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Brief Communication

Control of machine traffic in grain producing properties of the Brazilian central plateau

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Abstract

A modern alternative to reduce the effects of soil compaction by intensive agricultural machine traffic is the adoption of controlled machine traffic. The objective of this work was to implement and evaluate the effects of machine traffic control on grain crops in the Brazilian central plateau region. The work, carried out in farms of the Directed Settlement Program of the Federal District (PAD/DF), counted on researchers from the University of Brasília, Embrapa Cerrados, farmers and manufacturers of agricultural machinery. Given the experiences obtained, it can be reported that producers have a real need and interest in adopting control of machine traffic, driven by the high cost of compaction of soils to productivity and scarification. It is conclusive that implementing the technology has restrictive obstacles mainly referring to the adjustment of the gauge of tractors, harvesters and pulverized, not to mention multiple work widths between implements and accurate global positioning systems for the machines – items with little or no possibility of changes.

Key-words: Compaction, Agricultural Mechanization, Controlled Traffic

In order to cultivate increasingly larger areas and swiftly carry out agrarian operations, the size and weight of the machines has increased at a dizzying pace. This has corresponded with the proportional growth of traffic in the fields, caused by the subsequent seeding, greater infestation of pests and sicknesses, and the simple convenience of harvesters and trucks for transporting the product. Because of this, more than 80% of the cultivated area is run over by heavy farm machinery during the first and second grain harvests in Brazil.

According to Roque et al. (2010), the intense frequency and disorder of the agricultural operations compact the soil. Furthermore, Fontana et al., (2016) state that the increase of density in compacted soil reduces the microporosity, the rate of water infiltration and biological processes of the soil, resulting in a decrease in the development and productivity of the plant cultures.

Smith et al. (2014) explain that in a situation of haphazard machine traffic the operational costs increase because of the frequent necessity of using equipment to till the soil. According to studies by the Agricultural and Cattle Federation of the State of Gioás (FAEG, 2013), the effective operational cost for preparing the soil can increase the cost of soy production in the state by 14.4%. Chamen (2011), Masek et al. (2014) and Smith et al. (2014) describe an alternative for the optimization of production systems, which is the adoption of a traffic control of the machines on the farm, named CTF, which in Portuguese stands for controle de trafego de máquinas na fazenda, and translates to “traffic control of farm machinery.” According to Seixas and Souza (2007), the CTF method separates machine traffic zones from those of cultivation, concentrating the pressure of the wheels on specific and permanent paths within the

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fields throughout all farming operations over the years.

However, the adoption of CTF requires refined logistics, which brings important challenges. In Brazil, CTF is most widespread in sugarcane cultivation; however, it is pertinent to adopt it to other crops, as has been the case in countries like the UK, Australia, Germany, the United States and Argentina (Tullberg, 1997). Smith et al. (2014) verified that the management of soil compaction using CTF increased the productivity of an Eastern zone in England by 7%.

The objective of this work was to implant and evaluate the effects of traffic control of farm machinery on the grain fields in the central high plains region of Brazil. The work counted on the collaborative participation of educational and research institutions, as well as producers and manufacturers of farm machinery. It presents a minimum expectation of 10 years, with three phases of development, two of which already realized with one already begun and in development.

The first phase at the beginning of 2015 involved the collection and spreading of information regarding how CTF was realized in other countries. In-person and videoconference meetings, as well as a visit to Harper Adams University in Edgemond, UK, were made to exchange experiences about the use of farm machinery and the soil. Experienced British researchers and farmers indicated that the technology could create better soil conditions and productivity for Brazilian grain agriculture. Research realized at the institution by Smith et al. (2014) showed an increase of 9% of productivity of wheat and a reduction of €103 ha-1 because of the reduced random compaction of machines on the soil. The British adopted a practice of controlled traffic as a viable and necessary alternative to the conventional practices of cultivation, considering it an issue of management and sustainable use of soil and machines.

In Brazil the diffusion and collection of information about CTF occurred through a methodology of in person meetings with researchers from the Faculty of Agronomy and Veterinary Medicine at the University of Brasilia, Embrapa Cerrados, The Association of Direct Planting in the Cerrado, The Agriculture and Livestock Cooperative of the Federal District, the Laboratory of Agricultural and Environmental Technology, farmers and Michelin tire manufacturers. From these meetings an experimental area for the implementation of a CTF pilot project was decided, which is situated in the region of the Directed Settlement Program of the Federal District (PAD/DF), specifically at the Dom Bosco Farm situated in the municipality of Cristalina-GO, latitude 16°16'37.0" south, longitude 47°27'25.2" west.

According to the classification of Köppen, the region of the Dom Bosco farm presents an “Aw” - type climate, with an average annual precipitation of 1.600 mm, mostly coming between the months of October and April. The experimental area used is constituted of red earth with a texture of clay, and slight undulations in the topography. The experimental area totals 62.8 ha, divided into four parcels of 15.7 ha each. The total area has a history of grain cultivation with conventional soil preparation from 1974, and constant production since 1994, with corrections for pH level and fertility of the soil done over the period, according to the analysis and recommendations of agronomists. Generally, the area of production rotates between cultures of soy and corn for the first harvest, and corn and sorghum for the second.

After organizing information and encouraging debates, speeches, conferences and seminars, and then clarifying the importance and interest of the separate parts for CTF, the experimental stage of the project began with the implementation of the technique in the second semester of 2015, thus designated as the second phase of development.

The collection of information and data about the farm machinery available at the Dom Bosco Farm was the principle and indispensable activity of this phase. To correctly dimension the machines within tracks it became necessary to discover data about the track and wheel gauge required to carry out the work for each machine. It’s worth emphasizing that the measurement of the wheel gauge is done from the center of one wheel to the center of the opposite wheel on each side of an axle. Complementarily, in this phase we realized a survey about the relief, regional precipitation and soil texture in the experimental area.

With the information and data collected, the second phase finished with the mapping of the experimental parcels of land, including the random designation of the areas to receive intervention, and the demarcation of traffic lanes for the wheels. The interventions were distinguished by two methods of machine traffic: controlled traffic and random traffic, both minimally cultivated in the first year, with full planting in the following years. Of the four parcels, those designated A and B didn't receive initial tillage, whereas those designated C and D were tilled to .25 meters in the first year, with A and C being designated areas for controlled traffic, and B and D receiving random uncontrolled machine traffic.

The demarcation of spatial arrangement regarding the work width and traffic lanes for machine wheels, the areas wherein the wheels would permanently traffic on fields A and C, were made for a self-propelled sprayer with an adjustable wheel gauge from 2.8 to 3.2 meters and a 30 meter boom; a grain combine with 3.0 meter wheel gauge and a cutterbar length of 35 ft. (10.6 m); a seeder/fertilizer with 12 lines spaced at 0.5 m (6.0 m); a scarificator with 13 rods spaced at 0.3 m (3.9 m); a grain cart with a 20m3 of capacity, maximum cargo of 15,000 kg and a gauge of 2.45 m; five tractors: all 4x2 TDA with motors of 132.38 kW (180cv), 106.64 kW (145cv), 80.90 kW (110cv), and 62.51 kW (85cv) of power, and all with a gauge inferior of 3 m.

The third phase, begun in 2016, involved evaluations of the physical attributes of the soil, including porosity and density, obtained using a methodology proposed by EMBRAPA (1997). Studies regarding the content of the water, the measurement of infiltration of water into the soil, and the hydraulic conductivity of the saturated soil, were conducted in the field with the help of a Guelph constant flow permeameter device. The resistance of the soil to water penetration was determined to the depth of 0.6 m, using an impact penetrometer according to the methodology described by STOLF (1984). Beyond the physical attributes of the soil, the productivity of the plant species will be evaluated as well. Results and data in reference to the physics of the soil and the grain productivity are still being acquired, and current data is insufficient and restricted to demonstrate solid results.

The principle difficulty was the adaptation of work width and the wheel gauge for the machines available on the farm. Through the second phase of project development, it is possible to highlight in this discussion that the decision to implement CTF should be based on managerial organization, as much for the obtaining of technical information for all available machinery as for the correlation between necessary characteristics and operation during the cycle of the plant cultures. The experiences, technical knowledge, level of investment and capacity to accept the ideologies of those involved should be taken into account and appreciated. CTF, as in direct planting, should come from a change in the work model, and not just the technique.

A considerable difficulty for the implementation of CTF is the adequacy of the machines to fit into best arrangement for the traffic lanes of the wheels. It is common that in the fleet on the property some machines and implements are not adaptable to the track gauge and work width, and in these situations CTF requires the substitution of components, for example the front and rear axles of the tractors, or even the acquisition of more adequate machinery. Regarding this question, the participation of machine and tire manufacturers assumes an important role in the solutions for projects involving machines.

In the experience at the Dom Bosco Farm it became clear that seeders, fertilizer distributors, harvesting platforms, and grain carts would be limiting machines for CTF because they present restrictive options for the adjustment and adaptation to the work width. Because these machines are indispensable for the cultivation of grain, the acquisition of adaptable machinery over the short or medium term should be part of the financial planning of any property with interest in CTF. Regarding the machines cited above, they possess a relatively shorter working life and lower costs compared to the acquisition of tractors, harvesters and self-propelled sprayers.

It was commonly confirmed that the harvesters had the greatest restriction in terms of wheel gauge, being predominantly at 3 meters. Due to the fact they are items of high investment, it's suggested that the track gauge should reflect the wheel gauge of the harvesters.

The harvester with a 3-meter wheel gauge was adopted to fit the standard traffic lane of the wheels, and the work width was defined in multiples of 10 meters (Figure 1), based on the cutterbar length of 35 feet (10.6 meters). It's worth emphasizing that the measurement of the wheel gauge is done from the center of one wheel to the center of the opposite wheel on each side of the same axle.

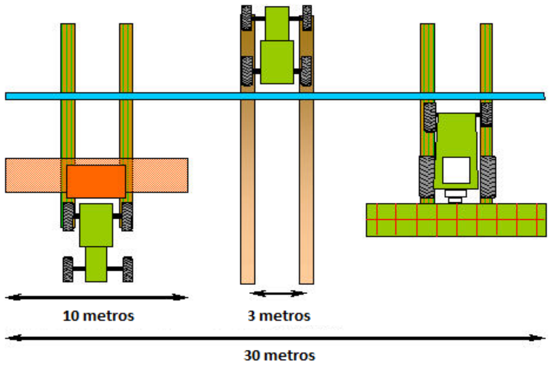

Fig 1. Spacing of machines, 3 m gauge and working width 10 m or multiple of 10 m.

Differently from the harvester, the self-propelled sprayer had track width adjustment that didn't require adaptation because of the adjustable axles and 30-meter-long bar. Some tractors have adjustable track width, although more powerful tractors like the model JD7195J present restriction in opening the track width, requiring the substitution of the axle for a longer one. The solution we found was to substitute the axle for one 3 meters in length. Since economically it already served as a tractor dimensioned for a seeder 10 meters in width (10 lines spaced at 0.5 meters).

Other than the factors already discussed, CTF requires automatic pilot, GPS, and a RTK correction antenna for the correct guiding of the machines. In general they are easy to obtain, however, much depends on the technical capabilities of the farm. For example, the constraint for many places is that the GPS signals are restricted or nonexistent, not to mention that it's possible there's not the skilled labor available to solve the problems, which is why it's recommended to capacitate those involved on the property.

Finally, the communication of data between different machine manufacturers makes implementing CTF difficult, as communication systems are not rigorously standardized, especially map software. It's suggested to beforehand map the area and save the maps in files that can be read by different machines with precision and reliability.

In conclusion, CTF requires operational management, adaptation, adjustment and substitution of machinery, not to mention initial investment and change of the work model, and should be the subject of mutual study among researchers, producers and manufacturers of farm equipment.

Conflict of interest: All authors declare no conflict of interest.

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