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Peanut harvest quality: Relationship between soil tillage management and threshing systems

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Abstract

Aim of study: The objective was evaluating the peanut combining process quality in three soil tillage systems associated with threshing and separation systems efficiency of peanut combine available on market.

Area of study: Brazil.

Material and methods: The treatments were three soil tillage systems (conventional, reduced and strip) and two harvesters with different threshing systems. The losses were collected (subdivided in internal mechanisms, pickup platform, and total losses) in fifteen points for each treatment, as impurity samples, following the statistical process control.

Main results: The soil tillage only in sowing line reduced the peanut combining quality (30.4% more mineral impurities and 37.7% more vegetal impurities). The machine with tangential flow presented lower capacity of mineral impurity removal, regardless the soil tillage system.

Research highlights: The losses were similar for conventional and reduced soil tillages, which indicates that it would be possible to reduce the number of agricultural operations before peanut sowing, consequently lessening costs without loss in process quality.

Additional key words: *Arachis hypogea* L.; rip strip; combining losses; statistical process control.

Abbreviations used: CV (coefficient of variation); IMPt (total impurity); I-MR (individual moving range chart); LCL (lower limit); PMI (losses in internal mechanisms); PPR (losses in the pickup platform); SPC (Statistical Process Control); UCL (upper limit).

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Introduction

The 2018 world peanut (*Arachis hypogea* L) production was approximately 46 t ha^{-1}, with 59.2% production located in Asia, 31.1% in Africa, and 9.6% in the Americas (FAO, 2020). In America, the crop stands out in the United States with 3.949 kg ha^{-1} in 2019 (USDA, 2020b). The crop yield in Brazil has increased, with 3.481 kg ha^{-1} estimated for 2019/20, an 17.5% increase compared to the previous crop year (CONAB, 2020). Cultivated mostly in São Paulo state, reaching 90% of country total production (CONAB, 2020), the importance of peanut crop in this region is due to its use in reform areas of sugarcane and pastures, also the region climatic conditions are favorable to their development.

The Brazil peanut crop areas use conventional soil tillage before crop sowing (Hawkins *et al.*, 2016). This soil tillage has been used, mostly, due to soil compaction problems occurrying in sugarcane crop areas due to harvesters and wagon traffic (Souza *et al*., 2015), which inhibits the peanut growth (Kuotsu *et al*., 2014). Thus, conventional tillage is an alternative to solve this problem (Shen *et al*., 2016). However, this soil tillage system both increase production cost, and lead to soil structure degradation, due to the number of operations.

In this sense, although not widespread among Brazilian producers, conservasionist soil tillage methods, such as strip tillage, are indicated as an alternative for peanut sowing in countries such as the United States (Mulvaney *et al*., 2017; Balkcom *et al*., 2018). The purpose of this management is minimum soil turnover, with reduction in number of operations and maintenance of more than 30% soil vegetation cover (CTIC, 2015). The conservationist soil tillage use increased from 19.9% in 2004 to 25.3% in 2013 (USDA, 2020a).

Conservationist systems causes changes in topography, biology and physics of the soil, and effect on crop production to be sown (Zhang *et al*., 2016; Bocianowski *et al*., 2019). Furthermore, due to these soil changes, the uniform seed distribution can be affected, which may interfere in efficiency of the harvesting process, carried out in two stages in peanut crop (digging and combining). The soil tillage impact on crop development aspects is commonly reported, but the harvested material quality is overlooked.

Peanut combine machines have two threshing and separation types, which can be tangential or radial flow, and axial flow (Camolese *et al*., 2015). The tangential flow harvesters thresh the material by promoting impact of the cylinder bars with the plant material. The axial flow harvesters thresh by friction, whereas the harvested material travels along the cylinder axis and is separated by the bars. As the internal mechanisms are different, the machines can have different responses when subjected to different soil tillage. However, the efficiency of threshing and separation mechanisms in peanut harvest quality needs more research, especially as for volume of losses and quality of the harvested material, regardless of the type of soil tillage.

Analysis of quality parameters during harvesting has been reported by several authors as a way of improving agricultural process quality (Cortez *et al*., 2019; Paixão *et al*., 2019; Bernache *et al*., 2020; Roca *et al*., 2020), mostly by monitoring losses. The control charts are used for this monitoring, through Statistical Process Control (SPC), which has obtained satisfactory results in several crops to indicate the best-quality operation, and to point out possible flaws during the process, with the final goal to improve the quality of the process.

Considering the lack of knowledge about threshing and separation mechanisms efficiency of commercial peanut combines for peanut harvest, and that soil tillage can affect the peanut combine operation quality, the objective was to evaluate the peanut combining process quality in three soil tillage systems associated with threshing and separation systems efficiency of peanut combine available on market.

Material and methods

The experiment was conducted in 2018/2019 crop, in Luzitânia-SP municipality (21°8'S; 48°15'W or -21.133333, -48.250000). According to Köppen (1923) classification, the study region is defined as Aw, which indicates rainy tropical, very hot (Fig. 1). The soil at the experimental area was classified as Eutrophic Red Latosol (EMBRAPA, 2013).

The cultivar adopted was IAC OL3, characterized as high oleic acid (70 to 80% oleic acid in oil), early cycle (125 to 130 days), more suitable for rotation with sugarcane, high-yielding, and germination of 70%.

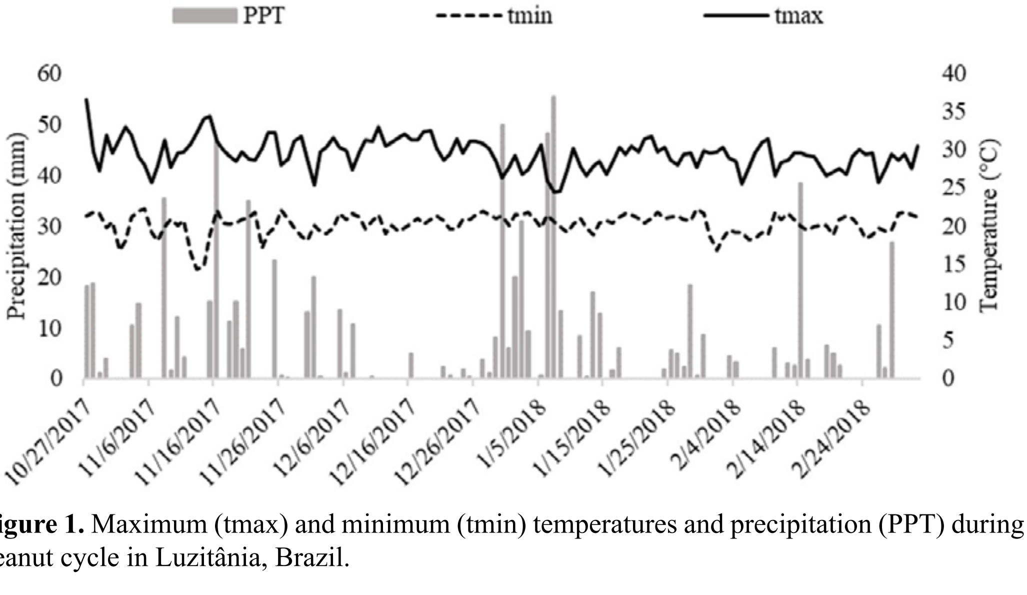

Figure 1. Maximum (tmax) and minimum (tmin) temperatures and precipitation (PPT) during peanut cycle in Luzitânia, Brazil.

Table 1. Variables and definitions to characterize the quality of harvested material.

Variable	Variable characteristic
Entire pods (EP)	Fully developed pods with no sign of mechanical damage.
Open pods (OP)	Pods that were open or broken in half, or those with signs of mechanical damage.
Seedless pods (SP)	Pods with misshapen seeds or seedless.
Thrashed field (TF)	Grains that for some reason, due to the harvesting process, get out the pods.
Vegetal impurity (VI)	Dried branches and/or leaves of plant itself or of weeds, gynophore, previous crop residues.
Mineral impurity (MI)	Soil, stone and all other non-vegetable materials from soil.

Experimental design and treatments

The experiment was conducted in a commercial area with treatments consisting of three soil tillage systems, P1 – conventional, P2 – reduced, P3 – strip; and harvesting (combining) with two different threshing systems, M1 – tangential flow, and M2 – axial flow. In each treatment, a combination of fifteen sample points was collected, following SPC premises.

The soil tillage operations in each treatment were performed as follows:

— Conventional soil tillage (P1): five to seven operations were carried out, using a shoots eliminator, harrow plow with 86.36-cm discs, subsoiler with five shank, moldboard plow (five moldboard), intermediate harrow with 71.12-cm discs and rotary tiller.

— Reduced soil tillage (P2): two operations were carried out, shoots eliminator and subsoiler with five rods.

— Strip tillage (P3): only rip strip equipment (KBM, Brazil) with four lines was used. The equipment performs seven processes in a single operation, cut previous crop residue (cutting discs), removing previous crop residue from sowing line (toothed discs), soil mobilization (rods), directing soil in sowing line (corrugated discs) and breaking clods formed by rods (fluted discs) and breaking clods completing the action of wavy discs and leveling (clod break roller) (Furlani *et al*., 2015).

The peanut combine used in this experiment were: (i) CB 4822 (KBM, Brasil) model with two lines and tangential threshing system, two cylinders and rotation of 1000 rpm, pulled by a New Holland TM 7040 tractor with 180 cv; and (ii) a Double Master III (MIAC, Brazil) model with an axial threshing system, rotation of 540 rpm, pulled by a New Holland 7630 tractor with 110 cv. Both peanut combines operated at 5 km h^{-1} and the beater fingers were set at +45° position.

Peanut yield losses were determined using four circular frames sealed with mesh, which together correspond to a 2 m^2 area. The frames were launched simultaneously (two on each side) between the pickup platform and the peanut combine wheels axis (Fig. 2). The material at the top of the frame corresponded to losses in internal mechanisms (PMI), while the material that was below the frame corresponded to losses in pickup platform (PPR).

Samples were weighted on a precision scale of 0.01 g, and then taken to an oven for 72 hours at 65°C until they reached constant mass, removed and weigthed again to determine the material moisture.

For the harvested material quality analysis in each treatment, samples were collected at the exit of grain elevator when the harvesters were operating in each treatment combination. The samples were collected using a 500-mL container in laboratory, then they were separated following the characteristics presented in Table 1 and finally weighed, to express each percentage into the sample.

For total impurities (IMPt) evaluation in harvesting process, samples of seedless pods, mineral impurity and vegetable impurity were considered. The sample weights were added, and each treatment percentage was determined.

Statistical analyses

To verify the data normality, Anderson-Darling test was performed, and for data general and behavior visualization, a descriptive analysis was performed. Quality analysis was performed by SPC using Individuals Moving Range Charts (I-MR) with Minitab 16 software. In the I-MR charts, the upper and lower limit values (UCL and LCL) were calculated (Eqs. 1 and 2, respectively) considering the average () more or less than three times the standard deviation (σ) of each process and the *p*-value <0.05.

$$UCL=x+3\sigma \tag{1}$$

$$LCL=x -3\sigma \tag{2}$$

The higher the distance between control limits, the higher is the process variability, and, consequently, the lower is the process quality. In addition, the interpretation of I-MR charts is based on the hypothesis that the process is under control when the two graphs, individual and moving range, do not have points beyond control limits, and points beyond the control limits must be investigated for upturn quality in process (Montgomery, 2009).

Figure 2. Methodology example to evaluate losses in peanut combining. The black circle represents frames being thrown between the platform and the peanut combine wheels axis, in movement (A). Frames arrangement after passing of peanut combine (B).

Results

The treatments studied had a normal distribution, except for P1M2 treatment, which had a non-normal distribution for losses in PMI (Table 2).

Differences in variability are highlighted within each process performed by peanut combine. The tangential flow peanut combine (M1) showed higher process variability, which can also be observed in the moving range chart (Fig. 3B), as higher losses volumes in relation to axial flow peanut combine (M2), regardless soil tillage. Nonetheless, it was observed that, as tillage operations number was reduced (strip tillage), the losses in internal mechanisms in tangential flow peanut combine decreased in 54.4%, compared to conventional soil tillage.

The moving range chart represents the variability within the process, so the point outside the control limit observed in P2M2 treatment (Fig. 3B) occurred due to the difference between points six and five of this treatment, because in point five there were no observed machine losses in machine internal mechanism, even as in 26.7% points in this treatment, reducing the treatment variability.

Considering that harvester internal mechanisms can cause damages and losses in harvested material quality, a higher percentage of open pods and grains outside the pod (threshed field) was found in operation with M1 harvester (Fig. 4A) in reduced soil tillage (P2). Also, in P2, lower percentages of entire pods (Fig. 4B) were obtained inside the grain tank (> 80%), which consequently reduced yield in this soil tillage to 5,297.87 kg ha^{-1}.

The mean volume of PPR increased as the number of soil tillage operations decreased, being higher in P3 regardless of the harvester (Fig. 5A). Comparing P1 and P3, there was an 29.5% increase in platform losses in M2. The losses volume in pickup platform was 47.6%, in average, higher than the losses in internal mechanisms in all treatments, except for P1M2 treatment. In these cases, losses in pickup platform were more significant in peanut combining process.

In total losses individual control chart (Fig. 6A), it is observed that M2 obtained lower losses in all tillage systems evaluated in present study. There was 45.9, 34.2, and 5.5% reduction in losses regarding to M1 for conventional, reduced and strip tillage, respectively. There was a reduction of 45.9, 34.2, and 5.5% in total losses in relation to M1 for conventional, reduced and strip tillage, respectively.

There was an entire pods average increase of 7.5% in soil tillage systems, when tangential and axial flow were compared. Regarding the soil tillage, the entire pods average percentage was 85.9, 81.0, and 76.4% for conventional (P1), reduced (P2) and strip (P3) soil tillages, respectively, justifying an 10.5% yield decrease when comparing conventional and reduced tillage, and 15.9% when comparing conventional and strip tillage.

The harvesters evaluated in strip tillage differed by only 5.5% in average, differently from other tillages, wherein the average variation was 40%. As for tangential flow harvester, there was reduction in total losses in relation to soil tillage, with a 19.6% reduction regarding to conventional and strip.

As observed in total impurity individual control chart (Fig. 7A), M2 showed greater quality in peanut combining process, with less variability (Fig. 7B), that is, higher stability in performing operation in reduced (P2) and strip (P3) soil tillage. In P3, an average increase of 54.5% was observed in comparison to the other treatments in mean values of sum impurities inside the harvester grain tank (Fig. 7A). Besides, the M1 harvester exhibited process instability (point above UCL). Differently of what was observed in Fig. 7A, wherein there was an out of control point in P1M1 treatment, in Fig. 7B, all points were into the control limits for the same treatment.

Table 2. Descriptive statistics for losses from internal mechanisms (PMI), losses in the pickup platform (PPR), total losses (PT), and total impurities (IMPt) in the peanut combine process.

	$\overline{X}$	Dp	CV	Median	Max	Min	Rg	AD
PMI								
P1M1	89.62	25.05	27.95	95.05	120.92	48.37	72.55	0.448 ^{N}
P1M2	12.51	12.67	101.31	18.04	34.24	0.0	34.24	1.354 ^{A}
P2M1	72.35	38.16	52.74	72.34	144.89	17.17	127.72	0.326 ^{N}
P2M2	16.02	13.17	82.21	18.71	46.58	0.0	46.58	0.704 ^{N}
P3M1	47.88	27.42	57.27	37.50	102.45	13.59	88.86	0.559 ^{N}
P3M2	16.36	7.49	45.77	17.66	28.26	4.95	23.32	0.291 ^{N}
PPR								
P1M1	83.40	31.64	37.94	73.50	155.22	32.72	122.50	0.486 ^{N}
P1M2	81.11	33.96	41.87	76.79	150.27	30.65	119.62	0.283 ^{N}
P2M1	84.80	41.0	48.35	76.10	175.50	28.10	147.40	0.518 ^{N}
P2M2	87.80	44.40	50.60	89.20	189.70	13.00	176.70	0.193 ^{N}
P3M1	91.20	47.10	51.63	91.20	182.20	16.50	165.70	0.135 ^{N}
P3M2	115.10	42.10	36.54	119.00	166.80	43.60	123.30	0.462 ^{N}
PT								
P1M1	173.02	31.34	18.12	169.67	217.61	103.93	113.68	0.253 ^{N}
P1M2	93.62	37.47	40.02	82.34	177.88	30.65	147.23	0.490 ^{N}
P2M1	157.10	64.80	41.21	170.40	288.60	61.30	227.30	0.226 ^{N}
P2M2	103.40	48.00	46.36	108.50	214.20	13.00	201.10	0.250 ^{N}
P3M1	139.10	50.90	36.5	128.80	225.30	30.10	195.30	0.864 ^{N}
P3M2	131.50	38.80	29.54	131.10	195.00	66.20	128.80	0.265 ^{N}
IMPt								
P1M1	8.60	5.10	59.25	7.62	21.71	2.95	18.76	0.576 ^{N}
P1M2	8.40	4.16	49.52	6.62	17.59	4.17	13.42	0.789 ^{N}
P2M1	10.70	5.72	53.49	8.40	24.27	3.89	20.38	0.640 ^{N}
P2M2	6.38	3.07	48.18	5.57	13.93	2.29	11.64	0.389 ^{N}
P3M1	18.51	6.17	33.33	18.47	30.86	9.21	21.65	0.313 ^{N}
P3M2	12.78	2.15	16.78	12.45	17.52	9.37	8.16	0.229 ^{N}

$\overline{X}$, mean; Dp, standard deviation; CV, coefficient of variation; Max, maximum value; Min, minimum value; Rg, range value; AD, Anderson-Darling test; P1, conventional soil tillage; P2, reduced soil tillage; P3, soil tillage with rip strip; M1, tangential flow; M2, axial flow. ^{N}, normal distribution data; ^{A}, non-normal distribution data.

Discussion

Samohyl (2009) ensures that control charts of variables that did not present normal data distribution can be used; however, when there is a normal probability distribution, the results obtained can be better interpreted and have a lower false alarms number (Table 2). According to Pimentel-Gomes (2009) classification, the coefficients of variation (CV) observed in Table 2, in general, are classified as very high, which indicate high variability in observed data. This variability is due to mechanized agricultural operations that have interference from several factors, including climate, topography, and soil. Another factor that justifies the high percentages of CV are the range values observed in treatments.

The quality of peanut combines internal mechanisms tested was not affected by soil tillages adopted in this work. This means that there were no occurrences of points that exceeded the control limits, that is, the combines with axial and tangential flow have operated as expected, regardless the situation (Fig. 3A).

The variability difference in losses between the two peanut combines may be associated to each threshing and separation mechanism. Tangential flow harvesters execute the threshing and separation process more aggressively, through the abrasion of cylinder bars and harvested mate-

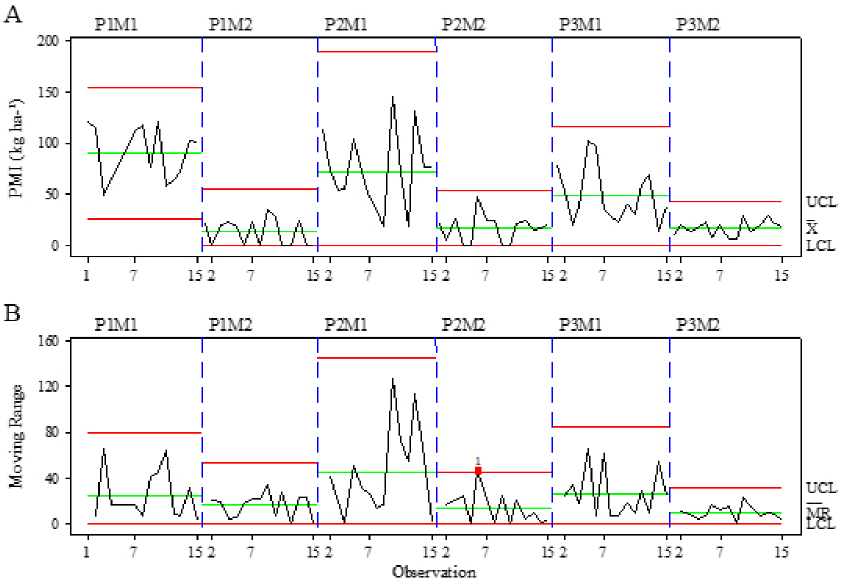

Figure 3. Individual control chart (A) and moving range (B) for losses in peanut combine internal mechanisms (PMI) in peanut combining. P1, conventional soil tillage; P2, reduced soil tillage; P3, soil tillage with rip strip; M1, tangential flow; M2, axial flow; UCL, upper control limit; LCL, lower control limit; **X**, mean; **MR**, moving range.

rial. Therefore, the pods that pass through the system will undergo compression, friction, and impact due to the high speed of cylinder bars, a component of threshing mechanism. Thus, the grains are separated due to the acceleration resulting from this impact (Li *et al*., 2007; Wang *et al*., 2011; Fu *et al*., 2018), which is not interesting for peanut harvest, as the grains must be kept inside the pod. Besides, the machines threshing and separation unit are considered important factors for increasing losses percentage (Taha, 2019), mainly due to harvesters' internal mechanisms with tangential flow (Gurgacz *et al*., 2019).

In the moving range chart for losses in internal mechanisms the point outside the control limits occurred due to the variability reduction in P2M2 treatment. The variability reduction indicates a quality increase, mostly due to the fact that it did not observe losses in machine internal mechanism.

The qualitative losses that can occur in harvested material are directly related to harvester internal mechanisms and its adjustments (Mesquita *et al*., 2006). These adjustments must be changed throughout the day, according to plant/material condition to be harvested, which can reduce the loss rates and maximize the harvesting operation quality, reducing losses and damages caused by threshing mechanism components (cylinder and concave) (Spokas *et al*., 2008; Alizadeh & Bagheri, 2009; Fu *et al*., 2018). However, regardless the soil tillage and harvester, in peanut crop the adjustments of internal mechanisms are not setting throughout the day, due to low machines technological level, which makes the settings difficult. The quality losses varied according to the harvesters and soil tillage, evidencing the need for internal mechanisms adjustments according to working condition throughout the day and soil tillage to increase entire pods percentage in grain tank.

In strip tillage, the machine feed rate may have been higher, due to the presence of crop remains over soil, when compared to conventional soil tillage. This higher feed rate may have overloaded the separation and cleaning system, also justifying the higher percentage of vegetal impurity in harvested material (Fig. 4A). Combined to this, there was a higher occurrence of straw accumulation during combining, especially when the digging operation did not provide uniform windrow, which consequently increased the material volume in peanut combine platform in some points.

The feed rate increase caused by the high material volume on cutting and pickup platform causes plants intertwining and overcrowding in cutter (straw accumulation), which results in prior detachment of material harvested before it even gets in harvester internal systems (Sangwijit & Chinsuwan, 2011), in addition to increasing the percentage of damages and losses (Olaye *et al*., 2016).

Another factor that may have influenced the higher volume of losses observed in strip tillage is the settings of pickup platform, which was the same in all tillage systems, in order to maintain treatments uniformity. Therefore, it is assumed that different settings on pickup platform according to windrow peanut quality, may enable reduction of losses in soil tillage with residue on surface.

The more significant losses in pickup platform may be associated with the difficulty in settings of different move-

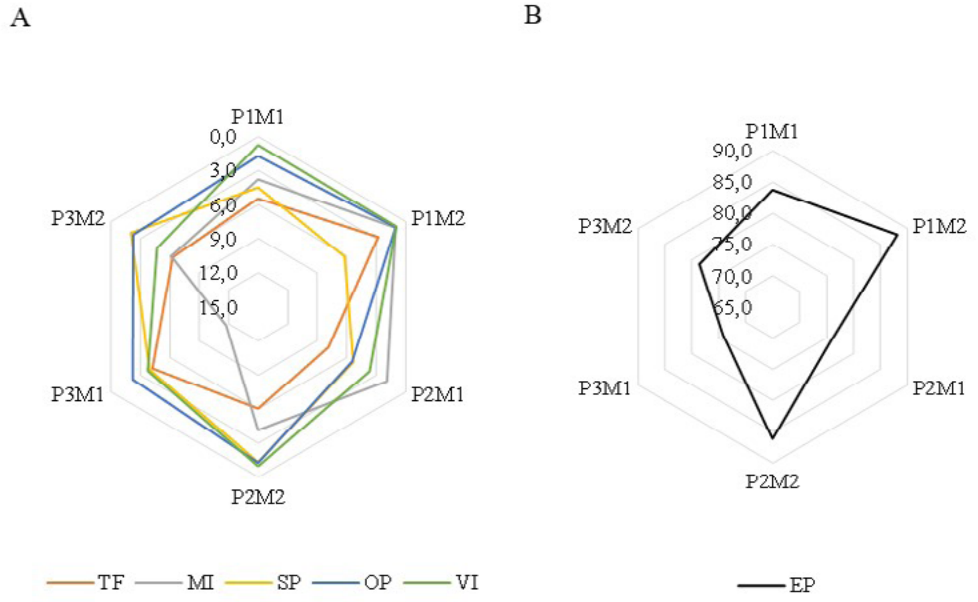

Figure 4. Radar chart for quality in peanut combining process. EP, entire pods; TF, threshed field; MI, mineral impurity; SP, seedless pods; OP, open pods; VI, vegetal impurity; P1, conventional soil tillage; P2, reduced soil tillage; P3, soil tillage with rip strip; M1, tangential flow; M2, axial flow.

ments that occur on peanut combine cutting platform, which is made by a chain on machine external side, without any use of technology. Souza *et al.* (2001) also verified that losses in pickup platform in bean harvest, using an axial flow harvester, similar to peanut combine, were higher than the losses caused on threshing, separation and cleaning systems.

Furthermore, the results verified for peanut crop in this study confirm what has already been reported in literature for grain harvesting which use more technified harvesters, such as soybean, in which the losses in platform can represent 80-85% of total losses, these being higher than the losses in internal mechanisms, and this is due to impact between the platform and plant material (Cunha & Zandbergen, 2007; Holtz *et al.*, 2019). However, it is highlighted that the increase or reduction of these losses is directly associated with the crop to be harvested condition (Compagnon *et al.*, 2012), being the operator responsible for analyzing the harvest conditions and adjusting harvester settings to increase efficiency and maintain grains harvested quality.

The lower losses observed with axial threshing mechanism may be linked to less aggressive threshing process. The process occurs along the cylinder axis, and the grain will be threshed by rubbing the cylinder bars with harvested material. This system occurs more slowly and gently. The more gently threshing that occurs in axial flow system, may also justify the higher percentage of entire pods observed in M2 in all treatments of present study (Fig. 4B).

According to the results for the total losses, the tangencial flow harvester is a greater threshing system, when there is plant residue over soil and high moisture in harvesting. The thresh by impact can be more efficient in separating vegetal material from the remaining crop.

The instability observed in total impurities (Fig. 7), may be associated to some obstacle at designated points, such as difference in soil topography and accumulation of plant residue on soil surface. These points are associated to high mineral impurities percentage, corresponding to 18.1 and 24.7% of the harvested material, respectively. However, one point out of control in agricultural process, which has high variability, does not disqualify it, although it is highlight that there is a need for constant verification and monitoring, to remove these flaws and improve the operation quality.

In the Fig. 7B all points were into control limits in P1M1 treatment; this can be justified because 66.7% of the points in this treatment were below average, reducing variability. Therefore, points with high impurity percentages tend to wend above upper control limit on individual control chart (Fig. 7A).

The tangential threshing mechanism presented a higher impurity percentage in all soil tillage, which may be associated to its impact threshing. Galindo *et al.* (2019) affirm that during harvested material threshing, immediate and latent damage may arise, considering that forces are applied to the material to detachment, being this force comes mainly from cylinder.

According to Marcondes *et al.* (2010) the purity of harvested grains is directly associated to the harvester cleaning system efficiency, *i.e.,* internal mechanisms. In the present study, the average impurities in axial flow har-

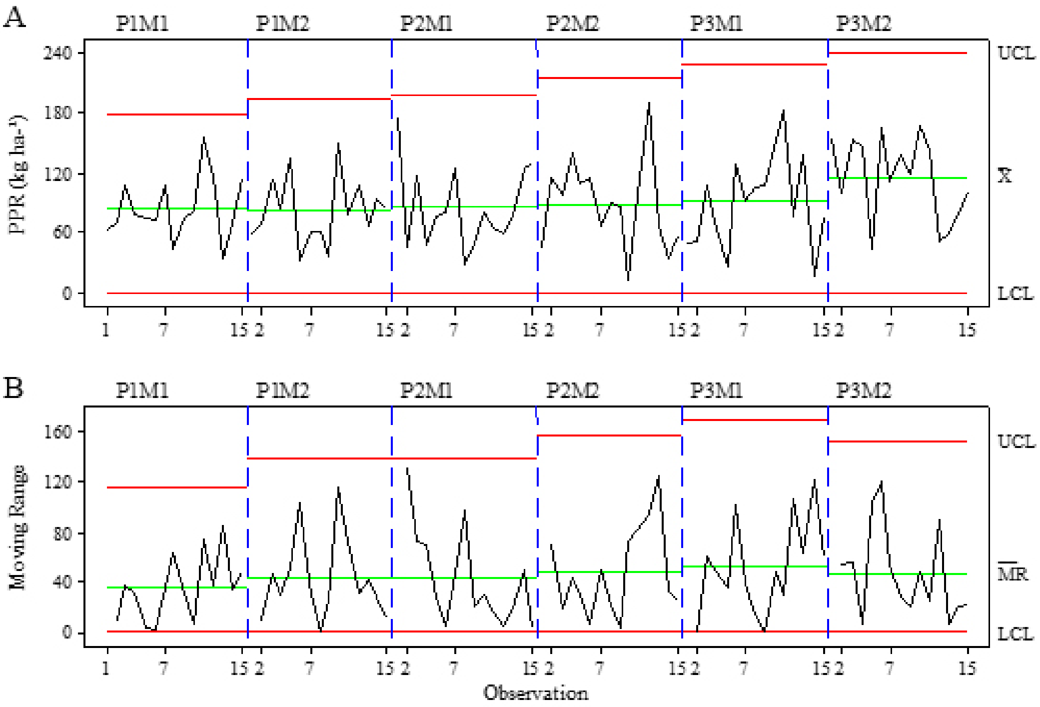

Figure 5. Individual control chart (A) and moving range (B) for losses in pickup platform (PPR) in peanut combining. P1, conventional soil tillage; P2, reduced soil tillage; P3, soil tillage with rip strip; M1, tangential flow; M2, axial flow; UCL, upper control limit; LCL, lower control limit; $\overline{\mathbf{X}}$, mean; $\overline{\mathbf{MR}}$, moving range.

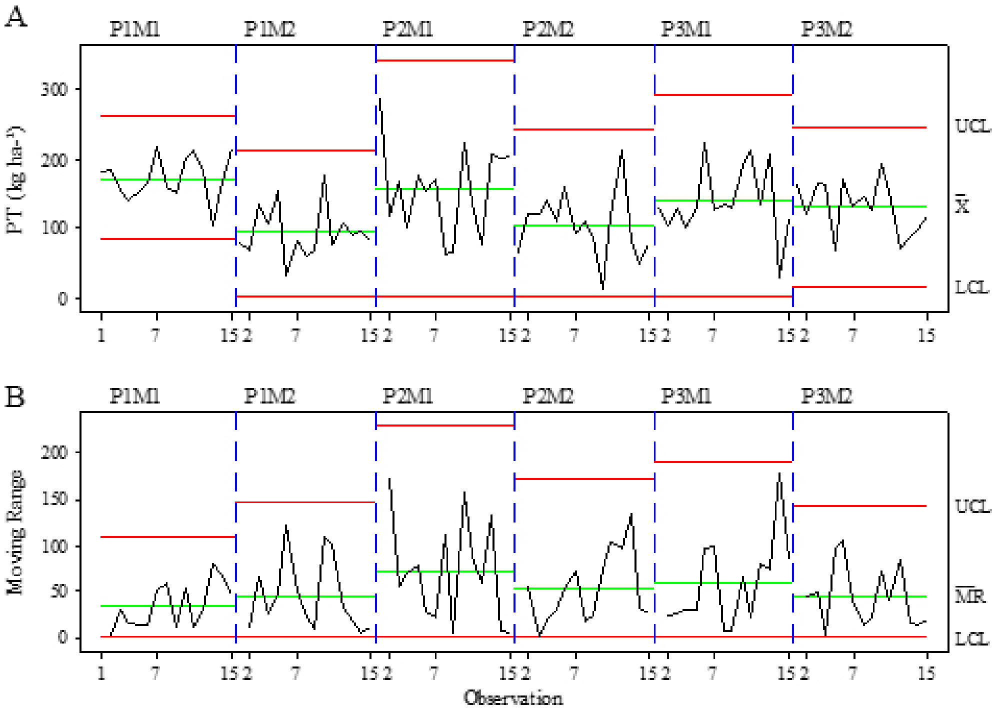

Figure 6. Individual control chart (A) and moving range (B) for total losses (PT) in peanut combining. P1, conventional soil tillage; P2, reduced soil tillage; P3, soil tillage with rip strip; M1, tangential flow; M2, axial flow; UCL, upper control limit; LCL, lower control limit; $\overline{\mathbf{X}}$, mean; $\overline{\mathbf{MR}}$, moving range.

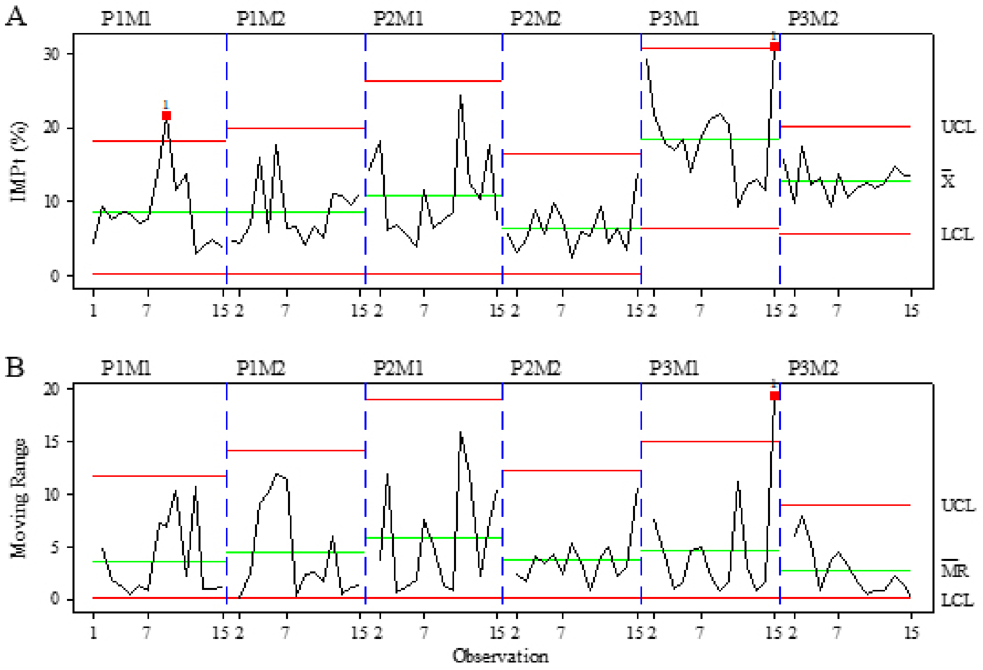

Figure 7. Individual control chart (A) and moving range (B) for total impurities (IMPt) in peanut combining. P1, conventional soil tillage; P2, reduced soil tillage; P3, soil tillage with rip strip; M1, tangential flow; M2, axial flow; UCL, upper control limit; LCL, lower control limit; **$\overline{X}$**, mean; **$\overline{MR}$**, moving range.

vester (M2) varied between 6 and 13%, which may also denote a deficiency in the cleaning system. Compared with soybean harvest, which has high technology-embedded machines, the impurity values found in the present study are considered high, since in soybean harvesting operation performed with tangential flow harvester, 1% impurities were found (Cassia *et al.*, 2015).

However, high variation in impurity levels between soybean and peanut harvest is mainly due to working height of pickup platform. In peanut harvest, the pickup fingers work directly in soil contact, since the harvested material (windrows) is piled over soil. Otherwise, in soybean harvest, the reel overturns the plants, and the cutting platform mows the plants at a height from 0.1 m above the soil surface (Valadão Júnior *et al.*, 2008; Pereira *et al.*, 2010; Rocha *et al.*, 2012).

Also, it was observed that it goes through harvester internal mechanisms, responsible for material cleaning and separating, seedless pods (Fig. 4A). Seedless pods occur due to problems during the period of grain filling and development, after the pods enter in soil, being the main problems water stress and temperature (Fig. 1). Ferrari Neto *et al.* (2012) emphasize that optimum temperature for peanut development is between 25 and 35 °C, which will promote higher carbohydrates backlog and consequently less porcentage of seedless pods.

The strip tillage showed a 30.4 and 37.7% on average more mineral and vegetal impurities than the other soil tillages, respectively (Fig. 4A); the use of rip strip may have affect this result. The equipment did not provide complete plant residues incorporation from the previous crop, hence there may be presence of clods on soil surface after operation.

In conclusion, the strip tillage showed lower quality in peanut combining, presenting higher total impurities percentage and presence of vegetal and mineral impurities in harvested material. The losses in internal mechanisms, losses in pickup platform and total losses were close, differing an average 6.8, 4.1 and 19.6 kg ha^{-1}, respectively, for conventional, reduced and strip tillage, implying that the number of agricultural operations in peanuts implantation can be reduced, reducing costs, without loss in quality of harvesting process. Comparing the two harvesting mechanisms, no major differences were observed in strip tillage. Otherwise, soil tillages P1 and P2, the axial flow peanut combine showed lower total losses percentages, which may be the best option in these soil tillages.

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