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ANALYSIS OF THE WORK OF THE SUGARCANE HARVESTER OPERATOR IN SUGARCANE FIELDS INFESTED BY BRACHIARIA

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Abstract

As sugarcane productivity decreases, gaps in the plantations begin to appear, giving way to the growth of Brachiaria. These infestations result in a reduction in the flow rate of the transshipment loads during harvesting and in 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 the performance of their activities. For this purpose, the course of action work analysis method was used. Two visits were made to harvesting situations on infested land, with different workers and machines, in a sugar and ethanol 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, sometimes the quality of the sugarcane delivered to the mill, in order to avoid supply failures. Automated components of the harvester were not efficient in cases of irregularities in the plantations, proving to be dependent on the intelligence and skills of the operators to operate satisfactorily.

Keywords: Course of action. Ergonomics. CTT. Productivity. Operational strategies.

1. INTRODUCTION

It took more than 100 years to produce a sugarcane harvesting machine that could operationally and economically overcome manual cutting in crops (KERR; BLYTH, 1993 apud NARIMOTO, 2015). This time was necessary, as it is a plant whose productivity and planting practice vary according to each region and country where it is grown. Thus, the difficulty of achieving a machine design convenient to the most diverse types of producers is perceived (Boletim informativo da International Harvester Company Managerial de 1955 (apud BURROWS; SHLOMOWITZ, 1992)).

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In order to maximize the availability of agricultural machinery, the use of embedded technologies, such as on-board computers, provides the mill with almost total control of human labor. Therefore, the pace of work is monitored and determined by the

production managers guided by the productivity bias and subsidized by a technological infrastructure (VERGÍNIO; ALMEIDA; 2013).

Agricultural productivity is the coefficient of the quantity in mass (tons) of sugarcane 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, the 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 made in the same sugarcane field. With each cut, productivity tends to reduce (UNICA, 2018). In addition, soil compaction, due to the traffic of machinery in moist soil, can induce changes in the absorption of nutrients in plants and, consequently, in their development (GUERINI; HOFF, 2015).

As productivity declines, more crop failures begin to appear, giving way 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 easy adaptation of the genus to the various soil and climate conditions (CRISPIM; BRANCO, 2002). In sugarcane planting, 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 pace. The harvester, therefore, is most of the time the bottleneck resource of the Cutting, Transshipment and Transportation of sugarcane (CTT) operation, since it tries to work with as few machines as possible to meet the demand of the mill, because its acquisition investment and maintenance cost are high, and its operational capacity is a function of an equation, never explicit, of variables of different natures and, many times, beyond the control of the operator (MENEGON; TOWERS; SILVA, 2017).

In addition to the quantity of sugarcane delivered to the mill, the quality of the sugarcane is also taken into account. The losses of stalk fractions left in the field are wasted raw material and the vegetable and mineral impurities taken to the cargo in transshipment take the place in the transport and processing of sugar-rich matter. 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 achieve the hourly goal of truck release, ensuring the continued operation of the mill.

In this sense, the objective of this article is to analyze the work of the sugarcane harvester operator in a harvesting situation in Brachiaria-infested terrain, from an ergonomic perspective, to highlight which commitments, knowledge and operative strategies are considered by these workers for the fulfillment of their activities.

2. METHODOLOGICAL FRAMEWORK: COURSE OF ACTION

This article is driven by the theory of the Course of Action (CA). This choice is justified by the dynamic nature of the harvesting process, which involves changes in variables and decision-making all the time. By this dynamism, it is understood that the CA reveals how the operator perceives the situation, what is relevant to him and what disturbances in the environment 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 of the situation itself (WISNER, 1995).

Theureau (2014) defines CA as the activity of one or more actors engaged in a situation, which is significant for the latter, that is, demonstrable, narratable and commentable by them at all times under favorable conditions. When the actor narrates and comments on his action, he has as his object the event carried out and the actions considered or foreseen and his reasoning, he reveals what was done consciously and also "non-consciously" during the AC, 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 former.

In other words, CA is a chain of tetradic signs, an "open-representamen-referential instance" 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. As a function of the actor's engagement with the situation, it is transformed on each occasion of the engendering of each tetradic sign. This element responds to what the actor expects, perceives or interprets and is related to the situation and the context experienced;

b) the "representâmen" is an actuality determined by the actor, it is the perceptual activity in the CA here and now (perceptual, proprioceptive and mnemonic judgments). The perception of

the elements of the situation, i.e., of the significant disturbances that emerge from the situation, is addressed here. This sign answers 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 represented, arising from the "density of experiences" of the actor, a product of the transformation of the perception and competences of individuals. Answers what knowledge is being mobilized and is related to the rules of office;

d) The "unity of course of action" is also an actuality determined by the actor, which is constructed from the open thanks to the instance of the referential. Here we find the actions, communications and feelings produced in the interaction of the three previous elements. It answers the questions: what is the actor doing, what does he feel/think in the situation?

Figure 1 represents the tetradic sign and the articulation between them. At first, there is the triad "open (object 1) – representation 1 – instance of reference 1", resulting in a unit of CA. 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 the possibilities of action in the next instant, modifying and constituting a new open (object 2). These four components are dynamic, subjective and inseparable and constitute a language for the intrinsic description of the AC.

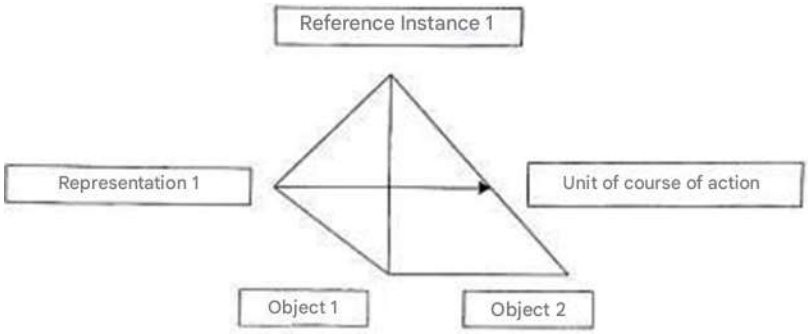


Figure 1. The tetradic sign (Theureau, 2014)

3. RESEARCH METHOD

This study has a qualitative approach, which is justified by the interest centered on the understanding of the operational logic produced by the activities experienced by the operators, from the perspectives and meanings attributed to them. A qualitative approach is adopted to research on the history, relationships, representations, beliefs, perceptions and opinions of the actors in relation to the way they live, build their artifacts and themselves, feel and think (MINAYO, 2010).

A field research was carried out, whose objective was the dialogue and interaction of the researchers with the sugarcane harvester operators to understand their strategies and the activities that were significant for them. Thus, observations of the CA of these workers and records of their verbalizations were recorded, mostly, from inside the cabin of the harvesting machine, during 17 visits to a sugarcane mill in the Midwest, which grinds from 1100 to 1200 tons of sugarcane/h. The results presented in this article come from two visits in two different shifts with different operators and harvesting machines. Two situations experienced by these harvesting workers in sugarcane fields infested by brachiaria were made outlined. 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 in the shift 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 through a cell phone and an action 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 data collected were gathered. At first, the field diary was digitized. Together, the filming and audio recordings were transcribed, completing the information in the diary. Having all the information digitized, the analysis of the material began following the CA theory.

4. ANALYSIS OF THE COURSE OF ACTION AT HARVEST IN PLOTS INFESTED BY BRACHIARIA

Infestation in the sugarcane field increases the complexity of the harvest, since the harvester was not designed to differentiate the sugarcane from a plant foreign to it. In addition, 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

Operator 1 began harvesting a plot partially infested by brachiaria. Under these conditions, he turned off the soil copier, justifying that the implement would copy the root of the bush, and could come to bush the harvester. Controlling the height of the cut manually, he decided to leave stumps high, "so as not to get braschiaria ratoon and the machine does not get plugged". Then, when the infestation began to decrease, he began to reduce the height of the stump:

> I'm adjusting the height, I'm adjusting, because, as the brachiaria has ceased, this 'loss' that is getting is no longer because of the brachiaria, but because of my cut that is very high. I raised the cut on purpose, because of the brachiaria, but now as there is not much brachiaria I want it to be a quality cut, close to the ground, without sending impurity. 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 weeds, operator 1 reactivated the soil copier of the base cut. 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 ratoon, the tractor's loading time was high, 30 minutes, since the density of sugarcane was low. At no time was operator 1 waiting for transshipment. "It's because my loading time is long. If there were a minor, the tractors would not be able to handle it" (operator 1).

4.2. Situation #2: Operator 2

The sugarcane cultivation was completely taken over by brachiaria, as can be seen in Figure 2. According to agricultural data, the farm was a seventh-cut farm and had a productivity of 40 tons/ha. Therefore, the density of stalks was extremely low and the frequency of bushing was high. Therefore, a tractor took more than an hour to be filled (an operator who was in another field made a load in 1h20min). The load was basically filled with straw and brush. It did not seem to be feasible to harvest in that field, according to the operator: "I don't think the mill pays its bills with that" (operator 2).

Figure 2. Sugarcane plantation taken over by brachiaria (Authorship

Jokingly, but not ceasing to be true, the tractor drivers showed dissatisfaction with the delay in loading. One of them joked on the radio saying that the harvester's extractor was working very well, making gestures saying how long it was taking to complete the load. Another advised: "turn on the turbo button, put 10, 11 km/h, then get there and get that comic strip so you don't have to talk". The operator noted "not even the street can be seen", given the extent of the infestation. He said he felt like drawing, but clarified that it was not possible to enter by cutting the streets until he found one that was worth it.

> There is no sugarcane here, but it will be a side hustle up front. For me not to lose the street... Because then if I jump here then I'll have to take a beak out on the other side, so not to do that there, so I have to go on. I could leave it, just like he left it there. But as we can't see the street due to the colonies, brachiaria, then I have to scratch here, so when I get there I hit it right to follow the beak that will work (operator 2).

In such a scenario, operator 2 harvested with the pointer off, because if it 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 will not leave here today" (operator 2).

It was 10:48 a.m. and operator 2 had sent only four tractors to the yard. "And the last of these four was going on the basis of straw" (operator 2). The situation was so serious

that the operator called the leader to assess the conditions of the cultivation and check if it was worth harvesting there. The goal of the harvest front was two trucks/h, with six harvesters. There was an area that was managing to load with 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 lamented, because the shot was big, but without sugarcane: "If the sugarcane was good, it would be too good". And he continued:

> There are times when we as operators can't do anything, but there is a lot to improve in this mill here in this sugarcane issue. They are very demanding operation, trampling, everything, but trampling damages a lot, but the care of the sugarcane, the right time to reform, the resumption... The resumption is very early here, there is resumption (after the rain) here that is very wet... This ends with the sugarcane field. Because it takes a lot of ratoon, compacts the soil a lot, compaction is worse than trampling on dry land... You step on the wet, on a soil that is already red, an example, which takes time to dry, when it dries it turns into concrete. I think that to improve this here, I had to start from there. There are plants that if they need to stay 9, 11, 15 days stopped because it's wet, they don't run. Not here. The resumptions are very, very early.
>
> Here you have nothing to do. If you see a person to condemn you, for example, if a multiplier comes to evaluate you here, it's very different, you know? ... 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 tighten knots. The bad thing about working with a goal is that (operator 2).

Stuffed the machine.

> Researcher: When you bush, what do you do? Turn on the reversal?

> Operator 2: Yes, it has reversal from the row dividers, the base cuts, and the feeder roller, all of them give reversal, chopper. Then she kicks it out, you back up. Then we always go with it raised a little, try to get a little, then come 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 a lot, if the secondary extractor was working, but the item was broken. And he went on to argue that the rotation of the extractor depended on the uniformity of the sugarcane. "Sometimes when there is a failure, then you have to decrease, if you get strong, you increase. It depends on the sugarcane, the way it is" (operator 2).

In the region that was most infested, the operator regulated a rotation of 900 rpm in the primary. The rotation was high, he explained, because he had to increase it to clean the harvested mass more and try to remove the sugarcane he had from the middle of the brachiaria. "If not, it's just brachiaria". But there was an area whose situation was more critical. So it reduced the entire primary extractor and even so nothing fell into the transshipment, because there was no sugarcane.

> Now that I'm in an area that has less manifestation (of brachiaria) I'm going to put the primary extractor at 650 (rpm). If a lot of straw falls, then I will dose it here (on the monitor). It's like the cut. 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', then I go and go down. In fact, I monitor it by the pressure of the base cut, right? If I see that the pressure is too high, then I raise the cut. If it has fallen too much... The right thing in a good sugarcane, with good harvesting conditions, is 900 to 1000 base cutting pressure. And the primary you will use between 850, 900, in a good sugarcane, about 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. In addition, he 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 get there (in the crop), 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, you know?
>
> (...) Oh, there, it got stuck, it's a train that has to be patient. Then there is also the maintenance of the machine, as there was no stop to review, the rollers, everything, then you have to tell all this, you know?! (...) It's not normal for her to give these embuchadas. Then I have to turn a blind eye, in the big manual.
>
> Machetes help a lot in cleaning too, because they cut the straws. When it's bad, it starts sending some whole sugarcane, or starts to crack the sugarcane, because it cuts, but it cuts forced. Then there's a loss too, right? It is the

> invisible loss that they talk about. The broth, which is the famous APR (operator 2).

The sensor on the monitoring platform was out of calibration. He estimated that the cargo in the transshipment was full, even before the transshipment had completed 50% of its capacity: "The (system) is saying that it is 100% (the cargo). The (system) has been saying that it's 100% for about 20 minutes... and look at the load, without condition" (operator 2). If there was no communication between the operator and the tractor drivers, the platform would send the signal for the first tractor driver in the virtual queue to go to the harvester, while it was not yet time.

The operator controlled the height of the cut manually. When he came across brachiaria, he lifted the cut. When I saw sugarcane, I went down. At one point, he was harvesting with the machine practically all up. At another time he explained that sometimes the brachiaria wound up so much that he had to stop the machine to remove it.

> Wrap everything in the base cut, then sometimes you have to go down, if there's a shovel, because we can't use a knife, right? The right one would be a saw knife, because it would be enough to saw. (...) Sometimes you have to call (the mechanic), it depends. Oh, with this here, with an infestation like this, I've already lost two deflectors, because the shins of the base cut are very large, they are not the original ones from the factory, then the shins are very... There are some very weird slats. Then it rolls up a colonião, then it gets bigger, ending up damaging the deflector with the base cut, which is the guide plate. I've already lost both from yesterday to today. Turn B or turn C lost on this side here, and yesterday I had already lost on the other side as well (operator 2).

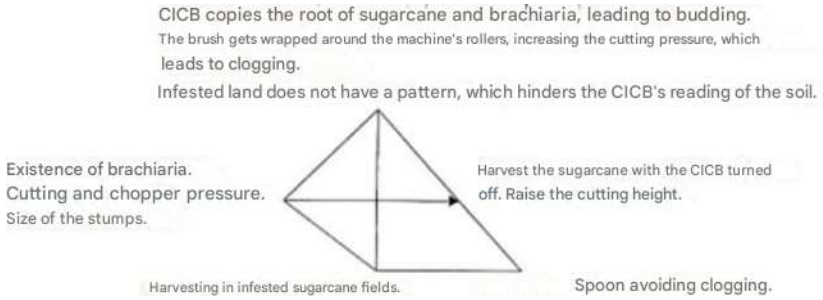
The state of the machine caught the operator's attention. He assumed that the lifting rollers were in trouble, because "this machine has some silly bushings" (operator 2). When asked how he knew that the defect was in the lifting rollers, he replied that when he bushed, the sugarcane stopped at the first rollers, from then on there was no more sugarcane.

He continued to harvest the egg, with no prospects of improvement, until the machine stopped to perform maintenance on an OS that had already been opened previously.

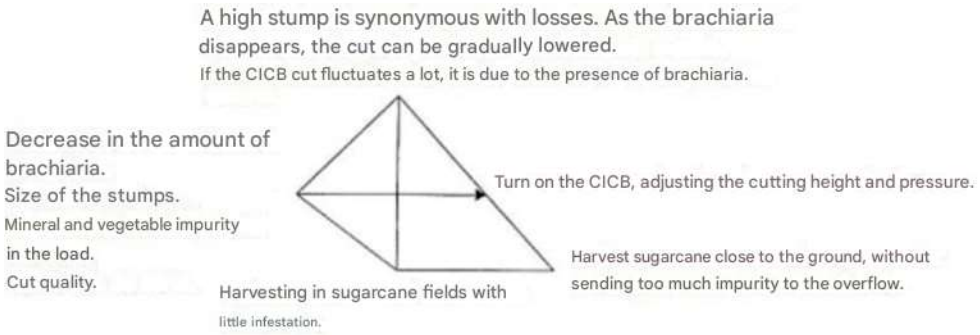
5. ANALYSIS OF THE CA OF SITUATIONS #1 AND #2

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 keeping the harvester running without bushing. If it did, times with reversals would be demanded. From the moment the operator realized that the cutting pressure was no longer suffering from the intervention of

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 began to test different configurations on the machine, verifying the results of these changes.



(a) Infested sugarcane field

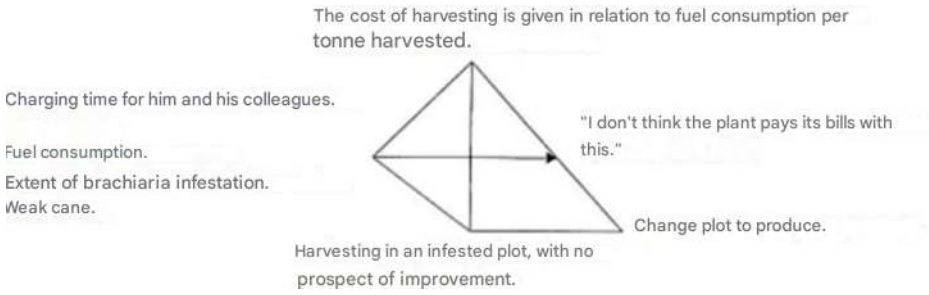


(b) Sugarcane field reducing infestation

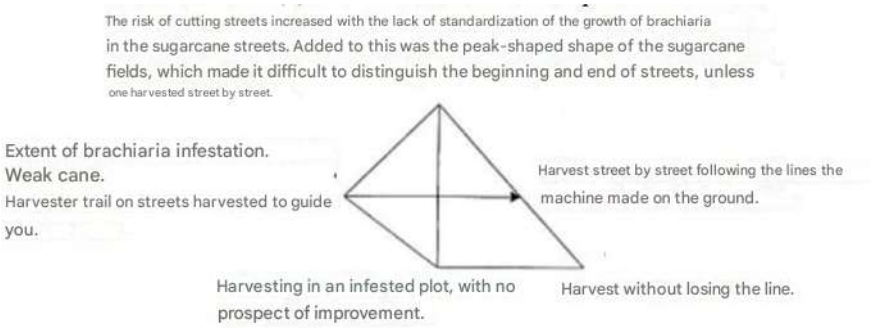
Figure 3. Tetradic Signs of Situation #1 (Elaborated by the authors)

What can be seen here is the importance of keeping the machine running with as few interruptions as possible and that the automation of 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 treatment of the most manual adjustments possible from the harvester by the operator.

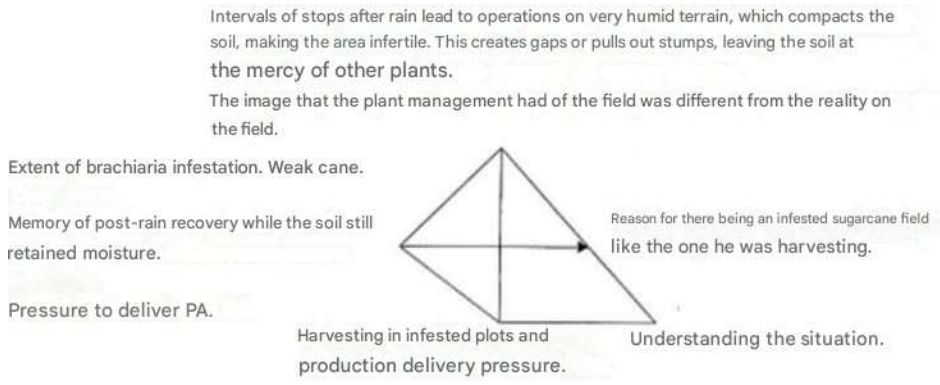
In turn, Figure 4 presents the tetradic signs of some excerpts of the CA of operator 2. These signs reinforce the conclusions drawn about the actions of operator 1, in addition to bringing other important considerations. Even with the increased possibility of bushings in the machine due to brachiaria,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



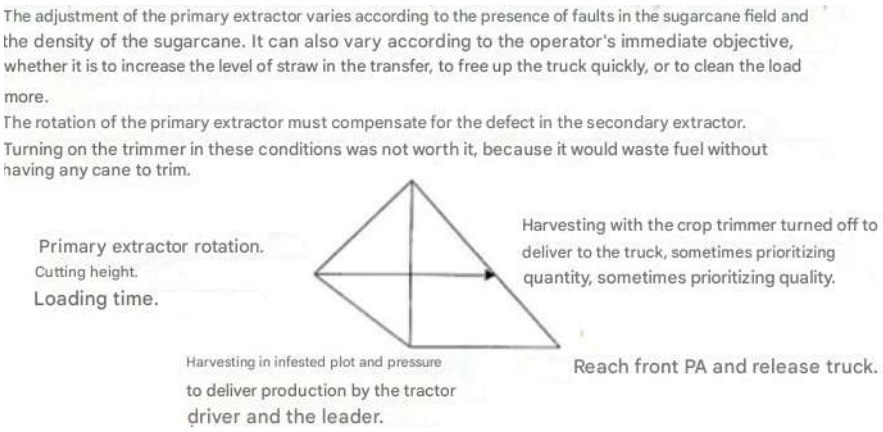
(a) Is Infested Sugarcane Field Worth It?



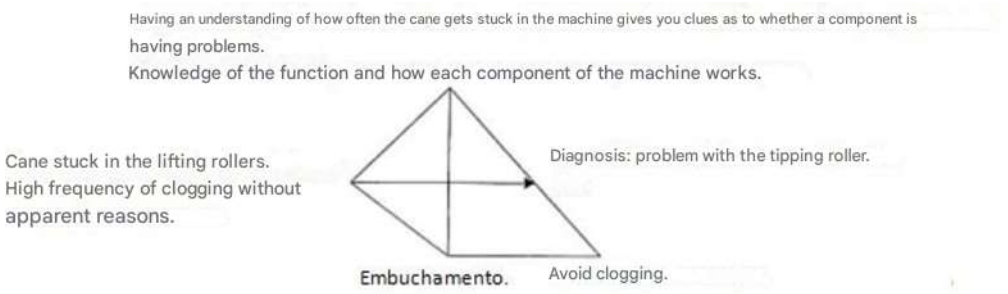
(b) Infested sugarcane field with beak



(c) Reasoning about the causes of the infestation



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



(e) Diagnosis of a problem in the harvest

Figure 4. Tetradic Signs of Situation #2 (Elaborated by the authors)

Operator 2 criticized the way goals are created and charged, since the conditions to achieve them are inappropriate. The sense of harvesting that harvest was null for operator 2, who only saw losses and wear and tear being produced without being able to deliver a satisfactory load at the right time. Neither cargo nor time was achieved in the desired way. For him, that situation was only a creation of unjustified charges. Demands felt both from fellow tractor drivers, because they had goals for delivering cargo in the truck, both from the leader in front to reach the PA, as well as the pressure of their own goals and those of their machine partners, production and fuel consumption goals.

Operator 2 understands that in the eagerness to produce sugarcane for the mill, post-rain resumptions happen too soon, leading to poor sugarcane fields, and harvester maintenance is postponed so as not to stop the machines. But the demands are maintained, because the goals

of results are plastered. This generated a snowball, where the operator, the immediate agent of sugarcane production, has to absorb and manage the pressures of all the other elements of the production chain, delivering what is possible at a given moment.

5.1. Other harvesting considerations in brachiaria-infested sugarcane fields

Operator 3 reported that it was not a rule to go up the cut when there was weeds in the sugarcane field. Even in brachiaria it was possible to cut the cane 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! You have to raise the cut a little" (operator 3). This statement corroborates what operator 2 had mentioned about the effects of delayed maintenance on operational performance.

In addition to considering the state of the machine, operator 3 also considered the operator's experience as a determinant in the success of the operation. He went on to observe that if the operator did not know the terrain well, he could make a mistake with the indicators in an infested area, since sometimes the brachiaria would curl around the rollers of the machine, increasing its cutting pressure, as mentioned by operators 1 and 2. An inexperienced operator would think he would be working with a high pressure, but he really wouldn't be. For the same reason that weeds get screwed on the harvester, the machine's travel speed should be reduced. "If you catch a very weak sugarcane, they go at more than 6 (km/h). But with brachiaria, he can't walk. Then he wraps those brachiaria around his shins" (operator 3).

6. CONCLUSION

Based on the analysis of real harvesting situations in different terrains infested by brachiaria, it is perceived that there are shared situations in the work process, while there are situations that require other skills from the operators to be fulfilled. Both operators guided their actions through an instantaneous reading of the machine's condition, the density of the sugarcane and the time it took to fill the transshipment. In short, the commitment that prevailed among them was to deliver sugarcane, when possible, with quality (clean cargo and low losses). When the quantity and quality of cargo were satisfactory, the concern with losses stood out. It can be seen, for example, that operator 1 with a transshipment time of 30 minutes was concerned with producing clean cargo and not leaving sugarcane on the land, while operator 2 was still in the priority of delivering a quantity of raw material, mainly to release transshipment, contributing to the fulfillment of his own goals and those of his colleagues.

In the action of the operator, he has also processed the judgment of the result of the previously cut lines for the more precise regulation of the harvester. In addition, collective work is present in determining the mode of operation.

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7. TERM OF RESPONSIBILITY

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