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Full Length Research Paper

Trade offs in grain and leaf yield of cowpea based on timing of leaf harvest

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The critical period for cowpea (*Vigna unguiculata* L. Walpers) leaf harvesting on grain yield of black eyed bean (BEB) cowpea type was determined by timing termination and commencement of leaf harvesting during 2005-2007 rain seasons. Two leaves were harvested from each plant per treatment up to pod formation as compared to no leaf harvesting. The times at which leaf harvesting began and ended had significant effects (p<0.05) on leaf yield, grain yield and above ground biomass. Highest leaf yield was obtained in the 2 - 8 weeks after crop emergence (WACE) leaf harvesting period for both on farm and on station in both seasons. The same period (2 – 8 WACE) produced the lowest grain yield, while highest grain yield was obtained when leaf harvesting was terminated at 2 WACE or commenced at 8 WACE. However, above ground biomass was less affected by leaf harvesting. Using Nieto curves to estimate grain and leaf yield trade offs, the critical leaf harvesting duration was 2 - 8 WACE, during which no leaf harvesting should be done to attain maximum grain yield, corresponding to start of branching to start of pod formation. It is recommended that farmers use morphological indicators to mark leaf-harvesting periods.

Key words: Black-eyed bean, cowpea, Nieto curves, critical leaf harvesting.

INTRODUCTION

The green portions of the plant, including leaves, form the photosynthetic machinery of the plant. Removal, therefore, of leaves constitute a reduction in photosynthetic tissue; hence reduction in production of photoassimilates used for crop growth. The rate of reduction in photoassimilation rate is even more pronounced if tender leaves are removed. The timing of leaf removal affects the cowpea's ability to recover from defoliation (Barrett, 1987). Defoliation during the vegetative developmental phase does not significantly affect yield, but defoliation during the reproductive phase often does (Saidi et al., 2007).

In Zimbabwe, smallholder- farmer's routinely carryout leaf harvesting of cowpea plants, for use as relish, without knowledge of the potential grain yield reduction effects this might have (Madungwe and Matikiti, 2004). There are several studies that have shown grain yield reduction, mainly due to leaf harvesting, but with variations owing to differences in time between leaf harvests and stage of development (Bittenbender, 1992; Madamba, 2000). It is therefore, important for the farmers to know the optimum period and stage when cowpea can tolerate leaf harvesting with minimum grain yield loss (Nielsen et al., 1997).

Deciding when to begin leaf harvesting in order to maximize both leaf harvest and full grain yield is a compromise between timing that allows the crop to recover from defoliation and timing that minimizes on leaf loss. The time between the maximum tolerated period of leaf harvesting and the minimum time of leaf harvesting is referred as to the 'critical duration of leaf harvesting', when leaf harvesting should not be done to minimise grain yield loss. Critical period represents the overlap of two separate components: (a) the length of time leaf harvesting can be done before it interferes with the formation of grain and (b) the length of time leaf harvesting must not be done so that subsequent leaf harvests does not reduce grain yield (Figure 1a).

There is little information on when leaf harvesting could be performed without affecting grain yield. Therefore, the aim of this study was to determine yield loss incurred with increasing period of leaf harvesting and to relate the critical leaf harvesting period to morphological or pheno-

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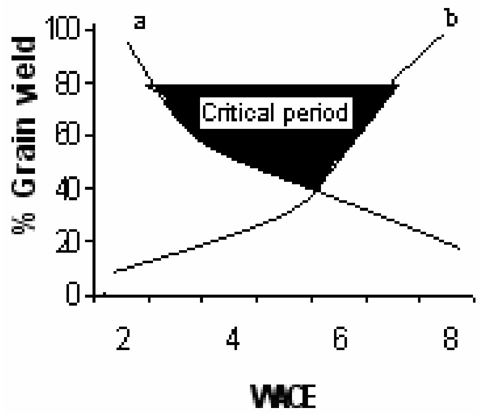

Figure 1a. Tradeoffs in grain and leaf yield of cowpea based on timing of leaf harvest. The shaded area is the critical period and denotes the period during which, a) leaf harvesting could be done and b) cannot be done with minimum reduction in yield.

logical indicators easily identifiable by smallholder farmers.

MATERIALS AND METHODS

Field experiment

An on – station experiment was carried out at the University of Zimbabwe, Department of Crop Science and in Mashonaland East Province, Mutoko, Nyadire Area during the 2005 – 2007 seasons. The department of crop sciences is located in the mount pleasant suburbs, 10 km northwest of the city of Harare. University of Zimbabwe is in natural farming region 2a, using the Zimbabwe rainfall pattern classification system, and receives a total rainfall of 750 – 1000 mm per annum. The area lies at 1500 m above sea level on red fersiallitic soils of 28% clay content. Generalized soil nutrient analysis was done at soils and chemistry department, ministry of agriculture, 2006 and the nutrient composition was 25 mgkg^{-1} available N; 7 mg kg^{-1} available P; 3.3 cmol$_c$ kg^{-1} exchangeable K; 6.75 cmol CEC; 1.1% carbon content and a pH of 5.5 ($CaCl_2$).

On- farm experiment was carried out in Katsukunya village161 km NE of Harare in Mutoko under Chief Kanyongo. The area lies between 32° 14'' and 32°17''East and between 17° 22'' and 17° 25'' South. The area is in natural farming region II characterized by the tropical savanna with three marked seasons: a warm wet summer (November-April), a cool dry winter (May-August) and a short dry spring (September-October). Soils are mainly coarse-grained sands and sandy loams over sandy clay loams (Mariatou and Kwaramba, 1999). The area is characterized by semi-extensive farming thus drought resistant crops and livestock production. Rainfall is confined to summer (Nov-April), and it is in the range 450 – 650 mm per annum. There are periodic seasonal droughts and severe dry spells during the rain season. The area was chosen because it simulates conditions under which most smallholder farmers are located and also cowpea varieties do very well under the conditions in the area. The soils are derived from granite rock and are sandy light textured and of fair agricultural potential. Due to the structural and textural characteristics, soils are subject to high levels of erosion, leaching and water logging under high rainfall conditions. Black eyed bean (BEB) cowpea type was used in this experiment. It has been recently introduced into the country by non-governmental organizations mainly due to its attractive colour that raises the market potential, combined with its high nutrition that has potential to raise health levels in the smallholder-farming sector. BEB types have a determinate growth habit, well adapted and combine excellent stable yields with very good tolerance to drought. Varieties in this group are short season requiring less than 100 days to reach physiological maturity, meaning that they can be grown twice in one length of the rain season or can be planted late in the season in higher rainfall areas (Madamba, 2000).

Experimental design and treatments

The experiment was set up as a randomized complete block design with timing of leaf harvesting as the treatment with two time series and 14 treatment combinations and three replications. A total of 42 plots were obtained. The first season experiment was planted on 14 December 2005 at the University of Zimbabwe, Crop Sciences Department experimental fields and on the 16 of December 2005 in Mutoko. The second season crop was planted on 17 January 2007 at UZ and on 24 January in Mutoko. The gross plot size was 4.5 x 10 m consisting of 10 rows, 10 m long, 0.45 m apart. The net plots were 7.70 x 8.20 m, consisting of six middle rows, 8.2 m long. Cowpea seeds were planted 0.15 m apart within row. In Mutoko, the experiment was only conducted on one farmer's field and was researcher managed.

Treatments were divided into plots that had early leaf picking or late leaf picking. Among those that had early leaf picking, leaves were picked for the first 2, 3, 4, 5, 6, or 7 weeks and then not for the rest of the season. Those that had late leaf picking, leaves were not picked for the first 2, 3, 4, 5, 6, or 7 weeks and then picked for the rest of the season.

The two series were however, randomly arranged within each block. Each treatment was replicated three times.

Measurements

Leaf harvesting started two weeks after crop emergence (WACE) and one leaf per growing branch was harvested per week and terminated at pod formation. The harvested leaves were weighed fresh, oven-dried at 70% for 48 h and weighed again. At the end of the season when the crop reached physiological maturity the grain was harvested and dry matter determinations made for leaves, grain and above ground biomass (remaining leaves and stems excluding root biomass).

Statistical analysis

Nieto curves, which are used to derive the critical weed-free and weedy periods in field crops, were exploited to determine the critical cowpea leaf harvesting periods. Plotting the two series of treatments each against yield on the same axis, determines the period during which weeds have to be eliminated in order to obtain higher yields (Nieto et al., 1968). Reading off values at points where the plotted lines drop below an identified threshold determines the period during which leaf picking should not be done if higher yields were to be obtained.

RESULTS

Effect of timing of termination of leaf picking on leaf dry mass, grain yield and above ground biomass of cowpea at University of Zimbabwe site

A significant decrease (P<0.05) in leaf yield from 2

Table 1. Effect of timing of termination of leaf picking on leaf yield, grain yield and aboveground biomass of cowpea at the University of Zimbabwe site and Mutoko site.

Leaf picking termination	UZ site					
	2005 - 2006 season			2006 - 2007 season		
	Leaf yield (kg/ha)	Grain (kg/ha)	Above ground biomass yield (kg/ha)	Leaf yield (kg/ha)	Grain (kg/ha)	Above ground biomass yield (kg/ha)
No leaf * picking	na	1329.4	4307	na	2350.8	10341
2 WACE	234.1[e]	1070.4[f]	3468[f]	282.8[f]	2102.8[f]	9963[b]
3 WACE	229.4[d]	855.7[e]	2773[e]	222.5[e]	1892.3[e]	9504[b]
4 WACE	222.1[d]	751.1[d]	2434[c]	165[d]	1668.8[d]	9153[ab]
5 WACE	193.9[c]	634.8[c]	2057[b]	114.7[c]	1350[c]	8667[a]
6 WACE	134.6[b]	572.3[b]	1854[b]	63.5[b]	1220.1[b]	7992[a]
7 WACE	91.2[a]	393.3[a]	1274[a]	22.3[a]	855.7[a]	7312[a]
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
SED	8.85	52.71	170.8	13.68	29.45	728.9
$LSD_{(0.05)}$	18.27	108.36	351.1	28.23	60.53	1493.3
	Mutoko Site					
Leaf picking termination	**2005 - 2006 season**			**2006 - 2007 season**		
	Leaf yield (kg/ha)	**Grain (kg/ha)**	**Biomass yield (kg/ha**	**Leaf yield (kg/ha)**	**Grain (kg/ha)**	**Biomass yield (kg/ha)**
No leaf * picking	na	364.08	696.12	na	1868	3825
2 WACE	205.48[a]	342.53[a]	667.43[a]	389.4[a]	1692[a]	3893[a]
3 WACE	191.14[b]	319.96[b]	559.58[a]	316.9[b]	1566[b]	3739[a]
4 WACE	145.26[c]	261.76[c]	535.50[a]	270.4[c]	1435[c]	3685[a]
5 WACE	103.13[d]	210.46[d]	459.19[b]	188.1[d]	1276[d]	3074[b]
6 WACE	58.66[e]	176.33[e]	420.14[b]	129.3[e]	950[e]	2609[c]
7 WACE	17.39[f]	138.06[f]	316.74[c]	68.0[f]	933[e]	2620[c]
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
SED	8.85	52.71	170.8	13.68	29.45	728.9
$LSD_{(0.05)}$	18.27	108.36	351.1	28.23	60.53	1493.3

No leaf picking * values were not included in the statistical analysis. Means followed by the same letter in a column are not significantly different at P<0.05. Sed = Standard error of deviation. Lsd $_{(0.05)}$ = Least significant difference.

WACE to 7 WACE was observed (Table 1). There was a reduction in grain yield and total plant biomass with increase in length of the weekly leaf picking duration from 2 WACE to 7 WACE. Grain yield was highest in the treatment without leaf picking and was lowest when leaf picking was terminated at 7 WACE. About twice, total above ground biomass yield was obtained when leaf picking was terminated at 2 WACE and when no leaf picking was done compared to termination at 7 WACE. Lowest above ground plant biomass was obtained when leaf picking was terminated at 7 WACE. However, leaf dry mass increased with increase in length of the weekly leaf picking duration. The highest leaf yield was obtained when leaf picking was terminated at the 7 WACE. However, termination of leaf picking at 2 WACE resulted in the same grain yield, above ground biomass and leaf yield with the treatment where no leaf picking was implemented throughout the crop's vegetative growth cycle. Differences in other treatments were due to differences in timing of termination of leaf picking (Table 1).

Effect of timing of commencement of leaf picking on leaf dry mass, grain yield and above ground biomass at University of Zimbabwe site and Mutoko site

Timing of commencement of leaf picking significantly increased (P<0.05) grain yield, and aboveground biomass but decreased leaf yield from 2 WACE to 7 WACE. There was an increase in grain and biomass yield with increased no- leaf- picking duration. Highest grain yield was obtained when leaf picking was commenced at 7 WACE and lowest grain yield was obtained when there was leaf picking for all the 8 weeks of vegetative crop growth. Highest total above ground biomass was also

Table 2. Effect of timing of commencement of leaf picking on grain yield total above ground biomass and leaf yield at the University of Zimbabwe site and Mutoko site.

Leaf picking commencement	2005 - 2006 season			2006 - 2007 season		
	Leaf Dry mass (kg/ha)	Grain (kg/ha)	Aboveground biomass (kg/ha)	Leaf Dry mass kg/ha	Grain (kg/ha)	Aboveground biomass kg/ha
			UZ site			
0*	306.8	546.8	1772	265.9	875.6	6156
2 WACE	262[e]	608.2[a]	1970[a]	258.4[d]	913.7[a]	7830[a]
3 WAC	211.5[d]	938.1[b]	3039[b]	253.5[d]	1112[b]	8316[a]
4 WACE	141.5[c]	1076.0[c]	3486[b]	254.4[d]	1253.2[b]	9018[b]
5 WACE	71.[2b]	1238.7[d]	4013[c]	204.1[c]	1367.2[c]	9234[b]
6 WACE	38.4[a]	1398.1[e]	4530[d]	150.6[b]	1865.4[d]	9558[b]
7 WACE	22.6[a]	1509.5[f]	4891[e]	68.9[a]	1988.5[e]	10260[c]
P- value	<0.001	<0.001	<0.001	<0.001	<0.00	<0.00
Sed	8.85	52.71	70.8	13.68	29.45	728.9
Lsd	18.27	108.36	351.1	28.23	60.53	1498.3
			Mutoko site			
0*	248.39	210.67	288.84	434.8	860	2296
2 WACE	220.08[a]	218.82[a]	333.97[a]	353.8[a]	986[a]	2458[a]
3 WACE	220.83[a]	233.16[ab]	425.08[b]	349.6[a]	1135[b]	2631[a]
4 WACE	191.06[b]	238.89[ab]	455.63[b]	276.3[b]	1308[c]	2739[b]
5 WACE	145.96[c]	249.30[b]	520.09[c]	220.0[c]	1583[d]	2868[c]
6 WACE	96.71[e]	290.24[c]	594.53[c]	165.8[d]	1745[e]	2976[d]
7 WACE	58.74[e]	440.58[d]	662.06[e]	87.5[e]	1887[f]	3117[d]
P- value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sed	8.25	10.19	29.09	13.13	61.0	201.1
Lsd	17.02	20.72	59.17	27.10	125.4	413.4

*0 Leaf picking was implemented for all 8 weeks of the cowpea's growth cycle. Sed = Standard error of deviation. Lsd = Least significant difference at $p < 0.05$ Means followed by the same letter in a column are not significantly different at $P<0.05$.

obtained when leaf picking was commenced at 7 WACE and lowest biomass was obtained when leaf picking was done for all the 8 weeks. Conversely, there was a decrease in leaf dry mass with increase in the length of the no-leaf-picking duration. Differences in other treatments were due to differences in the timing of commencement of leaf picking (Table 2).

Critical leaf picking period on leaf dry matter yield of cowpea

When the two series of data were plotted on the same axes, it was observed that if maximum leaf yields are to be obtained leaf picking should be done from 2 to 8 WACE (Figure 1b). However, 75% leaf yields are obtained when leaf picking is done from 3 to 5 WACE. Less than 50% leaf yields are obtained when leaf picking is terminated from 2 and 5 WACE.

Critical leaf picking period on grain yield of BEB cowpea type

When the two series of data were plotted on the same axes each against grain yield, it was observed that to obtain maximum grain yield (100%) no leaf picking should be done from 2 to 8 WACE (Figure 2). To get more than 50% grain yield leaf picking can be done from 3 to 5 WACE. However, more than 50% grain yield is obtained when leaf picking is commenced from 6 WACE. Terminating leaf picking at 6 WACE onwards resulted in less than 50% grain yield.

Critical leaf picking period on total aboveground biomass of BEB cowpea type

The two series of data were compared by plotting them on the same axes with each against total above ground biomass yield. In order to obtain maximum above ground biomass yield no leaf picking should be done from 3 to 7 WACE. However, from all the sites there was more than 50% biomass yield in both seasons. Therefore, the negative effects of leaf picking had reduced significant effect on biomass accumulation (Figure 3) for all sites in all the seasons.

Morphological indicators at various times in the growth cycle of BEB grown at the University of Zimbabwe Mor-

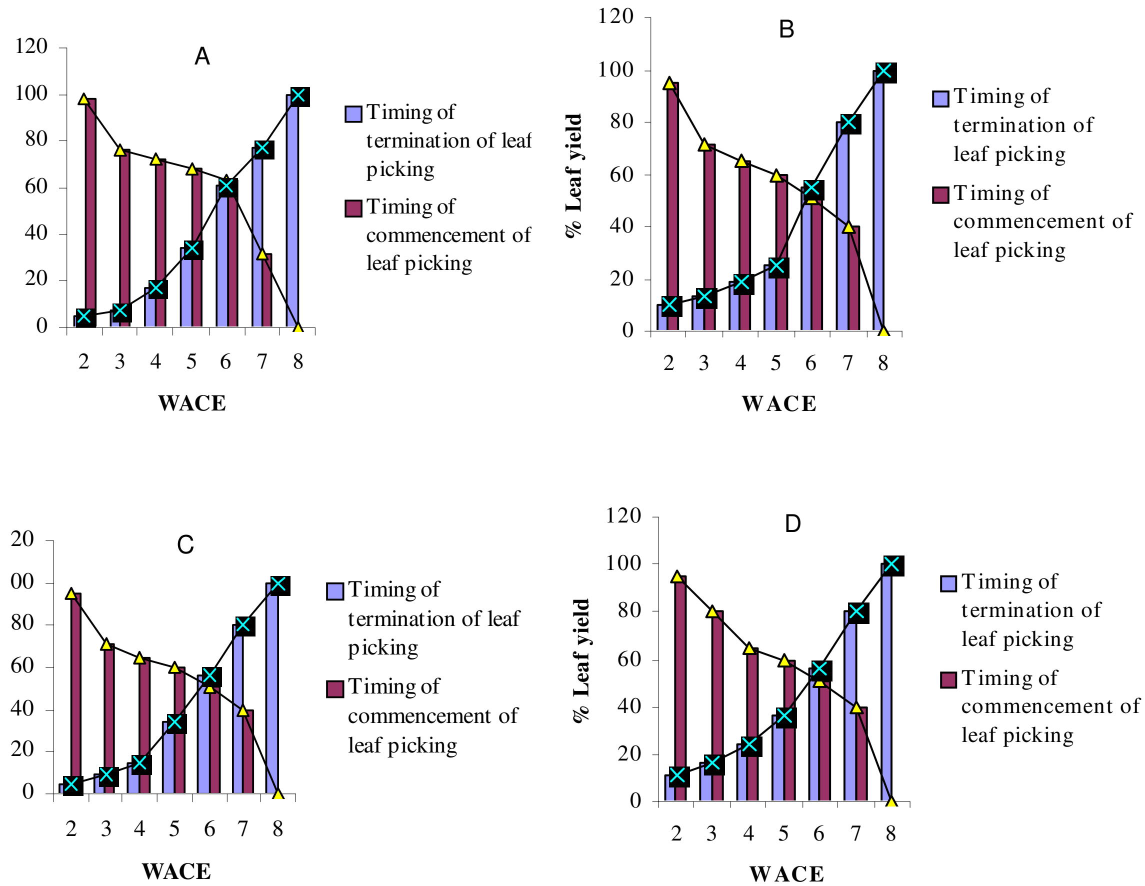

Figure 1b. Combined effects of critical duration on leaf yield for 2005 – 6 season on (A) UZ site, (B) Mutoko site, and for 2006 – 7 season on (C) UZ site, (D) Mutoko site.

phological indicators were identified so that in the future, farmers will be able to identify when (in the growth cycle) leaf picking is recommended to minimise negative effects on grain yield. The use of morphological indicators is more ideal than using calendar weeks as these vary with site characteristics, season and there is need for proper record keeping (Table 3).

The three-leaf stage was reached at 2 WACE whereas pod formation was reached at 8 WACE. The vegetative growth is from 2 to 5 WACE and from 6 to 8 WACE is the early reproductive stage.

DISCUSSION

An attempt to simulate smallholder farmer's practice of harvesting leaves up to pod formation resulted in substantial grain yield losses due to extensive reduction in leaf area for production of photoassimilates. Picking leaves untill the end of podding (7 WACE) substantially reduced grain yield due to removal of a greater proportion of the photosynthetic tissue, over a longer period. The plant was deprived of adequate photosynthetic tissue even during the early reproductive stage. Processes of producing reproductive structures and filling grain are strong energy sinks whose demand for photoassimilates is not met when photosynthetic area is depleted, thereby resulting in lower yields (Mujuru, 2005). Plants, which were harvested up to 7 WACE, were given less time to re-establish an adequate photosynthetic area and recover from defoliation, hence unable to compensate for loss of leaf surface from leaf picking.

On the other hand, shorter harvest duration exerted less pressure on the crop resulting in a partially full vegetative canopy phase. Early termination of leaf picking, 2 WACE, corresponding to the three- leaf stage, resulted in more grain yield. This was because the plants were deprived of less photosynthetic tissue, since leaf picking was done for a short period during the vegetative stage when the plant compensated by re-growth (Nielsen et al., 1997). On the contrary, short leaf harvesting duration will result in reduced amounts of vegetables being harvested as such the preserved small quantities of vegetables will only be available for a short period of time in winter when vegetables are scarce. This scenario is only beneficial to farmers whose priority is to increase grain yield. Hence, farmers can maintain or implement the critical leaf

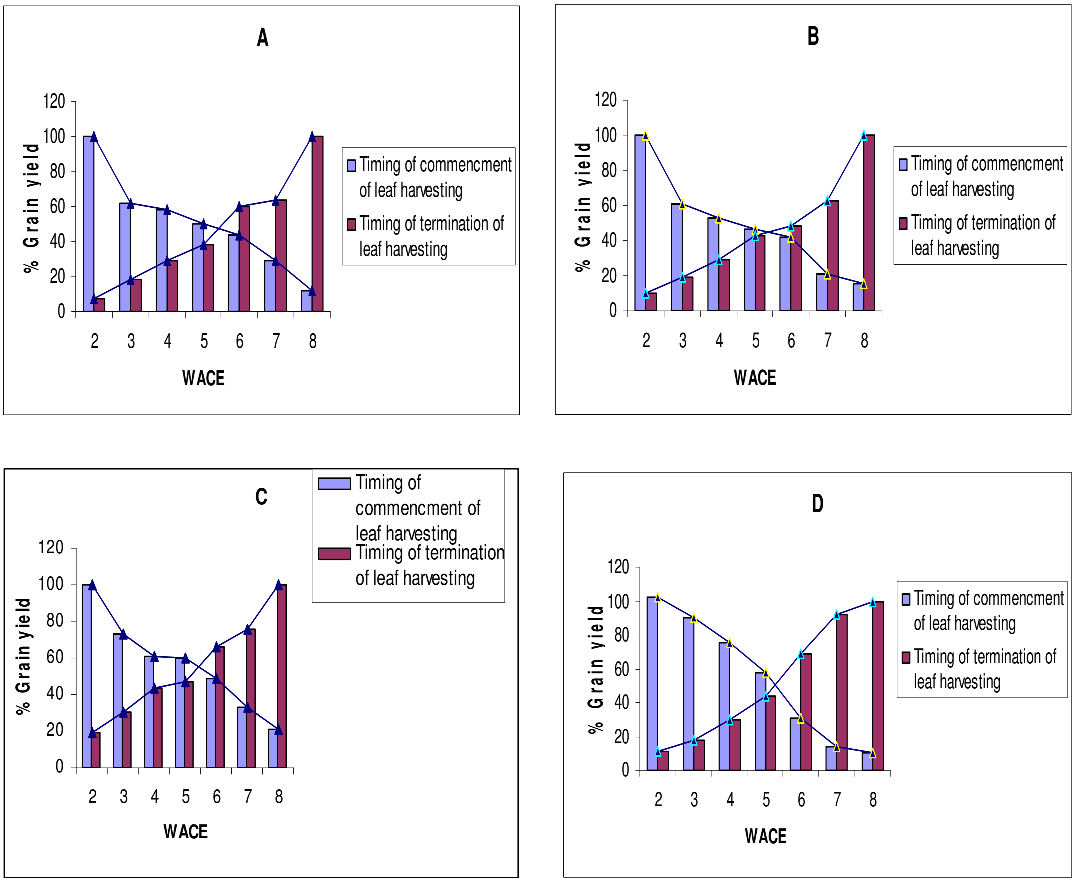

Figure 2. Combined effects of critical duration on grain yield for 2005–2006 seasons on (A) UZ site, (B) Mutoko site and for 2006 –2007 season on (C) UZ site, (D) Mutoko site.

grain harvesting practices used in this study for leaf and benefits depending on the preferences on the needs of the farmers and what form they want the cowpea.

Biomass accumulation was less affected by leaf picking than grain yield as more than 50% of the potential residual biomass yield was obtained from all the sites and treatments. The decline in residual above ground biomass was much less than expected considering the leaf numbers collected when leaf harvesting lasted up to 8 WACE. This maintenance of a stable weight might mean that the plant compensated leaf loss by re-growth of new shoots, though separation of the above ground biomass into component parts (leaves, shoots, grain) could have made it easier to make such a conclusion Despite the biomass compensation, there was however a decline in grain yield, possibly due to photoassimilates being channelled for growth of new shoots rather than grain. It could be deducted that the plant has to attain a threshold above ground biomass level, before channelling extra photoassimilates for grain formation.

Conversely, the increase in leaf yields when leaf picking was terminated late, that is at 7 WACE (the stage of pod formation), was as a result of more leaves collected since leaf picking was done over a longer duration; the leaves were fully expanded hence more leaf dry matter was accumulated. As a result new tender leaves were continuously produced throughout the crop's growth cycle as indicated by a greater percentage increase of leaf dry matter from where leaf picking was terminated early to where leaf picking was terminated late. Observations elsewhere are that early and longer harvesting will produce high shoot harvest indices (Ohler and Mitchell, 1995.)

The higher grain yield where leaf picking was commenced late, that is at 7 WACE, is likely to be as a result of more photoassimilates being channelled to pod filling rather than a greater amount of assimilates being produced, since residual biomass was comparable across all treatments. On the other hand early commencement of leaf picking that is 2 WACE and implementing leaf picking for all the 8 weeks will deprive the plant of more photosynthetic tissue and as a result least grain is obtained.

Low leaf yields are obtained with late commencement of leaf picking, that is at 7 WACE yields because less leaves were collected since the period during which leaf picking was done was short. Also, the leaves harvested at the late stage were smaller compared to those

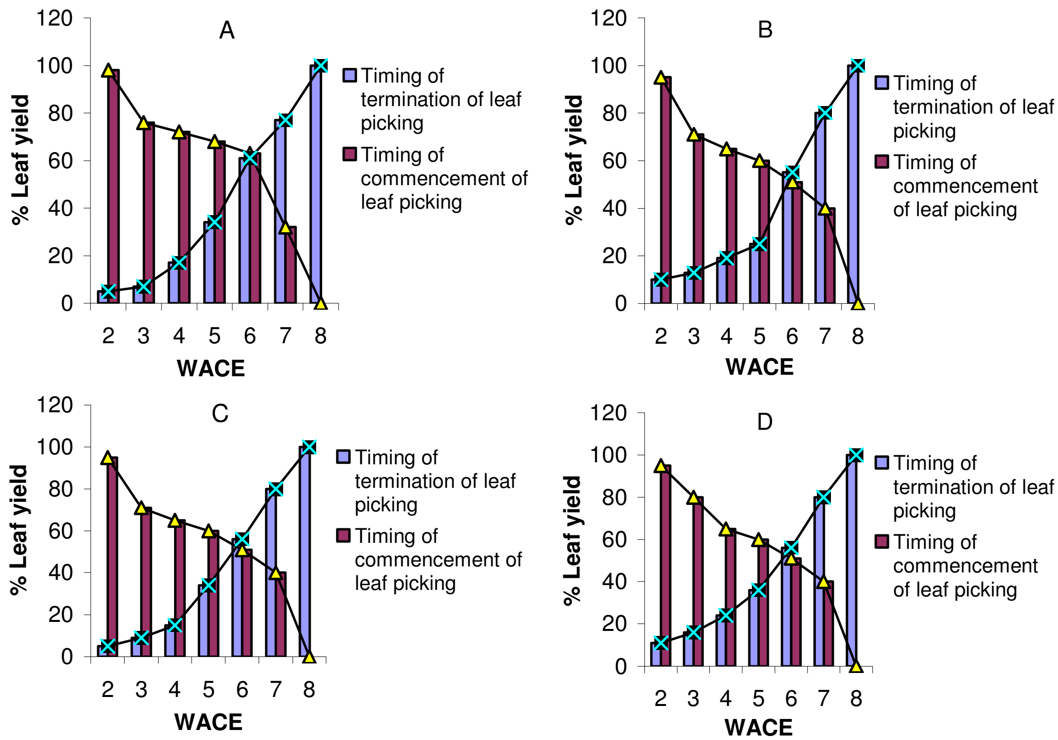

Figure 3. Combined effects of critical duration on aboveground biomass for 2005 – 2006 seasons on (A) UZ site, (B) Mutoko site, and for 2006 – 2007 seasons on (C) UZ site, (D) Mutoko site.

harvested at the vegetative stage, as the crop goes into the late stages the leaves become smaller and smaller until they are no leaves produced. Early commencement of leaf picking, that is at 2 WACE, resulted in more leaf yields because more leaves were collected since the duration over which leaf picking was done was long.

If maximum grain yield is to be attained leaf picking should be terminated at 2 WACE, which corresponds to the three leaf stage and it should be commenced at 8 WACE, which corresponds to start of pod formation. This means that the critical leaf picking period for maximizing grain yield is from 2 to 8 WACE. If maximum grain yield is to be obtained, no leaf picking should be done during this period. However this is impractical for most farmers since they also value leaf harvests. For these farmers, they can terminate leaf picking at 3 WACE and obtain 80% grain yield or they can commence leaf picking at 7 WACE and also obtain 80% of the potential grain yield, hence farmers can choose either to terminate leaf picking at 3 WACE or commence it at 7 WACE and only suffer a 20% grain yield reduction. This coincides with Barrett 1987 findings where timing of leaf removal greatly affected the ability of the crop to recover from defoliation. Alternatively, farmers can have two plots where in the first plot leaf picking is terminated at 3 WACE and in the other plot leaf picking is commenced at 7 WACE. Furthermore at least 60% grain yield is also obtained if leaf picking is terminated at 4, 5 or 6 WACE. Also starting leaf picking at 6 to 8 WACE will give 60% grain yield. However, leaf harvesting timing is also important to farmers as it is also associated with poor taste quality especially with those leaves that are harvesting late into pod-formation.

If leaf picking is terminated at any stage later than 6 WACE, which corresponds to 50%, flowering onwards less than 50% grain yield is obtained. For most farmers a 50% grain reduction is unacceptable since they sell some of their surplus produce for income. For this reason it is recommended that farmers should terminate leaf picking at 4 WACE or delay leaf picking and commence it at 6 WACE in order to get at least 60% grain yield.

Although leaf harvesting exerts some pressure on the total performance of the crop on some components contrary maximum residual biomass was obtained after leaf harvesting was done. Terminating leaf picking at 3 WACE and commencing it at 6 WACE only reduced residual biomass by less than 5%. Hence, if farmers pick leaves they will also benefit from residual biomass for other on-farm operations like compost making for organic manure, hence improving the productivity of the soil. With a higher amount of residual biomass biological nitrogen fixation is promoted and so soil fertility is improved. The residual biomass can be used as livestock feed for those Mutoko farmers with dairy cows as it is highly nutritious. In many regions, cowpea hay is highly valued as fodder where in Western Africa the crop residue is harvested as the most valuable product of cowpea. Some research done elsewhere showed that fodder from cowpea residues has a higher amount of protein and digestibility and intake

(Tarawali et al., 1997).

From the results in this study, simple phenological or morphological indicators at various weeks are more helpful to the farmers in identifying the periods during which leaf picking could be done without negatively affecting yield. Duration as measured by calendar days after crop emergence varies with the site characteristics or differences in seasons and is more difficult to record accurately.

Conclusions

i) If maximum grain yield is to be obtained no leaf picking should be done from 2 WACE, which corresponds to the 3 leaf stage to 8 WACE, which corresponds to the start of pod formation.
ii) However, 75% grain yield can be obtained if leaf picking is done from 2 to 3 WACE or from 7 to 8 WACE.
iii) Effects of leaf picking are minimal on residual biomass accumulation with termination of leaf picking at 3 WACE and commencing it at 6 WACE only reducing residual biomass by less than 5% on UZ site for both seasons and by less than 10% on Mutoko sites.

Recommendations

i) In order to minimize yield reduction from leaf harvesting, farmers are recommended to limit it to two weeks, from 2 to3 WACE or 7 to 8 WACE, which results in 80% of potential grain yield.
ii) Farmers are recommended to use simple phenological indicators as shown by external morphological changes to identify periods for leaf harvesting, instead of using calendar weeks.

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