J. Crop Prot. 2016, 5 (1): 1-10
doi: 10.18869/modares.jcp.5.1.1

Research Article

Insecticidal efficacy of *Cleistopholis patens* (Benth) against *Sitotroga cerealella* Olivier (Lepidoptera: Gelechiidae) infesting rice grains in Nigeria

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Abstract: New sources of botanical pesticides in the management of *Sitotroga cerealella* (Olivier) infesting rice grains are indispensable in farmers' quest towards achieving maximum protection of their rice produce. In this study, the efficacy of root and stem bark of *Cleistopholis patens* as an insecticidal agent against *S. cerealella* was investigated at 28 ± 2 ºC and 75 ± 6% relative humidity. Moths were exposed to contact and fumigant toxicity test at 0.5-2.5 g/20 g of paddy rice and mortality was assessed at 24, 48, 72 and 96 hours post-treatment respectively. Generally, moth exposed to root powders of *C. patens* showed higher mortality values (contact: 10 - 93%; fumigant: 13 - 100%) than their counterpart exposed to stem powder (contact: 6.67 - 78%; fumigant: 10 - 95%). Also, lethal doses (LD_{50} and LD_{95}) revealed that lower doses of *C. patens* root powder resulted in higher mortality of *S. cerealella* when compared to that of stem powder. The only exception was observed in LD_{95} values of stem (6.54 g / 20 g of paddy rice) and root (6.76 g / 20 g of paddy rice) powder of fumigant toxicity test. Both powders of *C. patens* also significantly reduced adult emergence in treated grains when compared to control. This study showed that powders of stem and root bark of *C. patens* would provide a much desired wherewithal to synthetic insecticides in the management of *S. cerealella* infesting rice grains in Nigeria.

Keywords: *Sitotroga cerealella,* insecticidal efficacy, *Cleistopholis patens*, toxicity, fumigant

Introduction

Rice, *Oryzae sativa* L. is the most economically important food crop of all cereals in most countries (Ashamo and Akinnawonu, 2012). It plays a major nutritional role in diet and strategic food security planning policies of most government in many developing nations (Norman and Kebe, 2006; FAO, 2013). For instance, it has helped Africa to conquer famine of 1203 (NRC, 1996). Nigeria, being the largest producer, consumer and importer of rice in West Africa with a local production of 4.2 million tonnes (FAO, 2013), is making concerted effort to meet her local rice demand. However, due to lack of good and efficient storage facilities which predisposes rice grains to insect pest attack especially during storage, the country still struggles to achieve self-sufficiency in rice production. Stored product pests such as *Sitophilus oryzae* (Linnaeus), *Sitophilus zeamais* (Motschulsky), *Rhyzopertha dominica* (Fabricius) and *Sitotroga cerealella* (Olivier) are usually sighted on rice in most

Handling Editor: Saeid Moharramipour

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Received: 27 June 2015, Accepted: 23 September 2015
Published online: 24 November 2015

stores. Of all these pests, *S. cereallela* remained one of the most destructive pests of rice (Togola *et al*., 2013). In fact, a starting population of female *S. cerealella* has been estimated to completely destroy 500g of hulled rice within three generations if left unchecked (Cogburn, 1975; Togola *et al*., 2010). Similarly, adults of this insect are active fliers capable of travelling to a distance of 600 metres and infest other grains (e.g. maize, sorghum, wheat, barley and millet) apart from rice through cross infestation (Trematerra, 2015). Thus, it not only infests a particular grain in storage, but other grains on the field which has further enhanced its ability to damage crops when compared to larval stage.

The use of synthetic insecticides has been adjudged to be the most effective method in the management of stored product pests especially under large scale production (Gbaye and Holloway, 2011). But, due to various adverse environmental, biological and health consequences associated with their usage; efforts are being shifted towards other methods of control which are effective and eco-friendly. One of such methods involves the use of insecticides derived from plant origin. Africa continent is believed to be richly endowed with several of these botanicals which possess insecticidal and medicinal properties (Akinkurolere *et al*., 2006; Gbaye and Oyeniyi, 2015; Oyeniyi *et al*., 2015a). Plant materials could therefore be touted as an important weapon in farmer's quest towards achieving good protection of their farm produce.

Although, several plants have been investigated for their efficacy in the control of *S. cereallela* (Zaidi *et al*., 2004; Iqbal, 2010; Ashamo and Akinnawonu, 2012); there is need to constantly search for more botanicals with better efficacy in the control of this infamous pest of rice. This is important in order to minimize post-harvest losses associated with rice storage in Nigeria. Consequently, the suitability of stem and root bark of *Cleistopholis patens* (Benth) as a botanical pesticide in the management of *S. cerealella* on rice grains was investigated in this study. In Nigeria and other parts of African countries, the root bark and leaves of this plant are used in the treatment of typhoid fever and urogenital infections (Adonu *et al*., 2013).

Materials and Methods

Insect culture

Adults *S. cerealella* used in this study were obtained from the existing cultures from Department of Biology, Research Laboratory, Federal University of Technology Akure, Ondo state, Nigeria. Clean FARO-52 paddy rice variety obtained from Agricultural Development Program, Akure, Nigeria was disinfested in the freezer at-18 ^{o}C for two weeks and thereafter allowed to equilibrate in the laboratory for three days. The moths were reared on the paddy rice variety inside 1.5 liters plastic containers. The containers were covered with perforated lid and muslin cloth to prevent the escape of insects and to allow air into them. The moths were reared for two generations on the paddy rice variety to eliminate the effect of parent food before being used for bioassay test. The plastic containers used for insect rearing were kept inside cages at 28 ± 2 ºC and 75 ± 6% relative humidity.

Collection and preparation of plant materials

Fresh stem and root bark of *C. patens* was obtained from a river bank at Modebiayo Camp, Ondo, Ondo state, Nigeria. The collected plant parts were first air dried in the laboratory for 30 days and then milled separately into fine powder using Lister 5 HSP grinding mill. Each plant part was sieved with a mesh size of 1mm^2 before being separately stored in plastic containers with airtight lids for subsequent use.

Contact toxicity

Twenty grams of paddy rice (FARO-52) seeds were weighed using Metler beam PB 3002 weighing balance and thoroughly mixed with 0.0 g (control), 0.5, 1.0, 1.5, 2.0 and 2.5 g of stem and root bark powders of *C. patens* in 170 ml plastic containers. The powders and paddy rice seeds were thoroughly mixed together

[DOR: 20.1001.1.22519041.2016.5.1.10.9]

using glass rod to ensure uniform coating of paddy rice with the powders. Five pairs of adult moths were introduced into each plastic container and covered. Each treatment was replicated four times and adult mortality was recorded after 24, 48, 72 and 96 hours of application. Both dead and live insects were removed on the fifth day and containers of the experiments were left for 28 days to allow for adult emergence and the number of emerged adults was counted. Inhibition rate (%IR) in adult emergence was calculated using the method described by Tapondju *et al.* (2002).

$$IR\,(\%) = \frac{C_n - T_n}{C_n} \times 100$$

Where C_n is the number of insects that emerged in the control treatment and T_n is the number of adult insects that emerged in the treated grains.

Fumigant toxicity

Fumigant effect of stem and root bark powders of *C. patens* were tested at different dosages (0.5, 1.0, 1.5, 2.0 and 2.5 g) against five pairs of moths. Twenty grams (20 g) of paddy rice was weighed into plastic containers and powders of *C. patens* at different dosages were weighed into muslin cloth and tied before being left hanging at the middle of the plastic containers through a string. Each container used for the experiment was tightly closed with a lid to maintain airtight condition. The strings hanging different dosages of plant powder parts passed through a tight fitting cork fixed to the lid of each container to prevent direct contact between the plant material, rice grains and moths. Adult moth mortality was assessed after 24, 48, 72 and 96 h post-treatment. The experiment was replicated four times together with the untreated control. Both dead and live insects were removed on the fifth day and the experiments were left for 28 days to allow for adult emergence and the number of emerged adults was counted. Inhibition rate (%IR) in adult emergence was also calculated using the method described by Tapondju *et al.* (2002) as stated above.

Statistical analysis

Abbott (1925) formula was used to correct data on mortality counts using control mortality. The data on adult mortality were checked for normality based on Shapiro-Wilk test before being subjected to one-way analysis of variance (ANOVA) ($P < 0.05$) and treatment means were separated using New Duncan Multiple Range Test. Contact and fumigant mortality data and dosages of stem and root bark of *C. patens* were also subjected to probit and log transformation respectively to determine the dosage lethal to 50% and 95% of *S. cerealella* (LD_{50} and LD_{95}) (Finney, 1971). All analyses were carried using SPSS 17.0 software package.

Results

Contact and fumigant toxic effects

Tables 1 and 2 show the contact and fumigant effect of plant powders of *C. patens* against mortality of *S. cerealella* exposed at four different durations. Generally, moth mortality increased with increasing dosage of plant materials and exposure time. However, the contact and fumigant effect of stem and root powder of *C. patens* on the percentage mortality of moth was significantly higher ($P < 0.05$) than that of control except those exposed to stem powder at 0.5 g after 24 h post-treatment (Table 1). Similarly, moth exposed to root powders of *C. patens* showed higher mortality values (contact: 10-93%; fumigant: 13-100%) than their counterpart exposed to stem powder (contact: 6.67-78%; fumigant: 10-95%). Also, irrespective of the mode of application of *C. patens*, the root powder of this plant elicited higher moth mortality when compared to stem powder (Tables 1 and 2). At the highest experimental dosage (2.5 g), mortality values of moths exposed to contact toxicity of root powder after 96 h post-treatment were significantly higher ($P < 0.05$) than those of their counterparts exposed at lower dosages (Table 1). Regardless of the dosage, exposure time, mode of application and plant part used, complete mortality (100%) was observed only in moth exposed to fumigant toxicity of *C. patens* roots at 2.5 g after 96 h post-treatment (Table 2).

[DOR: 20.1001.1.22519041.2016.5.1.10.9]

Table 1 Contact effect of plant powders of *Cleistopholis patens* over time after exposure on mortality of *Sitotroga cerealella.*

Plant materials	Dosages (g/20 g of paddy rice)	Adult mortality ± S. E (%)			
		24 h	48 h	72 h	96 h
Stem	0.5	6.67 ± 0.12^{ab}	14.40 ± 1.20^{b}	23.00 ± 0.00^{b}	43.33 ± 6.67^{b}
	1.0	13.33 ± 0.00^{bc}	33.13 ± 67.00^{c}	46.67 ± 1.33^{c}	50.00 ± 0.00^{bc}
	1.5	26.67 ± 1.02^{d}	41.00 ± 1.33^{cd}	58.67 ± 0.30^{cd}	63.33 ± 3.33^{cd}
	2.0	30.00 ± 0.15^{d}	46.30 ± 2.82^{cd}	65.12 ± 2.67^{d}	66.67 ± 6.67^{cd}
	2.5	40.00 ± 0.00^{e}	56.20 ± 1.23^{cd}	70.00 ± 0.00^{de}	78.00 ± 0.00^{d}
Root	0.5	10.00 ± 2.10^{bc}	18.10 ± 1.53^{b}	29.12 ± 1.28^{b}	57.13 ± 6.67^{bc}
	1.0	20.00 ± 1.82^{cd}	36.67 ± 2.66^{c}	58.57 ± 2.87^{cd}	63.00 ± 1.00^{cd}
	1.5	31.50 ± 0.00^{d}	43.33 ± 1.20^{cd}	63.12 ± 0.03^{cd}	70.00 ± 3.82^{cd}
	2.0	44.00 ± 1.33^{ef}	53.00 ± 3.88^{cd}	71.20 ± 1.53^{de}	81.23 ± 1.56^{d}
	2.5	52.00 ± 1.20^{f}	60.00 ± 2.02^{d}	78.00 ± 0.00^{e}	93.00 ± 1.00^{e}
Control	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}

Means followed by the same letters in each column are not significantly different ($P > 0.05$) using New Duncan Multiple Range Test.

Table 2 Fumigant effect of plant powders of *Cleistopholis patens* over time after exposure on mortality of *Sitotroga cerealella.*

Plant materials	Dosages (g/20g of paddy rice)	Adult mortality ± S.E (%)			
		24 h	48 h	72 h	96 h
Stem	0.5	10.00 ± 1.77^{b}	20.00 ± 1.77^{b}	29.00 ± 5.77^{b}	45.67 ± 1.67^{b}
	1.0	18.33 ± 1.33^{bc}	32.12 ± 0.77^{bc}	37.33 ± 8.82^{bc}	62.33 ± 8.82^{c}
	1.5	29.90 ± 2.77^{cd}	44.00 ± 2.82^{cd}	53.42 ± 3.33^{d}	82.10 ± 5.77^{d}
	2.0	33.12 ± 1.33^{d}	52.33 ± 2.33^{d}	73.14 ± 8.82^{e}	89.21 ± 0.00^{de}
	2.5	46.67 ± 2.67^{e}	59.00 ± 0.33^{de}	83.31 ± 3.33^{ef}	95.00 ± 0.00^{e}
Root	0.5	13.00 ± 2.77^{b}	26.60 ± 1.12^{b}	43.33 ± 2.08^{cd}	58.33 ± 1.67^{c}
	1.0	20.00 ± 0.00^{bc}	39.38 ± 1.82^{c}	61.20 ± 1.52^{de}	73.33 ± 1.74^{cd}
	1.5	33.33 ± 3.33^{d}	53.33 ± 1.20^{d}	68.67 ± 1.33^{e}	80.00 ± 5.77^{d}
	2.0	40.00 ± 0.13^{de}	63.33 ± 0.30^{de}	75.10 ± 0.22^{ef}	93.00 ± 2.10^{de}
	2.5	48.00 ± 0.00^{e}	74.12 ± 0.21^{e}	87.12 ± 0.10^{f}	100.00 ± 0.00^{e}
Control	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}

Means followed by the same letters in each column are not significantly different ($P > 0.05$) using New Duncan Multiple Range Test.

Effects of Lethal dose of *C. patens* powders against *S. cerealella*

The lethal dose of *C. patens* powders needed to achieve 50% and 90% mortality in *S. cerealella* after 72 hours post-treatment is presented in Table 3. Lower LD_{50} and LD_{95} values were obtained in *S. cerealella* exposed to root powder of *C. patens* when compared to those exposed to stem powder regardless of the experimental mode of application. The only exception was observed in LD_{95} values of moths exposed to fumigant effect of stem (6.536 g/20 g of paddy rice) and root (6.764 g/20 g of paddy rice) powder of this plant material. Powders of stem and root of *C. patens* used for contact and fumigant toxicity test were not significantly

[DOR: 20.1001.1.22519041.2016.5.1.10.9]

different (P < 0.05) from each other as inferred by their fiducial limits values (Table 3). In summary, lower amount of stem and root powder was needed to achieve LD_{50} and LD_{95} in moths exposed to fumigant test when compared to those exposed to contact test (Table 3).

Contact and fumigant effect of *C. patens* powders on adult emergence

Table 4 and 5 revealed the emergence of significantly higher (P < 0.05) numbers of *S. cerealella* (34.47%) from control paddy rice when compared to those that emerged from stem or root treated paddy rice. Also, moth emergence in both tables decreased with increasing dosage of stem and root powder. No insect however emerged at a dosage of 2.5 g of *C. patens* root administered by contact bioassay as well as 2.0 and 2.5 g of stem and root powder administered by fumigant bioassay. Percentage reduction in F_1 progeny of *S. cerealella* also increased with increasing dosages of stem and root powder of *C. patens* as shown in tables 4 and 5 which was significantly higher (P < 0.05) than control. Complete reduction (100%) in F1 progeny was however observed in rice exposed to contact effect of *C. patens* root at 2.5g as well as those exposed to fumigant effect of stem and root powder at 2.0 g and 2.5 g respectively.

Table 3 Lethal dose of *Cleistopholis patens* powders applied through contact and fumigant test on adult *Sitotroga cerealella* after 72 h post-treatment.

Bioassay methods	Plant materials	Slope ± SE	χ^2	LD_{50} (95% FL)	LD_{95} (95% FL)
Contact	Stem	1.80 ± 0.24	0.65	1.199 (1.025 - 1.388)	9.824 (6.328 - 20.647)
	Root	1.79 ± 0.24	2.00	0.921 (0.752 - 1.076)	7.640 (5.134 - 14.889)
Fumigant	Stem	2.15 ± 0.25	9.85	1.119 (0.594 - 1.678)	6.536 (3.217 - 9.855)
	Root	1.64 ± 0.24	2.55	0.668 (0.488 - 0.818)	6.764 (4.482 - 13.985)

Abbreviations: SE: Standard error; χ^2: Chi-square; LD: Lethal dose (g/20g of paddy rice); FL: Fiducial limits.

Table 4 Contact effect of plant powders of *Cleistopholis patens* on adult emergence and inhibition rate (IR) of *Sitotroga cerealella*.

Plant materials	Dosage (g/20 g of paddy rice)	No. of adult emergence[1]	Adult IR (%)[1]
Stem	0.5	8.35 ± 0.33^{d}	78.29 ± 0.11^{b}
	1.0	7.13 ± 0.84^{d}	81.47 ± 0.59^{bc}
	1.5	5.83 ± 1.23^{c}	84.85 ± 1.07^{c}
	2.0	$2.12 \pm 0.^{34ab}$	94.49 ± 0.41^{d}
	2.5	0.98 ± 0.09^{a}	97.45 ± 0.05^{e}
Root	0.5	6.23 ± 3.43^{d}	83.81 ± 1.89^{bc}
	1.0	5.17 ± 0.39^{c}	86.56 ± 0.05^{c}
	1.5	3.23 ± 1.27^{bc}	91.60 ± 1.22^{d}
	2.0	1.23 ± 0.03^{ab}	96.80 ± 0.01^{e}
	2.5	0.00 ± 0.00^{a}	100.00 ± 0.00^{e}
Control	0	38.47 ± 4.59^{e}	0.00 ± 0.00^{a}

[1] Means followed by the same letters in each column are not significantly different (*P* > 0.05) using New Duncan Multiple Range Test.

[DOR: 20.1001.1.22519041.2016.5.1.10.9]

Table 5 Fumigant effect of plant powders of *Cleistopholis patens* on adult emergence and inhibition rate (IR) of *Sitotroga cerealella*.

Plant materials	Dosage (g/20g of paddy rice)	No. of adult emergence[1]	Adult IR (%)[1]
Stem	0.5	5.27 ± 0.43^{c}	86.30 ± 0.21^{b}
	1.0	3.29 ± 0.33^{b}	91.45 ± 0.17^{c}
	1.5	0.15 ± 0.01^{a}	99.61 ± 0.00^{d}
	2.0	0.00 ± 0.00^{a}	100.00 ± 0.00^{d}
	2.5	0.00 ± 0.00^{a}	100.00 ± 0.00^{d}
Root	0.5	4.37 ± 0.57^{bc}	88.64 ± 0.11^{bc}
	1.0	2.16 ± 0.12^{b}	94.39 ± 0.06^{cd}
	1.5	0.19 ± 0.03^{a}	99.51 ± 0.00^{d}
	2.0	0.00 ± 0.00^{a}	100.00 ± 0.00^{d}
	2.5	0.00 ± 0.00^{a}	100.00 ± 0.00^{d}
Control	0	38.47 ± 4.59^{d}	0.00 ± 0.00^{a}

[1] Means followed by the same letters in each column are not significantly different ($P > 0.05$) using New Duncan Multiple Range Test.

Discussion

A lot of problems associated with the usage of fumigants and contact synthetic chemicals in the control of stored product pests have highlighted the need for other control measures that are believed to be safer and cheaper. Consequently, the use of botanicals has been advocated as an alternative wherewithal to most synthetic insecticides in the control of stored product pests (Ofuya and Lale, 2001). But, the efficacy of botanicals on target species varies as it depends on several factors such as part of plant from which they have been extracted, plant species, mode of application among others (Tuetun *et al*., 2004; Tehri and Singh, 2014).

Present study investigates the potential of stem and root powder of *C. patens* as a contact and fumigant insecticide for management of *S. cerealella* infesting rice grains. Considerable reduction observed in the numbers of *S. cerealella* exposed to both contact and fumigant toxicity test of *C. patens* powders, especially at the highest experimental dosage and exposure time, shows that this plant possesses insecticidal properties against *S. cerealella*. This is in agreement with the findings of Xiaosong and Weston (1995), Zaidi *et al*. (2004), Iqbal (2010), Ashamo and Akinnawonu (2012) and Gemechu *et al*. (2012) where insecticidal efficacy of different plant materials against *S. cerealella* has been reported. The high contact toxicity of both stem and root of this plant may be due to physical abrasion of the wings and cuticle of *S. cerealella* by this plant material. This could have resulted in loss of body fluid, dehydration and high mortality of *S. cerealella* observed in this study (Ogunwolu *et al*., 1998).

Higher mortality was also observed in moths exposed to fumigant test when compared to those exposed to contact test. This further suggests that *C. patens* may be better used as a fumigant against *S. cerealella*; although, it may also be used as a contact insecticide as there were no significant differences between the powders of stem and root of *C. patens* used in contact and fumigant toxicity tests according to their fiducial limits of lethal doses (LD_{50} and LD_{95}) (Table 3). The high fumigant toxicity of this plant may be ascribed to high flight activity of *S. cerealella* which may have enabled more botanical vapour to diffuse in through the spiracles. This might have led to the blockage of moth spiracles, suffocation and high mortality observed in insects exposed to fumigant test.

Similarly, higher mortality observed in moths exposed to root powder of *C. patens*

[DOR: 20.1001.1.22519041.2016.5.1.10.9]

when compared to stem powder regardless of the mode of application revealed that the root powder was more effective in controlling this insect than the stem. This is further confirmed by lower LD_{50} and LD_{95} values observed in moths exposed to root of *C. patens* when compared to those exposed to stem powder; in spite of the mode of application. The high mortality exhibited by the root bark of *C. patens* may be ascribed to the presence of some phytochemicals that have high insecticidal effects. For instance, higher level of five alkaloids and two sesquiterpenes has been reported in the root of *C. patens* when compared to the stem (Burkill, 1997; Adonu *et al*., 2013). The toxicity and antifeedant effect of alkaloids towards stored product insects has earlier been reported (Yang *et al*., 2006). Thus, high toxicity of the root bark may be linked to higher level of some of these phytochemicals in the root bark when compared to the stem. Further studies are however needed to establish the actual phytochemical responsible for the higher toxicity of the root bark powder in contrast to stem bark powder.

Powders of both stem and root of *C. patens* also significantly reduced emergence of *S. cerealella* when compared to control. This confirms the possible obvious effect of *C. patens* powders on the post embryonic survival of *S. cerelealla*, which, in turn, prevents and significantly reduces adult emergence from treated paddy rice when compared to control. Likewise, different chemical compositions, particularly alkaloids in this plant material (Adonu *et al*., 2013) could be accountable for complete inhibition in adult emergence observed at the highest experimental dosage (2.5g) of root powder for both toxicity tests as alkaloids generally disrupt larval growth, reduce their survival and disrupt insect life cycle (Yang *et al*., 2006; Ogungbite and Oyeniyi, 2014). This work is therefore in agreement with the findings of Akinneye and Ogungbite (2013) as well as Ogungbite *et al*. (2014) where powders of different plant materials successfully prevent emergence of adult insects. However, the emergence of few adult moths in some of the treated grains suggested that some of the adult moths were still able to oviposit before they give in to entomo-noxious effect of *C. patens* on the fourth day (Oyeniyi *et al*., 2015b).

Various result obtained from this study showed that *C. patens* could serve as a prospective insecticide in the management of *S. cerealella* infesting rice grains in Nigeria. This plant has been proved to be non-toxic to humans as evidenced by its therapeutic activity against several ailments in humans such as typhoid fever, malaria fever and urogenital infections, particularly in South-Western part of Nigeria (Pers. Comm., O. A. Akinneye). Thus, mixing powders of root or stem of this plant with rice grains should be encouraged as it is insecticidal and medicinal. This plant would play a major role in ensuring good protection of rice grains in Nigeria, thus contributing to food security of the nation.

Acknowledgements

The authors of this work are grateful to Agricultural Development Program, Akure, Nigeria for supplying us with clean paddy rice variety, FARO52 used for insect culture. Our appreciation also goes to Mrs E.T. Ojo, the principal technologist in Department of Biology, Federal University of Technology, Akure, Ondo State, Nigeria for supplying us with adults of *S. cerealella* as well as other materials used in this study.

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تأثیر حشره‌کشی گیاه *Cleistopholis patens* (Benth) روی بید غلات *Sitotroga cerealella* Olivier (Lepidoptera: Gelechiidae) در دانه‌های برنج آلوده نیجریه

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دریافت: ۶ تیر ۱۳۹۴؛ پذیرش: ۱ مهر ۱۳۹۴

چکیده: استفاده از آفت‌کش‌های گیاهی جدید برای مدیریت آفت بید غلات *Sitotroga cerealella* (Olivier) در بذرهای برنج آلوده به‌منظور دستیابی کشاورزان به حداکثر محافظت از تولید برنج ضروری است. در این مطالعه، تأثیر پوست ریشه و ساقه گیاه *Cleistopholis patens* به‌عنوان عامل حشره‌کش روی بید غلات در دمای ۲ ± ۲۸ درجه سلسیوس و رطوبت نسبی ۶ ± ۷۵ درصد مورد بررسی قرار گرفت. اثر سمیت تنفسی و تماسی در غلظت ۰/۵ تا ۲/۵ گرم پودر گیاه در هر ۲۰ گرم بذر برنج بررسی شد و تعداد حشرات کامل مرده ۲۴، ۴۸ و ۷۲ ساعت بعد از تیمار ارزیابی شدند. به‌طور کلی اثر پوست پودر ریشه گیاه (سمیت تماسی: ۱۰-۹۳ درصد، سمیت تنفسی: ۱۳-۱۰۰ درصد) بیش از پودر ساقه گیاه (سمیت تماسی: ۶/۶۷-۷۸ درصد، سمیت تنفسی: ۱۰-۹۵ درصد) بود. هم‌چنین دزهای کشنده (LD_{50} و LD_{95}) پودر ریشه گیاه نسبت به پودر ساقه موجب تلفات بیش‌تری در حشرات کامل بید غلات شد. به‌جز مقادیر LD_{95} که در سمیت تنفسی پودر ساقه (۶/۵۳ گرم در ۲۰ گرم بذر برنج) و پودر ریشه (۶/۷۶ گرم در ۲۰ گرم بذر برنج) مشاهده شد. پودر ریشه و ساقه گیاه *C. patens* به‌طور معنی‌داری ظهور حشرات کامل را نسبت به شاهد کاهش دادند. این مطالعه نشان داد که پودر ساقه و پوست ریشه *C. patens* امکان استفاده از این گیاه به‌جای حشره‌کش‌های مصنوعی در مدیریت بید غلات در بذور آلوده برنج در نیجریه را فراهم می‌نماید.

واژگان کلیدی: بید غلات، اثر حشره‌کشی، *Cleistopholis patens*، سمیت، تدخین