

## LOW OXYGEN ATMOSPHERES TO DISINFEST FABA BEAN FROM BRUCHIDAE

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### ABSTRACT

Bruchids are major insect pests of stored seed of faba bean and the use of controlled atmospheres (CAs) has gained popularity in recent years for the control of these pests. This study was carried out to investigate the influence of low oxygen atmospheres on the control of bruchids in infested faba beans. Controlling of infestation caused by *Callosobruchus maculatus* (F.) and *Bruchus rufimanus* Boh. in 6 different varieties was tested under two nitrogen (N<sub>2</sub>) atmospheres with low oxygen (O<sub>2</sub>) contents of 2% and 3% at two different exposure periods 7 and 14 days at 34 ± 4 °C and 70 ± 5% R.H. storage conditions. The above mentioned treatments have been controlled the infestation rates for 4-6 months from July to October-December. After this period, the infestation rates started to increase gradually until reaching 100% on the variety Giza 674 in April, while for other varieties it ranged between 17.7% (Giza 716) and 80.2% (Giza 3) at 3% O<sub>2</sub> and 7 days exposure. At 2% O<sub>2</sub> and 14 days exposure, the infestation rates reached up to 62.2% (Giza 674) and ranged between 6.6% (Giza 716) and 30.4% (Giza 429).

The conclusion of this investigation is to store faba bean for 6 months only after treatment with 2% O<sub>2</sub> and 98% N<sub>2</sub> for 14 days exposure.

### INTRODUCTION

Bruchids are well-known pests of stored legume seeds, frequently causing severe losses in many tropical and subtropical areas (Singh, 1990). The damage is the result of larvae feeding inside the seed, causing weight losses, reduced seed quality and poor seed viability (Reichmuth and Ofuya, 1993). Storage losses due to bruchids as high as 70% in beans (Khamala, 1978), sometimes reached up to 100% in some varieties (Hashem, 2000). Bruchid control in stored legumes using chemical fumigants and protectants is effective, but there may be problems of residues on treated commodities, handling hazards and insect development of resistance to the used chemicals.

Atmospheres with low oxygen content offer a safe, residue free alternative to chemical fumigants and protectants for controlling infesting stored grain and grain products (McGaughey and Akins 1989, Hashem *et al.* 1993 and Hashem 2000). Hither to, studies on the effects O<sub>2</sub> deficient atmospheres appear to have effect on insects that attack stored cereals (Bailey and Banks 1975 and 1980, Annis 1987, Banks and Annis 1990).

The present trials were undertaken to investigate the influence of low oxygen atmospheres 2% and 3% O<sub>2</sub> in 98% and 97% N<sub>2</sub> on the infestation rate of faba bean by bruchid beetles (*Callosobruchus maculatus* (F.) and *Bruchus rufimanus* Boh.) during and after one year storage period.

## MATERIAL AND METHODS

This work was carried out in the framework of the Agriculture Technology Utilization and Transfer Project (ATUT). The selected faba bean varieties were imposed on the recommended commercial varieties. These varieties were Giza 3, Giza 461, and Giza 716 that were cultivated at Sakha location in Delta soil, whereas the varieties Giza 429 and Giza 674 were cultivated in Seds location (clay soil) and Giza blanca which was cultivated in Nubaria (reclaimed soil). After harvesting in May 1998, 30 Kg beans from each variety were delivered to the laboratory for use in the experiments. Seeds of each variety were put in 170 L plastic container and covered tightly to prevent any external infestation during storage, and to ensure that the infestations were based on the field infestation.

The experimental unit was 5 kg of seeds per treatment as well as the untreated from each variety of Giza 3, Giza 461, Giza 716, Giza blanca, Giza 429 and Giza 674.

To estimate the percentages of infestation, three samples of seeds (200 gm each) were taken randomly from each variety per treatment as well as the treatment were examined to assess the susceptibility of each variety for infestation.

The 5-Kg experimental unit from each variety was put in a punched paper bag and the bags of different varieties were put in an appropriate container (45 L), which was tightly closed using a metal collar around the lid margins to avoid gas leakage. The lid of each container having two openings fitted with two copper tubes tightened by pieces of rubber tubes. Input opening was connected to the N<sub>2</sub> –cylinder with a rubber tube and the output opening was connected to the oxygen analyzer (Reichmuth 1987, Reichmuth and Ofuya 1992, and Hashem *et al.* 1993).

After preparing the different containers with the different varieties of beans, the containers were exposed to nitrogen (N<sub>2</sub>) by leading gas out of the N<sub>2</sub>-gas cylinder through copper tubes. After outlet of the container, O<sub>2</sub> content was determined by oxygen analyzer after about 20 min (time for about 5 replacements of total container volume by gas-mixture), outlet concentration of O<sub>2</sub> was identified with the required gas ratio as follows:

- 3% O<sub>2</sub> and 97% N<sub>2</sub>
- 2% O<sub>2</sub> and 98% N<sub>2</sub>

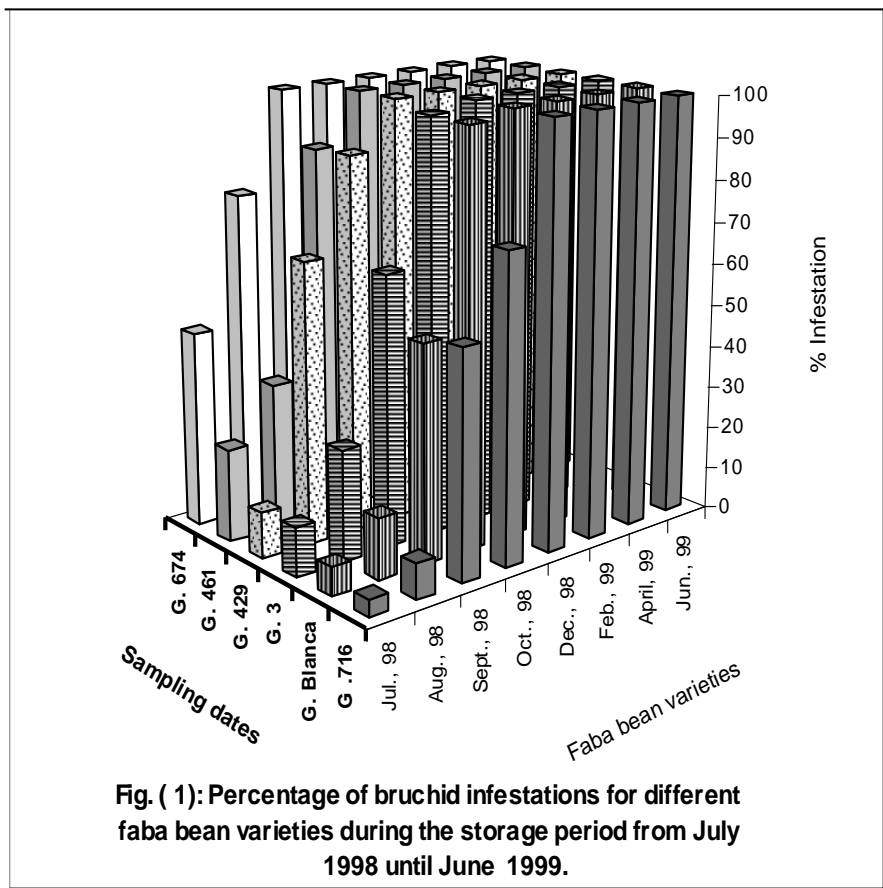
After 7 and 14 days exposure, containers were aerated and transferred to the storage room for the period of under normal conditions. The assessments of all treatments were carried out monthly from July to October and continued every two months until June 1999.

## RESULTS AND DISCUSSION

### **The relationship between field infestation and storage infestation in the untreated seeds (control).**

The lots of untreated seeds in the study were carefully examined in early July 1998 after harvesting. Newly deposited eggs on the seeds by *C.*

*maculatus*, the black small holes made by the larvae of *B. rufimanus* and a few of live adults from both species were found inside the containers. The beetles were identified as *C. maculatus* and *B. rufimanus* indicating the presence of field infestation in the seeds. The percentages of field infestation were 11.0%, 46.4%, 6.8%, 11.7%, 22.0% and 4.0% for the six varieties of faba bean Giza 429, Giza 674, Giza blanca, Giza 3, Giza 461 and Giza 716, respectively (Fig.1). These results lead to the conclusion that Giza 674 cultivated in Seds and Giza 461 cultivated in Sakha may be highly susceptible to field infestation by both pests mentioned above.



**Fig. ( 1): Percentage of bruchid infestations for different faba bean varieties during the storage period from July 1998 until June 1999.**

The data illustrated in Fig. (1) show that an extremely increase of infestation was observed in the untreated seeds in August 1998 for all varieties especially Giza 674 (76.8%), Giza 429 (66.6%) and Giza 461 (43.6%). These rates of infestation reached up to 100%, 88.1% and 88.8% in September 1998 for the three varieties, respectively.

As for the other three varieties, the infestation increased gradually from July to August 1998 then increased sharply from September 1998 to October 1998.

In October 1998, the infestation rates recorded 98.0%, 98.1% and 72.7% for Giza blanca, Giza 3 and Giza 716, respectively. These results can be attributed to the variety, insect development and different levels of field infestation during and after the harvesting.

The obtained results are in agreement in general with those of other workers (Prevett 1961, Booker 1967 and Hashem 2000). It can be concluded that, in Egypt as in other countries, faba bean (*Vicia faba*) is harvested after a pre-harvest period of field drying. During this drying period, the pods and seeds are liable to attack by *C. maculatus*, which lay their eggs on mature pods. Beside *C. maculatus*, *B. rufimanus* has already attack the pods before harvesting. These infestations provide an insect infestation nucleus sufficiently potent to cause serious losses during storage (reaching 100% as presented above). Because of this field infestation, farmers have to dispose of their crop as soon as possible after harvest.

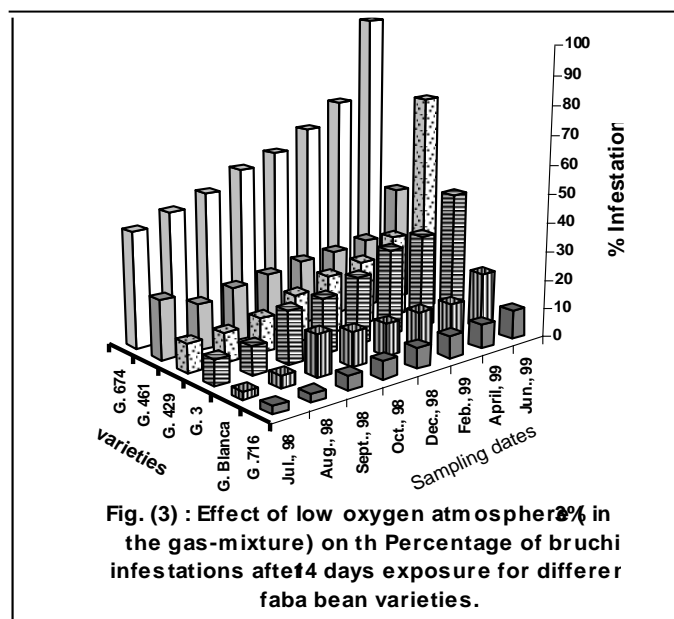
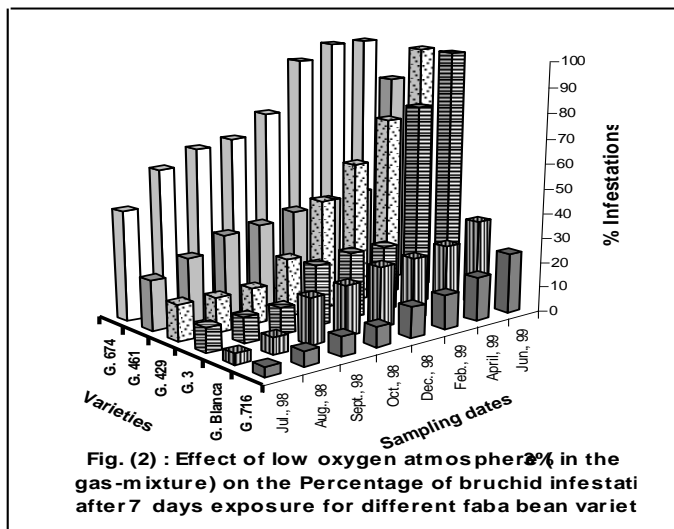
### **Effect of low oxygen atmosphere on the infestation rates caused by bruchids**

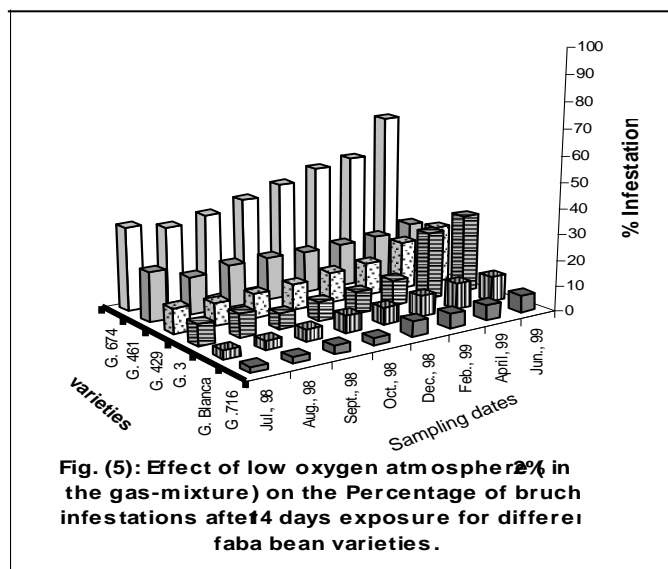
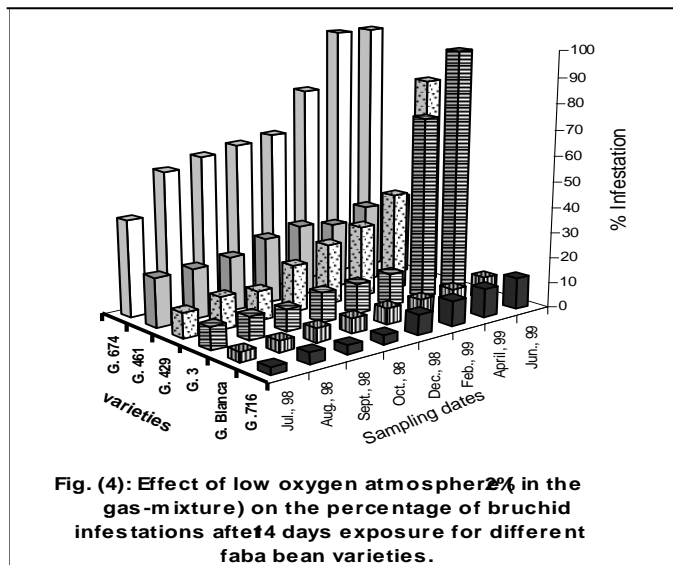
Results illustrated in Figs (2 & 3) show the treatment with 3% O<sub>2</sub> low oxygen atmospheres at 7 and 14 days exposure periods. Seven days exposure for 3% O<sub>2</sub> content were insufficient to preserve the yield of Giza 429, Giza 674 and Giza 3, respectively from infestation where the infestations increased gradually and reached up 100% in June 1999. The infestation rates of the other 3 varieties were 24.3% in Giza 716, 34.2% in Giza blanca and 86.0% in Giza 461. The same atmosphere at 14 days exposure improved the percentages of infestation for most varieties except Giza 674 (100% infestation). In the last assessment, the infestation percentages for the other five varieties were 10.0% for Giza 716, 19.3% for Giza blanca, 40.4% for Giza 461, 44.4% for Giza 3 and 75.7% for Giza 429. These high percentages indicate that the 3% O<sub>2</sub> is not efficient enough to protect the treated seeds from infestation.

Treatment with 2% O<sub>2</sub> for 7 and 14 days exposure gave the best results in all cases (Figs 4 & 5). For example, in the assessment of June 1999 (after about one year storage), the untreated control showed 100% infestation, whereas the infestation levels in Giza 429, Giza 674, Giza blanca, Giza 3, Giza 461 and Giza 716 (started in July 1998 with 11.0%, 46.4%, 6.8%, 11.4%, 22.0% and 4.0% and relatively reached 100% in October 1998) recorded 22.3%, 61.2%, 10.0%, 30.4%, 20.2% and 6.6%, respectively in June 1999 after 14 days exposure.

This mean that the treatment with 2% O<sub>2</sub> and 98% N<sub>2</sub> for 14 days exposure, almost killed the live stages of the bruchids, in addition, most of treated seeds become free from infestation.

These findings support the results obtained by Reichmuth (1988), Soderstrom *et al.* (1991), Hashem *et al.* (1993), Reichmuth and Ofuya 1993, and Hashem 2000 who reported that the bruchids are generally more susceptible to the low oxygen atmospheres (oxygen depletion) than to the oxygen enriched atmospheres.





The currently recommended exposure schedule by Banks *et al.* 1991 for low O<sub>2</sub> CAs for insect control in stored grain is 14 – 21 days in 1% O<sub>2</sub> at 25 – 29 °C. Reichmuth and Ofuya (1993) reported that the recommended exposure period (14 – 21 days) will be effective in controlling the legume seed pests *C. maculatus* and *Acanthoscelides obtectus* (Say) even if the O<sub>2</sub> content reaches 3%. Furthermore, for commodities stored at high temperatures (> 30 °C) that often prevail during harvest in many legume seed producing countries, low-O<sub>2</sub> CAs (3% O<sub>2</sub> or less) can provide a rapid means of disinfection with exposure for 11 days or even less.

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### إستخدام الأجواء منخفضة الأكسجين لحفظ الفول البلدي من الإصابة بحشرات Bruchidae

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تم تقدير معدلات الإصابة في محصول الفول البلدي والنتيجة عن الإصابة بكل من *Bruchus rufimanus* Boh. و *Callosobruchus maculatus* (F.) في ستة أصناف تجارية، هي: جيزه 429، جيزه 674 (الذان تم زراعتها في منطقة سدس – محافظة بني سويف)، جيزه 716 ، جيزه 461، جيزه 3 ( التي تم زراعتها في منطقة سخا – محافظة كفر الشيخ) وجيزه بلانكا (الذي تم زراعته في المناطق المستصلحة بالنوبارية)0

ولقد تزايدت معدلات الإصابة - تحت ظروف التخزين العادية – زيادة مضطردة من تاريخ الحصاد حتى وصلت إلى 100% بعد حوالي أربعة أشهر0 وعند إستخدام الأجواء منخفضة الأكسجين (2% ، 3%) لفترات تعريض 7 و 14 يوم، تم إيقاف معدلات الإصابة لمدة 4 – 6 أشهر0 وفي أبريل من العام التالي تزايدت معدلات الإصابة مرة أخرى حتى وصلت إلى 100% (جيزه 674) بينما تراوحت نسبة الإصابة في الأصناف الأخرى من 17.7% (جيزه 716) إلى 80.2% (جيزه 3) وذلك في معاملات المخلوط الأول الذي تراوحت نسبة الأكسجين به 3% لفترة تعريض 7 أيام0

وعند إستخدام مخلوط يحتوي على 2% أكسجين لفترة تعريض 14 يوماً، وصلت نسبة الإصابة إلى 62.2% في الصنف جيزه 674 (أكثر الأصناف حساسية) بينما كانت 6.65 في الصنف جيزه 716 (أكثر الأصناف تحملاً)، وذلك بعد عام كامل من التخزين0