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Bioefficacy of certain plant leaf powders against pulse beetle, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae)

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ABSTRACT : Laboratory experiments were conducted to evaluate the efficiency of leaf powders of *Tridax procumbens, Withania somnifera, Pongamia pinnata* and *Gliricidia maculata,* against the pulse beetle, *Callosobruchus chinensis,* which infests stored green gram seeds. Dried leaf powders of *T. procumbens* and *W. somnifera* (5 mg/g seed) was found to be more effective, causing 100% mortality, than leaf powders of *P. pinnata* and *G. maculata* (20 mg/g seed), revealed 73.1 and 69.2% mortality respectively. However, all plant leaf powders showed 100% ovicidal activity. No F1 adult emerged at 20 mg/g seed treated with all plant powders. It was concluded that leaf powders of *T. procumbens* and *W. somnifera* showed significant mortality, oviposition deterrence and F1 adult deterrence of *C. chinensis* at vary low concen- trations. Hence, these leaf powders may be suggested as admixtures in the integrated manage- ment of beetle infestation of pulse seeds during storage.

Keywords : Botanicals, *Callosobruchus chinensis,* F1 adult deterrence, green gram, mortality, oviposition deterrence

INTRODUCTION

The pulse beetle, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) is the most widespread and destructive major insect pest of stored legumes (Park *et al.,* 2003). This insect has been reported in the Philippines, Japan, Indonesia and the Indian sub-continent and is considered a notori- ous pest of green gram, chickpea, black gram, peas, cowpea, lentil and pigeon pea (Aslam *et al.,* 2002). Control of this insect population throughout the world has relied principally on the application of synthetic insecticides, viz. organophosphates and fumigants such as methyl bromide and phosphine, which are still the most effective means of protection of stored food and other agricultural commodities from insect infestation (EPA, 2001). Although effective, such synthetic pesticides cause consequently residual pollution of the environment and toxicity to consumers. Their repeated use for decades has disrupted biological control by natural enemies and has led to the resurgence of stored product insect pests. Many of these stored product insects have developed resistance to the commonly used chemicals (Subramanyam and Hagstrum, 1995; Srivastava and Singh, 2002). These problems have highlighted the need to develop insect control alternative means.

Many medicinal plants and spices have been used as pest control agents (Lale, 1992; Isman, 1995; Yankanchi and Gonugade, 2009). Farmers and researchers often claim the successful use of plant materials in insect pest con- trol, including ash (Ofuya, 1986; Ajayi *et al.,* 1987), vegetable oils (Schoovoven, 1978; Kazi *et al.,* 1999), plant extracts (Chiasson *et al.,* 2004; Devanand and Usha Rani, 2008; Yankanchi, 2009), and botanical powders (Abdullahi and Muhammad, 2004; Patil *et al.,* 2006; Shukla *et al.,* 2007; Gupta and Srivastav, 2008). It has been reported that certain plant preparations and tradi- tional methods are much safer than chemical insecticides (Verma and Dubey, 1999; Weaver and Sub- ramanyam, 2000; Yankanchi and Patil, 2009). Therefore, plant materials should be explored to protect stored products against pest infestation.

The present study aimed to protect stored green gram seeds from *C. chinensis* infestation under laboratory conditions using leaf powders of *Tridax procumbens, Withania somnifera, Pongamia pinnata* and *Gliricidia maculata*, as well as their impact on oviposition and F_1 adult deterrence of pulse beetle.

MATERIAL AND METHODS

Insect culture. The pulse beetle, *Callosobruchus chinensis* L. adults were ob- tained from naturally infested green gram seeds from a local market in Kolhapur, Maharashtra. The beetles were reared on clean and un-infested green gram (*Vigna radiata* L). One hundred adult insects were released in 500 g green gram seeds in a Kilner jar capped with muslin cloth to ensure ventilation. The jar was kept under controlled temperature (28 ± 2°C) and relative humidity (70 ± 5%). After 48 h, the adults were removed and the jar was left for 25 days to obtain adult beetles for the experiment.

Preparation of plant powders. The leaves of *Tridax procumbens* L. (Asteraceae), *Withania somnifera* L. (Solanaceae), *Pongamia pinnata* L. (Fabaceae) and *Gliricidia maculata* L. (Fabaceae) were col- lected (August, 2008) in and around the foothills of the Amba ghats (Western Ghats), Kolhapur District, Maharashtra. Plants were identified using standard volume of Flora of Kolhapur district (Yadav and Sardesai, 2002) and confirmed with the help of experts. Leaves were cleaned, dried in the shade and pulverized into fine powder using an electric grinder (Maharaja White-line, India).

Effect of powder on mortality, oviposition and F_1 emergence. Fine powders of leaves were evaluated at doses of 0 (control), 5, 10 and 20 mg/g green gram seeds (0-2% w/w) in separate transparent plastic containers (200 ml). The required amount of powder was mixed thor- oughly with 20 g green gram seeds. Ten pairs of 0-48 h old adults were released into each con- tainer and the containers were capped. The number of dead beetles was recorded after 48 h of treatment. Mortality was considered when the beetle did not respond to gentle pressure using a finger tip. To avoid the possibility of death mimicry, the beetles were watched for 30 min and again sub- jected to gentle pressure. Percentage insect mortality was calculated using the corrected formula of Abbott (1925). The total number of eggs laid on the seed surface was recorded after 4 days of treat- ment. Percent deterrence of oviposition was calcu- lated following Elhag, (2000).

To determine the F_1 progeny detergence efficacy of plant pow- ders, 20 g green gram seeds (each seed with two eggs) were placed in separate plastic boxes (200 ml) and treated with the above doses of leaf powders. After 25 days, the number of emerged F_1 adults was recorded and percent deterrence was calculated by Aldryhim (1995) formula (number of progeny in control – number of progeny in treatment / number of progeny in control X 100). All experiments were performed in triplicate and data are the mean ± SD. Data were subjected to one-way ANOVA. Means were separated by Duncan's multiple range test (DMRT) when ANOVA was significant ($p < 0.05$) (SPSS 10, version).

RESULTS AND DISCUSSION

The results are presented in Table-1 indicate that leaf pow- ders of*T. procumbens, W. somnifera, P. pinnata* and *G. maculate* were significantly effec- tive with respect to mortality, reduction in oviposi- tion and F1 progeny production of *C. chinensis*. Leaf powders of *T. procumbens* and *W. somnifera* were found to be more effective than leaf powder of *P. pinnata* and *G. maculate* because, 20 mg/g dose caused 100% mortality of the bruchids. A significantly higher number of eggs were laid on untreated control seeds than on powder treated seeds ($p<0.05$). Oviposition deterrence was recorded as 96.8% and 92.6% in seeds treated with 20 mg/g *W. somnifera* and *T. procumbens* powder respectively. Ovicidal activity was recorded as 100% at 5 mg/g *W. somnifera* and *T. procumbens* and 20mg/g *P. pinnata* and *G. maculata* leaf powder, which caused none of the F1 adults to emerge.

Table 1 : Effect of different plant powders on mortality, oviposition and F_1 adult deterrence of *C. chinensis.*

Plant powders (mg/g seed)	% Mortality	% Oviposition deterrence	% F_1 adult deterrence
T. procumbens			
5	67.8 ± 2.4b	55.1 ± 2.8c	100 ± 0.0a
10	78.4 ± 2.7b	81.2 ± 4.2a	100 ± 0.0a
20	100 ± 0.0a	92.6 ± 4.8a	100 ± 0.0a
W. somnifera			
5	73.1 ± 3.1b	73.3 ± 3.7b	100 ± 0.0a
10	87.5 ± 2.8a	86.4 ± 4.2a	100 ± 0.0a
20	100 ± 0.0a	96.8 ± 4.1a	100 ± 0.0a
P. pinnata			
5	24.9 ± 2.3c	44.1 ± 2.7c	48.7 ± 2.1c
10	42.2 ± 2.7c	57.3 ± 3.6c	74.7 ± 4.2b
20	73.1 ± 3.9b	68.0 ± 3.8b	100 ± 0.0a
G. maculata			
5	28.8 ± 1.6c	23.0 ± 2.6d	56.7 ± 3.4c
10	32.7 ± 2.1c	36. 3 ± 2.9d	68.0 ± 3.9b
20	69.2 ± 3.6b	67.8 ± 3.7b	100 ± 0.0a
Control (0)	02.6 ± 0.3d	8.6 ± 2.6d	11.2 ±1.7d

Values are mean ± stranded deviation of three replicates. Means followed by same letters within each column do not differ significantly by DMRT test ($p < 0.05$)

The results unambiguously demonstrated the efficacy of leaves of *T. procumbens, W. somnifera, P. pinnata* and *G. maculate* in reducing the longevity and deterring the oviposition of *C. chinensis*. Ovicidal activity of plant powders were observed to decrease progeny production of *C. chinensis* on stored green gram seeds. The dose at which *T. procumbens* and *W. somnifera* powder proved fatal, causing 100% mortality and completely inhibiting F1 emergence by ovicidal activity was determined as 20 mg/g (2% w/w). This dose was relatively lower against bruchid infestation than powdered materials of *Erigeron floribundus* at 4% (Koona and Koona, 2006), the leaf powder of *Tithonia diversifolia* at 5% (Adedire and Akinneye, 2004) and powders of clove, red and black pepper at 2.5% w/w (Aslam *et al,* 2002). The aromatic nature of the plant leaf powders suggests that in contains volatile constituents which are highly effective against insects.

Insecticidal activity of *T. procumbens* and *W. somnifera* is well docu- mented against a range of insect pests (Kazi*et al.,* 1999; Kim *et al.,* 2003; Shaktivadivel and Daniel, 2008; Gupta and Srivastava, 2009). However, previous researchers have paid at- tention only to plant extracts and its essential oils, and papers on the use of *T. procumbens, W. somnifera, P. pinnata* and *G. maculate* leaf powders are lacking. Essential oils can not be applied to control infestation of food commodities stored in jute bags due to gradual loss of volatility (Risha *et al.,* 1999). The present study recommends the exploitation of *T. procumbens* and *W. somnifera* leaf powdered form as a more feasible control method for bruchids than essential oil. Products derived from plants are used as pharmaceuticals worldwide and could therefore be considered less harmful to humans than most conventional insecticides (Shukla *et al.,* 2007).

The findings of the present investigation based on laboratory experiments, can therefore recommended the potential exploitation of leaves of *T. procumbens* and *W. somnifera* as admixtures in pest management strategies, especially by small scale farmers who store small amounts of pulses for consumption and planting. The plant of *T. procumbens* and *W. somnifera* may worth further investigation to determine the exact mode of action of active ingredients and their effect on non-target organisms.

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