Cercetări Agronomice în Moldova
Vol. XLV , No. 4 (152) / 2012

INFLUENCE OF DIFFERENT FERTILIZATION LEVEL OF ZINC SULPHATE AND PLANT DENSITY ON THE BREAKAGE SUSCEPTIBILITY OF TRITICALE SEEDS

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Received July 21, 2012

ABSTRACT. In order to determine the effects of different fertilization level of zinc sulphate and plant density on the breakage susceptibility of triticale seeds an experiment was conducted during 2011 growing season, at the experimental research station of Lorestan University, Iran. A factorial experiment was conducted with 3×3 treatments and three replications in a completely randomized block design (CRBD). Factors included three plant densities (200, 300 and 400 plants/m^2) and three levels of zinc sulphate (0 - control, 40 and 60 kg/ha). The harvested seeds were then subjected to impact energies of 0.05 and 0.1 J at constant moisture content of 15% using an impact test apparatus. The analysis of variance showed that fertilization level of zinc sulphate (at the 1% probability level), plant density (at the 5% level) and interaction between two variables (at the 5% level) significantly influenced breakage susceptibility of triticale seeds. The average values of percentage breakage of seeds decreased from 32.592 to 16.9268% as the fertilization level of zinc sulphate increased from 0 to 60kg/ha. As the plant density increased from 200 to 400 plants/m^2 the percentage breakage of seeds decreased from 27.942 to 21.350%. Increasing the impact energy from 0.05 to 0.1 J caused an increase in the percentage breakage of seeds from 14.07 to 36.9%.

Key words: Triticale; Mechanical damage; Harvesting; Handling; Fertilization; Zinc sulphate; Plant density.

INTRODUCTION

Triticale seeds (X *Triticosecale* Wittmack) are subjected to a series of static and dynamic loads during harvesting, handling, processing, and storage. Such loadings cause external and internal damage in seeds, which lead to decreases in quality and can compromise both viability and vigor (Grass and Tourkmani, 1999). Previous studies indicated that threshing seeds at high speeds could be the main reason behind abnormal seedling development in germination tests, reduction of vigor of the seeds, and increase in fungal attack

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(McDonald, 1985; Evans *et al.,* 1990; Entz *et al.,* 1991; Bourgeois *et al.,* 1996; Grass and Tourkmani, 1999; 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 impact energy, 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 energy 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 triticale seeds related to different fertilization level of zinc sulphate and plant density is limited. Therefore, the objective of this study was to investigate the effects of different fertilization level of zinc sulphate and plant density on the breakage susceptibility of triticale seeds under impact loading.

MATERIALS AND METHODS

Triticale seeds of the Jowalino 98 cultivar were chosen to be used in this research. An experiment was conducted during 2011 growing season, at the experimental research station of Lorestan University, Iran. A factorial experiment was conducted with 3×3 treatments and three replications in a completely randomized block design (CRBD). Factors included three plant densities (200, 300 and 400 plants/m^2) and three levels of zinc sulphate (0 - control, 40 and 60 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 10% (wet basis) determined with ASAE S352.2 (ASAE Standards, 1988). The moisture content samples were adjusted to 15% by adding calculated

amounts of distilled water, then sealing in polyethylene bags, and storing at 5ºC for 15 days. 15% moisture content is 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) and Oluwole *et al.* (2007) (*Fig. 1*). An aluminum drop bar (800 mm length; 25 mm external diameter; 0.2 kg) was inserted into a steel tube (750 mm length; 27 mm internal diameter; 29 mm external diameter). The steel tube had 4 mm diameter holes drilled at 5 cm intervals from 5 to 60 cm. The drop height of the aluminum bar was manually controlled by a pin inserted in the hole in the middle of a steel tube. The steel tube was clamped to a laboratory stand. Because the seed naturally lies on its length (*Fig. 1*) and also preliminary tests showed that impacts to the side of the seeds resulted in significantly more splits than impacts to top, the test seed was placed in the horizontal orientation on the base plate. The aluminum bar dropped, hitting the seed when the pin was manually removed at the given drop height. The impact energy on seed depends on the mass and drop height of the aluminum bar. The impact energy was determined using the following equation:

$$E_i \approx Mg(H - W) \qquad (1)$$

Where: E_i is the impact energy (J), M is the mass of the drop bar (0.2 kg), g is the acceleration due to gravity (9.8 m/s^2), H is the drop height from base plate (m), and W is the width (m) of seed (*Fig. 1*). In this experiment, the drop heights used for the drop tester were selected after preliminary experimentation (data not shown). The fixed drop heights of the aluminum bar were 2.5 and 5 cm, so the impact energies on seeds were 0.05 and 0.1 J, respectively.

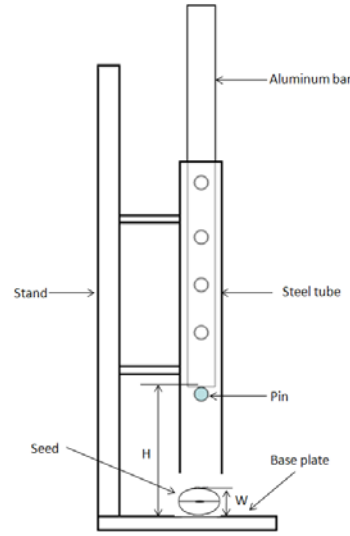

Figure 1 - Schematic diagram of the impact test apparatus

In this study, the effects of fertilization level of zinc sulphate (0 - control, 40 and 60 kg/ha), plant density (200, 300 and 400 plants/m^2) and impact energy (0.05 and 0.1 J) were studied on the percentage breakage of triticale 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:

$$\text{Seed breakage} = \frac{(\text{Weight of damaged seeds})}{(\text{Weight of total seeds}(\text{damaged} + \text{undamaged}))} \times 100 \quad (2)$$

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 triticale seeds to mechanical damages were revealed at different levels of of zinc sulphate fertilization, plant density and impact energy. The analysis of the data variance (*Table 1*) indicated that fertilization level (at 0.01 probability level), plant density (at 0.05 probability level) and impact energy (at 0.01 probability level) significantly influenced the percentage breakage of triticale seeds. Impact energy had the most influence (F=209.311) but, fertilization level (F=33.679) and plant density (F=6.957) had the least, respectively, within the ranges studied for variables (*Table 1*). The interaction effects of the fertilization level × plant density significantly influenced the percentage breakage of triticale seeds, at 5% level; meanwhile, the interaction effects of the fertilization level × impact energy, plant density × impact energy and the interactions effects of the three independent variables were not significant for the percentage breakage of triticale seeds (*Table 1*).

The results of Duncan's multiple range tests for comparing the mean values of the percentage breakage of seeds at different fertilization levels of zinc sulphate is presented in *Fig. 2*. It is evident from *Fig. 2* that the percentage breakage of seeds decreased as a quadratic function, with increase in zinc sulphate dose. There is a quadratic 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 triticale seeds were found to compare with the results obtained in this study. However, the significant effect of fertilizer dose on value of seed mechanical damage has also been noted for horse bean seeds by Gorzelany (1999). 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.

These results confirm that, as the fertilizer dose has significant effects on the biological, physical and thermal properties of materials of plant origin, it also has a bearing on the effects of seed hardness and resilience, which paling 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).

Table 1 - Analysis of variance (Mean square) for the percentage breakage of triticale seeds as affected zinc sulphate fertilization level, plant density and impact energy

Source	DF	Mean Square	F
Fertilization Level (FL)	1	1133.454	33.679**
Plant Density (PD)	4	234.125	6.957*
FL × PD	4	149.111	4.431*
Impact Energy (IE)	1	7044.313	209.314**
FL × IE	1	143.875	4.275ns
PD × IE	4	143.962	4.278ns
FL × PD × IE	4	39.262	1.167ns
Error	40	33.654	

**: significant at the 0.01 probability level; *: significant at the 0.05 probability level
ns: not significant

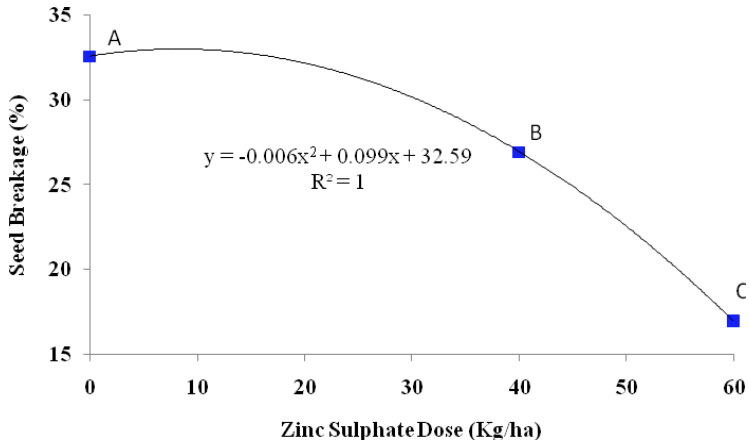

Figure 2 - Effect of sulphate dose on the percentage breakage of triticale seeds. Averages with the same letter have no significant difference at the 5% probability level.

With increasing the fertilization level of zinc sulphate from 0 to 60 kg/ha the mean values of the percentage breakage significantly decreased about two times (from 32.591 to 16.928%). The average values for the percentage breakage were found to be 32.591, 26.958 and 16.928% for fertilization levels of zinc sulphate of 0, 40 and 60kg/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. 2*).

Fig. 3 shows the triticale seeds breakage vs. plant density. The average values for the percentage breakage of triticale seeds were found

to be 27.942, 27.182 and 21.350% for the plant densities of 200, 300 and 400 plant/m^2, respectively. It is evident from *Fig. 3* that the percentage breakage of seeds decreased as a quadratic function, with increase in plant density (*Fig. 3*). No reported results for effect of plant density on the breakage susceptibility of triticale seeds were found to compare with the results obtained in this study. Base on the Duncan's multiple range tests there is no significant difference between the mean values of the percentage breakage at plant densities of 200 and 300 plant/m^2, but the difference between the mean values of plant density of 400 plant/m^2 with other densities is significant (P<0.05) (*Fig. 3*).

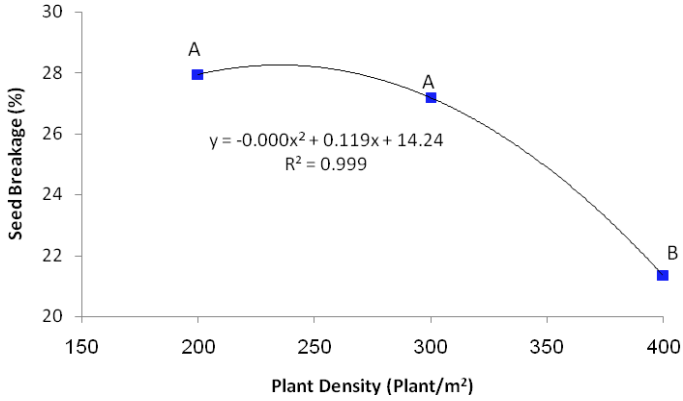

Figure 3 - Percentage breakage of triticale seeds at different plant densities. Averages with the same letter have no significant difference at the 5% probability level.

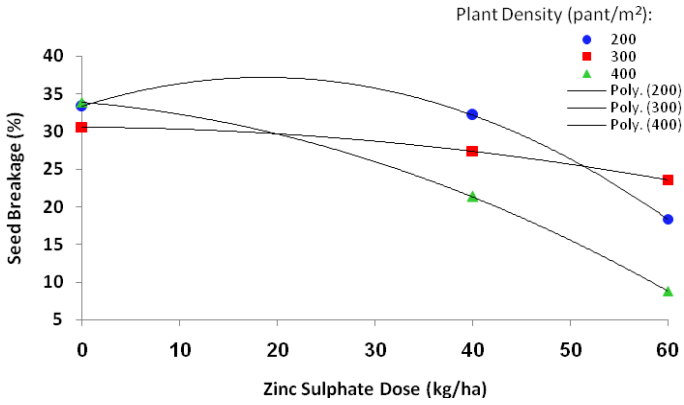

Figure 4 - Percentage breakage of triticale seeds in the integration between fertilization level of zinc sulphate and plant density

Fig. 4 shows the percentage breakage of triticale seeds in the in the integration between fertilization level of zinc sulphate and plant density. As follows from the *Fig. 4* the percentage breakage of seeds decreases with increase in fertilization level of zinc sulphate at all employed the plant densities. As shown in *Fig. 4*, 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 plant densities. The effect of fertilization level on the damage is stronger at higher plant densities than at lower ones. The highest percentage of seeds breakage in the *Fig. 4* was obtained as 33.887% for interaction between 0 kg/ha of zinc sulphate and 400 plant/m^2 plant density, while the lowest percentage was obtained as 8.832% for integration between 60 kg/ha of zinc sulphate and 400 plant/m^2 plant density (*Fig 4*).

The percentage breakage of triticale seeds in the in the interaction between the fertilization level of zinc sulphate and impact energy is shown in the *Table 2*. From the data in *Table 2* it is evident that increasing the zinc sulphate dose had a more significant effect over the percentage of damaged seeds at higher level of impact energy. The damage to seeds decreased from 46.296% to 25.184% at 0.1 J impact energy and from 18.887% to 8.667% at 0.05 J impact energy, with increase in zinc sulphate dose from 0 to 60 kg/ha. The average value for the breakage of seeds at the 0.1 J impact energy at all levels of zinc sulphate doses, in *Table 2*, was found to be 36.913% in comparing to the average value of 14.070% 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 2.62 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).

Table 3 shows the percentage breakage of triticale seeds in the in the interaction between plant density and impact energy. It is evident that increasing the plant density had a more significant effect over the percentage of damaged seeds at higher impact energy. The damage to seeds decreased with increase in plant density, for all impact energies used. In *Table 3* the lowest breakage of triticale seeds among the combinations was found to be 11.962% occurred in the interaction between 0.05 J impact energy with 400 plant/m^2 plant density, while the greatest breakage of triticale seeds was obtained as 42.593%, occurred in the 0.1 J impact energy with 200 plant/m^2 plant density interaction.

Table 2 - Interaction effects of zinc sulphate dose and impact energy on the percentage breakage of triticale seeds

Zinc sulphate dose (kg/ha)	Seed breakage (%)	
	Impact energy (J)	
	0.05	0.1
0	18.887 (1.29)*	46.296 (3.48)
40	14.654 (3.38)	39.260 (2.94)
60	8.667 (2.84)	25.184 (3.28)
Mean	**14.070 (4.78)**	**36.913 (6.72)**

* Data in parentheses are standard deviation.

Table 3 - Interaction effects of plant density and impact energy on the percentage breakage of triticale seeds

Plant density (Plant/m^2)	Seed breakage (%)	
	Impact energy (J)	
	0.05	0.1
200	13.291 (1.29)*	42.593 (3.48)
300	16.957 (3.38)	37.407 (2.94)
400	11.962 (2.84)	30.738 (3.28)

* Data in parentheses are standard deviation.

CONCLUSIONS

From the results of this study, the following conclusions can be drawn: There was a significant difference between the percentage breakage of triticale seeds at different fertilization levels of zinc sulphate (at 0.01 level), plant density (at 0.05 level) and impact energy (at 0.01 level). It was found that the percentage breakage of triticale seeds decreased as a quadratic function with increase in zinc sulphate dose. Increasing the fertilization dose of zinc sulphate from 0 to 60 kg/ha caused a decrease in the percentage breakage of seeds from 32.591to 16.928%. As the plant density increased from 200 to 400 plants/m^2 the percentage breakage of seeds decreased from 27.942 to 21.350%. Increasing the impact energy from 0.05 to 0.1 J caused an increase in the percentage breakage of seeds from 14.070 to 36.913%.

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