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Losses of corn in the harvest, loading and transportation at rural property level

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Corn belongs to the family of Poaceaes, and the corn grain is used mainly for human and animal consumption. This study aims to assess the total losses of maize grain in the harvest, losses in loading from the harvester to the truck and transportation losses up to its first point of reception. The experiment was conducted in the city of Itaipulândia-PR, Brazil. To perform the sampling of the losses in the crop methods of total loss provided by EMBRAPA, for the losses in loading we use samples of 24.5 m², for the evaluation of losses in transportation, the methodology was the determination of fixed points of 15 m² where the mass of the lost grains was obtained, the obtained values were extrapolated to the distance up to the first point of reception. The obtained results were subjected to analysis of variance and the averages were compared with the Tukey's test at 5% probability using the Assistat Beta program. It was observed that the lowest loss on the harvest was at the speed of 4.5 km / h, already on loading the smallest loss it was at low rotation per minute of the harvester, for loading were statistically equal.

Key words: *Zea mays*, Embrapa, fixed points.

INTRODUCTION

Corn *(Zea mays* L.*)* is a cereal which belongs to the family of Poaceaes. It can be considered one of the main sources of nourishment nowadays and it is used as a source of carbohydrates to feed both humans and animals (Borém and Giúdice, 2004).

In the past corn was relevant to the function of subsistence; today its production is associated to commercial crops based on the use of modern technologies. It is a crop planted throughout the entire Brazilian territory forming the main input to the production of animal feed (Souza and Braga, 2004). The corn is one of the most important crops for Brazilian agriculture, due to its wide variety of periods for planting, it stays on the field practically the whole year (Silva and Schipanski, 2006). A good amount of the food produced in the world is usually lost due to the neglect with which it is treated, occuring in the whole productive chain, from implementation of cultivation to its final consumption (Germiro, 2003). A significant part of the losses happen during the mechanized harvesting, decreasing productivity and yield of the operation, resulting in losses to the producer, as this is the final interference in the productive procedure, moment in which the grain has the highest added value (Sgarbi, 2006).

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Mantovani (1989) reported that the losses in the corn harvesting occur in three fundamental ways: in the pre-harvest, at the cutting deck and in the internal mechanisms of the harvester. These three factors combined bring extremely severe losses in production, in a state and national scale. Even though the origins of the losses are varied and occur both before and during harvest about 80 to 85% of them occur by the action of the cutting deck mechanisms for harvesters (Embrapa, 1998). According to Mesquita et al. (2001), grain losses are independent of brands and age of harvesters up to 15 years from 15 years losses can be high.

After the harvesting of the grains in the field, there is the need of properly storing them for future sales or consumption, done by institutes that may refer to the government, cooperatives or individuals (Silva and Rübenich, 2004). But until arriving to their destiny, there is a wide distance to be covered and expressive losses occur in the Brazilian crop, illustrated by the Agricultural Indicators 1996-2003 conducted by the Brazilian Institute of Geography and Statistics (IBGE) (2005). In Brazil, around 70% of Brazilian loads are moved by road transportation.

As described by Christopher (2011), the mission of logistics should be to plan and coordinate the activities in order to achieve the desired quality levels while having the lowest possible cost. According to the Brazilian Confederation of Agriculture and Livestock, the damage done by the spillage of grains during road transportation goes up to R$ 2,7 billions in each harvest, being an amount to be considered as it causes a strong impact in the quotation of prices to the producer and the consumer (Perdas, 2005). During transport, part of the load is being lost from the truck due to vibrations of the truck, and also due to bad load seal. Also, your old vehicle fleet causes serious damage (Carvalho et al., 2012).

Semprebom (2009) shows that the losses occurred due to the logistics activities must be studied, measured, and controlled, so they are sustained at acceptable levels. Regarding the losses in transportation, Semprebom (2009) and Anes (2003) claim that these can represent 0.25% per moved ton. This problem affects practically all producing regions of the country.

Considering the importance of transportation for agriculture, Gallimore (1981) states that as important as the skill in production there must be an ability of moving it to consumer cores. Michaels et al. (1982) stress that “road transportation by trucks has the capacity to adjust to the variations in demand”.

To Faria (2005), the road system is applied to small and medium loads, to short and medium distances, with collecting and delivery point to point, offering an extensive coverage, it can be described as flexible and versatile, being more related to the needs of customer service than other means of transportation.

Koo and Larson (1985) point out the importance of effectiveness of the transporting system for producers and consumers, besides its essential connecting function between the production and the agricultural trading of products and inputs. The authors connect the prosperity of agriculture to the transporting system that enables the distribution of products and inputs at the lowest possible cost. According to Girardi (2011), the Brazilian harvest is on the road. Thousands of trucks carrying grain to silos, cooperatives and ports and lose part of the cargo on the way. The prejudice is for those who produce and those who carry.

According to work done by Caneppele and Sardine (2014) losses at the time of loading of trucks on farms occur due to the high rotation of the system of the harvester, because the grains hit the truck arches and end up falling out. According to the authors at the time it was proposed measure these losses, It was observed reduction of loss in cargo trucks.

According to the considerations above the objective of this paper was to evaluate the total losses of grains found in the harvest, the setting of the harvester will be in accordance to the conditions encountered. In addition, it was also evaluated the losses that occur in transportation of property up to the first point of reception, and the losses on the unloading from the harvester to the truck, in order to report where the mistakes possibly are, and show the most important points to try to prevent these losses that exist in Brazil.

MATERIALS AND METHODS

The experiment was conducted in the city of Itaipulândia/PR, Brazil. In an area of 20 há$^{-1}$. The area was measured with a GPS Garmin Etrex 10 ® before initiating the experiment. The area had 40 collection points in the tillage, distributed by completely randomized design. For the losses in loading the evaluation was according to each discharge conducted from the harvester to the truck. The data collection in transportation was according to 20 evaluated trucks, being 10 sealed with pieces of tarp on the corners of the truck body and 10 without sealing, up until the reception point. The soil of the experimental area was classified as typic dystrophic Red Latosol (Embrapa, 2006).

The current study assessed the total losses in the harvest, the loading and the transportation up until the reception point. The total losses in the harvest were obtained in only one stage, the harvester used was an NH TC 57, the platform used was an NH 19 lines. After the operation of the harvester, random points were chosen with a 2 m² frame set in such a way that covered the whole width of the route taken by the harvester. All the grains within the frame were collected, including the ones that were on the cob, thus the mass of the grains was determined and this mass was converted into kg ha^{-1}, by using the following equation: loss (kg ha^{-1}) = mass of grains (g) x 10/ demarcated area (m^{2}), this way the total loss per hectare in the harvest was obtained.

For the assessment of loading the methodology was a little more complex due to the lack of written papers found in literature about the subject. The methodology used for this assessment was: after each unloading through the discharging pipe from the harvester to the truck, the truck was removed from the road, as this job was done by an Mercedez Benz 1513 truck with a body made of wood, 6.80 m long, in good conditions. The methodology for this evaluation is given as follows after each discharged from the harvester to the truck the truck was moved, the grains were

Table 1. Tukey's test 5% of significance for speed variable.

Treatment	Grain mass (kg ha^{-1})
3.0 km/h	86.74^{ab}
4.5 km/h	72.50^{b}
6.0 km/h	85.26^{ab}
8.0 km/h	109.58^{a}
Overall average	88.52
P- value	0.46
CV (%)	27.98

Averages followed by the same letter are not statistically different from each other. The Tukey's test was applied at 5% level of probability.

Table 2. Tukey's test 5% of significance for low and high rotation variable.

Treatment	Grain mass (g)
Low rotation 425 RPM	33.43^{b}
High rotation 1150 RPM	57.57^{a}
Overall average	45.50
P- value	0.072
CV(%)	17.98

Averages followed by the same letter are not statistically different from each other. The Tukey's test was applied at 5% level of probability.

Table 3. Tukey's test 5% of significance for sealed and unsealed variable.

Treatment	Lost mass (kg/5 km)
Unsealed	24.92^{a}
Sealed	21.98^{a}
Overall average	23.45
P-value	0.37
CV (%)	14.94

Averages followed by the same letter are not statistically different from each other.

collected considering the area where the truck he was. Whereas the truck body had 6.8 m we use a margin of 10 cm in front the truck body and 10 cm behind the truck body, and 25 cm on each side the truck body, that is, we collect 7.0 m x 6.8 m long considering the truck body more margin 20 cm. And wide 3.5 m whereas the width of road 3.0 m more 50 cm margin. These margins were considered because it has been observed that many grains beat the arches of the truck and fall a few centimeters outside the truck perimeter, the collected grains were weighed to evaluate the mass of the same and at the end we observed losses on high speed 1150 RPM speed 425 rpm with 30 repetitions of each, totaling 60 samples, considering that the ability in the grain tank is 3300 kg of corn. For the evaluation of the transport losses also it was an evaluation with difficulty, due to the lack of methodologies found in the literature to perform it, so the implemented methodology was as follows: within the property evaluated were chosen points on the roads, the width that was considered for these roads was of 3.0 m, each evaluated had an area of 5.0 m x 3.0 m^{-1} (width of the road), these points were chosen where the condition of the roads was worse as curves and areas declined, were collected grains within the points and thus determined the mass of grain, the figure was extrapolated for the mileage to the first point of reception, evaluated 20 trucks and 10 sealed with tarps in the truck vertices and 10, not every truck had 5 points with 5 linear meters, in each truck had 25 linear meters of collection, the mass found in these 25 linear meters was extrapolated to 5000 linear meters distance this until the first point of reception, therefore it was possible to quantify the losses in transportation to the first reception by truck, considering sealed and unsealed. With all these data it was possible to quantify how much is lost at each step. The results of the variables were subjected to the analysis of variance and the averages were compared with the Tukey's test at 5% of probability, using the Assistant Beta program version 7.7.

RESULTS AND DISCUSSION

Analysing Table 1 we can observe that the losses in the harvest are different at a significance level of 5% according to the speed adopted by the harvester. On Table 2 we can observe the mass of the lost grains at the moment of unloading from the harvester to the track, taking into consideration the low and high rotation at the moment of unloading, the values are statistically different when compared to the significance of 5% adopted on the test.

On Table 3 it is possible to visualize the losses during transportation, 1 truck was used in this assessment taking into consideration the sealed and unsealed cargoes coming to a total of 20 assessed truck. The collected averages of each truck were obtained, as 5 fixed points of each truck were collected and thus it was obtained the lost grains mass extrapolated up to the first reception point which was 5000 m away. We can see that the trucks did not differ at the 5% of significance to which they were subjected.

When analysing Figure 1 we can observe that the speeds too far below or too far above the recommended speed are more susceptible to losses, showing that there are statistical differences among the assessed speeds, the one with the lowest loss being the one at 4.5 Km/h, but all of them among the acceptable parameters of not more than 120 kg/ha (Embrapa, 2002). The indicated limits to working speed are from 4 to 7 km/h. When not respected, the rail system of the harvester gets overloaded, thus increasing the amount of not threshed grains (Cunha and Zandbergen, 2007). As shown on Figure 2, the losses of high and low speed are significantly different compared to the significance level of 5%, as these values are obtained in grams by bulk carriers taking into consideration 55sc/bulk carrier, that is, 3300 kg, being that the best way of unloading is with the machine at low rotation.

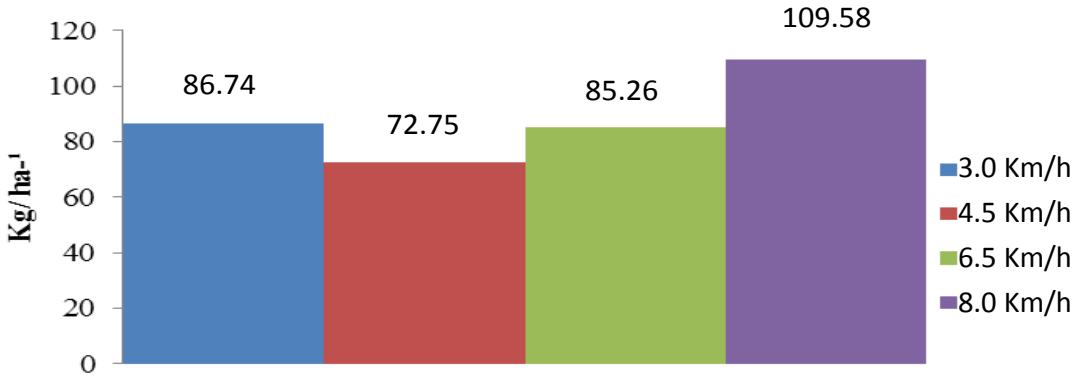

Figure 1. Crop losses as a function of the speed of the harvester.

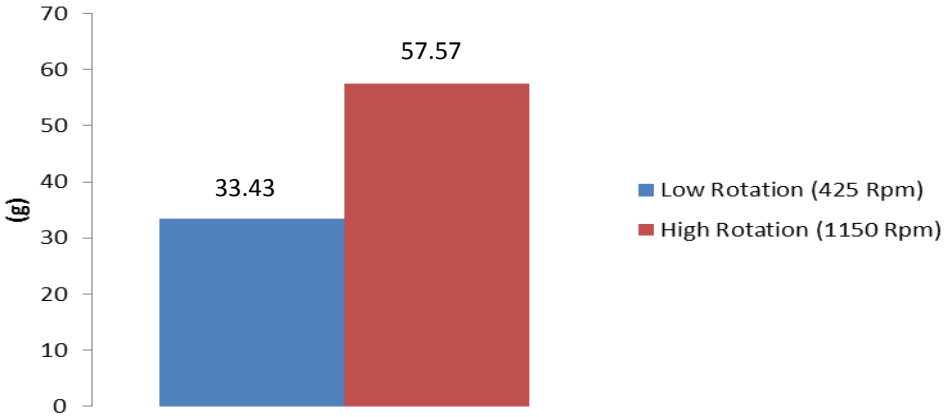

Figure 2. Unloading losses due to the harvester rotation, by bulk Carrier.

This loss was assessed according to each performed unloading and thus the average for both low and high rotation was obtained, taking into consideration that 6 unloadings were necessary to fill up the truck; the losses per truck were on average from 200.62 to 345.42 g, respectively. It was possible to observe that these losses in loading usually happen due to the hurry of the operator who increases the rotation of the machine causing the product to hit the truck arches and to fall out of its back, or even when the person does not wait for the complete unloading of the product and closes the discharging pipe in advance causing an unnecessary loss at this moment.

This chart from Figure 3 shows the losses obtained on the trucks. As we can see their values are very close to each other, not being statistically significant at the 5% level. But it is significant for the income of the producer who ended up losing part of his production up to the delivery point, factors which often happen by filling up the truck over its capacity or by a badly sealed truck body. The grains logistics in Brazil is currently outdated, as it did not have the expected development and success. The foundations for the consolidation of logistic concepts are fragile and their primary process, transportation, is currently dealing with a poor infrastructure with no conditions of support (Carvalho et al., 2012).

A solution for the upper sealing of bulk carrier trucks was presented by Tsiloufas et al. (2011). It is an innovating product, which puts on the tarp in an automated way, in a simple and robust design. From the point of view of the responsible ones for the carrier, the product is economically viable, once that the savings provided by the product exceeds the initial investment in a reduced number of trips.

Conclusion

Based on the results of this paper we can conclude that regarding the losses on harvest the best option is the speed of 4.5 km/h which caused a loss of 72 kg/há$^{-1}$ the lowest one among the assessed speeds value which is within the parameters described in literature. The results of losses on unloading are significantly different showing that the best way of unloading is at low rotation, thus

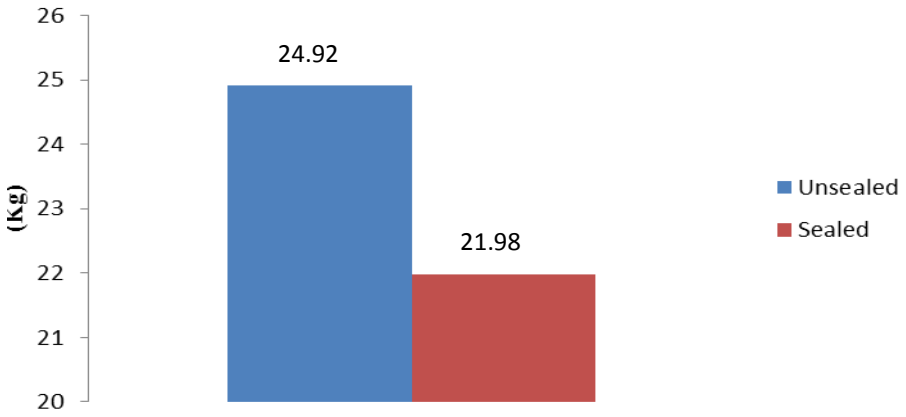

Figure 3. Transportation losses from the property to the first reception point 5 km away.

avoiding unnecessary losses. The losses on transportation were not statistically significant, but they are relevant for the producer, as they can go up to 31.72 kg of lost grains mass in 5 km, which is equivalent to 6.34 kg/km, facts that can be avoided if the weight limits of the truck are respected and if the truck is properly sealed.

Conflict of Interests

The authors have not declared any conflict of interests.

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