ORIGINAL ARTICLE

Evaluation of Aggregates Formed with Tractor YTO x1204, Harrows and Land Plane

Evaluación de los agregados formados con Tractor YTO x1204, gradas y alisador

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ABSTRACT: The present work was developed with the objective of analyzing work efficiency indicators of agricultural aggregates formed with a YTO x1204 tractor, harrows and a land plane, in order to establish them partially for the future planning of agricultural works in the Agroindustrial Company of Grains “Fernando Echenique” from Granma Province. To carry out the research, Cuban standards were used as well as instructions and methodologies referred on specialized literature. The results showed that most of the values of the efficiency indicators of these agricultural groups are below the technical possibilities. However, the utilization coefficient of the working width ($\varepsilon\beta$) for the land plane, the utilization coefficient of the working speed (εV) of the 52-disc heavy harrow and the utilization coefficient of work shift (τ) of the three aggregates are classified as acceptable. It is concluded that the magnitudes of real productivity (Wr) obtained behaved below the real possibilities of the set with magnitudes of 14.65; 17.71 and 29.1 ha shift^{-1}, respectively, which is due to violations of the kinematic parameters during work.

Keywords: Working Width, Working Speed, Working Depth, Shift Time and Productivity.

RESUMEN: El presente trabajo se desarrolló con el objetivo de analizar mediante el cálculo de indicadores de eficiencia del trabajo de los agregados agrícolas formados con tractor YTO x1204, gradas y alisador, estableciendo de forma parcial estos para la planificación futura de los trabajos agrícolas en la Empresa Agroindustrial de Granos Fernando Echenique de la provincia Granma. Para la realización de la investigación se utilizaron las normas cubanas. También se tuvieron en cuenta las instrucciones y metodologías expuestas por libros sobre el tema. Los resultaros mostraron que la mayoría de los valores de los indicadores de eficiencia de estos conjuntos agrícolas se encuentran por debajo de las posibilidades técnicas. Sin embargo, el coeficiente de aprovechamiento del ancho de trabajo ($\varepsilon\beta$) para el nivelador del suelo, el coeficiente de aprovechamiento de la velocidad de trabajo (εV) de la grada pesada de 52 discos y el coeficiente de aprovechamiento del tiempo de turno (τ) de los tres agregados se catalogan de aceptables. Se concluye que las magnitudes de productividad real (Wr) obtenidas se comportaron por debajo de las posibilidades reales del conjunto con magnitudes 14,65; 17,71 y 29,1 ha turno^{-1} respectivamente. Lo cual se debe a violaciones de los parámetros cinemáticos durante el trabajo.

Palabras clave: ancho de trabajo, velocidad de trabajo, profundidad de trabajo, tiempo de turno y productividad.

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INTRODUCTION

In Cuba, research has been carried out that has been aimed at determining and evaluating the different technological, exploitation and economic indicators of certain agricultural aggregates during soil preparation. An example of this are the studies carried out by Gutiérrez *et al.* (2004), Machado (2015), López & Herrero (2016), González *et al.* (2017) and González (2018). These studies have been carried out on aggregates made up of different tractors and farming implements, for which there was no information on the aforementioned indicators and consequently preventing their efficient exploitation, especially when they are newly acquired technologies and their exploitation qualities depend to a great extent on the working conditions as González *et al.* (2017) referred.

Other authors have developed computer programs that serve as tools to facilitate the different calculations of tractor operation. Some of these are the AnaExplo by Sotto *et al.* (2006), Explomat by Pereira *et al.* (2015), Tractor PT by Catalán *et al.* (2008), by TecExp de las Cuevas *et al.* (2008) and De las Cuevas *et al.* (2010) among others.

One of the processes benefited from new technologies in the rice production machine system is soil preparation. In Agroindustrial Company of Grains “Fernando Echenique” of Granma Province, medium and heavy Baldan harrows of 40 and 52 discs, respectively, were introduced, as well as the nationally manufactured land plane to form aggregate with the YTO tractor, model 1204 in the work of breaking and leveling. However, the possible technical performance of these aggregates is unknown till now, only the area realized at the end of the shift is measured, based on scientifically argued criteria and exploitation parameters. Taking this problem into account and starting from the experiences of the aforementioned investigations and from classics of studies on agricultural machinery exploitation, such as Jróbostov (1977), Garrido (1989) and González (1993) la p, the present investigation aimed to analyze indicators of work efficiency of the agricultural aggregates formed with a YTO x1204 tractor, harrows and a land plane of national manufacture, in order to partially establish the indicators calculated for future planning of agricultural work in the Agroindustrial Company of Grains “Fernando Echenique” in Granma Province.

MATERIALS AND METHODS

The present work was carried out at "La Gabina" Rice Farm in"La Gabina" Locality, Río Cauto Municipality, Granma Province, which is located at km 727 of Las Tunas-Bayamo Highway. The research was carried out in field 96 of lot 13 in the period from February to March 2020. The dry soil preparation technology for rice cultivation (*Oryza sativa* L.) was evaluated in a relatively flat Vertisol, according to the New Genetic Classification of Cuban soils, (FAO, 1988; MINAGRI, 1999; Soil Survey Staff, 2010) with an insignificant degree of weeds.

Description of how the aggregate was formed and how it was evaluated

The aggregates formed and subjected to the tests in the soil preparation work were the YTO X 1204 tractor and Baldan medium 40-disc harrows, heavy 52-disc harrows and land planer (Figure 1). The second gear step with reducer was selected, following the recommendations of the aforementioned tractor operating manual.

The method used was the investigative analytical and the photochrometry technique according to PG CA 043 (2003), NRAG XXI (2005) and NRAG XXII (2005) standards. Although for data processing, the instructions and methodologies referred by Jróbostov (1977), Garrido (1989) and González (1993) were also used.

RESULTS AND DISCUSSION

Turning Time

After carrying out the tests in the productive scenario of the Agricultural Rice Farm "La Gabina" and processing the data obtained, the following results are reached. In Figure 2, the results related to the turning time of the aggregate formed by the YTO X 1204 tractor and Holmeca land plane and the Baldan harrows of 52 and 40 discs can be seen.

It was appreciated that the magnitudes of this time ranged during the observations from 15 to 23 s for the aggregate formed by the tractor and YTO and the land plane (Figure 2a), from 9 to 21 s when it forms together with the 52-disc harrow (Figure 2b) and from 18.31 to 39.2 s with the 40-disc harrow (Figure 2c).

FIGURE 1. Tractor used to form aggregate with harrows and land plane. a) Tractor YTO x1204. b) Medium Baldan harrow with 40 discs. c) Baldan heavy harrow with 52 discs and d) Land plane of national manufacture.

a) b) c)

FIGURE 2. Turning time a) YTO X 1204 tractor and Holmeca land plane. b) YTO X 1204 tractor and the 52-disc heavy harrow. c) YTO X 1204 tractor and the medium 40-disc harrow.

An average value of 18.6; 14.46 and 24.32 s, respectively, were obtained.

In the case of the set formed by the tractor and the harrow, the result obtained is higher than the admissible values for this farming implement, according Companioni (1990). And for the case where aggregate was formed with the heavy and medium harrow, the results obtained behaved below those established by Jróbostov (1977), Companioni (1990) and González (1993), since for these field tillage implements with lengths between 300 and 600 m, the turning time is around 27 s. Although it is necessary to highlight that in the case of the medium harrow, there were magnitudes greater than 27 s (Figure 2c).

The reason why these magnitudes were higher than those established when using the land plane is that when leveling the ground was performed, the method used was the loop turn, when the appropriate one is the combined turn in such a way as to maintain approximately the same width of the demarcated furrow. In the case of the harrows, the result that these magnitudes were below what is established, was conditioned by the movement and turning methods used for this work, which were circular with the discs depending on the work. Although in the case of the medium harrow, there were times above what was established in the range, which is due to the fact that the kinematic parameters for the proper development of the work of the group are violated, since there is no demarcation of the turning strip at the end of the plot, which makes it difficult to turn the complex.

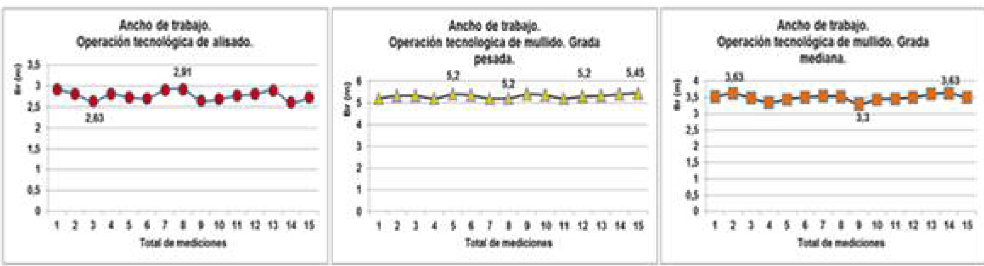
Researchers such as Ríos and Villarino (2014), reported that the length of the area is one of the most influential aspects, for which it is necessary to minimize the turning areas at the end of the furrows to take advantage of the available space. For this reason, it is important to have a tractor that has a minimum turning radius (NC ISO 789-3, 2006; NC ISO 4004, 2006).

Aggregates working width

Figure 3 shows that the working width values of the three sets studied ranged from 2.63 to 2.91 m for the land plane (Figure 3a), from 5.2 to 5.45 m for the heavy harrow (Figure 3b) and from 3.3 to 3.63 m for the medium harrow (Figure 3c). Obtaining average values of 2.77; 5.3 and 3.49m, respectively.

Table 1 shows the coefficients of the working width of the three implements that make up the aggregate with the tractor under study.

In the case of the land plane, the coefficient of utilization of the working width, *εβ*, reached a value of 0.96, result that is close to the unit, so it can be classified as acceptable. For the heavy harrow, a value of 0.78 was obtained, value that can be considered low for the real possibilities of this set, due to the fact that the construction width of the heavy 52-disc harrow is 6.85 m. In the case of the medium harrow, this indicator showed a value of 0.68. This result is classified as low for this farming implement because its construction work front is 5.25 m and authors such as Jróbostov (1977) and González (1993) report that



a) b) c)

FIGURE 3. Actual working width. a) YTO X 1204 tractor and Holmeca land plane. b) YTO X 1204 tractor and the 52-disc heavy harrow. c) YTO X 1204 tractor and the medium 40-disc harrow.

this indicator must be close to the unit with magnitudes of 0.98 and 0.99 as a maximum. They were also considered below the results found by García & Ramos (2011) and Ramos *et al.* (2020) which obtained a working width utilization coefficient of 0.94 and 0.97, respectively, when analyzed the technical performance of agricultural aggregates with similar characteristics.

The fundamental causes of the low value in this indicator for both harrows, is that the operator overlapped one pass of the harrow with respect to the other by more than one meter, which is equivalent to 4 and 6 discs of the disc battery of the harrow.

Working Speed

Figure 4 shows the magnitudes reached by this indicator with the three farming implements that formed an aggregate with the YTO X1204 tractor. In the case of the land plane, the working speed ranged from 5.6 to 9.3 km h^{-1} (Figure 4a), for the heavy harrow from 7 to 7.8 km h^{-1} (Figure 4b) and for the medium from 5.4 to 6.2 km h^{-1} (Figure 4c), with average values of 8.2; 7.39 and 5.82 km h^{-1}, respectively. This parameter for the leveling operation behaved below the real possibilities of the tractor, which is 10 km h^{-1}, according to Jróbostov (1977). In the case of the operation with the heavy harrow, this indicator is within the ranges established by Jróbostov (1977) and González (1993), which range between 7 and 10 km h^{-1} for the first author and between 6 and 9 km h $^{-1}$ for the second author. In the same way as in the case of leveling, the heavy harrow remained outside the established ranges, falling below what was reported by the previous authors and the working speed values obtained by Fajardo & Hernández (2013), which was 6 .12 km h^{-1}. It is valid to clarify that there are bibliographic references that refer permissible speeds for furrowing, harrowing, sowing and cultivation works, a range of 3.5 to 9 km h^{-1}.

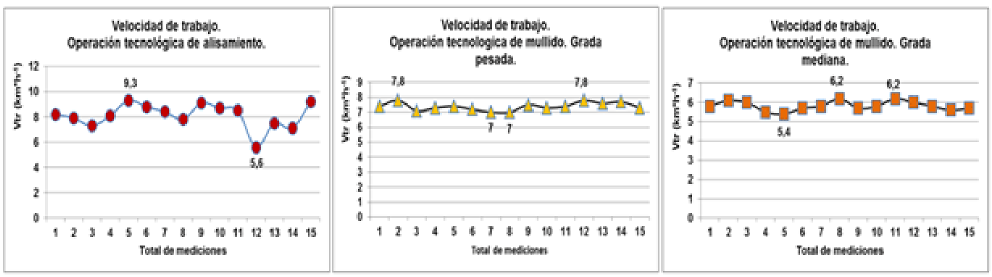
The reason why this magnitude is below what is permissible for the land leveler and the heavy harrow according to Jróbostov (1977), is conditioned by the skidding of the tractor propellers (which is on tires and it ranges between 8 and 12%), to the irregularity of the frequency of rotation of the crankshaft due to the variation of the load and also to the change of gear step and to the sinuous movement of the assembly.

Table 2 shows the coefficients of the working speed of the three implements that make up the aggregate with the tractor under study.

Regarding this coefficient of use of the working speed (εV), a value equal to 0.82 was obtained for the case of the land plane, magnitude that is below that one expressed by Jróbostov (1977), Companioni (1990) and González (1993), which is 0.88. In the case of the heavy harrow, this coefficient was 0.82; classifying as acceptable since González (1993) reports that this coefficient must be equal to or greater than 0.82 when this type of implement is used. Finally, for the medium harrow, a coefficient of 0.68 was obtained, which is low when compared to the magnitude reported by González (1993), which is 0.82.

TABLA 1. Utilization coefficients of the working width

Tractor YTO X 1204					
Land plane		**Baldan Heavy Harrow with 52 discs**		**Baldan Medium Harrow with 40 discs**	
Working Width Utilization Coefficient $\varepsilon\beta$	Construction width (m)	Working Width Utilization Coefficient $\varepsilon\beta$	Construction width (m)	Working Width Utilization Coefficient $\varepsilon\beta$	Construction width (m)
0,96	6,24 m	0,78	6,85 m	0,68	5,25 m



a) b) c)

FIGURE 4. Working speed. a) YTO X 1204 tractor and Holmeca land leveler. b) YTO X 1204 tractor and the 52-disc heavy harrow. c) YTO X 1204 tractor and the medium 40-disc harrow.

Working depth for heavy and medium harrows

Figure 5 shows the behavior of the working depth for both harrows, where the values range from 0.12 to 0.16 m for the heavy harrow (Figure 5a) and from 0.11 to 0.14 m for the medium harrow (Figure 5b). The average values were 0.14 and 0.12, respectively.

When comparing both working depth results with those reported Silveira (1982) for disc harrows and other types, it can be stated that the results obtained are satisfactory, since this author refers depths between 0.06 and 0.25 m. However, according to the instructions for this tilling implement, the working depth must be between 0.15 and 0.20 m. Obtaining magnitudes close to the lower limit. Despite this, these results can be considered acceptable, since rice germinates at a depth of 0.05 m. On the other hand, the values obtained for the median harrow (0.11 to 0.14 m) have a behavior lower than 0.22 m, obtained by Fajardo & Hernández (2013)

Work Shift Utilization Coefficient

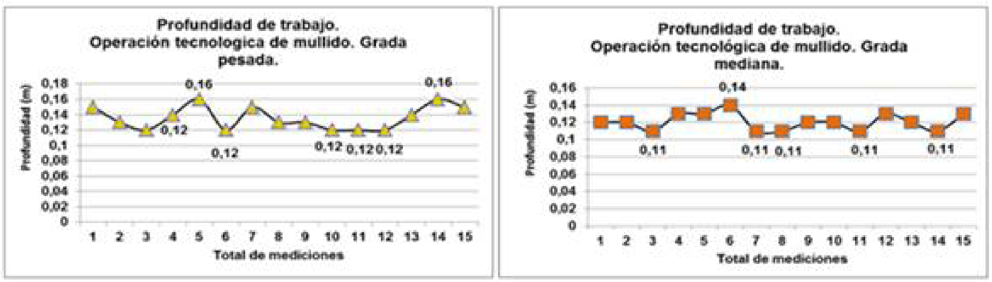
Table 3 shows the values obtained for the work shift utilization coefficient (τ) by the three groups evaluated. The resulting values of the observations are 0.78; 0.73 and 0.77. These magnitudes are classified as low when compared to the 0.89 declared by Jróbostov (1977) and the 0.91 obtained by García & Ramos (2011). However, they can be classified as acceptable considering the range referred by González (1993), which is from 0.70 to 0.95 and from 0.70 to 0.95.

Productivity

Table 4 shows the productivity values that were determined, the real (Wr) and the possible or theoretical (Wt) of the set. For the three cases under study, the magnitudes obtained are low, being lower than the possible values that these three sets can reach,

TABLE 2. Coefficients of utilization of the working speed

Tractor YTO X 1204					
Land plane		**Baldan Heavy Harrow with 52 discs**		**Baldan Medium Harrow with 40 discs**	
Working speed utilization coefficient (*εV*).	Theoretical speed (km·h^{-1})	Working speed utilization coefficient (*εV*).	Theoretical speed (km·h^{-1})	Working speed utilization coefficient (*εV*).	Theoretical speed (km·h^{-1})
0,82	10 km h^{-1}	0,82	7 y 10 km h^{-1}	0,68	7 y 10 km h^{-1}



a) b)

FIGURE 5. Actual working depth of the aggregate. a) YTO X 1204 tractor and the 52-disc heavy harrow. b) YTO X 1204 tractor and the medium 40-disc harrow.

TABLE 3. Work shift utilization coefficients

Tractor YTO X 1204					
Land plane		**Baldan Heavy Harrow with 52 discs**		**Baldan Medium Harrow with 40 discs**	
Work shift Utilization Coefficient (τ)	Aggregate net work time (Tc)	Work shift Utilization Coefficient (τ)	Aggregate net work time (Tc)	Work shift Utilization Coefficient (τ)	Aggregate net work time (Tc)
0,78	6,24 h	0,73	5,84 h	0,77	6,10 h
For a work shift of 8 hours					

TABLE 4. Productivity of the three groups evaluated

Tractor YTO X 1204					
Land plane		**Baldan Heavy Harrow with 52 discs**		**Baldan Medium Harrow with 40 discs**	
Real Productivity (*Wr*)	Theoretical Productivity (*Wt*)	Real Productivity (*Wr*)	Theoretical Productivity (*Wt*)	Real Productivity (*Wr*)	Theoretical Productivity (*Wt*)
17,71 ha·turn-1	20,47 ha·turn-1	29,01 ha·turn-1	43,71 ha·turn-1	14,65 ha·turn-1	27,85 ha·turn-1
For a shift time of 8 hours, ha·shift -1					

it is due to the low utilization of the coefficients of working width, speed and work shift.

CONCLUSIONS

- The values of the efficiency indicators of the three evaluated sets are below the technical possibilities of these farming implements, except for the utilization coefficient of the working width ($\varepsilon\beta$) for the land plane the utilization coefficient of the working speed (εV) of the 52-disc heavy harrow and the utilization coefficient of the work shift (τ) of the three aggregates.
- The working depth values obtained for the harrows analyzed are low when compared to what is established in the technical instructions for rice cultivation, with magnitudes of 0.12 and 0.14 m.
- The magnitudes of real productivity (Wr) obtained behaved below the real possibilities of the set with magnitudes of 14.65; 17.71 and 29.1 ha shift^{-1}, respectively.
- Analyzing the efficiency indicators of the aggregates in studies, it can be affirmed that the cause of the low values is the violations of what is regulated in the technical instructions and branch norms of agriculture, as well as to the unfavorable management of the administration.

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