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Interactive Effect of Environmental Factors on Biological Responses of Storage Pulse Beetle

Devina Seram[1*], Senthil Natesan[2], J.S. Kennedy[1] and Pandiyan Muthaiyan[3]
[1]Department of Agricultural Entomology, TNAU, Coimbatore - 641003, Tamil Nadu, India
[2]Department of Biotechnology, TNAU, Madurai - 625104, Tamil Nadu, India
[3]Department of Plant Breeding and Genetics, AC and RI, Thanjavur-614 902, TN, India

The individual and interactive effects of three external factors *viz*. insect population source (P), host seeds for rearing (S) and laboratory rearing conditions (C) on oviposition, per cent seed damage and developmental period of the South Indian bruchid, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) were investigated. Development of *C. maculatus* populations from Thanjavur and Coimbatore were studied on two important pulse crops of India, mung bean and urd bean. Temperature significantly influenced the oviposition of the insect with the highest number of eggs laid at 30ºC. Development time was found to be the shortest for the Thanjavur population reared on mung bean at 30ºC and 70% RH (inside incubator). The results revealed that rather than the interactive effects of the above three factors, their individual effects on *C. maculatus* are profound and significant. Hence, it can be suggested that *C. maculatus* is likely to cause greater damage to mung bean seeds at specific range of temperature and relative humidity during storage.

Key words*:* Pulse beetle, Biological response, Environmental factors, Oviposition

Crop damage caused by any insect species depends on the rate of population increase of the species, which is influenced by factors like temperature, humidity, nutritional quality of host species and insect geographical location (Howe, 1965). The two most common species of storage beetle, *Callosobruchus chinensis* and *C. maculatus* differ in their biology and ecology (Raina, 1970). Egg-laying behaviour and development of *C. chinensis* are influenced by environmental factors, chemical and physical characteristics of host species, mainly legume seeds (Messina, 2004). Although various studies on the temperature and humidity effects on bruchid biology have been conducted (Mookherjee and Chawla, 1964; Xu, 1999; Deng *et al*., 2002; Fox *et al*., 2006), studies on their interactive influences on the life processes of *Callosobruchus* species are meagre and little studies have been carried out only for one species, *C. chinensis* (Mainali *et al*., 2015) whereas, it has not been reported for *C. maculatus*. Moreover, interactive effects of the three factors under study have not been performed and reported as far as any bruchid species is concerned. Hence, the present study was undertaken with an objective to investigate the interactive effects of three external factors *viz*. source of bruchid populations, rearing host seeds and the laboratory rearing conditions on biological responses of *C. maculatus,* which is the most dominant *Callosobruchus* species in South India.

Material and Methods

Insect source and seed materials

Two different *C. maculatus* populations were obtained from the Indian Institute of Crop Processing Technology (IICPT), Thanjavur and Department of Seed Science and Technology, TNAU, Coimbatore, respectively. Prior to the study, both the insect populations were cultured on susceptible mung bean cv. Co-8 for one generation each (inside incubator at 30ºC and 70 % RH) following the procedure of Strong *et al*. (1968), so as to eliminate any short term changes in behaviour associated with the change of host variety from that used for culturing to that being tested (Dobie, 1974). Pesticide-free mung bean and black gram seeds (cv. Co-6 and T9) procured from the Department of Pulses, TNAU, Coimbatore were used for the present study.

Experimental set-up and data analysis

One pair each of the two bruchid populations was released per 50 seeds of mung bean and black gram, separately in plastic containers. The experiment was laid out in a completely randomized design (CRD) with five replications. One set was kept inside an incubator (30^0C, 70 % RH) and the other kept at room temperature (28^0C, 98.4 % RH). Observations on oviposition, daily adult emergence for calculating the MDP (Seram *et al*., 2016a) and per cent seeds damaged were recorded by following the formula described by Khattak *et al*. (1987) and Seram *et al*. (2016b). Data recorded were analyzed with three-factor ANOVA using AGRES Software (Version 3.01). Data on the ambient temperature and relative humidity during the study period were obtained from the Dept. of Agro-climatic Research Centre (ACRC), TNAU, Coimbatore.

*Corresponding author's email: devnah@gmail.com

Results and Discussion

The current study investigated the influence of environmental factors *viz*. temperature and relative humidity on the biological and reproductive aspects of the South Indian strain of storage bruchid beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae), in mung bean and urd bean (*Vigna radiata* and *V. mungo*, *cv*. C0-6 and T9, respectively) under

Table 1. Individual and interaction effects of *Callosobruchus maculatus* populations (P), seed crops (S), laboratory conditions (C):

	oviposition (number of eggs laid per 50 seeds)				seed damage (in per cent)				(iii) mean developmental period (in days)			
Combinations	SEd	CD (0.05)	F	Prob.	SEd	CD (0.05)	F	Prob.	SEd	CD (0.05)	F	Prob.
P	2.267	4.617	26.87	0.000 **	1.170	2.384	108.64	0.000 **	0.096	0.195	1376.42	0.000 **
S	2.267	4.617	388.05	0.000 **	1.170	2.384	236.49	0.000 **	0.096	0.195	2416.03	0.000 **
C	2.267	4.617	172.27	0.000 **	1.170	2.384	56.53	0.000 **	0.096	0.195	318.42	0.000 **
P X S	3.205	6.529	1.81	0.188 ns	1.655	3.372	0.03	0.865 ns	0.135	0.276	12.48	0.001 **
S X C	3.205	6.529	102.52	0.000 **	1.655	3.372	1.05	0.313 ns	0.135	0.276	7.85	0.009 **
P X C	3.205	6.529	0.26	0.615 ns	1.655	3.372	0.73	0.399 ns	0.135	0.276	20.68	0.000 **
P X S X C	4.533	9.234	0.90	0.350 ns	2.340	4.768	0.03	0.865 ns	0.191	0.389	32.34	0.000 **

**Significant at 5 per cent level by LSD; ns - Non-significant; P - Thanjavur and Coimbatore *C. maculatus* populations; S – mung bean (*Vigna radiata)* and black gram (*V. mungo*); C - Incubator (30ºC, 70% RH) and lab conditions (25.4 - 31.6°C and 83.20 -100% RH during stud y period, Oct. to Dec. 2014)

laboratory conditions. Oviposition (113.6 on 50 seeds) (Fig.1) and seed damage per cent (91.2%) (Fig.3) was found to be the highest with the lowest mean developmental period (MDP) of 24.88 days (Fig.3) for *C. maculatus* Thanjavur populations on mung bean under controlled conditions (incubator) when compared to that of Coimbatore populations

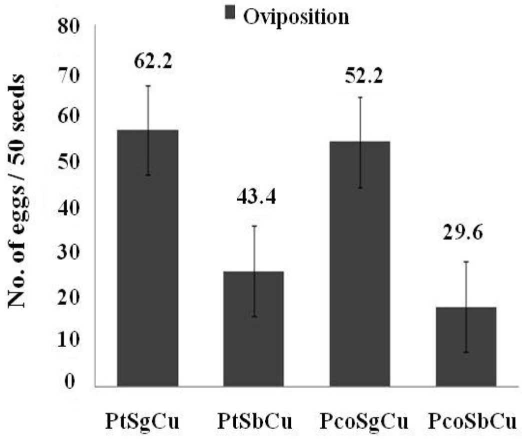

Fig.1. Oviposition by *C. maculatus* at 28ºC and 98.4 % RH (Bars indicate standard errors)

(Fig.1, 2 and 3). Egg-to-adult development periods were recorded for both the bruchid populations on different hosts and at distinct rearing conditions (Fig.3). The highest MDP of 35.38 days was observed for the Coimbatore populations reared on urd bean under laboratory conditions. This indicates that mung bean could be a suitable host for bruchid rearing than urd bean considering the lower MDP of *C. maculatus* on mung bean (26.96 days). For the South Indian bruchid strain (*C. maculatus*), the number of adult emergence is equivalent to the number of exit holes and only one adult emergence is observed from a single seed since the grubs are highly competitive inside the seed and it is rare for more than a single adult to emerge from any seed (Mitchell, 1991). Soares *et al*. (2014) studied the development of

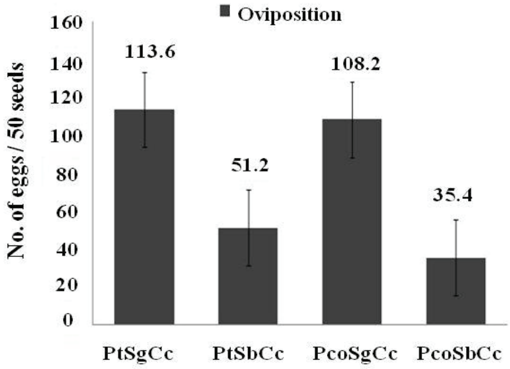

Fig.2. Oviposition by *C. maculatus* at 30ºC and 70 % RH (Bars indicate standard errors)

bean bruchid beetle, *Acanthoscelides obtectus* in common bean (*Phaseolus vulgaris* cv. Carioca) under five constant temperatures (16 - 32^{0}C). They found that developmental time from egg to adult and adult lifespan decreased with increasing temperature >20^{0}C. However, increasing temperature increased fecundity over the range of 24 - 28^{0}C, whereas adult emergence was maximized over the range of 20 - 28^{0}C, but prolonged at 16^{0}C and shortened at 32^{0}C, resulting in fewer emerged adults overall. These results provide useful knowledge on the biology and development of these South Indian populations of *C. maculatus* in stored Indian pulses.

Interaction effects between the three different factors and bruchid biological parameters were statistically analysed. Significant results ($p < 0.05$) were noticed from the individual effects of *C. maculatus* populations, crop species and laboratory rearing conditions on parameters like number of eggs laid (oviposition), seed damage per cent (based on the number of adult emergence) and mean developmental period (the number of days from 5th day of oviposition to 50% emergence of insect progenies [Table.1 (i), (ii) and (iii)]. However, interaction of these three factors had no significant effect on eggs laid and seed damage per cent

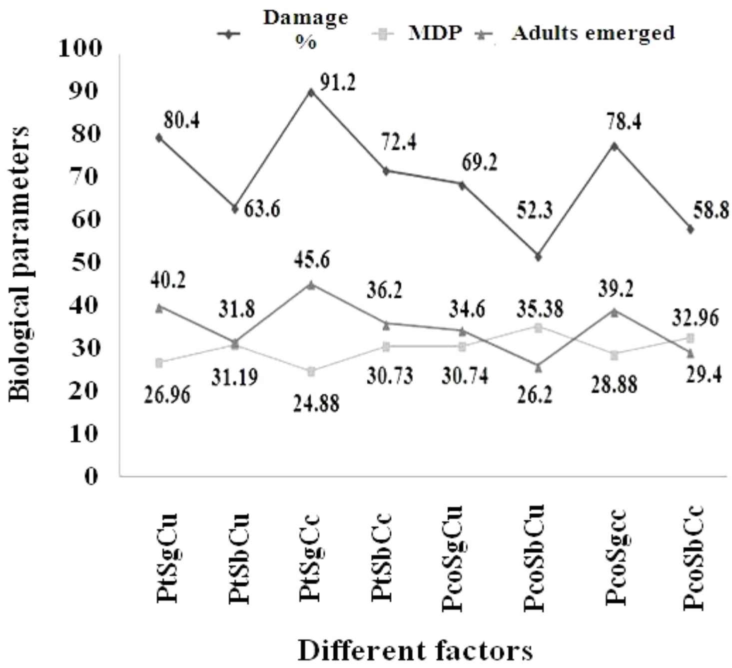

Fig.3. Biological responses of South Indian *Callosobruchus maculatus* strain

Note: P – bruchid population: t-Thanjavur, co-Coimbatore;
S – seed crop: g-mung bean, b-black gram;
C – laboratory conditions: u-uncontrolled; c-controlled
MDP – mean developmental period (in days)
Adults emerged - number of newly emerged adults per 50 seeds (equal to number of exit holes)

[(Table.1 (i) and (ii)] but significantly influenced the mean developmental period alone [Table.1 (iii)]. This may be explained from the fact that MDP (in days) calculation depends on daily adult emergence till its cessation, which mainly depends on rearing host, conditions and insect population source. Mainali *et al*. (2015) studied the interactive effects of temperature and relative humidity on oviposition and development of *C chinensis* (L.) on azuki bean. They were also of the view that rather than the interactive effects, their individual effects on *C. chinensis* were more profound, which supported the present findings and suggested that this could be just a pure chance event.

Conclusion

All the three factors studied had significant effects on *C. maculatus* development when acted individually, whereas adult emergence (MDP) was influenced by both individual and combined effects. The results suggest that *C. maculatus* has the potential for rapid, exponential increase to a devastating level at optimal temperature on its preferred host seeds and are likely to cause greater damage on seeds stored at 30ºC and 70-75% RH. Generally, in India, the greater part of the harvested produce of pulses are required to be stored for longer periods during summer season when temperature extremes are noted. Hence, care should be taken during bulk storage of food legumes in order to avoid storage losses due to bruchids for future sustainability.

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