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TECHNICAL PAPER

SOIL ATTRIBUTES AND INITIAL CORN DEVELOPMENT AS A FUNCTION OF FERTILIZATION AND INTERCROPPING SYSTEMS

Jorge W. Cortez[1*], Rouverson P. da Silva[2], Carlos E. A. Furlani[2], Nelci Olszevski[3], Hideo de J. Nagahama[3]

[1*]Corresponding author. Universidade Federal da Grande Dourados/ Dourados - MS, Brasil.
E-mail: jorgecortez@ufgd.edu.br | ORCID: http://orcid.org/0000-0003-1120-719X

KEYWORDS

compaction, vegetation cover, soil physical quality.

ABSTRACT

Fertilization systems that allow higher sowing speeds have been used in areas of grain production, as well as the use of intercropping to improve soil physical quality and provide better soil cover. This study aimed to evaluate soil attributes and the initial corn development and intercropping (corn + velvet bean, corn + pigeonpea, and corn + bonavist bean) as a function of fertilization systems (pre-sowing and sowing). The experiment was conducted in an Oxisol in a randomized block design in the 2 × 3 factorial scheme, with four replications. The number of days for emergence, plant stand, intercropping dry matter, soil straw cover, soil straw permanence index, penetration resistance, soil moisture, soil density, degree of compaction, and total soil porosity were measured. The percentage of soil straw cover was affected by fertilization system, mainly by pre-sowing fertilization. Soil physical attributes were not affected by fertilization and intercropping systems, except total porosity, in the 0–0.10 m layer, which has a combined effect of factors. The initial corn development was not affected by fertilization and intercropping systems. Velvet bean presented the highest number of days for the emergence and lower dry matter.

INTRODUCTION

The cultivated area increases as the demand for new production technologies also increases. Therefore, it is essential that alternatives be designed to reduce impacts and promote productivity gains, without compromising crop energy balance, as well as contributing to the improvement of soil physical, chemical, and biological conditions (Pereira et al., 2013; Cardoso et al., 2014).

The use of cover crops may lead to improvements in soil quality, microbial biomass, water storage, carbon sequestration, and improved nutrient supply to plants (Frasier et al., 2016). Plant stand is one of the main production components that changes crop productivity, maximizing the production environment for the crop (Ortiz et al., 2015).

Corn plants need adequate conditions of solar radiation interception, which is a direct function of population density and plant distribution in the area (Storck et al., 2015). Corn intercropped with legumes generates an advantage because its physiology is more efficient in carbon sequestration and dry matter accumulation at high temperatures, with a beneficial effect in subsequent years in the same intercropping area (Paz et al., 2012).

A conservationist system aims to promote adequate conditions for crop residue accumulation, which benefit water absorption and infiltration, increasing soil sorption, total porosity, and macro-aggregation (Sá et al., 2014). Despite the benefits, the occurrence of soil surface compaction has been observed in no-tillage systems, as well as a consequent increase in soil penetration resistance and reduction of porosity (Gozubuyuk et al., 2014).

The use of soil management systems provides changes, especially in its structure. In the long term, this aspect may be associated with the formation of compacted layers (Lima et al., 2013). Because soil management systems differ in their effect on aggregation indices and soil resistance, Betioli Junior et al. (2012) stated that one of the ways to increase soil structural quality is through the conservation and addition of organic matter in the soil.

[2] Universidade Estadual Paulista "Julio de Mesquita Filho"/ Jaboticabal - SP, Brasil.
[3] Universidade Federal do Vale do São Francisco/ Juazeiro - BA, Brasil.
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Vegetation cover hinders surface runoff, increasing the time and capacity of water infiltration, reduces the evaporation due to soil protection against solar radiation, and modifies the surface thermal amplitude at evaporation time (Cortez et al., 2015). A no-tillage system with adequate vegetation cover provides higher water savings and improved physical, chemical, and biological properties over the years when compared to other soil management systems (Silva et al., 2015).

Thus, the aim of this study was to evaluate soil attributes and the initial corn development and intercropping (corn + velvet bean, corn + pigeonpea, and corn + bonavist bean) in fertilization systems (pre-sowing and sowing).

MATERIAL AND METHODS

The experiment was conducted at the Experimental Farm of the University of São Paulo State (UNESP) in Jaboticabal. The study area has about 1.0 ha and is located on a typical Eutroferric Red Latosol, A moderate, clay texture (55%), and soft wavy relief (average slope of 4%), at the geodesic coordinates 21°14′ S and 48°16′ W, and an average altitude of 559 m. The data used as the basis for fertilization recommendation are shown in Table 1. According to Köeppen's classification, the climate is CWa, i.e. a subtropical humid climate, with drought in the winter season (Figure 1).

TABLE 1. Soil chemical analysis of the experimental area.

Soil layer	pH	MO	P	K	Ca	Mg	H+Al	SB	T	V
m	$CaCl_2$	g dm^{-3}	mg dm^{-3}	----------------------------------mmol$_c$ dm^{-3}------------------						%
0-0.1	6.0	28	46	4.8	50	30	20	85	105	81
0.1-0.2	5.7	23	37	4.5	38	17	25	60	85	70

OM: organic matter; P: resin phosphorus; SB: sum of bases; T: cation exchange capacity at pH 7.0; V: soil base saturation.

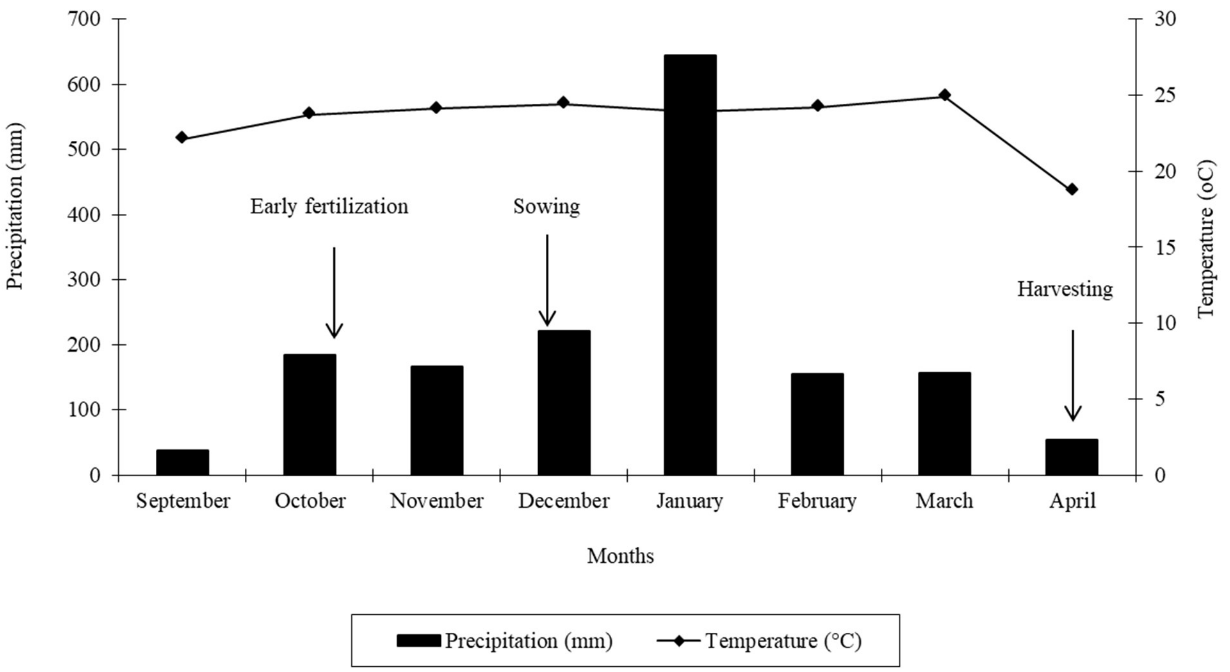

FIGURE 1. Monthly meteorological data (precipitation and temperature) obtained from the Department of Exact Sciences, UNESP, Jaboticabal, SP, Brazil.

The experimental area was maintained under fallow for a long time, favoring the infestation by guinea grass (*Panicum maximum* Jacq.) and bermudagrass (*Cynodon dactylon* (L.) Pers), which were mowed before the conventional soil tillage, with a heavy harrowing and two light harrowings. This area was used for planting different crops for eight years with fallow periods. Thus, before the experiment setup, millet (*Pennisetum* sp.) was sown in the area aiming at forming straw for soybean (*Glycine max* (L.) Merrill) direct sowing, which was carried out after seven months. After soybean harvesting, *Crotalaria juncea* L. and velvet bean (*Stizolobium niveum* L.) were sown in the area; corn (*Zea mays* L.) was sown after eight months. After four months, millet (*Pennisetum glaucum* (L.) R. Brown) and sorghum (*Sorghum bicolor*) were sown and soybean after eight months. Subsequently, crotalaria and velvet bean (*Mucuna pruriens*) were sown after soybean harvesting and corn were sown after eight months. After the corn harvesting, the area remained under fallow for eight months until soybean sowing. The area remained under fallow again for a year after soybean harvesting until the experiment was set up. At sowing time, soil presented 25% moisture in the 0–0.20 m layer, 67.2% vegetation cover according to Laflen et al. (1981), and penetration resistance of 1.3 and 3.1 MPa in the 0.00–0.10 and 0.10–0.20 m layers, respectively.

The experiment was set up in a randomized block design in a 2 × 3 factorial scheme with four replications, two fertilization systems (pre-sowing and sowing), and three intercropping systems (corn + velvet bean, corn + pigeonpea, and corn + bonavist bean). Each experimental plot occupied an area of 300 m^2 (25 × 12 m) and a space of 15 m was reserved in the longitudinal direction between plots for maneuvers, machinery traffic, and stabilization of the mechanized assemblies during sowing and other operations.

Fertilizer application in pre-sowing was performed with a tractor-seeder assembly at a speed of 4.2 km h^{-1} thirty days before sowing. At sowing, this treatment received only seeds and the fertilizer mechanism (furrowing ridger) was removed from the seeder. Tractor-seeder assembly speed was 6.6 km h^{-1}. Fertilizer application at sowing used a seeder with all the mechanisms of contact with the soil, including the furrowing ridger for fertilizer deposition.

Intercropping (corn + velvet bean, corn + pigeonpea, and corn + bonavist bean) was formed at sowing time, with legume seeds deposited seven centimeters deep in the soil and corn seeds three centimeters deep in order to obtain a delay in the intercropping emergence. At sowing, seed deposits of the seeder lines were alternately filled with corn and legume seeds.

The tractor-seeder-fertilizer assembly used in this study comprised a seeder-fertilizer (model Marchesan COP Suprema) with seven sowing rows spaced at 0.45 m and weight of 3,070 kg coupled to a tractor (model Valtra BM100) with auxiliary front-wheel drive (AFWD), power of 73.6 kW, and weight of 5,400 kg, and.

The simple corn hybrid DKB 390, with purity and germination of 96% and 60,000 plants per hectare, maturation close to 120 days (mean cycle), first ear height of 1.25 to 1.40 m, thermal summation until flowering of 870 degree-days, was used at sowing. Legumes used in the intercropping consisted of pigeonpea (*Cajanus cajan* L.), velvet bean (*Stizolobium deeringianum* Bort.), and bonavist bean (*Dolichos lablab*), with a density of 12, 9, and, 9 seeds per meter, respectively.

For pre-sowing and sowing fertilization, 370 kg ha^{-1} of the NPK formula 8–28–16 were applied. In addition, topdressing fertilization was carried out with 140 kg ha^{-1} of urea at 14 days after sowing (V4 – four leaves) and 200 kg ha^{-1} of urea at 30 days after sowing (V7 – seven leaves).

The soil cover was measured with a 7.5 m long wire with equidistant markings of 0.15 m and two poles at the tips to fix it to the ground, resulting in 50 reading points and two readings on the diagonals of the plot, totaling 100 points (adapted from Laflen et al., 1981). The percentage of vegetation cover on the soil surface was determined at different times during the experimental period. Soil cover was determined after pre-sowing fertilization (CTa), at 30 days after pre-sowing fertilization (CTb), and after sowing (CTc); the straw permanence index (PI) of corn (CTd), intercropping (CTe), and weeds (CTf) at 30 days after sowing; and bare soil at 30 days after sowing (CTg). PI is the relationship between post- and pre-sowing cover and was obtained from these evaluations.

Data were collected from the emergence of corn and intercropped plants to the stabilization of the number of seedlings emerged in two meters marked in the central part of the plot. The mean number of days for emergency (NDE) was determined according to Edmond & Drapala (1958). A one-meter wooden batten with a wooden handle, forming an inverted "T", was used to determine the initial plant stand (PS). In the field, the initial part of this equipment was placed next to corn or intercropped plants and the number of plants emerged in this space was counted. Counts were carried out in the central row of each plot in two meters.

Five consecutive plants were collected from the central part of the plot in order to determine the intercropping dry matter (IDM) at 30, 60, and 90 days after sowing (DAS), being oven dried at 70 °C for 48 hours until constant weight.

Penetration resistance (PR) was determined with an IAA/Planalsucar impact penetrometer (Stolf et al., 1983) with a 4 kg plunger mass, 40 cm free fall course, 30° cone angle, 1.3 cm in diameter and rod with a diameter of 0.95 cm. Readings were performed in all the experimental plots (one per plot) at 30 days after the sowing operation in the interrow, with values taken every 0.10 m at a depth of 0.50 m. The results were taken in blows dm^{-1} and transformed into MPa, as described by Stolf (1991).

Soil gravimetric moisture (SM), soil density (SD), and total soil porosity (TP) were determined according to the methodology of Donagema et al. (2011) from samples collected in the 0.00–0.10, 0.10–0.20, and 0.20–0.30 m layers within each plot at 30 days after sowing operation.

In addition, the degree of compaction, defined as the percentage of compaction that the soil has in relation to its maximum (Suzuki et al., 2007), was calculated. The maximum density value for the Eutroferric Red Latosol of the area is 1.85 g cm^{-3} (Beutler et al., 2005).

The data were submitted to analysis of variance and when the value of the F-test was significant at 5% probability, the Tukey's test was performed at 5% probability for the comparison of means.

RESULTS AND DISCUSSION

Soil cover after pre-sowing fertilization (Table 2) presented differences between fertilization systems. Thus, pre-sowing fertilization reduced soil cover by 43.1%. This is due to the amount of clay in the soil, which adheres to the seeder-fertilizer mechanisms, opening a wide groove and burying the straw. According to Francetto et al. (2015), this occurs due to the dimensional characteristics of the elements that interfere with the cutting, shear, and compaction stresses caused to the soil. After pre-sowing fertilization (30 days), soil cover increased by 8.8%, while at the site of fertilization only sowing increased by 6.1%.

TABLE 2. Summary of analysis of variance for soil cover after pre-sowing fertilization (CTa), at 30 days after pre-sowing fertilization (CTb), and after sowing (CTc); the straw permanence index of corn (CTd), intercropping (CTe), and weeds (CTf) at 30 days after sowing; and bare soil at 30 days after sowing (CTg).

Factor	Soil cover (%)							
	CTa	CTb	CTc	IP	CTd	CTe	CTf	CTg
Fertilization								
Pre-sowing	36.6 B	45.4 B	22.6 A	50.3 A	38.7 B	16.6 A	31.5 A	13.2 A
Sowing	64.3 A	70.4 A	23.6 A	34.0 B	50.1 A	17.7 A	19.6 B	12.6 A
Intercropping								
C + velvet bean	46.9 A	58.0 A	22.0 A	40.1 A	43.6 A	6.4 C	27 AB	22.7 A
C + pigeonpea	59.0 A	59.2 A	24.0 A	42.1 A	45.2 A	14.4 B	30.6 A	9.7 B
C + bonavist bean	45.5 A	56.5 A	23.2 A	44.2 A	44.2 A	30.9 A	18.7 B	6.1 B
F-test								
Fertilization (F)	39.2 **	29.2 **	0.1 ns	10.2 **	21.9 **	0.4 ns	12.7 **	0.1 ns
Intercropping (I)	3.7 *	0.1 ns	0.1 ns	0.2 ns	0.1 ns	67.6 **	4.5 *	19.0 **
F × I	1.1 ns	0.1 ns	1.5 ns	2.0 ns	0.5 ns	0.6 ns	1.5 ns	1.2 ns
CV (%)	21.5	19.6	35.7	29.1	13.5	24.9	32.1	44.0

Means followed by the same letter in the column do not differ from each other by the Tukey's test. ns: not significant (P>0.05); *: significant (P<0.05); **: significant (P<0.01). C: corn. CV: coefficient of variation (%).

After sowing, a marked reduction was observed in soil cover with intercropping installation (Table 2), but with no difference between fertilization and intercropping systems. Straw permanence index (PI) presented differences between fertilization systems, evidencing a higher soil cover in the pre-sowing fertilization system. Even with an initial reduction in soil cover by pre-sowing at 30 days after sowing, this treatment showed an increase of 47.9% when compared to sowing fertilization. This soil cover maximization may be associated with the lack of the furrowing ridge during the sowing operation. Thus, according to Nagahama et al. (2016), the use of disks for straw cutting should be used together with ridges in order to reduce straw incorporation, i.e. the use of only furrowing ridge in the seeder favors a soil cover reduction.

After sowing, soil cover was defined with corn, intercropping, and weeds, and in the bare soil (Table 2). For corn, a difference was observed between fertilization systems, demonstrating an effect on the initial crop development. According to Lacerda et al. (2015), this development is due to the characteristic of responsiveness of the species to fertilization, with the lowest soil cover observed in the pre-sowing fertilization. Intercropping presented differences regarding soil cover only between crops, with bonavist bean and velvet bean presenting the highest (30.9%) and lowest soil cover (6.4%), respectively. This result was due to the rapid initial growth of bonavist bean and slow of velvet bean. Soil cover by weeds was affected by fertilization and intercropping systems. Pre-sowing fertilization favored weed development, while pigeonpea (30.6%) differed from the bonavist bean (18.7%) in the intercropping. As observed, the highest value of bare soil was found in the intercropping system with velvet bean due to its lower initial development.

Soil cover (Table 2) is a criterion used to classify a system as being conservationist or non-conservationist. Thus, according to ASAE (1989), a conservationist system is that with a soil cover higher than 30% of residues after sowing. Marques & Benez (2000) evaluated soil cover after sowing under no-tillage system managed with herbicide and using a seeder with furrowing ridge and verified a coverage of 81%. In this sense, Furlani et al. (2004) observed a permanence of more than 60% in soil cover after sowing in a no-tillage system. Ziech et al. (2015) observed that the intercropping of plant species when compared to isolated crops, provided the formation of a soil cover closer to the ideal in terms of quantity and quality of residues, which brings benefits to crops in succession and no-tillage system.

Soil penetration resistance at 30 days after sowing (Table 3) presented no difference between fertilization and intercropping systems in all the evaluated layers. No increase in penetration resistance was observed even in the pre-sowing fertilization with an additional operation. According to Lima et al. (2015), cover plants that provide an increase in biopores also improve soil physical conditions considering the decompaction potential of some species.

TABLE 3. Summary of analysis of variance for soil penetration resistance (MPa) 30 days after sowing.

Factor	Layer (m)				
	0.00–0.10	0.10–0.20	0.20–0.30	0.30–0.40	0.40–0.50
Fertilization					
Pre-sowing	0.8 A	2.1 A	3.4 A	4.1 A	4.5 A
Sowing	1.1 A	2.4 A	2.9 A	3.5 A	3.8 A
Intercropping					
C + velvet bean	0.8 A	2.1 A	2.8 A	3.6 A	3.8 A
C + pigeonpea	1.1 A	2.4 A	3.2 A	3.6 A	4.4 A
C + bonavist bean	0.9 A	2.1 A	3.5 A	4.2 A	4.3 A
F-test					
Fertilization (F)	2.9^{ns}	1.8^{ns}	2.4^{ns}	2.1^{ns}	1.2^{ns}
Intercropping (I)	1.0^{ns}	0.5^{ns}	2.3^{ns}	0.9^{ns}	0.3^{ns}
F × I	0.3^{ns}	0.5^{ns}	0.5^{ns}	0.6^{ns}	0.7^{ns}
CV (%)	48.4	27.7	22.2	26.6	36.1

Means followed by the same letter in the column do not differ from each other by the Tukey's test. ^{ns}: not significant (P>0.05); *: significant (P<0.05); **: significant (P<0.01). C: corn. CV: coefficient of variation (%).

Penetration resistance (PR) increased as depth increased up to the 0.30–0.40 and 0.40–0.50 m layers. In a study with mechanized assemblies of soil tillage, Nagahama et al. (2016) also observed an increased PR as depth increased mainly due to the natural overlap of soil layers. Soil moisture at the measurement time of penetration resistance was between 0.25 and 0.27 cm^3 cm^{-3} in the soil layer of 0.00–0.50 m.

In areas of no-tillage system, it is expected a higher soil penetration resistance, especially below 0.10 m because this layer is usually affected by machinery traffic. According to Beutler & Centurion (2004), medium levels of penetration resistance of 2.55 MPa have been observed for clay soils when managed under a conventional tillage system. Other authors define as 2.0 MPa the limit above which restrictions occur to the root system, being this value usually found below the 0.10–0.20 m layer (Suzuki, 2005). In addition, according to Souza et al. (2014), PR increases exponentially as moisture decreases due to an increase of cohesive forces between soil particles.

Density and the degree of soil compaction were not affected by fertilization and intercropping systems (Table 4). Mean values of density of 1.5 g cm^{-3} and degree of compaction of 76% were observed in the 0.00–0.10 m layer and 80% in the 0.10–0.20 and 0.20–0.30 m layers. According to Torres et al. (2015), positive and negative correlations between soil density and other soil physical attributes show its importance as a good indicator of soil quality.

TABLE 4. Summary of analysis of variance for soil density (SD) and degree of soil compaction (DC) in the 0.00–0.10, 0.10–0.20, and 0.20–0.30 m layers.

Factor	SD (g cm^{-3})			DC (%)		
	0–0.1 m	0.1–0.2 m	0.2–0.3 m	0–0.1 m	0.1–0.2 m	0.2–0.3 m
Fertilization						
Pre-sowing	1.4 A	1.4 A	1.5 A	77.3 A	80.7 A	80.8 A
Sowing	1.4 A	1.5 A	1.5 A	76.1 A	81.5 A	81.1 A
Intercropping						
C + velvet bean	1.4 A	1.4 A	1.5 A	76.0 A	82.1 A	81.3 A
C + pigeonpea	1.5 A	1.5 A	1.5 A	77.9 A	81.4 A	80.8 A
C + bonavist bean	1.4 A	1.5 A	1.5 A	76.1 A	79.9 A	80.7 A
F-test						
Fertilization (F)	0.5^{ns}	1.7^{ns}	0.9^{ns}	1.5^{ns}	0.4^{ns}	0.1^{ns}
Intercropping (I)	2.8^{ns}	0.4^{ns}	0.6^{ns}	1.6^{ns}	1.0^{ns}	0.2^{ns}
F × I	1.7^{ns}	0.6^{ns}	0.2^{ns}	0.3^{ns}	1.7^{ns}	1.2^{ns}
CV (%)	3.9	14.9	3.1	3.2	3.9	2.6

Means followed by the same letter in the column do not differ from each other by the Tukey's test. ^{ns}: not significant (P>0.05); *: significant (P<0.05); **: significant (P<0.01). C: corn. CV: coefficient of variation (%).

Soil moisture and total soil porosity were not affected by fertilization and intercropping systems (Table 5), except for total porosity in the 0.00–0.10 m layer, which had a combined action from fertilization and intercropping systems (Table 6). The mean values of moisture varied from 0.250 to 0.280 cm^3 cm^{-3}, whereas the mean values of total porosity varied around 40%. Soils with vegetation cover are less affected by the impact of rainwater with consequent increase of infiltration. When the soil is under the drying process, vegetation cover retains soil moisture better. Therefore, according to Oliveira et al. (2000), the moisture of the soil profile is evenly distributed, especially when it is under the no-tillage system.

TABLE 5. Summary of analysis of variance for soil moisture (SM) and total soil porosity (TP) at 30 days after sowing in the 0–0.30 m layers.

Factor	SM ($cm^3\ cm^{-3}$)			TP (%)		
	0–0.1 m	0.1–0.2 m	0.2–0.3 m	0–0.1 m	0.1–0.2 m	0.2–0.3 m
Fertilization						
Pre-sowing	0.283 A	0.255 A	0.266 A	40.7 A	39.3 A	40.2 A
Sowing	0.277 A	0.259 A	0.266 A	40.8 A	39.5 A	40.1 A
Intercropping						
C + velvet bean	0.285 A	0.262 A	0.266 A	40.7 A	39.9 A	40.0 A
C + pigeonpea	0.271 A	0.247 A	0.264 A	39.9 A	38.4 A	40.2 A
C + bonavist bean	0.284 A	0.267 A	0.267 A	41.5 A	40.0 A	40.3 A
F-test						
Fertilization (F)	1.6^{ns}	0.3^{ns}	0.1^{ns}	0.1^{ns}	0.1^{ns}	0.1^{ns}
Intercropping (I)	3.5^{ns}	1.6^{ns}	0.1^{ns}	3.3^{ns}	1.0^{ns}	0.1^{ns}
F × I	2.4^{ns}	2.5^{ns}	1.8^{ns}	5.1 *	1.8^{ns}	0.2^{ns}
CV (%)	4.1	7.1	3.9	3.0	6.3	3.1

Means followed by the same letter in the column do not differ from each other by the Tukey's test. ^{ns}: not significant (P>0.05); *: significant (P≤0.05); **: significant (P≤0.01). C: corn. CV: coefficient of variation (%).

The total porosity underwent a combined action of fertilization and intercropping systems in the 0.00–0.10 m layer (Table 6). In this sense, pre-sowing fertilization had the lowest porosity in the intercropping with pigeonpea. This may be associated with the root system development because Matoso et al. (2015) observed a considerable improvement in total porosity due to the higher amount of roots in the soil.

TABLE 6. Summary of the slicing of the interaction fertilization (F) and intercropping (I) for the total porosity in the 0.00–0.10 m layer.

Intercropping	Fertilization	
	Pre-sowing	Sowing
C + velvet bean	41.5 Aa	39.9 Aa
C + pigeonpea	38.8 Bb	41.1 Aa
C + bonavist bean	41.8 Aa	41.3 Aa

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Tukey's test at 5% probability. C: corn.

In the sowing fertilization system, no difference was observed between intercropping systems (Table 6). Only the intercropping with pigeonpea differed in the fertilization systems, with the lowest porosity in the pre-sowing.

The number of days for emergence (NDE) was not significant for corn (Table 7), but a significant difference was observed for fertilization systems and crop types in the intercropping. Fertilization systems showed the need for a higher NDE in pre-sowing. Regarding the intercropping, differences were observed between crops, being higher for velvet bean, pigeonpea, and bonavist bean, even with seeds sown at a depth of 7 cm. According to Alves et al. (2014), sowing depth is specific for each species and when it is appropriate, it provides uniform germination and emergence of seedlings, but excessive depths may prevent seedlings from emerging to the soil surface.

TABLE 7. Summary of analysis of variance for the number of days for the emergence of crops (NDEcrop), number of days for the emergence of corn (NDEcorn), initial corn stand (Scorn × 1000 plants), and crop stand (Scrop × 1000 plants).

Factor	Variable			
	NDEcrop	NDEcorn	Scorn	Scrop
Fertilization				
Pre-sowing	5.5 A	4.0 A	67.6 A	71.7 A
Sowing	5.2 B	4.1 A	64.4 A	79.1 A
Intercropping				
C + velvet bean	7.2 A	4.0 A	65.9 A	31.9 B
C + pigeonpea	4.7 B	4.1 A	68.8 A	103.5 A
C + bonavist bean	4.1 C	4.0 A	63.2 A	90.9 A
F-test				
Fertilization (F)	4.8 *	2.1^{ns}	0.9^{ns}	1.4^{ns}
Intercropping (I)	213 **	2.1^{ns}	0.9^{ns}	51.0 **
F × I	2.0^{ns}	0.1^{ns}	0.5^{ns}	0.2^{ns}
CV (%)	5.9	2.0	12.6	20.0

Means followed by the same letter in the column do not differ from each other by the Tukey's test. ^{ns}: not significant (P>0.05); *: significant (P≤0.05); **: significant (P≤0.01). C: corn. CV: coefficient of variation (%).

The initial corn stand (Scorn) did not differ between treatments (Table 6). The results of the initial stand were close to those recommended by the manufacturer. For intercropping systems, a difference was observed as a function of crops, being higher for pigeonpea and bonavist bean. Araldi et al. (2016) pointed out that seedling emergence is reduced by increasing sowing depth from 2 cm, thus influencing stand establishment.

Intercropping dry matter (Table 8) showed a significant difference at 30, 60, and 90 days. No difference was observed for fertilization systems at all periods. Bonavist bean presented the highest dry matter at all periods. At 30 days after sowing, velvet bean had the lowest dry matter and at 60 days after sowing, pigeonpea and velvet bean had the lowest dry matter. Herrada et al. (2017) pointed out that differences in the amount of dry matter and nitrogen of legumes, when intercropped under different proportions, should condition the decomposition and release dynamics of nitrogen after the species management.

TABLE 8. Summary of analysis of variance for intercropping dry matter (IDM).

	Intercropping dry matter (kg ha^{-1})		
Factors	30 days	60 days	90 days
Fertilization			
Pre-sowing	415.0 A	751.8 A	860.7 A
Sowing	419.5 A	646.6 A	864.3 A
Intercropping			
C + velvet bean	201.7 C	357.6 B	472.2 B
C + pigeonpea	424.3 B	659.6 B	944.2 AB
C + bonavist bean	625.8 A	1080.3 A	1171.3 A
F-test			
Fertilization (F)	0.1 ^{ns}	0.9 ^{ns}	0.1 ^{ns}
Intercropping (I)	75.9 **	14.3 **	5.1 *
F × I	0.2 ^{ns}	0.2 ^{ns}	0.1 ^{ns}
CV (%)	16.5	38.8	51.3

Means followed by the same letter in the column do not differ from each other by the Tukey's test. ^{ns}: not significant (P>0.05); *: significant (P≤0.05); **: significant (P≤0.01). C: corn. CV: coefficient of variation (%).

CONCLUSIONS

The percentage of soil cover with straw was affected by the fertilization system, especially by the pre-sowing fertilization.

The soil attributes density, degree of compaction, moisture, porosity, and penetration resistance were not affected by fertilization and intercropping systems. However, the total porosity in the surface layer underwent a combined effect of factors.

The initial corn development was not affected by fertilization and intercropping systems.

Velvet bean had the highest number of days for the emergence and the lowest dry matter at 90 days after sowing.

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