EFFECT OF GAMMA RADIATION ON CERTAIN STORED GRAIN PESTS

THESIS

Submitted in partial fulfilment for the requirements for the degree of

DOCTOR OF PHILOSOPHY

In

E N T O M O L O G Y

By

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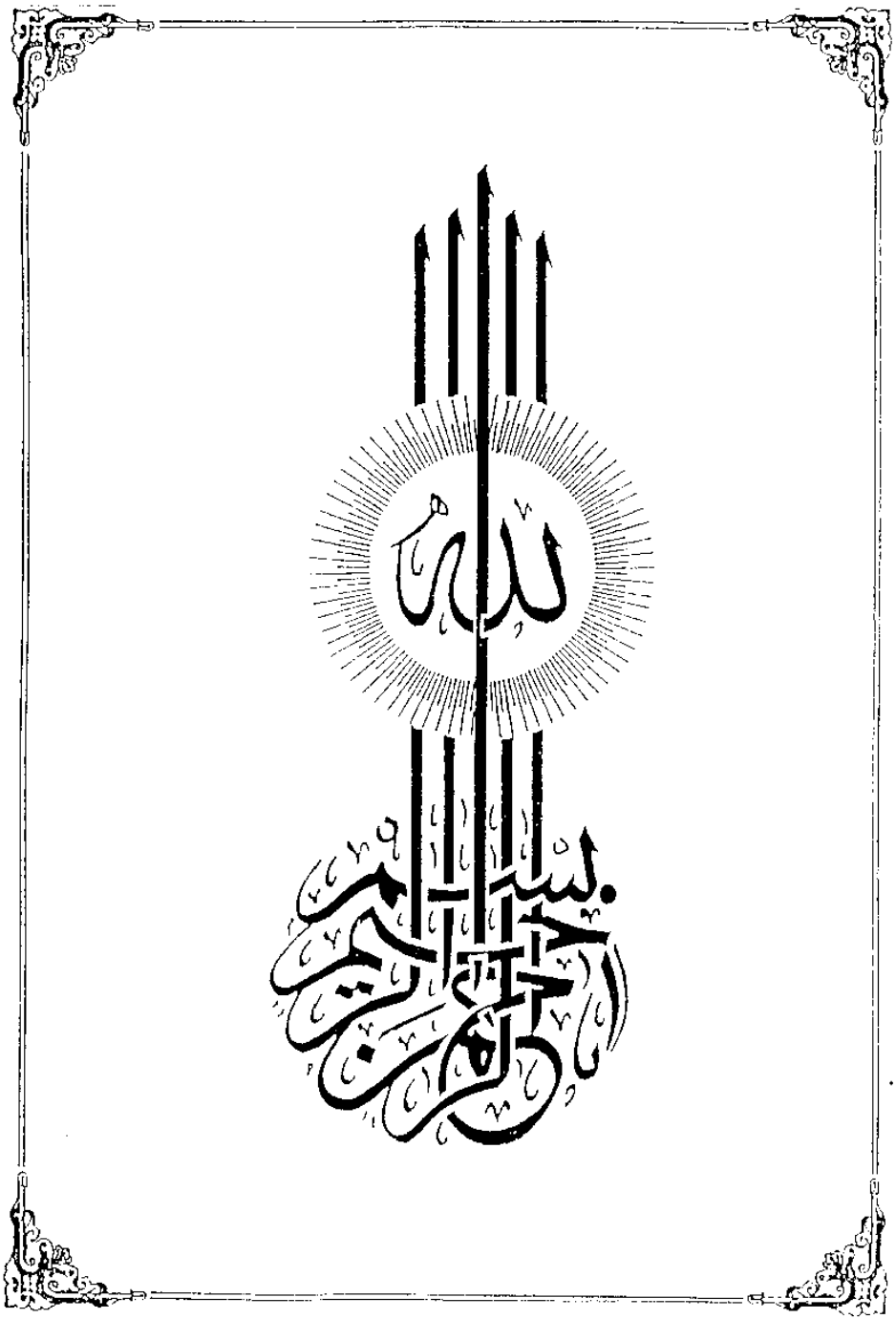

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III

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Grain Pests	Good

Thanks to God

Thanks to my mother and Father
for their valuable advices,
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CONTENTS

I. INTRODUCTION

The cowpea, Vigna sinensis Endl., is one of the most important hay-crops, and its seeds are considered as the principal leguminous food for human consumption in many parts of the world. This crop is likely to be more extensively cultivated in Egypt in the near future owing to the new agricultural policy of increasing the areas allocated for vegetable crops.

Unfortunately, wherever cowpeas are cultivated, the seed is subject to very severe attacks by the Bruchid beetle commonly known as the southern cowpea weevil, the cowpea Bruchid, or the four-spotted bean or cowpea weevil.

The southern cowpea weevil, Callosobruchus maculatus F., is known to be occurring long ago in many parts of the world. At the present time there is every reason to believe that this Bruchid has, through the channels of commerce, become of world-wide distribution. However, it can safely be stated that it occurs wherever cowpeas are grown or stored extensively.

The southern cowpea weevil does not confine its attack to cowpeas in storage, but also lays its eggs on the exterior of ripening pods in the field and on seeds in split pods as well. The adult weevil is a fairly strong flier and will fly from infested seeds in storage, from neglected small lots

of cowpeas in warehouses or farms, or from cowpeas remaining in straw-stacks, to the fields where it causes pre-harvest infestation.

The efficient control and removal of insects from food commodities has long been the goal of producers and processors. Although many methods of control are now being used, the food industry is continually seeking safer and more economical means. Fumigation, though by far the most effective method of grain disinfestation, has its own serious limitations. Chemical treatments, in some cases, may create problems by leaving undesirable residues. The development of resistance to insecticides by insects is yet another incentive to develop alternate methods for pest control. Irradiation techniques seem to offer solutions that are desirable in many respects.

A great deal of information on radiation effects on stored-product insects has now been accumulated. For the most part, however, the data are scattered and incomplete, and much of it is little more than qualitative observations. Most data are not strictly comparable because of difference in types of radiation used, exposure rates, and often poor dosimetry. In addition, it is now known that various pre- and post-irradiation treatments or conditions profoundly affect the results obtained. A uniformity in criteria for

determining mortality or other effects is badly needed. Further problems arise because radiosensitivity changes greatly through the course of an insect's life cycle and may change drastically even within a single stage. The earliest studies of radiation effects on stored-product insects were concerned with the cigarette beetle, Lasioderma serricorne F. and the rice weevil, Sitophilus oryzae L. Runner (1916) showed that eggs, larvae and adults of Lasioderma could be killed in cigars by X-rays, but that the doses required would be very large. Although this work discouraged other actual control attempts, many studies have been carried out since that time on the effects of radiation on stored product insects. Hilchey (1957) compiled an excellent summary of work on radiation effects on insects. More recently O'Brien and Wolfe (1964) have discussed the principles and some of the works related to radiation disinfestation.

Radiation disinfestation of commodities is a relatively new field, and definite conclusions as to economic feasibility must wait further research and pilot-plant studies. Two main types of units have been proposed. Some workers advocate electron accelerators with high grain flow rates and low penetrating powers, while others favour radioisotopic sources for the more penetrating gamma rays such as Cobalt-60 or Cesium-137.

Suggestions have been made for mobile irradiation facilities installed in trucks, railroad cars, and ships. By moving such facilities to locations where they are needed, maximum use can be made of the irradiator, and this proportionally reduces the unit cost. Horne and Brownell (1962) have described some of the various types of radiation facilities and discussed their relative merits.

Use of gamma radiation for control of the stored-product insects has received increased emphasis during the last ten years. Cromwell et al. (1966) suggested that by sterilizing a resistant population some measure of protection against reinfestation by the same species could be obtained. One of the criteria for success of this technique is that gamma-sterilized males compete favourably with normal males.

The primary objective of the present study is to investigate the effect of gamma radiation on the different developmental stages of Callosobruchus maculatus F. If the comparative sensitivity between stages can be determined, the dosages to kill the most resistant stage present can be regulated. The second purpose is to study the mating competitiveness between normal and sterilized males. Finally the proposed dose must not affect seeds germination or its quality as human food.

II. REVIEW OF LITERATURE

Biological Effects of Radiation

The present review, reports briefly, the influence of radioisotopes and ionizing radiations on many biological aspects of different insects. Special emphasis was made to their role in the induction of sterility and lethality in various species of insects and their applications in the control of insect populations.

Potentially, all insect species that occur in stored products can be controlled by gamma radiation. There are, however, certain problems associated with the use of this method of control for commercial purposes. One of the major problems is to determine the minimum dosages of radiation needed to control the insects while keeping the cost of treatment at an economical level. Furthermore, the threshold of radiation that will produce quality changes in some commodities does not permit the use of higher dosages.

Insect populations in stored products can be controlled by producing immediate mortality or by producing sterility of the irradiated insects. Since the dosage level required for death in all metamorphic stages within 24 h. may be 15 or more times that required to produce

sterility (Cornwell and Bull, 1960), the latter method appears to offer the greater promise under most conditions. However, in packaging plants where the primary concern is the destruction of eggs and young larvae, immediate insect mortality may be attainable, since many workers have shown that eggs and larvae are considerably more susceptible to radiation damage than are the adults.

Howden and Auerbach (1958) studied the effects of single and fractionated doses of gamma radiation (from Co^{60}) on reproduction and larval development of Trogoderma sternali Jayne. All doses applied to the larvae adversely affected the reproduction of the resulting adults, but the reduction in population caused by exposure to 4000 r or less may have been due to lowered vitality or morphological deformity. Continuous exposure to 5000 r and above inhibited reproduction.

Jefferies and Cornwell (1958) studied the effects of lethal and sterilizing single and fractionated doses of gamma radiation (Co^{60} source) on Calandra granaria L. They used single dose of 4012 rep given when larvae grew into very few adults, or 5 fractions of 802 rep each at 1 min. to 10 min. intervals. Intervals of up to 5 d were tested. They reported that the increase of longevity obtained by the use of fractionated doses at daily intervals, could