Mechanical Damage to Navy Beans as Affected by Moisture Content, Impact Velocity and seed Orientation

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ABSTRACT

The objective of this experiment was evaluate of impact damage to navy beans where seed moisture content, velocity of impact and seed orientation were independent variables. The study was conducted under laboratory conditions, using an impact damage assessment device. The results indicated that impact velocity, moisture content and seed orientation were all significant at the one percent level on the physical damage in seeds. Increasing the impact velocity from 5 to 15 m/s caused an increase in the mean values of damage from 0.17 to 32.88%. The mean values of seed damage decreased by 1.96 times, with increase in their moisture content from 10.03 to 14.98%. However, by a higher increase in the moisture from 14.98 to 24.89 %, the mean value of damage showed a non-significant increasing trend. It was found that the relationship between beans mechanical damage with moisture content and velocity of impact was non-linear and the percentage damage to seeds was a quadratic function of moisture content and impact velocity, respectively. Impacts to the end of the seed produced the higher damage (20.615) than side of the seed (11.14%)

Keywords: Navy bean, impact damage, moisture content, impact velocity, seed orientation.

1. INTRODUCTION

Bean seed quality is greatly affected by harvesting, cleaning, drying, handling and storage activities during the seed production process. In these operations, seeds are often subjected to impact forces repeatedly against metal surfaces predisposing them to mechanical damage.Navy beans and other large seeded legumes are especially vulnerable to rough treatment. These seeds are particularly delicate because of their seed anatomy. The mechanical resistance to the impact damage of seeds, such as navy beans, among other mechanical and physical properties, plays a very important role in the design of harvesting and other processing machines (Baryeh, 2002). The value of this basic information is necessary, because during operations, in these sets of equipment, seeds are subjected to impact loads which may cause mechanical damage. Damaged seed commands in lower value, storability problem, and reduced seed germination and seedling vigor and subsequent yield of crops (Shahbazi and Khazaei, 2002). Impact damage of seeds depends on a number factors such as velocity 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 (Keller et al., 1972; Hoki and Picket, 1973; Paulsen et al., 1981; Bartsch et al., 1979; Evans et al., 1990). Information relating the amount of navy bean seed impact damage to velocity of impact and seed orientation is limited. In light of above facts, the objectives of this study were to evaluate the impact damage to navy bean seed and determine the effects of impact velocity, seed moisture content and seed orientation on the percentage of physical damage to beansbiography.

2. MATERIAL AND METHOD

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 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. In this study, the effects of impact velocity (at 5, 7.5, 10, 12.5, and 15 m/s), seed moisture content (at 10.03, 12.65, 14.98, 17.49, 20.12, and 24.89% wet basis) and seed orientation (side and end) were studied on percentage of physical damage in beans. 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 beans include the broken, cracked, and bruised and split beans were accurately identified by a handy lens and weighed. The percentage of beans damage was calculated as:

Beans damage= (Weight of damaged beans)/ (Weight of total beans (damaged + undamaged) (1)

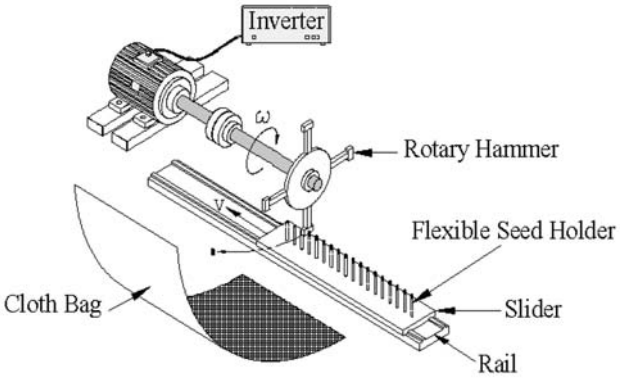

Figure 1: Diagram of the impact damage assessment device.

3. RESULTS AND DISCUSSION

The analysis of variance indicated that, Impact velocity, moisture content and seed orientation significantly influenced the percentage physical damage in beans, at 1% probability level. Impact velocity had the most influence; seed orientation and moisture content the least, respectively, within the range studied for these variables. The results of Duncan's multiple range tests for comparing the mean values of the damage to beans at different impact velocities is shown in figure 2a. It is evident that seed damage increased, as a quadratic function, with increasing impact velocity. For all the levels of impact velocity, the differences between the mean values of the damage are significant (P=0.05). With increasing the impact velocity from 5 to 15 m/s, the mean value of the damage increased from 0.17 to 32.88%. In figure 2b the percentage damage to seeds is plotted against the velocity of impact. The figure reveals that, at all the seed orientations considered, the seed damage increases as the impact velocity increases. Due to the significant interaction effects between impact velocity and seed orientation, the rates of increase in damage are not the same for all levels of orientations. The effect of impact velocity on the damage is stronger at end orientation than at side. At end orientation, damage increased from 0.34 to 38.67% with increasing the impact velocity from 5 to 15 m/s. Corresponding damages are from 0 to 27.08 at side orientation.

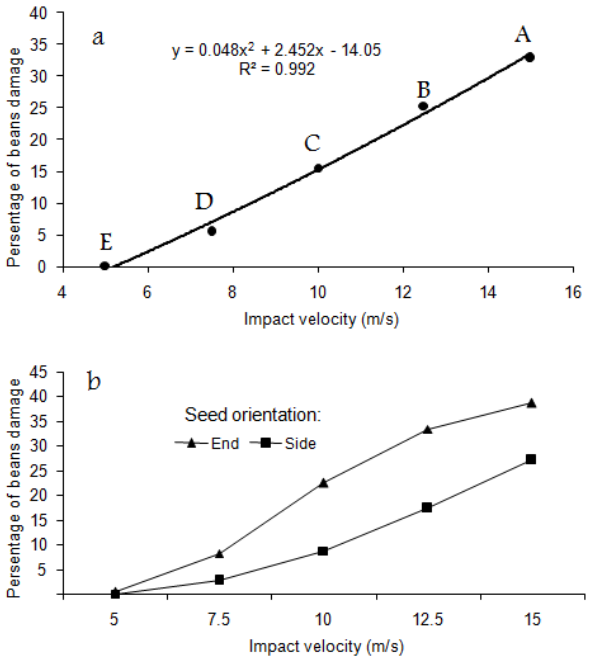

Figure 2. a: Effects of impact velocity on percentage damage to beans. Averages with the same letter have no significant difference at the 5% probability level. b: Beans damage variation with impact velocity at different seed orientations.

The results showed that the percentage of beans damage decreased, as a quadratic function, with increase in their moisture content (figure 3). With increasing the moisture content from 10.03 to 14.98%, the mean values of the percentage damage decreased from 27.09 to 13.79% (by 1.96 times) (figure 4). However, by a higher increase in the moisture from 14.98 to 25.89%, the mean values of damage showed a non significant increasing trend (figure 3). Figure 4 shows the beans damage variation with seed moisture content for various impact velocities. As follows from the relations presented in the figure 4, for all the impact velocities considered, the percentage of the beans damage decreases with increase in their moisture content but the rates of increase in percent damage to beans by decrease in their moisture content are not the same for all the levels of impact velocity. The effect of moisture content on the damage is stronger at higher impact velocities than at lower ones. At the critical range of the tests, when the moisture content decreased from 14.98 to 10.03%, the maximum rate of increase in the damage to beans is obtained for the impact velocity of 15 m/s, which is equal to 26.39% (from 28.87 to 55.26%).

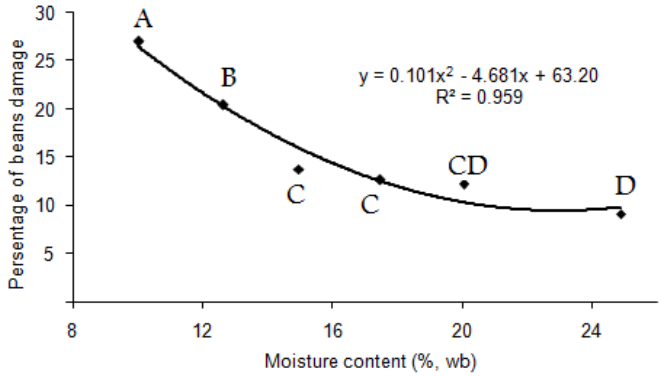

Figure 3: Effects of moisture content on percentage damage to beans. Averages with the same letter have no significant difference at the 5% probability level.

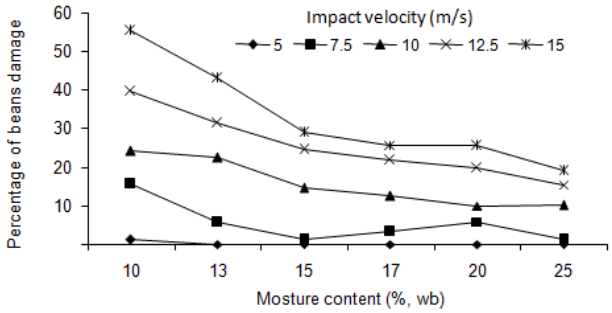

Figure 4: Beans impact damage variation with seed moisture content for different impact velocities

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