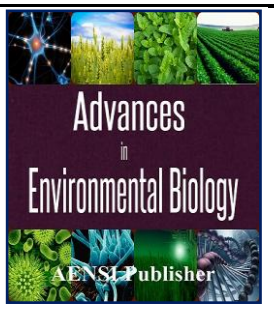
Advances in Environmental Biology, 9(23) October 2015, Pages: 338-344

AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/AEB/



Effect of Stored Product Insects on Viability of Farmer's Barley Seeds Stored For Planting in Jordan

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ARTICLE INFO

Article history:
Received 28 September 2015
Accepted 30 October 2015
Available online 24 November 2015

Keywords:
Barley, Seeds, Cultivars, Purity, Viability, Germination, Storage food insects.

ABSTRACT

This study is aimed to know the different variables affecting seeds viability and germination, and the different stored product insects attacking several barley cultivars under Jordanian farmer's storage, and to know stored cultivars infestation by the occurred insects and their effect on some biological aspects of the stored seeds to assist in finding different integrated pest management practices in controlling pests in store houses. Many barley seeds of several cultivars were collected from farms of different regions in Jordan to study the variables which affect barley seeds quality, viability and germination % in 2012 and 2013 to clarify barley yield in Jordan. Viability, germination, purity % of the barley samples were determined by the international standards. Viability was ranged from 5 to 100% depending on the location and the cultivar. Seeds germination % ranged from 10 to 100 depending on the region and the cultivar. The correlation between viability % and germination % was greatly positive. The barley seeds purity ranged between 81 and 99.7% in all cultivars. Number of holes caused by the storage pests in all seeds in the local cultivar, Deir-Alla 2 was significantly less than the other cultivars. Number of seeds containing immature insect stages in the local cultivar, Mouta was significantly less than the other cultivars.The most common insects in the barley seed samples of all cultivars were *Rhyzopertha dominica*, followed by *Sitophilus granarius*, *Tribolium confusum* and *Oryzaephilus surinamensis*. Several agricultural practices were recommended to get high quality barley seeds to be cultivated. It is concluded that quality control practices are needed. It is needed to get high viability and seeds germination percentages. Insects and diseases infecting barley seeds in the field should be controlled before and after harvesting. Barley seeds should be screened to get rid of insects, their debris, diseases, diseased seeds, impurities, small stones, weed seeds, and broken and crushed seeds.

To Cite This Article: Tawfiq M. Al Antary and Talal A. Thalji., Effect of Stored Product Insects on Viability of Farmer's Barley Seeds Stored For Planting in Jordan. ***Adv. Environ. Biol., 9(23),*** *338-344, 2015*

INTRODUCTION

The barley belongs to Graminae . It is cultivated all over the world to get the grains for animal feed and food industry. The area cultivated with cereals is considered to be half of the cultivated areas worldwide. The barley is considered to be a major daily animal feed in the world to obtain an important source for the required carbohydrates for most of the plant feeding animals [20]. Barley is considered to be an important crop cultivated in Jordan to feed animals. It can be cultivated in the irrigated area such as Jordan valley and arid regions in Jordan such as the upper lands. Barley can be cultivated in areas with around 200 ml rainfall. Unfortunately, the yield from this crop does provide only less than 10%of the annually needed amount for animal feed. Barley is considered to be an important strategic commodity in Jordan or elsewhere to feed animals. This crop must be stored to face the necessity during war, natural catastrophic, demand and other main problems [2]. During storing, the barley will be attacked by several pests, particularly insects. Seed stored for more than six weeks must be protected against insect damage [5]. Seeds should only be stored when dried. High temperature reduces the efficacy of barley protectants, encouraging insects to increase. The infestation by insects causes several direct or indirect damage. These injuries might change colour and appearance, bad odors, high in temperature and humidity, holes and dark spots on grains. Insects might also kill grain embryos, produce not required flour and powdered products leading to deterioration and contamination of grains [4]. Direct feeding damage results in reductions in weight, nutritional value, germination and market value [22]. About 500 species of insects have

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been associated with stored grain products. Nearly 100 species of insect pests of stored products cause economic losses. In India, [26], post harvest losses caused by the unscientific storage, insects, rodents and microorganisms account for about 10% of the total food grain. Insects feed on seeds. In addition, insects molting around the world which is equal to more than 5% of the annual production [4,26]. Stored-grain insects are divided into primary pests that attack whole kernels and secondary pests that feed on broken or cracked grains [1,8].

MATERIALS AND METHODS

1.1. Sampling Method of Barley Seeds:

Samples of barley seeds were collected from different sources from farmers and stores of cooperatives societies for two years from 2012 to2014 to be represented for all agricultural seeds qualities in Jordan and then transferred in paper bags to laboratory and then kept in refrigerators at 5°C and 85% relative humidity for two weeks and then exposed to different tests. Temperature in store houses where they were collected was in average 22 ± 3 and relative humidity% was in average 40 – 60% .There were eight collected barley cultivars. The collected samples for each of the cultivars were replicated from 3 to 6 replications. The size of each sample was 2 Kg randomly taken from the quantity of seeds which were brought for seeds health tests and then mixed together. These seeds for each source were separately kept in paper bags labeled with a code number for each sample and with the source of collection and then stored in refrigerator until seed testing and seed insect examination. The mixed samples from each source were randomly divided to get the needed quantity for each test. The most important fungi isolated were: *Fusarium moniliforme*, *Rhizopus stolonifer*, *Aspergillus niger and Penicillum spp.* at different levels, but never sprayed with fungicides [25].

1.2. Seeds Germination Capability and Purity Percentages Examination:

Forty grams from each sample with three replicates ware taken. The impurities and other crops and weeds seeds were separated and weighed according to the international standards. The seeds were dipped in water for 24 hours to study the germination ability. Four hundred seeds from the dipped ones with three replications and then divided to four groups (average of 100 seeds per group). The seeds were placed over moistened filter papers in special dish and then covered with pieces of plastic to prevent seeds from drying. These seeds were kept under room temperature 25°C ± 2 and relative humidity 60% ± 5, moistened when needed and examined after five days. The seedlings were categorized to healthy, not healthy and dead ones according to the international standers. The seeds were examined, counted and reevaluated after two weeks to be sure from the primary counting. The percentage of seed germination was calculated according to this formula % seed germination = normal seedlings / total number of seeds X100 And then the average for the four replicates was calculated.

1.3. Seeds Viability Test:

The seeds were placed over moistened filter papers for two days to test seeds viability under room temperature 25°C ± 2 and relative humidity 60% ± 5. The percentage of seed germination was calculated by calculating the seeds with emerged embryos. After one week, the reevaluation was conducted to calculate the normal seeds germination.

1.4. Holes and External Dark Spots Counting on the Seeds:

Fifty grams from each replicate for each cultivar were placed in a Petri dish (10 cm in diameter) to count the number of holes and external dark spots caused by the stored product insects in all seeds under binocular dissecting microscope when needed. There were 6 replicates for each cultivar. Dark spots indicate for the occurrence of larvae or pupa inside the seed. Total number of holes and dark spots and average number of holes and dark spots per a seed were separately calculated. Differences between means for number of holes for all seeds and per a seed for the eight cultivars were found using the RCD design , one way analysis of various (F-test) and the LSD-test .

1.5. Stored Product Insect in Each Cultivar:

Fifty grams from each replicate for each cultivar were placed in a Petri dish .The occurred stored product insects were separated, identified using the key Pfadt (1978) and then separately counted. Differences between numbers of each insect for the eight cultivars were found using the RCD design , one way analysis of variance [F-test] and the LSD test.

Results:

1.6. Seeds Viability:

Generally, seeds viability was ranged between 5 and 100%, depending on the region, the cultivar and the storing period in farmers stores. Seeds collected from farmers stores in the sothern parts of Jordan particularly from Madaba, Husban and Maan were with low viability %. Seeds collected from the farmers stores in the northern part of Jordan such as Mafrak, Irdid and others were with high viability %(Table1) . Local cultivars

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(Rum, Athroh, Balady and Dier Allah 2) were with high viability % . Balady from Madaba was the lowest in viability %, followed by Americana and Exad 176 cultivar (Table1).

Table 1: Percentages of germination, viability and purities for wheat seeds of several cultivars in different parts of Jordan collected in 2012 and 2013.

Sample No.	Sample source	Cultivar	Purity%	%Germination	Viability %
5	Abu Ensear	Deir Alla 2	70	80	98
11	Shafa Bdran	Yarmouk	70	70	96
13	Madaba	Balady	90	85	96
17	Mushakar	Rum	80	75	81
25	Jubbiha	Rum	95	95	99.6
27	Madaba	Amricana	80	80	92.4
32	Mushaka	Rum	95	95	98.8
42	Karak	Balady	90	90	92.2
47	Shoubak	Yarmouk	90	85	86.6
53	Shoubak	Deir Alla 2	80	75	92
54	Mushakar	Mouta	95	95	99
62	Maan	Athroh	60	80	92.1
68	Mafrak	Deir Alla 2	75	70	97.3
69	Mafrak	Deir Alla 2	100	85	99.7
71	Madaba	Balady	95	45	97.4
72	Madaba	Mouta	80	75	95.4
87	Irbid	Mouta	95	80	98.4
88	Irbid	Yarmouk	95	90	99.2
89	Irbid	Exad 176	85	80	99
90	Irbid	Athroh	90	85	99
91	Irbid	Rum	100	95	99
113	Irbid	Amricana	70	70	95.2
115	Irbid	Exad 176	90	90	99.8
118	Irbid	Exad 176	65	75	99.5
126	Irbid	Rum	100	100	99.2
137	Deir Yousef	Athroh	95	95	94.8
140	Madaba	Balady	5	10	98.7
145	Husban	Amricana	15	20	96.3
146	Madaba	Balady	10	25	98.5
147	Madaba	Balady	35	40	98.5

1.7. Seeds germination %:

Seeds germination % were ranged from 10 to 100% (Table1). The correlation between germination % and viability % was greatly positive (r^2 =0.808)(Tables 1 and 2). However, germination% for these samples collected from the northern parts of Jordan was higher than those from the southern regions (Table1). The lowest germination % in Balady cultivar in Madaba region was ranged between 10% and 40% (Table 1).Table (2): Values of correlation coefficient (r^2) between germination %, viability% and purities for barley seeds collected from different sources in Jordan during 2012 and 2013.

Table 2:

Variables	Correlation coefficient (r^2)
Seeds germination % vs seeds viability %	0.808
Seeds germination % vs seeds purity %	0.009
Seeds viability % vs seeds purity %	0.001

1.8. Seeds Purity:

The seeds prity% was ranged from 81% to 99.7% in all cultivars collected from all regions in Jordan (Table 1). The correlation coefficient between purity% and viability was very low (0.001) (Table 2). The correlation coefficient between seed germination percentage and seeds purity% was also low (0.009).

1.9. Holes in Seeds:

Table (3) shows means numbers of holes in eight barley cultivars collected from different parts of Jordan in 2012 and 2013, caused by several stored product insects in all seeds and per one seed. Number of holes in all seeds and per seed in Rum and Yarmouk cultivars were significantly the highest, followed by Athroh cultivar and then Balady, Exad 176 and Americana. However, number of holes in all seeds and per a seed in the local cultivar, Deir Alla 2 was significantly less than the other cultivars (Table 3).

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1.10. Immature Stages in Seeds:

Table (3) shows mean number of seeds containing immature stages (Larvae or pupae) in eight barley cultivars collected from different regions in Jordan in 2012 and 2013. Number of seeds containing immature stages in Exad 176, Athroh, Deir Alla 2 and Rum cultivar were significantly the highest, followed by Yarmouk and Balady cultivar.

Table 3: Mean number of holes for eight barley cultivars caused by several stored product insects collected from different regions in Jordan in 2012 and 2013.

Barley Cultivar	No. of holes ±SE		No. of seeds containing immature stages ±SE
	All seeds	Per a seed	
Rum	503.25a ±30	1.2a ± 0.2	70ab ± 5.1
Balady	339.1c ± 16	0.52c ± 0.05	64.3b ± 3.0
Americana	288c ± 10	0.73b ± 0.1	28.3d ± 2.1
Exad 176	301.13c ± 15	0.53c ± 0.05	83.3a ± 8.1
Deir Alla 2	80.6d ± 5	0.1d ±0.01	80.6a ± 7.2
Athroh	424.9b ± 20	0.8b ± 0.06	83.3a ± 8.2
Yarmouk	525.6a ± 40	1.1a ±0.2	66.6b ± 3.1
Mouta	300c ± 15	0.5c± 0.05	50c ± 2.8

Means in columns with the same letters are not significantly different at 0.05 probability using LSD test However, number of seeds containing immature insect stages in the local cultivar, Mouta was significantly less than the other cultivars (Table 3).

1.11. Stored Product Insects in Seeds Samples:

Table (4) shows means numbers of five species of stored product insects in eight barley cultivars seeds collected from different regions in Jordan in 2012 and 2013. The most common species in the seeds samples of all cultivars was the lesser grain borer, *Rhizopertha demonica* L. (Bostrichidae: Coleoptra), followed by the granary weevil, *Sitophilus granarius* L. (Curculionidae: Coleoptrea, the confused flour beetle, *Tribolium confusum* L. (Tenebrionidae: Coleoptra) and the saw-toothed grain beetle, *oryzaephilus surinamensis* L. (Silvanidae: Coleopetra) (Table 4). Balady, Yarmouk and Exad 176 cultivar were significantly infested with *R. dominica* with the highest means, respectively.

Table 4: Means numbers of four stored products insects for eight barley cultivars seeds collected from different regions in Jordan in 2012 and 2013.

	No. of counted insects cultivar ± SE			
Barley cultivar	*Oryzaephilus surinamensis*	*Rhyzopertha dominica*	*Sitphilus granaries*	*Tribolium confusum*
Rum	0c ± 0	11b ± 0.9	0.4c ± 0.05	0c ± 0
Balady	0.3b ± 0.01	25.2a ± 4	2.3b ± 0.11	0c ± 0
Americana	0c ± 0	14.7b ± 1.2	1.33b ± 0.15	1a ± 0.05
Exad 176	1a ± 0.02	21a ± 3	2.6b ± 0.10	0c ± 0
Deir Alla 2	0 c ± 0	7.5c ± 0.5	0d ± 0	0c ± 0
Athrouh	0 c ± 0	12.3b ± 1.0	0 d ± 0	0.3b ± 0.01
Yarmouk	0 c ± 0	23.3a ± 3.5	8.3a ± 0.5	0.3b ± 0.01
Mouta	0 c ± 0	8.3c ± 0.5	0.7c ± 0.05	0c ± 0

Means in columns with the same letters are not significantly different at 0.05 probability using LSD test. Americana, Athroh and Rum cultivar were medium in infestation, compared with Mouta cultivar which was significantly the lowest.

The Yarmouk cultivar was significantly infested with *S. granarius* with a greatest mean (8.3) compared with the other cultivars infestations (Table 4). Exad 176, Balady and Americana cultivar were significantly medium in infestation, followed by Mouta cultivar. Deir Alla 2 and Athroh cultivars were without infestation with the *s. granaries* weevil (Table 4). Americana, Yarmouk and Athroh were significantly infested with *T. confusum* with greatest means compared with the other cultivars, but unfortunately with low means (Table4). Exad 176 and Balady cultivar were significantly infested with *O. surinamensis* with greatest means compared with the other cultivar, but unfortunately with low means (Table4).

Discussion:

Globally , post-harvest losses caused by the irrelevant storage , insects ,pathogens , rodentia and other pests could reach to more than 10 percent of the total food grains [25] .Grain stores should be built in a suitable engineering conditions to have stored seeds under intensive control to protect them from damage and pests infestation. The stores should be well ventilated without seal crack and crevices to prevent insects from getting in. Seeds when harvesting should be protected from pests particularly stored product insects. Some stored

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product insects might move with the grain seeds from the field to the food stores. Grain seeds after harvesting should be stored in the proper way to have healthy ones from insects and diseases. Several steps are needed to prevent and control of insect damage. These are the keeping of bins clean, repaired, use residual sprays, store only clean, dry grain, aerate the grain and inspect the grain regularly. The stored feed and grain seeds should be stored in the well clean, well prepared stores for such storing, free of impurities and pests, with less than 12% moisture, free of weed seeds, will ventilated, suitable temperature and humidity and well prepared for pests fumigation when necessary. Small and broken seeds should be screened because their viability and germination will be low [22,26,4].

In general, barley seeds might be infested with stored products insects in the field and then transferred into the grain bins to be increased in population if not chemically controlled (Al-Mommany and Al-Antary, 2008). Grain seeds selection might be an economic factor in the agricultural practices. Recently, grain technology is considering viability, germination, purity, insects and diseases carried by the seeds are important factors to be successful. In addition, the grain might be cultivated in a country, harvested, and then packed in another country, sold and planted in a third country. These agricultural practices could make the spread of insects and disease easy throughout the world, leading to an increase significant loss in barley yield and expose to hazardous substances. In addition, barley infestation with stored product insects in store houses might cause an increase in temperature and relative humidity which lead to more chances to be infected with different seeds mould's. These microorganisms (fungal organism) are more active when seed-moisture contents are high. Accidental wetting of grain might also stimulate the fungal spores to germinate and cause further mould development [1,2,4].

Storage insect pests detected in the different cultivars seeds of barley are categorized into two types. The first is the primary storage pests which able to infest health, non healthy, broken and crushed seeds such as *R.dominica* [6] and *S.granarius [6,19,15,9]*. The second type is the secondary storage pests which able to infest and damage broken, damaged grain, non healthy, crushed seeds, and flour such as *T. confusum* and *O.surina*mensis. However, the primary storage insects when infesting healthy stored seeds might lead to infestation with the secondary storage insects [15,2,4].

In general, some of the local cultivar barley seeds such as Deir Alla 2, and then Mouta and Balady from the present study have been shown less in numbers of holes in the tested seeds. These results might encourage Jordanian farmers to cultivate and store them, and researchers' specialists in plant breeding to use and develop them to obtain new cultivars with high yield and less infestation with the primary and secondary storage pests in the field and store houses [7].

Generally, the most common species of the stored product insects in the tested and examined barley cultivar seeds were *R. dominica* and *S.granarius*. These two primary storage pests, might dig holes or develop their larvae and pupae stages in the kernels of the healthy and non healthy seeds, damaging seeds, and causing the secondary storage pest to infest and make damage to stored barley seeds. These two primary insects might able to cause holes and live with their different stages on/in the dried barley seeds which were less than 12% water content. Larvae, pupae and adults of those pests might live and develop inside kernels killing embryos, and decreasing viability and seeds germination percentages. They might leave dark spots on the external surfaces of the barley seeds indicating the occurrence of the larvae or pupae or adults inside seeds.

The two secondary storage pests (*T.confusum* and *O.surinamensis*) are very common in Jordan, but they did occur in few numbers in the present study. The first mentioned secondary pest could form sometimes 80% of the whole stored product insects population in the store houses with flour, wheat and barley products [2,4]. These insects might cause direct feeding damage, bad odors, reducing the nutritional value, viability , germination and market value. In addition, they lead to bad seeds quality and deterioration and contamination from the presence of insects and their debris and secretion results in downgrading of grain and heat damage which could transfer to the breads of consumers [2,4,22].However , the most important practice that the grain should be dry before being put in the storage .For long term storage producers are urged the lower the grain temperature below 15 °C [1]

Conclusion:

According to the present records and other related ones in the developing countries; it is concluded that quality control practices are needed. It is needed to get high viability and seeds germination percentages. Insects and diseases infecting barley seeds in the field should be controlled before and after harvesting. Barley seeds should be screened to get rid of insects, their debris, diseases, diseased seeds, impurities, small stones, weed seeds, and broken and crushed seeds.

It is recommended not to store new seeds with old ones or mixing them; not to store seeds in dirty bins; to remove all old seeds, broken and crushed kernels, including nearby or outside store houses. Barley seeds should be stored dry. Storing should be in well equipped buildings for ventilation, computer system to detect any increase in temperature or relative humidity, away from the direct sun, water and insects, well prepared for fumigation when needed, away from feed storage, and animal feeders or stables. Barely seeds should be

inspected daily or at the maximum terms weekly. Thus detecting early any new infestation. In case of finding new infestation, increasing in temperature or infesting with the primary and secondary storage pests; applied fumigation should be immediately initiated as an effective mean of insect control.

ACKNOWLEDGMENT

The authors would like to thank the Research Deanship at the University of Jordan for financing this study. Thanks are also for Engineer lina Al-Oleamy for her lab help and Ms. Nada Al-Antary for typing this manuscript.

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