

Effect of Feeding on Peanut Growth by Corn Earworm, *Helicoverpa Zea*

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Abstract

Two growth chamber experiments were conducted to evaluate the effect of feeding by corn earworm, *Helicoverpa zea* (Lepidoptera: Noctuidae) on peanut growth and development. In Experiment 1, *H. zea* eggs and larvae were transferred to peanut plants during the vegetative growth stage and larvae were allowed to feed on components of the peanut canopy. Feeding resulted in 25%, 50%, and 65% defoliation. In Experiment 2, 25% or 35% of the leaves were defoliated by corn earworm introduced at the pod forming and pod-filling stage. Results and observations showed that corn earworm preferred feeding on young peanut shoots. Excessive damage was caused by the large larvae feeding on new shoot growth, flowers, pegs, portions of the stems, and leaves. Corn earworm feeding resulted lower leaf, stem, root, peg, and pod masses. The effect lasted throughout the sampling period (about 5 weeks). The infested plants recorded fewer pods and lower pod mass at harvest.

Key words : Peanut, Growth, Defoliation and Corn earworm.

1. Introduction

Defoliation of peanut and reflected radiation of sunlight from peanut canopies are two important parameter of peanut growth and development model (Forrest *et al.*, 1996). Because yield often is related to the amount of radiation intercepted by the crop canopy (Ma *et al.*, 1992) and defoliation is directly related to the leaf area, which found a better relationship with pod yield in peanut (Forrest *et al.*, 1996). In North Carolina, the corn earworm, *H. zea* can cause severe defoliation of peanuts. They are usually found in peanut fields during the months of August and September (90 to 130 days post plant) (Linker *et al.*, 1984). Corn earworm damage to peanuts in North Carolina varies from year to year and from field to field depending on cultivar, weather conditions, and presence of other pests, parasites, and predators. Defoliations of 10% to 20% of the canopy are probably most common although severe defoliations up to 90% have been recorded. Corn earworm damage to peanuts in North Carolina prior to 1977 was considered sub-economic, but recently defoliation levels of 50% or more have been recorded (Campbell *et al.*, 1982).

In North Carolina, the appearance of corn earworm early during the growing season has not been reported. In the tropics, the corn earworm may appear in peanut fields early in the growing season. Yield losses associated with it have been

considered insignificant since there has been no massive build-up in the corn earworm population. Our previous study on hand defoliation of peanut (Endan *et al.*, 2006) showed that the peanut plant would quickly recover when defoliated 25% by hand during the vegetative growth stage. Even though corn earworm may feed on flowers, pod production and final yield will not be affected very much (Campbell *et al.*, 1986). Defoliation studies on peanuts (Wilkerson *et al.*, 1984) reported significant losses in yield when plants were defoliated during the pod-forming or the pod-filling stage. The objectives of this study were to observe corn earworm canopy feeding of peanuts and to study the effect of defoliation levels on the growth and development of Florigiant peanuts.

2. Materials and Methods

Peanuts (*Arachis hypogaea* L., cv. Florigiant) were grown in two walk-in chambers at the Phytotron Unit of the Southeastern Plant Environment Laboratory (SEPEL) at North Carolina State University, Raleigh, North Carolina. The chambers were identically set at 30/26° C day/night temperatures and 15 hours of photosynthetically active radiation at 680 $\mu\text{Em}^{-2}\text{s}^{-1}$. Seeds were sowed (day 1 of growth) in 11 cm diameter pots filled with 1/2 peat 1/2 sand. Two seeds were sowed in each pot and seedlings were thinned to 1 within 10 days and transplanted into 19 cm pots (Experiment 1) or plastic trays measuring 50 X 35

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X 10 cm at 2 seedlings per tray (Experiment 2). A mixture of 1/3 Redi-Earth (a peat vermiculite mixture) and 2/3 gravel by volume growth media was used. The pots and trays were placed on carts arranged in 2 rows of 6 carts/row per chamber at 4 pots per cart or 1 tray per cart giving plant densities of 5.38 and 2.69 plants/m², respectively. Extra plants were planted and used as dummies to close the end of the row. Plants were irrigated twice daily and supplied with complete nutrient solution twice a week.

Three methods of transferring the larvae to the peanut plants were tested in separate trials made prior to these experiments. They were; i) introducing large corn earworm (approximately 1.5 cm) with a brush on to the peanut plants, ii) introducing small corn earworm (4 mm to 9 mm) with a brush on to the peanut plants, and iii) introducing a mixture of eggs and newly hatched larvae by dropping them on the peanut canopies. The techniques were tested in a greenhouse and in a growth chamber at Weaver Laboratories at North Carolina State University, Raleigh, North Carolina. The trials were made to; a) estimate the length of time that the corn earworm would take to defoliate a plant, b) to develop techniques for achieving several levels of defoliation, and, c) to develop proper techniques of control of the adult population in a growth chamber for safe introduction into the controlled environment chambers at the Phytotron Unit of the SEPEL. Methods i) and ii) were unsuitable and were not used in these experiments because the desired defoliation levels were not achieved. Furthermore, these methods did not imitate corn earworm defoliation of peanuts in the field where the adults fly into a peanut field and oviposit on peanut canopies. The third method was used in this study because defoliation levels of up to 90% were achieved on the small peanut plants used in the trials.

In Experiment 1, four cups of newly hatched larvae and eggs of *H. zea* were obtained from the *H. zea* colony maintained by the Department of Entomology at North Carolina State University. The four cups contained approximately 5000 total larvae and eggs. They were transferred to a row of peanuts in chamber "A" 19. After 1 week, plants were moved and arranged into 3 groups according to severity of defoliation so as to obtain 3 levels of defoliation at the end of the defoliation treatments. Care was taken not to drop the larvae from the plants or to cause unnecessary disturbances. After 11 days, the group of plants that was least severely defoliated had reached the 25% level of defoliation.

The larvae that were still on this group of plants were then transferred to plants that were intended for a higher level of defoliation by slowly brushing them into a cup and dropping them on the canopy of the intended plants. By this time the other groups of plants had both achieved about 35% defoliation. De-ionized water was flushed on the group of plants (25% defoliation) to wash away any larvae that remained on the plants. Two plants each for the control (0% defoliation) and the 25% defoliation were sampled. Four further samplings were made for the control and the 25% defoliated plants over a period of 30 days. Five days later (day 45) the second group of plants had reached 50% defoliation. Similar techniques were used to remove the larvae from this group of plants. Two plants were sampled and 4 further samplings were made over a period of 3 weeks after the defoliation. Two days later (day 47) the remaining group of plants had reached about 65% defoliation and there were only 5 large larvae remaining on the 10 plants that were intended for 75% defoliation. It was decided that 65% would be the third level of treatment. De-ionized water was again used to flush any larvae remaining on the plants. Two plants were sampled for this treatment (65% defoliation) and four further samplings were spaced equally until day 77 of growth.

In Experiment 2, *H. zea* larvae and eggs were introduced on to the peanut plants 5 times, on the following days coinciding with the pod-forming and filling stage (i.e. between stage R3 to R6 as described by Boote (1982); i) Day 64, 4 cups (approximately 5000 larvae), ii) Day 68, 2 cups (approximately 2500 larvae), iii) Day 74, 3 cups (approximately 3750 larvae), iv) Day 78, 2 cups (approximately 2500 larvae), and v) Day 85, 4 cups (approximately 5000 larvae).

In the first, second, and third transfers, larvae were equally distributed among the two rows of peanuts grown in chamber A 18 which were intended for two levels of defoliation treatment. The fourth and fifth transfers were made only to the row of peanuts that was intended for the higher defoliation treatment. By day 78 all the plants in chamber A 18 had been defoliated at the 25% level. There were only a few larvae remaining on the plants. This defoliation level was maintained in the row intended for the 25% defoliation by transferring a few large larvae from the adjacent row of plants. Two more fresh introductions were made for the row intended for the higher defoliation treatment; however, by day 93 of growth only 35% defoliation was achieved. No further transfers were made and

the larvae that remained on the plants were flushed away with de-ionized water. Two plants for each treatment (control, 25%, and 35%) were sampled every week until day 128.

3. Results and Discussion

3.1 Feeding behavior of *H. Zea* on peanut canopy

As soon as the larvae were transferred to the peanut plants, 2 to 6 larvae were seen on all the new shoots. They fed and grew on the folded leaves resulting in the leaves becoming jagged at the edges with numerous tiny holes. Feeding progressed towards older leaves as the food requirement increased with the increase in size of the larvae. When the larvae were at the first to the third instar, 2 to 4 individuals shared a shoot of folded leaves. The small larvae, which measured 1 mm. to 8 mm, fed on the folded leaves by biting and chewing from the edges. Since the mandibles were not large enough to chew a complete cross-section of the leaves, they fed on tissues of the upper and lower layers of the older leaves leaving scratch marks on the upper and lower epidermal layers. On the young unfolded leaves and on the leaf tier immediately below the folded leaves the larvae bit and fed on the leaves leaving numerous holes up to 1 mm in diameter. The peanut plants quickly compensated for these injuries by producing a sealing substance to block the exposed surfaces.

In both the experiments, the larvae immediately sought and remained on young peanut shoots as soon as they were transferred to the peanut plants, others, moved to less attractive older leaves beginning with the youngest available ones. After 1 week, the larval population had declined drastically to less than a tenth of the original population. This decline was probably due to cannibalism resulting from competition for young peanut shoots. Others may have fallen off the canopies and dropped to the floor, or drowned at the soil surface due to flooding during automatic irrigation. A few larvae that dropped on the flowers during the transfer remained and fed on them. Generally, small larvae were not seen on the flowers until they were about 5 mm long or about 6 days old. This was probably due to the restricted mobility because of their small appendages. After 10 days, only 1 or 2 larvae were seen on each terminal shoot. Those that remained on the terminal shoots appeared larger than those seen elsewhere indicating that the young leaves were favorable diet for the corn earworm.

As the larvae grew in size, the population dropped further and the damage to the peanut leaves changed from surface-scratching and jagged-young-leaves to complete suppression of new shoot growth in all the laterals and the main branch. At this stage, the larvae had consumed most of the young peanut leaves and the only other favorable portions of the leaves were tissues between the leaflet veins and mid-ribs of the older leaves. The larvae consumed these tissues leaving the mid-rib and veins. Those that had access to the terminal shoot region exhibited territorial dominance over the shoot region and remained in this region. They were often seen with their head engulfed in the terminal shoot to further consume the plant tissues and juices available at the feeding site. Larvae that fed on the young leaves and shoots were large and had light green color, whereas, those that fed on the older leaves were dark green, a combination of yellow and green, yellowish brown, or combinations of these colors with black. Massive foliage consumption started when the larvae were about 1.5 cm long at about the fourth instar. At this larval stage they were very active and mobile and were observed moving from leaf to leaf and from shoot to shoot. This movement which continued until just before pupation probably contributed to the decline in the larval population due to the increased chance of confrontation with other larvae. At this larval stage, damage to the peanut plants was most severe since the larvae fed on the flowers, cut off pegs, bit the base of leaf petiole, and bit and chewed portions of young stems.

3.2 Effect of feeding by *H. Zea* on peanut growth

In Experiment 2, similar observations were made, but in this experiment the plants were much bigger and more mature than those of Experiment 1, hence, there was minimal damage since there were ample young leaves for the larvae to consume. In this experiment, the maximum defoliation level after 5 transfers was 35%. Table 1 show that the percentage reductions of the plant variables for the defoliated plants at vegetative stage (Expt. 1) were between 26.1% and 53.0% and at the pod-forming and filling stage (Expt. 2) were between 0.3% and 82.4% (Table 3). The reductions of the variables on the early defoliation were almost consistent throughout indicating that the plant probably did not have a definite priority of partitioning the photosynthate to a particular plant part during recovery. With the exception of pod mass, all other variables showed significant reduction at the vegetative growth stage (Table 1; Figure 1 & 2). Root mass was not affected (0.3% reduction) by 25% and 35% defoliation at the pod forming and filling stage (Table 3). This was

probably because of the small mass of the roots when compared with the mass of other parts of the plants.

The effects of defoliation at the vegetative growth stage shown in Figure 1 & 2 were obvious only after day 49 of growth. This was because of the size of the plants. Rapid vegetative growth started only after day 46. The adverse effects of defoliation lasted throughout most of the sampling period (5 weeks) indicating that the effects of defoliation were more serious than the one-time hand defoliation of young leaves reported earlier (Endan *et al.*, 2006). This was probably due to the extended stress imposed on the plants and the continuous suppression of new shoot growth. Even though differences between the defoliated plants and controls were significant for most variables, there were no obvious differences among defoliation treatments. A contrast between 25% and 65% defoliation (Table 2) showed significant differences in the leaf variables (leaflet number, leaf area, and leaf mass) and the stem mass. The 65% defoliation had lower leaflet number, leaf area, leaf mass, and stem mass. The differences in the number of leaflets between defoliated plants and controls were small when compared with differences for the leaf area and the leaf mass. This was because all leaves were included in the sampling (i.e., including those that had less than 5% of the leaflet area remaining). Hence, the differences in the number of leaflets between the control and the defoliated plants were mostly due to the suppression of new shoot growth.

The suppression of new shoot growth caused the stems and leaves to look thick. The thickenings were possibly due to translocation and distribution of fresh photosynthate to remaining plant tissues in the leaves and stems rather than for the regeneration of new shoots. This observation was

surprising since it was contradictory to our observation in the hand defoliation experiment (Endan *et al.*, 2006). In our hand defoliation studies, we observed that the stems of the heavily defoliated plants were chlorotic and elongated. In their defoliation studies, Wilkerson *et al.* (1984) reported that all defoliations resulted in lower stem weight to length ratio. The observation led us to conclude that some of the stored reserve material in the stem may have been redirected to the shoot region for new growth. Despite the overall thickenings of the stems, the total stem masses of the defoliated plants were lower than the controls (Table 1 and 2).

The reduction in stem mass was small and insignificant (Table 3; Figure 4) for defoliation at the pod-forming and filling stage. At this stage the plant had almost reached its maximum size, hence, new stem growth constituted only a small fraction of the total stem mass. From Table 4, note that the mean peg number, peg mass, pod number, and pod mass of plants defoliated at 35% were lower than for plants defoliated at the 25% level. The mean peg number and mass of controls were significantly higher than those of the defoliated plants. Although pod number and mass of the controls were not higher than the defoliated plants 3 weeks after the defoliation, the pod number and mass of the controls were higher than the defoliated plants in the last 2 weeks of sampling. Defoliation resulted in lower peg and pod mass at harvest. The leaflet number, stem mass, root mass, and pod mass of the defoliated plants were not significantly different from the controls (Table 3). This was probably due to the inherent variability of the peanut plants at the pod forming and filling stage. Similar results were obtained in our experiments with hand defoliation of young leaves during the pod-forming or filling stage (Endan *et al.*, 2006).

Table 1. Mean of the un-defoliated (Control) and reduction from the control when plants were defoliated during the vegetative growth stage (Experiment 1)

Variable	Control versus Defoliated	
	Mean of control	Reduction, %
Leaflet number, leaflets/plant	1906.91	40.0 *
Leaf area, cm ² /plant	10778.38	50.1 **
Leaf mass, g/plant	44.68	40.4 **
Stem mass, g/plant	54.86	28.5 **
Root mass, g/plant	6.63	26.1 *
Peg number, pegs/plant	102.67	44.5 **
Peg mass, g/plant	3.72	53.0 **
Pod number, pods/plant	12.67	49.3 **
Pod mass, g/plant	5.99	49.8 ^{ns}

**Highly significant ($\alpha = 0.01$); *significant ($\alpha = 0.05$); ^{ns} not significant. Analysis was based on average of the Control, 25%, and 65% sampled on day 47, 53, and 69.

Table 2. Mean of the 25% defoliated plants and % difference of the 65% defoliated plants from the 25% when plants were defoliated during the vegetative growth stage (Experiment 1)

Variable	25% versus 65%	
	Mean of 25%	Difference, %
Leaflet number, leaflets/plant	1479.93	-22.7*
Leaf area, cm ² /plant	6909.63	-22.1**
Leaf mass, g/plant	31.67	-15.9**
Stem mass, g/plant	44.20	-11.3**
Root mass, g/plant	4.22	16.1 ^{ns}
Peg number, pegs/plant	63.67	-10.5 ^{ns}
Peg mass, g/plant	1.94	-9.9 ^{ns}
Pod number, pods/plant	5.50	16.7 ^{ns}
Pod mass, g/plant	2.55	18.0 ^{ns}

**Highly significant ($\alpha = 0.01$); *significant ($\alpha = 0.05$); ^{ns} not significant. Analysis was based on the average of the Control, 25%, and 65% sampled on day 47, 53, and 69.

Table 3. Mean of the un-defoliated (Control) and % reduction from the control when plants were defoliated during the pod forming and filling stage (Experiment 2)

Variable	Control versus Defoliated	
	Mean of Control	Reduction, %
Leaflet number, leaflets/plant	4717.67	13.9 ^{ns}
Leaf area, cm ² /plant	23133.33	56.8**
Leaf mass, g/plant	103.31	25.1*
Stem mass, g/plant	179.50	7.7 ^{ns}
Root mass, g/plant	12.85	0.3 ^{ns}
Peg number, pegs/plant	461.75	70.0**
Peg mass, g/plant	33.42	82.4**
Pod number, pods/plant	69.75	22.5*
Pod mass, g/plant	45.24	15.7 ^{ns}

**Highly significant ($\alpha = 0.01$); *significant ($\alpha = 0.05$); ^{ns} not significant. Analysis was based on average of weekly samples for 6 weeks after defoliation.

Table 4. Mean of the 25% defoliated plants and % difference of the 35% defoliated plants from the 25% when plants were defoliated during the pod-forming and filling stage (Experiment 2)

Variable	25% versus 65%	
	Mean of 25%	Difference, %
Leaflet number, leaflets/plant	4604.08	-9.9 ^{ns}
Leaf area, cm ² /plant	16731.32	-19.2*
Leaf mass, g/plant	90.60	-10.5 ^{ns}
Stem mass, g/plant	182.64	-10.8 ^{ns}
Root mass, g/plant	12.30	4.4 ^{ns}
Peg number, pegs/plant	285.33	-21.4 ^{ns}
Peg mass, g/plant	15.30	-21.6 ^{ns}
Pod number, pods/plant	62.42	-12.2 ^{ns}
Pod mass, g/plant	43.41	-16.4 ^{ns}

**Highly significant ($\alpha = 0.01$); *significant ($\alpha = 0.05$); ^{ns} not significant. Analysis was based on average weekly samples for 6 weeks after defoliation.

Since this variability is characteristic of peanut growth, it may be better to obtain data (for the purpose of modeling) early in the growing season when the variability is small, than to obtain data

towards the end of the growing period when the variability is large. However, the best situation would be to have data throughout the growing period.

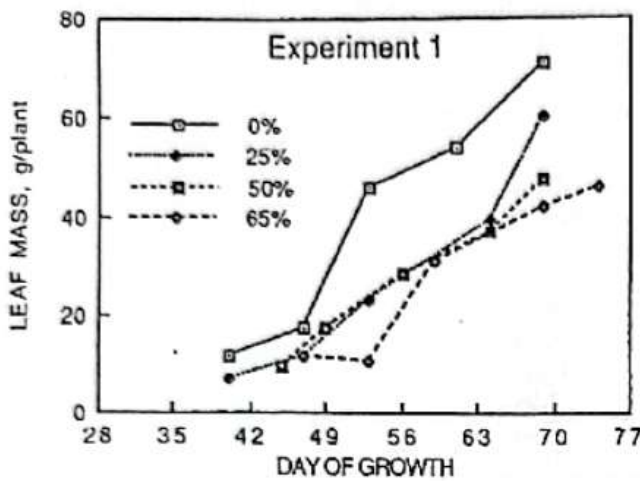


Fig. 1. Effect of defoliation on leaf growth

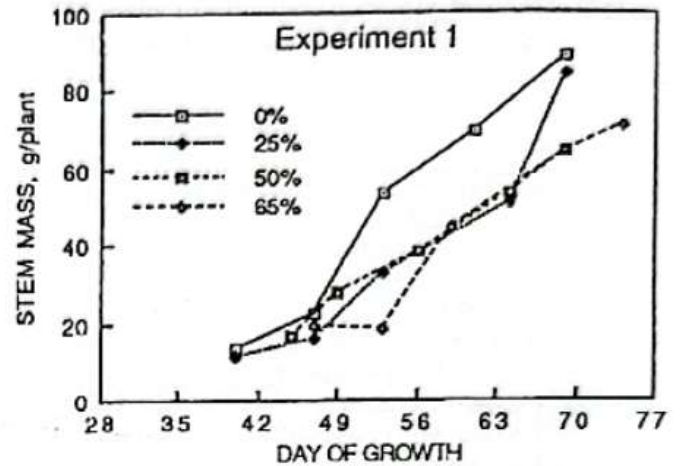


Fig. 2. Effect of defoliation on stem growth

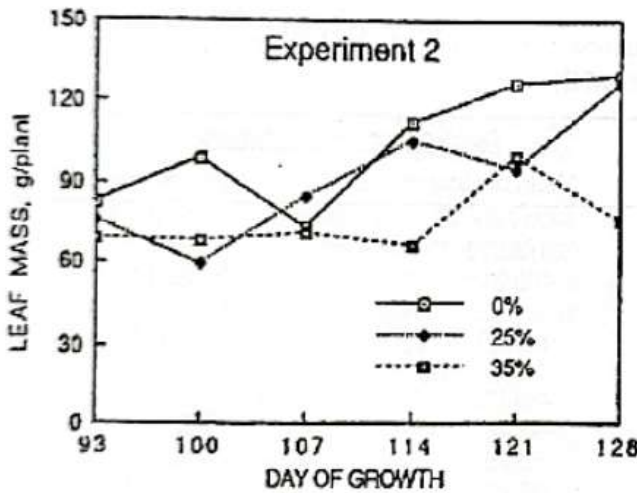


Fig. 3. Effect of defoliation on stem growth

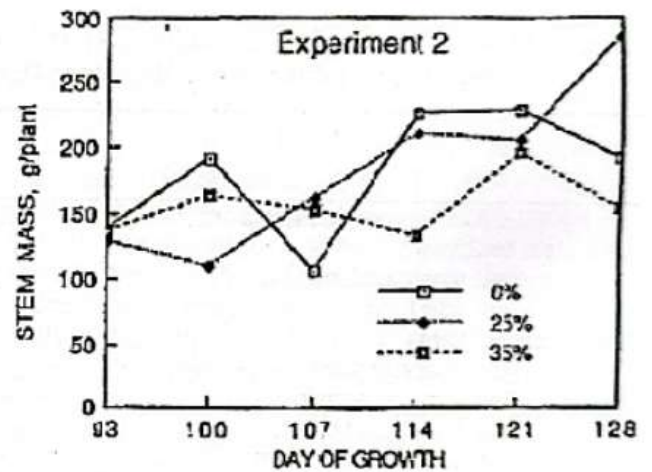


Fig. 4. Effect of defoliation on stem growth

4. Conclusions

Results of this study showed that the corn earworm preferred to feed on young peanut shoots. The type of damage caused by the corn earworm depended on the larval stage and size of its mandibles. Excessive damage to peanuts was caused by the large larvae feeding on the flowers, cutting-off pegs, chewing portions of the stems, feeding on leaf tissues between the leaf veins, and suppressing new shoot growth. Corn earworm defoliation resulted in lower leaf, stem, root, peg, and pod masses. While there were significant reductions in the plant variables between defoliated plants and controls, there were no significant differences among the various levels of defoliation treatments for defoliation during the vegetative growth stage or defoliation at the pod-forming and filling stage. Contrary to the reports of other investigators, feeding and destruction of flowers resulted in substantial reduction in the growth and

development of the pegs and pods. When the peanuts were defoliated at the vegetative growth stage, there was no definite priority of partitioning of the photosynthate to a particular plant part. However, there may be priority of partitioning of the photosynthate to the pegs for defoliation at the pod forming and filling stage.

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