The Effect of Some Plant Powders on the Mortality of Cowpea Beetle, *Callosobruchus maculatus* Fab. (Coleoptera: Chrysomelidae)

Nagat Ali Abuelnnor
Plant Protection Department, Faculty of Agriculture, University of Tripoli, Tripoli, Libya
Email address of corresponding author: najat.abuelnnor@gmail.com

Abstract

Abuelnour, N.A. 2023. The Mortality Effect of Some Plant Powders on the Cowpea Beetle, *Callosobruchus maculatus* Fab. (Coleoptera: Chrysomelidae). Arab Journal of Plant Protection, 41(3): 327-331. https://doi.org/10.22268/AJPP-41.3.327331

This study aimed to test the biological effect of four plant powders: black pepper (*Piper nigrum*), ginger (*Zingiber offiicinale*), retem (*Retama raetam*) and rosemary (*Rosmarinus officinalis*) against cowpea weevil, *Callosobruchus maculates* Fab. in chickpeas using five concentrations, 0.0, 1.0, 2.0, 3.0 and 4.0% (w/w). Results obtained showed that all tested plant powders produced significantly higher mortality than the control and reached 80.63% in 96 h. Mortality rates increased proportionally with duration of exposure. The black pepper *P. nigrum* caused the highest beetles mortality at all exposure times which differed significantly from mortalities caused by the other plant powders used in this experiment.

Keywords: *Callosobruchus maculatus*, plant powders, chickpeas, mortality.

Introduction

Chickpea (*Cicer arietinum* L.) is a highly nutritious pulse cultivated throughout the world and is ranked third in importance among food legumes (Shukla *et al.*, 2007). Worldwide, India is the largest producer of chickpeas accounting for a total of 64% of the global chickpea production (Gaur *et a*l., 2010). However, chickpeas are vulnerable, both in the field and in storage, to attack by insects (Sharma & Thakur, 2014).

The cowpea beetle *Callosobruchus maculatus* Fabricius (Coleoptera: Chrysomelidae: Bruchinae), is the main insect pest of chickpeas in storage and cause considerable economic losses worldwide (Kang *et al*., 2013; Massango *et al*., 2017). The *C. maculatus* is the principal field-carry-over storage pest of pulses including cowpeas, chickpeas, green gram, black gram, and red gram (Loganathan *et al*., 2011). Females lay eggs on the seed coat and larvae develop exclusively inside the seeds, at the expense of grain endosperm and embryo, and causing serious damage such as grain weight loss, reduction in germination, weak seed viability, and lower nutritional quality (Oke & Akintunde, 2013).

Although, chemical control is a limited choice due to the strict guidelines for the safe use of insecticides on or near stored food, its use reduces some losses in the grains during storage. The chemicals should have low toxicity to humans, minimum residue levels and they should not affect the quality of food products (Padín *et al*., 2002; Zdárková, 1991). Use of chemical compounds to control storage insects can also have significant environmental impact. For instance, methyl bromide was used worldwide to control pests, but has been found to be a powerful atmospheric zone depletory, and as a result it has been withdrawn by international treaty and there is a search for alternatives (Fields & White, 2002; Rees, 2004). In addition, insecticides are toxic to species other than those they are aimed to control; they often kill predators and parasites that decrease insect populations naturally (Fields, 1992). Therefore, environmentally safe and convenient methods such as the use of inert dusts, plant powders, oils and pressurised carbon dioxide and temperature management techniques represent a safer alternative to replace synthetic pesticides (Yuya *et al.*, 2009). Researchers have been searching natural products derived from plants as an alternative to conventional insecticides for insect control (Raja *et al.*, 2000; Talukder & Howse, 1995). Previous studies reported that the use of different plant parts such as: leaf, bark, seed powder, or oil extracts when mixed with the stored grains have resulted in reduced rates of grain damage and insect oviposition, as well as suppression of adult emergence in various stored grain insect pests (Bakkali *et al*., 2008; Shaaya *et al*., 1997). In Libya, the cowpeas beetle, *C. maculatus* is an economical insect pest of stored legumes. The present study was undertaken to evaluate the effect of leaf powders of rosemary (*Rosmarinus officinalis*), retem (*Retama raetam*), fruit of black pepper *(Piper nigrum* L.) and rhizomes of ginger (*Zingiber offiicinale)* on the mortality of *C. maculates*.

Materials and Methods

Insect rearing

The chickpeas (*C. arietinum*) used for this study were purchased from the local market, broken chickpeas and particles were removed and then disinfested by keeping them in a freezer at temperature of −4°C for 2 weeks to kill all hidden infestations before use. The initial population of *C. maculatus* was taken from a laboratory culture maintained for several generations on dry chickpeas. The beetles were reared on whole chickpeas in 2 L. glass jars. The substrate jars were infested with one hundred adults (males + females), which were allowed to feed and lay eggs

https://doi.org/10.22268/AJPP-41.3.327331

for seven to ten days, after which they were removed. Muslin cloth and rubber bands were used to cover the top of the jars to prevent beetles from escape. The jars were kept under controlled temperature (28±2°C) and relative humidity (60±5%). Newly emerged adult insects (1–2 days old) were used for the experiments.

Preparation of plant powders

The four plant materials used in the experiment are presented in Table 1. These plant materials were dried in the laboratory and ground into a fine powder using an electric blender. The freshly prepared powder was then used immediately in the experiment.

Table 1. Details of the plants tested for their toxicity against cowpea beetle, *C. maculatus*

Scientific name	Common name	Family	Part used	Collected from
Rosmarinus officinalis	Rosemary	Lamiaceae	Leaves	Tarhuna city
Retama raetam	Retem	Fabaceae	Leaves	Tarhuna city
Piper nigrum	Black pepper	Piperaceae	Fruit	Local market
Zingiber offiicinale	Ginger	Zingiberaceae	Rhizome	Local market

Insect bioassay

Quantities of 0.2, 0.4, 0.6 and 0.8 g powder of each of the plant materials: *S. rosmarinus*, *R. raetam*, *P. nigrum* and *Z. offiicinale* were added respectively to four glass jars (100 ml capacity) containing 20 g of chickpeas to give 1.0, 2.0, 3.0 and 4.0 % w/w. The chickpeas in the control contained no plant powders. The jars with their contents were gently shaken to ensure thorough mixture of the chickpeas and treatment powders. Five pairs of 1-2 days old male and female adult *C. maculatus* were introduced to each jar and then covered with muslin cloth and rubber bands to prevent them from escaping. Four replicates of the treated and untreated controls were laid out in Complete Randomized Design. All treatments were incubated at 28°C±2°C and 60%±5% relative humidity (R.H.) and darkness. The adult mortality was assessed every 24 h for 96 h and data on percentage adult insects mortality were recorded. The insect was considered dead if it did not respond to a probe with a pin. Percent mortality was calculated using the corrected formula of Abbott (1925). The mortality rate was determined as follows:

$$\text{MR (\%)} = \frac{\text{Number of dead insects}}{\text{Total number of insects}} \times 100$$

Statistical analysis

The mortality of *C. maculatus* was corrected by using Abbott's (1925) formula. The data obtained from the experiments were subjected to analysis of variance (ANOVA), and the experimental design followed was the completely randomized design (CRD) and significance between means was based on the least significant difference (LSD) at P=0.01.

Results and Discussion

The effect of *P. nigrum*, *Z. offiicinale*, *R. raetam* and *R. officinalis* powders on mortality rate of adults *C. maculates*

Generally, all the plant powders used in this study gave significantly better results than the control (10.0%) (Figure 1). The effect of the plant powders on adult mortality of *C. maculatus* is presented in Figure (2). Analysis of variance indicated highly significant differences of mortality rates among various concentrations ($p < 0.01$), exposure time ($p < 0.01$) and combined effect of plant powders and exposure time ($p < 0.01$). All the test plant powders caused beetle mortality at different levels 24 h after exposure, reaching 80.63% in 96 h. Mortality rates increased proportionally with duration of exposure. Forty eight hours after treatment, *P. nigrum* caused the highest mortality of (22.50%) followed by *Z. offiicinale* (16.88%), *R. officinalis* (15.62%) and *R. raetam* (11.25%), compared to the control which was (0.00%). *P. nigrum* caused highest beetles mortality at all exposure times and this differed significantly from mortalities caused by the other plant powders used in this experiment. The results obtained showed a significant difference due to different concentrations of the plant powders on adult's mortality rate which increased proportionally with concentration (Figure 1). The concentrations used showed various levels of toxicity against adult *C. maculate*. *P. nigrum* powder resulted in no survival at 4 % w/w with mortality rate of 92.50% at 3% w/w concentration, whereas the lowest concentration of 1% w/w gave a mortality rate of 55.00% to *C. maculatus*. *Z. offiicinale* powder resulted in 85.00% mortality rate on *C. maculatus* at 4% w/w concentration, whereas the lowest concentration of 1% w/w gave a mortality rate of 30%. *R. officinalis* and *R. raetam* powders gave a mortality rate of 72.50% and 67.50%, respectively, at 4% w/w concentration, whereas the lowest concentration of 1% w/w gave a mortality rate of 45.0% and 30.0%, respectively, over a period of 96 h.

Several studies had investigated the effects of plants with insecticidal potential to control the cowpea beetle *C. maculates* (Boeke *et al*., 2004; Dabiré & Sanon, 2008; Ileke & Olotuah, 2012). Plant derived extracts, powders, and essential oils were reported as repellent against stored grain insect pests such as *C. maculates* and *Tribolium castaneum* (Boeke *et al*., 2004; Owusu, 2001). Many species of plants have the potential to be used as insect control agents for the treatment of various stored grains, particularly against cowpea weevil (*Callosobruchus analis*) in gram (Sarwar *et al*., 2012). A study by Abdullahi & Muhammad (2004) used plant powders of *Guirea senegalensis*, *Piliostigma reticulatum* and dried fruit powder of *Piper guineense*, to assess their toxic potentials on survival and development of *C. maculates* compared with a conventional insecticide, Actellic-2-Dust. It was reported that *P. guineense* had the highest larvicidal effect and lower productivity. Also, a study by Fotso *et al*. (2018) investigated the efficacy of *Hemizygia welwitschii* leaf powders against *C. maculatus* and *Sitophilus zeamais* in stored cowpea and maize. The use of plant materials for grain preservation, particularly against cowpea beetle *C. maculates* is considered to be a

promising alternative to synthetic insecticides (Boeke *et al*., 2004). Previous studies reported that plant materials may produce volatile chemicals that repel or confuse the adult beetles, preventing infestation or causing emigration from treated stock (Boeke *et al*., 2004). Furthermore, some other plants produce secondary metabolites that directly affect development and reproduction of storage pests.

The results obtained in this study clearly showed that the *P. nigrum*, *Z. offiicinale*, *R. raetam* and *R. officinalis* can be used to protect chickpeas against *C. maculatus*. Adedire & Akinneye (2004) investigated the powder and ethanol extract of *Tithonia diversifolia* leaves for their efficacy at different concentrations on the mortality, oviposition and adult emergence of cowpea weevil *C. maculates*. It was found that the extract and the powder caused significant mortality of adults and reduced oviposition and weevil development. The high mortality rates recorded in this study are in agreement with the finding of Reuben *et al*., (2006) who reported that black pepper *P. nigrum* powder gave significantly better results than the control in suppressing *C. maculates* adults survival, higher numbers of undamaged seeds and fewer holes per seed.

It can be concluded from this study, that all tested plant powders were toxic against *C. maculatus* adults and can protect chickpeas from infestation. The black pepper *P. nigrum* caused the highest beetles mortality at all exposure times which differed significantly from mortalities caused by the other plant powders used in this experiment. Therefore, the use of black pepper *P. nigrum* fruit powder as an insecticide should be encouraged in stored chickpeas management because of its high toxicity potential against cowpea weevil (*C. maculatus*) in storage.

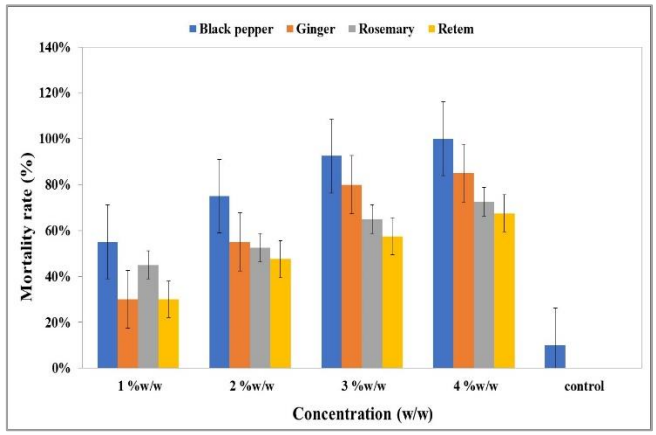

Figure 1. Mortality rate of *Callosobruchus maculatus* adults exposed to some plant powders over a period of 96 h.

Acknowledgements

The author thanks Dr. Khaled Aisawi, Department of crops, Faculty of Agriculture, Tripoli University for his help with statistical analysis. Also, thanks Dr. Khalifa Dabaj for his assistance in preparing the manuscript.

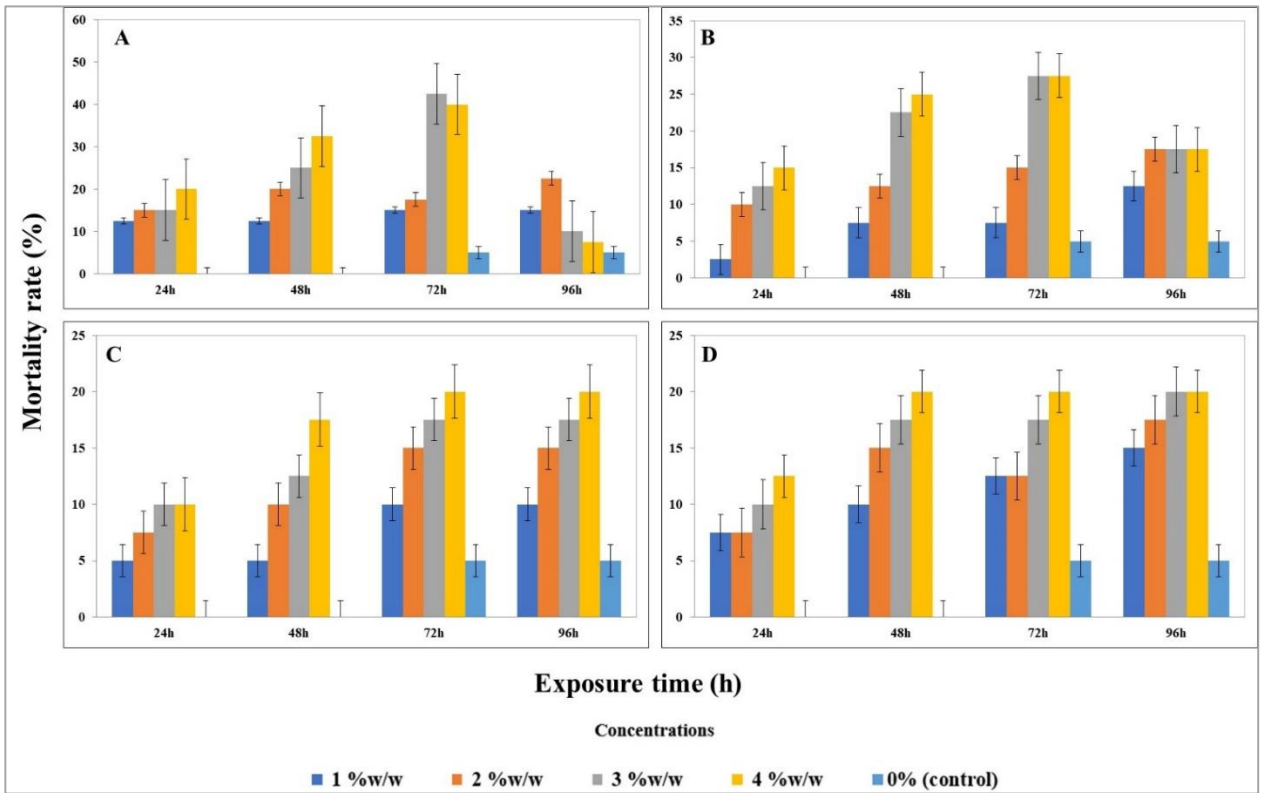

Figure 2. Mortality rate of *Callosobruchus maculatus* adults exposed to (A): the black pepper *(Piper nigrum*) powder, (B): the ginger *(Zingiber offiicinale)* powder, (C): the retem *(Retama raetam)* powder, (D): the rosemary *(Rosmarinus officinalis)* powder over a period of 96 h.

الملخص

أبو النور، نجاة علي. 2023. تأثير بعض المساحيق النباتية في معدل قتل حشرة خنفساء اللوبياء (*Callsobruchus maculates* Fab.) (Coleoptera: Bruchidae). مجلة وقاية النبات العربية، 41(3): 327–331. https://doi.org/10.22268/AJPP-41.3.327331

استهدفت هذه الدراسة اختبار الفعالية الحيوية لأربعة مساحيق نباتية وهي: الفلفل الأسود (*Piper nigrum*)، الزنجبيل (*Zingiber offiicinale*)، الرتم (*Retama raetam*) وإكليل الجبل (*Rosmarinus officinalis*) ضد حشرة خنفساء اللوبياء (*Callosobruchus maculates* F.) التي تصيب الحمص. رصدت نسبة الموت عند استخدام التراكيز 0.0، 1.0، 2.0، 3.0 و4.0% (وزن/وزن). أوضحت النتائج أن جميع المساحيق النباتية المختبرة قد سجلت تأثيراً معنوياً على معدل قتل الحشرات المستخدمة مقارنةً بمعاملة الشاهد، إذ بلغ معدل الموت 80.63% خلال 96 ساعة. كما لوحظ زيادة معدل الموت نسبياً مع زيادة وقت التعرّض. سبَّب مسحوق الفلفل الأسود (*P. nigrum*) أعلى معدل موت خلال جميع فترات التعرض وبفروقٍ معنوية عن بقية المساحيق النباتية المستخدمة في هذه التجربة.

كلمات مفتاحية: *Callosobruchus maculatus*، المساحيق النباتية، الحمص، معدّل قتل.

عناوين الباحثين: نجاة علي أبو النور، قسم وقاية النبات، كلية الزراعة، جامعة طرابلس، طرابلس، ليبيا. البريد الالكتروني للباحث المراسل: najat.abuelnnor@gmail.com؛ N.Abuelnnor@uot.edu.ly

References

Abbott, W.S. 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18:265–267. https://doi.org/10.1093/jee/18.2.265a

Abdullahi, Y. M. and S. Muhammad. 2004. Assessment of the toxic potentials of some plants powders on survival and development of *Callosobruchus maculatus*. African Journal of Biotechnology, 3(1):60–62.

Adedire, C.O. and O. Akinneye. 2004. Biological activity of three marigold, Tithonia diversifolia, on cowpea seed bruchid, *Callosobruchus maculatus* (Coleoptera: Bruchidae). Annals of Applied Biology, 144:185–189. https://doi.org/10.1111/j.1744-7348.2004.tb00332.x

Bakkali, F., S. Averbeck, D. Averbeck and M. Idaomar. 2008. Biological effects of essential oils–a review. Food Chemical Toxicology, 46(2):446–475. https://doi.org/10.1016/j.fct.2007.09.106

Boeke, S.J., I.R. Baumgart, J.J.A. van Loon, A. van Huis, M. Dicke and D.K. Kossou. 2004. Toxicity and repellence of African plants traditionally used for the protection ofstored cowpea against *Callosobruchus maculates*. Journal of Stored Products Research, 40(4):423–438. https://doi.org/10.1016/S0022-474X(03)00046-8

Dabiré, L.C.B., M.N. Ba and A. Sanon. 2008. Effects of crushed fresh *Cleome viscosa* L. (Capparaceae) plants on the cowpea storage pest, *Callosobruchus maculatus* Fab. (Coleoptera: Bruchidae). International Journal of Pest Management, 54:319–326.

Fields, P.G. 1992. The control of Stored-product insects and mites with extreme temperatures. Journal of Stored Products Research, 28(4):89–118. https://doi.org/10.1080/09670870802266953

Fields, P.G. and N.D.G. White. 2002. Alternatives to methyl bromide for stored-product and quarantine insects. Annual Review of Entomology, 47(1):331–359. https://doi.org/10.1146/annurev.ento.47.091201.145217

Fotso, T.G., E.N. Nukenine, R. Tchameni, J.W. Goudoungou, D. Kosini, V. Tigamba and C. Adler. 2018. Use of Cameroonian *Hemizygia welwitschii* Rolfe-Ashby (Lamiaceae) leaf powder against *Callosobruchus maculatus* and *Sitophilus zeamais*. Journal of Entomology and Zoology Studies, 6(4):1261–1269.

Gaur, P.M., S. Tripathi, CL L. Gowda, G.V. Ranga Rao, H.C. Sharma, S. Pande and M. Sarma. 2010. Chickpea seed production manual. international crops research institute for the Semi-Arid Tropics (ICRISAT), Andhra Pradesh, India. 28 pp.

Ileke, D.K. and O.F. Olotuah. 2012. Bioactivity of *Anacardium occidentale* (L) and Allium *sativum* (L) powders and oils extracts against cowpea bruchid, *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae). International Journal of Biology, 4(1):96–103. https://doi.org/10.5539/ijb.v4n1p96

Kang, J.K., B.R. Pittendrigh and D.W. Onstad. 2013. Insect resistance management for stored product pests: a case study of cowpea weevil (Coleoptera: Bruchidae). Journal of Economic Entomology, 106(6):2473–2490. https://doi.org/10.1603/EC13340

Loganathan, M., D.S. Jayas, P.G. Fields and N.D.G. White. 2011. Low and high temperatures for the control of cowpea beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in chickpeas. Journal of Stored Products Research, 47(3):244–248. https://doi.org/10.1016/j.jspr.2011.03.005

Massango, H., L. Faroni, K. Haddi, F. Heleno, L.V. Jumbo and E. Oliveira. 2017. Toxicity and metabolic mechanisms underlying the insecticidal activity of parsley essential oil on bean weevil, *Callosobruchus maculatus*. Journal of Pest Science, 90:723–733. https://doi.org/10.1007/s10340-016-0826-8

Oke, O. and E. Akintunde. 2013. Reduction of the nutritional values of cowpea infested with *Callosobruchus maculatus* (Coleoptera: Bruchidae). International Journal of AgriScience, 3(1):30–36.

Owusu, E.O. 2001. Effect of some Ghanaian plant components on control of two stored-product insect pests of cereals. Journal of Stored Products Research, 37:85–91. https://doi.org/10.1016/S0022-474X(00)00010-2

Padín, S., G. Dal Bello and M. Fabrizio. 2002. Grain loss caused by *Tribolium castaneum*, *Sitophilus oryzae* and *Acanthoscelides obtectus* in stored durum wheat and beans treated with *Beauveria bassiana*. Journal of Stored Products Research, 38(1):69–74. https://doi.org/10.1016/S0022-474X(00)00046-1

Raja, N., S. Albert and S. Ignacimuthu. 2000. Effect of solvent residues of *Vitex negundo* Linn and *Cassia fistula* Linn on pulse beetle *Callosobruchus maculatus* Fab. and its larval parasitoid *Dinarmus vagabundus* (Timberlake). Indian Journal of Experimental Biology, 38:290–292.

Rees, D. 2004. Insects of Stored Products. Manson Publishing Ltd, London. 138 pp.

Reuben, S.O.W.M., M. Masunga, R. Makundi, R.N. Misangu, B. Klonzo, M. Mwatawala, H.F. Lyimo, C.G. Ishengoma, D.G. Msuya and L.S. Mulungu. 2006. Control of cowpea weevil (*Callosobruchus maculates* L.) in stored cowpea (*Vigna unguiculatus* L.) grains using botanicals. Asian Journal of Plant Sciences, 5(1):91–97. https://doi.org/10.3923/ajps.2006.91.97

Sarwar, M., N. Ahmad, M. Bux and M. Tofique. 2012. Potential of plant materials for the management of cowpea bruchid *Callosobruchus analis* (Coleoptera: Bruchidae) in gram *Cicer arietinum* during storage. The Nucleus, 49:61–64.

Shaaya, E., M. Kostjukovski, J. Eilberg and C. Sukprakarn. 1997. Plant oils as fumigants and contact insecticides for the control of stored-product insects. Journal of Stored Products Research, 33(1):7–15. https://doi.org/10.1016/S0022-474X(96)00032-X

Sharma, S. and D.R. Thakur. 2014. Comparative developmental compatibility of *Callosobruchus maculatus* on cowpea, chickpea and soybean genotypes. Asian Journal of Biological Sciences, 7(6):270–276.

Shukla, R., B. Srivastava, R. Kumar and N.K. Dubey. 2007. Potential of some botanical powders in reducing infestation of chickpea by *Callosobruchus chinensis* L. (Coleoptera:Bruchidae). Journal of Agricultural Technology, 3:11–19.

Talukder, F.A. and P.E. Howse. 1995. Evaluation of *Aphanamixis polystachya* as a source of repellents, antifeedants, toxicants and protectants in storage against *Tribolium castaneum* (Herbst). Journal of Stored Products Research, 31(1):55–61. https://doi.org/10.1016/0022-474X(94)00036-S

Yuya, A.I., A. Tadesse, F. Azerefegne and T. Tefere. 2009. Efficacy of combining Niger seed oil with malathion 5% dust formulation on maize against the maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae). Journal of Stored Products Research, 45:67–70. https://doi.org/10.1016/j.jspr.2008.09.003

Zdárková, E. 1991. Stored product acarology. Pages 211-218 In*:* Modern Acarology. F. Dusbabek and V. Bukva. (eds.). Academic Press, Prague. 1504 pp.

Received: February 12, 2021; Accepted: November 27, 2022

تاريخ الاستلام: 2021/2/12؛ تاريخ الموافقة على النشر: 2022/11/27