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Full Length Research Paper

Nodulation, leaf harvesting intensity and interval of the black-eyed bean (BEB) (*Vigna unguiculata L.* Walpers) cowpea type at the University of Zimbabwe, Harare, Zimbabwe

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A glasshouse pot experiment was carried out at the University of Zimbabwe, Crop Science Department in 2006 to 2007 rainy season to determine the effect of leaf harvesting intensity and interval on cowpea biological nitrogen fixation through nodulation. The experiment was designed as a three factor factorial. The first factor was leaf harvesting frequency with two levels: leaves harvested weekly or fortnightly. The second factor was leaf harvesting intensity with three levels: harvesting one leaf, two leaves and three leaves per branch. The third factor was soil with two levels: Mutoko sand and UZ red clay soil. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications. There was no significant difference (p>0.05) on the number of nodules formed at different intensities and frequency at 6, 9 and 12 weeks after crop emergence. Significant difference (p<0.05) in nodule weight was observed as it decreased with increase in leaf harvesting intensity. Harvesting weekly produced lower nodule weight (0.31 g) than harvesting fortnightly (1.08 g). Mutoko sand soil produced higher nodule weight (0.69 g) than UZ clay soil (0.43 g). Leaf yield increased with increasing leaf harvest intensity, harvesting weekly produced higher yield (10.43 g) than harvesting fortnightly (3.22 g) and Mutoko soil had lower leaf yield than UZ clay soil. There was a significant (p<0.05) difference in seed yield, highest yield was obtained when no leaves were harvested and lowest yield when three leaves were harvested. Soil type effect also significantly (p<0.05) reduced harvestable seed weight from 1.00 g on sand soil to 4.12 g on clay soil. Similar trends were observed for aboveground and total biomass yield. In this study, leaf harvesting intensity and interval has been observed to affect nodulation, grain and biomass yield of glasshouse grown Black-eyed bean (BEB) cowpea. The extent to which these effects were felt also depends on the characteristics of the soil.

Key words: Black-eyed bean, cowpea, nodulation, leaf harvesting.

INTRODUCTION

Cowpea (*Vigna unguiculata L.* Walpers) is the second most important pulse grown in Africa (Bussy, 1975) and the most commonly grown pulse in the communal areas of Zimbabwe (Mariga et al., 1993). In these communal areas, cowpea is grown for its tender leaves, green pods and dry grain, to meet the protein and nutrient needs of communal and city dwellers. This protein and nutrient source is relatively cheap as compared to animal protein sources such as meat.

Black-eyed bean (BEB) was introduced into the country in Mutoko District by non-governmental organisations

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Table 1. Summary of soil analysis results for the experimental soils.

Characteristics	UZ Sites	Mutoko sites
	Block 13	Chinyanga
Soil texture	MG/SCL	MG/S
Soil colour	Dark brown	Light brown
pH ($CaCl_2$)	5.5	4.4
Mineral nitrogen (ppm)	32	13
Initial nitrogen (ppm)	15	2
Phosphorus (ppm)	38	12
Potassium (ppm)	0.17	0.14
Calcium (ppm)	6.72	0.94
Magnesium (ppm)	2.40	0.36
Total chromium (ppm)	9.3	1.4

MG/SCL – medium grained, SCL – sand clay loam, S – sand.

mainly to offer smallholder farmers a nutritious and relatively low input crop, which also had market appeal. When BEB was introduced in the rural farming systems, farmers seemed to follow cultural leaf harvesting practices that they commonly apply to the local traditional landraces. However, leaf picking routinely carried out by most small scale farmers of Zimbabwe reduces the total leaf area (Madamba, 2000). Once the leaf area has been reduced, it is possible that plant photosynthetic capacity is reduced and the total amount of assimilates channelled towards nitrogen fixation in nitrogen fixing plants is also reduced, resulting in nodule starvation and impairment of nitrogen fixation such that the amount of nitrogen fixed under leaf harvesting might be reduced (Rachie and Silvestre, 1977). It is estimated that the total amount of fixed nitrogen by well nodulated cowpea is 73 to 240 kg/ha. For each tonne of leaves harvested, it is estimated that 40 kg of nitrogen is lost from the plant (Sinha, 1974). If these estimates above hold, it means that, provided conditions for nodulation are favourable, biologically fixed nitrogen provides adequate nitrogen to sustain cowpea production at the current productivity levels.

While most research conducted to date has been investigating the effect of environmental factors affecting nitrogen fixation, not much has been done to investigate the effect of leaf harvesting on cowpea nitrogen fixation. This research is therefore aimed at investigating the influence of leaf picking on nitrogen fixation through nodulation. Because of the high cost of manufacturing, transporting and applying nitrogen fertilizers, most smallholder farmers of Zimbabwe cannot afford adequate inorganic nitrogen fertilizers and therefore farmers have to take advantage of the plant's natural ability to fix atmospheric nitrogen. In crop rotation, legumes are fundamental to sustainable cropping systems. Legumes in the rotation can be used to increase the available soil nitrogen. The amount of nitrogen fixed by legumes not removed from the land by harvest becomes available to a succeeding crop as the legume tissues undergo microbial decomposition (Board, 2000). Results from this research will go a long way in helping farmers adjust their leaf picking (frequency and intensity) to utilize the ability to fix nitrogen and minimize yield losses. The objectives of this reported work was to determine the effects of cowpea leaf harvesting intensity and frequency on nitrogen fixation based on the nodule growth.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the glasshouses at Crop Science Department University of Zimbabwe in Harare in the 2006 to 2007 season using red fersiallitic clay soils (Series 5E), (Nyamapfene, 1991) from Crop Science research plots Block 13 and sandy soils collected from Chinyanga site in Mutoko where the on-farm experiments were conducted (Table 1). Nutrient levels were assessed according to the guidance set by the Chemistry and Soils Research Institute of Zimbabwe.

Experimental design and treatment

The pot experiment was designed as a three factor factorial. The first factor was leaf harvesting frequency with two levels: leaves harvested weekly or fortnightly. The second factor was leaf harvesting intensity with three levels: harvesting one leaf, two leaves and three leaves per branch. The third factor was soil which had two levels: Mutoko sand and UZ red clay soil. Two unharvested controls were included, one for each soil. The experiment therefore had fourteen (14) treatments. The treatments were replicated three times (three pots per block) and arranged in a Randomised Complete Block Design with three blocks. There were two plants per pot. The variety used was Black-eyed bean (BEB).

Operations

Pots (top diameter 31 cm, height 30 cm and bottom diameter 23 cm) were filled with soil of equal volume for the two soils. Single Super Phosphate (18.5% P_20_5) was applied as a basal fertilizer at a rate of 40 kg/ha. Seed was inoculated with rhizobium (100 g/15 kg seed) to ensure that all the soils had inoculum at the beginning of the experiment. To prevent fungal infections, the seed was treated with Thirum (thiram 80%, inert ingredients 20%) before planting. Four seeds were planted in each pot. Cowpea seeds are quite large and as such, one seed was planted in each hole and then watered. The plants were thinned one week after emergence to two plants per pot. The pots were hand weeded and watered on a five day cycle. Snail and slug kill baits were placed around the pots for control of snails at 2 weeks after crop emergence (WACE). Leaf harvesting commenced at 4 WACE and terminated at 8 WACE. Dimethoate (40% EC) was applied at 5 and 7 WACE for the control of aphids. To recover maximum number of nodules from the soil, the pots were watered a day before sampling.

Measurements

Nodule yield

Measurements were recorded at 6, 9 and 12 WACE (one pot per treatment per block at each sampling time). Sampling was done by carefully loosening the soil and then uprooting the whole root system with nodules intact. Great care was exercised as soil was shaken off the roots in order to retrieve as much roots with nodules as possible. Distilled water was used to wash off soil from the roots of the plant. Nodules were plucked off by hand, counted and then weighed to obtain fresh weight. To assess the efficiency of the nodules, selected nodules were cut lengthwise. If the inside of the nodule was pink reddish it was efficient, and if cream to whitish, it was inefficient (Mpepereki and Makonese, 1998). Nodules were dried in an oven set at 70°C for 24 h. The samples were then weighed to determine nodule dry matter.

Efficiency of the nodules

To assess the efficiency of the nodules some selected nodules were cut lengthwise. The inside of all the selected nodules were observed to be reddish pink indicating that they were efficient and that they were capable of fixing nitrogen.

Leaf harvest and yield

Leaf harvesting started at 4 WACE to allow the cowpea to set a sufficient framework and establish enough leaves to harvest. Leaf harvesting was done once a week, following a pattern which was prepared prior to harvesting, and it was terminated at 8 WACE because the leaves were becoming very small and very rough on the surface therefore not suitable for consumption. Leaves were dried to a constant weight using a drier with a well moderated temperature 70°C for 48 h to ensure even drying and then weighed on a scale. Only the harvested leaf dry mass was recorded.

Grain harvesting and yielding

The pods were harvested when they were dry. Since the rate of maturity was not uniform, harvesting took place over a period of three weeks from 10 WACE to 12 WACE. The pods were shelled and the grain weighed.

Data analysis

Data was subjected to Analysis Of Variance using Minitab Version 12 (2003).

RESULTS

Effects of leaf harvesting on number of nodules formed on cowpea

There was no significant difference in the number of nodules formed at different intensities and frequency at 6, 9 and 12 weeks after crop emergence. The two soils showed no significant difference at all nodule measurement stages.

Effect of leaf harvesting on nodule dry weight

There was significant interaction ($p<0.05$) between harvesting intensity and frequency on nodule dry weight at 6 WACE (Figure 1). Harvesting three leaves, weekly and fortnightly, had the greatest effect in reducing the nodule dry weight. As the intensity of harvesting was reduced to two leaves less effect was observed. Harvesting two leaves weekly produced less nodule weight than harvesting two leaves fortnightly. Also, harvesting only one leaf weekly produced more nodule weight than harvesting two leaves weekly and fortnightly. Harvesting one leaf fortnightly produced the highest nodule weight compared to the other harvesting intensity and frequency combinations. At 9 WACE the highest nodule dry weights were produced, while 12 WACE had the lowest (Figure 1). There was a significant difference ($p<0.05$) in nodule dry weight between the two soils as it increased from 6 WACE to 9 WACE and then decreased at 12 WACE (Figure 2). In all the weeks when nodules were extracted, Mutoko sandy soil had a higher mean nodule dry weight than UZ soil (Figure 2).

Effect of leaf harvesting on cowpea leaf yield

Leaf harvesting intensity and interval had a significant interaction ($p<0.05$) effect on cowpea leaf yield (Figure 3). Harvesting two leaves weekly had the highest leaf dry weight while harvesting one leaf per fortnight resulted in the lowest weight. In addition, harvesting one leaf per week had statistically similar leaf dry weight to harvesting two leaves per fortnight. Harvesting three leaves fortnightly produced more weight than harvesting three leaves per week. Leaf yield harvested fortnightly increased with increase in leaf harvesting intensity. There was significant difference ($p< 0.05$) in leaf yield between the two soils as UZ soil produced higher leaf yield than Mutoko soil (Figure 4). Harvesting two leaves produced a higher leaf yield than the two other leaf harvesting intensities.

Effect of leaf harvesting on cowpea grain yield

There was a similar pattern of results for number of

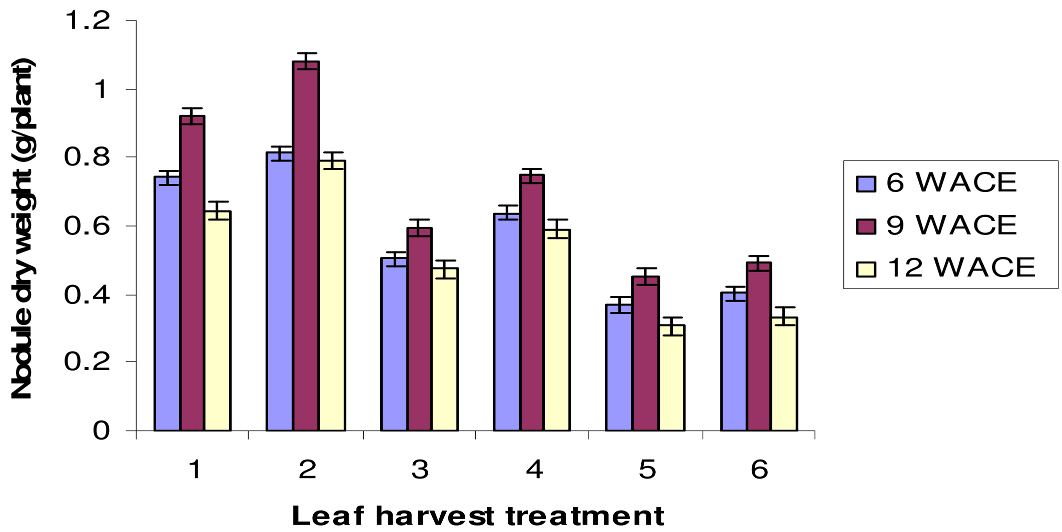

Figure 1. Effect of the interaction of leaf harvesting intensity and interval on nodule dry weight (g/plant) at 6, 9 and 12 WACE. Leaf harvesting treatments, 1, 2, 3, 4, 5, and 6 represent one leaf harvested weekly, one leaf harvested fortnightly, two leaves harvested weekly, two leaves harvested fortnightly, three leaves harvested weekly and three leaves harvested fortnightly respectively. Bars indicate SED value.

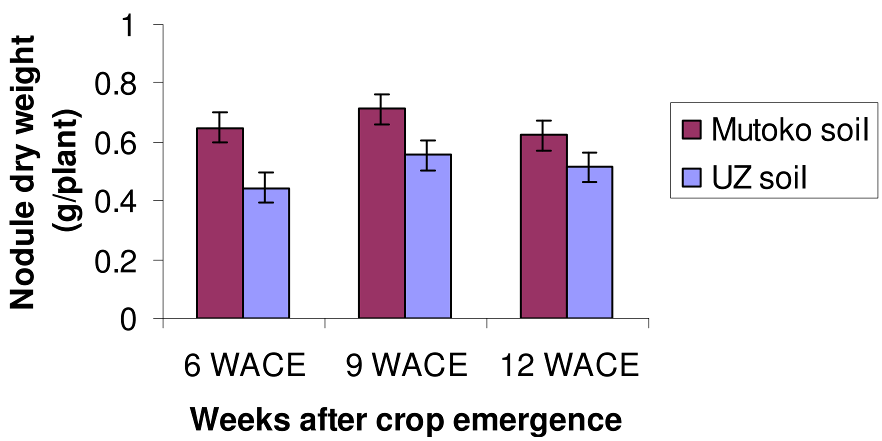

Figure 2. Effect of soil type on nodule dry weight (g/ plant) at different stages of cowpea growth cycle; bars indicate SED value.

seeds per plant and seed weight per plant for leaf harvesting intensity, interval and soil type. There was significant interaction ($p<0.05$) between frequency and intensity in affecting number of seeds produced per plant at maturity (12 WACE) (Figure 5). Number of seeds decreased with increase in leaf harvesting intensity. Harvesting leaves fortnightly produced higher number of seeds than harvesting weekly. For seed weight, there was a significant interaction ($p<0.05$) observed between leaf harvesting intensity and interval among the harvested treatments and also the unharvested control. Seed weight decreased with increase in leaf harvesting intensity and frequency. UZ soil produced higher seed weight than Mutoko soil at all the leaf harvesting intensities. The unharvested control produced the highest seed weight and harvesting three leaves produced the lowest seed weight (Figure 6).

Effect of leaf harvesting on crop residue

There was a significant interaction between leaf harvesting intensity and frequency in affecting crop residue (Figure 7). Crop residue weight decreased with increase in leaf harvesting intensity with both weekly and fortnightly harvests. Harvesting three leaves weekly

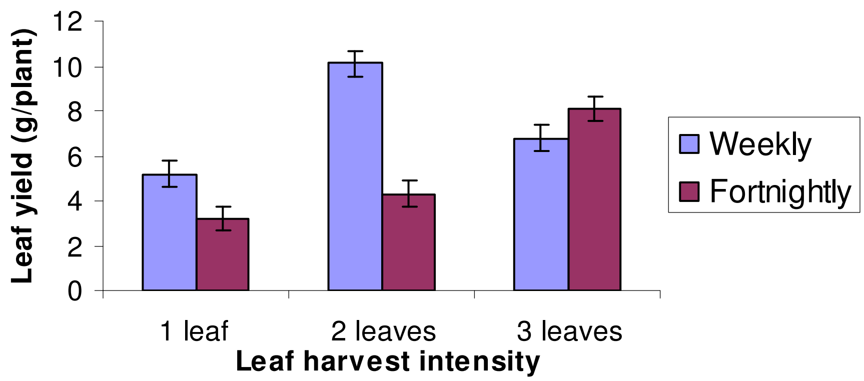

Figure 3. Effect of leaf harvesting intensity and interval on leaf yield (g/plant). Bars indicate SED value.

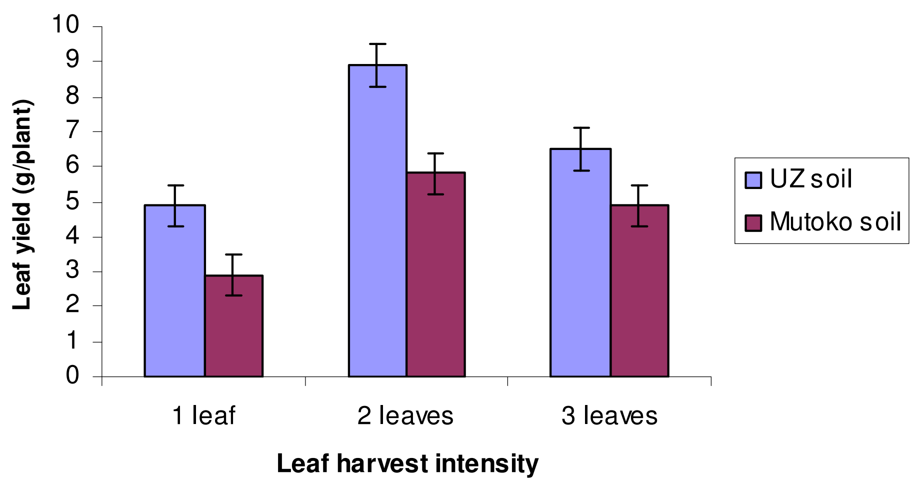

Figure 4. Effect of soil type on leaf yield (g/plant) at different leaf harvesting intensity. Bars indicate SED value.

greatly reduced crop residue weight; this had almost the same effect as harvesting three leaves fortnightly. A significant difference ($p = 0.05$) was observed between treatments on crop residue in both soils. Crop residue decreased with increase in leaf harvest intensity. On Mutoko soils, the control was not significantly different from harvesting one leaf weekly or one or two leaves fortnightly, which attained greater biomass than the other treatments. However, there was significant difference on harvesting three leaves weekly, of which the effect was more severe on both soils (Table 2).

DISCUSSION

There was no difference in number of nodules formed at 6, 9, and 12 WACE at different frequencies and intensities, indicating the same rate of root infection and nodulation. The photo-assimilates, despite the difference in quantities caused by the difference in photosynthetic capacity, were sufficient for nodule formation and also the soil was inoculated with rhizobia of which the levels were adequate for nodulation (Sinha, 1974). At 6 WACE the number of nodules produced was the same because legume seeds contain phytohaemoglobin (or lectins), which are responsible for stimulating the root infection process to form nodules in the early stages given that rhizobia is abundant (Giller, 2001).

Photo-assimilates might have helped later when nodules had already been formed in all treatments. In later stages nodules were again formed at the same rate. Nodules continue to be formed until the nitrogen requirements of the plant are met: this was shown in the experiment as nodules were formed up to 12 WACE. In plants where nodules would have met the nitrogen requirements, nodules will stop forming (Whiteman, 2007). Therefore some plants continued to form nodules whilst others were no longer producing, thus giving the

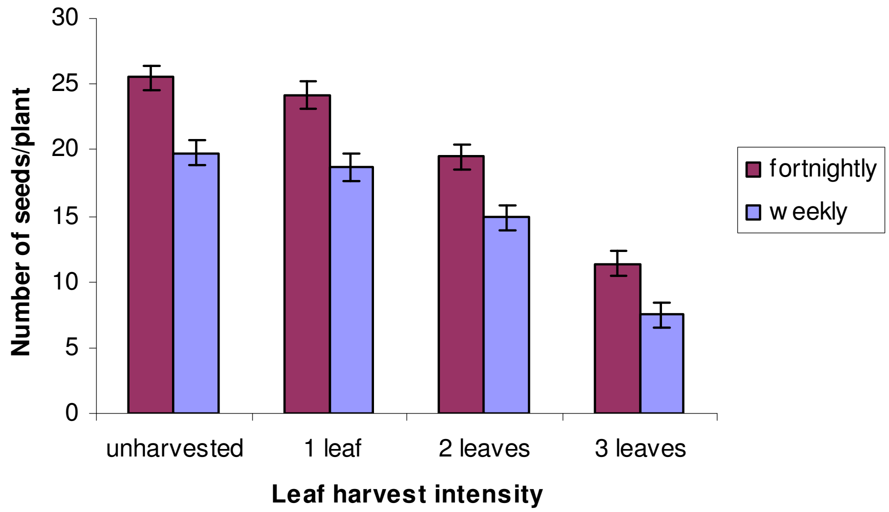

Figure 5. Effect of the interaction of leaf harvesting intensity and frequency of harvesting on seed number (number of seeds/plant). Bars indicate SED value.

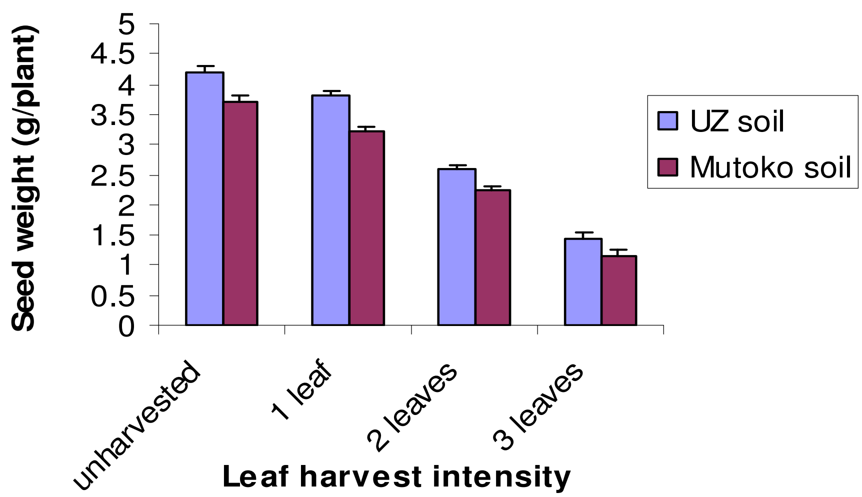

Figure 6. Effect of the interaction of leaf harvesting intensity and interval on seed dry weight (g/plant). Bars indicate SED value.

same number of nodules at the end. Both Mutoko sand and UZ clay soil had properties that enabled them to produce the same effect on nodule number or this might be a plant characteristic. The inoculation of the seed with rhizobium enhanced the chances of infection of the plants, although the sizes of the nodules maybe different (Board, 2000). Their differences in texture, pH and amount of nutrients had no effect in reducing the number of nodules formed at different leaf harvesting intensity and frequency. Egbe and Egbo (2011) made similar observations and they were significant differences in the number and biomass of nodules evaluated at 50% flowering (33 to 50 days after planting) were obtained in Nigeria. On Mutoko soils, the control was not significantly different from harvesting one leaf weekly or one or two leaves fortnightly which attained greater biomass than the other treatments (Table 3).

There was a lower nodule dry weight in cowpea at 6 WACE probably due to the reduced amount of photo-assimilates channelled towards the nodule development. At this stage, there is a possibility of competition for photosynthates between the developing flowers and the nodules. According to Sinha (1974), the removal of flowers on cowpea and chickpea prolonged the life of nodules owing to reduced competition from flowers. However, the increase in nodule dry weight at 9 WACE was due to an increase in the expansion of the already produced nodules due to demand in nitrogen by the plants. The aforementioned scenario results as nitrogenous substances accumulate in leaves during

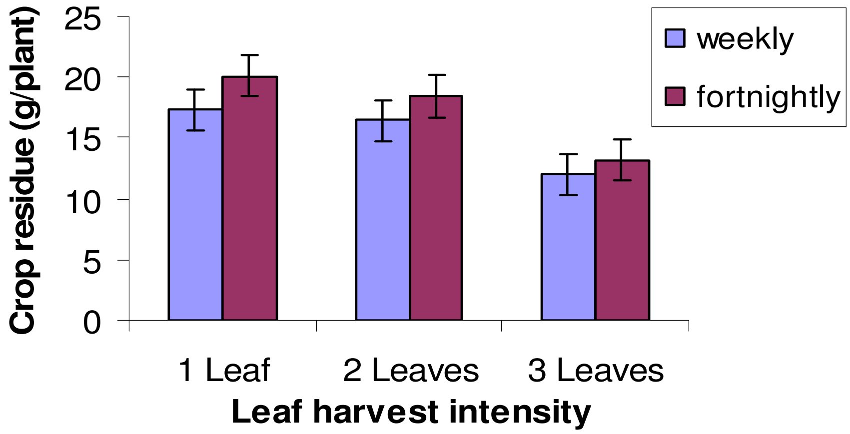

Figure 7. Effect of the interaction of leaf harvesting intensity and interval on crop residue (g/plant). Bars indicate SED value.

Table 2. Treatment combination of leaf harvesting intensity, frequency and soil type.

Treatment	Intensity	Frequency	Soil type
T1	1 leaf	Weekly	UZ clay
T2	2 leaves	Weekly	UZ clay
T3	3 leaves	Weekly	UZ clay
T4	1 leaf	Fortnightly	UZ clay
T5	2 leaves	Fortnightly	UZ clay
T6	3 leaves	Fortnightly	UZ clay
T7	Unharvested	Control	UZ clay
T8	1 leaf	Weekly	Mutoko sand
T9	2 leaves	Weekly	Mutoko sand
T10	3 leaves	Weekly	Mutoko sand
T11	1 leaf	Fortnightly	Mutoko sand
T12	2 leaves	Fortnightly	Mutoko sand
T13	3 leaves	Fortnightly	Mutoko sand
T14	Unharvested	Control	Mutoko sand

Table 3. Effect of soil type, leaf harvesting intensity and interval on crop residue dry weight in g/plant.

Treatment	U Z clay soil	Mutoko sand soil
	Biomass	Biomass
Control	22.615[f]	18.529[c]
One leaf weekly	20.216[d]	17.733[c]
Two leaves weekly	18.948[c]	15.333[b]
Three leaves weekly	13.067[a]	11.933[a]
One leaf fortnightly	22.300[f]	18.267[c]
Two leaves fortnightly	21.685[e]	17.492[c]
Three leaves fortnightly	16.527[b]	14.988[b]
P-value	0.050	0.050
LSD $_{(0.05)}$	1.803	1.803
Sed	3.625	3.625

Means followed by the same letter are not significantly different at p<0.05. Lsd = Least significant differences; Sed = Standard error of difference.

vegetative growth and migrate to the seeds during pod filling (Rachie and Silvestre, 1977). Caldwell and Vest (1970) as cited by Sinha (1974) produced similar results in cowpeas where nodule weight increased with increase in days after planting. The decline in nodule weight from 9 WACE could have been due to the formation of new sinks in the form of developing pods where all the photosynthates are channelled from the source in the form of leaves, depriving the nodules at all cost. Hardy (1974) as cited by Giller (2001) showed that in soybean under field conditions nitrogenase activity was reduced and nodules disintegrate at early pod development stage. At all harvesting intervals, nodule dry weight was higher in Mutoko sand soil than in UZ red due to the differences in soil characteristics. Based on the soil analysis results, the main factor that led to the low nodule dry weight in UZ red clay soil was the phosphorous level (33 ppm). UZ clay had a lower phosphorous level than Mutoko soil (42 ppm). Under low phosphorous levels, nodules develop at a slower rate (Saidi et al., 2007). Phosphates are absorbed by cowpea roots thereby enhancing their development and increasing nodulation because of adequate nutrients and good water uptake and finally incorporated into compounds such as ATP, nucleic acids and membrane proteins (Nutman, 1967). For this reason, the nodules for UZ soil could not grow as vigorously and thus gained less dry weight than in Mutoko soil. Mutoko soil was a medium grained sand soil, which is friable and allows easy development of nodules in diameter. However, UZ soil was medium grained clay (Nyamapfene, 1991), which is compact and does not allow free expansion of the nodules. Therefore, the nodules in UZ soil expanded at a lower rate than in Mutoko sand giving a lower nodule dry weight. This means that at all leaf harvesting intervals, cowpeas on Mutoko soil were producing bigger nodules than those of UZ soil.

The zig-zag pattern observed in the interaction of leaf harvesting intensity and interval on nodule dry weight was due to the leaf harvesting treatments exerting a lot of stress on the crop growth. The induced stress resulted in reduced nodule dry weight in some treatments and increasing it in others. Meanwhile, harvesting fortnightly in all the treatments had a possibility of compensatory growth in leaf size with longer leaf harvesting intervals, which gave the plant enough time to recover from defoliation, whereas weekly harvests did not give plants time to recover. Whiteman (2007) also obtained the same results where the effect of leaf defoliation on nodule weight was related to the severity of the initial leaf defoliation in *Desmodium uncinatum* and *Phaseolus atropurpureus* in the field.

The yield of a plant is affected by the amount of nitrogen acquired either from fertilizers or from biological nitrogen fixation (Basra, 1994). Harvesting of three leaves weekly reduced the number of leaves per plant. The reductions in leaf area reduced the photosynthetic capacity of the plant and as a result it is likely that less assimilates were channelled towards nitrogen fixation. As a result of less nitrogen fixation, plants photosynthetic capacity was also stressed and less assimilates were channelled into grain, as supported by the lower grain weight in intensely harvested plants. Poor vegetative growth may result in few flowers being formed causing the seed numbers to be low in treatments where two and three leaves were harvested weekly. However, the internal competition for photosynthates between the developing pods and the nodule deprives the latter of carbohydrates supply, leading to the inactivation or disintegration of nodules (Rachie and Silvestre, 1977). Therefore, this result in reduced nodule mass as observed in this experiment where fortnightly harvested treatments had higher nodule weight than weekly harvested. As a result of the aforementioned scenario, nitrogen accumulated in the plant becomes the only source for the developing grain protein (Sinha, 1974). Harvesting three leaves fortnightly gave the plant a chance to generate new leaves thus, the rate of photosynthesis is likely to have been higher. More assimilates were channelled towards nitrogen fixation as shown by the higher nodule dry weight. As a result, more nitrogen was produced and channelled towards plant growth, therefore, producing more grain as compared to harvesting three leaves every week.

Leaf harvesting interval and frequency had an effect on the performance of the cowpea where harvesting weekly resulted in more leaf yield but less seed weight, whereas harvesting fewer leaves fortnightly imposes less pressure on the crop resulting in less leaf yield but more seed weight. There was a marked difference in leaf yield and seed weight between soil types, with UZ clay soil producing a higher leaf and grain yield than Mutoko sand soil despite a lower nodule mass. Cowpea plants in UZ soil were observed to have more leaves when compared to those in Mutoko sand soil. Generally, harvesting one leaf at fortnightly intervals had a higher seed dry weight than harvesting two and three leaves fortnightly, due to differences in partitioning of assimilates. Therefore, harvesting less leaves resulted in more assimilates being channelled towards reproduction and hence, giving a higher seed dry weight. Harvesting fortnightly enabled the plant leaves to remain intact a week longer, especially, tender leaves, enhancing the photosynthetic capacity of the leaves. Thus, assimilates were shared between the leaves and the growing seeds. In an experiment conducted on mung beans, the earlier formed inflorescence produced more fruits and the number of fruits decreased as the node number increases (Sinha, 1974), implying that those pods formed later in the growth stage of the plant produces less seed yield. General observations revealed that besides the number of fruits, the size of the fruits was also affected where some grains are big and others are small, affecting their weights. In cowpea, the same pattern in mung beans was also observed where the earliest set flowers produced more fruits than those formed late in the growing stage of the crop. However, the late formed fruits sometimes drop, therefore, reducing the seed yield under high leaf harvesting intensities.

On UZ red clay, the higher seed numbers in un-harvested controls could be due to higher photosynthesis taking place. The cowpeas, which were not harvested attained higher canopy cover as shown by its residual above ground dry weight, which was also high. Because of high photosynthesis, more assimilates could have been channelled towards nitrogen fixation, thus, more nitrogen channelled towards reproduction giving a higher seed number. The aforementioned scenario also occurred in cowpea seed weight where it increased with decrease in leaf harvest intensity. Plants where one leaf was harvested fortnightly could have compensated for the leaves harvested through increased photosynthesis in the remaining leaves (Jacques et al., 1994) thus giving a higher seed yield. The high crop residue dry weight also indicates that the plants recovered from defoliation.

Mutoko sand soil produced less grain yield than the UZ clay soil suggesting that nodule weight is not related to yield in this type of soil. The inoculation of rhizobium on the seed could have enhanced the production of nodules. According to the analysis conducted on the soils, Mutoko had lower fertility in terms of mineral content than UZ, indicating that the minerals may be a limiting factor during production of cowpea in order for the crop to enhance its fruit development for better grain yield. This is supported by the crop residue dry weight which was also less than on the UZ soil. The high total biomass in plants where one leaf was harvested fortnightly probably shows the chances of high nitrogen fixation levels, indicated by the high nodules mass. The plants in turn could have benefited from the high nitrogen levels to attain a higher biomass. Individual cowpea leaves have maximum rates of photosynthesis at full leaf expansion reference hence, the photosynthetic capacity of the crop was reduced as the intensity of the leaf harvesting increased, therefore, the plants were not able to compensate for the loss of the photosynthetic area. Harvesting three leaves weekly reduced the plant’s vigour, hence, less total biomass accumulated.

Conclusion

It can be concluded that harvesting three leaves weekly or fortnightly on BEB greatly reduces nodulation and cowpea grain yield and furthermore, reducing the intensity and increasing the interval of harvesting to one leaf at two week intervals produces high nodule dry weight and is more productive in terms of grain yield, implying that nitrogen fixation is not adversely impaired at this level on BEB cowpea type.

RECOMMENDATIONS

Farmers should reduce their harvesting intensity to one leaf per branch at two week intervals for them to benefit from leaves of cowpea and also to obtain a better grain yield from the same crop, and secondly, further experiments should be done in the field to investigate the influence of leaf harvesting on biological nitrogen fixation, soil fertility and role of cowpea in crop rotations under field conditions.

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