EFFECT OF CARBON DIOXIDE IN AIR ON DIFFERENT STAGES OF THE RICE WEEVIL *SITOPHILUS ORYZAE* (L.) (CURCULIONIDAE : COLEOPTERA)

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Abstract

The rice weevil *Sitophilus oryzae* (L.) was exposed to CO_2 concentrations of 15%, 30%, 45%, 55%, 65% and 75% in air at 25°C and 70% R.H. Eggs, larvae, pupae and adults showed different susceptibilities. 75% CO_2 in air had produced 100% mortality for both adult and developmental stages after 4 days from exposure. The larvae were the most susceptible stage, while pupae were the most tolerant. Eggs and adults were more susceptible compared with the pupal stage.

INTRODUCTION

The effect of modified or controlled atmospheres on pests of stored products had recived much attention in the last ten years, but in some areas, there is a lack of precise information because of the difficulties in comparing data gathered in different ways by different authors regarding the influence of temperature, and relative susceptibility of different species and life stages (Bell, 1983).

The early work by Bailey (1965) included an examination of carbon dioxide

(CO_2) concentrations up to 60% in the presence of 21% oxygen (O_2). He found that insects died in O_2 concentrations less than 3.4% or with 40-60% CO_2 (depending on the species). The present work deals with the effect of CO_2 concentrations on different stages of the rice weevil *S. oryzae* exposed for four days at 25°C.

MATERIALS AND METHODS

The stock cultures of the rice weevil, *S. oryzae* were set up by introducing 500 adults of the insect in a two pounds glass jar, half filled with wheat and tightly covered with muslin, held in place by rubber bands (Sun, 1947). The adults were permitted to oviposit in these cultures for 48h and then removed by sieving. This process was maintained regularly until sufficient numbers of insects were obtained.

The exposure tests were carried out on 2 days-old eggs, one-week old larvae, 3-days old pupae and one week old adults of *S. oryzae*. Because the eggs, larvae and pupae of *S. oryzae* are living inside the grain kernels, exposure tests on these stages were carried out in samples of wheat containing a definite number of them.

Samples of *S. oryzae* were taken from cultures and were dealt with according to the following standard methods : two pounds glass jar were half filled with wheat grains. In each jar, 500 newly emerged adults were released and left to deposit eggs for 2-days after which they were removed. Samples of wheat grains that held 0-2-days-old eggs were chosen from these cultures and were used in exposure tests for eggs. Other samples of grains with eggs were left for 3-5 days for hatching and kept inside the grains to reach the appropriate stage.

The experimental unit was 3g of grain kernels having the definite age. This unit was prepared in a glass tube, 5 cm long and 1 cm diam., covered in both ends with qauze. Each tube contained one stage of *S. oryzae*. The tubes were introduced to a gas-washing bottle (dressel flask).

The exposure period was four days for all stages of *S. oryzae*, CO_2 -concentrations were 15%, 30%, 45%, 55%, 65% and 75%.

Grain kernels with different developmental and adult stages in gastight connected dressel flasks were held in a constant temperature room at 25°C and exposed to CO_2 -concentrations by leading CO_2 gas out the gas cylinder through copper tubes and humidifying unit at 70% R.H., consisting of saturated $NaCl/H_2O$ solution into the flasks.

At the outlet of the flasks, O_2 content was determined continuously by oxygen

Table 1. Percentage mortality of eggs, larvae, pupae and adults of *S. oryzae* exposed to CO_2-concentrations at 25°C for 4 days.

Gas No.	CO_2 conc. %	(%) Mortality of treated stages			
		Eggs	Larvae	Pupae	Adults
1	15	18	23	14	8
2	30	57	65	37	40
3	45	81	91	69	78
4	55	90	100	82	92
5	65	100	100	92	100
6	75	100	100	100	100

analyzer. After about 15 minutes, outlet concentration was identical with inlet concentration. The gastight sealed flasks were then separted from the gas mixture cylender to permit further experiments with other flasks. After 4 days as a exposure period, flasks were aerated and the seeds were transferred to Petri-dish (5 cm diam.) in a culture room and examined at 25°C for emerged adults. Each

sample was accompanied by a control. Experiments were repeated three times.

In order to determine mortality of adults, the insects had to be examined 48h to detect any delayed effects and mortality counts were corrected by comparison with the relevant untreated trials (Abbott, 1925). For the other developmental stages, mortality was assessed by counting the emerged adults that was related to the count of untreated emerged adults.

RESULTS AND DISCUSSION

The obtained results indicated that the lethal concentration of the larvae was 55% CO_2 and for both eggs and adults was 65% CO_2 , while it was 75% CO_2 for the pupal stage. Consequently, the concentration 65% CO_2 gave complete mortality for the exposed stages of *S. oryzae* except the pupal stage.

The probit analysis according to the computer program of Noack and Reichmuth (1978) indicated that the larvae of S. oryzae were more susceptible to the different CO_2 concentrations than the other stages at the LC_{50} and LC_{95} levels. The pupae were less susceptible than the other stages at both LC levels, followed by eggs, adults and larvae (Fig. 1).

The LC_{50} and LC_{95} values were 25 and 47.47 % CO_2 for eggs, 21.87 and 38.03 % for larvae, 29.42 and 58.22 % for pupae, and 28.08 and 48.77 % for adults.

The present results are in agreement with the findings of Jay (1971) who found that CO_2 concentrations of about 60% gave over 95% kill for most of the stored grain insects after 4 days of exposure at 27^{o}C or higher. At all O_2 concontations less than 4%, with some exceptions like *S. granarius*, susceptibility to anoxia was rather similar for all insects independent of the mixture at 15^{o}C and

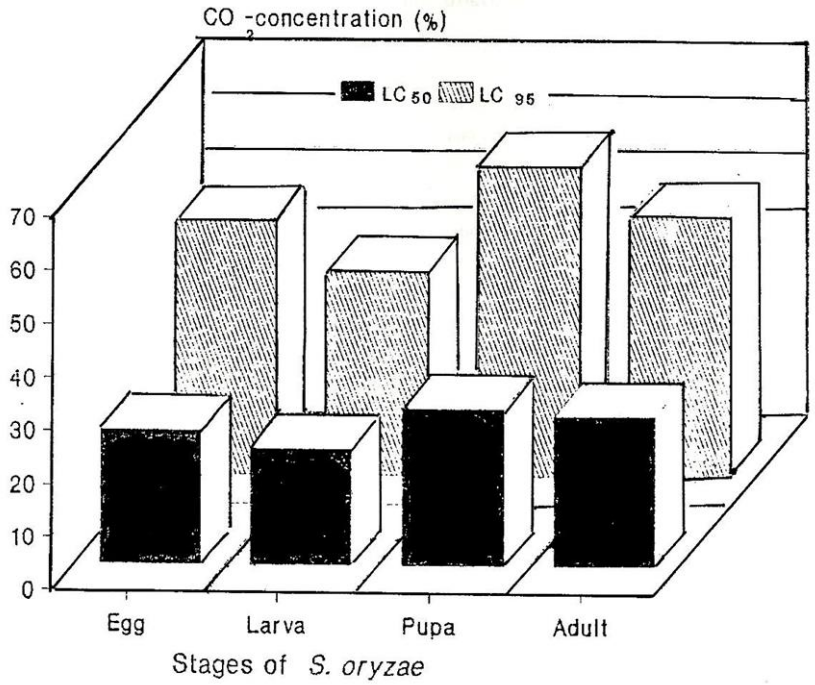

Fig. 1. LC_{50} and LC_{95} of CO_2 for different stages of *S. oryzae* at 25°C and 4 days exposure.

20°C, mostly high CO_2 concentrations had the strongest effect (Reichmuth, 1986). Essential was the lack of O_2 , which leads to increase in acidity by formation of lactic acid in the insect, so that increased CO_2 content in the atmosphere does not necessarity increase mortality (Navarro and Friedlander, 1975).

O_2 consumption of insect eggs is low so that O_2 deficiency may not harm this stage in the same short time as the larvae (Reichmuth, 1986). The reduced need for O_2 may also explain the high tolerance of the pupal stage. Fig. 1 shows a change in susceptibility of immature and adult stages of *S. oryzae*. It seems that 55 O_2 at 75% CO_2 is sufficient to allow some metabolism, which accelerates the onset of death (Bell, 1983).

Larvae in the present study are unsuitable for evaluating the tolerance of this species to inert gases due to their rather high susceptibility.

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تأثير تعرض الأطوار المختلفه لحشرة سوسة الأرز *Sitophilus oryzae* L. لجو محدد المحتويات الغازيه من غاز ثانى أكسيد الكربون

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عند تعريض أطوار البيضه واليرقه والعذراء والحشرة الكامله لحشرة سوسة الأرز للتركيزات ١٥ ، ٣٠ ، ٤٥ ، ٥٥ ، ٦٥ ، ٧٥٪ ك أ٢ فى مخلوط الهواء الجوى على درجة حراره ٢٥م ورطوبه نسبيه ٧٠٪ تبين أن تركيز ٧٥٪ ك أ٢ فى الهواء لمدة تعريض قدرها ٤ أيام عند نفس درجتى الحراره وا لرطوبه النسبيه كفيل بإعطاء نسبة موت قدرها ١٠٠٪ لكل من الحشرات الكامله والأطوار الحشريه الأخرى.

وقد تبين كذلك أن طور اليرقه لسوسة الأرز هو أشد الأطوار حساسيه لتأثير الغاز وأن طور العذراء هو الطور الأكثر مقاومه للغاز بينما كان طورى البيضه والحشره الكامله أكثر حساسيه للغاز مقارنه بالأطوار الأخرى.