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INSECTICIDAL AND GROWTH INHIBITORY IMPACT OF DIFFERENT PLANT EXTRACTS ON *Tribolium castaneum* (HERBST)

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Red flour beetle, *Tribolium castaneum* (Herbst) is the major pest of wheat flour with economic importance throughout the world. Due to side effects of pesticides, it is needed to evaluate the alternative strategies to control the stored grain insect pests. For this purpose, toxic and growth inhibition effects of five different plant extracts: *Melia azedarach, Pegnum hermala, Salsola baryosma, Azadirachta indica* and *Zingiber officinale*, were evaluated on different life stages of *T. castaneum*. Series of experiments were conducted under laboratory conditions at 30$\pm$2°C and 65$\pm$5 % R.H at Grain Research Training and Storage Management Cell of Department of Entomology, University of Agriculture, Faisalabad using incubators (Sanyo M.I.R 254) in order to maintain the temperature and humidity. Three different concentrations (5, 10 and 15%) for each of the plant extract were prepared by dissolving in acetone as control treatment. At highest concentration, used during experiments, highest mortality (10.14%) of *T. castaneum* was recorded with *A. indica* and minimum mortality (6.08%) was recorded with *Z. officinale*. Similarly, highest population inhibition was (89.70%) with *A. indica* but minimum population inhibition (75.15%) was recorded with *P. hermala* at 15% concentration. The results regarding growth inhibition clearly show that in case of *A. indica*, lowest numbers of larvae (32.67), pupae (16.33) and adults (11.33) were emerged at 15% concentration, while *Z. officinale* was least effective with highest emergence rate of larvae (80.33), pupae (75.00) and adult (71.00). The study can be very helpful in future as the plant extracts can be a best replacement of pesticides.
Keywords: Growth inhibition, mortality, plant extracts, progeny inhibition, *Tribolium castaneum*.

INTRODUCTION

Food security is an emerging threat to the world expanding population. Food security and food safety cannot be achieved without safe storage of products. Thus it is ultimate need of the time to protect stored products and avoid qualitative and quantitative losses during storage (Ali *et al*., 2020). Wheat is a staple food in Pakistan. Stored grain insect pests are severely damaging our economy by invading our valuable products like wheat. These stored grain pests cause economic loss in the stored commodities and are responsible to cause 10% loss of cereals all over the world (Danahaye *et al*., 2007).

The *T. castaneum* is one of the major pest of stored products (Amad *et al*., 2019). It is the pest of economic importance throughout the world which damage stored products (Arbogast, 1991). It is one of the major pests of wheat flour (Howe, 1965). Both larvae and pupae are responsible for the losses. In case of severe destruction, flour converts into greyish and moldy which produce pungent off-smell. Thus the commodity becomes unfit for human use (Atwal and Dhaliwal, 2002). It can cause economic loss of 40% of wheat flour (Ajayi and Rahman, 2006).

Voracious use of pesticides is posing a serious threat to the environment and human beings (White, 1995; Altinkoy *et al*., 2020; Iftikhar *et al*., 2020). So, use of bio pesticide for the control of stored commodity pests has attained attention throughout the world (Rizvi *et al*., 2001; Faraz *et al*., 2015). Bio pesticides have potential to replace the use of conventional insecticides (Regnault-Roger *et al*., 2004). More than 120 plants have been reported for the efficient control of stored grain insects (Imtiaz *et al*., 1999).

Plant extracts contain several compounds which are responsible for the control of insect's pests of stored grain (Wink, 1993; Rahman and Schmidt, 1999). Several plant derivatives have been investigated to have mortality effect on stored product pests (Shaaya *et al*., 1997; Mukherjee and Joseph, 2000) and a number of plants of Pakistan have been known for their repellency in stored grain pests (Tripathi *et al*., 2000; Verma *et al*., 2000). Few plants show repellence and growth inhibition effects (Kanvil *et al*., 2006). The plants which have been used in this research are abundantly available and possess numerous medicinal properties (Iqbal *et al*., 2010).

The current research was conducted with the objective (i) to assess the toxic effect (ii) to evaluate the long term effect on progeny (iii) the growth inhibitory activities of different plant extracts (*Azadirachta indica, Melia azedarach, Pegnum hermala, Salsola baryosma* and *Zingiber officinale*) against *T. castaneum* using acetone as solvent.

MATERIALS AND METHODS

***Collection and rearing of insects*:** The heterogeneous population (larvae and adults) of *Tribolium castaneum* was collected from grain market, located at Faisalabad District, Punjab, Pakistan. The insect culture was reared in plastic jars (1.5 kg capacity) in Grain Research Training and Storage Management Cell of Department of Entomology, University of Agriculture, Faisalabad. In rearing jars, 50 adults of each *T. castaneum* were released on wheat flour. After 5 days, adults were removed from rearing jars and culture medium containing eggs of insects were again shifted into the rearing jars and were kept in incubator (Sanyo M.I.R 254) at optimum conditions for getting homogenous population. Wheat was sterilized at 65^{0}C for 30 minutes before putting into rearing jars.

***Collection and preparation of plant materials*:** Fresh leaves of *Melia azedarach* and *Azadirachta indica,* Seeds of *Pegnum hermala,* Stem of *Salsola barysoma* and Rhizome of *Zingiber officinale* were collected from different farms and fields located at District Faisalabad. Plant parts were washed and after drying in shade for 5 days were ground using electrical grinder (Pascall Mortar grinder, Machine no. 20069) into fine powder. In 250 ml flask, 50 gram of plant powder was soaked in 100 ml of acetone. The flasks were placed on rotary shaker at 220 rpm for 24hr. Then the prepared extracts were filtered. The filtrate thus obtained was used to make different concentrations for further experiments. Three concentrations (5, 10 and 15%) of plant extracts were prepared in acetone (solvent).

Bioassay

***Insecticidal effect of Plant Extracts*:** The diet incorporation method was used to estimate the efficacy in terms of mortality of each extracts treatments. Various concentrations of plant extracts were applied to favorite diet of insect and 30 adults of the test insects were replicated thrice using Completely Randomized Design. The data was recorded after 24, 48 and 72 hrs for plant extracts. The survivors of *T. castaneum* from the experiment were released on fresh grains for population build-up studies. Population build up data was recorded after 30 and 60 days.

Corrected mortality was calculated using Abbot's formula given below:

$$\text{Corrected Mortality (\%)} = \frac{(\text{Mo} - \text{Mc})}{(100 - \text{Mc})} \times 100$$

Where, Mo = observed mortality; Mc = control mortality

Percent inhibition rate of progeny was calculated using following formula:

$$\text{Inhibition Rate (\%)} = \frac{(\text{Cn} - \text{Tn})}{\text{Cn}} \times 100$$

Where, Cn = No. of progeny in control jars; Tn = No. of progeny in treated jars

***Growth Inhibitory Impact of Plant Extracts*:** Wheat flour was sterilized and various concentrations of plant extracts 5, 10 and 15% were applied separately for each experiment. 100 g of treated flour was put into vials and adults of *T. castaneum* were released in these vials. The growth regulatory data about larvae emergence, pupae transformation and adult formation was recorded after 15 days for larvae, 25 days for pupae and 40 days for adult's emergence.

RESULTS

The current research was carried out in order to examine the insecticidal and growth inhibitory effects of different plant extracts against *T. castaneum* using different concentrations. Significant results were achieved after experimentation. In case of *T. castaneum*, with *A. indica*, highest mortality values were 3.33, 7.38 and 10.14%, highest mortality values were 3.33, 6.04 and 9.46% with *M. azedarach*, 2.00, 4.02 and 8.79% with *S. baryosma*, 1.33, 5.37 and 6.76% with *P. hermala* and 0.67, 3.35 and 6.08% with *Z. officinale* at 15% concentration after 24, 48 and 72hrs, respectively (Table 1).

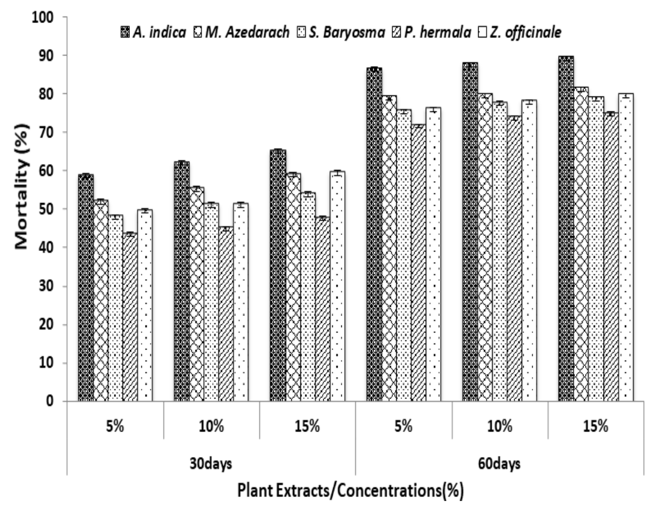

Figure 1. Mortality percentage of different plant extracts against *Tribolium castaneum*

Table 2 shows the highest mean values for percent inhibition of *T. Castaneum* progeny were 65.43 and 89.70% with *A. indica*, 59.30 and 81.62% with *M. azedarach*, 54.27 and 79.10% with *S. baryosma,* 47.92 and 75.15% with *P. hermala* and 59.74 and 80.06% with *Z. officinale* at 15% concentration after 30 and 60 days respectively.

Table 1. Mortality percentage of *Tribolium castaneum* treated with different plant extracts

Time (hrs)	Conc. (%)	Mortality (%) ± S.E.				
		A. indica	***M. azadirach***	***S. baryosma***	***P. hermala***	***Z. officinale***
24	5	1.33±0.66e	1.33±0.66e	0.00±0.66e	0.00±0.66d	0.00±0.66c
	10	2.67±0.67de	2.00±0.65de	1.33±0.66de	0.67±0.66d	0.00±0.67c
	15	3.33±0.67cde	3.33±0.66cde	2.00±0.67cde	1.33±0.65d	0.67±0.66c
48	5	3.35±0.65cde	2.68±0.67de	2.01±0.67cde	1.34±0.67d	1.34±0.67bc
	10	5.37±0.65bc	4.69±0.67bcd	3.35±0.67bcd	3.35±0.67c	2.01±0.67bc
	15	7.38±0.66b	6.04±0.66bc	4.02±0.66bc	5.37±0.66ab	3.35±0.66b
72	5	4.73±0.68cd	3.38±0.68cde	3.38±0.68bcd	3.38±0.68c	2.03±0.67bc
	10	7.44±0.68b	6.76±0.68ab	5.41±0.68b	4.73±0.68bc	3.38±0.68b
	15	10.14±0.67a	9.46±0.65a	8.79±0.67a	6.76±0.67a	6.08±0.68a

Table 2. Population inhibition percentage of *Tribolium castaneum* treated with different plant extracts.

Time (days)	Conc. (%)	Population Inhibition (%) ± SE				
		A. indica	***M. azadirach***	***S. baryosma***	***P. hermala***	***Z. officinale***
30	5	59.08±0.21f	52.30±0.21e	48.36±0.22f	43.76±0.21f	49.89±0.21f
	10	62.36±0.22e	55.58±0.22d	51.42±0.22e	45.29±0.21e	51.42±0.22e
	15	65.43±0.22d	59.30±0.21c	54.27±0.21d	47.92±0.22d	59.74±0.21d
60	5	86.83±0.05c	79.52±0.10b	75.75±0.05c	72.04±0.06c	76.35±0.05c
	10	88.08±0.06b	80.06±0.10b	77.96±0.06b	74.13±0.06b	78.32±0.05b
	15	89.70±0.05a	81.62±0.06a	79.10±0.06a	75.15±0.05a	80.06±0.06a

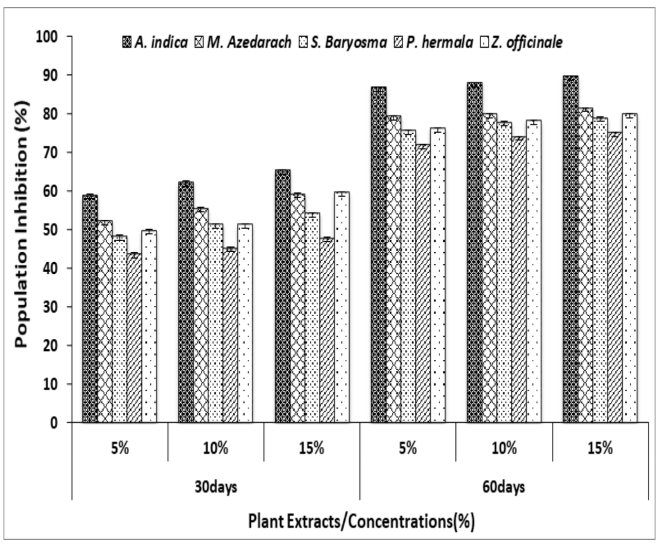

Figure 2. Population inhibition percentage of different plant extracts against *Tribolium castaneum*

The results regarding growth inhibition has been shown in Table 3 which depict that highest inhibition of larvae, pupae and adults was observed at highest concentration (15%). Highest no. of larvae (111.00) was emerged in control treatment. Minimum numbers of larvae (32.67) were emerged with *A. indica*, minimum no. of larvae (38.00, 52.67, 57.33 and 71.67) were observed with *M. azedarach, S. baryosma, P. hermala and Z. officinale* respectively. Maximum no. of pupae (110.00) was emerged in control treatment. Minimum numbers of pupae (16.33) were emerged with *A. indica*, minimum no. of pupae (14.67, 32.67, 39.00 and 57.33) was observed with *M. azedarach, S. baryosma, P. hermala* and *Z. officinale* respectively. Maximum no. of adults (110.00) was emerged in control treatment. Minimum numbers of adults (11.33) were emerged with *A. indica*, minimum no. of adults (10.67, 26.00, 32.00 and 47.33) was observed with *M. azedarach, S. baryosma, P. hermala* and *Z. officinale* respectively.

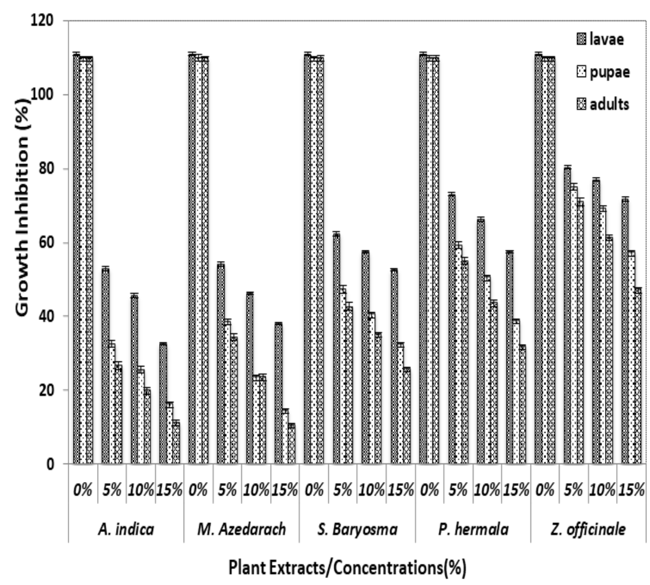

Figure 3. Growth inhibition percentage of different plant extracts against different life stages of *Tribolium*

Table 3. Growth inhibition percentage of different plant extracts against different life stages of *Tribolium castaneum*

Plants	Conc. (%)	Larvae No.±S.E	Pupae No.±S.E	Adults No.±S.E
A. indica	5	53.00±0.57h	32.67±0.88h	26.67±1.00h
	10	45.67±0.57i	25.67±0.88i	20.00±0.66i
	15	32.67±0.33k	16.33±0.33k	11.33±0.67j
	0	111.00±0.33a	110.00±0.33a	110.00±0.33a
M. azadirach	5	54.00±0.57h	38.67±0.57g	34.33±1.00g
	10	46.33±0.33i	23.67±0.33j	23.67±0.66h
	15	38.00±0.33j	14.67±0.33l	10.67±0.33j
	0	111.00±0.57a	110.00±0.88a	110.00±0.33a
S. baryosma	5	62.33±0.57f	47.33±0.88f	42.67±1.00f
	10	57.33±0.33g	40.67±0.33g	35.33±0.33g
	15	52.67±0.33h	32.67±0.33h	26.00±0.33h
	0	111.00±0.31a	110.00±0.33a	110.00±0.57a
P. hermala	5	73.00±0.51d	59.33±0.88d	55.00±1.00d
	10	66.33±0.57e	50.67±0.33e	43.67±0.57f
	15	57.33±0.33g	39.00±0.33g	32.00±0.33g
	0	111.00±0.33a	110.00±0.57a	110.00±0.57a
Z. officinale	5	80.33±0.57b	75.00±0.88b	71.00±1.00b
	10	77.00±0.33c	69.33±0.58c	61.33±0.57c
	15	71.67±0.57d	57.33±0.33d	47.33±0.33e
	0	111.00±0.33a	110.00±0.33a	110.00±0.33a

castaneum

DISCUSSION

In our study, effect of plant extracts on mortality percentage of *T. castaneum* was recorded low, which agree with Fang *et al*. (2002) who believe that *Tribolium* sp. are the most resistant among all stored grain insect pests so they are more difficult to control than remaining insects, yet the mortality of this sp. vary with the change in pesticide. Due to being polyphagous *T. castaneum* has been controlled successfully by the use of different insecticides (Okonkwo and Okoye, 1996; Islam and Talukdar, 2005). But this pest got resistant against these pesticides (Guedes *et al*., 1997). Some plants have toxic effect against *T. castaneum* (Tripathi *et al*., 2000). Plant extracts contain several compounds which are responsible for the control of insects (Wink, 1993; Rahman and Schmidt, 1999). The plants like neem, sweet flag, turmeric, balchar, harmal, kuth and ner have been reported to show medicinal activities (Iqbal *et al*., 2010). In the present study, *A. indica* extract was proved most effective in term of mortality that is in accordance with Ahmed *et al*., 2000 according to whom *A. indica* possesses toxic effect against *T. castaneum*. Similarly, the effectiveness of neem has been reported by some researchers who found that many compounds in neem have been reported for their toxic effects the most common is *azadirachtin* (Mordue and Blackwell, 1993; Lin-er *et al*., 1995). *A. indica* may be used as alternative to the fumigant and contact pesticides (Isman, 2000; Enan, 2001; Wang *et al*., 2001).

Our results regarding growth inhibition percentage were in accordance with the results of different researchers. The plant products have growth regulatory effects on different pests particularly red flour beetle, *Tribolium castaneum* (Joseph *et al*., 1994; Haque *et al*., 2000). The most effective plant was *A. indica* in our study. So, minimum numbers of larvae, pupae and adults of *T. castaneum* emerged were 32.67, 16.33 and 11.33 with *A. indica* at 15% concentration respectively. This result is in accordance with Mordue (Luntz) and Blackwell, 1993 and Singh, 1993 according to which *A. indica* includes bioactive compounds like azedarachtin and which affects the growth behavior and reproduction of stored grain insect pests. *A. indica* interrupts the normal development of larvae and adults as well as metamorphosis of insects (Koul *et al*., 1987). *A. indica* also significantly reduces the emergence of adults of *T. castaneum* and weight of the adults (Anonymous, 1992). The emergence of larvae, pupae and adults is affected by the change in dose rate of the plant extracts (Sagheer *et al*., 2011). Reduced growth of the *T. castaneum* was observed with the use of different plants including *P. hermala* (Jbilou and Sayah, 2006). *Melia azedarach* has been found to have insecticidal, antifeedant, growth regulatory activities (Nakatani *et al*., 2004; Al-Rubae, 2009). To use the plant extracts as bio pesticides, farmers should be well aware of its production as well as application (Hellpap and Dreyer, 1995).

***Conclusion*:** Keeping in view the above results it can be concluded that plant extracts are safe and can be used in IPM techniques for the control of insects both in the crops growing in the field and stored commodities. Use of plants as an insect control tactic can prove a better substitute of synthetic insecticides.

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