

MEDIÇÃO E ANÁLISE DAS CONDIÇÕES DE TRANSPORTE DE SOJA DA FAZENDA PARA UNIDADES ARMAZENADORAS NO MÉDIO-NORTE DE MATO GROSSO, BRASIL

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RESUMO: Os produtores da região Centro-Oeste têm colhido a soja mais cedo para otimizar a janela de semeadura da segunda safra. Os efeitos do aumento da segunda safra sobre as práticas operacionais de colheita e transporte da soja, e, sobre as perdas pós-colheita, ainda não foram bem avaliadas e documentadas. A hipótese desse estudo é que os altos teores de umidade do produto no período de colheita, combinadas às condições de operação no campo e transporte até os armazéns, contribuem substancialmente para mudanças no padrão de qualidade do grão. Nesse estudo, as condições de temperatura, umidade relativa, e nível de dióxido de carbono da massa de grãos foram mensuradas durante o transporte das cargas de soja que saíam do campo para as unidades armazenadoras. Localização, distâncias, duração do transporte até o armazém, tempo de manejo (recepção e expedição), e velocidade de trânsito foram obtidos via GPS. Resultados apotam variação da umidade da soja durante a colheita (10.8-25.7%), distâncias da fazenda ao armazém (5-125km), tempo de trânsito (0.4-5.8h), duração da viagem (0.55-27h), e velocidade de trânsito (17.5-61.4km/h) para 10 fazendas próximas à Sinop, MT. Espera-se que as informações fornecidas à partir desse estudo ajudem no desenvolvimento de melhores práticas operacionais relacionadas ao manejo e transporte da soja, visando a redução de perdas pós-colheita relacionadas à qualidade do grão.

PALAVRAS-CHAVE: qualidade de soja, logística de transporte, perda de pós-colheita

MEASUREMENT AND ANALYSIS OF SOYBEAN TRANSPORTATION CONDITIONS FROM FARM TO STORAGE IN THE MIDDLE-NORTH REGION OF MATO GROSSO, BRAZIL

ABSTRACT: Grain producers in Center-West Brazil have increased double-cropping, for example, planting corn immediately after soybean harvest. The effects of this practice on soybean harvest, handling, and transportation practices and corresponding soybean quality losses have not been documented. Our hypothesis is high harvest moisture content, conditions during transit and handling, and transport duration contribute to quality changes even before the soybeans are delivered to storage for drying. In this study, environmental conditions such as temperature, relative humidity, and carbon dioxide levels were measured inside the grain trailer. Location, distances, trip duration, handling times (loading, transit, and unloading), and transit velocity were determined using a global positioning system (GPS). This report covers the variability in harvest moisture content (10.8 to 25.7%), distances from farm to storage (5 to 125 km), transit times (0.4 to 5.8 h), trip duration (0.55 to 27 h), and transit velocities (17.5 to 61.4 km/h) for 10 soybean farming operations near Sinop, MT. This study will be useful in developing future guidelines for better handling and transportation of soybeans to minimize postharvest losses.

KEYWORDS: soybean quality, transportation logistics, postharvest loss

INTRODUÇÃO

There has been a growing trend among the grain producers of Central-West Brazil where a second safrinha crop is being planted directly after the harvest of the safra. Examples of this practice are the planting of corn or cotton after the soybean harvest in January to March each year (ARVOR *et al.*, 2012). Currently, Brazil produces 86.1 Mt in 30 million ha of soybeans and 43.9 Mt in 8.84 million ha of second crop corn (CONAB, 2014). The state of Mato Grosso alone has 8.58 million ha of soybeans that is double cropped with 3.16 and 0.62 million ha of corn and cotton, respectively (CONAB, 2014). The adoption of second crops in this state has produced new requirements and challenges to the agronomic system. Second crops require planting as early as possible into the rainy season in order to take full advantage of the precipitation, as rainfall sharply declines in May (DE TONI, 2013). This creates a need to harvest the soybean safra at earlier dates and higher moisture contents than was customary. High moisture contents can contribute to postharvest losses if not dried immediately. Estimates of losses previously reported in the literature or farmer surveys are often fraught with assumptions and measurements done with non-representative samples. Therefore in this study, we used advances in sensing and data acquisition to monitor soybean conditions from the point of harvest to handling, transportation, and delivery to the first storage facility. These advances included temperature and relative humidity sensors to estimate equilibrium moisture content of the soybean; carbon dioxide sensors to measure of grain respiration and dry matter loss; and a global positioning system (GPS) unit to analyze handling and transportation logistics, such as location; loading, transit, and unloading times; trip duration, and transit velocity. This study is among the first to document postharvest and transportation conditions of soybean and correlate these parameters to changes in moisture content and soybean classification. In this paper, we discuss our measurements of handling and transportation practices of soybeans in north-central Mato Grosso.

MATERIAL E MÉTODOS

The study was conducted at 10 farms and 12 storage facilities surrounding Sinop, MT. During the harvest from January 23 to March 22, 2014, this region experienced 18.8 to 35.2°C and 17.9 to 27.3°C dry bulb and dewpoint temperatures, respectively, and daily precipitations of up to 90 mm. The total rainfall during the test period was 607 mm, comparable to the 10% yearly probability amount of 747 mm for this region in the months of February and March (DE TONI, 2013).

Six grain monitoring probes, each consisting of up to four temperature, relative humidity, and carbon dioxide sensors (K33-BLG, CO2Meter, Inc., Ormond Beach, Florida, USA) with a GPS receiver and antenna module (Model No. 18x LVC, Garmin, Olathe, Kansas, USA), were developed for this study. The probes were used to monitor conditions as beans were loaded into grain trailers and transported to storage. Measurements were recorded every six minutes using a microcontroller (Mega 2560, Arduino, Ivrea, Italy) from the time of installation and were checked periodically using a radio (Series 1 XBee, Digi International Inc., Minnetonka, Minnesota, USA). Details of the data acquisition system and corresponding program are described in OLSEN *et al.* (2013).

Samples collected from the farm were aggregated using a *quarteador* (Eagri Equipamentos, Dourados, Mato Grosso do Sul, Brasil) and used to represent a “field sample”. Samples collected at the storage facility were also mixed using the *quarteador*. Three subsamples, approximately 15 g each, from the aggregated field sample and mixed storage sample were used to determine wet-basis moisture content by gravimetric method according to ASABE Standard 352.2 (2008). Another set of subsamples, approximately 125 g each, from the field and storage samples were classified according to patterns defined by the Ministério da Agricultura Portaria MA N° 262 (1983).

Distances, transit time, trip duration, and transit velocity were calculated using the coordinates and timestamps collected by the onboard GPS. The Haversine formula was used to find the great circle distance between each set of GPS coordinates (Robusto, 1957). Transit time was defined as the time between the trailer’s departure from the farm and its arrival time at the storage facility. Transit velocity was calculated using the total distance between farm and storage divided by transit time. Trip duration was the time elapsed between the start of soybean loading and the end of soybean unloading. Duration velocity was determined by dividing total distance by trip duration.

The variables studied were harvest moisture content (categorized as low, zero to 13.9%; medium, 14.0 to 19.9%; and high, greater than 20.0%) and trip duration (categorized as short, less than 3 h; medium, 3 to 6 h; and long, greater than 6 h). Descriptive statistics of response variables from 38 trips

observed were conducted using a spreadsheet (M.S. Excel Version 2013, Microsoft Corporation, Redmond, Washington, USA) and graphing software (Origin Pro Version 9.1, Origin Lab, Northampton, Massachusetts, USA).

RESULTADOS E DISCUSSÃO

Soybean harvest moisture contents ranged from 10.8 to 25.7% with an average of 17.1%. For the low moisture beans, the average was 12.0%; medium, 16.2%; and high, 22.6% (Figure 1a). Soybean harvesting in the United States is typically done from 12 to 14% moisture based on recommendations regarding minimizing mechanical damage, improving seed viability, and extending storage times (MESQUITA *et al.*, 2007).

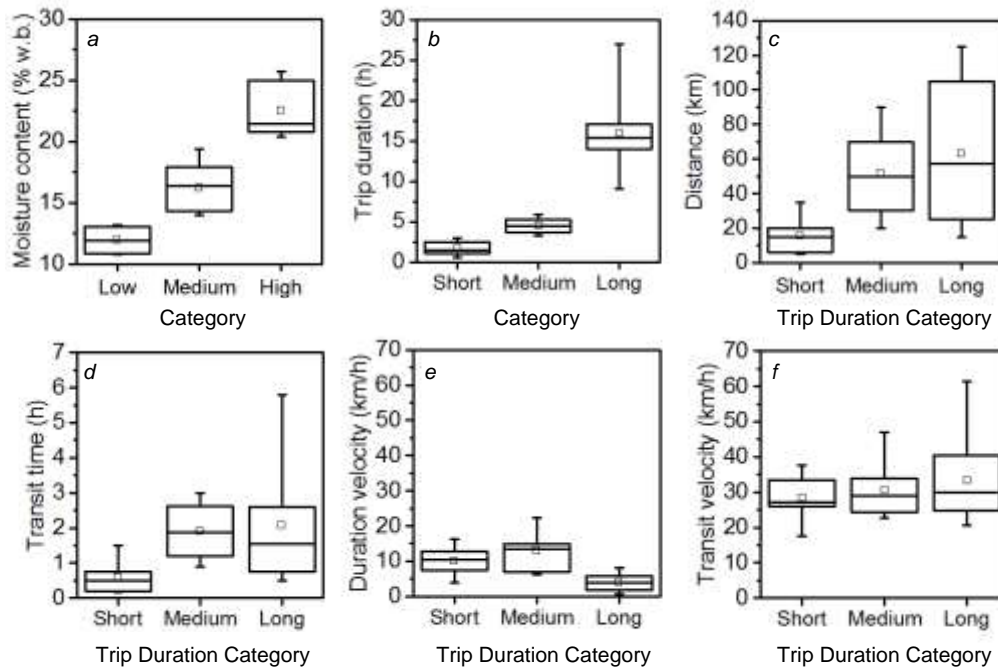


FIGURA 1. Variability in (a) harvest moisture content, (b) trip duration, (c) distance, (d) transit time, (e) duration velocity, and (f) transit velocity observed in this study. These median-based box plots represent minimum, maximum, and interquartile range (IQR), including the mean (\square).

Duration was highly variable, ranging from 0.55 to 27 h. The average duration for the short trips was 1.5 h; medium trips, 3.9 h; and long trips, 16.0 h (Figure 1b). Duration, however, was not directly correlated with distance (Figure 1c). For the 10 farms visited, distances between farm and storage ranged from 5 to 125 km with an average of 39.15 km. The short distance category had an average of 15.4 km; medium, 52.1 km; and long, 63.2 km (Figure 1c). The shortest distance occurred in a farm that had on-site storage. While on-site storage improves logistics and allows the farmer to control marketing and increase overall profitability, only 13% of Brazilian farms have on-site storage (CONAB, 2006; TRAMONTINA *et al.*, 2008). Nationally, Brazil has a 25% grain storage deficit (PATINO *et al.*, 2007). The average distance for short trip durations was 15.3 km and the average distances for medium and long trip durations were comparable at 52.1 km and 63.2 km, respectively. We observed 13 trips falling in the medium and long trip duration categories were left full overnight, either at the farm or at the storage facility, and grain was delivered the next day.

Overall, transit times ranged from 0.4 to 5.8 h. Short trips tended to be 0.5 h long; medium trips, 1.6 h; and long trips, 2.1 h (Figure 1d). Since these transit times were comparable to one another, trucks spent most of the time during long trips sitting idle, either at the farm for loading or at the storage facility for unloading. This behavior was supported by both duration and transit velocity values. Duration velocity ranged from 0.7 km/h to 22.3 km/h with an overall average of 8.5 km/h. Average duration velocity for short trips was 9.8 km/h; medium trips, 13.0 km/h; and long trips, 4.0 km/h (Figure 1e). However, when we look at transit velocities, values were comparable across the trip duration range: short trips had an average transit velocity of 28.5 km/h; medium trips, 30.5 km/h; and long trips, 33.3

km/h (Figure 1f). Based on these figures, trip duration was independent of transit, or road, conditions. Trip duration varied largely due to the efficiency of loading and unloading practices at the farm and storage.

CONCLUSÕES

We found high variabilities in moisture content, trip duration, distances between farms and storage facilities, transit times, and duration velocity. The variation in trip duration depended on whether or not the soybeans could be delivered immediately after harvest. If not, the beans were effectively stored in the grain trailer overnight and delivered early the next day. This practice may lead to quality losses in high moisture beans. The average duration velocity of trailers, 10 to 14 km/h, were comparable for trips that were less than six hours. For long trips, the average duration velocity dropped to 5 km/h. However, transit velocities for all trip lengths were comparable, 25 to 30 km/h, which suggested, for most of the time, beans were in idle trucks during long trips.

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