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Effectiveness of medicinal plant powders on *Sitophilus granarius* and *Tribolium confusum*

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Abstract: Medicinal plant powders have traditionally been used as grain protectants against stored-product insect pests. In this study, insecticidal activity of *Carum copticum* L. and *Cuminum cyminum* L. powders was assessed on adults of *Sitophilus granarius* L. and *Tribolium confusum* Jacquelin du Val. Experiments were carried out on wheat at 27 ± 1 ºC and 55 ± 5% r. h. The mortality increased with increasing concentration level and time exposed to each concentration. For *S. granarius*, 7 days and in case of *T. confusum* 14 days exposure time was sufficient to obtain considerable mortality. For example, 3500 mg/kg of *C. copticum* 7 days after treatment caused 80% mortality in *S. granarius*; while for *T. confusum* 29% mortality was achieved and increased to 100% after 14 days. Therefore, it can be concluded that adults of *S. granarius* were more susceptible than *T. confusum* to plant powders. Also, according to the findings, *C. cyminum* powder had more insecticidal efficacy than *C. copticum* on both insects' species. For *S. granarius*, 950 and 2700 mg/kg powders of *C. cyminum* and *C. copticum* was enough to cause ca. 50% mortality after 5 days, respectively. In case for *T. confusum*, 3200 and 4400 mg/kg of the plant powders caused the same mortality after 7 days. Findings of the present study show that the plant powders could be applied for grain protection in small-scale storage facilities.

Keywords: *Carum copticum*, *Cuminum cyminum*, Pest management, Plants powder, Stored products insects

Introduction

Sitophilus granarius L., granary weevil, is a primary pest with worldwide distribution and infests whole cereal grains after harvest. The adults cannot fly and life cycle averages about 40 days; 300 to 400 eggs per female. The adults are very similar in appearance and behavior to *Tribolium castaneum* (Herbst), red flour beetle, except that the antennal segments enlarge gradually toward the tip of the antenna *Tribolium confusum* Jacquelin du Val., confused flour beetle, is a secondary pest with worldwide distribution and infests grain dusts, fines, broken kernels, other dockages and flour. Thus, pest control and protection of stored products from pest's infestations seems inevitable (Hill, 2002; Rees, 2007).

Botanicals are to some extent toxic and able to control storage insect pests. They are natural products derived from plants which protect crops. They degrade rapidly, and have less hazardous effects to non-target species and beneficial organisms and environment contamination (Guleria and Tiku, 2009). Among botanicals plant powders were traditionally used as grain protectants (Isman, 2000; Rajashekar *et al*., 2012). The contact toxicity of most plant powders to insect pests, and repellency effects as they repel and prevent their infestations has been demonstrated (Boeke *et al*., 2004). Devi and Devi,

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(2012) investigated insecticidal and oviposition deterrent effects of some spices such as *Carum copticum* L., Ajowan, (Apiaceae) and *Cuminum cyminum* L., Cumin, (Apiaceae) against *Sitophilus oryzae* (L.). Kestenholz *et al*., (2007) evaluated efficacy of *Cassia sophera* L. extracts and powdered leaves against adults and progeny of *Callosobruchus maculatus* (F.), and *S. oryzae*.

Curum copticum, Ajowan is an annual medicinal plant with white flowers and small brownish fruits. It grows in Iran, Pakistan, Egypt and India (Sahaf and Moharramipour, 2008). *C. cyminum*, Cumin, is an important, medicinal plant with white or pink flowers, small green seeds, lateral fusiform or ovoid achene fruit and slender branched stem. It is an aromatic, annual plant that grows in Iran, Egypt, Saudi-Arabia, and some other parts of the world (Boskabady *et al*., 2006). Studies have not been reported previously concerning the insecticidal efficacy of *C. copticum* and *C. cyminum* powders on *S. granarius* and *T. confusum*. Therefore, the aim of the current study was to determine insecticidal activity of *C. copticum* and *C. cyminum* seed powders against these two important stored-products insect pests.

Materials and Methods

Plant powders

C. copticum and *C. cuminum* seeds were obtained from the research farm in Ferdowsi University of Mashhad, Mashhad in June 2010. The seeds were stored at – 24 ºC until used for experiments. At the time of conducting bioassays, seeds were milled and sifted using laboratory sieve with opening of 595 µm (30 mesh) to obtain uniform particles and remove larger particles.

Insects and commodity

S. granarius and *T. confusum* were obtained from laboratory cultures in the Entomology laboratory, Tarbiat Modares University for at least 3 years with no history of exposure to insecticides. *S. granarius* were reared on whole clean wheat and adults of *T. confusum* on wheat flour plus 5% brewers' yeast (by weight) at 27 ± 1 ºC and 65 ± 5% relative humidity (r. h.). Adults used in the experiments were 7-14 days old of mixed sex.

Wheat variety Pishtaz Madary was obtained from Agricultural Support Services Company. Wheat grains were maintained at -24 ºC until the beginning of experiments. Wheat gains were poured to glass petri dishes and held in incubator set at 27 ± 1 ºC and 55 ± 5% r. h. for a week to equilibrate moisture content. Grain moisture content was measured by milling then drying 10 g of wheat in a ventilated oven set at 110 ºC and ranged about 12%. For *T. confusum* whole plus cracked wheat kernels with the ratio of 9:1 was used for experiments. Cracked wheat was included both to represent real practice and to make sure food was accessible for adults.

Bioassays

Laboratory bioassays were conducted to assess toxicity of plant powders against *S. granarius* and *T. confusum* with the method of Tapondjou *et al.*, (2002). Wheat (50 g) was poured in 280 ml glass vials and treated with different concentrations of plant powders. Concentrations were determined on the basis of equal interval (Robertson *et al*., 1984) and untreated wheat was served as control. Concentrations of *C. copticum* and *C. cyminum* powders on *S. granarius* ranged between 300 and 1500 mg/kg and in case of *T. confusum* concentrations were between 400 to 4400 mg/kg. Glass vials were shaken manually for 5 min to distribute the powder in the grain mass. Subsequently, 25 adults of each species were introduced into each vial. The vials caps were screwed tightly and kept in incubator set at 27 ± 1 ºC and 55 ± 5% r.h. in continuous darkness. Experiments were replicated four times and mortality was counted after 2, 5, and 7 days for *S. granarius* and continued to 11 and 14 days in case of *T. confusum*. When no leg or antennal movements were observed, insects were considered dead (Ziaee and Moharramipour, 2012).

Data analysis

The mortality was corrected using Abbott's formula (Abbott, 1925). Mortality percentages

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were transformed to square root of arcsine to normalize the data, but non-transformed data are presented in the figures. The data were analyzed using one-way analysis of variances and Tukey's test was used to determine significant differences between concentrations and time exposed to each concentration at $P < 0.05$ (SPSS, 2007).

Results

The effect of concentrations and time exposed to concentration was significant for *S. granarius* exposed to *C. copticum* ($F_{14, 59} = 205.05$; $P < 0.001$) and *C. cyminum* powder ($F_{14, 59} = 198.63$; $P < 0.001$). The mortality of *S. granarius* adults was low at low concentration of 300 mg/kg and didn't exceed 25% even at the highest exposure time of 7 days to *C. cyminum*. The concentration required to cause 50% mortality after 7 days of exposure to *C. copticum* and *C. cyminum* powder were 1128 and 673 mg/kg, respectively. In both *C. copticum* and *C. cyminum* powder, mortality of weevils increased with increasing concentration level and time exposed to each concentration (Fig. 1).

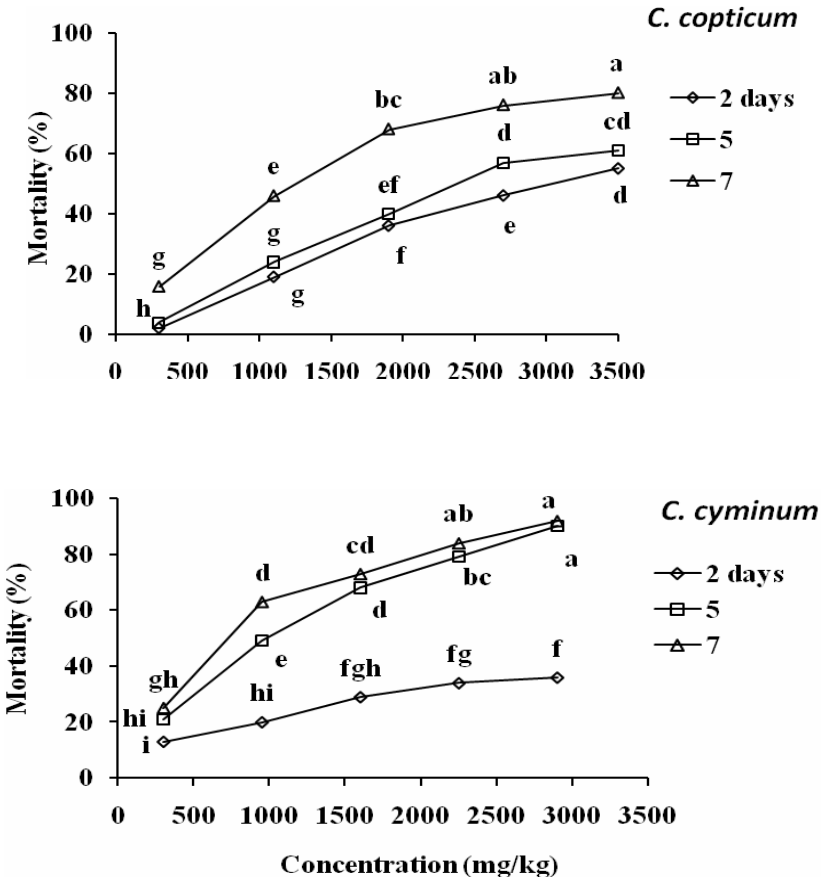

Figure 1 Percent mortality of *Sitophilus granarius* exposed to various concentrations of *Carum copticum* and *Cuminum cyminum* powder. Means followed by the same letter are not significantly different (Tukey's test at $P < 0.05$).

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In the case of *T. confusum* the effect of concentrations and exposure times to *C. copticum* plant powder ($F_{24, 99}$= 627.77; P < 0.001) and *C. cyminum* powder ($F_{24, 99}$= 685.84; P < 0.001) was also significant. *T. confusum* seems to be more tolerant of plant powders and because of the low mortality level of *T. confusum* in the early days of treatment even at the highest concentration; mortality counts were continued for days 11 and 14 post-treatment. The concentration of 2600 mg/kg caused 20% mortality 7 days after exposure to *C. copticum* powder and after 14 days reached 100%. However, at the time interval of 7 and 14 days, *C. cyminum* powder caused 44 and 97% mortality. (Fig. 2).

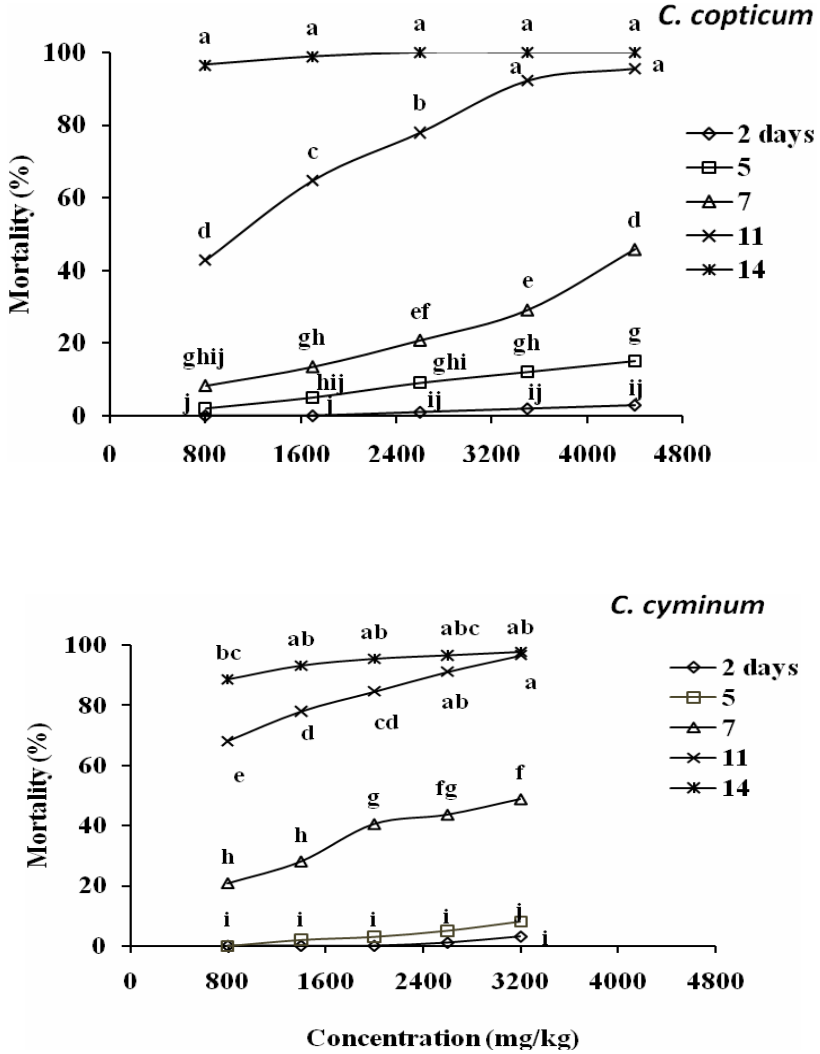

Figure 2 Percent mortality of *Tribolium confusum* exposed to various concentrations of *Carum copticum* and *Cuminum cyminum* powder. Means followed by the same letter are not significantly different (Tukey's test at P < 0.05).

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Discussion

Insecticidal activity of *C. copticum* essential oil has been demonstrated by many researchers against different insect species such as *C. maculatus*, *Callosobruchus chinensis* L., *S. oryzae*, *Rhyzopertha dominica* F., *T. confusum*, *T. castaneum*, *Oryzaphilus surinamensis* L. and *Plodia interpunctella* Hubner (Habashi *et al*., 2011; Sahaf and Moharramipour, 2008; Sahaf *et al*., 2007; Shojaaddini *et al*., 2008; Upadhyay *et al*., 2007). Also, the toxicity of *C. cyminum* essential oil has been evaluated on *C. maculatus, C. chinensis*, *Acanthoscelides obtectus* Say, *T. castaneum*, *S. oryzae* and *S. granarius* (Arabi *et al*., 2007; Chaubey, 2007, 2008, 2011; Karakoc, *et al*., 2006). However, there are no data on insecticidal toxicity of the powders of these plants. Antifungal and anti bacterial properties of *C. copticum* and *C. cyminum* have however been proved (Behtoei *et al*., 2012).

Devi and Devi, (2012) found that ajowan powder was moderately and cumin less effective against adults of *S. oryzae*. Nevertheless, they could partly suppress progeny production. Based on the results of this study, both plant powders were effective against tested species; however, their effectiveness varied according to the concentration level and exposure time. Comparing the results of this study with other researches indicate that plant essential oils are more effective than the powders and cause faster and higher mortality (Arabi *et al*., 2007; Sahaf *et al*., 2007). Tapondjou *et al*., (2002) stated that essential oil of *Chenopodium ambrosioides* (L.) leaves was more toxic than the powder against six different insect species. Also, according to the Kestenholz *et al*., (2007), extracts of *C. sophera* was more effective than the powdered leaves at reducing infestations of *C. maculatus* and *S. oryzae*. This could be attributed to some chemical constituents of the plant powder that are not released with milling but they are easily released with extraction, even the extraction procedure used will have a great effect on the chemical nature of the oils. Although plant essential oils have more insecticidal toxicity than their powders, the high costs of extraction, their volatility and strong odor limit their application. While, powdered herbs are cost effective, long lasting and locally available. So that powdered herbs are still traditionally used in some Latin American, South-east Asian and African countries for the protection of stored products (Boeke *et al*., 2004; Tapondjou *et al*., 2002). Therefore, *C. copticum* and *C. cyminum* powders can be applied to control pests infestations in small scales or as a part of an integrated pest management (IPM) strategy combined with other reduced risk control techniques. However, additional experimental work is required to confirm the results.

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کارایی پودر گیاهان دارویی روی شپشه گندم *Sitophilus granarius* و شپشه آرد *Tribolium confusum*

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چکیده: پودر گیاهان دارویی به‌طور سنتی برای حفاظت دانه از تهاجم آفات محصولات انباری استفاده می‌شود. بدین‌منظور، اثرات حشره‌کشی پودر زنیان *Carum copticum* L. و زیره سبز *Cuminum cyminum* L. روی حشرات کامل شپشه گندم *Sitophilus granarius* (L.) و شپشه آرد *Tribolium confusum* Jacquelin du Val بررسی شد. آزمایش‌ها روی گندم در دمای ۱ ± ۲۷ درجه سلسیوس و رطوبت نسبی ۵ ± ۵۵ درصد انجام شد. میزان مرگ و میر با افزایش غلظت و زمان تیمار افزایش یافت. برای شپشه گندم ۷ روز و شپشه آرد ۱۴ روز قرارگیری در مجاورت پودر گیاهان مرگ و میر قابل-توجهی ایجاد نمود. به عنوان مثال، پودر زنیان در غلظت ۳۵۰۰ میلی‌گرم بر کیلوگرم پس از ۷ روز موجب ۸۰ درصد تلفات روی حشرات کامل شپشه گندم شد. این درحالی است که در غلظت و مدت مشابه ۲۹ درصد از حشرات کامل شپشه آرد تلف شدند، اما این تلفات پس از ۱۴ روز به ۱۰۰ درصد رسید. لذا، می‌توان نتیجه گرفت که حشرات کامل شپشه گندم بسیار حساس‌تر از شپشه آرد هستند. همچنین با توجه به نتایج به‌دست آمده، پودر زیره سبز اثر حشره‌کشی بیشتری نسبت به زنیان روی هر دو گونه حشره داشت. به‌طوری که غلظت ۹۵۰ و ۲۷۰۰ میلی‌گرم بر کیلوگرم پودر زیره سبز و زنیان روی حشرات کامل شپشه گندم ، ۵ روز پس از تیمار باعث حدود ۵۰ درصد تلفات شدند. در مورد شپشه آرد این میزان تلفات به‌ترتیب با ۳۲۰۰ و ۴۴۰۰ میلی‌گرم از پودر گیاهان زیره و زنیان حاصل شد. به‌طور کلی براساس یافته‌های این پژوهش پودر گیاهان می‌توانند جهت حفاظت از دانه در انبارهای با مقیاس کوچک مورد استفاده قرار گیرند.

واژگان کلیدی: زنیان، زیره سبز، مدیریت آفات، پودر گیاهان، گندم

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