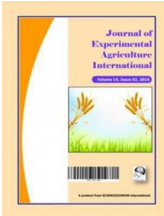

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Soil Management in the Physical Attributes and the Wheat Crop Irrigated Productivity

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Authors' contributions

This work was carried out in collaboration among all authors. Authors PSXP, AB, DSP and WMD conducted the experiment and wrote the first draft of the manuscript. Authors PSXP, ARBS, RFD and AB discussed the results, correct and improve the writing of the manuscript in Portuguese and English versions. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this work was the influence of three management systems on the physical attributes and productivity of irrigated wheat, cultivar BRS-254, in the city of Tangará da Serra, MT, Brazil. The experimental design was a randomized block design in split plots, with eight replications, being considered as plots the three systems of soil management: Conventional management (MC) with two gradations (one heavy and one light); minimum management (MM) with light harrowing; and direct seeding (SD). As a subplot: two layers of soil (0 to 10 cm and 10 to 20 cm) and two seasons, being at 42 and 97 days after sowing (DAS) of wheat. The soil physical attributes evaluated were: macro and microporosity, total porosity, soil density and soil resistance to penetration. The yield of wheat crop was also evaluated. For the effects of MC, MM and SD, of the soil layers and DAS in the parameters macroporosity, microporosity and total soil porosity the

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MC and MM provided higher values of macroporosity and microporosity decrease at 42 DAS. The macroporosity was higher in the layer up to 10 cm and the microporosity in the 20 cm layer at both the 42 and the 97 DAS. The aeration capacity of the soil followed in ascending order in the management systems SD <MC <MM. In SD there was a significant increase in macroporosity from 42 to 97 DAS. Microporosity presented higher value at 97 DAS. Total porosity, as well as macroporosity, presented the highest value at 42 DAS. For the effects on soil density at 42 DAS it was observed that the lowest density value was found in the MM followed by MC. At 97 DAS, the density values practically returned to the initial value before the management intervention. It was verified that the soil density at the end of the crop cycle had an average value around 1.02 kg dm^3. At 42 and 97 DAS the lowest soil density value was found in the 0 to 10 cm layer. In the 10 to 20 cm layer at 42 DAS, the SD had the highest soil density value in relation to the treatments studied, but at 97 DAS the SD had the lowest density value. For the effects on soil penetration resistance it was observed that soil resistance to penetration between MM and MC always remained below 2 MPa. The resistance curve showed that the soil rotation was efficient up to 10 cm depth, as they presented values lower than those found for SD, which presented resistance values between 1.5 and 2 MPa. For the effects on yield of irrigated wheat, the use of MM and SD as a way to reduce soil compaction did not contribute to the increase of yield of irrigated wheat. The MC provided higher productivity.

Keywords: Soil physical; soil penetration resistance; Triticum aestivum.

1. INTRODUCTION

Wheat is an important and strategic source for Brazil, as it is a major source of starch for baking. In the 2018 harvest, the country produced approximately 5.42 million tons of wheat grains. Increase of 6.6% in planted area in order. At 19.1% (2,657 kg / ha), although in the accumulated of the year, the amount of ethanol increased (19.5%) [1].

The implantation of irrigated wheat in Mato Grosso, where soybean, cotton and maize predominates, may be an option in the short term to diversify production. According to Secco et al. [2], the wheat presents sensitivity to the structural state of the soil, and the soil preparation should be defined as the most suitable for the establishment of the crop. For [3], the establishment of management practices that optimize the applied inputs and the implantation of the crop can contribute to the increase of the yield of wheat in Brazil.

It is observed that 90% of the area planted with wheat is under no-tillage system (SPD) and more than 50% for other grains in Brazil [4]. The SPD is proven to be effective in controlling soil losses due to water erosion [5]. However, increased machine traffic and trampling by grazing animals under SPD soil the structural degradation with reduction of total porosity and macroporosity, elevation of soil density and resistance to penetration, resulting in the formation of compaction [6,7,8].

With the increasing demand for an increasing food production being necessary that the soil offers the physical, chemical and natural conditions to express its productive potentialities. Soil management systems can play an important role in the process, as they can influence the physical properties and the development of the crops.

Changes in physical attributes by soil preparation may lead to changes in crop development and for this reason it is important to study the behavior of each soil management under cerrado conditions. According to Viana et al. [9], some physical attributes linked to the soil structural form and stability, such as density, soil penetration resistance and porosity are used to study the impacts of the use and management on soil physical quality. According to Pereira et al. [10] the physical quality of the soil is related to the sustainability of agricultural systems and its evaluation must be carried out by the indicators that reflect its behavior. These physical indicators exert a soil support function and their evaluation is in the process of expansion [11], since it is observed a relation between the improvement of the physical quality and consequently improvement in the chemical and biological quality of the soil. only [12,13]. Thus, the main physical indicators pointed out by Araújo et al. [14] are the texture, soil density, total porosity, resistance to penetration.

The present work was developed with the objective of evaluating the influence of three management systems on the physical attributes and productivity of irrigated wheat, cultivar BRS-254, in the city of Tangará da Serra, MT, Brazil.

2. MATERIALS AND METHODS

2.1 Experimental Site Description

The experiment was carried out in the experimental field of the Mato Grosso Research, Assistance and Rural Extension Company (EMPAER), in the municipality of Tangará da Serra, located southwest of the state of Mato Grosso, in the geographical coordinates, 14º04 '38" latitude South, 57º03'45" west longitude and 427 m altitude.

The climate of the region, according to the Köppen classification, is predominantly tropical - Awi, with two well-defined periods, that of the rains, which runs from November to March, with the highest index in December and January, and the dry season, which goes from April to October. Rainfall and annual mean temperature are 1,348 mm and 25.2°C, respectively.

The soil was characterized as a Distroferric Red Latosol according to the Brazilian System of Classification of Soil-SBCS [15], of clay texture, whose chemical and granulometric characteristics are in Tables 1 and 2.

The experimental area was kept fallow for approximately one year after the cultivation of the wheat in the previous harvest, so that during the implantation of the management systems there was a large amount of organic matter on the surface.

The wheat crop was sown on June 4 and harvested on September 9, 2011. Seeding was carried out on 15 sow lines with spacing of 0.17 m between rows and 0.05 m between plants. The sowing strips had 6 x 18 m, totaling 108 m2 of area in each treatment. The cultivar BRS-254, of medium cycle (115-125 days) with seed density of 120 seeds.m^{-1} was used.

2.2 Experimental Design description

Three types of soil management were considered as plot: conventional management (MC) with two gradations (one heavy and one light) regulated to a depth of 17 cm; minimum management (MM) with a light harrow regulated to 0.075 m depth; and direct seeding (SD). As a subplot, two soil layers (0 to 10 cm and 0 to 20 cm) and two seasons were considered, being at 42 and 97 DAS.

The 6 x 18 m sowing strips presented two passes of the sowing machine, being considered as repetitions of the treatments within each plot. This was done so that the experiment reached the minimum degree of freedom required, following the statistics proposed by Banzatto and Kronka [16].

The culture was maintained under irrigation by spraying, with uniform distribution of water over the area, up to 30 DAS to ensure uniform germination and emergence. After 30 DAS, irrigation was made by only one central line, a system known as a line source, which promotes a decreasing gradient of the irrigated blade along the perpendicular distance from the irrigation center line.

With the objective of applying a water depth of 507 mm for the whole crop cycle, the irrigation blade was considered to be 6 to 9 m apart from the center line. The irrigation shift was controlled through the use of tensiometers distributed in the experimental plots, installed in the depths of 0.20 and 0.40 m, and the reading was done daily at seven o'clock in the morning.

The soil physical attributes evaluated were: macro and microporosity, total porosity, soil density and soil resistance to penetration (RSP).

In order to determine the porosity (total, macro and micro) and soil density, undisturbed samples were collected in each plot at depths of 0 - 10 and 10 - 20 cm, obtained with a Kopec sampler with a metal ring 50 mm in diameter and 50 mm high. The collection occurred in two seasons, being at 42 and 97 DAS of the wheat.

Table 1. Soil chemical analysis of the experimental area. Tangará da Serra, Mato Grosso, Brazil

Layer(cm)	pH($CaCl_2$)	P	K	Ca+Mg	SB	CTC	V	MOS
		mg dm^{-3}		cmol$_c$ dm^{-3}			%	g dm^{-3}
0-10	6.2	3.8	254	7.53	8.2	14.27	57.53	51.23
10-20	6.1	1.8	220.7	6.8	7.4	13.3	55.4	48

Table 2. Soil granulometric analysis of the experimental area. Tangará da Serra, Mato Grosso, Brazil

Layer (cm)	Sand	Silte	Clay
		%	
0-10	17.8	26.2	56
10-20	17.1	25.2	57.7

Table 3. Mean macroporosity, microporosity and total soil porosity as a function of management systems and days after sowing were evaluated in the 0 - 10 and 10 - 20 cm layers. Tangará da Serra, Mato Grosso, Brazil

Managements	0 - 10 cm			10 - 20 cm		
	Macroporosity (%)					
	42	97	Mean	42	97	Mean
	DAS			DAS		
MC	22.8 aA	19.6 aB	21.2 ab	15.6	9.2	12.4 a
MM	22.2 aA	21.4 aA	21.8 a	16.9	8.2	12.6 a
SD	17.4 bB	21.1 aA	19.3 b	15.2	9.5	12.2 a
Mean	20.8 A	20.7 A	**20.7***	15.9 A	8.9 B	**12.4***
Managements	Microporosity (%)					
	42	97	Mean	42	97	Mean
	DAS			DAS		
MC	38.4	41.3	39.8 a	42.2	45.5	43.9 a
MM	38.9	37.9	38.4 a	41.3	47.4	44.3 a
SD	41.1	41.0	41.1 a	42.6	47.5	45.1 a
Mean	39.5 A	40.1 A	**39.8***	42.0 B	46.8 A	**44.4***
Managements	Total porosity (%)					
	42	97	Mean	42	97	Mean
	DAS			DAS		
MC	61.1	60.9	61.0 a	57.8	54.7	56.3 a
MM	61.1	56.2	58.7 a	58.2	55.5	56.9 a
SD	58.5	62.1	60.3 a	57.8	56.9	57.4 a
Mean	60.3 A	59.7 A	**60.0***	57.9 A	55.7 B	**56.8***

*MC = Conventional management, MM = Minimum management, SD = Direct seeding, DAS = Days after sowing. Means followed by the same lowercase letter in the column indicates no difference between handles or, upper case in the row, indicates no difference between layers, by the Tukey test (p <0.05). * Average of treatments*

After the samples were collected in a way that maintained their original characteristics and transported to the Soil Physics Laboratory of the Faculty of Agronomy and Veterinary Medicine of the Federal University of Mato Grosso in Cuiabá-MT. Macro and microporosity analyzes, total porosity and soil density were obtained by the method described by [17].

The soil penetration resistance was evaluated in the layer from 0 to 30 cm, using an automatic electronic penetration constant penetrator, developed by Bianchini et al. [18], being collected at 97 DAS, being 5 points around each point collected with the Kopec sampler in each plot.

2.3 Wheat Grain Yield Analysis

In order to determine the productivity of the BRS-254 irrigated wheat crop, the central plants of each plot were harvested, in a useful area of 2 m^2, and the corresponding values transformed in kg ha^{-1}, with moisture corrected to 13%.

2.4 Statistical Analysis

The experimental design was in randomized blocks. The treatments to evaluate the soil physical attributes: macro and microporosity, total porosity and soil density were arranged in subdivided plot scheme, with eight replications.

The data were analyzed comparing the two seasons 42 and 97 DAS and the layers 0 to 10 and 10 to 20 cm for porosity (total, macro and micro) and soil density.

For the RSP, the standard error bars of the mean for each depth level were considered, since the analysis of variance would require the grouping of acquisition points, obtaining averages of depth intervals, which would reduce the quality of the evaluation of soil resistance in depth. Thus, at the points where the standard error bars are found, there is no difference in RSP at that depth level between managements.

For statistical analysis, the analysis of variance (Test F) was performed, and the means were compared by the Tukey test, for ($p \leq 0.05$), using the Assistat software [19].

3. RESULTS AND DISCUSSION

3.1 Effects of MC, MM, SD, Soil Layers and DAS on Macroporosity, Microporosity and Total Soil Porosity

There was a layer and soil management effect for the variables macroporosity and microporosity ($p < 0.05$) at 42 and 97 DAS, and for total porosity ($p < 0.05$) at 97 DAS. For total porosity at 42 DAS there was interaction ($p < 0.05$) between soil and layer management (Table 3).

The MM and MC soil management promoted an increase in macroporosity at 42 DAS when compared to SD. The use of the disk grid in these maneuvers provided higher values ($p < 0.05$) of macroporosity and decreased microporosity in relation to SD, corroborating with the studies carried out by Tormena et al. [20], who attributed the highest values of macroporosity in systems with revolving to the persistence of the effects of the mobilization of the soil that results in the breakdown of the aggregates and the development of pores, especially macropores.

The results obtained are in agreement with those of [21,22], who verified an increase in macroporosity with the soil revolving. Thus, the assertion that soil tillage increases the volume of drainable pores is also confirmed by the results obtained for tillage with this experiment. According to the authors cited in the reference [23] also verified that direct seeding reduces macroporosity, total porosity and increases soil microporosity.

At 97 DAS, the effects of the gradings were no longer verified. This is due to the soil accommodation, which returned to the initial condition, before the action of the grids, and this, may be related to the successive effects of irrigation, which potentiated the soil accommodation and formation of a new condition of structure.

Direct sowing modifies soil conditions at rates and directions different from those observed in management systems that include their rotation [24]. According to the authors cited in the reference [25], in Red Latosol of clayey texture, concluded that the effect of the soil rotation under a no-tillage system disappears in a few crops, in the case 2.5 years later. The fact is that in the conditions of this work the direct sowing done in the area that was also cultivated with wheat in the previous year and was set aside for one year was not enough to stabilize the SD system. Surface soil compaction is pointed out as one of the main problems of the SPD and can stimulate the abandonment of the system, even if temporarily [26].

For the effect of a layer independent of the soil management, the macroporosity was higher in the layer up to 10 cm in both the 42 and the 97 DAS ($p < 0.05$), and the microporosity was higher in the 20 cm layer for the evaluated ($p < 0.05$). This is probably due to soil mobilization by the grid, which promotes soil disruption and loosening so that macroporosity increases, with consequent increase in total soil porosity. On the other hand, the microporosity, which basically depends on the intra-aggregate pores, was higher in the layer where there was less soil rotation.

With soil accommodation at 97 DAS, microporosity remained different in the two studied layers, demonstrating that the soil rearrangement did not promote significant differences in the micropore volume in the layers and that the time of evaluation was not sufficient for the formation of new aggregates ensure increased micropore volume. This result demonstrates that in soil management, the effect on the increase in macroporosity in the 0 to 10 cm layer (higher tillage layer) extends until the end of the crop cycle, and in the layer of 10 a 20 cm (thinner layer) there is a marked decrease in macroporosity due to the tendency of the smaller particles of the pulverized soil to settle in the deeper layers, a potent effect with the infiltration of the irrigation water in the systems.

The results obtained in the 42 DAS suggest that the aeration capacity of the soil followed in ascending order in the management systems SD <MC <MM.

Aeration porosity values below 10% are generally adopted as restrictive for the growth and productivity of most crops, despite the dependence of the plant species and the soil biological activity, so for this experiment, it was observed that all types of management presented critical macroporosity values for the root development of the crop in the 10 to 20 cm layer at 97 DAS. At 42 days, the SD system presented lower values than the others, but greater than 10%.

Considering the averages of the layer-independent management, the porous soil distribution reached values close to those considered ideal, according to [27], which characterize as good quality soil to store water and air, when the porous space in the field capacity presents 2/3 micropores and 1/3 macropores, in relation to the total porosity of the soil.

The data of macroporosity, microporosity and total soil porosity as a function of soil management and days after sowing the wheat crop, evaluated in the 0 - 10 cm and 10 - 20 cm layers are shown in Table 3.

There was a significant interaction ($p < 0.05$) between soil management and DAS for macroporosity in the 0 to 10 cm layer, and there was no significant effect of soil management as of DAS for microporosity and total porosity in the same layer. In the 10 to 20 cm layer there was a significant effect ($p < 0.05$) of days after sowing (DAS) and soil management for macroporosity, microporosity and total porosity (Table 3).

In the 0 to 10 cm layer the soil management MM and MC promoted an increase in macroporosity at 42 DAS, when compared to SD, whereas at 97 DAS. In this study, in the range of 42 to 97 DAS, higher root growth of the wheat crop could be observed in SD, especially in the 0 to 10 cm layer, favoring the increase of macroporosity in this system.

In the macroporosity evaluated in the layer of 10 to 20 cm there was a significant effect ($p < 0.05$) only of the DAS independent of the soil management where there was a significant decrease ($p < 0.05$) at 97 DAS due, possibly to an effect of accommodation of the smaller particles of the soil revolved in the surface of the soil in the deeper layers, potentiated effect with the infiltration of irrigation water in the soil profile.

For microporosity and total porosity of the soil there was also no significant effect of soil management, however, there was a significant effect of the DAS on these variables. The microporosity presented higher value at 97 DAS ($p < 0.05$) due to the effect of accommodation of the smaller soil fractions, which decreased the macropores of the soil at this date. Total porosity, as well as macroporosity, presented its highest value at 42 DAS, in response to the still recent effect of the soil rotation, which increased the mean soil macropores when the DAS average was evaluated independently of the evaluated managements.

3.2 Effects of MC, MM, SD, Soil Layers and DAS on Soil Density

However, there was a significant effect of soil management ($p < 0.05$) and layer ($p < 0.05$) on this soil density. Regarding the effect of layer-independent soil management, at 42 DAS, it was observed that the lowest density value was found in the MM followed by MC, and this result can be attributed to the soil rotation and incorporation of residues. These results are consistent with those obtained for the porosity, because in these same management macroporosity was higher. As with the porosity variable, at 97 DAS, the density values practically returned to the initial value before the management intervention. It was verified that the soil density at the end of the crop cycle had an average value around 1.02 kg dm^3, similar to the soil density in SD at 42 days, which in this case can be considered as a control, since who did not undergo management intervention. This result demonstrates that 97 DAS in the experimental conditions evaluated is a sufficient time for the soil to re-match and reorganize to a physical condition similar to that of the management without soil rotation.

The mean densities obtained for the independent layer of soil management revealed significant differences at 42 and 97 DAS. In both dates, the lowest soil density value was found in the superficial layer (0 to 10 cm) as a response to the soil-tossing maneuvers, which decreased the average of the superficial layer and did not cause significant mobilization in the deeper layer (10 to 20 cm), which consequently obtained the highest values of density in the two dates evaluated (Tables 4 and 5).

In the 0 to 10 cm layer there was no significant interaction ($p < 0.05$) of soil management and DAS on soil density and no effect of these factors on the variable. This result shows that already at 42 DAS the soil had an accommodation after the management change, reaching values close to that found in SD. As no significant difference was found for the means of density independent of management and DAS, then we can infer that under irrigated systems 42 days after the management is a sufficient time interval for total soil resilience, that is, period necessary for the soil reorganize, recovering from the disturbance of the soil management with tilting. This inference is still true when correlated with the results of the analysis of the variables microporosity and total porosity, which also did not present significant effects of soil management or DAS, showing that already at 42 days the soil had already recovered the condition of common porosity of the system.

In the layer of 10 to 20 cm there was interaction between soil management and DAS. At 42 DAS the SD presented the highest soil density value in relation to the studied managements, but at 97 DAS the SD had the lowest density value (p <0.05). The increase in soil density at 97 DAS in the shifting management may have occurred to the detriment of the accommodation of the smaller fragmented soil particles during the rooting in the deeper layers, accommodation is enhanced by the infiltration of the irrigation water into the soil profile, which effect over time generates the process known as foot-of-grid. The present study corroborates [28] who evaluated the changes in soil physical attributes after the minimum tillage using the rotary hoe and the scarifier plow verified that in the same year the soil density in the chiseling process was statistically similar in layers up to 40 cm deep.

Considering that the averages of soil moisture at the time of penetration resistance readings and soil density at the same date did not show significant differences between managements, we can then evaluate the relative differences between the observed RSP values (Fig. 1).

3.3 Effects of MC, MM, SD, Soil Layers and DAS on Soil Penetration Resistance

It was observed that the soil penetration resistance between the MM and MC did not differ at any point of the depth evaluated, and both maintained resistance values always below 2 MPa. The resistance curve for the MM and MC

Table 4. Mean soil density (kg cm^{-3}), as a function of management and layer, evaluated at 42 and 97 days after sowing. Tangará da Serra, Mato Grosso, Brazil

	Bulk density (kg dm^{-3})					
	42 DAS			97 DAS		
	0-10 cm	10-20 cm	Mean	0-10 cm	10-20 cm	Mean
MC	0.94	1.01	0.98 ab	0.98	1.09	1.03 a
MM	0.95	0.99	0.97 b	0.98	1.07	1.03 ab
SD	1.00	1.05	1.02 a	0.97	1.03	1.00 b
Média	0.96 B	1.02 A	**0.99***	0.98 B	1.06 A	**1.02***

*MC = Conventional management, MM = Minimum management, SD = Direct seeding, DAS = Days after sowing. Means followed by the same lowercase letter in the column indicates no difference between handles or, upper case in the row, indicates no difference between layers, by the Tukey test (p <0.05). * Average of treatments*

Table 5. Mean soil density (kg dm^{-3}), as a function of soil management systems and days after sowing, were evaluated in the 0-10 cm and 10-20 cm layers. Tangará da Serra, Mato Grosso, Brazil

	Bulk density (kg dm^{-3})					
	0-10 cm			10-20 cm		
	42 DAS	97	Mean	42 DAS	97	Mean
MC	0.94	0.98	0.96 a	1.01 ab B	1.09 a A	1.05 a
MM	0.95	0.98	0.97 a	0.99 b B	1.07 abA	1.03 a
SD	1.00	0.97	0.99 a	1.05 a A	1.03 b A	1.04 a
Mean	0.96 A	0.98 A	**0.97***	1.02 B	1.06 A	1.04*

*MC = Conventional management, MM = Minimum management, SD = Direct seeding, DAS = Days after sowing. Means followed by the same lowercase letter in the column indicates no difference between handles or, upper case in the row, indicates no difference between layers, by the Tukey test (p <0.05). * Mean of treatments*

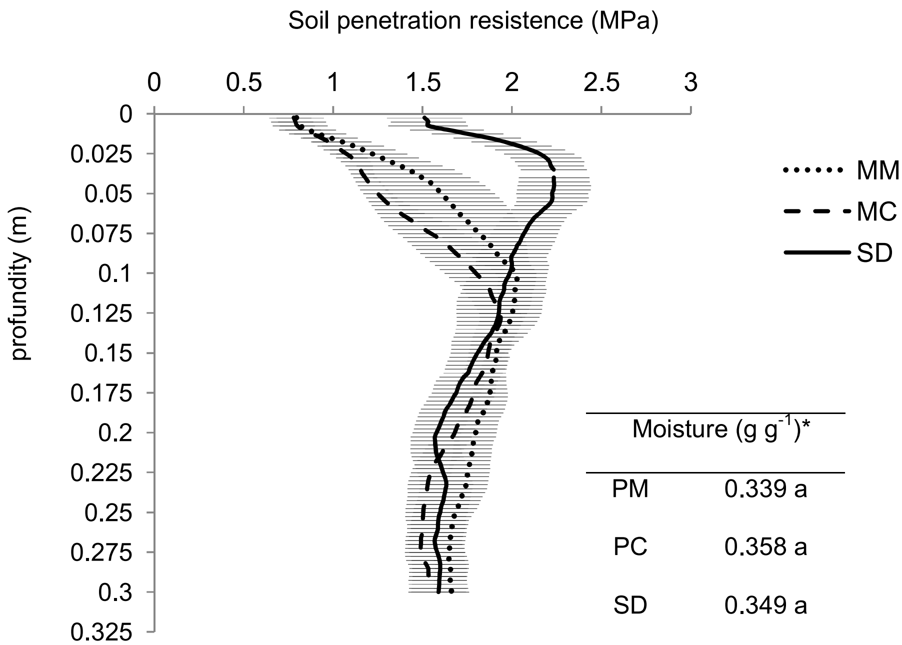

Fig. 1. Soil penetration resistance (MPa) of each soil management, evaluated at 97 (DAS - Days after sowing) in the 0-0,3 m layer in wheat irrigated in Tangará da Serra, MT. The bars indicate the standard error values of the mean and the overlap of these denotes the absence of differences between the means of the treatments. * Means followed by the same letter do not differ from each other, by the Tukey test (p <0.05). Tangará da Serra, Mato Grosso, Brazil

show that the soil rotation was efficient to the depth of 0.1 m and 0.125 m, respectively, as they present values of RSP lower than those found for the non-mobilized soil. The points from this point remained close to that observed in SD up to a depth of 0.3 m.

The RSP curve for the SD presented statistically different values, according to analysis of the standard error bars of the mean, in relation to the maneuvers with tilting, to the depth of 0.070 m and, from this, there was no difference between the maneuvers. SD had values of resistance between 1.5 and 2 MPa already in the layer of 0 to 0.025 m. Between 0.025 and 0.075 m soil resistance remained with values above 2 MPa, considered not yet limiting for the development of wheat, states that values of RP greater than 3.5 MPa are considered as limiting its growth. From the 0.075 m the RSP presented behavior similar to the other maneuvers. This behavior of higher densities found in SD up to 0.075 m is characteristic, and represents the effect of the pressures exerted by the traffic of machines in the area, which causes this effect of greater soil densification in the superficial layers.

In general, the penetration resistance data made it clear that the soil tillage methods used in the MM and MC were efficient to promote the sowing bed of the crop, necessary for the initial good development of the plants, however, to the above depths of 0.1 m, the plants had similar conditions for root growth in all treatments, finding resistance below the critical value for growth up to the depth of 0.3 m.

3.4 Effects of MC, MM, SD on Wheat Yield

The BRS-254 wheat yield did not differ among evaluated soil management (Table 6). The disk grid can promote negative aspects of subsurface compaction (foot-of-grid), and direct seeding in surface compaction. However, according to the results of soil penetration density and resistance, the grid action in MC and MM, and non-soil rotation in SD did not reach values that would limit the development of the crop and the physical attributes of the soil. Similar responses were found by Flores et al. [29] and Secco et al. [30] when evaluating different soil tillage in soybean cultivation. These authors concluded that there was no influence on grain yield, even inducing compaction of the soil by the compactor roller. In a red nitosol cultivated with wheat under no-tillage system, mechanical scarification altered the physical properties of the soil in the superficial layer, thirteen months after the intervention and the use of the subsoiler as a way to reduce soil compaction did not contribute to the increase of productivity and quality of wheat grains [31].

Table 6. Average irrigated wheat yield BRS-254, as a function of soil management systems. Tangará da Serra, Mato Grosso, Brazil

	Productivity (Kg/ha^{-1})
MC	2174.8 a
MM	2078.5 a
SD	2196.8 a
Mean	2150.1*
CV (%)	12.41
F	0.2225 ns

*MC = Conventional management, MM = Minimum management, SD = Direct seeding. Means followed by the same lowercase letter in the column indicates no difference between handles or, upper case in the row, indicates no difference between layers, by the Tukey test (p <0.05). * Mean of treatments*

The positive effect of soil mobilization by the fertilizer sowing mechanisms, which like the grid used in the MC and the MM, mobilize the soil up to approximately 0.1 m depth, facilitated the root growth of the irrigated wheat crop.

4. CONCLUSION

The use of MC and MM interfere in the physical attributes of the soil. These managements promoted increased macroporosity and microporosity decreased up to 42 DAS, but at 97 OF the effects were no longer observed. The soil penetration resistance curve for the MM and MC show that the soil upturn was efficient to the depth of 10 cm.

The use of MM and SD as a way to reduce soil compaction did not contribute to the increase of yield of irrigated wheat. The MC provided higher productivity. It is recommended for the farmer the management of soil more economical and that causes improvement in the physical attributes of the soil.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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