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Effect of Defoliation Timing and Severity on the Yield and Nutritive Value of *Phaseolus vulgaris* L.

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ABSTRACT: The effects of removal of one (33%) or two (66%) leaflets per matured leaf of *P. vulgaris* L. within different growth periods on the yield and nutritive value of the plants were investigated. Leaf removal was done during vegetative (V), flowering (F) and pod development stages (P). There was no correlation between total number of pods and seeds. The plants had a significant increase in seed yield when defoliation was done at 33%F (at P=0.05). There was a significant decrease in pod and seed yield when defoliation was done at pod development stage (at P=0.05). Defoliation had no effect on the weight of seeds produced. There was a significant increase in carbohydrate content of seeds at 66V but a significant decrease at 33F and when defoliation was done at pod development stage (at P=0.05). A significant (at P = 0.05) decrease in protein content of seeds occurred as defoliation level increased from 0% to 66% at all growth stages. The stage of defoliation, the level of defoliation and the rate of leaf re-growth are factors that could have affected the effect of defoliation on the yield of *P. vulgaris*. Other causes include the delay in senescence of lower remaining leaves. Defoliation of *P. vulgaris* for the use of the green leaves results in the production of lower quality seeds as defoliation reduces the protein content drastically. Hence, defoliation should be discouraged. However, where it cannot be avoided due to non-availability of other vegetable plants or animal feeds, it should be done at 33% defoliation (a leaflet per leaf) appreciably, before fruit set.

Key Words: Defoliation timing; *Phaseolus vulgaris*; Grain yield; Nutritive value.

Introduction

Defoliation or leaf removal due to external factors, affects growth and yield of plants. The effect of defoliation on the physiology of remaining leaves varies between plant species (Welter, 1989). The damages caused by defoliation are minimal in plants that produce leaves rapidly (Muro *et al*, 1998). The effect of leaf loss on yield has been associated with the fact that seed numbers limited by the activity of the source (leaves; Egli, 1998).

Studies on the effect of defoliation on plant growth and yield are aimed at speculating the effect of defoliation caused by pests, such as, weevils (Peterson *et al*, 1992), clover worm (Higgins *et al*, 1983), Ostlie and Pedigo, 1985), and arthropods in general (Weelter, 1989; Higley, 1992). Other effects are drought (Klubertanz *et al*, 1996; Caviness and Thomas, 1980)and man (Garcia del Moral *et al*, 1995).

The period and level of defoliation due to these factors have been found to determine the extent of the effect. Defoliation of above 50% during the reproductive stage has caused significant reduction in tyield (Sacchan *et al*, 1980; Diogo *et al*, 1997; Muro *et al*, 1998). The higher the level of defoliation, the higher is the yield loss (Muro *et al*, 1998). According to Caviness and Thomas (1980), reduction in number of pods appeared to be the yield component primarily responsible for yield losses caused by defoliation.

Apparently, the percentage in seed yield alone cannot account for reduction in yield. However, they have no information to substantiate their view. Defoliation has been shown to affect not only seed/grain yield, but also, their nutritive value. Defoliation has been shown to increase grain protein in *Triticel* (*Triticum aestivum x Secale cereale* L; Garcia del Moral *et al*, 1995) and reduce sugar content in sugar beet (Sacchan *et al*., 1980; Muro *et al*, 1998). Increase in percentage grain protein in *Triticel* either due to cuttings or to drought may be attributed to a reduction in starch accumulation (Garcia del Moral *et al*; 1995). An increase in the demand for green leaves, green pods, green seeds and dry seeds of Phaseolus *vulgaris* L. resulting in increased cultivation led to the investigation of the effect of defoliation on the yield and nutritive value of *P. vulgaris* seeds.

Materials and Method

Seeds of *P. vulgaris* L. cv. Ife Brown were collected from Institute of Agricultural Research and Training (I.A.R.&T.), Moor Plantation, Ibadan, Nigeria. The experimental site was located at the Botanical garden of the University of Lagos, Akoka-Yaba, Lagos.

Growth experiment

Twenty-one, 0.7m x 1.5m beds were made at the site. Three beds were taken as replicates for a treatment, resulting in seven treatments labeled 33V, 66V, 33F, 66F, 33P, 66P and Control. These numbers represent the percentage defoliation 33%= one terminal folio and 66%= two opposite folios of each matured trifoliate according to Diogo *et al*, 1997. The letters represent the growth period during which the defoliation was done: V = vegetative; F= flowering and P = pod development period and Control = 0% or No defoliation throughout growth. Four seeds were placed in every hole about 0.3m apart in the beds. They were watered on alternate days till seed maturity. A total of 36 plants per bed were used.

Growth parameters determined

Harvest was done at maturity for about three weeks removing pods as they get ripe each day. The total number of pods harvested per bed and the number of seeds per pod in each set were recorded. The seed weight and total number of seeds harvested per bed were recorded.

Carbohydrate content

One-gram sample of ground bean seeds from each bed, were each mixed thoroughly in 250µl of distilled water. The methods of Stark *et al*, (2000) and Wright and Rebers (1972) were modified and used for the estimation of the carbohydrate content of seeds. 200µl of the solution was cooled in an ice bath and 900µl of reagent A (4ml distilled water = 24ml conc. H_2SO_4) was added. The mixture was shaken carefully. It was boiled in water bath for exactly 20 minutes and then cooled to room temperature under cold water tap. 20µl of reagent B (freshly prepared, 0.3g cysteine in 10ml distilled water) was added and the mixture shaken before being allowed to stand for 30 minutes in the dark at room temperature. Standards were prepared using 1,2,3,4 and 5µl of glucose at 2µg/ml. The blank was prepared by using all the above reagent mixtures without the sample. The optical density was measured at 505 and 545 using a Corning 258 spectrophotometer. The differential absorbance H_{545}-H_{505} was used to determine the carbohydrate absorbance. The carbohydrate content was determined from the standard curve prepared from values of glucose used.

Lowry protein estimation

Two grams of ground bean seeds from each bed, were each mixed thoroughly in 200µl of distilled water. 1ml of a mixture (25ml of 2% Na_2CO_3 in 0.1N NaOH, 0.25ml of 2% NaK Tartrate and 0.25ml of 1% $CuSO_4.5H_2O$) was added. The resulting solution was mixed well with vortex and incubated for 10 minutes at room temperature. 50µl of Folin Ciocalten phenol reagent was added and the solution was mixed well with vortex. It was incubated for 30 minutes at room temperature. The optical density was read at 540 nm against a water-blank. The protein content was determined from a standard curve from bovine serum albumin (Mangel *et al*, 1992; Lowry *et al*, 1951).

Analysis of Data

The data obtained were analysed by ANOVA and tests of significance (at P=0.05) were determined using Duncan's Multiple Range Test.

Results and Discussion

Pod and Seed Yield

The total number of pods/harvest and total number of seeds/harvest are shown on Fig. 1 and 2 respectively. The total number of pods and seed yield appears to be affected by percentage defoliation and the stage of growth (vegetative, V; flowering, F and pod development, P) at which defoliation occurs in *P. vulgaris* L. cv. Ife Brown. Plants defoliated only by 33% at the vegetative and flowering stages increased number of pods and seed number in comparison with the undefoliated plants (control), though the increase was significant only in the number of seeds produced by the plants subjected to 33% defoliation at the flowering stage (at P=0.05, 33F).

Plants defoliated at pod development stage had significant decrease in pod and seed yield as % defoliation increased from 0% to 66%. The weights of seeds were not significantly affected by defoliation except in plants subjected to 66% defoliation at vegetative and pod development stage (at P=0.05, 66%). According to Carviness and Thomas (1980), a reduction in number of pods appeared to be the yield component primarily responsible for yield losses from defoliation in irrigated and non-irrigated soybeans (*Glycine max* L.). The result of these experiment using *P. vulgaris* showed that there is no correlation between number of pods and total number of seeds. Therefore, it could be assumed that the level of seed set within each pod determines the seed harvest index. Increasing rates of defoliation in late development stage (pod development) has been shown to significantly reduce seed yield in soybean (*Glycine max*) and sorghum (*Sorghum bicolour*), with a reduction reaching 80%when all leaves were removed during pod development (Diogo *et al*, 1997).

Egli (1998) has shown that the number of seeds produced by soybean (*Glycine max*) community is related to canopy photosynthesis during flowering and pod set. He stated that seed number is limited by the activity of the source (leaves). Invariably, the higher the number of leaves during flowering and fruiting, the higher the seed yield. Defoliated-stressed plants have been found to conserve more water than non-defoliated-stressed plants. Also, compensatory re-growth was observed following defoliation, resulting in more leaves in defoliated plants than predicted. Delayed senescence and an increase in the activity of lower leaves have also been reported (Higgins *et al*, 1983; Ostlie and Pedigo, 1985; Welter, 1989; Higley, 1992; Klubertanz *et al*, 1996; Peterson *et al*, 1998). These responses according to Klubertanz *et al*, (1996), may aid soybean in tolerating defoliation during vegetative and early reproductive stages. The results of this experiment showed that *P. lgaris* could have been aided by these responses, to tolerate defoliation at vegetative and flowering stages, and even boost yield significantly as observed in the 33F plants.

Nutritive Value:

Defoliation at the vegetative stage increased the carbohydrate content of the seeds though only significantly at 66% defoliation (at P=0.05). On the other hand, a significant decrease in carbohydrate content was observed at 33F and when defoliation was done during pod development stage (at P=0.05, Fig. 4). Sacchan *et al* (1980), have shown that significant losses in sugar content were not noticed for defoliations below 75%. Despite the lower percentage of defoliation (66%0 used in this study, the decrease in carbohydrate content was still significant.

The protein content decreased significantly with increase in the level of defoliation from 0% to 66% at all growth stages (Fig. 5). However, Garcia del Moral *et al* (1995) reported an increase in protein content due to defoliation in the monocot, *Triticel*. No record of experiments involving the effect of defoliation on

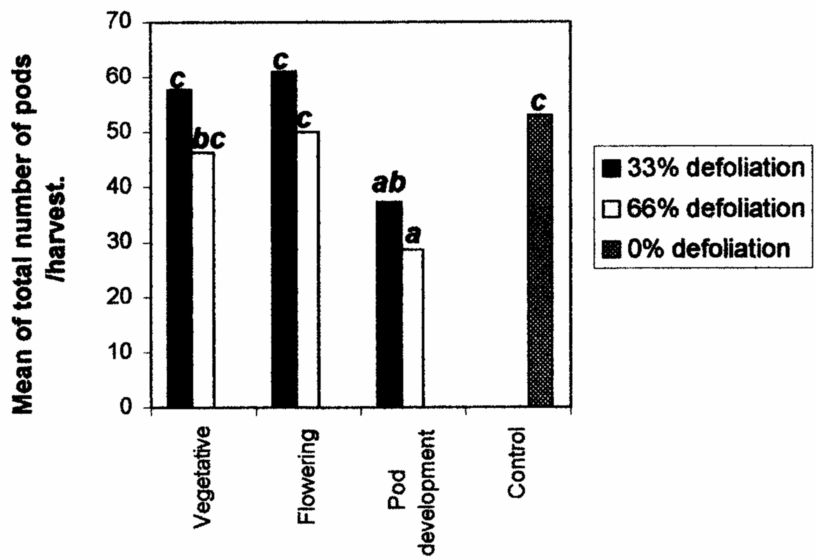

Fig. 1: Mean of total number of pods/harvest at different levels and periods of defoliation. Means followed by the same letters are not significantly different at P = 0.05, according to Duncan's Multiple Range Test.

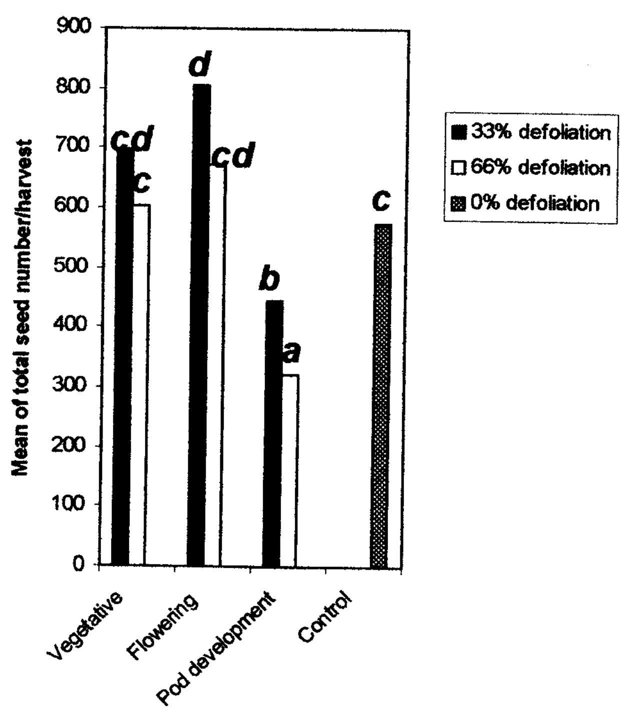

Fig. 2: Mean of total number of seeds/harvest at different levels and periods of defoliation. Means followed by the same letters are not significantly different at P = 0.05, according to Duncan's Multiple Range Test.

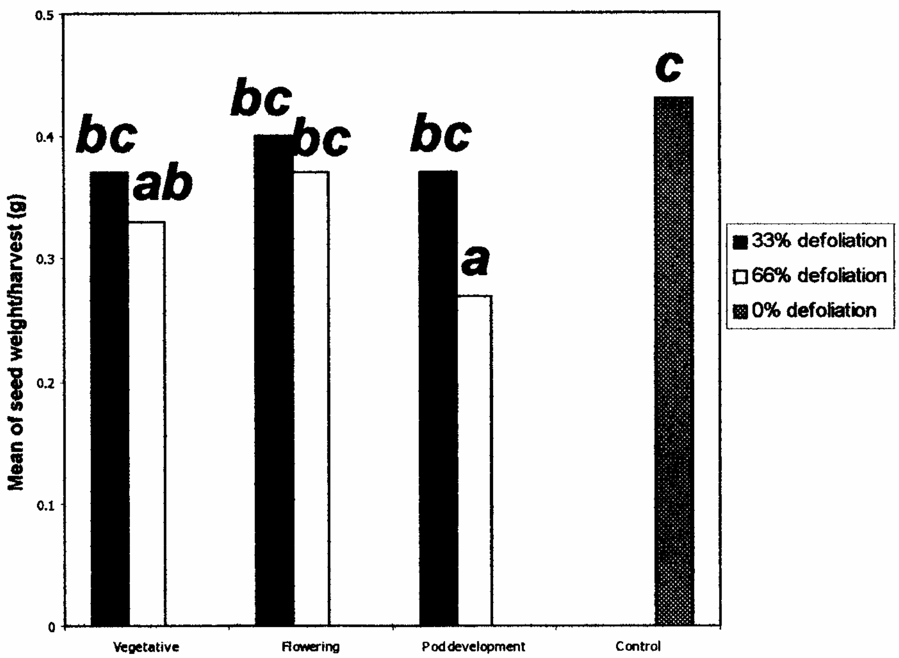

Fig. 3: Mean of seed weight (in g)/harvest at different levels and periods of defoliation. Means followed by the same letters are not significantly different at $P = 0.05$, according to Duncan's Multiple Range Test.

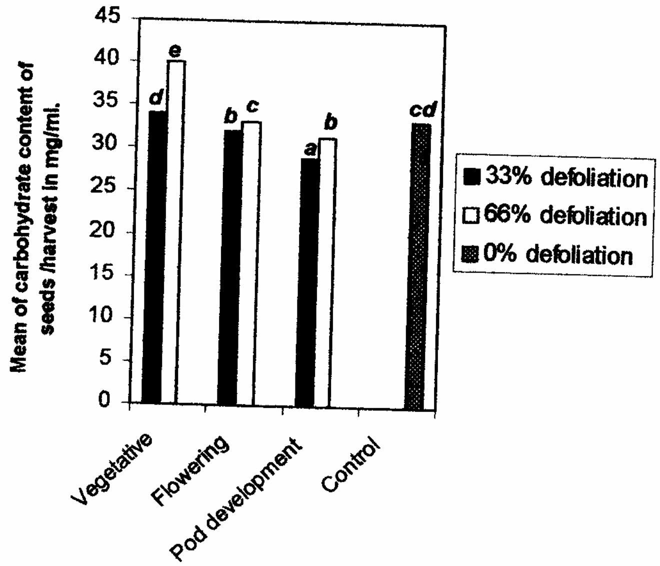

Fig. 4: Mean of carbohydrate content of seeds (in mg/ml)/harvest at different levels and periods of defoliation. Means followed by the same letters are not significantly different at P = 0.05, according to Duncan's Multiple Range Test.

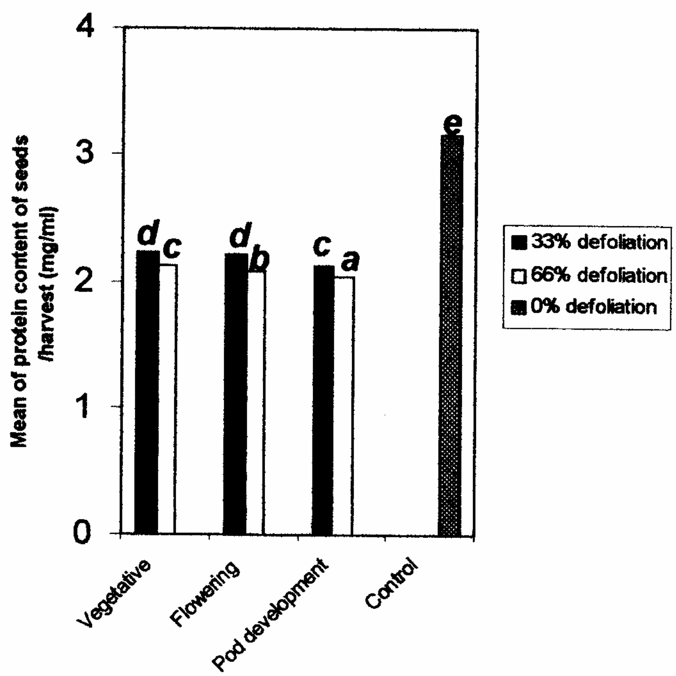

Fig. 5: Mean of protein value of seeds (in mg/ml)/harvest at different levels and periods of defoliation. Means followed by the same letters are not significantly different at P = 0.05, according to Duncan's Multiple Range Test.

the protein content of dicotyledons was found. Since the large drop in protein level occurred with defoliation, it suggests that any act of defoliation is detrimental to the protein value of *P. vulgaris*. The critical stage of defoliation effect on the yield and nutritive value of *P. vulgaris* is at the pod development stage. This is in agreement with the report of Muro *et al* (1998), who worked on sugar beet. They stated that at the stage of pod development when plants had accumulated photosynthates, defoliation is detrimental. The stage of defoliation, the level of defoliation and the rate of leaf re-growth might have affected the effect of defoliation on the yield of *P. vulgaris*. Other causes include the delay in senescence of lower remaining leaves and the rate of increase in the physiological activities of lower remaining leaves. All these could hold true for other plant species, except that the effect of defoliation on the physiology of remaining leaves varies between plant species (Welter, 1989).

Defoliation of *P. vulgaris* for the use of the green leaves results in the production of lower quality seeds as defoliation reduces the protein content drastically. Hence, defoliation should be discouraged. However, where it cannot be avoided due to non-availability of other vegetable plants or animal feeds, it should be done at 33% defoliation (a leaflet per leaf) appreciably, before fruit set.

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