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Susceptibility of *Sitophilus granarius* (L.) to three herbal insecticides under laboratory conditions

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Abstract
The granary weevil, *Sitophilus granarius* is one of the most important pests of stored products. This pest is internal feeder and causes considerable damage to cereals. In this research, three herbal insecticides including Sirinol, Palizin and Tondexir were evaluated for their efficacy in the control of *S. granarius* under laboratory conditions. The $LC_{16.6}$, LC_{25} and LC_{50} values of Sirinol, Palizin and Tondexir were estimated on adult insects. Results showed that LC_{50} values for Sirinol, Palizin and Tondexir treatments were 3019.7, 1793.6, 1947.8 ppm after 24 hours, respectively. Our results demonstrated that Palizin was the most effective insecticide. There were significant differences (P<0.001) in the mortality of adult beetles when treated with combination of three herbal agents compared with their exposition to Sirinol, Palizin and Tondexir alone and control. The results highlighted that the combination of Sirinol, Palizin and Tondexir had better effects on granary weevil compared to their individual use.

Keywords: *Sitophilus granaries*, Palizin, Tondexir, Sirinol, Bioassay

1. Introduction

Conservation of several food grain stocks is necessary to ensure a continuous supply at stable prices [1]. Because of some insufficiencies in protection systems in world transformation and contribution, significant crops are wasted. Damage by insects, ticks, fungi and seed germination in storehouse cause much loss to stored products [2]. A wide variety of insects can be found in durable stored food products of plant and animal origin. They are generally denoted as stored-product insect pests [3]. It was estimated that over 20,000 species of field and storage pests destroy approximately one-third of the world’s food production, valued annually at over $ 100 billion, among which the highest losses (43% of potential production) occur in developing countries [4, 5]. In these countries, existence of warm and appropriate climate for pest’s growth in storehouses with lack of sufficient opportunities for storage and protection of stored productions is the reason [6]. Damage of storehouse pests is 9 percent in developed countries and more than 20 percent in developing countries [7]. According to above cases, to reduce the damage, pest population control is inevitable and in this case synthetic pesticides have been considered the most effective and accessible means to control insect pests of stored-products [8]. They had good effects at first but these results were unstable because in a short time after using these pesticides many problems were appeared. These chemicals are associated with undesirable effects on the environment due to their slow biodegradation in the environment and some toxic residues in the products for mammalian health [9, 10, 11]. The adverse effects of synthetic pesticides have amplified the need for effective and biodegradable pesticides. Natural products are excellent alternatives to synthetic pesticides as means to reduce negative impacts to human health and the environment. Botanical insecticides have a selective mode of action, avoid the emergence of resistant races of pest species, pose less risk to humans and animals, and as a result, they can be safely used in integrated pest management [12]. Also, botanical insecticides are more efficacious, safe, ecologically acceptable, nature friendly and biodegradable. One of these botanical insecticides is Palizin (eucalyptus extract) that pests are unlikely to develop resistance to it, has no phytotoxic effects, lasts longer than most insecticides on plants when it does not rain or there is no excessive dew, is nontoxic to humans and is relatively harmless to natural enemies. Sirinol (garlic extract) also has an effective range of insecticidal, repellent, antifeedant, bactericidal and fungicidal effects [13]. *Sitophilus granarius* L. (Coleoptera: Curculionidae) is a small black-brown weevil that is of significant economical importance in comparison to the generally heterophagus stored-product pests. The granary weevil primarily afflicts grains such as wheat, barley, rye and oats as well as triticale, corn, rice, millet and sometimes manufactured pastas [14, 15]. This pest is internal feeder and causes considerable loss to cereals affecting the quantity as well as quality of the grains [16, 17]. The present study was conducted to develop an integrated pest management protocol (IPM) which might be an alternative to the practices being adopted presently for the control of insect pests of stored grains at farm level but are safe, economical, and easy to apply and nature friendly. For this purpose efficacy of Palizin, Sirinol, Tondexir (pepper extract) was appraised by applying different concentrations against granary weevil, *Sitophilus granarius* in laboratory conditions.

2. Material and Methods

The present study was carried out in entomology laboratory of Plant Protection Department, Agriculture Faculty of Urmia University in Iran at summer of 2016.

2.1 Insect rearing

The granary weevil, *S. granarius* was used for the present experiments. Colony of *S. granarius* was obtained from storage products in the laboratory of Urmia University. They were reared under storage conditions, on wheat at 27±2 °C, with L: D 14: 10 and 65±5 % RH.

2.2 Insecticides

In this study, the botanical insecticides of Sirinol (garlic extract) with formulation (EC 80%), Tondexir (pepper extract) with formulation (EC 85%) and Palizin (*Eucalyptus* extract) with formulation (SL 65%) were used (Kimia Sabzavar Co., Iran) to control *S. granarius*. These insecticides are considered nontoxic to mammals (rat oral acute LD_{50} is >5000 $mg.kg^{-1}$). 2500 CC/1000L water was used for each insecticide.

2.3 Bioassay

To estimate the $LC_{16.6}$, LC_{25} and LC_{50} values of insecticides, five concentrations (800, 1000, 1500, 2000, 2500 ppm) of each botanical insecticide were used after preliminary experiments. Distilled water was considered as control. Each Petri dish (9 cm in diameter) was lined with filter paper (Whatmann No. 1). Then, ten adult insects (1-3 days old) were treated by spraying method and released in each container. Each treatment was repeated three times. The mortalities were recorded after 24, 48 and 72 hours [18].

2.4 Combined effects of Sirinol, Palizin and Tondexir

After calculating $LC_{16.6}$, LC_{25} and LC_{50} values of Sirinol, Palizin and Tondexir on adult stages, combination effects of Sirinol plus Palizin, Tondexir plus Sirinol, Palizin plus Tondexir by spraying method in Petri dish were evaluated. All experiments were in compeletly randomized design in 8 treatments including LC_{25} Sirinol + LC_{25} Palizin, LC_{25} Tondexir + LC_{25} Sirinol, LC_{25} Palizin + LC_{25} Tondexir, $LC_{16.6}$ Sirinol + $LC_{16.6}$ Palizin + $LC_{16.6}$ Tondexir and distilled water as control in three replications after drying. Filter papers were put in Petri dishes and ten adult *S. granarius* (1-3 days old) were selected randomly and put in Petri dishes, covered completely with Parafilm glue. After 24, 48 and 72 hours mortality percentages were calculated by Abbott's formula: ($M\% = [(T - C)/C] \times 100$) [19]; where: M, corrected mortality; T, the number of mortality in related treatment; and C, the number of mortality in control insects.

2.5 Data Analysis

The LC_{50}, LC_{25} and $LC_{16.6}$ values (with 95% confidence intervals) were calculated using Probit analysis method. Mortality data subjected to analysis of variance (one Way ANOVA) and means were compared with Tukey's HSD with SPSS statistical analysis software (version 22.0). Graphs were constructed using Excel 2010.

3. Results

3.1 LC_{50}, LC_{25} and $LC_{16.6}$ of Sirinol, Palizin and tondexir on adult stages

LC_{50}, LC_{25} and $LC_{16.6}$ of Sirinol, Palizin and tondexir on adult stages in three times were shown in Tables 1, 2 and 3. Results showed that Palizin had the lowest LC_{50} values in all time intervals. However, it was not statically different with other insecticides, revealed by 95% confidence intervals.

Table 1: LC_{50}, LC_{25} and $LC_{16.6}$ values of Sirinol, Palizin and Tondexir on adults of granary weevil after 24 hours

Insecticide	Slope±SE	Chi-square	Lethal concentrations (ppm)		
			$LC_{16.6}$ (95% CI*)	LC_{25} (95% CI)	LC_{50} (95% CI)
Sirinol	1.912±0.628	1.984	939.925 (359.46-1263.03)	1340.120 (837.409-1772.290)	3019.708 (2147.069-11059.828)
Palizin	1.414±0.570	0.449	371.505 (2.614-710.828)	598.227 (19.901-954.442)	1793.633 (1266.453-5180.239)
Tondexir	2.721±0.618	1.349	856.796 (513.224-1083.272)	1100.723 (778.059-1330.801)	1947.888 (1620.878-2654.105)

* Confidence Intervals

Table 2: LC_{50}, LC_{25} and $LC_{16.6}$ values of Sirinol, Palizin and Tondexir on adults of granary weevil after 48 hours

Insecticide	Slope±SE	Chi-square	Lethal concentrations (ppm)		
			$LC_{16.6}$ (95% CI*)	LC_{25} (95% CI)	LC_{50} (95% CI)
Sirinol	2.735±0.613	0.673	831.557 (495.147-1055.027)	1066.956 (747.453-1292.251)	1882.663 (1571.617-2510.616)
Palizin	1.551±0.571	0.257	284.059 (4.69-578.275)	438.997 (20.092-756.853)	1194.683 (597.523-1648.044)
Tondexir	2.727±0.604	1.647	705.895 (386.409-922.406)	906.389 (587.085-1120.490)	1602.059 (1335.519-2004.100)

* Confidence Intervals

Table 3: LC_{50}, LC_{25} and $LC_{16.6}$ values of Sirinol, Palizin and Tondexir on adults of granary weevil after 72 hours

Insecticide	Slope±SE	Chi-square	Lethal concentrations (ppm)		
			$LC_{16.6}$ (95% CI*)	LC_{25} (95% CI)	LC_{50} (95% CI)
Sirinol	2.214±0.585	2.026	594.985 (219.764-845.936)	808.823 (402.553-1059.425)	1631.255 (1306.302-2220.669)
Palizin	1.727±0.578	0.186	309.953 (13.543-551.50)	418.670 (40.039-707.763)	1028.783 (490.556-1355.694)
Tondexir	1.991±0.583	1.202	856.796 (60.955-625.381)	522.664 (131.612-786.858)	1140.091 (731.518-1449.122)

* Confidence Intervals

3.2 Effects of Sirinol, Palizin and Tondexir on *S. granarius*

Effects of different treatments showed that there were significant differences between LC_{50} of Tondexir with all other treatments in 24 hours ($F = 30.63$, $P = 0.001$, $df = 7$) (Fig. 1). Furthermore, the combination of all $LC_{16.6}$ values of insecticides was significantly effective on *S. granarius* in 48 hours (Fig. 2). After 72 hours, the mortality percent was near to each other except LC_{50} of Tondexir and combined effect of LC_{16} of insecticides (Fig. 3). Results showed that combined effect of insecticides imposed the highest mortality to insects compared to other treatments.

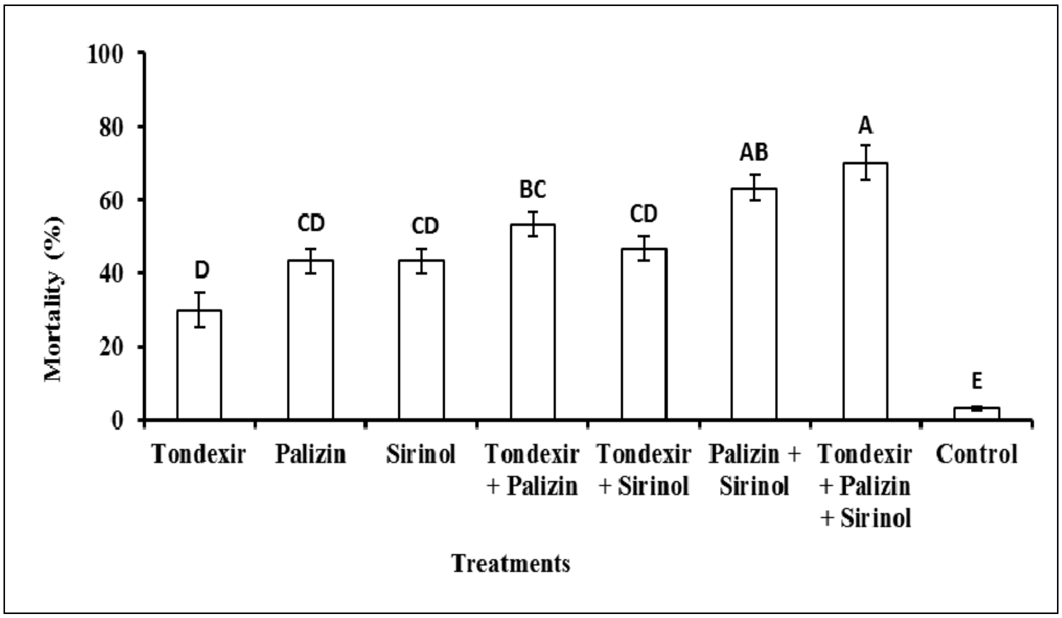

Fig 1: Mortality of *S. granarius* after 24 hours of treatment with Sirinol, Palizin and Tondexir and their combinations. Columns with different letters are statistically different (Tuckey test, $P<0.001$)

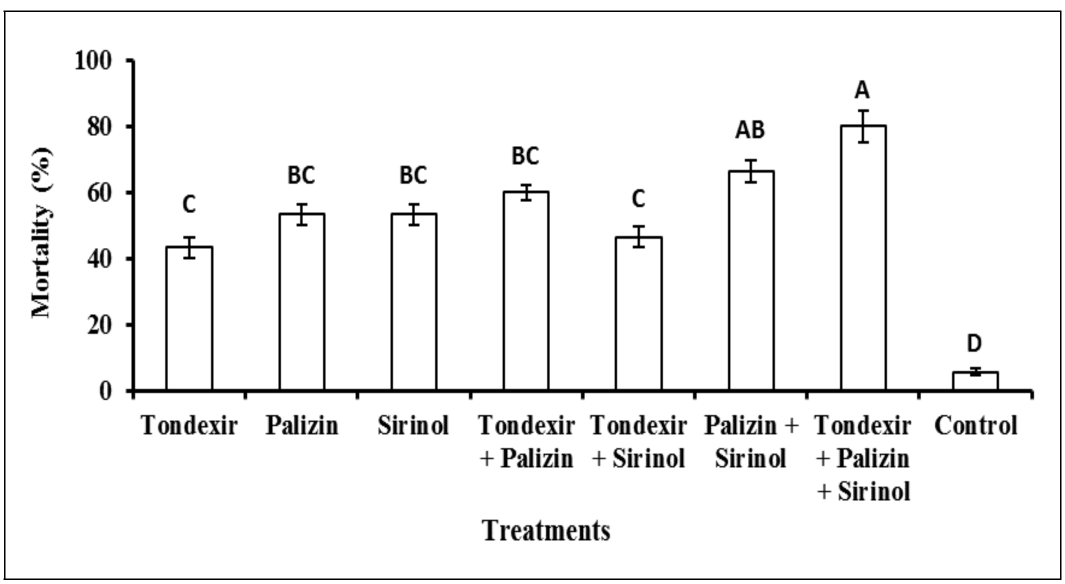

Fig 2: Mortality of *S. granarius* after 48 hours of treatment with Sirinol, Palizin and Tondexir and their combinations. Columns with different letters are statistically different (Tuckey test, $P<0.001$)

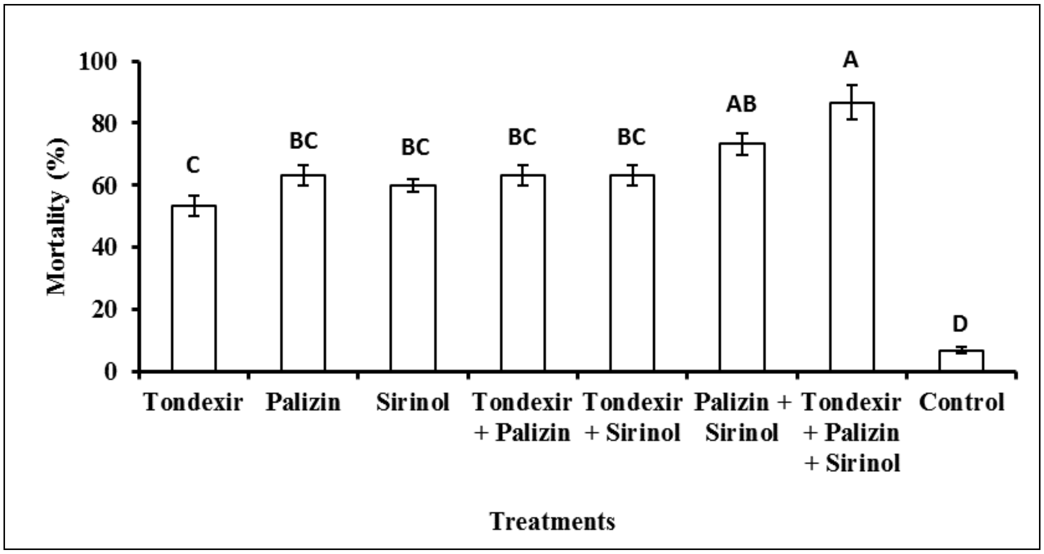

Fig 3: Mortality of *S. granarius* after 72 hours of treatment with Sirinol, Palizin and Tondexir and their combinations. Columns with different letters are statistically different (Tuckey test, $P<0.001$)

4. Discussion

Botanical pesticides can control pests more effectively and are less harmful for the environment, people and also for non-target organisms [20]. Also, they may be proved suitable and be used as products of choice for organic food production [12]. Reviewing the previous results indicated that Sirinol, Tondexir and Palizin had potential effect when mixed with each other that increased the reduction in infestation rates by *S. granarius*. Results of Soleimani *et al* [21] indicated that the botanical extract, Sirinol had the highest impact on control of fig spider mite. In a comparative research, toxicity of Sirinol and chemical insecticides, Mospilan® and Consalt® on two natural enemies including *Oenopia conglobata* and *Psyllaephagus pistaciae* were accomplished. Results revealed that Sirinol caused lower casualties of the natural enemies of pistachio psylla in comparison to chemical insecticides [20]. In another research, the study on the casualties of blights (insects) of two stored products with Sirinol in a composition with low air pressure was accomplished that the mature insects of red flour beetle were perceptibly sensitive to Sirinol in composition with low air pressure [22]. Also, Sohail *et al* [23] investigated the effect of garlic extract on *Toxoptera aurantii* and concluded that this extract caused 66% mortality. The results of these researchers are consistent with this study. Kabiri and Amiri-Besheli [20] reported that Palizin provides a physical and chemical barrier against insect pests and showed considerable potential for effective control of insect pests in certain agricultural crops. Repellent effects of Palizin against *Tribolium castaneum* (Herbest) and *Lasioderma serricorne* (F.) showed that the maximum repellency effect of Palizin was in concentration of 10% and the repellency percentages were 78.87%, 74.27% and 56.93% for adults of *T. castaneum* and 72.70%, 85.86% and 45.60% for *L. serricorn* in Petri-dish, Y-shape Busvine tube and Leaky glass techiniques, respectively [24]. These results were consistent with the results of this study. Effect of Palizin and Tondexir was investigated on pomergaranate aphid and mite. Results indicated that application of Palizin and Tondexir with 2000 ppm concentration were effective in decreasing pomergaranate aphid and mite damage [25]. Also, Antonious *et al* [26] investigated the effect of pepper extract on cabbage looper, *Trichopulsia ni* (Hubner) and spider mite, *Tetranychus urticae* (Koch) and reported that this extract caused 94% mortality in *T. ni* and showed repellency effect on *T. urticae*. Kazem and El-shereif [27] concluded that garlic and pepper extracts have lethal effects on *Aphis gossypii* and *Tetranychus urticae*. Also, Buba *et al* [28] showed that garlic extracts significantly control *Bemisia tabaci* (Gennadius) and *Megalurothrips sjostedti* (tryloom).

5. Conclusion

In this study, combination of Palizin, Sirinol and Tondexir were most effective in the mortality of *S. granarius* than Palizin, Sirinol and Tondexir alone. The highest and the lowest mortality belonged to the insects that were treated with combination of all of used insecticides and Tondexir, respectively. Overall, we recommend using combination of $LC_{16.6}$ values of all three herbal agents in control of *S. granarius*. Finally, it can be concluded that herbal insecticides such as Sirinol, Palizin and Tondexir may inhibit pest populations efficiently on stored products with no chemical residues on them and far from development of resistant insects.

6. Acknowledgments

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7. References

1 Talukder FJ. Insects and insecticide resistance problems in post-harvest agriculture. Proc. Intern. Conf. Postharvest Technology and Quality Management in Arid Tropics, Sultan Qaboos University, Oman, 2005, 207-211.
2 Harein PK, Meronuck R. Stored grain losses due to insects and molds and the importance of proper grain management. In: Stored Product Management, (Krischik, V., Cuperus, G., Galliart, D, eds.), E-912, CES Division of Agricultural Science Natural Research, OSU, USDA, FGIS, ES, APHIS, 1995, 31.
3 Reichmuth C, Scholler M, Ulrichs C. Stored Product Pests in Grain. AgroConcept, Bonn, 2007.
4 Jacobson M. Plants, insects and man their interrelationship. Journal of Economic Botany. 1982; 36:

346-354.
5 Ahmed S, Grainge M. Potential of neem tree (*Azadirachta indica*) for pest control and rural development. Journal of Economic Botany. 1986; 40:201-209.
6 Jayas D, White G, Munir WE. Stored grain ecosystems. Marcel. Dekker, Inc. New York, Basel, Hongkong, 1994, 1-3.
7 Phillips TW, Throne JE. Biorational approaches to managing stored-product insects. Annual Review of Entomology. 2010; 55:375-379.
8 Huang F, Subramanyam B. Management of five stored-product insects in wheat with pirimiphosmethyl and pirimiphosmethyl plus synergized pyrethrins. Pest Management Science. 2005; 61:356-362.
9 Benhalima H, Chaudhry MQ, Mills KA, Price NR. Phosphine resistance in stored-product insects collected from various grain storage facilities in Morocco. Journal of Stored Products Research. 2004; 40:241-249.
10 Isman MB. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology. 2006; 51:45-66.
11 Halder J, Srivastava C, Dureja P. Effect of methanolic extracts of periwinkle (*Vinca rosea*) and bottle brush (Callistemon lanceolatus) alone and their mixtures against neonate larvae of gram pod borer (Helicoverpa armigera). Indian Journal of Agricultural Sciences. 2010; 80(9):820-823.
12 Ntalli NG, Menkissoglu-Spiroudi U. Pesticides of botanical origin: a promising tool in plant protection, Pp. 3-24. In: M, Stoytcheva (ed.) pesticides-Formulations, Effects, Fate, InTech, 2011, 808.
13 Loth SM, Elice NL, Owmr S, Robert NM. Effectiveness of local botanicals as protectants of stored beans (*Phaseolus vulgaris* L.) against bean Burchid (*Zabrotes subfaciatus* Boh) (Genera: Zabrotes. Family: Burchidae). Journal of Entomology. 2007; 4:210-217.
14 Dobie P, Kilminster AM. The susceptibility of triticale to post-harvest in infestation by *Sitophilus zeamais* Motschul-sky, *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.). Journal of Stored Products Research. 1978; 14:87-93.
15 Schwartz BE, Burkholder WE. Development of the granary weevil (Coleoptera: Curculionidae) on barley, corn, oats, rice, and wheat. Journal of Economic Entomology. 1991; 84:1047-1052.
16 Kucerova Z, Aulicky L, Stejskal V. Accumulation of pest arthropods in grain residues found in an empty store. Journal of Plant Diseases and Protection. 2003; 110:499-504.
17 Park IK, Shin SC, Choib DH, Park JD, Ahn YJ. Insecticidal activities of constituents indentified in the essential oil from leaves of *Chamaecyparis obtuse* against *Callosobruchus chinensis* (L.) and *Sitophilus oryzae* (L.). Journal of Stored products research. 2003; 39(4):375-384.
18 Finney DJ. Probit analysis. 3rd ed. Cambridge University Press, London, 1971, 318.
19 Abbott WS. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology. 1925; 18:265-267.
20 Kabiri M, Amiri-Besheli B. Toxicity of Palizin, Mospilan and Consult on *Agonoscena pistacia* Burckhardt and Lauterer (Hemiptera: Psyllidae), *Oenopia conglobate* L. (Coleoptera: Coccinellidae) and *Psyllaephagus pistaciae* Ferriere (Hymenoptera: Encyrtidae). Academic Journal of Entomology. 2012; 5(2):99-107.
21 Soleimani M, Rafei Z, Sedaghatfar E. Survey on the impact of botanical insecticides Sirinol and Palizin on (*Eotetranychus Hirsti*) population control of the Fig spider Mite in the township of poledochtar (Lorestan province). Canadian Journal of Basic and Applied Sciences. 2015; 3(4):118-125.
22 Ghane Jahromi M, Pourmirza A, Safaralizadeh MH. Evaluation of the mortality of two stored-product insects by garlic emulsion (Sirinol) in combination with low air pressure. African Journal of Biotechnology. 2011; 10:19650-19657.
23 Sohail A, Hamid FS, Waheed A, Ahmed N, Aslam N, Zaman Q *et al*. Efficacy of different botanical materials against aphid *Toxoptera aurantii* on tea (*Camellia Sinensis* L.) cutting under high shade nursery. Journal of Materials and Environmental Science. 2012; 3(6):1065-1070.
24 Sadeghi R. Repellent effect of Coconut soap (Palizin) against *Tribolium castaneum* (Herbst) and *Lasioderma serricorne* (F.) using three laboratory methods. Journal of Entomological research. 2013; 6(3):269-279.
25 Farazmand H, Sirjani M, Yousefi M, Jafari-Nodooshan A, Azadbakht N, Moshiri A *et al*. Effect of herbal insecticides, Palizin and Tondexir, on pomergaranate aphid and mite. 20th Iranian Plant Protection Congress, 2012.
26 Antonious GF, Meyer JE, Rogers JA, Hu Y-H. Growing hot pepper for cabbage looper, *Trichopulsia ni* (Hubner) and spider mite, *Tetranychus urticae* (Koch) control. Journal of Environmental Science and Healthy. 2007; 42:559-567.
27 Kazem MGT, El-Shereif S. Toxic effect of capsicum and garlic xylene extracts in toxicity of boiled linseed oil formulations against some piercing sucking cotton pests. American-Eurasian Journal of Agricultural and Environmental Science. 2010; 8(4):390-396.
28 Buba IA, Aliyu A, Sani YR, Namwa V. Field evaluation of some selected plant materials for the control of major insect pests of cowpea *Vigna unguiculata* (L.) (Walp.) in the Northern Guinea Savannah of Nigeria. Archive of Phytopathology and Plant Protection, 2007, 1-9.