.

The yield and yield components of cowpeas were determined at physiological maturity. Number of pods per plant, number of beans per pod, cowpea grain yield, 1000-bean weight and the residual vegetative biomass of cowpea plants were measured. Cowpea pods were picked when they were brown and rattling within the pod, but before
they shattered. A random sample of ten cowpea plants was selected and means permuted. Moisture content was measured for each cowpea sample using a moisture meter and the final cowpea grain yield was standardized to 11% moisture content. Maize was dried in greenhouses for fourteen days, thrashed and grain yield per plot was measured using a suspension scale. Moisture content was measured for each maize sample and the final maize grain yield was standardized to 12.5% moisture content.

**Data analysis**

Cowpea grain yield, above ground biomass (minus grain), number of pods per plant, cowpea 1000 seed weight and number of cowpeas per pod were analyzed as a 4*3 factorial in a RCBD testing the effect of cropping system (maize-cowpea intercrop with maize leaf stripped and detasselled, maize cowpea intercrop with maize intact, sole cowpea), and the effect of variety (BEB, CBC₃, Local Landrace (L. Landrace) and Red ex Mbare) as well as their interactions. Maize grain yield and 1000 grain were analyzed as a 4*2 factorial in a RCBD testing the effect of leaf stripping and detasselling (leaf stripped and detasselled maize) and cowpea variety (BEB, CBC₃, L. Landrace and Red ex Mbare) as well as their interactions. To compare the performance of sole maize treatments with detasselling and leaf stripping and cowpea variety treatment combinations, a RCBD with 10 treatments was used. Weed density were expressed on a square metre basis and was square root transformed before the Analysis of Variance (ANOVA) (Steel and Torrie, 1984) using Minitab Version 12. Weed biomass was expressed in g m⁻² and weed density was expressed in number m⁻² before ANOVA. Maize grain and cowpea yield were expressed in tonnes ha⁻¹ and kg ha⁻¹ respectively before the Analysis of Variance (ANOVA). Means were separated using Least Significant Difference (LSD) at P<0.05. Productivity of intercropping was assessed by calculating the Land Equivalent Ratios (LERs) from component crop yields (Mead and Willey, 1980) using the following formula;

\[ \text{LER}_T = \text{LER}_M + \text{LER}_C = \frac{Y_{IM} + Y_{IC}}{Y_{SM} + Y_{SC}} \]

Where \( \text{LER}_T \) is the total LER
- \( \text{LER}_M \) is the partial LER for the maize crop
- \( \text{LER}_C \) is the LER for the cowpea crop
- \( Y_{IM} \) is the mass of yield unit area⁻¹ of intercropped maize and cowpea
- \( Y_{SM} \) is the mass unit area⁻¹ of sole maize
- \( Y_{SC} \) is the mass unit area⁻¹ of sole cropped cowpeas.

If LER is greater than one, then intercropping has a yield advantage (Willey, 1979).

**RESULTS AND DISCUSSIONS**

**Cowpea-maize intercrops compared to sole crop controls**

Intercropping BEB, CBC₃ and Red ex Mbare with maize leaf stripped and detasselled reduced cowpea grain yield by 16.5%, 25.2% and 37.2% respectively. Under intact maize, BEB, CBC₃ and Red ex Mbare cowpea grain yield was lower by 16.2%, 30.5% and 44% when compared to the respective sole crop grain yield of each variety. When local landrace was intercropped there was no significant difference in grain yield compared to its monocrop treatment. Monocropped upright cowpea cultivars, BEB and CBC₃ had significantly higher 1000 grain weight than intercropped cowpeas with maize.
intact or leafstripped and detasselled (Table 1). Intercropping BEB and CBC with intact maize reduced 1000 grain weight by 41.95% and 35.5% respectively while under leafstripped and detasselled maize 1000 grain weight was reduced by 3.5% and 29.5% respectively, when compared to sole crops of each variety. The test weights of sole climbing cowpea cultivars, L. Landrace and Red ex-Mbare were not statistically different from their respective intercrops (Table 1).

BEB showed no significant difference in number of grains per pod when it was either intercropped or monocropped (Table 1). When maize was leafstripped and detasselled the number of grains per pod for CBC and L. Landrace were reduced by 15.4% and 50.1% respectively. Red ex-Mbare intercrop had an 8% increase in number of grains per pod when it was intercropped with leafstripped and detasselled maize compared to the monocrop. However, this variety showed no significant differences with the intercrop in number of grains per pod when maize were intact (Table 1).

Table 1: Cowpea grain yield and yield components in the maize-cowpea intercrops compared to sole cowpeas.

<table>
<thead>
<tr>
<th>Treatment</th>
<th># of pods plant$^{-1}$</th>
<th># of grains pod$^{-1}$</th>
<th>1000 grain (weight g$^{-1}$)</th>
<th>grain yield (kg ha$^{-1}$)</th>
<th>Plant biomass (kg ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize-BEB Lsdetass</td>
<td>3.27c</td>
<td>9.47d</td>
<td>198.47d</td>
<td>118.98c</td>
<td>94.35a</td>
</tr>
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<td>Maize-BEB intact</td>
<td>2.73bc</td>
<td>8.93d</td>
<td>191.44b</td>
<td>119.44c</td>
<td>83.24a</td>
</tr>
<tr>
<td>Maize-CBC$_3$ Lsdetass</td>
<td>3.40cd</td>
<td>11.53e</td>
<td>153.80c</td>
<td>140.05d</td>
<td>87.24a</td>
</tr>
<tr>
<td>Maize-CBC$_3$ intact</td>
<td>3.27c</td>
<td>10.60c</td>
<td>140.74bc</td>
<td>130.09d</td>
<td>73.74a</td>
</tr>
<tr>
<td>Maize-Lrace Lsdetass</td>
<td>2.27b</td>
<td>6.87c</td>
<td>176.07cd</td>
<td>49.24b</td>
<td>147.71ab</td>
</tr>
<tr>
<td>Maize-Lrace intact</td>
<td>2.20b</td>
<td>6.93e</td>
<td>164.42cd</td>
<td>44.81ab</td>
<td>111.41a</td>
</tr>
<tr>
<td>Maize-R,Mbare Lsdeta</td>
<td>1.53b</td>
<td>2.47b</td>
<td>95.67a</td>
<td>36.16a</td>
<td>150.43ab</td>
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<tr>
<td>Maize-R,Mbare intact</td>
<td>0.73a</td>
<td>0.80a</td>
<td>82.20a</td>
<td>32.25a</td>
<td>129.98ab</td>
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<tr>
<td>BEB monocrop</td>
<td>4.07d</td>
<td>9.47d</td>
<td>205.70e</td>
<td>142.49d</td>
<td>146.10ab</td>
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<tr>
<td>CBC$_3$ monocrop</td>
<td>5.67e</td>
<td>13.63f</td>
<td>218.15e</td>
<td>187.27e</td>
<td>109.92a</td>
</tr>
<tr>
<td>Landrace monocrop</td>
<td>2.47bc</td>
<td>13.77f</td>
<td>178.90c</td>
<td>59.61b</td>
<td>203.1b</td>
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<tr>
<td>Red,Mbare monocrop</td>
<td>0.93a</td>
<td>1.37a</td>
<td>94.14a</td>
<td>57.64a</td>
<td>186.96b</td>
</tr>
</tbody>
</table>

P-value, Sed, LSD$_{0.05}$

<table>
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<tr>
<th>P-value</th>
<th>Sed</th>
<th>LSD$_{0.05}$</th>
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<tr>
<td>0.000</td>
<td>0.37</td>
<td>0.77</td>
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</tbody>
</table>

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

The residual vegetative biomass of CBC$_3$, BEB and Red ex-Mbare were not significantly different when they were either grown in monocrops or in the intercrop. The climbing cultivars, L. Landrace and Red ex-Mbare in monocrops had significantly higher residual vegetative biomasses compared to their intercropped treatments (Table 1).

Leafstripping and detasselling maize in a maize-cowpea intercrop (P<0.05) significantly affected 1000-grain weight as well as the grain yield. Cowpea cultivar grown with maize did not significantly affect (P>0.05) 1000 grain weight. There was no significant interaction between cowpea cultivar and leafstripping and detasselling on 1000-grain weight as well as maize grain yield). Maize yield and 1000-grain weight increased by 12% and 11.7% respectively in leafstripped and detasselled maize compared to intact maize averaged across cowpea cultivars. 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 13.9%-22.9% higher grain yield than maize intercropped with the climbing varieties (Table 1). There was no significant interaction (P>0.05) between cowpea cultivar and leafstripping and
detasselling on 1000-grain yield and maize grain yield.

The upright cowpea cultivars intercropped with maize reduced maize grain yield probably due to the small staturedness of the upright cowpea cultivars that offered little competition with maize for important growth resources. The crawling cowpea varieties crawled over the maize and shaded some of the most photosynthetically active leaves such as the cob leaves, therefore reducing maize grain yield. The upright cultivars also appeared to mature too early (Mashingaidze, 2004 and Wein and Nangju (1976) prior to the reproductive phase of maize therefore reducing competition at the reproductive phase of maize. The vigorous nature of the climbing cowpea cultivars resulted in competition for water, nutrients and light therefore reducing the amount of incident light to penetrate the cob leaves (Mashingaidze, 2004) as well as other leaves that contribute assimilates for the grain filling processes therefore significantly reducing maize grain yield.

Maize yield reduction in intercropped maize compared to the sole maize reductions could be due to a higher degree of interspecific competition in mixed stands and the absence of interspecific competition in the monocrops (Agboola and Fayemi, 1971), Semu and Jana 1975 and Enyi, 1973). The delays in senescence in the monocropped treatment increased the grain filling period therefore increasing the size of kernels contributing to higher maize yield.

Cowpea grain yield was reduced at varying rates for BEB, CBC3, Local Landrace and Red ex Mbare, respectively when intercropped with maize. These variations could be due to the different architectures of cowpea cultivars. BEB and CBC3 are short statured semi-prostrate cowpea cultivars (Musundire, 2005) as indicated by their low residual vegetative biomass. The cultivars spent much of their energy in reproductive growth at the expense of vegetative growth. CBC3 and BEB produced relatively high number of pods per plant, grains per pod and the extent of grain filling was relatively higher compared to the climbing cultivars. The L. Landrace and Red ex-Mbare produced relatively lower yield components because of extensive vegetative growth at the expense of reproductive growth. A relatively longer length of time the cowpeas take to reach the reproductive phase as well as a shorter grain filling period in the climbing cultivars also contributed to the reduced cowpea grain yields in the climbing cultivars.

Leafstripping and detasselling increased cowpea yield and its yield components compared to the intact treatments averaged across cowpea cultivars. This was due to the increase in the amount of incoming PAR into the canopy to the benefit of the dominated minor crop (Subedi, 1996 and Mashingaidze, 2004). Detasselling and leafstripping was also likely to benefit a companion crop grown under the canopy of the maize that continues to grow and reproduce long after leafstripping and detasselling interventions were implemented (Mashingaidze, 2004) therefore increasing cowpea yield. The indeterminate Local landraces and Red ex-Mbare were therefore more likely to exhibit the greater yield benefits from leafstripping and detasselling but however failed due to disease attack. The cowpea cultivar*leafstripping and detasselling interactions showed that leafstripping and detasselling treatment affected the production of pods on cowpea cultivars differently. The effects of leafstripping and detasselling treatment was only expressed when Red ex Mbare intercropped with maize that was leafstripped and detasselled. The results suggest that as long as farmers intercrop maize with cowpeas there is no additional gain in number of pods per plant as a result of leafstripping and detasselling maize, however grain yield is positively affected.
Weed density and biomass

Weed density and biomass were significantly affected by cropping system (P<0.05). However, cowpea cultivar grown with maize had no significant effect on the number of the weeds that emerged as well as weed growth at 6 WACE. There was a significant cultivar* cropping system interaction on weed density at 6 WACE. Weed density and biomass were significantly lower when maize was intercropped with cowpeas than sole cowpeas (Table 1). Significantly higher weed density (32%) and biomass (27%) were recorded in sole cowpeas than the maize-cowpea intercrops. Cropping system had a significant effect (P<0.05) on weed density and biomass at physiological maturity. Cowpea cultivar grown with maize (P>0.05) had no significant effect on weed density and biomass. There was no significant interaction between cropping system and cowpea cultivar grown with maize.

There was a significant interaction (P=0.042) between cropping system and cowpea cultivar grown with maize on weed density at 6 WACE. There was a difference in the effectiveness of cowpea cultivars to suppress weed emergence in the intercrop and when planted as monocrops. When Local Landrace, BEB and CBC were intercropped with maize, weed density was significantly reduced by 34%, 42% and 50.5% respectively compared to the cowpea monocrops. In contrast when Red ex Mbare was intercropped with maize, weed density was not significantly reduced compared to the monocropped treatment.

Leafstripping and detasselling (P<0.05) significantly affected weed density at physiological maturity. This intervention significantly increased weed density by 37.2% than intact maize averaged across cowpea cultivars and cropping system. Weed biomass was 33.3% lower in intact maize compared to leafstripped and detasselled maize although not statistically significant. There was no significant interaction between leafstripping and detasselling of maize at anthesis and cowpea cultivar on weed density and biomass.

Figure 1 Interaction between cowpea cultivar and cropping system on weed densities at 6 WACE. (Error bars are ±standard error of the difference SED).

Maize-cowpea intercropping reduced weed germination as well as weed. Weed biomass was significantly reduced by 46.2% in the intercropped treatments compared to sole cowpea treatments (Figure 1). There was no significant cropping system*cultivar interaction (P>0.05) on weed biomass and density. Cowpea cultivars grown with maize did not have a significant effect on weed density and biomass at 6 WACE probably due to similar initial growth rates of the various cultivars (Musundire, 2005). The growth rates were almost the same such that the number of weeds that emerged as well as their growth was almost similar.

The cultivar*cropping system interactions on weed density showed that weed density did not respond to cropping system only when Red ex-Mbare was grown but with all the other varieties, the intercrops had lower weed density when intercropped than monocropped. These results mean that as long as smallholder farmers intercrop maize with cowpeas there is a gain in weed suppression in intercropped treatments than sole treatments as indicated by the lower weed densities in intercropped treatments, however there is not much benefit in intercropping Red ex-Mbare with maize for the purpose of weed suppression.

Maize-cowpea intercrops reduced density and weed biomass when compared to sole crops. This was consistent with the work of Mashingaidze, Nyakanda, Chvinge,
Mwashaireni and Dube (2000) in a maize-pumpkin live mulch experiment. The reduction in weed densities of intercropped treatments was as a result of limited availability of resources to weed species (Gahlot, 1978). The interrow spaces provide room for weeds to flourish in monocrops compared to the intercrops (Gahlot, 1978) therefore increasing weed density in monocrops. In intercrops, the combined foliage of the cereal and legume crop intercepted most of the green and red light leaving far red to reach the ground. Far red light is known to be inhibitory to weed germination (Bridgemohan and Braithwaite, 1987), and total ground cover by intercrops (Clark and Francis, 1985) was responsible for weed suppression by the intercrops. Weed biomass reduction in intercrops can be explained by the reduction in total incoming PAR reaching the ground caused by maize-cowpea intercrop. Similar to work done by Mashingaidze (2004) with a maize-pumpkin intercrop were the pumpkin had a similar growth habit to the climbing cowpea cultivars.

The increase in weed density and biomass (in leaf stripped and detasselled treatments at physiological maturity) can be attributed to an increase in the amount of incident PAR reaching the ground late in the season due to leafstripping therefore encouraging the germination of late weeds (Mashingaidze, 2004). The break in canopy architecture as a result of leafstripping and detasselling stimulated tremendous weed emergence (Bridgemohan and Brathwaite, 1987) resulting in the higher weed numbers observed late in the season in leafstripped and detasselled treatments compared to intact maize treatments.

CONCLUSION AND IMPLICATIONS TO FARMERS
The upright cowpea cultivars (CBC3 and BEB) were the more adaptable cowpea varieties for maize-cowpea intercropping where they gave the least maize and cowpea yield reduction and highest LERs (1.44-1.63) in contrast to the traditional trailing and climbing varieties that reduced maize and cowpea yields and had relatively lower LERs (1.17-1.51).

Leafstripping and detasselling increased maize grain filling and grain yield, compared to intact maize. Maize-cowpea intercrops reduced weed emergence at 6 WACE and physiological maturity. However, maize-CBC3 and maize-BEB intercrops were more effective in suppressing weeds compared to the maize-Local Landrace and maize-Red ex-Mbare intercrops.

The new upright cowpea varieties are suitable for intercropping with maize and are recommended for use in traditional maize-cowpea intercrops used by smallholder farmers in Zimbabwe. The traditional trailing and climbing varieties produced very low grain yields both in monocrops and when intercropped with maize. Leafstripping and detasselling maize at anthesis can be used by smallholder farmers to increase the productivity of maize and cowpea. Maize-cowpea intercropping increases the efficiency of land utilization (higher LER) and has potential to reduce the weeding burden of smallholder farmers-recommended in low input smallholder farming.

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