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EFFECT OF DIETARY ASCORBIC ACID ON THE DEVELOPMENT OF BEET ARMYWORM, **Spodoptera exigua** (Hubner) *

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The beet armyworm, *Spodoptera exigua* (Hubner) is a particularly insidious pest of cultivated plants, and its larval stage feeds on leaves, stems, and roots of field and vegetable crops [Metcalf and Flint, (13)]. Recently, an artificial diet has been developed which facilitate a systematic study of its specific dietary requirements [Shorey (17), Shorey and Hale (18)]. Ascorbic acid is not required by *Drosophila,* Sp. *Tribolium* Sp. and pink bollworm, *Pectinophora gossypiella* (Saunders) [Bacot and Harden (1), Sweetman and Palmer (19), Vanderzant *et al* (21)].

Ascorbic acid is probably of universal occurrence in both plant and in many species of insects and, in so animal tissues; it has been indentified in many species of insects and, in so far most insects studied have not needed dietary ascorbic acid, it must be presumed that the ability to synthesize it is widespread in the class [Giroud and Ratsimamanga (5), Haydak and Vivino (7), Joly (9), Day (3)]. Sarma and Bhagvat (16) found that the rice moth, *Corcyra cephalonica* (Stainton) was also the case with the cockroaches *Blatella* sp. and *Periplaneta* sp. [Wollman *et al.* (22), Roussel (15)].

Several studies using artificial diets have demonstrated that ascorbic acid or vitamin C must be incorporated in appreciable amounts (0.1 to 0.8 per cent wet weight) into the food of a number of different insect species for them to grow and reproduce normally on such diets [Dadd (2) Levinson and Navon (10), Mittler and Kleijan (14)], Thorsteinson (20) found that ascorbic acid acted as a feeding stimulant for three plant-feeding insects, the grasshopper, *Chorthippus longicornis* Latreille, the Colorado potato beatle, *Leptinotarsa decemlineata* (Say), and the diamond-back moth larva, *Plutela maculipennis* (Curt). Ito (8) suggested that the ascorbic acid was both a feeding stimulant and a nutritional requirement for silkworm, *Bombyx mori* L., Vanderzant *et al* (12), have also shown that the boll weevil, *Anthomus grandis* (Boh.), the bollworm, *Heliothis zea* (Boddie), and the salt-marsh caterpillar, *Estigmene acrea* (Drury) all fail to develop on synthetic diets lacking ascorbic acid.

Our study, attempts to estimate the significance of fluctuating levels of ascorbic acid on lima bean diet in the development of beet armyworm, *S. exigua* (Hubner).

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MATERIAL AND METHODS

Beet armyworm eggs, *S. exigua* (Hubner) from Western Cotton Insects Research Laboratory on Campbell Farm, Tucson, Arizona, were used in this experiment. After hatching, the young larvae were transfered to small plastic cups measuring 45mm top diameter and 45mm in height containing lima bean diet [Shorey (17)]. The levels of ascorbic acid on the diet were: 0.00, 0.15, 0.31, and 0,62 per cent wet weight. In each cup there was approximately 30g of diet which was sufficient to feed one larva during the whole process of development. In such way, one larva per cup consisted the experimental unit and each treatment was made up of fifteen experimental units, that is: each treatment was replicated fifteen times [Li, (11)]. The cups containing the young larvae were covered and placed on a cardboard plate and transfered to a shelf on the laboratory, at 23°C, 30 - 40 per cent RH, and a photophase of 12 hours in the 24 hours cycle. The evaluation of the development was done daily by weighting the larvae individually on a Mettler balance, type H6T. The period of observation lasted nineteen days and few larvae were reported dead due to handling process.

RESULTS

For statistical purposes, the data of the 15th day of observation were used and the values for each treatment were obtained by sampling replacement, Li, (11).

Analysis of variance for weight in milligrams of last instar larva of beet armyworm, *S. exigua* (Hubner) reared on lima bean diet at four levels of ascorbic acid is shown on Table I.

According to Table I, F value was highly significant at 99 per cent confidence interval with 3 and 28 degrees of freedom (22.17 greater than 5.32). So, there is evidence that some means of the treatments are statistically unequal.

TABLE I

Analysis of Variance for Weight in mg of Last Instar Larva of Beet Armyworm, *Spodoptera exigua* (Hubner) Reared on Lima Bean Diet at Four Levels of Ascorbic Acid, Tucson, Arizona, 1971.

Source of Variation	Sum of squares	Degrees of freedom	Mean square	F (1)
Treatments	303,349.80	3	101,116.60	22.17
Error	127,681.30	28	4,560.00	
Total	431,031.10	31		

(1) — F tabulated at 0.01 level, 3 and 28 degrees of freedon is equal to 5.32.

Four levels of ascorbic acid were used on lima bean diet, that is: 0.00, 0.15, 0.31, and 0.62 per cent wet weight, and the mean weights of the last instar larvae are shown in Table II.

TABLE II

Weight in mg of Last Instar Larva of Beet Armyworm, *Spodoptera exigua* (Hubner) Reared on Lima Bean Diet at Four Levels of Ascorbic Acid, Tucson, Arizona, 1971.

	Percentage of ascorbic acid			
	0.00	0.15	0.31	0.62
Means:	27.13	204.56	298.22	179.30

The means which were used on the significance test were placed on crescent order and these values are shown on Table III.

TABLE III

Rank of the Means for Weight in mg of Beet Armyworm, *Spodoptera exigua* (Hubner) Reared on Lima Bean Diet at Four Levels of Ascorbic Acid, Tucson, Arizona, 1971.

Rank of the means			
$\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	$\overline{X}_4$
27.13	179.30	204.56	298.22

On Table IV: p, q, n2, and wp values are arranged for the Student-Newman-Keuls' test. The standard error was equal to 39 and the confidence interval was 99 per cent.

Based upon Wp values, the mean differences were computed and comparisons were done. These results are shown on Table V.

Based upon the results of Table V, the significance of the means for weight in miligrams of beet armyworm, *S. exigua* (Hubner) reared on lima bean diet at four levels of ascorbic acid are placed on Table VI.

TABLE IV

Student-Newman-Keuls' Test for Weight in mg of Beet Armyworm, *Spodoptera exigua* (Hubner) Reared on Lima Bean Diet at Four Levels of Ascorbic Acid, Tucson, Arizona, 1971.

p	2	3	4
q (p, n2) (2)	3.91	4.48	4.83
Wp	152.49	174.72	188.37

(2) — $p = 4$, $n_2 = 28$, $= 0.01$, $S_{\bar{X}} = 39$, and $W_p = q \cdot S_{\bar{X}}$.

TABLE V

Test of the Differences for Weight in mg of Beet Armyworm, *Spodoptera exigua* (Hubner) Reared on Lima Bean Diet at Four Levels of Ascorbic Acid, Tucson, Arizona, 1971.

	$\bar{X}_4 - \bar{X}_1$	$\bar{X}_4 - \bar{X}_2$	$\bar{X}_4 - \bar{X}_3$	$\bar{X}_3 - \bar{X}_1$	$\bar{X}_3 - \bar{X}_2$	$\bar{X}_2 - \bar{X}_1$
	271.09	118.92	93.66	177.43	25.26	152.17
Wp:	188.37	174.72	152.49	174.72	152.49	152.49

TABLE VI

Significance of the Means for Weight in mg of Beet Armyworm, *Spodoptera exigua* (Hubner) Reared on Lima Bean Diet at Four Levels of Ascorbic Acid (3), Tucson, Arizona, 1971.

Means			
$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
a	abc	bc	c
27.13	179.30	204.56	298.22

(3) According to Student — Newman-Keuls' test.

DISCUSSION

The present study describes such an artificial medium which meets all the chemical requirements of beet armyworm, *S. exigua* (Hubner) [Shorey and Hale (18)]. This medium contained six components and the levels of ascorbic acid were made variable (0.00, 0.15, 0.31. and 0.62 per cent wet weight) in order to observe the development of the larval stage.

The "F" value on Table I denotes a consistent difference between treatments. Student-Newman-Keuls' technique was used as statistical test, Harter (6).

According to Table II a poor development was observed at 0.00 per cent of ascorbic acid on lima bean diet and the optimum was reached at 0.31 per cent of ascorbic acid, this amount is normally present in this diet. These results were obtained at the 15th day of observation. At the 19th day, some larvae on those diets with ascorbic acid started to pupate and the larvae on the diet with 0.00 per cent of ascorbic acid failed to do it. So, there is evidence that the ascorbic acid is required for the perfect growth and development of this insect.

Beet armyworm larvae, *S. exigua* (Hubner) reared at 0,15 and 0.31 per cent of ascorbic acid were not statistically different (Table VI). It appears that both levels can supply the requi-

rements of the insect on the lima bean diet. These values were strongly different from the results obtained at 0.00 per cent where the larvae presented the worst development and all failed to pupate at the 19th day of observation. It could be stated that the ascorbic acid has a high nutritional significance for the beet armyworm, *S. exigua* (Hubner) in providing a normal development. This phenomenon was also found by Lichtenstein (12) and Fraenkel and Blewett (14) when they worked with the mosquito. *Culex molestans* and larvae of meal moth, *Ephestia* sp. respectively.

At high concentration of ascorbic acid (0.62 per cent) the development of beet armyworm, *S. exigua* (Hubner) was below of those 0.15 and 0.31 per cent levels, but at the 19th day of observation the larvae were able to pupate. There is evidence that the excess of ascorbic acid can block any mechanism of the Beet Armyworm metabolism, retarding its development, however this observation requires a deep study in order to assess the role of the Vitamim C in the physiology of *S. exigua* (Hubner).

SUMMARY

The development of beet armyworm, *Spodoptera exigua* (Hubner) on lima bean diet with four levels of ascorbic acid was studied, 0.00, 0.15, 0.31, and 0.62 per cent wet weight. There was a consistent significant difference in development between 0.00, 0.15, and 0.31 per cent levels with optimum occurring at 0.31 per cent of ascorbic acid on the diet. The process of developing was measured by the daily weight gain of the larval stage.

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