

A Study on the Seed Susceptibility of Wheat (*Triticum aestivum* L.) Cultivars to Impact Damage

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ABSTRACT

Mechanical damage due to harvesting, handling, and other processes is an important factor that affects the seeds quality. Seed damage results in lower grain value and more storability problem and reduces seed germination and seedling vigor and subsequent yield of crops. Tests were conducted to determine the percentage of physical damage (PPD) and percentage of loss in germination (PLG) of wheat seeds due to impact. The effect of wheat seed cultivar and impact velocity was determined. Wheat seed cultivars selected for testing included: Kohdasht, Maron, Simereh, Sardari and Zagros. Four impact velocities: 10, 20, 30 and 40 m s⁻¹ were used. Results showed that effects of impact velocity and seed cultivar on seed damages were significant. PPD to seeds was higher than PLG in higher impact velocities. It found that the total damage of seeds increased from 4.17% (0.48 PPD and 3.68 PLG) to 73.32% (47.59 PPD and 25.73 PLG) as impact velocity increased from 10 to 40 m s⁻¹ for all wheat cultivars studied. Impact results indicated that Sardari wheat cultivar was more susceptible to PPD (27.39%), while Maron seeds were more susceptible to PLG (14.70%). Among the cultivars studied, Sardari wheat seeds showed the highest level of total damage i.e. sum of PPD and PLG.

Keywords: Handling, Harvesting, Loss in germination, Mechanical damage, Processing.

INTRODUCTION

Wheat seeds are subjected to a series of static and dynamic loads during harvesting, handling, processing, and storage. Such loadings cause external and internal damage of seeds, which reduces quality and can compromise both viability and vigor (Grass and Tourkmani, 1999). Many studies have been conducted to investigate the effects of mechanical damage to wheat seeds (King and Riddolls, 1960; Mitchell and Roundthwaite, 1964). The general conclusion is that mechanical damage might significantly reduce the viability of wheat seed. Planting of low vigor wheat seed results in poor establishment, slow seedling development, and yield reduction (Ayre, 1980). Wheat threshed at a high cylinder

speed causes abnormal seedling development in germination tests (Mitchell and Roundthwaite, 1964). Fiscus *et al.* (1971) tested the damage of some grains (corn, soybeans, and wheat) due to various handling techniques and observed that dropping of grains from heights greater than 13 m caused more breakage than those handled by the grain thrower or bucket elevator. They also observed that the grain stream from 200 mm diameter orifice incurred more breakage than the grain stream from 300 mm diameter orifice.

Paulsen *et al.* (1981) observed that an increase in impact velocity resulted in increase of split beans. Evans *et al.* (1990) studied soybean seeds impacted with a seed impacting device at four moisture contents (7.2, 10.1, 12.9, and 16.2%), four impact

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velocities (10, 20, 30, and 40 m s⁻¹), and five seed orientations (end opposite the hypocotyl, hilum, hypocotyl, back or side opposite the hilum, and either side of the cotyledon). A steel impact surface caused the highest damage, while the polyurethane surface caused the least. Seed damage increased with impact velocity and decreased with moisture content. Bartsch *et al.* (1979) observed that impact damage for soybeans at 5 m s⁻¹ and 10 m s⁻¹ was statistically similar. Nevertheless, damage increased when the impact velocity increased from 10 m s⁻¹ to 15 m s⁻¹. Moisture content and temperature also significantly affected impact damage. As moisture decreased from 18 to 8% (wet basis) and as temperature decreased from 20 to 0°C, in both cases, the impact damage increased. In a study of breakage susceptibility of lentil seeds, Tang *et al.* (1991) observed that, for the same moisture content, the breakage in samples was higher at -25°C than at room temperature of 22°C. The increase in breakage at -25°C was attributed to crystallization of the available free water. Nevertheless, when moisture content was less than 10%, the lower temperature did not cause an increase in breakage.

The objective of the present research was to test various cultivars of wheat seed for damage due to impact (PPD= Percentage of physical damage and PLG= Percentage of loss in germination) and to determine the effects of wheat seed cultivar and impact velocity on the degree of damage.

MATERIALS AND METHODS

Experimental Design

In this study, the effects of wheat variety and impact velocity were studied on the PPD and PLG. Table 1 shows the variable levels used in this study. The data recorded in the laboratory test conditions were statistically analyzed using the two factors randomized complete block design. Cultivars selected for testing included current popular cultivars

Table 1. Variables levels used in impact experiments.

Wheat Cultivar	Impact Velocity (m s ⁻¹)
Kohdasht	10
Maron	20
Sardari	30
Simereh	40
Zagros	

grown in Lorestan Province, Iran. The selected impact velocities used in this study were in agreement with those occurring in head-stripper combines as well as in harvesters, threshers, separator, conveyor, and other processing systems (Stout and Cheze, 1999; Khazaei *et al.*, 2008).

Sample Preparation

Undamaged seeds were obtained by hand harvesting from the farms in Lorestan, Iran. The seeds of the wheat cultivars were placed in a humid environment for one month to standardize moisture content. Before impact test, initial moisture content and germination of seeds were determined. Moisture contents (wet basis) of the samples were measured by drying triplicate sub-samples in a convection air oven at 130°C for 19 hours (ASAE, 1993).

Impact Device

The tests were conducted under laboratory conditions. Each sample was impacted using an impact device shown in Figure 1. Four steel impact tips (hammer), having a striking face 5 cm wide by 20 cm high, were mounted on a disk (40 cm diameter), rotating in the vertical plane. The impact point on the steel tips moved through a path having a radius of 30 cm. A horizontal slider and rail were mounted just under the disk and impact tips. The slider has 15 seed-supporting pedestals made of flexible plastic tubing. Seeds were held on the pedestals by gravity and the slider was moved toward the

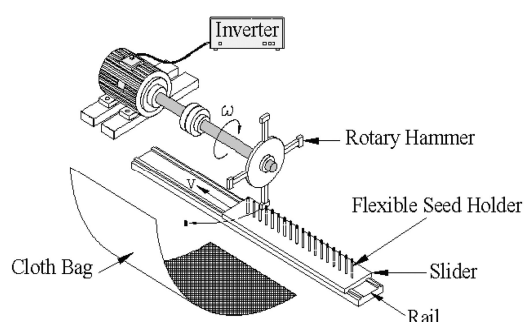


Figure 1. Schematic diagram of impact device.

impact tips and seeds were impacted one-by-one. A cloth bag behind the machine caught the impacted seeds. The impact velocity of the tips was adjusted by changing the velocity of the electromotor through an inverter set. Rigid parts of the device were covered with soft cloth to prevent additional impact to seeds. The average values of the temperature and relative humidity of the laboratory where the tests were carried out were $25\pm 2^{\circ}\text{C}$ and $50\pm 10\%$, respectively.

Seed Damage Assessment

Seed damage was evaluated using two different methods. The first method was by visual inspection of the physical damage to seeds including splits, cracks, or any seed coat penetration. Physical damage was quantified by removing and weighing the damaged seeds from the sample and expressing this weight as a percent of the original sample weight (Khazaei *et al.*, 2008). The second assessment method was to quantify hidden damage (physiological damage) to the seeds. Hidden damage was determined by subjecting the undamaged seeds from each combination of variables to germination tests. For germination tests, samples were placed in presoaked germination paper and then placed in a seed germinator at 20°C for 7 days. After 7 days, the percentage of the normally germinated seeds was recorded (Khazaei *et al.*, 2008; Bourgeois *et al.*, 1995). The loss of germination was determined based on the initial percentage of germination of the

untreated (control) seeds (Table 2). Total damage was calculated as the sum of the PPD and PLG damages.

Data Analysis

The data collected during the experiments were analyzed using the procedure of SAS (SAS 1985) to study the effects of wheat cultivar and impact velocity on the parameters of seed damages.

RESULTS AND DISCUSSION

Table 2 shows the initial conditions of wheat seed cultivars before the impact tests. The analysis of variance of the impact damage data indicated that the effects of wheat seed cultivar and impact velocity were significant on the PPD and the total damage to seeds at 1% probability level, while the effect of impact velocity was significant on PLG (Table 3). Impact velocity had a larger influence on the physical and physiological damages to wheat seeds than wheat seed cultivar within the range studied (Table 3).

Table 4 shows the Duncan's multiple range tests comparing the means of each independent variable. As shown in the Table 4, the seed damages increased as impact velocity increased from 10 to 40 m s^{-1} . Impact velocities of 10 and 20 m s^{-1} caused the highest levels of PLG, while 30 and 40 m s^{-1} velocities caused the highest levels of PPD. Similar results have been reported by Bilanski (1966) for wheat, Evans *et al.* (1990) for soybeans, Bergin *et al.* (1993) for

Table 2. The initial conditions of wheat seed cultivars before impact test.

Wheat cultivar	Moisture content (%)	Germination (%)
Kohdasht	9.15	96.93
Maron	8.95	96.49
Sardari	9.09	97.60
Simereh	9.20	97.93
Zagros	9.27	98.98

**Table 3.** Analysis of variance (mean square) for the percentage of physical damage, percentage of loss in germination and total damage to seeds as affected by wheat cultivar and impact velocity.

Source of variation	DF	Mean square (MS)		
		PPD (Percentage of physical damage)	PLG (Percentage of loss in germination)	Total damage (PPD+PLG) (%)
Wheat cultivar (WV)	4	280.91**	24.92 ^{ns}	314.61**
Impact velocity (IV)	3	7807.30**	1479.91**	15927.89**
WV×IV	12	74.93 ^{ns}	45.39 ^{ns}	80.24 ^{ns}
Error	40	38.89	46.91	73.50

** Significant at the 0.01 probability level. ns: Not significant.

Table 4. The Duncan's multiple range tests comparing the means of each independent variable.

Independent variable	PPD	PLG	Total damage (%)
Impact velocity (m s ⁻¹)			
10	0.48c*	3.68c	4.17c
20	3.88c	6.26c	10.14c
30	32.85b	14.57b	47.43b
40	47.59a	25.73a	73.32a
Wheat cultivar			
Kohdasht	24.08ab	11.27a	35.36ab
Maron	21.19abc	14.70a	35.90ab
Sardari	27.39a	12.93a	40.33a
Simereh	14.95c	12.72a	27.68 b
Zagros	18.38bc	11.18a	29.57ab

* Means followed by the same letter for columns (a, b and c) are not significantly different (P= 0.01).

Larid lentils, Bourgeois *et al.* (1995) for wheat, Baryeh (2002) for bambara beans, Szwed and Lukaszuk (2007) for rapeseed and wheat kernel and Shahbazi (2010) for chickpea seeds. As shown in the Table 4, the difference between all damages at 20, 30 and 40 m s⁻¹ impact velocities were significant at the 1% level.

According to Table 4, Simereh cultivar showed the highest resistance to impact damage, followed by Zagros, Maron, Kohdasht, and Sardari cultivars. Sardari cultivar showed the maximum susceptibility to the PPD (27.39%) and had the highest level of total damage among all wheat cultivars studied. The difference between Sardari and Simereh cultivars was significant at the 1% level (Table 3).

Figure 2 shows the means comparison of the interaction effects of wheat cultivar and impact velocity on the PPD to seeds. From

Figure 2, it can be seen that increasing of impact velocity for each wheat cultivar increased the PPD. Based on this figure, the average value for the PPD to wheat seeds at all velocities was found to be 21.20%. As shown in Figure 2, the greatest PPD value obtained was 57.98%, as recorded for the 40 m s⁻¹ impact velocity for Sardari cultivar. The lowest value recorded was 0.18% corresponding to the 10 m s⁻¹ velocity for Zagros cultivar.

Kohdasht cultivar had the highest level of damage (1.02%) and Zagros cultivar had the lowest level of damage (0.18%) at 10 m s⁻¹ velocity. Sardari cultivar had the highest level of damage (5.69%) and Zagros cultivar had the lowest level of damage (2.12%) at 20 m s⁻¹ velocity. Sardari seeds had the highest levels of damage (45.49 and 57.98%, respectively) and the lowest levels were for Simereh (23.13 and 33.78%) at 30 and 40 m

s^{-1} velocities, respectively. From the data in Figure 2 it can be seen that Sardari wheat cultivar was more susceptible to PPD than the other cultivars at impact velocities higher than $10 m s^{-1}$.

The means of the PLG due to different treatments are given in Figure 3. Increased velocities from 10 to $40 m s^{-1}$ caused an increase in the physiological damage to wheat seeds for all cultivars, except for Sardari. The PLG of Sardari cultivar at $20 m$

s^{-1} velocity (6.60%) was lower than that of the $10 m s^{-1}$ (7.62%).

In Table 3, the lowest physiological damage among the combinations was 2.01% and occurred in the $10 m s^{-1}$ velocity for Simereh cultivar, while the greatest physiological damage was 33.37% at the $40 m s^{-1}$ velocity for Maron cultivar. The average values for the PLG damage to wheat seeds (Figure 3) was 12.56% . In comparison to the average values for the PPD in Figure 2

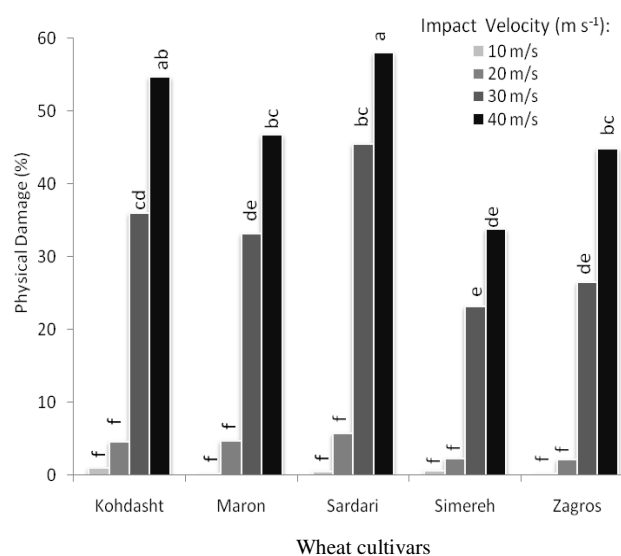


Figure 2. Effect of wheat cultivar and impact velocity interactions on the percentage of physical damage of seeds.

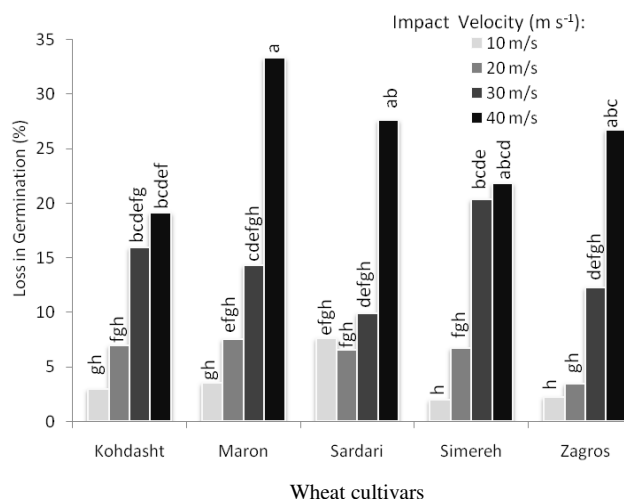


Figure 3. Effect of wheat cultivar and impact velocity interactions on the percentage of loss in germination of seeds.



(21.20%), it was found that the percentage of physical damage to wheat seeds was 1.68 times higher than that of the percentage of physiological damage.

As shown in Figure 3 at impact velocity of 10 m s⁻¹, Sardari cultivar had the highest level of the PLG damage (7.60%) and Simereh cultivar had the lowest level of damage (2.01%). At velocities of 20 and 40 m s⁻¹, the highest levels of the PLG were for Maron (7.58 and 33.37 %, respectively) and the lowest levels were for Zagros and Kohdasht cultivars, respectively (3.46, and 19.16%, respectively). At the velocity of 30 m s⁻¹, Simereh seed cultivar had the highest level of damage (20.37%) and Sardari cultivar had the lowest (9.93%).

Figure 4 shows the total damage (sum of the PPD and PLG) to wheat seed cultivars at the four impact velocities used. From this figure, it can be seen that, at all four impact velocities, Sardari cultivar had the highest levels of damage among the cultivars studied. The percentage of the total damage to this cultivar was found to be 8.02, 12.29, 55.42, and 85.58%, at velocities of 10, 20,

30 and 40 m s⁻¹, respectively. At 10, 20 and 30 m s⁻¹ velocities, Zagros cultivar (2.43, 5.58 and 38.75%, respectively), and at the velocity of 40 m s⁻¹, Simereh cultivar (55.58 %) had the lowest levels of the total damage, respectively (Figure 4).

Mitchell and Rounthwaite (1964) have reported similar results. They studied two wheat cultivars to determine their resistance to impact. They used a rotating hammer to strike individual grains. It was reported that for both cultivars, visual impact damage increased as the velocity of impact increased. It was also reported that the resistance to damage varied from one cultivar to the other. Similar results have been reported for other crops by Kirk and McLeod (1967), Ptasznik *et al.* (1995), Parde *et al.* (2002), and Sosnowski (2006). The explanation of why some wheat cultivars are more susceptible to PPD or PLG damage due to impact may be related to the difference in the structural features of the seed of different cultivars, such as composition, density, size, shape, rupture, and hardness.

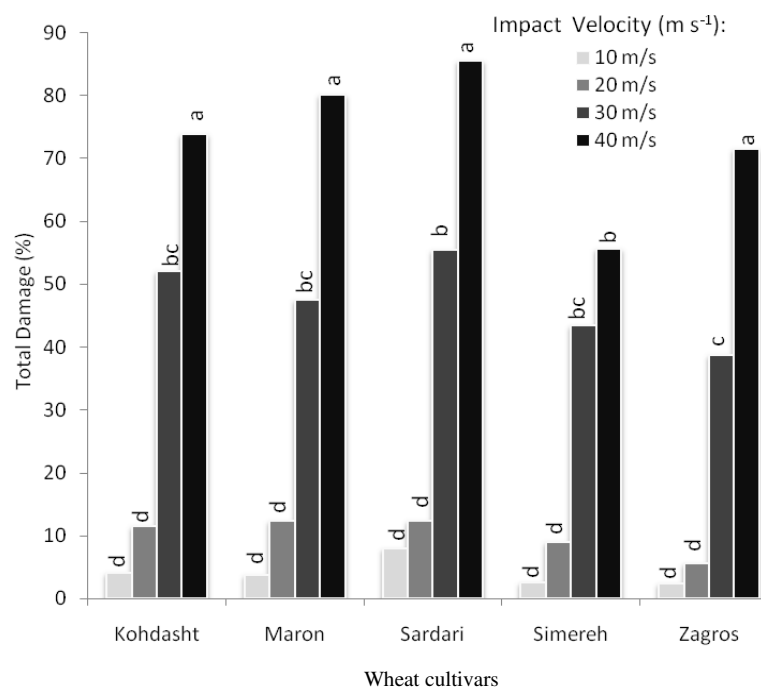


Figure 4. Interaction effects of wheat cultivar and impact velocity on the total damage to seeds.

CONCLUSIONS

Results of this study showed that the impact velocity was a significant factor causing physical and physiological damages to wheat seeds. With increasing impact velocity from 10 to 40 m s⁻¹, the mean values of PPD and PLG increased from 0.48 to 47.59% and from 3.68 to 25.73%, respectively. Impact velocities of 30 and 40 m s⁻¹ caused the highest levels of PPD, PLG and total damage. Physical damage to seeds was approximately 1.68 times higher than physiological damage. Sardari wheat cultivar had the highest levels of the total damage among the cultivars studied and its seeds suffered a mean total damage of 40.33% in comparison with the means of 35.90, 35.36, 29.57, and 27.68% for Maron, Kohdasht, Zagros, and Simereh cultivars, respectively. However, the data indicated that Simereh cultivar appeared to have the optimum damage resistance, resulting in minimal physical and physiological damages.

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بررسی حساسیت بذر ارقام گندم به صدمات ناشی از ضربه

ف. شهبازی

چکیده

صدمات مکانیکی بذرها که در طی برداشت، انتقال و دیگر فرآیندها رخ می‌دهد، فاکتور مهمی است که بر روی کیفیت آن‌ها تاثیر می‌گذارد. صدمه بذر باعث کاهش ارزش محصول، کاهش قابلیت نگهداری، کاهش درصد جوانه زنی و قدرت رویشی بذر و در نتیجه کاهش عملکرد محصول می‌شود. در این تحقیق صدمات وارده به بذر گندم در اثر ضربه به صورت درصد صدمات فیزیکی (PPD) و درصد کاهش جوانه زنی (PLG) مورد بررسی قرار گرفت. اثر رقم گندم و سرعت ضربه بر روی میزان صدمات اندازه‌گیری شد. رقم‌های گندم مورد مطالعه عبارت بودند از: کوهدشت، مارون، سرداری، سیمره و زاگرس. سرعت ضربه در چهار سطح: ۱۰، ۲۰، ۳۰ و 40 m s^{-1} در نظر گرفته شد. نتایج نشان داد که اثرات سرعت ضربه و رقم محصول بر روی صدمات وارده به بذرها معنی‌دار است. صدمات وارده به بذرها به صورت PPD بیشتر از PLG بود. کل صدمات وارده به بذر همه رقم‌های مورد مطالعه با افزایش سرعت ضربه از 10 به 40 m s^{-1} از $4/17$ درصد (PPD $0/48$ و PLG $3/18$) به $73/32$ درصد (PPD $47/59$ و PLG $27/73$)، افزایش یافته بود. نتایج تست ضربه نشان داد که رقم گندم سرداری بیشترین حساسیت را از لحاظ PPD ($27/39$ درصد) و رقم مارون بیشترین حساسیت را از لحاظ PLG ($14/70$ درصد) داشتند. بذرهای رقم گندم سرداری بیشترین مقدار کل صدمات (مجموع PPD و PLG) را نسبت به دیگر ارقام از خود نشان داده بودند.