Effects Of Artificial Defoliations On The Growth And Yield Of Okra (Abelmoschus Esculentus (L.)(Moench.) CV 'Smooth Cayene' Under Mid-Elevation Condition

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Abstract: Defoliation of the lower leaves of the stem provides the upper leaves to maximize their photosynthetic activity, thus optimizing their growth and yield potentials. This study was conducted to determine the effect of artificial defoliations on the growth and yield of okra under the mid-elevation condition of Bukidnon, Northern Mindanao, Philippines. A Randomized Complete Block Design (RCBD) with four treatments and three replications was used, namely: T_1 (no defoliation), T_2 (defoliation of lower half of the stem- DLHS at 5 weeks after sowing-WAS), T_3 (DHLS at 6 WAS), and T_4 (DLHS at 7 WAS). Results revealed that artificial defoliations significantly influenced the production of pods, weight of pods per plant and the total pod yield per hectare, but not with the plant height, pest resistance, days to flowering, and length and diameter of pods. Removal of the lower leaves of the stem paved the way for upper leaves to intensify photosynthetic activity and minimized mutual shading and competition for foods. Treatment 4 consistently obtained the most number of pods (82), heaviest pods per plant (394.81 g) and highest total yield (9.87 t/ha). Consistently, T_4 (defoliation at 7 WAS) registered the highest ROI with 425%, while T_1 obtained the lowest with 316.11%. Thus, defoliations at 7 WAS of the lower leaves gave better growth and yield performance of Smooth Cayene variety than those undefoliated under the mid-elevation condition of Bukidnon.

Index terms: Defoliation, defoliation of lower half of the stem (DLHS), erectophile, leaf area index (LAI), mutual shading, pods, Smooth Cayene, return on investment (ROI), week after sowing (WAS)

1 INTRODUCTION

Okra (Abelmoschus esculentus (L.) (Moench.) belongs to Mallow family. Although mainly grown for its immature fruits, okra has multiple and integral uses. Okra is an herbaceous annual crop with thick branched and semi-woody stem that can reach up to 4 meters. It has large lobe, rough, bristly leaves and shiny yellow flowers with a purple center. It is an important food vegetable because of its economic and nutritional value [1]. Okra is a good source of vitamins A, B and C; calcium and iron. It is especially rich in calcium compared to tomato and eggplant. It is also good source of dietary fiber, a fat-free and a low calorie food that is ideal for weight loss diets. Its seeds are high in protein. Aside from food uses, okra can also be utilized for cattle feeds. The stem fibers are used to card, paper, and textiles and as substitute to jute. Likewise, it has also a number of medical applications [9]. Okra can be grown from low to mid elevation areas throughout the year where Musuan in Bukidnon province favors this condition. The total net income of okra per hectare is about 40% to 80% with yield of 12-15 t/ha at a farm gate price of US $ 0.255 per kilogram [11]. Bukidnon serves as the main strategic source of vegetables in Region X, thereby producing more than half of the supplies in the vegetable market of Cagayan de Oro City for local, national and export consumption [4,5]. Defoliation is the removal of leaves.

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According to many researchers, defoliation in plants may have varied effects to their growth and performance, depending on the stages of plants; the types, sites, sizes and the time defoliation is performed in plants. In this study, defoliation was done by removing the lower leaves because okra produces more leaves before flowering. The more number of leaves being defoliated in okra, the earlier the plants to produce flowers, the shorter the plant it became and more pest resistant, though yields and its components showed no significant differences regardless of defoliation intensities and organic fertilization [12]. It was found-out that removal of leaves of okra from the upper half of the stem only had a similar effect to complete defoliation whereas the removal of leaves from the lower half only had no significant effect, indicating that the leaves on the upper stem contributed more to growth and yield than those lower down [8]. Defoliations were done before reproductive stage. Significant time and degree of defoliation interactions occurred for most growth and yield parameters. However, leaf defoliations were only done once simultaneously. It further revealed different light environments were created by 50% defoliation at vegetative growth and at first flower 50% shading from vegetative growth to first flower, and two light enrichment treatments initiated at the first flower and pod formation stages [6]. The 50% shade treatment prior to flowering significantly decreased harvest index and seed yield. Light enrichments increased seed yield only one of those location years (the four sites excluded because of diseased damage). Defoliation at vegetative growth or first flower had a marginal effect on seed yield, largely as a result of the regrowth of vegetative tissues compensating for the plant tissues. It was proven that silking was delayed by increasing plant density. Defoliation (even partial) at the 16th fully expanded leaf stage resulted in substantial reduction in LAI and such yield components as number of ears, ear length, era diameter and 1000-grain weight [13]. On the other hand, partial defoliation at the 10th fully expanded leaf stage to simulate an erectophile canopy

led to yield increases even under high plant density (9000 plants/ha) in the kharif (rainy season), mainly through an increase in number of ears, 1000-grain weight and grain to stover ratio coupled with a reduction in barrenness and percentage of lodging. Furthermore, it revealed that most productive treatment in terms of fresh above-ground biomass was the treatment with 12 functional leaves retained, which were significantly greater than control plants [14]. The optimized functional parameters of Greenlab for the source and sink relationships were found to be affected in relation with the number of functional leaves retained on the plants. The Smooth Cayene variety of okra exhibited larger leaf structures especially at the lower half of the stem, thus annoying the plants especially in their flowering and reproductive stage, and delaying a little bit in their flowering [2]. Thus, this study aimed to investigate whether artificial defoliation at 5, 6, and 7 weeks after sowing with complete removal of the lower-half of the leaves per plant have significant effects on the growth and yield of okra under the mid-elevation condition of Bukidnon, Philippines.

2 MATERIALS AND METHODS

This study was conducted at the garden area of Sunrise Residence Hall (Graduate Dormitory) of Central Mindanao University (CMU), Musuan, Maramag, Bukidnon, Philippines from December 2013 to March 2014.The Randomized Complete Block Design (RCBD) with four (4) treatments and three (3) replications was used in this study, namely: Treatment 1(No defoliation),Treatment 2 (defoliation at lower half of the stem 5 weeks after sowing), Treatment 3 (defoliation at lower half of the stem 6 weeks after sowing), and Treatment 4 (defoliation at lower half of the stem 7 weeks after sowing). The study utilized a total land area of 20.25 sq.m. and composed of 12 plots with a dimension of 0.6 x 0.6 m or an area of 0.36 sq.m. per plot. Each plot was planted with 4 hills with a distance of 60 cm from apart. The distance of plots within blocks was 50 cm and 75 cm between blocks. Soil samples were collected from the bulk of the media for soil analysis such pH, P, K and organic matter. Cleaning, cultivation, pulverization and elevating the whole plots were likewise done with the whole area being enclosed with plastic twines. Labeling of the experimental plots was done before sowing the seeds. Needed fertilizers were applied basally to the plants. A total of 10 g 14-14-14 was applied per plant and 40 g for vermicast. Thirty days after emergence, each hill was side dressed with 10g 46-0-0 (urea). A recommended amount of benlate was applied in each plot before planting. Seeds were sown and thinning was done when seedlings were already established in the area bearing at least three (3) leaves. One seedling was maintained per hill throughout the study. Removal of weeds from the area was done along with cultivation to facilitate proper aeration and growth of experimental plants. Defoliation of leaves started when the plants reached 25, 30 and 35 days old at the lower half of the stem (Figure 1). Pods were harvested 8 days after flower opening or when they were about 10-12 cm long or while the pods are young, tender and snappy. The pods were marketed to retailers or any outlet in CMU. Among the data gathered were the plant height; number of days to first flowering; pest resistance; average number, length and diameter of pods; weight of pods; total yield; and cost and return analysis. The analysis of variance (ANOVA) was used to determine the level of significance with the Tukey's Test on post hoc analysis.

***Figure 1**. Defoliating the lower leaves of Okra*

3 RESULTS AND DISCUSSION

3.1 Plant height and plant resistance

The plant height and pest resistance of okra were not significantly affected by artificial defoliations (Table 1). Statistical analysis revealed no significant differences observed among treatment means. Plants in Treatment 1 which were not defoliated obtained the tallest height with 85.81 cm. They were not, however, significantly far from those in T_3 (85.64 cm), T_4 (85.59 cm) and T_2 (84.14 cm). Regardless of defoliation intensities, the height of okra was not affected. Growth and development of plants is controlled by its genetic make-up, though environmental factors enhance it [7]. On the pest resistance, okra was likewise not affected by various artificial defoliations. However, T_1 and T_3 obtained the highest resistance rating with both 5.00 (strongly resistant). While, T_2 and T_4 garnered with both 4.67 resistance rating and could still be categorized as strongly resistant. Without applications of any pesticide, the Smooth Cayene variety was resistant to pests and diseases as the seeds were already pre-treated with pesticides.

3.2 Number of days to first flowering, length and diameter of pods

On the number of days to first flowering, length and diameter of pods, statistical analysis revealed no significant differences observed among treatment means (Table 2). However, T_2 (defoliated after 5 weeks) flowered first at 47.67 days after sowing. Plants in T_1 (no defoliation) flowered first at 49 days after sowing. As the same variety was used (Smooth Cayene), their genetic constituents would much dictate given the same environmental conditions for the plants [7,3], though, those being defoliated flowered earlier than those grown normally. Artificial defoliations did not statistically affect the length and diameter of the pods of okra (Table 2). Statistical analysis showed no significant differences observed among treatment means. It showed, however, that T_4 (defoliated after 7 weeks) obtained the longest pod (19.02 cm), followed by those in T_3

and T_2 with 18.79 cm and 18.23 cm, respectively. The shortest was T_1 (control) with 16.47 cm. On the diameter of the pods, it revealed consistently that T_4 was measured to have the widest with 2.26 cm and was not significantly different from the rest of the treatments. The shortest diameter was obtained by T_1 with 1.96 cm.

Table 1. *Plant height (cm) and pest resistance of okra (Abelmochus esculentus L.) (Moench.) cv 'Smooth Cayene' as influenced by artificial defoliations under mid-elevation condition*

Treatments	Plant Height (cm)	Pest Resistance
T_1 - (No defoliation)	85.81	5.00
T_2 - (Defoliation of lower half of the stem 5 weeks after sowing)	84.14	4.67
T_3 - (Defoliation of lower half of the stem 6 weeks after sowing)	85.64	5.00
T_4 - (Defoliation of lower half of the stem 7 weeks after sowing)	85.59	4.67
F-test	ns	ns
CV (%)	6.99	9.12

Rating scales: 5 - Strongly resistant (100% healthy), 4 - Moderately resistant (1-10% damage), 3 - Slightly resistant (11-20% damage), 2 - Strongly yellow/shows very weakling appearances (21-30% damage) and 1 – Very susceptible (31-40% damage)

Table 2. *Number of days to first flowering, length and diameter of pods (g) of okra (Abelmochus esculentus L.) (Moench.) cv 'Smooth Cayene' as influenced by artificial defoliations under mid-elevation condition*

Treatments	No. of Days to First Flowering	Length of Pods (cm)	Diameter of Pods (cm)
T_1 - (No defoliation)	49.00	16.47	1.96
T_2 - (Defoliation of lower half of the stem 5 weeks after sowing)	47.67	18.23	1.92
T_3 - (Defoliation of lower half of the stem 6 weeks after sowing)	48.33	18.79	2.01
T_4 - (Defoliation of lower half of the stem 7 weeks after sowing)	48.67	19.02	2.26
F-test	ns	ns	ns
CV (%)	3.46	6.02	7.38

ns – non significant

3.3 Number of pods, weight of pods per plant and pod yield per hectare

Table 3 shows the number of pods, weight of pods per plant and the total pod yield per hectare which were significantly influenced by artificial defoliations given the same environmental conditions. On the number of pods, T_4 (defoliated 7 weeks after sowing) obtained the most number with an average of 82, while the least was garnered by T_1 (not defoliated) with 68 pods. Treatment 4 was not statistically different from those in T_3 and 2 with 76 and 71 pods, respectively, but significantly far from those in T1 (control). Though defoliation affects the photosynthetic activity of the plants [7 as cited by 12], leaves of okra at the lower half of the stem are mutually shading with each other as exhibited by the morphological leaf structures of Smooth Cayene variety, thus contributing very less light reception needed by the plants in photosynthesis. The lower leaves become detrimental to the upper leaves as these serve as competitors of the photosynthates [10]. Thus, the removal of the leaves at the lower half of the stem provides opportunity for the upper leaves to maximize their photosythetic activity at faster intensity, so production of phtosynthates to the growing organs of the plants could easily be facilitated [10,3,7]. On the weight of pods per plant, it showed that plants in Treatment 4 obtained the heaviest pods with 394. 81 g, and was not statistically far from T_3 and T_2 with 358.73 g and 333.35 g, respectively. The lightest pods were found in T_1 with 316.11 g. This signifies that defoliations at various stages significantly influenced the respective weights of pods of okra. The more number of pods obtained per plant with their varied sizes, the heavier the pods per plant would become. Likewise, defoliations at various stages significantly influenced the total pod yield of Smooth Cayene okra in a hectare basis. Treatment 4 (defoliated after 7 weeks) obtained the highest pod yield with 9.87 t/ha and was not statistically different from T_3 and T_2 with 8.74 and 8.58 t/ha, respectively, but was significantly different from those in T_1 with 8.16 t/ha. This finding consistently conformed with the previous parameters as these were contributory to the yield. Simultaneous defoliations of okra at earlier stages obtained lower yields compared to those defoliated at 7 days after sowing. Defoliation at this stage often results to hampering the photosynthetic activity of the plants where the process maximizes, while defoliation at late vegetative stage is less contributory to the flowering and fruit-bearing activities of the plants where photosynthates are already translocated in the reproductive regions of the plants [10].The condition in the mid-elevation level of Bukidnon also optimizes the growth of Smooth Cayene okra.

Table 3. *Number of pods, weight of pods (g) per plant and total pod yield per hectare of okra (Abelmochus esculentus L.) (Moench.) cv 'Smooth Cayene' as influenced by artificial defoliations under mid-elevation condition*

Treatments	No. of Pods	Weight of Pods/Plant (g)	Total Yield (tons/ha)
T_1 - (No defoliation)	68[b]	316.11[b]	8.16[b]
T_2 - (Defoliation of lower half of the stem 5 weeks after sowing)	71[b]	333.35[ab]	8.58[a]
T_3 - (Defoliation of lower half of the stem 6 weeks after sowing)	76[a]	358.73[a]	8.74[a]
T_4 - (Defoliation of lower half of the stem 7 weeks after sowing)	82[a]	394.81[a]	9.87[a]
F-test	*	*	*
CV (%)	12.52	14.41	14.60

Means of same column followed by common letters are not significantly different at 5% using Tukey Test.

3.4 Cost and return analysis

In the cost and return analysis shown in Table 4, it is revealed that Treatment 4 (defoliated at 7 weeks after sowing) obtained the highest return on investment (ROI) with 425.00%. This was followed by T_3 (defoliated at 6 weeks after sowing) with 364.89%, T_2 (defoliated at 5 weeks after sowing) with 337.77% and the least in T_1 (control) with 334.04%. These ROIs were likewise based from the respective net returns over the expenses and multiplied by 100. It shows that the highest ROI which is registered in T_4 was due to the highest net returns with highest gross sales.

Table 4. *Summary of the cost and return analysis (US $) of okra (Abelmochus esculentus L.) (Moench.) cv 'Smooth Cayene' as influenced by artificial defoliations.*

Treatments	Gross Sales	Total Expenses	Net Return	Return on Investment (%)
T_1 - (No defoliation)	4,434.78	1,021.74	3,413.04	334.04
T_2 - (Defoliation of lower half of the stem 5 weeks after sowing)	4,472.83	1,021.74	3,451.09	337.77
T_3 - (Defoliation of lower half of the stem 6 weeks after sowing)	4,750.00	1,021.74	3,728.26	364.89
T_4 - (Defoliation of lower half of the stem 7 weeks after sowing)	5,364.13	1,021.74	4,342.39	425.00

US $ 0.5319/kg – prevailing farm gate price (US $1 = PhP 46.00)

4 CONCLUSION

Defoliations of the lower leaves at 7 weeks after sowing gave better growth, yield and return on investment of Smooth Cayene okra than those not defoliated under the mid-elevation condition of Bukidnon.

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