Research Article

The Damage Caused by Cowpea Weevil *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) to Some Stored Pulses at Different Temperature and Humidity Levels

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Abstract | Cowpea weevil, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae), is one of the major stored grain insect pests of pulses throughout tropical and subtropical world. As pulses are important food source for many people, it is imperative to protect them from the infestation of cowpea weevil which causes considerable economic damage. Using no choice tests, this laboratory study investigated the effect of different temperature (20, 30 and 40°C) and humidity (50, 55 and 60%) regimes on the damage extent and weight loss caused by *C. maculatus* to some stored pulses *i.e.* green gram (*Vigna radiata* (L.) Wilczik), mash gram (*Vigna mungo* (L.) Hepper), cowpea (*Vigna unguiculata* (L.) Walp.) and brown colored chickpea (*Cicer arietinum* (L.). The results revealed that the infestation percentage was significantly ($P \leq 0.05$) variable among different host pulses. Moderate temperature (30°C) and high relative humidity (60%) were the most favorable for growth and multiplication of beetles because the maximum damage (97.8, 93.2, 59.0 and 27.7%) and weight loss (58.0, 57.8, 37.8 and 34.46%) was found on cowpea, green gram, chickpea and mash gram, respectively. While the lowest temperature (20°C) and humidity (55%) were found unfavorable for *C. maculates* as no significant damage and weight loss of pulses induced by *C. maculates* was observed at these conditions. High temperature (40°C) and low humidity (50%) also reduced the infestation rate of *C. maculatus*. Furthermore, cowpea and green gram were the most susceptible pulses, while chickpea and mash gram were moderately resistant to *C. maculates* infestation. It is concluded based on overall study results that temperature and relative humidity have great influence on insect feeding behavior and reproduction, and could be usefully manipulated for stored grain management.

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Introduction

Pulses constitute a main source of food and nutrition for people throughout the world. These are used on daily basis to fulfill the nutritional requirements as these are the major source of proteins, vitamins and minerals (Harrison *et al*., 2017). In Pakistan, pulses are cultivated only on 5% of the total agricultural land

(PARC, 2016). Due to this minor production and high consumption, Pakistan imports considerable quantity of pulses to meet pulses demand (Vanzetti *et al*., 2017). Pulse grains are usually vulnerable to be attacked by many stored grain insect pests including *Callosobruchus* species such as *Callosobruchus analis*, *C. chinensis* and *C. maculatus* (Hajam and Kumar, 2022).

Among them, *C. maculatus* (Coleoptera: Bruchidae) causes heavy losses to all pulses in storage conditions (Perzada *et al*., 2022). It infests almost all kinds of whole pulses such as mung gram or green gram, mash gram, chickpea, kidney beans, lentils, pigeon pea, pea nut, cowpea, dry Peas and adzuki beans (Beck and Blumer, 2014; Majeed *et al*., 2016). Cowpea weevil multiplies very rapidly in stores. The adult weevils and eggs are found on grain surfaces, while larvae and pupae live inside the grains. The larvae bore into the grains by making circular holes where they feed on endosperm (Ahmady *et al*., 2016). These infested grains became unfit for human consumption as well as for livestock feed. Damaged grains also lose their germination ability (Elhag, 2010).

There are various methods to control stored grain insect pests including *C. maculatus* such as the use of synthetic insecticides (aluminum phosphide a methyl bromide) in storage (Arora and Srivastava, 2021), but at the same time chemical insecticides have many negative effects on human health and livestock and other environment hazards (Rani *et al*., 2012). Owing to these non-target effects of synthetic insecticides usage in stored food, there is need looking for better understanding of the behavior and damage of stored grain insect pests in different storage conditions such as different prevailing temperature and humidity levels. *C. maculatus* can also be controlled by determining their life cycle at different temperature and moisture conditions (Ahmady *et al*., 2016). A study showed that the cowpea weevil selects its host depending on the geographical region in which they live (Kawecki and Mery, 2003). This pulse beetle also switches its host if new host becomes available to them (Rova and Bjorklund, 2011).

As agro-climatic and weather conditions of different regions of Pakistan including Sindh are getting fluctuated, stored grain pests also adopt these environmental conditions accordingly by modifying their feeding and reproduction behaviors. Keeping it in view, the aim of this study was to assess the damage and weight loss extent incurred by cowpea weevil *C. maculatus* to some local stored pulses at varying temperature and humidity regimes, with an ultimate objective to find-out appropriate environmental factors which can be manipulated for suitable pest control measurements.

Materials and Methods

Laboratory (no choice) experiments were conducted in completely randomized design following a previously described protocol (Ahmady *et al*., 2016). Experiments were done at different temperature (20, 30 and 40°C) and humidity (50, 55 and 60%) conditions set in an incubator in the Entomology Laboratory of the Department of Zoology, University of Sindh, (Jamshoro, Sindh, Pakistan) during 2022.

Insect culture

A small colony of *C. maculatus* was obtained from the grain storage market of Hyderabad (Sindh) from cowpea grains. One pair of beetle was separated from the collected population and was released on the sieved 500 g of cowpea grains to culture homogenous population (Sarwar, 2012). The culture was maintained in a Kilner jar under ambient temperature and relative humidity (*i.e.* at 30±2°C and 70%) in the laboratory (Ahmady *et al*., 2016). Newly emerged adults of F_3 generation were used for experimental purpose.

Plant material

Four different pulses were tested in this investigation *i.e.* green gram (*Vigna radiate* (L.) Wilczik), mash gram (*Vigna mungo* (L.) Hepper), cowpea (*Vigna unguiculata* (L.) Walp.) and brown colored chickpea (*Cicer arietinum* (L.). These pulses were purchased from the local grain market and were used as a diet of *C. maculatus* during experimental work. All pulses were properly cleaned to remove any dust and debris and damaged and broken grains. Healthy grains were kept in refrigerator at 6°C before experiment in order to kill the life stages of any insect pests, if present on the grain surfaces (Adenekan *et al*., 2012). Thereafter, these grains were taken out of refrigerator and were placed in a dry environment.

Experimental protocol

To evaluate the percent damage and weight loss of host pulses, about 100 g grains of each pulse were put into a 550 g Kilner jar, then five pairs of newly emerged *C. maculatus* adults were released in each jar including control. The rearing jars were covered with thin muslin cloth to prevent beetles from escaping the jar and to provide aeration. The samples were placed inside an incubator at three above mentioned levels of temperatures and humidity separately, while the control jar was kept under ambient temperature and humidity (30±2°C and 70% relative humidity) in the laboratory (Adenekan *et al*., 2012). The cowpea weevils were left to oviposit on all the host pulses and all jars were observed on daily basis.

After eight weeks of storage, the data regarding insect damage and grain weight loss were collected from each replication. Damaged grains were estimated by counting the exit holes on the surface of the grains, while the weight loss was found out by weighing of pulses before and after the experiment. The same procedure was repeated for each experiment at different temperature and humidity regimes. All experiments were replicated thrice.

Statistical analysis

Data regarding insect damage and product weight loss were calculated usng the following formulae (Sarwar, 2012).

$$\text{Damage (\%)of pulse formula} = \frac{\text{Damage no. of grains}}{\text{Total no. of grains}} \times 100$$

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of grains} - \text{Final weight of grains}}{\text{Initial weight}} \times 100$$

The data obtained were analyzed using the completely randomized design. Treatment mean values were statistically analyzed by analysis of variance (ANOVA) using Statistix 8.1 version software and treatment means were compared using Fischer's least significant different (LSD) post-hoc test. Standard P-value (0.05) was considered as significant to categorize different pulses as resistant or susceptible one.

Results and Discussion

The mean percent damage and weight loss caused by *C. maculatus* to host pulse grains was highly significant (P<0.05). The results showed a significant difference (P<0.05) in the mean number of exit holes on surface of the pulse grains and weight loss of each pulse infested by *C. maculatus* at varying temperature and humidity regimes after eight weeks of storage (Table 1). The lowest infestation/damage (0.0%) on all the tested pulses was recorded at 20°C temperature and 50% humidity, while the highest infestation was recorded at 30°C temperature and 60% humidity. Highest damage was found on cowpea (97.8%), green gram (93.8%), followed by chickpea (59.0%) and mash gram (27.7%) at 30°C temperature and 60% humidity, and also in the control treatments at the ambient laboratory conditions (30±2 °C and 70% humidity) *i.e.*, on cowpea (98.7%), green gram (95.9%) followed by chickpea (61%) and mash gram (29.1%). A mild infestation of *C. maculatus* was observed on cowpea (55.6%), green gram (40.8%), chickpea (35.6%) and mash bean (14.31%) at 40°C temperature and 50% humidity. There was no significant difference between the infestations at 30°C temperature and 60% humidity and the control, but was significantly different when compared with infestations at 20°C temperature and 55% humidity and at 40°C temperature and 50% humidity).

The data also revealed that a temperature regime of 30°C temperature and 60% humidity significantly induced the highest weight loss of the all pulse grains (*i.e.* 97.78, 93.2059.00 and 27.7% for cowpea, green gram, chickpea and mash gram, respectively (Table 2). Similarly control sample also showed highest weight loss percentage of cowpea (61.92%) and green gram (61.35%) followed by chickpea (40.47%) and mash gram (33.8%). Whereas the least mean weight loss

Table 1: *Effect of different temperature and humidity regimes on the damage percentage caused by cowpea weevil Callosobruchus maculatus to different pulse grains.*

Temperature (°C)	Humidity (%)	Mean damage (%)			
		***Vigna unguiculata* (cowpea)**	***Vigna radiate* (green gram)**	***Cicer arietinum* (brown chickpea)**	***Vigna mungo* (mashgram)**
20	55	0c	0c	0c	0c
30	60	97.78a	93.2a	59a	27.7a
40	50	55.6b	40.8b	35.6b	14.31b
Control	--	98.7a	95.9a	61a	29.1a

Means with different letters are significantly different from each other at P≤0.05 (factorial ANOVA; LSD at α = 0.05).

Table 2: *Effect of different temperature and humidity regimes on the weight loss percentage caused by cowpea weevil Callosobruchus maculatus to different pulse grains.*

Temperature (°C)	Humidity (%)	Mean final weight loss (%)			
		Vigna unguiculata (cowpea)	*Vigna radiate* (green gram)	*Cicer arietinum* (brown chickpea)	*Vigna mungo* (mashgram)
20	55	0c	0c	0c	0c
30	60	58a	57.78a	37.8a	34.46a
40	50	7.12b	5.19b	4.56b	3.0b
Control	--	61.92a	61.35a	40.47a	33.8a

Means with different letters are significantly different from each other at P≤0.05 (factorial ANOVA; LSD at α = 0.05).

percent of grains was recorded at 20°C temperature and 55% humidity. The weight loss percentage of grains was significant at 20 and 30°C and at 55 and 60% humidity, respectively. Likewise, the mean weight loss percent of host grains at 30°C temperature and 60% humidity and the control (at 30±2°C temperature and 70% humidity was not significantly different. There was a significant reduction (P<0.05) in the mean weight loss percent at 40°C temperature and 50% humidity in cowpea (7.12%), green gram (5.19%), chickpea (4.56%) and in mash gram (3.0%) when compared it with the weight loss percent of control treatments at 30°C temperature and 60% humidity.

Furthermore, pulses cowpea and green gram were found to be the most susceptible pulses because maximum damage and weight loss was observed on these two stored pulses, whereas chickpea and mash gram were considered as resistant due to less infestation of *C. maculatus* on them against cowpea weevil during storage. During the present study, it was found that temperature and humidity play an important role in feeding and reproduction of *C. maculates* during storage because the insect causes severe infestation to the host pulse grains at 30˚Ctemperature and 60% relative humidity. While low temperature (20˚C) and relative humidity (55%) reduced the life activities of the cowpea weevil probably by inducing insect hibernation and these conditions were found unfavorable for *C. maculatus*. Similarly, high temperature (40°C) and low relative humidity (50%) also had adverse effect on weevil population.

It was observed that these both environmental components have considerable impact on the behavior of *C. maculates* by increasing and decreasing their feeding and reproduction. Perzada *et al*. (2022) worked on *Callosobruchus* spp. including *C. analis*, *C. chinensis* and *C. maculatus* in Sindh, Pakistan, on various host stored pulses. They observed that *C. maculatus* was the most distributed and dominant species throughout the studied areas and it caused highest damage and weight loss to the host pulses then the *C. chinensis* and *C. analis* at the temperature (30±2 ˚C and relative humidity 60±5 %). Adenekan *et al*. (2012) observed the effect of four different temperature degrees (10, 20, 30 and 40 °C) in incubators on various parameters of *C. maculatus*. This study found that as temperature increased up to 30°C, it also increased oviposition and adult emergence of the beetle but its life cycle was slow down at 10 and 20°C. Also high temperature (up to 40°C) had unfavorable effect on egg hatching, adult emergence and developmental period of *C. maculatus*. The result of Ahmady *et al*. (2016) revealed that the standard temperature for *C. maculatus* suitability range from 30-35°C and its optimum humidity was 65% but the activeness of *C. maculatus* also dependent on its feed.

A study by Ouedraogo *et al*. (1996) on *C. maculatus* demonstrated that environmental factors had great influence on population of *C. maculatus*. They observed that there were variations in climatic conditions in Ouagadougou and Bobo Dioulasso, the two regions of Burkina Faso. These both abiotic factors affect the fecundity and development of *C. maculatus* and its parasitoid *Dinarmus basalis* in stores of both zones. The findings of our experiments also showed that the *V. unguiculata*(cowpea) and *V. radiate* (green gram) were severely damaged and incurred by high weight loss during storage due to their soft grain coat and internal content than *C. arietinum* (brown chickpea) and *V. mungo* (mash beans). These both have hard grain surface and internal content. Previously, Sarwar (2012) and Akhtar *et al*. (2022) also reported that the most susceptible varieties of chickpea had soft and smooth grain surface, bigger sized and white color, whereas hard and wrinkled grain surface, small sized and brown colored varieties was found resistant against *C.*

maculatus. These results also corroborate the findings of Loko *et al*. (2022) who demonstrated that soybean varieties with soft seed coat were considerably more infested by the *C. maculatus* as compared to hard-seed coat germplasm.

Conclusions and Recommendations

Based on the findings of present research work, it was concluded that the damage extent and weight loss caused by *C. maculatus* to host pulses depend upon on the prevailing temperature and humidity conditions. Low (20°C) and high (40° C) temperature and humidity (50 to 55 %) beyond optimum threshold of the pest (*i.e.* around 30 ° C temperature and 60% humidity) had negative effect on the biology and infestation of *C. maculatus*. Moreover, it was found that cowpea and green gram were most susceptible pulses, while chickpea and mash gram were found resistant against *C. maculates* attack. Therefore, it is recommended that the manipulation of temperature and humidity could have significant effect in controlling stored grain insect pests such as cowpea weevil in integrated pest management programs. Furthermore, it is also recommended not to store susceptible varieties of pulses together in stores in order to prevent them from cross infestations of cowpea weevil *C. maculatus*.

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Novelty Statement

The data of current study provides the information about the life activities of *C. maculates* and it's favorable as well as unfavorable temperature and humidity; this record would be helpful to control the studied weevil under eco-friendly management by changing its surrounding environment in subtropical parts of the World including Pakistan.

Authors' Contribution

Nosheen Jehajo: Conducted the research work.
Naheed Shah: Helped in data analysis.

Conflict of interest

The authors have declared no conflict of interest.

References

Adenekan, M.O., A.I. Makinde, A.A. Adeniran, D.O. Aremu and E.A. Oluade. 2012. The morphometrics and developmental stages of *Callosobruchus maculatus* (F) at varying temperature regimes on *Vigna unguiculata* (L.) Walp. Int. J. Appl. Res. Technol., 1(4): 82-88.

Ahmady, A., N. Rahmatzai, Z. Hazim, M.A.A. Mousa and A.A. Zaitoun. 2016. Effect of temperature on the biology and morphometric measurement of cowpea beetle, *Callosobruchus maculatus* Fabr. (Coleoptera: Chrysomelidae) in cowpea seed. Int. J. Entomol. Res., 1(7): 5-9.

Akhtar, M., K. Khawar, M. Rafique, K. Hussain, S. Ashraf and M. Hassan. 2022. Relative resistance of seed of advance genotypes of *Cicer arietinum* against *Callosobruchus chinensis* during storage. Sarhad J. Agric., 38(4): 1228-1234. https://doi.org/10.17582/journal.sja/2022/38.4.1228.1234

Arora, S. and C. Srivastava. 2021. Locational dynamics of concentration and efficacy of phosphine against pulse beetle, *Callosobruchus maculatus* (Fab). Crop Prot., 143: 105475. https://doi.org/10.1016/j.cropro.2020.105475

Beck, C.W. and L.S. Blumer. 2014. A handbook on bean beetles, *Callosobruchus maculatus*. National science foundation. Published online at www.beanbeetles.org-2014/.

Elhag, E.A., 2010. Deterrent effects of some botanical products on oviposition of the cowpea bruchid *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Int. J. Pest Manage., 46(2): 109-113. https://doi.org/10.1080/096708700227462

Hajam, Y.A. and R. Kumar. 2022. Management of stored grain pest with special reference to *Callosobruchus maculatus*, a major pest of cowpea: A review. Heliyon, e08703. https://doi.org/10.1016/j.heliyon.2021.e08703

Harrison, S., R. Harrison, M. Qasim, S. Rani, A.G. Chaudry, K. Sadazoi, D. Vanzetti and E. Petersen. 2017. Pulse production in Pakistan. A literature review. How can policy reform remove constraints and increase productivity in Pakistan? Islamabad, 3 April www.aciar.gov.au-2017/.

Kawecki, T.J. and F. Mery, 2003. Evolutionary conservatism of geographis variation in host preference in *Callosobruchus maculatus*. Ecol. Entomol., 28(4): 449-456. https://doi.org/10.1046/j.1365-2311.2003.00526.x

Loko, Y.L.E., J. Toffa, A. Orobiyi, G.A. Dassou, R. Okpeicha, D. Gavoedo and A. Dansi. 2022. Effects of seed physical characteristics of benin soybean germplasm on their resistance to *Callosobruchus maculatus* Fabricius (Coleoptera: Bruchidae). Sarhad J. Agric., 38(4): 1468-1477. https://doi.org/10.17582/journal.sja/2022/38.4.1468.1477

Majeed, M.Z., M. Javed, A. Khaliq and M. Afzal. 2016. Estimation of losses in some advanced sorghum genotypes incurred by red flour beetle, *Tribolium castaneum* L. (Herbst.) (Tenebrionidae: Coleoptera). Pak. J. Zool., 48(4): 1133-1139.

Ouedraogo, P.A., S. Sou, A. Sanon, J.P. Monge, J. Huignard, B. Tran and P.F. Credland. 1996. Influence of temperature and humidity on population of *Callosobruchus maculatus* (Coleoptera: Bruchidae) and its parasitoid *Dinarmus basalis* (Peteromalidae) in two climatic zones of Burkina Faso. Bull. Entomol. Res., 86(6): 695-702. https://doi.org/10.1017/S0007485300039213

PARC, 2016. Pakistan Agricultural Research Council, national coordinated pulse programme, National Agricultural Research Center (NARC), Islamabad. www.parc.gov.pk-2016/.

Perzada, A.A., A.A. Gilal, L. Bashir, J.G.M. Sahito and M.I. Kubar. 2022. Distribution and damage potential of pulse beetles, *Callosobruchus* spp. (Coleoptera: Bruchidae) in Sindh, Pakistan. Life Environ. Sci., 59(3): 9-22. https://doi.org/10.53560/PPASB(59-3)716

Rani, C.R., C. Reema, S. Alka and P.K. Singh.2012. Salttolerance of *Sorghum bicolor* cultivars during germination and seedling growth. Res. J. Rec. Sci., 1(3): 1-10.

Rova, E. and M. Bjorklund. 2011. Can preference for oviposition sites initiate reproductive isolation in *Callosobruchus maculatus*? PLoS One, 6(1): 1-6. https://doi.org/10.1371/journal.pone.0014628

Sarwar, M., 2012. Assessment of resistance to the attack of bean beetle *Callosobruchus maculatus* (Fabricius) in chickpea genotypes on the basis of various parameters during storage. Songklanakarin J. Sci. Technol., 34(3): 287-291.

Vanzetti, D., E.H. Petersen and S. Rani. 2017. Economic review of the pulses sector and pulses-related policies in Pakistan. A literature review. How can policy reform remove constraints and increase productivity in Pakistan? www.aciar.gov.au-2017/.