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RESPONSE OF THE ONION (*Allium cepa* L.) PLANT TO SIMULATED PEST DAMAGE

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ABSTRACT

The effect of the different levels of simulated damage on each leaf at various crop growth stages on weight and size of onion bulb was investigated in farmers' fields in Bongabon and Talavera, Nueva Ecija, from December 2000 to April 2003. In 2001 and 2002, simulated damage was done by cutting off part of each leaf to the desired level. Simulated damage of up to 75% at 15 days after transplanting (DAT) had no significant effect on onion bulb size and weight in both sites. The bulb formation stage (45-65 DAT) was sensitive to any level of simulated damage as shown in the measured yield components. In 2002, artificial defoliation of up to 25% at 15 DAT and 10% at 30 DAT had no effect on bulb size and weight.

In 2003, the effect of cutting off 1,2 or 3 leaves or the youngest leaf at different crop ages on onion bulb size and weight was also investigated. Removal of most, if not all, the leaves (3 leaves) at 15 DAT resulted in a significant reduction in onion bulb size and weight in both locations. Similar result was recorded when the youngest leaf was removed at 60 DAT. Removal of only the oldest leaf at 15, 30, 45 or 60 DAT generally did not affect bulb size and weight. Results of this study suggest that onion plants can tolerate some damage caused by defoliators.

Key words: simulated damage, defoliators of onion, plant damage compensation, yield loss

Abbreviations : DAT - days after transplanting

INTRODUCTION

The common cutworm *Spodoptera litura* (F.), the beet armyworm *S. exigua* (Hubner), and on some occasions the tomato fruit worm *Helicoverpa armigera* (Hubner), are considered the most common defoliators of onion in the Philippines and its neighboring countries. In most cases, any level of damage caused by these insects instinctively prompt farmers to apply insecticides, believing

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that significant yield loss would be avoided. This is probably one of the reasons for the high incidence of insecticide misuse in onion and other vegetables. The widespread pesticide misuse in vegetable and rice production in the Philippines was reported earlier (Medina, 1987; Heong et al., 1995; Litsinger, 1995; Tjornhom et al., 1997).

Damage to onion by insect defoliators is easily recognized in the field. However, there is serious lack of information about insect damage and yield loss relationships. Effective management strategies can be developed only after understanding the relationships among insect density, damage and the resulting yield loss.

Manipulation of natural insect populations, creation of artificial infestations and insect damage simulations are the common methods for determining damage-yield loss relationships (Poston et al., 1983). However, due to difficulties in maintaining population densities for determining thresholds, simulation of insect damage has been commonly used to assess crop response to damage. In soybean, approximately 90% of published studies have used simulated insect damage to study yield loss due to defoliators (Ostlie and Pedigo, 1984). Several studies on simulation of damage caused by insect pests were done on cereals to determine the effect on photosynthetic parameters and yield components.

Compensation is a process by which plants decrease the negative effects of injury (Pedigo, 1991). As reported earlier, some plants compensate for damage caused by insects. Rice compensates for damage caused by stemborer during the vegetative stage and, to some extent, during the reproductive stage (Rubia et al., 1990; Rubia et al., 1996) or when simulated defoliation of 10% and 25% was done at maximum tillering and ripening stages of rice growth (Arida et al., 1988). In addition, cutting off 50% of tillers at stem elongation did not reduce yield (Bunnarith et al., 2000). In hybrid corn, defoliation of either 50 or 100% prior to tasseling did not affect kernel weight and shelling percentage (Hicks et al., 1977). A 25% leaf removal at 3 weekly intervals did not affect pod yield of okra (Olasantan, 1988). Similar observation was reported in tomato (Stacey, 1983). Djoni et al. (1996) reported that artificial defoliation of up to 60% at 4, 8, and 10 weeks after transplanting did not affect yield in shallot.

This study aimed to determine the effect of early season defoliation on onion bulb size and weight.

MATERIALS AND METHODS

The study was conducted in farmers' fields in Bongabon and Talavera, Nueva Ecija from December 2000 to May 2003. All agronomic practices (fertilizer application, weeding and water management) were done as normally practiced by farmers in the study area. The onion variety planted was Red Creole. Plants were grown in 2m x 3m plots with treatments replicated four times in a randomized complete block design. Four levels of artificial defoliation (10, 25, 50,and 75%) were made at 15, 30, 45, or 60 days after transplanting (DAT). In 2001 and 2002, simulated damage was done by cutting off part of each leaf to the desired level, for example 50% defoliation was obtained by clipping all the leaves in half. At harvest, bulb size and weight were recorded from 40 randomly selected bulbs per treatment.

During 2003 season, artificial defoliation was accomplished by cutting off the desired number of leaves one cm above the leaf sheath using a pair of scissors. Simulated damage was done at 15, 30, 45 or 60 DAT. There were 4 levels of defoliation: 1, 2, 3 leaves or youngest leaf (YL) removed from each plant. For the one leaf defoliation, the oldest leaf was removed or the two oldest for the 2 leaves defoliation level.

At harvest, the size and weight of bulb from 40 randomly selected onion plants per treatment were recorded.

RESULTS AND DISCUSSION

2001 Trial

Simulated damage at vegetative stage

Table 1 shows the effect of artificial defoliation on size and weight of onion bulbs in Bongabon and Talavera fields during the 2001 season. Defoliation at early vegetative stage (15 DAT) had no significant effect on the weight of onion bulbs regardless of the level of defoliation. There were even cases when weight of onion bulbs was higher in the 10% and 25% defoliated onions compared to the control plots. A similar trend was observed in the diameter of the onion bulbs. Again, there were cases where the diameter of the onion bulbs was bigger than that of the control (i.e., 10% defoliation in both Bongabon and Talavera).

Defoliation at late vegetative stage (30 DAT) resulted in reduction in the weight and size of the onion bulbs relative to the control plots at almost all levels of defoliation. However, said weight reduction was significant only at 25%, 50%, and 75% defoliation in Talavera and at 75% defoliation in Bongabon.

Defoliation at bulb formation stage

There were greater reductions in weight and size of the onion bulbs when defoliation was done at this stage most especially at 60 DAT and at high defoliation levels (50 and 75%) compared to the control plots. The reductions in bulb diameter and weight at 10% and 25% defoliation levels were not significant in both places. The only exception was the significant reduction in blub weight at 25% defoliation in Talavera.

Defoliation effect on plant height

In general, there were no significant differences in the height of onion plants subjected to varying levels of defoliation when measured at 45 and 55 DAT. The exceptions were those plants defoliated at 60 DAT and their heights taken 5 days later (Fig. 1).

These results indicate that onion plants can recover satisfactorily from varying levels of defoliation incurred during the early stage of growth.

Table 1. **Effect of simulated pest damage at different crop stages on size and weight of onion bulbs. 2001 Dry season.**

TREATMENT Crop age, Defoliation (%)	BONGABON[1] Diameter (mm)	BONGABON[1] Weight (gm)	TALAVERA[1] Diameter (mm)	TALAVERA[1] Weight (gm)
Control	37.0 bcde	30.0 b	41.2 bcd	39.8 abc
		Vegetative Stage		
15, 10	39.9 a	33.9 a	44.0 a	42.6 a
15, 25	37.9 bcd	30.6 b	42.5 ab	41.3 ab
15, 50	36.5 cdef	30.1 b	39.4 def	38.0 abcd
15, 75	38.6 ab	29.8 b	39.6 cdef	39.3 abc
30, 10	36.4 cdef	29.2 bc	40.2 bcde	37.2 bcde
30, 25	38.3 abc	29.7 b	36.8 ghi	31.3 fg
30, 50	37.4 bcde	28.9 bc	35.1 ij	27.5 gh
30, 75	35.6 efg	26.1 cde	36.1hi	32.6 ef
		Bulb Formation Stage		
45, 10	36.3 defg	27.8 bcd	34.9 ij	33.3 ef
45, 25	36.8 bcdef	28.7 bc	39.4 cdef	35.8 cdef
45, 50	35.9 efg	27.4 bcd	38.6 efg	32.2 f
45, 75	34.5 g	23.5 e	32.9 j	26.6 h
60, 10	36.9 bcdef	29.8 b	41.8 bc	41.4 ab
60, 25	37.2 bcde	28.3 bcd	38.8 defg	34.1 def
60, 50	35.1 fg	24.0 e	37.5 fgh	31.3 fg
60, 75	36.2 def	25.1 de	38.2 efgh	33.6 def

[1] Ave. of 4 replications, In a column means followed by the same letter are not significantly different at 5% level by DMRT.

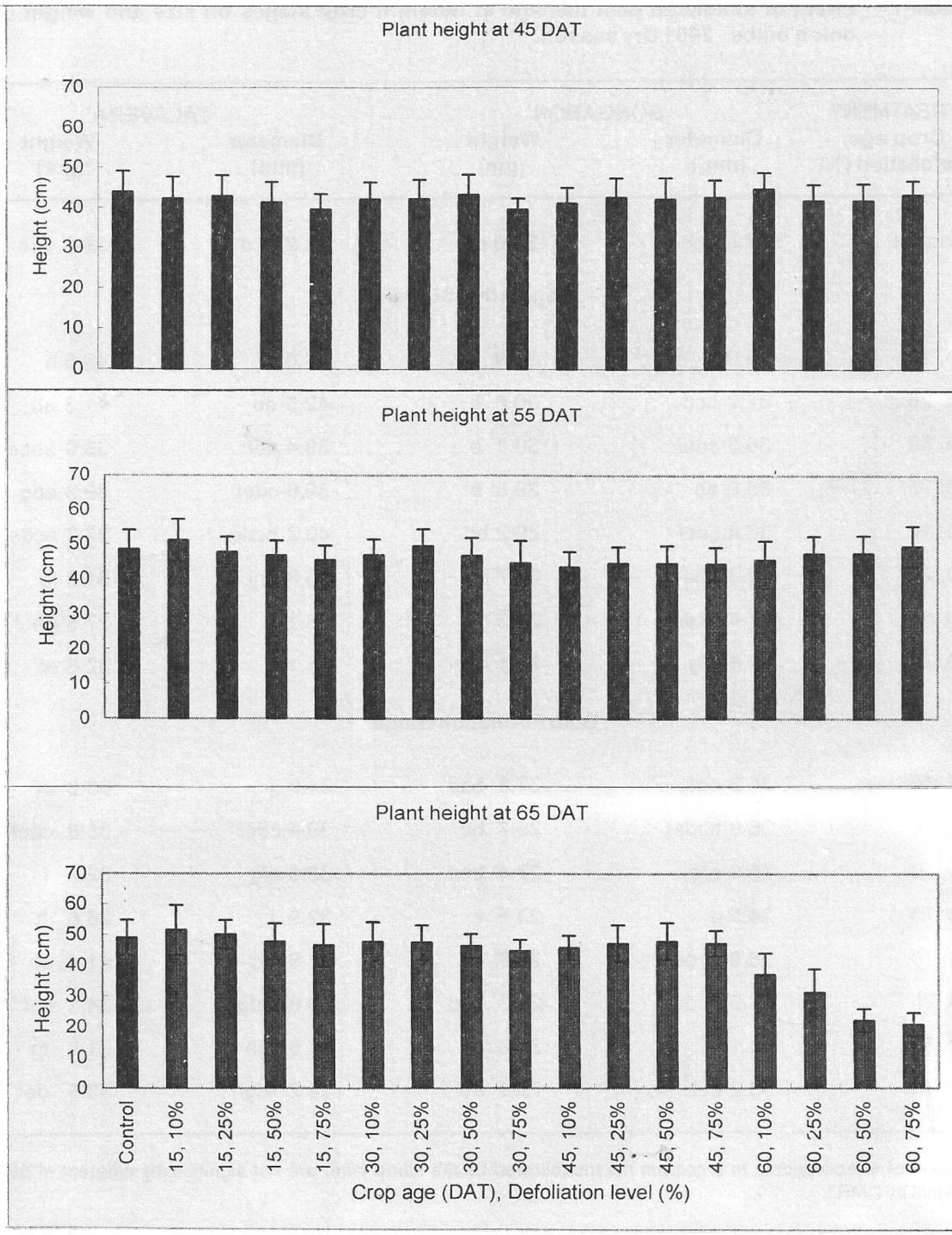

Fig. 1. Height of onion plants (mean ± std) at 45, 55, and 65 days after transplanting (DAT). Plants were subjected to different levels of defoliation at various ages. Bongabon, Nueva Ecija 2001 Dry season.

2002 Trial

Defoliation at vegetative stage

Defoliation at vegetative stage (15 and 30 DAT) resulted in statistically significant reduction in the weight and size of the onion bulbs compared to the control plots except at 10% and 25% defoliation level at 15 DAT, and 10% defoliation level at 30 DAT (Table 2). Ten percent defoliation at 15 DAT resulted in some increase in bulb size and weight compared to the control, but not significantly.

Defoliation at bulb formation stage

There were more reductions in weight and size of the onion bulbs both in Bongabon and Talavera when defoliation was done at this stage, especially at higher defoliation levels (50 and 75%) (Table 2). At lower defoliation levels (10 and 25%) results in the two study sites were not parallel; that is, reductions in size and diameter at 45 DAT were significant in Bongabon but not in Talavera. The same trend was observed for defoliation at 60 DAT although the reduction in onion bulb weight and diameter in Bongabon at 25% defoliation did not reach a significant level. Results indicate that in general the onion plant could recover from low level of damage even at bulb formation stage.

2003 Trial

Number of leaves per plant at different growth stages

The average total number of leaves per plant when the crop was subjected to leaf removal treatments in the field are shown in Fig. 2. The number of leaves per plant in Talavera site was slightly higher than that in Bongabon and the highest number of leaves per plant was recorded at 45 DAT which was the start of bulb formation growth stage. This probably explains why in Talavera lower levels of defoliation (10 and 25%) at bulb formation stage did not result in significant reduction in bulb weight and diameter.

Effect of removal of some leaves at vegetative and bulb formation stages

Tables 3 and 4 present the data for the trials in Bongabon and Talavera, respectively. Generally, leaf removal at vegetative and bulb formation stages did not result in a significant reduction in bulb size and weight. One exception was when 3 leaves were removed at 15 DAT. In this treatment, there were marked reductions in bulb diameter recorded in both sites. At this time almost all the leaves were removed from the plant which had only 3 to 4 leaves (Fig. 2). The other exception was the removal of the youngest leaf at bulb formation stage which again resulted in marked reduction in bulb diameter in both sites. However, the magnitude of reduction reached a significant level in Talavera only.

Table 2. Effect of simulated pest damage at different crop stages on size and weight of onion bulbs. 2002 Dry season.

TREATMENT Crop age, Defoliation (%)	BONGABON[1] Diameter (mm)	BONGABON[1] Weight (gm)	TALAVERA[1] Diameter (mm)	TALAVERA[1] Weight (gm)
Control	42.7ab	39.9ab	46.6ab	47.8ab
		Vegetative Stage		
15, 10	43.7 a	42.5 a	48.1 a	51.7 a
15, 25	42.7 ab	39.4 ab	46.4 ab	47.0 abc
15, 50	39.2 cd	32.2 cdef	42.9 cdef	39.2 defg
15, 75	39.1 cd	31.9 cdef	40.3 fg	34.5 gh
30, 10	40.2 bc	35.9 bc	45.7 abc	46.1 abcd
30, 25	38.6 cde	31.0 cdefg	42.1 def	36.0 fg
30, 50	38.4 cde	30.6 cdefg	42.6 def	40.1 cdefg
30, 75	37.9 cdef	29.8 defg	42.8 cdef	39.3 defg
		Bulb Formation Stage		
45, 10	30.4 cd	33.7 cde	44.5 bcde	42.8 bcdef
45, 25	39.2 cd	33.1 cde	46.1 ab	46.6 abc
45, 50	36.4 def	28.6 defg	42.7 def	38.7 efg
45, 75	37.2 cdef	27.8 efg	41.7 ef	36.1 fg
60, 10	38.7 cd	31.1 cdefg	45.0 bcd	43.2 bcde
60, 25	40.3 bc	34.4 bcd	44.7 bcd	43.3 bcde
60, 50	35.6 ef	26.3 fg	43.2 cdef	38.5 efg
60, 75	35.3 f	25.8 g	38.4 g	29.4 h

[1] Ave. of 4 replications. In a column, means followed by the same letter are not significantly different at 5% level by DMRT.

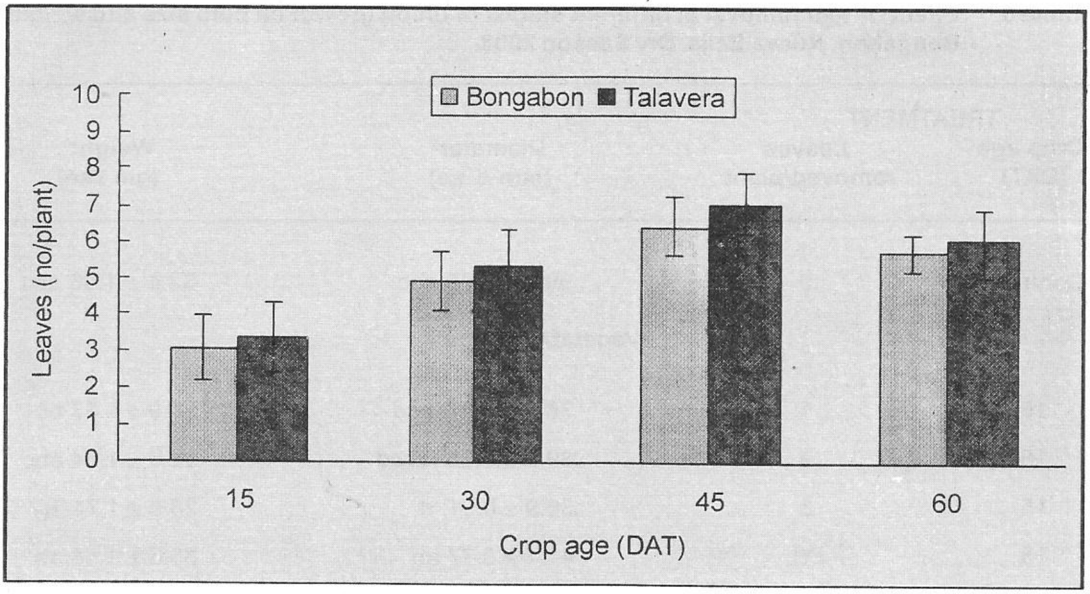

Fig. 2. Total number of leaves per onion plant (mean ± std) at different crop ages. Bongabon and Talavera, Nueva Ecija. 2003 Dry season.

Relevance of the two schemes for insect damage simulation and important implications of the results obtained

In the field, damage of defoliators to onion is normally low. It is observed on only few or some plants but rarely on all of them. The damage simulated by cutting off a portion of each leaf is observed during high infestation of the cutworm *S. litura* which cuts several leaves of a plant but this does not happen very often. More commonly when the larvae are still young, they tend to stay together or aggregate thus their damage is almost concentrated on a single leaf. Such damage was simulated by the second defoliation scheme, removing 1,2,3 or the youngest leaf. Thus, both schemes are realistic simulations of actual damage of insect defoliation to onion plants in the field.

Most farmers spray insecticide several times during the first month after transplanting reaching 6 to 31 times in a cropping season. They normally would like to maintain a clean or pest-free field perceiving that any level of insect damage at any stage of plants growth will reduce onion yield. This practice results in high production cost. Results of this study indicated that most of the insecticide applied during this time is unnecessary and wasted specifically when damage on the leaves is not more than 25%. However, during the bulb formation stage, onion plants are sensitive even at low level of defoliation (10%), suggesting the need for ample protection from insect damage at this time.

Table 3. Effect of leaf removal at different stages of onion growth on bulb size and weight. Bongabon, Nueva Ecija. Dry Season 2003.

TREATMENT Crop age (DAT)	Leaves removed/plant	Diameter[1] (mm ± se)	Weight[1] (gm ±se)
Control	0	39.9 ± 0.80 abc	32.4 ± 1.56 abc
		Vegetative Stage	
15	1	38.7 ± 0.87 bcd	30.9 ± 1.67 bc
15	2	39.8 ± 0.88 abcd	32.6 ± 1.64 abc
15	3	36.9 ± 0.91 d	28.8 ± 1.71 c
15	YL	41.1 ± 0.77 ab	35.6 ± 1.58 ab
30	1	38.8 ± 0.92 bcd	30.8 ± 1.92 bc
30	2	40.6 ± 0.88 abc	33.8 ± 1.77 bc
30	3	39.6 ± 0.96 abcd	33.8 ± 1.97 abc
30	YL	40.0 ± 0.97 abc	33.7 ± 2.02 abc
		Bulb formation Stage	
45	1	41.2 ± 0.96 ab	36.2 ± 2.04 ab
45	2	40.0 ± 0.99 abc	34.1 ± 2.07 abc
45	3	40.6 ± 0.93 abc	34.7 ± 1.93 abc
45	YL	40.1 ± 0.83 abc	34.0 ± 1.56 abc
60	1	42.0 ± 0.73 a	37.3 ± 1.76 a
60	2	40.3 ± 1.01 abc	33.6 ± 2.17 abc
60	3	39.5 ± 0.96 abcd	32.2 ± 1.88 abc
60	YL	38.8 ± 1.05 bcd	32.1 ± 2.08 abc

[1] Ave. of 4 replications. In a column, means followed by the same letter are not significantly different at 5% level by DMRT. YL-youngest leaf, 1 leaf - removal of the oldest leaf one cm. from the sheath, 2 leaves - removal of the 2 oldest leaves and 3 leaves - removal of the 3 oldest leaves. DAT = days after transplanting.

Table 4. Effect of leaf removal at different stages of onion growth on bulb size and weight. Talavera, Nueva Ecija. Dry Season 2003.

TREATMENT Crop age (DAT)	Leaves removed/plant	Diameter[1] (mm ± se)	Weight[1] (gm ±se)
Control	0	45.4 ± 1.04 abc	47.9 ± 2.49 abcd
		Vegetative Stage	
15	1	46.0 ± 0.96 abc	47.6 ± 2.23 bcd
15	2	44.0 ± 0.94 bcd	44.2 ± 2.09 cd
15	3	42.7 ± 0.99 d	41.3 ± 2.26 de
15	YL	44.5 ± 0.79 cd	44.9 ± 2.01 cd
30	1	45.5 ± 0.91 abc	48.8 ± 2.25 abcd
30	2	48.6 ± 1.03 a	52.0 ± 2.43 bcd
30	3	46.6 ± 1.21 ab	50.4 ± 3.16 abc
30	YL	54.8 ± 0.74 abc	47.6 ± 1.68 bcd
		Bulb formation Stage	
45	1	45.4 ± 1.06 abc	47.6 ± 2.57 bcd
45	2	46.3 ± 0.92 ab	49.3 ± 2.13 abcd
45	3	45.5 ± 0.96 abc	45.9 ± 2.32 bcd
45	YL	46.0 ± 1.08 abc	49.2 ± 2.93 abcd
60	1	47.1 ± 1.22 ab	47.3 ± 1.93 bcd
60	2	46.0 ± 1.05 abc	48.4 ± 2.88 abcd
60	3	44.4 ± 1.33 bc	43.0 ± 2.48 cde
60	YL	41.1 ± 1.02 d	41.3 ± 1.42 de

[1] Ave. of 4 replications. In a column, means followed by the same letter are not significantly different at 5% level by DMRT. YL-youngest leaf, 1 leaf - removal of the oldest leaf one cm. from the sheath, 2 leaves - removal of the 2 oldest leaves and 3 leaves - removal of the 3 oldest leaves. DAT - days after transplanting.

The non-significant effect of complete removal of as many as 3 of the oldest leaves of plants at least 30 days old suggests less photosynthetic activities on older leaves than on the younger ones. The same message is conveyed by the significant reduction in bulb weight and diameter when the youngest leaf was removed at 60 DAT or at bulb formation stage, therefore, more attention should be given to insect damage on younger leaves for timely application of control interventions to minimize yield loss.

CONCLUSION AND RECOMMENDATION

Based on the findings in this study, it can be concluded that application of insecticide to control insect defoliators on onion is necessary only when a certain level of damage is reached during specific stages of plant growth. It is recommended that farmers monitor closely the level of insect damage on their onion crop to minimize unnecessary pesticide application thereby reducing production cost, health hazard from the toxic chemical and environmental risk without adversely affecting crop yield.

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LITERATURE CITED

ARIDA GS , EG RUBIA, & BM SHEPARD. 1988. Response of the rice plant to simulated and actual damage. Paper presented at the 19th Annual Conf. of the Pest Control Council of the Phil. 3-7 May. Cebu City, Philippines.

BUNNARITH K & GC JAHN. 2000. Effects of simulated pest damage on rice yields. International Rice Research Notes. p. 27.

DJONI, ZAMZANI, SHEPARD, BM, A RAUF & R DILTS. 1996. Response of shallots to defoliation. Palawija and Vegetable IPM Newsl. Bogor Agricultural University. Bogor, Indonesia.

HEONG, KL, MM ESCALADA, & AA LAZARO. 1995. Misuse of pesticides among rice farmers in Leyte, Philippines. In: P.L. Pingli and P.A. Roger (eds.) Impact of Pesticides on Farmer Health and the Rice Environment. IRRI (Norwell, Massachusetts: Kluwer Academic Publishers).

HEONG, KL, AA LAZARO & GW NORTON. 1997. Pest management perceptions and practices of farmers growing rice and vegetables in Nueva Ecija, Philippines. In: K.L. Heong and M.M. Escalada eds. Pest Management of Rice Farmers in Asia. International Rice Research Institute, Los Baños, Laguna.p. 161-170.

HICKS, DR, WW NELSON & JH FORD. 1977. Defoliation effects on corn hybrids adapted to the northern corn belt. Agronomy Journal. (69):387-390.

LITSINGER JL, VP GAPUD & GW NORTON. 1995. Participatory appraisal for IPM research planning in the Philippines. IPM-CRSP Working Paper No. 1. Virginia Tech, Virginia, USA. August 1995.

MEDINA, JP. 1987. Pest control practices and pesticide perceptions of vegetable farmers in Loo Valley, Benguet, Philippines. In: Tait J and Napompeth B, Eds. Management of pests and pesticides: farmers' perceptions and practices. Boulder (Colo., USA): Westview Press. p. 150-157.

OLASANTAN, FO. 1988. Effect of leaf removal on the growth and yield of okra *Abelmoschus esculentus* and its relevance to leaf harvesting patterns and pest damage. Expl. Agric. 24: 449-455.

OSTLIE, KR. & LP PEDIGO. 1984 Water loss from soybeans after simulated and actual insect damage. Environ. Entomol. 13 (6): 1675-1680)

PEDIGO, LP 1991. Entomology and Pest Management. New York: Macmillan. 646p.

POSTON FL, LP PEDIGO, & SM WELCH. 1983. Economic injury levels: reality and practicality. Bull. Entomol. Soc. Am. 29: 423-426.

RUBIA, EG, BM SHEPARD, EB YAMBAO, KT INGRAM, GS ARIDA & FWT PENNING DE VRIES. 1990. Stem borer damage and grain yield of flooded rice. J. of Plant Protec Tropics 6:205-221.

RUBIA, EG, KL HEONG, M ZALUCKI, B GONZALES & GA NORTON. 1996. Mechanisms of compensation of rice plants to yellow stem borer *Scirpophaga incertulas* (Walker) injury. Crop Protection 13 (4): 335-340.

STACEY, DL 1983. The effect of artificial defoliation on the yield of tomato plants and its relevance to pest damage. Journal of Horticultural Science 58:117-120.

TJORNHOM JD, NORTON GW, KL HEONG, NS TALEKAR & VP GAPUD. 1997. Determinants of pesticide misuse in Philippine onion production. Philipp. Ent. 11(2): 139-149.