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Effect of Stage and Intensity of Defoliation on the Performance of Vegetable Cowpea (*Vigna unguiculata* (L.) Walp)

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Abstract: Field experiments were conducted in 2006 and 2007 on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria to determine the effect of stage and intensity of defoliation on the performance of vegetable cowpea. The treatment consisted of factorial combination of three growth stages (vegetative, flowering and podding) and five defoliation intensity (0, 25, 50, 75% 100%). Artificial defoliation was carried out at each of the stages at different intensities. Defoliation for vegetative, flowering and podding were carried out at 5,7 and 9 weeks after sowing(WAS), respectively. Cowpea defoliated at the early stages just prior to podding significantly ($p<0.05$) reduced both growth and developmental characters. Also, the yield and yield components were significantly reduced by early defoliation. The intensity of defoliation significantly affected the growth and development of cowpea and the yield loss increased as the percentage of defoliation was higher. The interaction between stage and intensity of defoliation was significant for pod yield and shows that defoliating up to 50% at vegetative and flowering stages was detrimental to yield of vegetable cowpea.

Key words: Defoliation intensity · Vegetable cowpea · Vegetative characters · Developmental characters · Yield component

INTRODUCTION

Cowpea is one of the most important legumes which serve as vital source of protein in the diet of the people of developing countries. Cowpea is grown primarily in the third world for its cheap source of dietary protein, Lysine [1] and as a supplement for meat. It may be consumed at various stages of its development; green leaves, green pod, green peas, dry grains and the straw are excellent animal feed. Cowpea is use for human food, as concentrate for animals, hay, silage; pasture, soil cover and green manure for maintain the productivity of soils [2]. The young leaves and shoot are consumed as spinach and provide one of the most widely used pot herbs in African. In India the leaves are also used in dyeing o obtain green dye while the young pods are eaten as vegetables [3]. In the United State of America, the fresh seed and immature pods are sometimes frozen or canned as baked beans are eaten and exported to other part of the world. Virtually all the component of cowpea are source of food [4] for both developed and the developing world.

The vegetable cowpea differs slightly from the grain types in their vegetative characters physiological characteristic and green pod yield [5]. Utilization of vegetable cowpea for leaf and pod consumption may provide nutritional and harvest versatility not available with other vegetative crops like lettuce cabbage [6] Harvest strategies practiced in the field to utilize foliage include; harvest of the entire vegetative plant prior to flowering or partial defoliation and later pod harvest from the same plant [6].

Cowpea production is beset by an array of pests and diseases that can cause serious devastation, thus leading to reduced yield and profitability. Several foliage defoliators insects chiefly among which are Acrididae have been reported to cause severe defoliation of cowpea. A considerable number of Lepidoptera have been reported feeding on cowpea leaves sketolonizing and sometimes defoliating the plant. Other major defoliators belong to the family Chrysomelidae [7]. The effects of defoliators can cause reduced seed yield depending on the stage and growth of the crop [8].

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Therefore, quantifying yield decrease resulting from defoliation may play an important role in predicting yields, establishing threshold for pesticide treatments or assessing indirect damage caused by pests [4].

Recent studies in crop defoliation have been receiving more attention to determine the effect of removing leaves for livestock and human consumption and for industrial use on the green pod yield for human consumption using various crops. Also to determine the effect of defoliation at different stages on yield of crops as it may be caused by pest and diseases. For instance, study on sorghum defoliation Ogunlela and Ologunde [9] compared varying defoliation intensity applied at different growth stages. Rahman *et al.* [4] reported on the effect of defoliation on the profitability of cowpea. Yahya [10] worked on the effect of variety and defoliation on grain cowpea. Ibrahim [11] also worked on the effect of stages and intensity of defoliation on the growth and yield of grain cowpea. Badi [12] also worked on the effect of intensity of defoliation and spacing on cowpea. All these studies concluded that yield response depends on the extent of damage.

Other studies on defoliation are on grain crops there is little or no information on vegetable cowpea in Nigeria and other developing countries where it is largely grown.

This study was therefore conducted to determine the effect of defoliation at three growth stages (vegetative, flowering and podding) and at five defoliation intensity (0, 25, 50, 75 and 100%)

MATERIALS AND METHODS

Field experiments were conducted during 2006 and 2007 growing seasons at the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru Zaria (11° 11^{1} N and 7°38^{1}E, 686M above sea level) in Nigeria. The experimental field was ploughed, harrowed and ridged at 0.75m apart. The treatments were laid out in a randomized complete block design replicated three times (RCBD). The treatments consisted of factorial combination of three growth stages (vegetative, flowering and podding) and five defoliation intensity (0, 25, 50, 75 and 100%) . Artificial defoliation was carried out at each of the stages at different intensities. Defoliation for vegetative, flowering and podding were carried out at 5, 7 and 9 weeks after sowing respectively. Cowpea variety IT92KD 267-2 used for the experiment was developed by International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria. The variety is day neutral and takes average of 75 days for the pod to mature. At sowing, the seeds were dressed with FernasanD. The cowpea seeds were sown at a spacing of 0.3m x 0.75m, 3 seeds were sown per hill. At two weeks after sowing the plants were thinned to two plants per stand. Four weeks after sowing it was weeded using hand hoe and subsequent weeds were hand pulled on observation from the field. At five weeks after sowing, aphids' larva stage of insect and matured insects were observed feeding on the vegetative part of the plant. (Karate (Lamda-cyhalothrin) 2.5E.C. was reconstituted with water and a knapsack sprayer (20 liters) was used in spraying. The spray was repeated at seven weeks after sowing. Assessment of vegetative character such as plant height, number of leaves, number of branches, leaf area index and crop growth were done from third to eleven weeks after sowing.

Assessment of developmental character such as days to 50% flowering, number of days to 95% pod maturity and number of flowers at seven weeks after sowing were done weekly. Yield and yield parameters were determine by harvesting mature green pods at 10 and 11 WAS. All pods harvested from each plots were measured, counted and weighed at each picking. Data from the picking were polled together to determine the total yield. Data collected were subjected to analysis of variance and where significant differences existed the Duncan Multiple Range Test was applied. All statistical procedure was done according to the procedure described by Gomez and Gomez [13].

RESULTS

Vegetative Characters: As presented in Table 1a and b the vegetative characters of vegetable cowpea was significantly ($p \leq 0.05$) affected by stage of defoliation. Plant height, number of branches and crop growth rate were significantly reduced by defoliating at the vegetative and flowering stages. The number of leaves was significantly reduced by defoliating at the flowering stage, while, leaf area index was not affected by stage of defoliation. The intensity of defoliation significantly ($p \leq 0.05$) affected the vegetative characters. Plant height, number of leaves, number of branches and leaf area index were all affected by 25% defoliation while crop growth rate was affected by 50% defoliation, though there were statistical similarity among the various intensity in some cases, but the effect of intensities of defoliation increases as the percentage of defoliation becomes higher.

Table 1a: Effect of stage and intensity of defoliation on the vegetative characters of cowpea at Samaru during the 2006 rainy season

Treatments	Plant height	Number of leaves	Number of branches	Leaf area index	Crop growth rate
Stages					
Vegetative	15.67[b]	42.80[a]	19.60[b]	1.35	4.27[b]
Flowering	15.80[b]	38.20[b]	17.07[b]	1.10	8.26[b]
Podding	19.53[a]	48.93[a]	23.87[a]	1.58	13.08
SE±	0.340	3.350	0.996	0.018	2.474
Defoliation (%)					
0	18.56[a]	69.78[a]	23.89[a]	2.38[a]	19.97[a]
25	17.89[b]	52.67[b]	19.44[b]	1.87[b]	12.53[a]
50	17.44[b]	49.56[b]	18.67[b]	1.85[b]	7.81[b]
75	16.67[c]	35.89[c]	18.58[b]	1.27[b]	6.24[c]
100	16.44[c]	8.67[d]	18.67[b]	0.08[b]	6.18[c]
SE±	0.438	4.325	1.286	0.035	3.194
Interactions	NS	NS	NS	NS	NS
S X D					

Table 1b: Effect of stages and intensity of defoliation on the vegetative characters of vegetable cowpea at Samaru during the 2007 rainy season

Treatments	Plant height	Number of leaves	Number of branches	Leaf area index	Crop growth rate
Stages					
Vegetative	17.33[b]	43.70[a]	17.40[b]	1.13	4.26[b]
Flowering	16.93[b]	31.53[b]	21.00[b]	0.94	8.76[b]
Podding	20.71[a]	43.93[a]	24.00[a]	1.28	15.33[a]
SE±	0.633	3.179	1.196	0.012	2.375
Defoliation (%)					
0	19.11[a]	64.22[a]	23.22[a]	1.66[a]	13.67[a]
25	18.70[b]	49.44[b]	20.00[b]	1.61[b]	12.84[a]
50	18.67[b]	42.22[b]	19.44[b]	1.38[b]	7.66[b]
75	18.33[c]	30.83[c]	18.13[b]	0.97[b]	6.34[c]
100	18.22[c]	10.72[d]	17.56[b]	0.33[b]	6.19[c]
SE±	0.817	4.104	1.544	0.026	3.237
Interactions	NS	NS	NS	NS	NS
S X D					

Table 2: Effect of stage and intensity of defoliation on the developmental characters of vegetable cowpea at Samaru during the 2006 and 2007 rainy seasons

	2006			2007		
	Developmental			Characters		
Treatments	Days to 50% flowering	Number of flowers at 7WAS	Days to 95% pod maturity	Days to 50% flowering	Number of flowers at 7WAS	Days to 95% pod maturity
Stages						
Vegetative	49.8[a]	2.73[b]	71.3[a]	49.3[a]	2.00[b]	71.7[a]
Flowering	47.0[b]	4.33[a]	70.0[b]	47.5[b]	3.86[a]	70.7[b]
Podding	47.0[b]	4.33[a]	70.0[b]	47.0[b]	3.93[a]	70.5[b]
SE±	0.490	0.145	0.190	0.390	0.101	0.530
Defoliation (%)						
0	47.0[b]	4.33[a]	70.0[b]	47.0[b]	3.78[a]	71.1[b]
25	47.0[b]	4.00[b]	70.0[b]	47.0[b]	3.56[b]	71.1[b]
50	47.0[b]	3.78[bc]	70.0[b]	47.0[b]	3.33[b]	71.1[b]
75	49.3[a]	3.56[bc]	70.0[b]	48.6[a]	2.89[c]	71.3[b]
100	49.3[a]	3.33[c]	71.7[a]	49.3[a]	2.77[c]	72.2[a]
SE±	0.720	0.187	0.250	0.51	0.130	0.69
Interactions	NS	NS	NS	NS	NS	NS
S X D						

Means within a column of treatments followed by unlike letter(s) are significantly different using DMRT at 5% level of significance.

SxD – Interaction between stages and intensity

NS – Not Significant

Table 3: Effect of stage and intensity of defoliation on the yield and yield parameters of vegetable cowpea at Samaru during the 2006 and 2007 rainy seasons

	Yield and yield parameters of vegetable cowpea					
	2006			2007		
Treatments	Weight of pod kg/ha	Number of pods	Length of pod (cm)	Weight of pod kg/ha	Number of pods	Length of pod (cm)
Stages						
Vegetative	969^{b}	8.23^{c}	9.87^{b}	872^{b}	8.27^{b}	9.27^{b}
Flowering	1256^{ab}	13.83^{b}	12.07^{a}	1416^{ab}	12.20^{b}	11.20^{ab}
Podding	1945^{a}	23.10^{a}	11.47^{ab}	2336^{b}	24.33^{a}	12.00^{a}
SE±		1.895	0.658		3.330	0.873
Defoliation(%)						
0	1733^{a}	27.06^{a}	12.33^{a}	1902^{a}	23.11^{a}	12.33
25	1652^{a}	16.89^{b}	11.56^{ab}	1843^{a}	18.89^{ab}	10.78
50	1347^{a}	12.06^{b}	12.11^{a}	1756^{a}	15.89^{ab}	9.16
75	1232^{b}	11.28^{b}	10.52^{ab}	1139^{b}	11.22^{a}	11.65
100	985^{b}	7.89^{b}	9.11^{b}	1065^{b}	5.56^{a}	9.89
SE±		2.446	0.849		4.300	1.127
Interaction	X	NS	NS	X	NS	NS
SXD						

Means within a column of treatments followed by unlike letter(s) are significantly different using DMRT at 5% level of significance.

SxD – Interaction between stages and intensity

NS – Not Significant X-Significant at5%

Table 4: Interaction of stage and intensity of defoliation on the yield of vegetable cowpea at Samaru during the 2006 and 2007 rainy seasons

	2006			2007		
	Stages			Stages		
Treatments	Vegetative	Flowering	Podding	Vegetative	flowering	Podding
0%	2603^{a}	2893^{a}	2767^{a}	2034^{a}	2028^{a}	2058^{a}
25%	1232^{b}	1576^{b}	2427^{a}	955^{c}	1968^{b}	2589^{a}
50%	1090^{b}	1206^{b}	1701^{b}	913^{c}	1623^{b}	2144^{a}
75%	1031^{b}	1070^{b}	1603^{b}	505^{c}	919^{c}	1794^{b}
100%	953^{b}	1003^{b}	1222^{b}	462^{c}	837^{c}	1050^{b}
SE						

Means within a column of treatments followed by unlike letter(s) are significantly different using DMRT at 5% level of significance.

Developmental Characters: The developmental characters such as days to 50% flowering, days to 95% pod maturity were significantly $p<0.5$ increased by defoliating at the vegetative stage, while number of flowers at 7 WAS reduced by defoliating at the vegetative stage. As shown in Table 2 the intensity of defoliation significantly increased the number of days to 50% flowering by defoliating at 75% and 100%,while number of days to pod maturity was increased by 100% defoliation. Number of flowers at 7 WAS reduced by the various intensities of defoliation. The highest intensity of defoliation at lower flower formed.

Yield and Yield Parameters: Yield and yield parameter as shown in Table 3 were significantly $p<0.05$ reduced by stage of pod length; and pod weight were reduced by defoliating at the vegetative stage; number of pods was also reduced by defoliating at both vegetative and flowering stages. The intensity of defoliation significantly affected the yield parameters. The intensity of defoliation significantly affected the yield parameters. Pod length was reduced by 100% defoliation, numbers of pods were affected by 25% defoliation, but there were no significant differences between 25-100% defoliation. Pod weight was reduced when 75 and 100% of the leaves were defoliated. There was no significant difference between 75 and 100% defoliation. The interaction between stage and intensity of defoliation was significant (add the statistic value) for pod yield and reveals that defoliating above 50% at vegetative and flowering stages was more detrimental to the yield of vegetable cowpea as shown in Table 4.

DISCUSSION

The effect of stage and intensity of defoliation on the vegetative showed that the removal of young expanding leaves prior to podding suppressed the vegetative growth and altered partitioning. This result is in agreement with those obtained by Shibles *et al.* [14] who reported that plants are affected by various manipulation that alters the source sink ratio including depoding, partial or total shading of the foliage, foliage removal, light and carbon dioxide enrichment. Mondae *et a*l. [15] and Selter *et al.* [16] reported that defoliation alters hormone balance, starch, sugar, protein and chlorophyll concentration of source leaves as well as stomata resistance and senescence rate. The effect of defoliation depends, however on the growth at which defoliation takes place.

The effect of stage and intensity of defoliation on the developmental characters suggested that the presence of mature leaves is necessary for floral initiation and pod development. Defoliation had reduced the rate of leaf photosynthesis and alter the ability of the photosynthetic source leaves to export assimilate. Similar results were reported by Bubehein *et al.* [6] who found that the days to 50% flowering was increased by two days when cowpea were defoliated at the early stage.

Yield and yield parameters were significantly affected by stage and intensity of defoliation and according to Ogunlela and Ologunde [9] if defoliation occurs in sorghum too early in the growth cycle it is likely to depress the grain yield. Also Asgar and Ingram [17] pointed that when the flag leaves of wheat were removed at different growth stages it significantly reduced grain yield of wheat. Muro *et al.* [18] showed that crop yield loss of sunflower was increased with increasing level of defoliation. The interaction between stages and intensity of defoliation showed that both stage and intensity of defoliation affected the pod yield of vegetable cowpea. Leaves are needed throughout the growth and developmental stages of the plant and the combined effects of stage and intensity of defoliation was greater than the individual effect of stage or intensity alone.

Conclusion and Recommendations: The finding from the study revealed that removal of leaves from vegetable cowpea affects the vegetative and developmental characters and yield and yield parameters of cowpea. The performance of the crop was poor for defoliation imposed at vegetative and flowering stages while 75 and 100% defoliation was detrimental to cowpea growth and development. The yield was impressive at podding stage and at 50% intensity. Cowpea may be defoliated at podding stage and at intensity below 50%.

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