THE PERFORMANCE PARAMETERS OF *SOPDOPTERA LITTORALIS* (BOISD.)(LEPIDOPTERA: NOCTUIDAE) FED ON COTTON LEAVES GROWN IN ENRICHED CO_2 ATMOSPHERE

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INTRODUCTION

Interactions between herbivorous insects and their host plants are expected to be altered significantly as atmospheric CO_2 concentrations continue to rise (Fajer *et al.*, 1989; Bazzaz 1990; Lincoln *et al.*, 1993) enhanced CO_2 levels generally lower plant nitrogen because of increased plant growth, which results in a nitrogen dilution effect (Lincoln *et al.*, 1993). Consequently, performances of insect herbivores are highly variable and may include compensatory feeding (Linclon *et al.*, 1984; Fajer 1989; Fajer *et al.*, 1989; Lincoln and Couvet 1989; Johnson and Lincoln 1990 & 1991); a lower or incomplete development of larvae (Fajer *et al.*, 1991); decreased fecundity (Fajer *et al.*, 1989) and increase mortality (Osbrink *et al.*, 1987; Fajer 1989; Fajer *et al.*, 1989). Laboratory feeding studies and growth chamber experiments have provided useful information about the responses of insect herbivores to particular leaf tissue or to individual plants grown under ambient and elevated CO_2 (Akey *et al.*, 1988; Fajer 1989; Caulfield and Bunce 1994; Adham *et al.*, 2005).

The aim of the present work was to study the biological parameters of *Spodoptera littoralis* (Boisd.) fed on cotton leaves grown under enriched CO_2 atmospheres.

MATERIAL AND METHODS

All insects used in the bioassays were from a standard laboratory colony maintained at the Department of Entomology, Faculty of Science, Cairo University since 2000.

Larval stage

Ten newly deposited egg batches obtained from *Spodoptera littoralis* females were selected randomly to feed through the entire larval instars on *Gossypium barbadens* (Giza 85) cotton leaves grown in either ambient (350 ppm) or enriched (700 ppm) CO_2 regime (Adham *et al.*, 2005). Newly emerged larvae were placed into polyvinyl plastic box (12 W x 6 H x 18 L cm) lined with Whatman filter paper no. 1. Clean and fresh cotton leaves from the two regimes were supplied daily to the larvae. Uneaten and nibbled leaves were removed and newly fresh ones were provided. As the larvae increased in size, the number of soft as well as big tough leaves also increased. Each CO_2 treatment had twenty replicates of ten newly hatching larvae per box and each replicate was treated as a single unit. Larvae were observed daily to record the larval duration of the 3rd and 5th larval instars and the percentage survival.

Pupal stage

Newly formed prepupae were weighed to record the average fresh weight and then they were provided sterilized, sieved, moistured saw wood dust to form the pupal cases. Percent of pupation, average fresh weight, pupal duration as well as adult emergence and sex ratio were recorded.

Adult stage

Mating pairs of newly emerged male and female moths were fed on a 10% sugar solution and were offered small fresh twig of nerium tree (*Nerium oleander*) soaked in a small bottle filled with water to serve as an ovipositional site. Adult longevity was determined. Newly deposited egg batches (F_1) were collected daily, then transferred into 100 cm^3-rearing cups secured with screw plastic caps till hatching. The preoviposition period, number of deposited eggs, number of hatched eggs, and percentage of egg fertility were recorded.

Statistical analysis

Student's *t*-test was used for the analysis of larval duration. Data was analyzed using two ways analysis of variance (ANOVA) and Duncan's multiple range test. All statistical computations were carried out using SAS programm (Anonymous, 2000).

RESULTS AND DISCUSSION

Larval stage

Data depicted in Ttable (1) revealed insignificant difference ($P > 0.05$) between the means larval duration for the 3rd, 5th and 6th larval instars when fed on

cotton leaves from ambient (3.3±0.12, 4.2±0.41, 4.6±0.29, respectively) and enriched (3.6±0.29, 4.5±0.35, 4.8±0.26, respectively) CO_2 regimes. Similar results were reported by Akey *et al.* (1988) as they stated no difference in developmental time of *Pectinophora gossypiella* raised on CO_2-enriched compared with those raised in ambient CO_2 cotton. However, a significant difference ($P < 0.05$) in the means total percentage survival of the whole larval instars (1st instar till prepupa) was observed between the two CO_2 regimes. It seemed that larval mortality has been associated with nutritional deficiency that resulted from reduced foliar nitrogen concentrations in enriched CO_2 (Brooks and Whittaker, 1999). Similar results were obtained by Thompson and Drake (1994), they reported that a decrease in insect populations on whole plants when compared among different CO_2 levels; compared with those raised on ambient CO_2 cotton. However, the present results were not in agree with those reported by Caulfield and Bunce (1994), they reported an increase survival in *Spodoptera exigua* when both insect and plant were kept and consuming leaf material under enriched CO_2, and by Hughes and Bazzaz (1997), they stated that enriched CO_2 had no effect on populations of *Frankliniella occidentalis* on *Ascelpias syriaca* measured on per plant basis.

TABLE (I)

The mean values of the 3rd, 5th and 6th larval duration and total percentage of larval survival of *Spodoptera littoralis* fed on cotton plant leaves *Gossypium barbadens* grown under ambient (350 ppm) and enriched (700 ppm) CO_2 regimes.

Larval stage / CO_2 regimes	Larval duration (days)			% total larval survival Mean ± S.E.
	3rd instar Mean ± S.E.	5th instar Mean ± S.E.	6th instar Mean ± S.E.	
Ambient (350 ppm)	3.3 ± 0.12 [a]	4.2 ± 0.41 [a]	4.6 ± 0.29 [a]	91.5 ± 2.1 [a]
Enriched (700 ppm)	3.6 ± 0.29 [a]	4.5 ± 0.35 [a]	4.8 ± 0.26 [a]	84.0 ± 2.56 [b]
(P) value	0.3706	0.5927	0.6195	0.0155

Means in columns followed by the same letters are insignificantly different ($P > 0.05$) by ANOVA and Duncan'smultiple range test.

Pupal stage

Results presented in Table (2) showed that the mean prepupal fresh weight was highly significant ($P < 0.01$) for larvae fed on cotton leaves from enriched CO_2 regime (1.261±0.013 g.) than that from ambient CO_2 regime (2.194±0.147 g.).

Although the mean percentage of pupation was found to be lower for larvae fed on cotton leaves from enriched CO_2 (83.67±4.34) rather than from ambient CO_2 regime (90.85±1.56), no significant ($P > 0.05$) difference between the mean percentage pupation was observed.

The mean pupal fresh weight of larvae fed on cotton leaves grown in enriched CO_2 regime (1.097±0.0164) showed a highly significant ($P < 0.01$) difference as compared to ambient CO_2 regime (1.713±0.0257).

Obtained data showed that the mean pupal duration was highly significantly ($P < 0.01$) different for pupae resulting from larvae fed on cotton leaves from ambient (10.318±0.013) and enriched (8.365±0.078) CO_2 treatments.

TABLE (II)

The mean values of the prepupal fresh weight, percentage of pupation, pupal fresh weight, and pupal duration of *Spodoptera littoralis* resulting from larvae fed on cotton plant leaves *Gossypium barbadens* grown under ambient (350 ppm) and enriched (700 ppm) CO_2 regimes.

Pupal stage / **CO_2 regimes**	Prepupal fresh weight (g.) Mean ± S.E.	% pupation Mean ± S.E.	Pupal fresh weight (g.) Mean ± S.E.	Pupal duration (days) Mean ± S.E.
Ambient (350 ppm)	2.194 ± 0.147 [a]	90.85 ± 1.56 [a]	1.713 ± 0.0257 [a]	10.318 ± 0.013 [a]
Enriched (700 ppm)	1.261 ± 0.013 [b]	83.67 ± 4.34 [a]	1.097 ± 0.0164 [b]	8.365 ± 0.078 [b]
(P) value	0.003	0.1404	0.0004	0.0001

Means in columns followed by the same letters are insignificantly different ($P > 0.05$) by ANOVA and Duncan'smultiple range test.

Adult stage

Results presented in Table (3) showed a significant ($P < 0.05$) differences between means of the adult emergence percentage. Although the mean percentage of males (54.529 ± 4.28 & 56.868 ± 3.97) and females (45.468 ± 4.28 & 43.129 ± 3.97) resulting from larvae fed on CO_2 enriched cotton leaves was higher and lower, respectively, no significant ($P > 0.05$) difference were obtained for either males or females. Despite that the longevity of males and females resulting from larvae fed on cotton leaves grown in enriched CO_2 was shorter, no significant ($P > 0.05$) difference between the means of either male or female longevity were observed. Moreover, the mean longevity of males was comparatively longer than that of

females for both CO_2 regimes. These results disagree with that obtained by Tripp *et al.* (1992) and, Roth and Lindroth (1994) who stated that laboratory feeding trails have indicated that insects have longer developmental times and higher mortality on foliage grown under enriched CO_2.

TABLE (III)

The mean values of percentage adult emergence, sex ratio, and longevity of *Spodoptera littoralis* resulting from larvae fed on cotton plant leaves *Gossypium barbadens* grown under ambient (350 ppm) and enriched (700 ppm) CO_2 regimes.

Adult stage / CO_2 regimes	% adult emergence Mean ± S.E.	Sex ratio		Longevity (days)	
		% male Mean ± S.E.	% female Mean ± S.E.	Male Mean ± S.E.	Female Mean ± S.E.
Ambient (350 ppm)	95.5 ± 2.78 [a]	54.529 ± 4.28 [a]	45.468 ± 4.28 [a]	8.05 ± 0.39 [a]	6.05 ± 0.35 [a]
Enriched (700 ppm)	80.04 ± 4.58 [b]	56.868 ± 3.97 [a]	43.129 ± 3.97 [a]	6.74 ± 0.36 [a]	5.35 ± 0.27 [a]
(P) value	0.0388	0.6908	0.6908	0.1315	0.2566

Means in columns followed by the same letters are insignificantly different ($P > 0.05$) by ANOVA and Duncan'smultiple range test.

Egg stage

Results presented in Table (4) showed no significant difference ($P > 0.05$) between the mean values of the incubation period of the eggs deposited by females resulting from larvae fed on cotton leaves grown in both CO_2 regimes. Meanwhile differences between mean values of the preoviposition period, number of eggs deposited, number of hatching eggs and percentage of egg fertility were significantly different ($P < 0.05$).

Evidence from previous study (Adham *et al.*,2005) showed that the mean efficiency of conversion of digested food to body substances (E.C.D.) values were not significantly lower ($P > 0.05$) during the 3rd instar larvae of CO_2 cotton leaves. Thus, the net effect was less efficient feeding despite that more leaves were consumed. Moreover, developing larvae developed into small pupae that weighed significantly less. Also preoviposition period, egg production, egg hatchability, percentage egg fertility and percentage egg mortality of *S. littoralis* were all affected being significantly different. These differences were believed to result from

corresponding differences in nutritional qualities of the cotton leaves plant (Fajer *et al.*, 1989 and Adham *et al.*, 2005).

TABLE (IV)

The mean values of preoviposition period, number of eggs, incubation period, number of eggs hatched, percentage of egg fertility, and percentage of egg mortality of *Spodoptera littoralis* adults resulting from larvae fed on cotton plant leaves *Gossypium barbadens* grown under ambient (350 ppm) and enriched (700 ppm) CO_2 regimes.

Egg stage / CO_2 regimes	Preoviposition period (days) Mean ± S.E.	No. of eggs deposited Mean ± S.E.	Incubation Period (days) Mean ± S.E.	No. of ggs hatched Mean ± S.E.	% egg fertility (hatchability) Mean ± S.E.
Ambient (350 ppm)	2.85 ± 0.21 [a]	435.52 ± 58.87 [a]	2.8 ± 0.12 [a]	3919.2 ± 540.2 [a]	89.82 ± 1.34 a
Enriched (700 ppm)	4.73 ± 0.38 [b]	245.98 ± 51.42 [b]	3.0 ± 0.16 [a]	2099 ± 461.7 [b]	84.29 ± 1.53 b
(P) value	0.0468	0.0415	0.3466	0.0336	0.0263

Means in columns followed by the same letters are insignificantly different (P > 0.05) by ANOVA and Duncan'smultiple range test.

From these results, it appeared that there is a relationship between larval growth, initial pupal weight and egg production of *S. littoralis*. Larvae fed on ambient CO_2 grown cotton leaves had the best growth, the heaviest pupae and produced females, which deposited the greatest number of eggs. While larvae fed on enriched CO_2 cotton plant leaves had smaller larval growth, produced smaller pupae and adults with a very low oviposition potential. However, Akey *et al.* (1988) reported no difference in pupal weight of *Pectinophora gossypiella* raised on CO_2-enriched cotton.

We might conclude that the reproductive capacity and consequently the population dynamics of *S. littoralis* could be influenced by the increase in future enriched CO_2 environment and high quality food may be ever less available.

SUMMARY

Data obtained from the insect performance parameters of *S. littoralis* (Boisd.) fed on cotton plant leaves *Gossypium barbadens* Giza 85 (Malvaceae) grown at ambient (350 ppm) and enriched (700 ppm) CO_2 regimes showed that: The

mean larval duration of the 3rd and 5th instars showed no significant differences between the two CO_2 regimes; the mean total percentage survival of the whole larval instars (1st instar till prepupa) significantly decreased when larvae fed on enriched CO_2 cotton leaves. Highly significant differences between means of the prepupal fresh weight, pupal fresh weight and pupal duration were obtained. However, insignificant differences in the percentage pupation were recorded. A significant differences between mean percentage of adult emergence were obtained with significant differences between means sex ratio, male and female longevities and incubation period of the eggs. On the other hand, a significant difference between mean values of the preoviposition period, number of eggs deposited, number of hatching eggs, percentage egg fertility and percentage egg mortality were observed. Thus the reproductive capacity could be influenced by the increase in future enriched CO_2 environment and also high quality food might be even less avaliable.

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