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EFFECT OF CARBON DIOXIDE CONCENTRATION IN AIR ON SOME BIOLOGICAL ASPECTS OF THE ONION BULB FLY, *Eumerus vestitus* BEZZI (SYRPHIDAE, DIPTERA)

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ABSTRACT

The 2nd, 3rd instar larvae, 3 and 8 days old pupae of the onion bulb fly, *E. vestitus* were exposed to 3 different concentrations of CO_2 in air for 24, 48 and 72 hr. The rate of mortality in all treatments was positively correlated with CO_2-concentration air and the exposure period . Treatments of the 2nd and 3rd instar larvae resulted increasing the larval duration while the rate of pupation was reduced by increasing the CO_2 concentration and/or the exposure period. Also, the pupal duration was increased while the rate of adult emergence was greatly reduced.

Treatments of 3 and 8 days old pupae resulted increasing the pupal duration but the percent of adult emergence was decreased by increasing the CO_2 concentration and/or the exposure period. In general, the pupae were more tolerant than the larvae and the 8 days old pupae were more sensitive than the 3 days pupae.

INTRODUCTION

In practice, the effectiveness of any control measure, chemical or non-chemical, is based on insect mortality, thus ignoring other effects that could be greater than those shown by mortality data alone. Alteration in the biology of insects surviving from treatment with sub-lethal CO_2 concentrations in atmosphere or sub-lethal doses of fumigants had been indicated by some investigators (Storey, 1978; Spratt, 1979a&b ; El-Nahal *et al.*,1984/1985; Ismail *et al.*,1995a&b).

Many investigators had focused on the possibility of using the inert gases (CO_2 and/or N_2) as an alternative for chemical fumigants. This method of treatment is commonly termed modified atmosphere (MA) or controlled atmosphere (CA) (Jay *et al.*,1970; Jay and Pearman,1971; Jay, 1980; Reichmuth, 1986; 1992; Hashem and Reichmuth, 1994; 1996; Conyers and Bell, 1996; Hashem, 2000).

The onion bulb fly, *Eumerus vestitus* Bezzi is always associated with other species, *E. amoenus* where, the larvae of the two species are always found together in the infested bulbs (El-Sherif, 1971 and Elshabrawy,1990).The effect of carbon dioxide as control agent on the developmental stages of *E. vestitus* was studied by Risha *et al.*, 1999).

The present work is a study on the effect of CO_2 concentrations air on some biological aspects of the onion bulb fly, *E. vestitus* at different exposure periods.

MATERIALS AND METHODS

The insects used in the present study were from a laboratory culture reared by the technique described by Elshabrawy (1990). All treatments were carried out at 25±1°C and 60 ±5% R.H.

Preparation of larval and pupal stages to treatment:

Larval stage:

10 larvae of the 2nd and 3rd instar were placed in a plastic tube (6 cm length and 2 cm diameter) closed at both ends with fine muslin. Onion pieces were put in these tubes as a natural food for larvae during the exposure period to different concentrations of CO_2 in air.

Pupal stage:

10 pupae of 3 and 8 days old pupae were put in a wire cage (4.5 cm length and 1.5 cm diameter) with rubber stoppers.

Treatment with carbon dioxide:

The treated stages were exposed for three exposure periods (24, 48 and 72 hours) to different atmospheres containing 10, 20 and 40 % CO_2.

Dreshel flasks, 550 ml capacity were used as exposure chambers (Desmarchelier,1984).

The flasks were closed with glass stoppers, each fitted with two glass tubes, one extending to near the bottom and the other to the upper quarter of the chamber. Both tubes were fitted with glass stopcocks, the short tube was used as gas exit and the long one as gas inlet for interval determination of the gas concentrations. The technique of treatment with CO_2 was as described by Hashem (1990). Control treatments were those flasks untreated with gas. All treatments were replicated three times including the untreated ones.

At the end of each exposure period, the larvae were transferred to labeled cylindrical plastic containers containing onion slices as a food and covered with two layers of muslin and black cloth, fitted by rubber bands. The full grown larvae which pupated between the two layers were collected daily and were followed up till adult emergence.

Also, the treated pupae were transferred to labeled plastic poly-pots with perforated plastic covers and kept till adult emergence.

Least significance of differences between the treatments was suggested (Snedecor and Cochran, 1967) .The rate of mortality has been corrected using Abbott`s formula (Abbott,1925).

RESULTS AND DISCUSSION

Effect on the larval stage:

The effects of different concentrations of CO_2 in air on the 2nd instar larvae are present in Table (1). The results indicate that, the rates of larval mortality were positively correlated with CO_2 concentration in air and the exposure period. These rates ranged between 36.2% and 89.4% .

The larval duration of treated larvae was increased (28.8-35.2 days) compared with untreated larvae (28.4 days).The differences were significant

between the untreated and all treatments except 10 % CO_2 at 24 and 48 hr exposure periods .

The rate of pupation was greatly affected by increasing either CO_2 concentration or exposure period compared with untreated . This rate was reduced to 33.3% at 40% CO_2 for 72 hr exposure period. Also, the mortality rates of resulted pupae from the treated larvae were positively correlated with CO_2 concentration and the exposure period (53.2%-100%) .

The pupal duration of resulted pupae from the treated larvae was significantly increased in all treatments (14.7-19.8 days) compared with the untreated (13.5 days) .

Also, obvious reduction occurred in the rate of adult emergence by increasing CO_2 concentration in air and the exposure period for each concentration. It ranged between 50% and 76.7% the treated larvae compared with the untreated (91.5%0) and no adults were emerged at 40% CO_2 for 72 hr exposure period.

Table (1): Effect of treatment by different concentrations of CO_2 in air on the mortality and development of the 2nd instar larvae of *E. vestitus* at different exposure periods.

CO_2 % in air	10%			20%			40%			Untreated
Exposure period(hr)	24	48	72	24	48	72	24	48	72	
Larval mortality%	36.2	46.8	78.7	36.2	65.9	85.1	78.7	78.7	89.4	-
Larval duration (in days)	29.7 abc	28.8 ab	34.1 ef	30.3 bc	32.4 de	34.8 f	31.1 cd	35.2 f	34.6 f	28.4 a
Pupation (%)	93.3	91.4	90.0	89.3	78.9	75.3	90.9	53.3	33.3	94.0
Pupal mortality%	53.2	63.8	87.3	51.1	76.6	93.6	85.1	89.4	100	-
Pupal duration (in days)	14.7 b	18.5 c	19.8 d	14.9 b	19.4 d	19.7 d	18.6 c	19.8 d	-	13.5 a
Adult emergence (%)	76.7	68.0	60.0	71.0	73.3	42.9	70.0	50.0	0.0	91.5

L.S.D. $_{0.05\%}$ for the larval duration = 1.86.
L.S.D. $_{0.05\%}$ for the pupal duration = 0.54.
Means within a row followed by the same letter are not significantly at 5%.

The results in Table (2) show that, the rates of larval mortality of treated 3rd instar larvae were ranged between 12.8% and 93.6%. These rates are lower than those in the treated 2nd instar larvae. There was a significant increase in the larval duration in all treatments (28.8-37.7 days) compared with untreated larvae (25.9 days)

The rate of pupation was decreased to 37.5% at 40% CO_2 for 72 hr exposure compared with untreated (94%). The mortality rates of resulted pupae from the treated larvae were 21.3% with 10% CO_2 for 24 hr exposure reached to 97.9% with 40% CO_2 for 72 hr exposure. Also, these rates are lower than those in the resulted pupae from the treated 2nd instar larvae.

Table (2) : Effect of treatment by different concentrations of CO_2 in air on the morality and development of the 3 rd instar larvae of *E. vestitus* at different exposure periods.

CO_2 % in air	10%			20%			40%			Untreated
Exposure period(hr)	24	48	72	24	48	72	24	48	72	
Larval mortality%	12.8	31.9	65.9	17.0	44.7	89.4	25.5	51.1	93.6	-
Larval duration (in days)	28.8 b	31.8 cd	32.9 cd	29.3 bc	32.6 cd	34.5 d	31.7 c	32.7 cd	37.7 e	25.9 A
Pupation (%)	91.1	88.9	80.0	92.8	81.3	50.0	87.5	79.3	37.5	94.0
Pupal mortality%	21.3	59.6	80.9	29.8	46.8	93.6	55.3	59.6	97.9	-
Pupal duration (in days)	16.1 bc	16.8 cd	18.2 e	15.5 ab	16.5 cd	18.7 e	17.1 d	16.8 cd	18.3 e	15.3 A
Adult emergence (%)	90.2	59.4	56.3	84.6	80.6	40.0	60.0	86.9	33.3	97.8

L.S.D. $_{0.05\%}$ for the larval duration = 2.82 .
LS.D. $_{0.05\%}$ for the pupal duration = 0.81 .
Means within a row followed by the same letter are not significantly at 5%.

The pupal duration of resulted pupae from the treated larvae was significantly increased (16.5-18.7 days) except at 20% CO_2 for 24 hr exposure compared with untreated (15.3 days) . The rate of adult emergence from those pupae was greatly reduced by increasing CO_2 concentration and the exposure period for each concentration. It ranged between 33.3% and 90.2% in treatments compared with untreated (97.8%).

The results indicate that, the 2nd instar larvae were more sensitive than the 3rd instar larvae to the controlled atmosphere. Similar to these findings, El-Nahal *et al.*(1984/1985) found that the larval period increased by increasing the exposure period from 8 to 48 hours, as the exposure periods increased the number of offspring emerged of the progeny decreased.
They added that , the developmental period from egg to adult in the treatments was always longer than the untreated control and increased by increasing the exposure period.

Effect on the pupal stage:

Table (3) show the effect of CO_2 concentration in air on the 3 days old pupae. The rate of pupal mortality ranged between 6.3% and 72.9% depended on CO_2 concentration and the exposure period. The duration of treated pupae was significantly increased (14.3 - 17.1 days) except at 10% CO_2 for 24 hr compared with untreated pupae (13.9 days). The rate of adult emergence from treated pupae was greatly decreased where, it ranged between 26% and 90% in treatments compared with 96% in untreated .

Table (3): Effect of treatment by different concentrations of CO_2 in air on the mortality and development of the 3 days old pupae of *E. vestitus* at different exposure periods.

CO_2 % in air	10%			20%			40%			Untreated
Exposure period(hr)	24	48	72	24	48	72	24	48	72	
Pupal mortality %	6.3	12.5	22.9	12.5	18.8	43.8	31.3	41.7	72.9	-
Pupal duration (in days)	14.3 ab	15.4 d	15.7 de	14.4 bc	15.5 de	15.9 e	14.8 c	15.8 De	17.1 f	13.9 A
Adult emergence (%)	90.0	84.0	74.0	84.0	78.0	42.0	66.0	56.0	26.0	96.0

L.S.D. $_{0.05\%}$ for the pupal duration = 0.50 .
Means within a row followed by the same letter are not significantly at 5%.

Table (4) show that, the mortality rates in the treated 8 days old pupae (10-84%) were higher than those in the treated 3 days old pupae.
The duration of the treated pupae was significantly increased in treatments (14.9- 19.3 days) except at 10% CO_2 for 24 hr compared with untreated (14.5 days) .The rate of adult emergence from treated pupae was ranged between 16% and 86 % in treatments compared to 100% in control.

From the previous results it is clear that the mortality rats of the treated stages were positively correlated with CO_2 concentration in air and the exposure period, this agree with Jay (1980); Conyers and Bell (1996) and Risha *et al.* (1999). The effect on the old pupae was greater than on the young ones, this may be the reflection of lesser oxygen requirements in the latter than the formers in response to differential events. Also, the pupae were more tolerant than larvae, this may be due to that larvae are adapted to live inside the onion bulbs in semi controlled atmosphere while the pupae are formed to exit outside the bulbs under open air conditions.

These results agree with those obtained by Ismail *et al.*(1995 a&b) who found that, the sublethal concentrations of CO_2-air mixture had effect on some biological aspects of *Sitophilus oryzae* and *Callosobruchus maculates*. Also , Hashem (2000) who reported that, the pupal stage of *Stegobium paniceum* is the most tolerant stage.

Table (4): Effect of treatment by different concentrations of CO_2 in air on the mortality and development of the 8 days old pupae of *E. vestitus* at different exposure periods.

CO_2 % in air	10%			20%			40%			Untreated
Exposure period(hr)	24	48	72	24	48	72	24	48	72	
Pupal mortality%	10.0	18.0	30.0	24.0	34.0	44.0	36.0	70.0	84.0	-
Pupal duration (in days)	14.9 a	17.0 d	17.6 e	15.6 b	16.2 c	18.6 f	15.4 b	16.1 c	19.3 g	14.5 a
Adult emergence (%)	86.0	78.0	70.0	76.0	60.0	34.0	56.0	24.0	16.0	100

L.S.D. $_{0.05\%}$ for the pupal duration = 0.49 .
Means within a row followed by the same letter are not significantly at 5%.

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تأثير تركيز ثانى أكسيد الكربون فى الهواء على بعض النواحى البيولوجية لذبابة البصل الكبيرة *Eumerus vestitus*

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قسم الحشرات الإقتصادية و المبيدات ــ كلية الزراعة ــ جامعة القاهرة ــ الجيزة.

عرضت يرقات العمر الثانى و الثالث و عذارى عمر ٣ و٨ أيام من ذبابة البصل الكبيرة *Eumerus vestitus* لثلاث تركيزات مختلفة من ثانى أكسيد الكربون فى الهواء لمدة ٢٤ و ٤٨ و٧٢ ساعة. زادت نسبة الموت فى جميع المعاملات بزيادة كل من تركيز ك ٢ و فترة التعريض. زادت مدة طور اليرقة لليرقات المعاملة و كذلك مدة طور العذراء للعذارى الناتجة عنها زيادة معنوية بالمقارنة باليرقات غير المعاملة ،إلا أنه حدث إنخفاض شديد فى نسبة التعذير و نسبة خروج الحشرات الكاملة. كذلك أدت معاملة العذارى إلى زيادة معنوية فى مدة طور العذراء و إنخفاض شديد فى نسبة خروج الحشرات الكاملة بالمقارنة بالعذارى غير المعاملة. كانت العذارى أكثر تحملا من اليرقات للمعاملة بالغاز كما أظهرت العذارى الأكبر عمرا حساسية أكثر عن العذارى الأصغر عمرا .