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EFFECT OF ZINC SULPHATE FERTILIZER RATE ON THE BREAKAGE SUSCEPTIBILITY OF THREE WHEAT VARIETIES

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ABSTRACT. Mechanical damage of seeds due to harvest, handling and other process is an important factor that affects the quality and quaintly of seeds. Seed damage results in lower grain value, storability problem, and reduces seed germination and seedling vigor and subsequent yield of crops. The objectives were to determine the effect of different levels of zinc sulphate fertilization on the breakage susceptibility of three irrigated wheat varieties (*Bahar*, *Shiraz* and *Pyshtaz*). An experiment was conduct at the Experimental research station of Lorestan University, Iran. A factorial experiment was conducted with three replicates in a completely randomized block design (CRBD). Factors included three levels of zinc sulphate. Zinc sulphate treatments were combinations of three fertilization rates (0 - control, 25 and 50 kg/ha) at three replicates. The harvested seeds were subjected to impact energies of 0.05 and 0.1 J at constant moisture contents of 9.8, 15 and 20% using an impact test apparatus. The analysis of variance showed that wheat variety, fertilization level of zinc sulphate and moisture content significantly influenced breakage susceptibility of wheat seeds at the 1% probability level. Resistance to the breakage of wheat seeds for all varieties increased, as polynomial functions, with increase in the zinc sulphate rate. The average values of percentage breakage of seeds decreased from 37.07 to 27.80% as the fertilization level of zinc sulphate increased from 0 to 50 kg/ha. *Bahar* variety exhibited the highest resistance to breakage than other varieties. As the moisture content increased from 9.8 to 20% the percentage breakage of seeds decreased from 36.58 to 30.03%. Increasing the impact energy from 0.05 to 0.1 J caused an increase in the percentage breakage of seeds from 16.19 to 50.47%.

Key words: Wheat; Mechanical damage; Harvesting; Handling; Fertilization; Zinc sulphate.

INTRODUCTION

Cereal seeds such as wheat are subjected to a series of static and dynamic loads during harvesting, handling, processing, and storage.

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Such loadings cause external and internal damage in seeds, which lead to decreases in quality and can eliminate both viability and vigor (Khazaei *et al*., 2008). The harvesting and the postharvest operations negatively influenced the seeds quality. The machinery and equipment for harvesting, transporting, storage and processing caused significant mechanical damage to seeds i.e. skin rupture, seed fracture etc. The damage resulted from mechanical interaction between biological material (seeds) and machineries material (steel, rubber, etc.). Most authors admit that the seeds damage mainly occurs in the course of harvest and transport, where the seeds are damaged by impact forces (Baryeh, 2002; Khazaei *et al*., 2008).

The mechanical resistance to the impact damage of seeds among other mechanical and physical properties plays a very important role in the design and operational parameters of equipment relating to harvesting, threshing, handling and other processing of the seeds (Baryeh, 2002). Impact damage of seeds depends on a number factors such as velocity (energy) of impact, seed structural features, seed variety, seed moisture content, stage of ripeness, fertilization level and incorrect settings of the particular working subassemblies of the machines. Among above factors, the seed moisture content and impact velocity are important factors influencing the damage. Some researchers found a significant influence of the impact velocity and moisture content upon the seed damage and found that the damage increases significantly as the energy of the impact increases and as the moisture content decreases (Baryeh, 2002; Parde *et al*., 2002).

Impact damage to seeds has been the subject of much research due to the loss in product quality incurred during harvesting, handling and processing. Researchers have used different impact damage assessment devices to conduct impact tests on seeds. Many studies have been conducted to determine the mechanical damage to seeds, such as: Fraczek and Slipek (1998) on wheat, Kim *et al*. (2002) on maize, Parde *et al*. (2002) on soybean seed, Sosnowski (2006) on bean seed, Szwed and Lukaszuk (2007) on rapeseed and wheat kernels, Khazaei *et al*. (2008) on wheat seed, Khazaei (2009) on white kindey bean, Shahbazi (2011) on chickpea seed, Shahbazi *et al*. (2011a) on pinto bean, Shahbazi *et al*. (2011b) on navy bean and Shahbazi (2012) on wheat seed.

Information on the breakage susceptibility of wheat seeds varieties related to different fertilization level of zinc sulphate is limited. Therefore, the objective of this study was to investigate the effects of different fertilization level of zinc sulphate and wheat variety on the breakage susceptibility of wheat seeds under impact loading.

MATERIALS AND METHODS

Wheat seeds of the *Bahar*, *Shiraz* and *Pyshtaz* cultivars were chosen to be used in this research. An experiment was conducted during 2013 growing season, at the Experimental research station of Lorestan University, Iran. A factorial experiment was conducted with three replicates in a completely randomized block design (CRBD). Factors included three levels of zinc sulphate (0 (control), 25 and 50 kg/ha).

After attaining optimum maturity, samples of seeds were harvested by hand and cleaned in an air screen cleaner. The initial moisture content of seed treatments were about 9.8% (wet basis) determined with ASAE S352.2 (ASAE Standards, 1988). The higher moisture content (15 and 20%) samples were prepared by adding calculated amounts of distilled water, then sealing in polyethylene bags, and storing at 5ºC for 15 days. 9.8, 15 and 20% moisture contents are including the normal moisture level during harvesting and postharvest processing for seeds (Khazaei *et al*., 2008). The laboratory apparatus used to impact seeds, operated in a way similar to the impacting energy instruments used by Asoegwu (1995), Kim *et al*. (2002), Oluwole *et al*. (2007) and Shahbazi *et al*. (2012).

In this study, the effects of wheat variety (*Bahar*, *Shiraz* and *Pyshtaz*), fertilization level of zinc sulphate [0 (control), 25 and 50 kg/ha], moisture content (9.8, 15 and 20%) and impact energy (0.05 and 0.1 J) were studied on the percentage breakage of whet seeds. The factorial experiment was conducted as a randomized design with three replicates. For each impact test, 100 seeds were selected randomly from each sample and impacted by using the impact device. After each test, damaged seeds include the broken, cracked, and bruised seeds were accurately identified and sorted by visual inspection. A handheld magnifying glass was used to augment the visual inspection. Sample mass was recorded with a digital electronic balance having an accuracy of 0.001 g. The percentage of seed damage was calculated as:

$$Seed\ breakage = \frac{(Weight\ of\ damaged\ seeds)}{\left(Weight\ of\ total\ seeds\left(damaged + undamaged\right)\right)} \times 100 \quad (1)$$

Experimental data were analyzed using analysis of variance (ANOVA) and the means were separated at the 5% probability level applying Duncan's multiple range tests in SPSS 17 software.

RESULTS AND DISCUSSION

The data obtained from this study showed that the significant differences in the susceptibility of wheat seeds to mechanical damages were revealed at different levels of of zinc sulphate fertilization, wheat variety, moisture content and impact energy. The analysis of the data variance (*Table 1*) indicated that fertilization level, wheat variety, moisture content and impact energy significantly influenced the percentage breakage of wheat seed at the 1% probability level. Impact energy had the most influence (F=12950.58) but, fertilization level (F=351.29), moisture content (F=157.41) and wheat variety (F=139.23) had the least, respectively, within the ranges studied for variables (*Table 1*).

The results of Duncan's multiple range tests for comparing the mean values of the percentage breakage of wheat seeds at different fertilization levels of zinc sulphate is presented in *Fig. 1*. It is evident from *Fig. 1* that the percentage breakage of seeds decreased as a quadratic function, with increase in zinc sulphate dose. There is an exponential relationship between seed breakage and zinc sulphate dose with an R^2 value of 1. No reported results for effect of fertilization level of zinc sulphate on the breakage susceptibility of wheat seeds were found to compare with the results obtained in this study. However, Gorzelany (1999) has also noted the significant effect of fertilizer dose on value of seed mechanical damage for horse bean seeds. He reported that beans from the plot with a fertilization dose: N-40 kg/ha, P_2O_5-120 kg/ha and K_2O-70 kg/ha exhibited the highest resistance to cracking. Shahbazi *et al*. (2012) reported that the percentage breakage of triticale seeds decreased from 32.592 to 16.9268% as the fertilization level of zinc sulphate increased from 0 to 60 kg/ha.

Table 1 - Analysis of variance (Mean square) for the percentage breakage of wheat seeds as affected by moisture content, wheat variety, zinc sulphate fertilization level and impact energy

Source	DF	Mean Square	F
Moisture content (MC)	2	578.615	157.417**
Wheat variety (WV)	2	511.795	139.238**
MC× WV	4	20.589	5.602**
Fertilization level (FL)	2	1291.259	351.297**
MC× FL	4	27.842	7.575**
WV × FL	4	396.350	107.830**
MC× WV× FL	8	13.143	3.576*
Impact energy (IE)	1	47602.368	12950.588**
MC× IE	2	34.142	9.289**
WV × IE	2	296.829	80.754**
MC× WV× IE	4	2.408	0.655ns
FL × IE	2	422.572	114.964**
MC× FL× IE	4	8.029	2.184 ns
WV × FL× IE	4	309.330	84.155**
MC× WV× FL × IE	8	5.188	1.411 ns
Error	108	3.676	

**: significant at the 0.01 probability level, *: significant at the 0.05 probability level and ns: not significant.

These results confirm that, as the fertilizer dose has significant effects on the biological, physical and thermal properties of materials of plant origin, also have a bearing on the effects of seed hardness and

resilience, playing an important role in the resistance to damage. The higher seed resilience, the better resistance to damage and therefore higher their sowing value/potential. Particularly important here is the seed cover, its structure, position and chemical composition (Gorzelany, 1999). With increasing the fertilization level of zinc sulphate from 0 to 50 kg/ha the mean values of the percentage breakage significantly decreased about 1.33 times (from 37.074 to 27.801%). The average values for the percentage breakage were found to be 37.074, 35.130 and 27.801% for fertilization levels of zinc sulphate of 0, 25 and 50 kg/ha, respectively. The mean values of the percentage breakage at the different fertilization levels of zinc sulphate had significant differences (P<0.05) base on the Duncan's multiple range tests (*Fig. 1*).

The interaction between zinc sulphate fertilizer rate and seed moisture content on the percentage damage to wheat seeds was significant ($P<0.01$) (*Table 1*). *Fig 2* shows the variation of the seed breakage with the fertilization rate of zinc sulphate, at different moisture contents. As follows from the relations presented in the *Fig. 2*, for all the moisture contents considered, the breakage of seeds decreased as polynomial equations, with increase in rate of zinc sulphate. In addition, the damage decreased with increase in the moisture content, for all the zinc sulphate rates. The average values for the percentage breakage of wheat seeds were found to be 36.583, 33.384 and 30.0370% for the moisture contents of 9.8, 15 and 20%, respectively, at all the zinc sulphate rates. Similar results about reducing the seed breakage with increasing in the seed moisture content were also reported by Parde *et al* (2002), Szwed and Lukaszuk (2007) Khazaei *et al* (2008) and Khazaei (2009). The highest seed breakage value in *Fig. 2* was obtained as 39.315% in the 0 kg/ha zinc sulphate rate at a moisture content of 9.8%, while the lowest value was found to be 23.407% in the 50 kg/ha zinc sulphate rate at a moisture content of 20%. As shown in *Fig. 2*, the rate of decrease in breakage of seeds by increase in the rate of zinc sulphate is not the same for all the levels of moisture contents. The effect of fertilization level of zinc sulphate on the reducing of the seeds breakage is stronger at higher moisture contents than at lower ones. At 9.8% seed moisture content, the percentage breakage of seeds decreased from 39.315 to 32.583% (by 1.20 times) with increasing in the zinc sulphate rate from 0 to 50 kg/ha. Corresponding percentage damages were from 37.148 to 27.413% (by 1.35 times) and from 34.759 to 23.407% (by 1.48 times) for the same zinc sulphate rate, at 15 and 20% moisture contents, respectively.

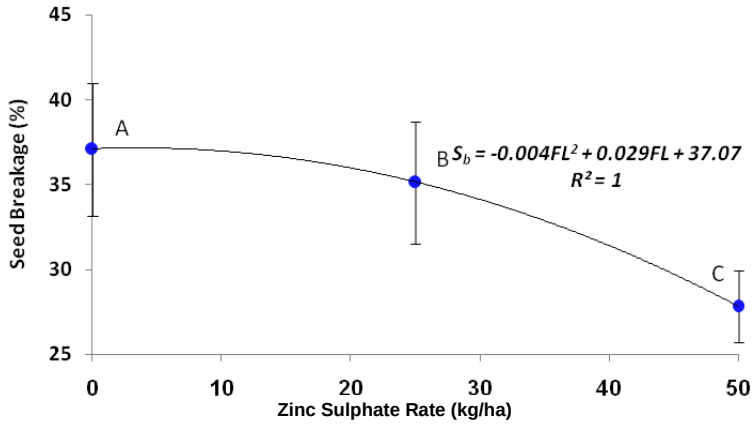

Figure 1 - Effect of sulphate rate on the percentage breakage of wheat seeds. A-C: Averages with the same letter have no significant difference at the 5% probability level.

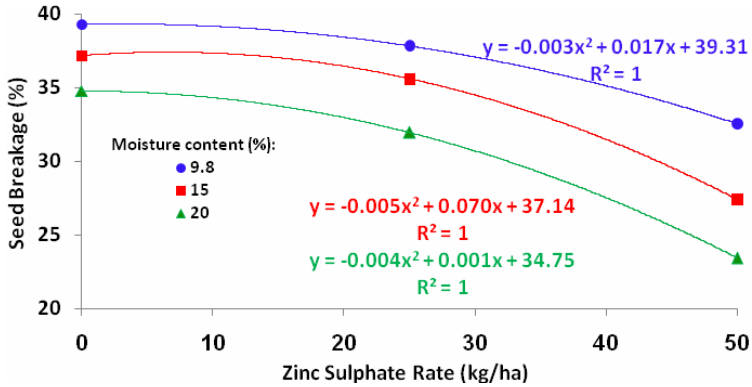

Figure 2 - Wheat seed breakage variation with zinc sulphate fertilizer rate at different seed moisture contents

The interaction between zinc sulphate fertilizer rate and wheat variety on the breakage of wheat seeds was significant ($P<0.01$) (*Table 1*). *Fig. 3* shows the percentage breakage of wheat seeds in the in the integration between fertilization level of zinc sulphate and wheat variety. As follows from the *Fig. 3* the percentage breakage of seeds decreases, as polynomial equations, with increase in fertilization level of zinc sulphate, at all the employed wheat varieties. As shown in *Fig. 3*, the rate of decrease in breakage of seeds by increase in fertilization level of zinc sulphate is not the same for all the levels of wheat varieties. The highest percentage of seeds breakage in the *Fig. 3* was obtained as 37.611% for

the interaction between 0 kg/ha of zinc sulphate and *Shiraz* wheat variety, while the lowest percentage was obtained as 18.88% for integration between 50 kg/ha of zinc sulphate and *Bahar* wheat variety (*Fig.3*). The average values for the percentage breakage of wheat seeds, at all the zinc sulphate rates, were found to be 29.838, 35.637 and 34.530% for the *Bahar*, *Shiraz* and *Pyshtaz*, wheat varieties, respectively, shows that *Bahar* variety exhibited the highest resistance to breakage than other varieties. In addition, base on the Duncan's multiple range tests, there was no significant difference between the mean values of the percentage breakage of *Shiraz* and *Pyshtaz* varieties, but the difference between the mean values of *Bahar* variety with other varieties was significant ($P<0.05$).

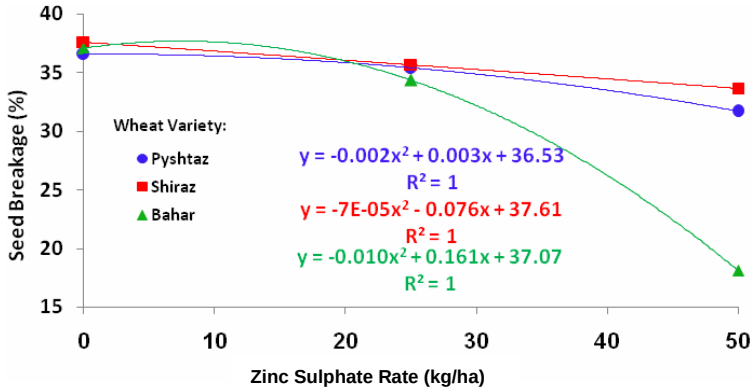

Figure 3 - Percentage breakage of wheat seeds in the in the integration between fertilization level of zinc sulphate and wheat variety

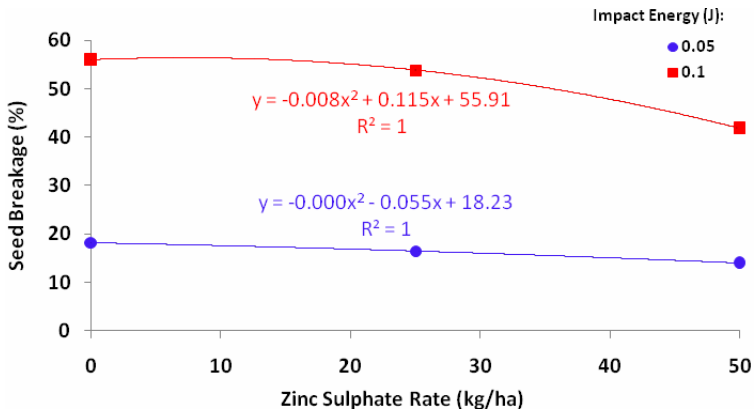

Figure 4 - Interaction effects of zinc sulphate rate and impact energy on the percentage breakage of wheat seeds

The interaction between zinc sulphate fertilizer rate and impact energy on the breakage of wheat seeds was significant ($P<0.01$) (*Table 1*). The percentage breakage of wheat seeds in the in the interaction between the fertilization level of zinc sulphate and impact energy is shown in the *Fig. 4*. As follows from the *Fig. 4* the percentage breakage of seeds increased with increase in impact energy for all levels of zinc sulphate fertilization. In addition, the damage to seeds decreased as polynomial functions, with increase in zinc sulphate dose, for all the impact energies used. In *Fig. 4* the lowest breakage of wheat seeds among the combinations was found to be 18.888% occurred in the interaction between 0.05 J impact energy with 50 kg/ha zinc sulphate rate, while the greatest breakage of wheat seeds was obtained as 55.914%, occurred in the 0.1 J impact energy with 0 kg/ha zinc sulphate rate. The average value for the breakage of seeds at the 0.1 J impact energy at all levels of zinc sulphate, in *Fig. 4*, was found to be 50.477% in comparing to the average value of 16.193% at the 0.0 5 J impact energy. This data shows as impact energy increased about two times (from 0.05 to 0.1 J) the mean value for the breakage of seeds increased about 3.11 times. Similar results about this effect of impact energy have been reported for other grains by other investigators (Chawla *et al*., 1998; Kirkkari *et al*., 2001; Baryeh, 2002; Parde *et al*. 2002; Khazaei *et al*., 2008).

CONCLUSIONS

From the results of this study, the following conclusions can be drawn: There was a significant difference between the percentage breakage of wheat seeds at different fertilization levels of zinc sulphate, moisture content, wheat variety and impact energy, at the 1% significant level. It was found that the percentage breakage of seeds for all wheat varieties studied decreased as a quadratic function with increase in zinc sulphate dose. Increasing the fertilization dose of zinc sulphate from 0 to 50 kg/ha caused a decrease in the percentage breakage of wheat seeds from 37.07 to 27.80%. the seeds of *Bahar* wheat variety exhibited the highest resistance to breakage than other varieties. As the moisture content increased from 9.8 to 20% the percentage breakage of seeds decreased from 36.58 to 30.03%. Increasing the impact energy from 0.05 to 0.1 J caused an increase in the percentage breakage of seeds from 16.193 to 50.477%.

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