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Effects of Mechanical Damage and Shriveling of Seed on Germination and Vigour of Two Wheat Varieties

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ABSTRACT Exposure of seeds to mechanical damage and shriveling during production and harvest may reduce seed quality of wheat. In Jordan, wheat is usually exposed to extended drought stress after anthesis, which results in premature termination of seed development and production of shriveled seeds. Therefore, this experiment was conducted to study the effects of mechanical damage and shriveling of seed on seed quality of wheat. Two wheat varieties (Hourani and Sham-1), grown in northren Jordan, were separated into four physical categories; sound seeds, mechanically-damaged seeds, shriveled seeds and foreign materials. Seed germination and vigour, as estimated by seedling dry weight, germination rate index (GRI), germination after accelerated aging, and electrical conductivity (EC) of seed leachate were evaluated for un-separated seeds (control), sound, shriveled, and damaged seeds in both varieties. Sound seeds represented 94 and 92% for Sham-1 and Hourani, respectively. In standard germination test and GRI, only damaged seeds showed significantly lower percentage of normal seedlings and GRI than other seed categories. Percentage of normal seedlings in standard germination test for sound seeds were not significantly different from control and shriveled seeds. In seedling dry weight, both damaged and shriveled seeds produced significantly lower seedling dry weight than sound and control seeds. Sound seeds had significantly higher AA-germination than control, shriveled and damaged seeds for both varieties which indicated that AA-test was useful test to separate seed categories based on quality. Similar results were observed in electrical conductivity (EC) from seed leachate, where the damaged and shriveled seeds had significantly higher electrical conductivity from seed leachate than sound and control seeds.

Key words: Mechanical damage, shriveled seed, germination, wheat

Wheat (Triticum durum) is a major field crop in Jordan. During 2003 season, a total area of 29,781 hectares was harvested, which produced about 42,526 metric tons of wheat [1]. A small part of the produce was used for seeding purposes, whereas, the rest was used for human and livestock feed. Mechanical damage and shriveling of seed adversely affect seed quality. Seed damage and shriveling may result from several factors including adverse environmental conditions, insects and mold damage during production, seed harvesting and handling. Mechanical damage is defined as any physical chop, break, or crack which results from physical stress inflicted upon seed during mechanical harvesting and subsequent handling [2]. Mechanical damage promotes faster seed quality deterioration and easier fungal invasion, more insect infestation, and increased breakage during subsequent handling [3], which results in poor seed viability and vigour.

Several researchers have reported that mechanical damage and shriveling of seeds reduce seed quality. Welch and Delouche [4] showed that germination percentage of cotton seeds increased with the decrease in the mechanical damage. Chowdhury and Buchele [2] correlated the degree and severity of mechanical damage in corn with standard germination test. They reported that the mechanically damaged kernels might germinate as

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long as the embryo and a reasonable portion of the kernel remained intact. They reported a decrease in germination percentage with increase in damage severity. Chowdhury and Kline [5] used the seedling growth rate test to evaluate the effect of internal damage from compression loading on the corn kernel.

The objective of this research was to study the effect of mechanical damage and shriveling of seed on germination and vigour of two wheat varieties harvested in Jordan.

MATERIALS AND METHODS

An experiment was conducted at Jordan University of Science and Technology, Irbid, Jordan to study the effects of mechanical damage and shriveling of wheat seeds (Triticum durum) on germination and vigour. Seeds of two wheat varieties (Hourani and Sham-1) were obtained from Cooperation Organization of Agriculture (Irbid, Jordan) immediately after harvest. Seeds were sealed in plastic bags and stored at 4°C to protect their quality. Random samples of seeds were taken, weighed, and separated into sound (whole kernels), mechanically-damaged, shriveled, and foreign materials under magnification. Sound kernels are those having whole kernel with no visual defect. Mechanically-damaged kernels are those having any physical damage inflicted upon the kernel during harvest or post-harvest operation, and was determined visually under magnification. The shriveled kernels included those seeds with shrunken endosperm and irregular surface. The foreign materials included the inert material, stones, and other crops. The weight percentage of each category (sound, damaged, shriveled, and foreign materials) was obtained by dividing weight of each category by the total seed weight in each physical category were subjected to seed quality analyses.

Standard germination

Twenty five seeds of each physical category (un-separated, sound, mechanically-damaged, and shriveled seeds) were subjected to germination test according to 1STA rules [6]. Four replicates of 30 seeds were placed between moistened, folded germination papers in plastic boxes and covered with lids. The plastic boxes were incubated at 20°C in the dark for 14 days. At the end of the germination test, number of normal seedlings was counted and expressed as a percentage.

Seedling growth rate

Seeds of each category were germinated as described in the standard germination test. At the end of the test (14 days), the shoots and roots of the normal seedlings were excised from the storage organ (endosperm), oven-dried at 80°C for 72 hours, and weighed to determine the dry weight.

Speed of germination

Speed of germination was evaluated for the seeds in each physical category. In the standard germination test, the number of normal seedlings was counted at 4, 7, 10, and 14 days from seed sowing. Speed of germination was calculated according to formulae:

$$GRI = S \frac{\text{No. of normal seedlings}}{\text{day x}}$$

where, x: number of days from sowing

Accelerated aging test

Seeds from each category were placed on a wire mesh screen in plastic containers (11 Lx 11 W x 3.5 H) filled with 50 ml of deionized water. Seeds were subjected to aging by incubating seeds at 45°C for 48 h. After ageing, seeds were planted as described previously for standard germination. At the 14th day of germination, number of normal seedlings were counted and recorded.

Electrical conductivity

Electrical conductivity of seed leachate was measured for seeds in each physical category. In this test, twenty five seeds were soaked in 75 ml of deionized water in 250 Erlenmeyer flasks covered with parafilm and kept at 25°C for 24 h. Electrical conductivity of the seed leachates was measured after 24 h using a conductivity meter. Data were expressed as nб cm^{-1} g^{-1} of seed.

Statistical Analysis

The collected data were statistically analyzed in a randomized block design using SAS program (SAS

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institute, V 8.2). Means were separated and the least significant difference (LSD) was calculated.

RESULTS AND DISCUSSION

Percentage of sound, mechanically-damaged, shriveled, and foreign materials for the two wheat varieties (Hourani and Sham-1) harvested in northern Jordan is shown in table 1. The majority of seeds were sound (seeds without physical defects), with Sham-1 having slightly more sound kernels (94 %) than Hourani (92 %). Both varieties had some degree of shriveling; Sham-1 had about twice shriveling as much as Hourani (2.3 % and 1.3 %), respectively. As far as mechanical damage, Hourani showed about 4 per cent damage, whereas, Sham-1 had no damaged seeds. This might be due to genotype differences that resulted in harder Sham-1 kernels compared with Hourani kernels. The results indicated that sound seeds represented the majority of the harvested seeds in both varieties.

Table 1. **Percentage by weight of different seed categories of two wheat varieties**

Variety	% by weight			
	Sound	Damaged	Shriveled	Foreign materials
Hourani				
Average	92.1	4.0	1.3	2.6
SD	0.5	0.3	0.3	0.6
Sham-1				
Average	94.3	0.0	2.3	3.4
SD	1.6	0.0	0.6	1.0

Seed germination and vigour [as estimated by standard germination test, seedling dry weight, germination rate index (GRI), accelerated aging test, and electrical conductivity of test] for different seed categories [Un-separated (control), sound, shriveled, and damaged] were shown in tables 2 and 3. The percentage of normal seedlings and the values of GRI were generally high for both varieties for all physical categories except for the mechanically-damaged. Only damaged seeds showed a significantly lower percentage of normal seedlings and value of GRI than other physical categories of seed as shown in table 2. Chowdhury and Buchele [2], working with corn, reported that

Table 2. **Standard germination test, seedling dry weight and speed of germination (as measured by germination rate index) of different seed categories of two wheat varieties**

Variety/ Treatment	Standard germination test (%)			GRI	Seedling dry weight mg/seedling
	N	Ab	D		
Hourani					
Control	86	3	11	3.65	16.5
Sound	93	2	5	3.98	17.3
Shriveled	87	3	10	3.75	9.2
Damaged	2	2	96	0.05	10.0
LSD ($p \leq 0.05$)	9.9	4.5	7.9	0.40	8.0
Sham-1					
Control	94	1	5	3.95	16.5
Sound	98	2	0	4.10	18.1
Shriveled	95	3	2	3.95	8.4
Damaged	*	*	*	*	*
LSD ($p \leq 0.05$)	6.8	5.3	2.7	0.35	2.2

*The damage was 0 % for this variety. [N - Normal; Ab - Abnormal; D - Dead; GRI - Germination rate index]

severely damaged corn kernels had germination less than 5 per cent. Mechanical damage reduced seed germination of amaranth (Amaranthus spp.) compared with hand-harvested seeds [7, 8]. They concluded that the decrease in germination was probably due to damage caused by the plot combine. Al-Yahya [9] showed that seed germination in wheat was reduced as mechanical damage increased. In our study, the reduction in the percentage of normal seedlings for the mechanically damaged seeds was as a result of production of dead seeds. Sound seeds were not significantly different in percentage of normal seedlings in standard germination test from control and shriveled seeds. These results indicated that mechanical damage in seed significantly reduced the standard germination and GRI of wheat, whereas, seed shriveling had no significant effect on both parameters. In seedling dry weight, both damaged and shriveled seeds produced significantly lower seedling dry weight than sound and control seeds as indicated in table 2. Similar results were reported for corn by Chowdhury and Kline [5]. However, no significant difference in

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seedling dry weight was observed between sound and control seeds in present study. In the accelerated aging test, sound seeds had a significantly higher percentage of normal seedlings than control, shriveled, and damaged seeds in both varieties (Table 3). The difference, however, appeared to be higher in Sham-1 than in Hourani variety. This reduction in the percentage of normal seedlings in accelerated aging test was mainly due to the presence of high number of dead seeds. These results indicated that sound seeds had the best AA-germination compared with other seed categories, although the overall germination percentage of the sound seeds in both varieties was lower than 65 per cent. Similar results were reported by Al-Yahya [9], who found that undamaged wheat seeds stored at high temperature and moisture content maintained higher germination as compared to damaged seeds stored under the same conditions. Present investigation showed that shriveled seeds had lower germination after accelerated aging than sound seeds. Electrical conductivity (EC) of seed leachate supported the results of the accelerated aging test, where damaged and shriveled seeds had significantly higher electrical conductivity than sound and control seeds. However, values of EC were not significantly different between sound and control seeds.

Mechanical damage has been shown to be detrimental to seed quality as reported by many workers [2, 4]. Many reports have shown that damaged seeds had lower germination and faster deterioration during storage [9]. Our results are in agreement with the previous findings. Our results showed that lower quality of the damaged seeds was identified by standard germination test, whereas, the quality of the shriveled seeds was not sufficiently detected by the standard germination test and required other seed vigour tests. The germination after accelerated aging test proved to be useful to separate low quality shriveled seeds from high quality sound seeds. These findings are very important for agronomists and growers, especially in Mediterranean regions, where crops are often exposed to extended severe post-anthesis drought periods during seed development and maturation, resulting in produc-tion of high percentage of small and shriveled seeds.

Table 3. Accelerated aging test and electrical conductivity of seed leachate of different physical categories of two wheat cultivars

Variety/Treatment	Accelerated aging test (%)			EC
	N	Ab	D	
Hourani				
Control	38	6	56	84
Sound	57	5	38	72
Shriveled	24	3	73	145
Damaged	5	0	95	185
LSD ($p \leq 0.05$)	17	5.6	19	22
Sham-1				
Control	36	5	59	70
Sound	65	2	33	65
Shriveled	16	3	81	117
LSD ($p \leq 0.05$)	9.9	5	14.0	30

N - Normal; Ab - Abnormal; D - Dead; EC - Electrical conductivity

In conclusion, the results of seed standard germination and vigour tests indicated that shriveled seeds had lower seed vigour (as determined by SDW test, AA-germination test, EC test) than sound seeds, whereas, standard germination test showed that the difference between sound and shriveled seeds was not significant. Mechanically damaged seeds had lower ratings of both seed vigour and standard germination tests compared to sound seeds. The standard germination test, therefore, can be used to evaluate the mechanically damaged seeds.

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