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ANALYSIS OF THE WORK OF SUGAR CANE HARVESTING OPERATORS IN SUGAR CANE FAILS INFESTED BY BRACHIARIA

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Summary
As the productivity of sugarcane fields decreases, flaws in plantations begin to appear, giving rise to the birth of brachiaria. These infestations result in a reduction in the flow rate of transshipment loading at harvest and a loss of quality of the harvested mass. In this sense, the objective of this article is to analyze the work of the sugarcane harvester operator in a harvesting situation on land infested by brachiaria, from an ergonomic perspective, to highlight which commitments, knowledge and operational strategies are considered for compliance of its activities. For this purpose, the course of action work analysis method was used. Two visits were made to harvesting situations in infested land, with different workers and machines, in a sugar-energy plant. From the analysis of tetradic signs, it was possible to demonstrate that operators establish operational strategies to deal with the commitments established both with the delivery of trucks and with tractor partners, sometimes prioritizing the quantity and sometimes the quality of the sugarcane delivered to the plant, in order to avoid supply failures. Automated components of the harvester were not efficient in cases of irregularities in plantations, proving to be dependent on the intelligence and skills of the operators to operate satisfactorily.
Keywords: Course of action. Ergonomics. CTT. Productivity. Operative strategies.

1. INTRODUCTION

It took more than 100 years to produce a sugarcane harvesting machine that operationally and economically surpassed manual cutting in crops (KERR; BLYTH, 1993 apud NARIMOTO, 2015). This time was necessary, as it is a plant whose productivity and planting practices vary according to each region and country where it is grown. In this way, one can see the difficulty of achieving a machine design suitable for the most diverse types of producers (Informative bulletin of the International Harvester Company Managerial of 1955 (apud BURROWS; SHLOMOWITZ, 1992)).
With the aim of maximizing the availability of agricultural machinery, the use of embedded technologies, such as on-board computers, provides the plant with almost total control over human work. Therefore, the pace of work is monitored and determined by

production managers guided by the productivity bias and subsidized by a technological infrastructure (VERGÍNIO; ALMEIDA; 2013).
Agricultural productivity is the coefficient of the mass quantity (tons) of sugar cane divided by the planted area in hectares (ha). For an area to be productive and efficient in its planting

and harvesting, there are many factors involved, such as the level of mechanization of these processes, the type of soil, the type of relief, the types and quantities of inputs used for fertilization, irrigation, variety of sugarcane planted, the climate and the company's logistics. Another factor that varies the productivity of the cultivated area is the number of cuts carried out in the same sugarcane field. With each cut, productivity tends to reduce (UNICA, 2018). Furthermore, soil compaction, due to machinery traffic in moist soil, can induce changes in nutrient absorption in plants and, consequently, in their development (GUERINI; HOFF, 2015).

As productivity declines, more flaws in plantations begin to appear, giving rise to the birth of brachiaria. Theoretically, brachiaria is a genus of grass used in the breeding, rearing and fattening phases of animals. This is due to the genre's easy adaptation to various soil and climate conditions (CRISPIM; BRANCO, 2002). When planting sugarcane, brachiaria is one of the names given to refer to weeds or any plant that grows in the sugarcane field other than sugarcane.

As seen, the mechanized harvesting production regime is influenced not only by the number of harvesters in operation, but also by the agronomic, environmental, geographic and operational variables that condition the production rhythm. The harvester, in this way, is most of the time the bottleneck resource in the sugarcane Cutting, Transshipment and Transport (CTT) operation, since attempts are made to work with as few machines as possible to meet the mill's demand, as its acquisition investment and maintenance costs are high, and its operational capacity is a function of an equation, never explicit, of variables of different natures and, often, outside the operator's control (MENEGON; TORRES; SILVA, 2017).

In addition to the quantity of sugarcane delivered to the mill, the quality of the sugarcane is also taken into account. The loss of stem fractions left in the field is wasted raw material and the vegetable and mineral impurities taken to the load during transshipment take their place in the transport and processing of sugar-rich material. Therefore, supply in terms of quantity and quality constitutes the strategic objective of the harvester operator's action. In daily operation, the objective is to reach the hourly target for releasing trucks, ensuring the continued operation of the mill.

In this sense, the aim of this article is to analyze the work of the sugarcane harvester operator in a harvesting situation on land infested by brachiaria, from an ergonomic perspective, to highlight which commitments, knowledge and operational strategies are considered by these workers. to carry out its activities.

2. METHODOLOGICAL FRAMEWORK: COURSE OF ACTION

This article is driven by Course of Action (CA) theory. This choice is justified by the dynamic nature of the harvesting process, which constantly involves changes in variables and decision-making. By this dynamism, it is understood that the AC reveals how the operator perceives the situation, what is relevant to him and what environmental disturbances he admits in his social context. The CA theory is a scientific method of analyzing work inserted in Situated Cognitive Anthropology, in which the operator is the creator of his own activity, which depends on what he understands about the situation itself (WISNER, 1995).

Theureau (2014) defines AC as the activity of one or more actors engaged in a situation, which is significant for them, that is, showable, narrable and commentable by them at all times under favorable conditions. When the actor narrates and comments on his action, his object is the event carried out and the actions considered or predicted and his reasoning, he reveals what was done consciously and also "non-consciously" during the CA, which are reconstituted by a process of reflection. For data collection, Theureau (2014) emphasizes that only data from observations and verbalizations of the CA should be considered. Other data participate in the scientific knowledge of the work only if they are articulated with the first.

In other words, the CA is a chain of tetradic signs, an “open-representation-instance of reference” triad underlying the CA unit, where (THEUREAU, 2014):

a) the “open” represents the situation/context of the action and characterizes the field of possibilities open to the subject in action, in a dynamic oriented towards consecutive objectives. Depending on the actor's engagement with the situation, it is transformed each time each tetradic sign is engendered. This element responds to what the actor expects, perceives or interprets and is related to the situation and context experienced;

b) the “representamen” is an actuality determined by the actor, it is the perceptual activity in the AC here and now (perceptual, proprioceptive and mnemonic judgments). Here we address the perception of the elements of the situation, i. e., of the significant disturbances that emerge from the situation. This sign responds to which element of the situation the actor is considering;

c) the “referential instance” is the sequence of rules that mediates between the open and the representation, arising from the actor’s “density of experiences”, a product of the transformation of individuals’ perception and skills. It answers what knowledge is being mobilized and is related to the rules of the trade;

d) the “unit of course of action” is also an actuality determined by the actor, which is constructed from the open thanks to the instance of the reference. Here are the actions, communications and feelings produced in the interaction of the three previous elements. Answers the questions: what is the actor doing, what does he feel/think about the situation?

Figure 1 represents the tetradic sign and the articulation between them. Initially, there is the triad “open (object 1) – representation 1 – reference instance 1”, resulting in an AC unit. At the same moment that the actor engages in the situation in the present moment, he anticipates what the result of his engagement here and now will affect in the possibilities of action in the next moment, modifying and constituting a new opening (object 2). These four components are dynamic, subjective and inseparable and constitute a language for the intrinsic description of CA.

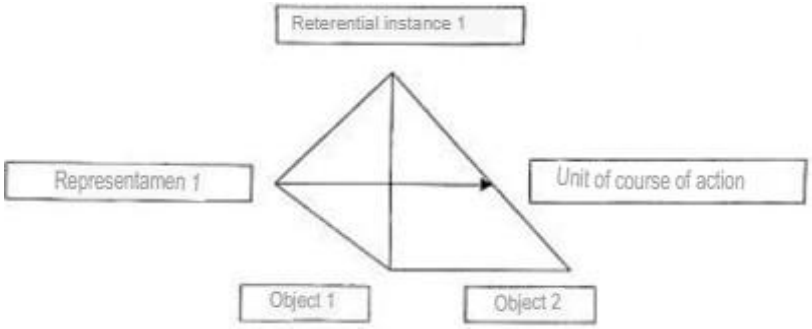

Figure 1. The tetradic sign (Theureau, 2014)

3. RESEARCH METHOD

This study has a qualitative approach, which is justified by the interest focused on understanding the operational logic produced by the operators' lived activities, based on the perspectives and meanings attributed to them. A qualitative approach is adopted to research the history, relationships, representations, beliefs, perceptions and opinions of actors in relation to the way they live, build their artifacts and themselves, feel and think (MINAYO, 2010) .
Field research was carried out, the objective of which was dialogue and interaction between researchers and sugarcane harvester operators to understand their strategies and the activities that were significant to them. Thus, CA observations of these workers and records of their verbalizations were recorded, mostly, from inside the cabin of the harvesting machine, during 17 visits to a sugar-energy plant in the center-west, which grinds 1100 to 1200 tons of sugar cane. /H. The results presented in this article come from two visits in two different shifts with different operators and harvesting machines. A selection was made of two situations experienced by these workers harvesting sugarcane fields infested by brachiaria. Other considerations were made taking into account the speech of a third operator while working.
The first visit was carried out in August, while the second, in September 2018, both from 6:30 am to 2:30 pm. Observations and unstructured interviews with harvester operators were used as data collection techniques. As a record, notes and audio and video recordings were used using a cell phone and an adventure camera. The notes were made in the form of a field diary. The interviews took place during breaks due to breakdowns, supplies and when the researchers intervened when they thought it was necessary at the time of the event to understand what had happened and the cause and effects of the decisions made.
The collected data was gathered. Firstly, the field diary was digitized. Together, the filming and audio recordings were transcribed, completing the information in the diary. Once all the information was digitized, the analysis of the material began following the CA theory.

4. ANALYSIS OF THE COURSE OF ACTION IN HARVESTING IN LAND INFESTED BY BRAQUIARIA

Infestation in the sugarcane field increases the complexity of the harvest, since the harvester was not designed to differentiate the sugarcane from a foreign plant. Furthermore, time is wasted processing a vegetable that only generates costs and impurities for the plant.
The situations of operators 1 and 2 are analyzed and compared here.

4.1. Situation #1: operator 1

perator 1 began harvesting a plot partially infested with brachiaria. Under these conditions, he turned off the soil copyer, justifying that the implement would copy the roots of the bush, potentially jamming the harvester. Controlling the height of the cut manually, he decided to leave tall stumps, “so as not to get brachiaria stumps and the machine wouldn't embuzz”. Then, when the infestation began to decrease, he began to reduce the height of the stump:

> I'm adjusting the height, I'm adjusting it, because, as the brachiaria has stopped, these 'losses' that are getting are no longer due to the brachiaria, but because of my cut, which is too high. I raised the cut on purpose, because of the brachiaria, but now as there isn't much brachiaria I want it to be a quality cut, close to the ground, without causing impurities. So according to my shots, I evaluate the streets that I have already harvested to define and optimize my harvest better (operator 1).

With the reduction of the bush, operator 1 reactivated the base cut soil copyer. He spent two minutes adjusting the height and pressure of the cut, which fluctuated because of the

brachiaria that insisted on appearing.
In addition to the losses in the ratoon, the tractor loading time was long, 30 minutes, as the sugarcane density was low. At no point was operator 1 waiting for transfer. “It's because my loading time is long. If there were any smaller ones, the tractors wouldn’t be able to handle it” (operator 1).

4.2. Situation #2: operator 2

Sugarcane cultivation was completely taken over by brachiaria, as can be seen in Figure 2. According to agricultural data, the farm was a seventh-grade farm and had a productivity of 40 tons/ha. Therefore, the culm density was extremely low and the bushing frequency was high. Therefore, a tractor took more than an hour to fill (an operator in another field filled it in 1h20min). The cargo was basically filled with straw and brushwood. It did not seem viable to harvest that plot, according to the operator: “I don't think the plant pays its bills with that” (operator 2).

Figure 2. Sugarcane field taken over by brachiaria (Own authorship, 2018)

In a joking tone, but still true, the tractor drivers showed dissatisfaction with the loading delay. One of them joked on the radio saying that the harvester extractor was working very well, making gestures saying how long it was taking to complete the load. Another advised: “turn on the turbo button, speed up to 10, 11 km/h, then get there and grab that little strip so you don’t have to talk.” The operator observed “you can't even see the street”, given the extent of the infestation. He said he felt like going out drawing, but clarified that it wasn't possible to cut through the streets until he found one that was worth it.

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> There's no cane here, but there's a spot up front. So I don't miss the street... because if I jump here then I'll have to take a nozzle on the other side, so I don't do that there, so I have to keep going. I could leave it, just like he left it there. But as we can't see the street due to the colonists, brachiaria, then I have to scratch here, so when I get there I can hit it correctly to follow up with the nozzle that will give (operator 2).

Faced with such a scenario, operator 2 harvested with the harvester turned off, because if it were turned on, it would take even longer to fill the transshipment. This logic was also applied with the rotation of the primary extractor, which was reduced: “If not, the tractor won't leave here today” (operator 2).
It was 10:48 am and operator 2 had only sent four tractors to the yard. “And the last of these four was going at the base of the straw” (operator 2). The situation was so serious that the operator called the leader to evaluate the cultivation conditions and check whether it was worth harvesting there. The target for the harvest front was two trucks/h, with six harvesters. There was an area that was able to load in 25 minutes, compensating for the harvesters that were in the bad part. Even so, operator 2 did not believe that two trucks/h would come out and regretted it, because the shot was big, but without cane: “If the cane was good, it would be really good”. And he continued:

> There are times when we, as operators, cannot do anything, but there are a lot of things to improve at this plant here in terms of sugarcane. They are very demanding of operations, trampling, everything, but trampling damages a lot, but the care of the sugarcane, the right time to renovate, the resumption... the resumption is very early here, there is resumption (after the rain) ours here that It's very wet... this destroys the sugarcane field. Because it takes a lot of tamping, it compacts the soil a lot, compaction is worse than trampling on dry land... you step on wet ground, on land that is already red, for example, that takes a long time to

> dry, when it dries it turns into concrete. I think that to improve this here, it had to start from there. There are plants that, if they need to be stopped for 9, 11, 15 days because it's wet, won't run. Not here. The resumptions are very, very early.
> Here you have nothing to do. If a person comes to condemn you, for example, if a multiplier comes to evaluate you here, it's very different, understand? ... we can't do anything... I have a PA, two trucks/h, but they want to know their PA, two trucks have to leave, two have to leave. Then the leader starts to squeeze us. The bad thing about working with a goal is this (operator 2).

Plugged the machine.

> Researcher: When you embucha, what do you do? Turn on reversal?
>
> Operator 2: That's right, it has reversion from the line dividers, the base cutters, and the feeder rolls, they all give reversion, chopper. Then she throws it out, you reverse it. Then we always go with it raised a little, try to get a little, then go back and get the rest.

Operator 2 also explained that, in the sugarcane he was harvesting, 700 rpm of rotation in the primary extractor would be too much, if the secondary extractor was working, but the item was broken. And he continued to argue that the rotation of the extractor depended on the uniformity of the cane. “Sometimes when there is a failure, then you have to reduce it, if it becomes strong, you increase it. It depends on the sugarcane, the way it is” (operator 2).

In the region that was most infested, the operator set the primary speed to 900 rpm. The rotation was high, he explained, because he had to increase it to clean more of the harvested mass and try to remove the sugarcane that was in the middle of the brachiaria. “If not, it’s just brachiaria.” But he had one area, whose situation was more critical. So he reduced the entire primary extractor and still nothing fell into the overflow, because there was no cane.

> Now that I'm in an area that has less manifestations (of brachiaria) I'm going to set it to 650 (the primary extractor rpm). If a lot of straw falls, then I dose it here (on the monitor). The cut is the same. I see the cut there (on the monitor) when I go to calibrate the copier, I'm harvesting at 21, but 'ah, it's getting high', so I go and lower it. In fact, I'm monitoring the base cut pressure, right? If I see that the pressure is too high, then I raise the cut. If it is falling a lot... the correct rate for good sugarcane, with good harvesting conditions, is 900 to 1000 base cutting pressure. And the primer you will use between 850, 900, on a good cane, around 80, 90 (TCH).

The operator was operating at a base cutting height of 29 (high) and the copier was not turned on because of the infestation. Furthermore, I had to deal with maintenance problems on the machine, which increased the frequency of bushings.

> If I put pressure here (on the monitor), it will reach there (in the cultivation), this pressure will give more because it is one of the brachiaria, and (when) it reaches the sugarcane, it will already be infested (...) and the cut will be high... in short, you can't calibrate the machine at the right pressure, understand?
>
> (...) oh, there, embuchou, it's a train that has to be patient. Then there is also the maintenance of the machine, as there was no stop to check it, on the rollers, on everything, so you have to tell all of this, understand?! (...) It's not normal for her to give these things. Then I have to turn a blind eye, really manually.
>
> Machetes help a lot with cleaning too, because they cut the straw. When he's bad, he starts to send some whole cane, or he starts to split the cane, because he cuts it, but he cuts it by force. There's a loss there too, right? It's the invisible perch they talk about. The broth, which is the famous APR (operator 2).

The monitoring platform sensor was out of calibration. He estimated that the load in the transshipment was full, even before the transshipment had completed 50% of its capacity: “The (system) is saying that it is 100% (the load). The (system) is saying that it is 100% in about 20 minutes... and look at the load, no condition” (operator 2). If there was no communication between the operator and the tractor drivers, the platform would send the signal to the first tractor driver in the virtual queue to go to the harvester, while it was not yet

time.

The operator controlled the cutting height manually. When he came across brachiaria, he would lift the cut. When he saw sugarcane, he went down. At one point, he was harvesting with the machine practically completely raised. At another point he explained that sometimes the brachiaria curled up so much that he had to stop the machine to remove it.

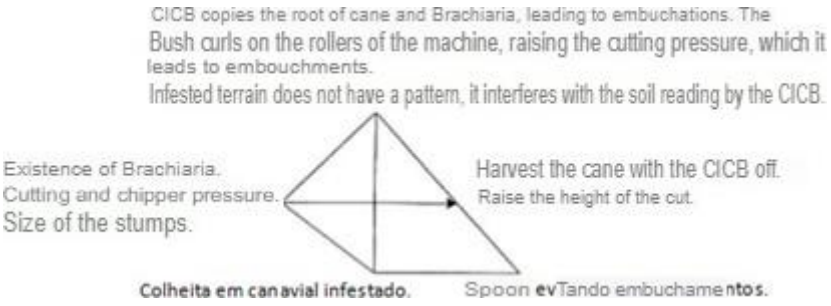
> Roll everything up in the base cut, then there are times when you have to go down, if you have a shovel, because we can't use a knife, right? The right thing would be a serrated knife, because you could saw it. (...) Sometimes you have to call (the mechanic), depending. Oh, with this here, with an infestation like this, I've already lost two deflectors, because the shanks on the base cut are very large, they're not the original ones from the factory, so the shanks are very... there are some really weird talisques. Then a colony gets bigger and ends up damaging the deflector with the base cut, which is the guide plate. I already lost both from yesterday to today. Shift B or shift C lost on this side here, and yesterday they had already lost on the other side too (operator 2).

The condition of the machine caught the operator's attention. He assumed that the lift rollers were having problems, because “this machine has some silly bushings” (operator 2). When asked how he knew that the defect was in the lifter rollers, he replied that when he stuffed, the cane stopped in the first rollers, and then there was no more cane.

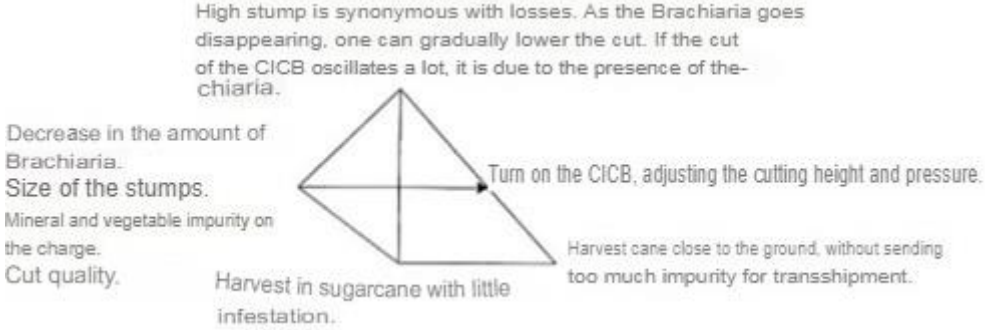
He continued to reap the consequences, with no prospect of improvement, until the machine stopped to carry out maintenance on an OS that had already been opened previously.

5. CA ANALYSIS OF SITUATIONS #1 AND #2

Figure 3 shows the tetradic signs of two moments of operator 1's activity. When the operator perceived the amount of brachiaria as a disturbance in his operation, he considered increasing the size of the stumps in the field, losing in terms of quality, but maintaining the harvester working without bushings. If it embucha, times with reversals would be required. From the moment the operator realized that the cutting pressure was no longer suffering due to the intervention of the brachiaria, he began to consider other elements, as his operation began to aim to produce a clean load without losses. Then, gradually and simultaneously, he started testing different configurations on the machine, checking the results of these changes.



(a) Infested sugarcane field

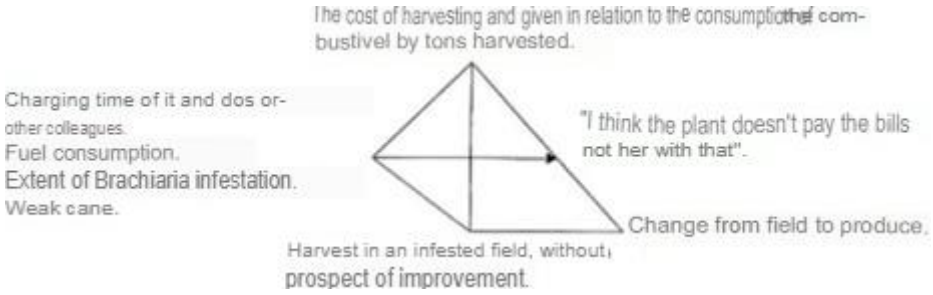


(b) Sugarcane plantation reducing infestation

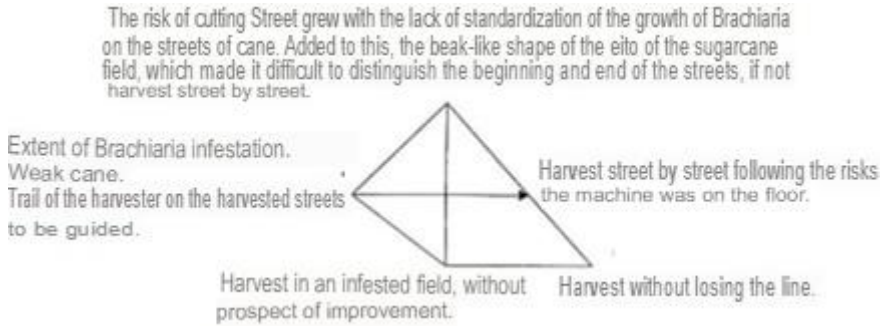
Figure 3. Tetradic signs of situation #1 (Elaborated by the authors)

What can be seen here is the importance of keeping the machine running with as few interruptions as possible and that the automation of the implements that copy the soil is inoperative in the presence of plants other than sugarcane. In other words, irregularities in both the plant and the soil require the most manual adjustments of the harvester possible by the operator.

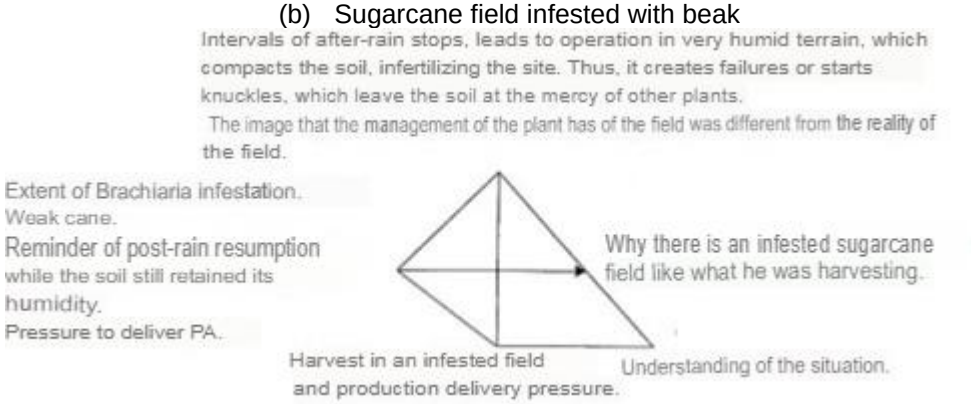
In turn, Figure 4 presents the tetradic signs of some sections of the CA of operator 2. These signs reinforce the conclusions drawn regarding the actions of operator 1, in addition to bringing other important considerations. Even with the increased possibility of bushings in the machine due to brachiaria, the operator was able to distinguish when these bushings were caused by infestations or because of a problem with the harvester. So, if the measures regarding cutting speed and height had been taken, something would be wrong with the mechanical part, requiring a diagnosis of the possible dysfunction. In this case, knowledge of the operation is fundamental to this conclusion.



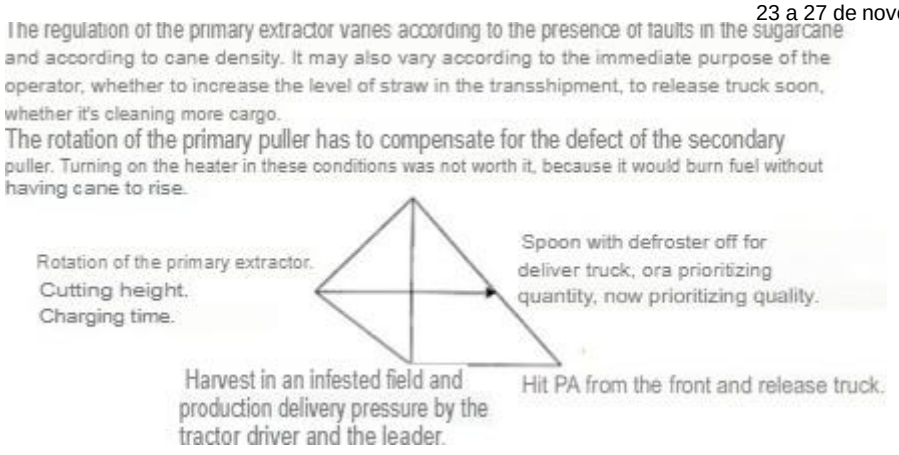
(a) Is an infested sugarcane field worth it?



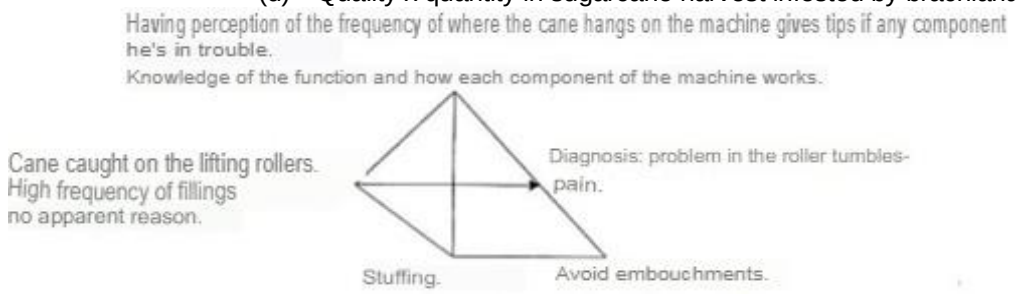
(b) Sugarcane field infested with beak



(c) Reasoning about the causes of the infestation



(d) Quality x quantity in sugarcane harvest infested by brachiaria



(e) Diagnosis of harvest problem

Figure 4. Tetradic signs of situation #2 (Elaborated by the authors)

Operator 2 criticized the way in which targets are created and charged, as the conditions for achieving them are inappropriate. The point of reaping that effect was null for operator 2, who only saw damage and wear being produced without being able to deliver a satisfactory load in the appropriate time. Neither load nor time were achieved as desired. For him, that situation only created unjustified demands. Demands felt coming both from fellow tractor drivers, because they had targets for delivering cargo to the truck, both from the leader at the front to reach the PA, as well as pressure from their own targets and from their machine partners, production and consumption targets. fuel.
Operator 2 understands that in the rush to produce sugarcane for the plant, post-rain recovery happens too early, leading to poor sugarcane fields, and harvester maintenance is postponed so as not to stop the machines. But the demands are maintained, because the results targets are fixed. This generated a snowball, where the operator, the immediate agent of sugarcane production, has to absorb and manage the pressures of all other elements of the production chain, delivering what is possible at any given moment.

5.1 Other considerations about harvesting in sugarcane fields infested by brachiaria

Operator 3 reported that it was not a rule to climb the cut when there was weeds in the sugarcane field. Even in brachiaria, it was possible to cut the sugarcane at a low height, but only if all the implements were working perfectly: “If the machete is sharp and new, if the extractors are working properly. But if something is wrong, that's it! The cut has to be raised a little” (operator 3). This manifestation corroborates what operator 2 had mentioned about the effects of delayed maintenance on operational performance.
In addition to considering the condition of the machine, operator 3 also considered the operator's experience as a determining factor in the success of the operation. He continued by observing that if the operator did not know the terrain well, he could make a mistake with the indicators in an infested area, as sometimes the brachiaria wrapped around the machine's rollers, increasing its cutting pressure, as mentioned by operators 1 and 2. One An inexperienced operator would think he would be working with high pressure, but in reality he would not be. For the same reason that weeds stick to the harvester, the machine's travel speed should be reduced. “If you get a very weak cane, they travel at more than 6 (km/h).

But with brachiaria, he can't walk. After he wraps those brachiariae around his shins" (operator 3).

6. CONCLUSION

Based on the analysis of real harvesting situations in different fields infested by brachiaria, it is clear that there are shared situations in the work process, while there are situations that require other skills from operators to be fulfilled. Both operators based their actions on an instantaneous reading of the state of the machine, the density of the sugar cane and the time it took to fill the transshipment. In short, the commitment that prevailed between them was to deliver sugarcane, whenever possible, with quality (clean load and low losses). When the quantity and quality of the cargo were satisfactory, concerns about losses came to the fore. It can be seen, for example, that operator 1, with a transshipment time of 30 minutes, was concerned with producing a clean load and not leaving sugarcane on the ground, while operator 2 still had the priority of delivering a quantity of raw material,
mainly to free up overflow, contributing to the achievement of their own goals and those of their colleagues.
The operator's action has also processed the judgment of the result of the previously cut lines for more precise regulation of the harvester. Furthermore, collective work is present in determining the mode of operation.

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