ORIGINAL ARTICLE

Evaluation of the Mechanization Level of Aldeia Nova Farm

Avaliação do nível de mecanização da fazenda Aldeia Nova

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ABSTRACT: Agricultural mechanization plays a major role in food production. Its proper implementation requires knowing the indicators that affect its performance. The aim of the present investigation was to evaluate the main mechanization indices of Aldeia Nova Farm in Cela Municipalty. For this, the execution of the study consisted of a non-experimental descriptive investigation, which was divided into two parts. The first consisted of collecting personal data for the operation of the machine and tractor park, maintenance and repair, as well as production. Subsequentle, the mechanization indicators were determined by following methodological recommendations established by various authors. Within the results, the ratio values of tractors per hectare (0,008 tract ha^{-1}), the ratio of average power per tractor (108,86 kW tract^{-1}), the machines per tractor ratio (2,05), the ratio of arable hectares per tractor (126,5 ha tract^{-1}) and the ratio of arable hectares per combine (631,25 ha col^{-1}) were magnitudes studied that behaved outside the established. Finally, the level of mechanization of Aldeia Nova Farm was evaluated using the indices established for this purpose, and it was shown that it is low, since although the value of the available power per hectare (0,86 kW ha^{-1}) is higher than the 0,75 kW ha^{-1} established in the specialized literature, the rest of the indicators register unfavorable magnitudes, except technical assistance indicators.

Keywords: agricultural machinery, tractor, combine harvester, potency, availability.

RESUMO: A mecanização agrícola desempenha um papel primitivo na produção dos alimentos sua implementação adequada requer conhecer os indicadores que incidem em seu desempenho. O objetivo da presente investigação foi avaliar os principais índices de mecanização da fazenda Aldeia Nova do Município da Cela. Para isso a execução do estudo consistiu em uma investigação do tipo descritiva não experimental, a qual foi divida em duas partes. A primeira consistiu em efetuar uma coleta de dados com o pessoal que atende a exploração do parque de máquinas e tractores, sua manutenção e reparação assim como, a produção. Posteriormente foram determinados os indicadores de mecanização para o qual se seguiram as recomendações metodológicas estabelecidas por vários autores. Dentro dos resultados ressaltam os valores de a relação tractores por hectares (0,008 tract ha^{-1}), a relação potência média por tractor (108,86 kW tract^{-1}), a relação máquinas por tractor (2,05), a relação hectares cultiváveis por tractor (126,5 ha tract^{-1}) e a relação de hectares cultiváveis por colheitadeira (631,25 ha col^{-1}) magnitudes que se comportaram fora do estabelecido. Finalmente, avaliou-se o nível de mecanização da fazenda Aldeia Nova mediante os índices estabelecidos para isso, e se comprovou que o mesmo é baixo, pois apesar de que o valor da potência disponível por hectare (0,86 kW ha^{-1}) é superior aos 0,75 kW ha^{-1} estabelecido na literatura especializada, o resto dos indicadores apresentaram magnitudes desfavoráveis. A exceção dos indicadores de assistência técnica.

Palavras chave: maquinaria agrícola, tractor, colhedoras, potência, disponibilidade.

INTRODUCTION

Agricultural mechanization is for the world, the mechanism for the development of agriculture and the right answer to the need to meet the demand generated by the population increase of men in society and animals in production. Likewise, the benefits of mechanization that attract the most attention from farmers are the opportunity for field operations, high efficiency, productivity and reduction of heavy work (Pérez de Corcho *et al.*, 2017).

Therefore, it is an agricultural process that requires a work programming and activity control system for both production indicators and economic, technical and technological indicators that allow for increased efficiency (Herrera *et al.*, 2011).

In agricultural mechanization, three levels are differentiated (human, animal and driving) considering the energy source used (Shkiliova *et al.*, 2014; Daum and Birner, 2020; Gavino *et al.*, 2020). In addition, mention should be made of the incorporation of sensors, drones and robots (Marinoudi *et al.*, 2019; Franco *et al.*, 2020) that allowed the optimization of resources, considering this as a new level. The tractor, due to its variability, is the main symbol to measure the mechanization index, whose calculation uses basic information from the production area (Magalhães *et al.*, 2013; Sharifi and Taki, 2016; Kumar and Tripath, 2019).

At an international level, several investigations have been carried out with the aim of diagnosing the level of agricultural mechanization. They were developed through the calculations established for their future planning, having as a premise the knowledge of the amount of agricultural land available and the desired production, in order to be able to make the right decisions (Gutiérrez *et al.*, 2018; Macías *et al.*, 2018; Rodríguez and Orbegoso, 2018; Loor *et al.*, 2019; Hernández *et al.*, 2020; Llano, 2021; Aragundi and Pacheco, 2022).

However, in Angola and specifically in the province of Cuanza Sul, there are no evidences of scientific publications on studies to diagnose or evaluate the level of mechanization of agricultural production companies. Only the report carried out by Gutiérrez *et al.* (2018), who referred that, in Africa, there is an estimate of 0,6 tractors for every 100 hectares.

Aldeia Nova Farm (S.A.) has a wide range of agricultural machines and tractors, which are designed to tackle mechanized tasks, humanizing work, in addition to increasing the productivity and yield of the different crops grown there. However, despite having modern technology and qualified personnel in the field of mechanization, no evidence was found to demonstrate that they take control of the different indicators of mechanization on the farm. This deficiency does not allow neither carrying out a correct planning of the exploitation of the machinery and tractors and the production plan, nor developing an assessment of whether with the available technique is possible to rationally fulfilling the mechanized tasks. Bearing in mind the above, the present investigation was carried out, which aimed to evaluate the main mechanization indices of the Aldeia Nova Farm in the Municipality of Cela.

MATERIALS AND METHODS

Location and Characterization of Aldeia Nova Farm

The investigation was carried out at Aldeia Nova-Waco Kungo S.A. Farm. Its main objective is agricultural production, industry and commerce, located on the right street of Kissanga. It is located in the city of Waco Kungo, Cela Municipality, Cuanza-Sul Province.

Diagnosis of Mechanization Level of Aldeia Nova Farm

For the evaluation of the diagnosis of the Aldeia Nova Farm, the mechanization indicators were determined, following the methodological recommendations established by Jróbostov (1977), Garrido (1989), González (1993), Muñoz *et al.* (2011) and Azoy *et al.* (2016) referring to the fundamentals of operating and maintaining the fleet of tractors and machines.

Tractors per Hectares (N_{th})

$$N_{th} = \frac{N_{tt}}{T_{hp}} \quad (1)$$

Where:

N_{tt} :is the total number of tractors

T_{hp} :is the total hectares of land cultivated with and without mechanization.

Average Power per Tractor (N_{mt})

$$N_{mt} = \frac{\sum N_c}{N_{tt}} \quad (2)$$

Where:

$\sum N_c$:is the power in kW

N_{tt} :is the total number of tractors

Available Power per Hectare (N_d) or Mechanization Index (IM)

$$N_d = \frac{\sum N_c}{T_{hp}} \quad (3)$$

Where:

$\sum N_c$:is the power in kW

T_{hp} :is the total hectares of land cultivated with and without mechanization

Ratio of Machines per Tractor (Ri.t)

$$R_{it} = \frac{Total\,of\,machines\,for\,tractors}{Total\,of\,tractors} \quad (4)$$

Ratio of Arable Hectares per Tractor (Rha.t)

$$Rhat = \frac{Arable\,area}{Total\,of\,tractors} \quad (5)$$

Ratio of Arable Hectares per Harvester (Rha.c)

$$R_{ha.c} = \frac{Arable\,area}{Total\,of\,harvesters} \quad (6)$$

Technical Availability (DISP)

$$DISP = \frac{Pa}{Pt} * 100 \quad (7)$$

Where:

Pa :is active park

Pt :is total park

Technical Preparation (ε_{pt})

$$\varepsilon_{pt} = \frac{nbest * Dbest}{nb * Dc} \quad (8)$$

Where:

$nbest$:is the average number of machines in good technical condition during the working period

$Dbest$:is trim equipment

nb :is the average number of tractors during the period

DC:is the total number of machines

Use of the Park ($\tau_{apr.par}$)

$$\tau_{apr.par} = \frac{D_{tr.r}}{D_{tr.p}} \cdot 100 \quad (9)$$

Where:

$D_{tr.r}$:is the sum of machine-days actually worked in the period

$D_{tr.p}$:is the sum of days planned machines.

RESULTS AND DISCUSSION

Tractors per Hectare

Table 1 presents the values of the indicators that characterize the level of mechanization of the Aldeia Nova Farm. For the ratio of tractors per unit of arable land area N_{th} with and without mechanization, a value of 0,008 tractor ha^{-1}. was obtained. This result is cataloged as low, as it indicates that the amount of tractors that the farm has to tackle agricultural tasks is insufficient. This magnitude is also lower than the value reported by Gutiérrez *et al.* (2018) which is 0,25 tractor ha^{-1} to the region of San Pablo Atotonilco. The difference between the results obtained in the present investigation and those presented by this author is the amount of hectares of arable land, which in our case is 2 525 ha.

Average Power per Tractor

As for the magnitude relating the average power per tractor (N_{mt}), the result was 108,86 kW tract^{-1} (Table 1). Result that is considered low, because thirteen tractors of the total (60% of tractors) have a power inferior to this magnitude. The average power value per tractor obtained in this investigation exceeds the 61,14 kW tract^{-1} reported by Larqué *et al.* (2012), result conditioned by the power values presented by the tractors of Aldeia Nova Farm, (82,02 to 171,51 kW). Magnitudes greater than those reported by Larqué *et al.* (2012), because in their investigation the tractors that were inspected did not exceed 74,57 kW.

Power Available per Hectare

The ratio of power available per hectare (N_d) obtained is 0,86 kW ha^{-1} (Table 1). This result can be considered as satisfactory since Gaetan (2007) cited by Sánchez *et al.* (2014), state that this indicator should be 0,75 kW ha^{-1}. These results are above those reported by Rodríguez and Orbegoso (2018) as well as by Llano (2021), who reported values of 0,24 kW ha^{-1} and 0,12 kW ha^{-1}, respectively (Figure 1).

This indicates that the farm has a higher mechanization rate than many regions of Latin America and even countries like Peru. However, the latter presents a mechanization index that is not 0,75 kW according to Gaetan (2007) cited by Sánchez *et al.* (2014), it means that it is low. It has the highest yields for major crops such as rice, corn and sugar cane, which denies the thesis supported by researchers who maintain that the highest level of mechanization technology corresponds to the highest yields.

On the other hand, this indicator is lower (Figure 1) than the values reported by Sharifi and Taki (2016) Gutiérrez *et al.* (2018), Loor *et al.* (2019) and Aragundi and Pacheco (2022) This is due to the fact that the research carried out by these authors demonstrates that the tractors that are used to tackle agricultural tasks have more power than necessary per unit of area to be worked or worked on. Even so, the value obtained for this indicator is good.

TABLE 1. Mechanization level indicators at Aldeia Nova farm

IM	N_{th} (tract ha^{-1})	N_{mt} (kW tract^{-1})	N_d (kW ha^{-1})	R_{it}	$Rhat$ (ha tract^{-1})	$R_{ha.c}$ (ha col^{-1})	D_{tec} (%)	ε_{pt} (%)	$\tau_{apr.par}$ (%)
	0,008	108,86	0,86	2,05	126,5	631,25	75	76	84

Legend: N_{th} - is the tractors per hectares ratio; N_{mt} - is the average power ratio per tractor; N_d - is the available power per hectare ratio; R_{it} - is the ratio of machines per tractor; $Rhat$ - is the ratio of cultivable hectares per tractor, $R_{ha.c}$ - is the ratio of cultivable hectares per harvester; D_{tec} - is the technical availability, ε_{pt} - is the coefficient of technical preparation and $\tau_{apr.par}$ - is the coefficient of utilization of the park

Ratio Machines per Tractor

The machine per tractor ratio (R_{it}) resulted in 2,05 (Table 1). This magnitude is classified as low, as referred by authors such as Negrete (2011) and Macías *et al.* (2018), as these researchers state that this indicator should be between 4 and 7. This parameter behaves below those reported by Gutiérrez *et al.* (2018), Macías *et al.* (2018) and Hernández *et al.* (2020), with magnitudes of 3,31; 3,82 e 4,59 machines per tractor, respectively.

Hectare Ratio per Tractor

The magnitude of the hectare per tractor ratio (*Rhat*) determined is 126,5 ha tract[-1] (Figure 3), value that is high if it is considered that FAO (2011) reports that this indicator should be around 50 ha tract[-1]. This result indicates that in order to tackle agricultural tasks on the 2,525 hectares of land that the farm has, it is necessary to buy more tractors or rent them. Other investigators such as Larqué *et al.* (2012), Gutiérrez *et al.* (2018), Loor *et al.* (2019) and Hernández *et al.* (2020) determined this indicator. The values reported by them are equal to 10,96; 12,4; 48,8 e 13,08 ha tract[-1], respectively, results that are below and close to the maximum reported by FAO (2011) which is 50 ha tract[-1]. However, in this investigation, the value of this indicator exceeds the magnitudes found by these authors and the FAO, which indicates that this indicator is not good, since the area to be worked is greater than the number of tractors.

Ratio of Harvesters per Arable Land Area

In the same way, the ratio of harvesters per arable land area behaves $(R_{ha.c})$ with a magnitude of 631,5 ha col[-1]. This result indicates that the number of harvesters that the farm has is also insufficient to face the total area of arable land. For this reason, farm management should consider purchasing new harvesters on the market or renting the service to other companies. The value obtained for this indicator is more than ten times above the 50 ha tract[-1] established by FAO (2011). This indicates that the number of harvesters is insufficient to face the harvesting processes.

Technical Availability and Technical Preparation

In the case of technical availability, the value obtained is 75%. This magnitude can be said to be acceptable, as Pérez (2006) and Zingg (2009) reported that this coefficient should range from 70 to 90%. Which indicates that despite the technical failures that
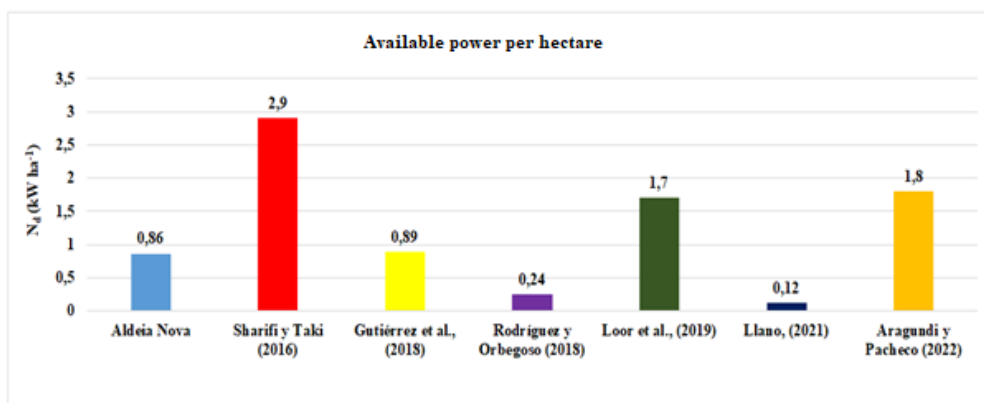

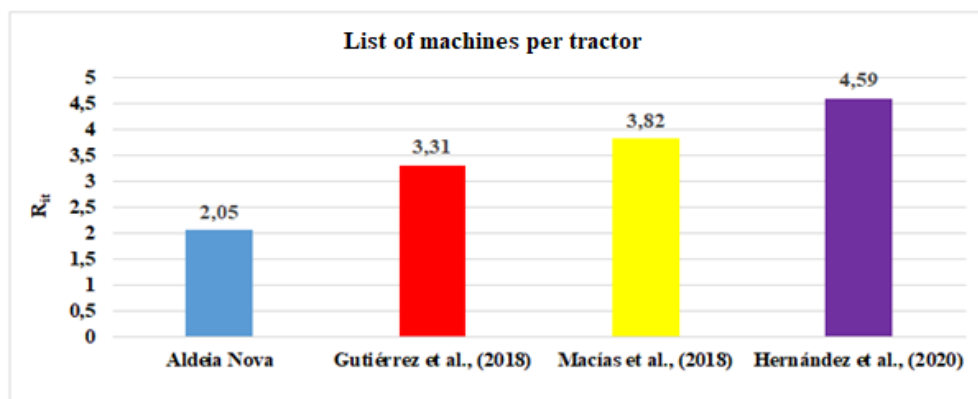**FIGURE 1.** Available power per hectare.

FIGURE 2. List of machines per tractor.

occurred, the administration acceptably manages the inputs and spare parts that are required. In our case, it can be seen in Figure 4 a) that the value obtained (75%) is similar to that reported by Azoy *et al.* (2016).

But it behaved below the value reported by Macías *et al.* (2018) which was 78%. Although the said value is lower, it is considered acceptable since it is in the same range mentioned by other authors.

Technical Preparation

The coefficient of technical preparation (ε_{pt}) determined is 76% (Figure 4 b), which is low, as Jróbostov (1977) referred that the parameter values should oscillate in an interval between 85 and 95%. Evidencing that good management must be done to keep most tractors in good condition. As with technical availability, the coefficient of technical preparation obtained (76%) is below that reported by Macías *et al.* (2018) which was 87% (Figura 4 b).

Use of the Park

The coefficient of utilization of the park was 84%. Considering this result as acceptable, since it is within the range (80 - 95%) reported by Gutiérrez (2007), result superior to that reported by Macías *et al.*
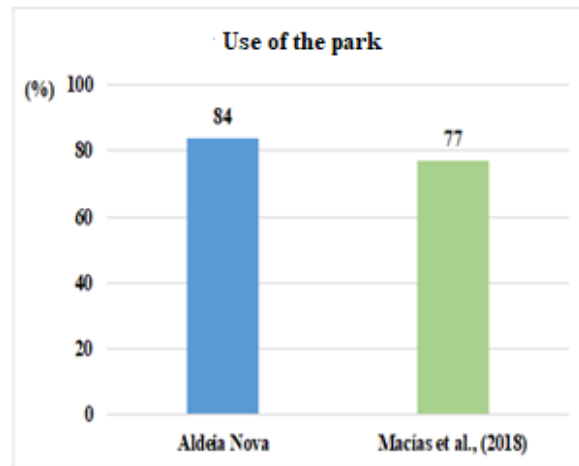
FIGURE 5. Use of the park.

(2018)) which is 77% (Figure 5). This result indicates that the management of the use of the park of machines and tractors is better than that carried out in the study of the previous authors. They state that this low result is due to the fact that the days actually worked on machines were below machine per day planned. The cause is attributed to the equipment that were inactive and for not having the spare part to carry out the repair work.
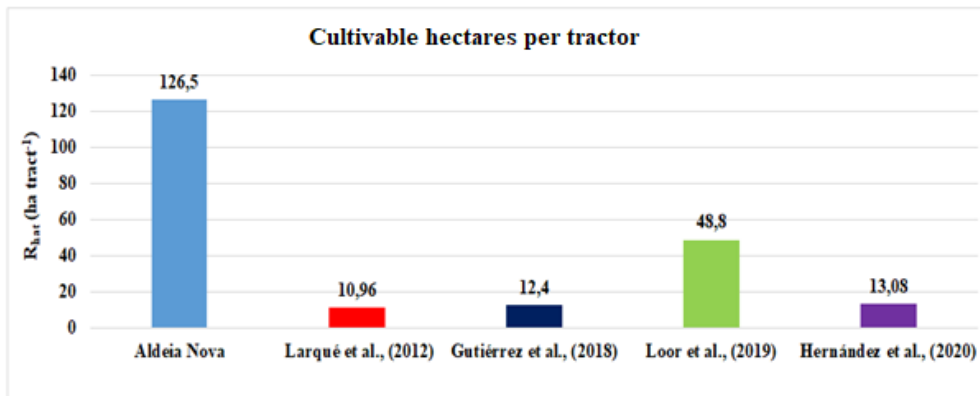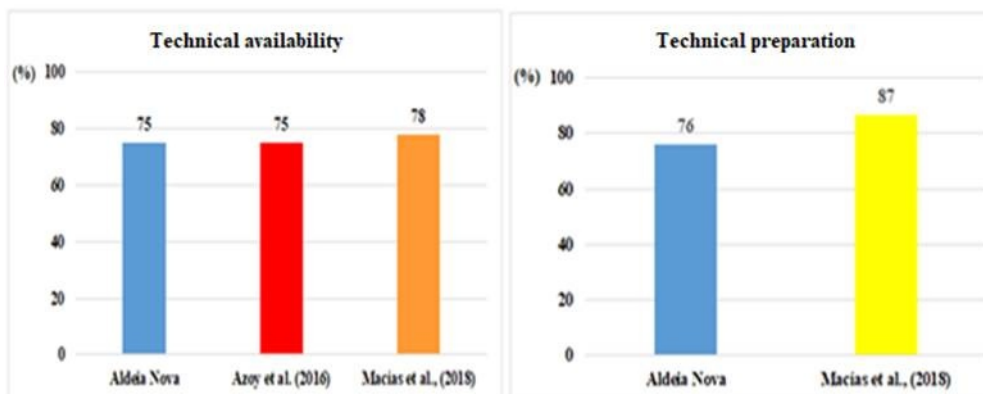
FIGURE 3. Cultivable hectares per tractor ratio.

a)   b)

FIGURE 4. Technical assistance to machinery. a) Technical availability and b) Technical preparation.

CONCLUSIONS

- The level of mechanization of the Aldeia Nova Farm was evaluated through the indices established for this purpose, and it was proved that it is low, because despite the fact that the value of available power per hectare (0.86 kW ha^{-1}) is higher than the 0.75 kW ha^{-1} established in the specialized literature, the rest of the indicators showed unfavorable magnitudes. Except for the indicators related to technical assistance and the use of the park, which, although not high, are within the range.

- The determination of the mechanization indicators under the real working conditions of the farm allows stating that the ratio hectares per tractor is high with a value of 126.5 ha tract^{-1} behaving above the 50 ha tract-1 established, and the 60% of the tractors are below the 108.86 kW tract^{-1} of average power, which indicates that to fulfill the tasks, it is necessary to reorient the planning of the tractor park or rent its service.

- The ratio of agricultural machines per tractor does not exceed two implements per tractor, which limits the full use of the tractor in an agricultural cycle of the crops grown there, such as corn, soybean and sorghum.

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