# *Original Research Article*

**Utilization of Brachiarias in the improvement of physical and chemical attributes of a Yellow Oxisol**

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*This work was carried out in collaboration between all authors.*

**ABSTRACT:**

The study evaluated the effect of the cultivation of five species of grasses of the genus *Brachiaria* (*B. decumbens, B. ruziziensis, B. brizantha, B. humidicola and B. brizantha* CV MG-5) in physical and chemical properties and in the formation and stabilization of aggregates of a Yellow Oxisol. The test with the grasses in the absence and presence of fertilization was conducted in the Chã de Jardim area, belonging to the Centro de Ciências Agrárias-UFPB, located in the county Areia-PB. The experimental design was in randomized blocks, with subdivided parcels, in factorial scheme 5 × 2 × 4, with four repetitions, being: five species of Grass (Braquiarias), two conditions of mineral fertilization with NPK (absence or presence) and four depths of soil samples collection (0-5, 5-10, 10-20, 20-30 cm), totaling 40 subplots of 5.0 × 5.0 m, with 3 repetitions, totaling 120 sampling points. The grasses favored the formation of aggregates and contributed to their stability. *Brachiaria brizantha* is the most suitable grass to raise the organic matter content of an Oxisol without mineral fertilization.

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**Keywords:** soil aggregation, grasses, pasture fertilization, organic matter.

## 1- INTRODUTION

The inadequate choice of fodder, the misuse of soil conservation practices, the lack of maintenance of soil fertility and the high rate of animal stocking are the main causes of soil degradation. These factors alter the physical properties of the soil, being the main causes of its compaction Flávio Neto et al. [1]. The compression process reduces the density and macroporosity of the soil, increases the resistance of this to the root growth, in low humidity conditions, and reduces its oxygenation, when humid Bonini et al. [2].

Pastures can protect and improve the physical characteristics of the soil, Flávio Neto et al. [1], moreover, some plants, such as the Brachiarias are known for the ability to penetrate the compressed layers of the soil. Another contribution of the grasses is related to the growth of roots in the soil profile, which promotes the increase of the organic matter content, acting in the formation of stable aggregates, because the organic matter and the stability of aggregates have a strong correlation, as noted by Borges et al. and Gazzola et al. [3-4]. The root system in the soil profile, in the process of growth, promotes the approximation of the particles as the roots make pressure on the mineral particles in their advance through the porous space. The absorption of water by the roots, also provides drying in the region adjacent to the root systems, promoting an increase in the cohesion force among the particles, favoring the aggregation of the soil, Zonta et al. [5].

However, despite the large extent of areas cultivated with *Brachiaria* species, it can be stated that the available information still represents little in the universe of situations in which the genus *Brachiaria* is inserted, Lima et al. [6]. *Brachiaria* is one of the most widely used forages in Central Brazil and among its favorable agronomic characteristics stand out: High yields of dry matter and low soil fertility tolerance, high nutritional value and high resistance to stresses, Arroyave et al. [7].

Although the number of forage species available in Brazil is high, the genera *Brachiaria* and *Panicum* are the most important, with the predominance of 80% of pasture areas cultivated in the country, Fernandes et al. [8]. The Paraíba has a total pasture area of 1,471,069 ha, of which, the county of Areia, in the Brejo region, contributes 6,791 ha, of this area, 797 ha are pastures planted in degraded areas, IBGE [9].

Due to the lack of information for correct management of pastures which are currently in low production capacity due to the lack of nutrient replacement, Euclides et al. [10], it is necessary to adopt practices that enable to maximize the forage production respecting soil resilience. In this context, Euclides et al. [10] suggested that the expectation is that the forage plant be used more rationally, through the use of specific methods of management, capable of making available for pastures, a continuous and expressive production, with greater competition in agribusiness, throughout the agricultural system.

In view of the above, this research aimed to evaluate by means of physical and chemical attributes, the effect of the cultivation of five varieties of *Brachiaria*, on the quality of a Yellow Oxisol, as well as the formation and stabilization of aggregates in this soil.



## 2- MATERIAL AND METHODS

The soil used for the realization of the experiment is classified as Yellow Oxisol EMBRAPA [11] and was collected in the experimental area Chã do Jardim, located in the county of Areia-PB, belonging to the Center of Agrarian Sciences of the Federal University of Paraiba, with coordinates 6º58’12’’S e 35º42’15’’W and at an altitude of 620 m.

The climate of the region, where the experiment is installed, according to the classification of Köppen, is type As ', Tropical subhumid (hot and humid), with a rainy season in the autumn-winter period, with greater rainfall in the months of June and July, Jacomine et al. [12]. In the county of Sand-PB, of the region of the Brejo Paraibano according to the data of the meteorological station of the CCA/UFPB (average of 30 years), the average annual temperature is 24.5 ºC, the average annual relative humidity is 85% and the average annual rainfall precipitation is 1,400 mm, being concentrated in more than 75% in the months of March and August.

The experimental area was prepared for establishment of the test with ploughing and grading, for planting the grasses at the beginning of the year 2005. Five species of the genus *Brachiaria* were chosen, including: *Brachiaria decumbens, Brachiaria humidicola, Brachiaria ruziziensis, Brachiaria brizantha, Brachiaria brizantha* cultivate MG5 and distributed in experimental portions of 10.0 m of length by 5.0 m of width.

The experimental design adopted was in randomized blocks, with subdivided parcels, in factorial scheme 5 × 2 × 4, referring to five species of Brachiarias, two conditions of mineral fertilization with NPK (absence and presence) and four depths (0-5, 5-10, 10-20, 20-30 cm) and four replications, totaling 40 subplots of 5.0 × 5.0 m with 3 repetitions,  totaling 120 sampling points.

Soil samples, for each treatment, were collected in the months of June to July 2011, in each subparcels (absence and presence of mineral fertilization) by treatment (*Brachiaria*), the treatment considered "control" is the soil without the grasses. Undisturbed soil samples were collected at the depths (0-5, 5-10, 10-20 and 20-30 cm) for the physical and chemical determinations of the soil.

The density of the soil was determined for each depth, with three repetitions, using the method of the paraffin Clod, EMBRAPA [11]. The separation of the aggregate size of the soil by dry screening was carried out according to the method of Silva et al. [13]. With the results, the aggregate diameter classes were determined: < 0.053, 0.053-0.106, 0.106-0.25, 0.25-0.50, 0.50-1.00, 1.00-2.00 and 2.00-9.52 mm and the weighted average diameter of dried aggregates (DMPAs) Silva et al. [13]. The separation of soil aggregates size by wet sieving was performed, using a sieve set with mesh diameter of: < 0.053, 0.106, 0.25, 0.50, 1.00, 2.00 and 9.52 mm, through the method described by Tisdall et al. [14], adapted by Carpenedo et al. [15].

Subsamples of approximately 50 g were moistened, by capillary, for a period of 24 h, through the use of plastic containers, perforated in its lower part, containing cotton and filter paper inside, to facilitate the damping and placed on a tray with water. After the damping, the subsamples were transferred to plastic tubes of 21 cm in length and 9.5 cm in diameter, containing 50 ml of water and stirred for 2 minutes at 16 rpm in a rotary agitator. Then the contents of each tube were placed in a sieve set with mesh diameter of: < 0.053, 0.106, 0.25, 0,50, 1.00, 2.00 and 9.52 mm, to obtain the size of aggregates in the classes: < 0.053, 0.053-0.106, 0.106-0.25, 0.25-0.50, 0.50-1.00, 1.00-

2.00 and 2.00-9.52 mm and obtaining the weighted average diameter of wet aggregates (DMPAu) after kiln drying.

The determination of the stability of aggregates was carried out using the ratio of the weighted average diameter of wet and dry aggregates (DMPAu/DMPAs), according to Silva et al. [13]. After obtaining soil density and soil aggregation by dry and damp, soil samples were disaggregated for physical determinations (particle density and soil porosity) and chemical properties.

Soil chemical analyses were carried out in the Laboratório de Química e Fertilidade do Solo do Departamento de Solos e Engenharia Rural do CCA-UFPB, being three replicates per treatment and control (soil without grasses) and consisted of: pH in water in proportion 1:2.5 (soil/water) and the phosphorus (P), potassium (K) contents were extracted with Melich 1 solution; The P was determined by photocolorimeter (ammonium molybdate and ascorbic acid) and K by flame photometry, calcium (Ca), magnesium (Mg) were extracted by KCl solution and its determination in atomic absorption spectrometry, exchangeable acidity, acidity (H + Al) was extracted by buffered solution of calcium acetate at pH 7 and determined by NaOH solution in the presence of phenol-ain as indicator, per unit titration of ferrous ammonium sulphate (0.05 mol $L^{-1}$) in the presence of diphenylamine as indicator after oxidation of the organic matter with $K_2Cr_2O_7$ and $H_2SO_4$ and soil organic matter, as well as the sum of bases, the ability to exchange cations and the saturation by bases, following the methods of EMBRAPA [11].

The averages obtained for the Brachiarias × Brachiarias treatments were compared by the test "F" and the averages compared to each other by the Tukey test to 5% probability, for the results obtained for the treatments Brachiarias × control the averages were compared to each other by the Dunnett test at 5% probability.

## 3- RESULTS AND DISCUSSION

For the evaluated treatments, the pH of the soil obtained significant values in relation to the control, the only one that did not obtain significant value was the *Brachiaria ruziziensis* with mineral fertilization (table 1).

**Table 1.** Values of the chemical determinations of the Oxisol cultivated with the different grasses in the presence and absence of mineral fertilization

| | | Mean squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | pH | P | K | Ca | Mg | Al | SB | M.O. |
| | | -----mg $dm^{-3}$------ | | --------------------$cmol_c$ $dm^{-3}$------------------- | | | | g $kg^{-1}$ |
| Control | 4.47 | 5.63 | 16.58 | 0.94 | 0.78 | 0.69 | 1.79 | 32.48 |

| Grass | With fertilization | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *B. decumbens* | 5.29* | 10.36 | 18.78 | 1,53 | 1,03 | 0,45 | 2.66 | 28.13 |
| *B. brizantha* | 5.15* | 9.04 | 20.69 | 1.50 | 1.10 | 0.55 | 2.69 | 30.78 |
| *B. humidicola* | 5.21* | 9.22 | 15.54 | 1.38 | 1.01 | 0.46 | 2.30 | 29.86 |
| *B. brizan. MG5* | 5.22* | 13.00 | 13.82 | 1.62 | 0.91 | 0.38 | 2.54 | 28.90 |
| *B. ruziziensis* | 4.88 | 6.17 | 19.42 | 1.10 | 0.88 | 0.85 | 1.90 | 29.83 |
| | Without fertilization | | | | | | | |
| *B. decumbens* | 5.64* | 3.32 | 17.65 | 1.41 | 0.96 | 0.45 | 2.46 | 27.75 |
| *B. brizantha* | 5.32* | 3.603 | 18.44 | 1.34 | 1.03 | 0.46 | 2.44 | 26.84* |
| *B. humidicola* | 5.47* | 6.77 | 13.01 | 1.13 | 0.65 | 0.43 | 2.04 | 25.64* |
| *B. brizan. MG5* | 5.15* | 2.29 | 10.30 | 1.33 | 0.78 | 0.49 | 2.16 | 26.66* |
| *B. ruziziensis* | 5.28* | 4.35 | 16.22 | 0.92 | 0.65 | 0.56 | 1.60 | 28.29 |

* Significant and superior to the control, by the Dunnett test, at a level of 5% probability. SB= Sum of bases, M.O.= organic matter.

The elevation of the soil pH can be attributed to the adsorption of the $H^+$ in the functional groups of organic compounds of plant residues, Miyazawa et al. [16] and to the biological oxidation potential of organic anions, which are released in greater quantity in Beginning of the decomposition of the waste, Helyar et al. [17].

Ribeiro et al. [18] affirm that such pH values (Table 1) may be linked to the presence of cations ($Ca^{2+}$ and $Mg^{2+}$), as a consequence of the increase in pH values and the levels of basic cations in the surface layer of soils, there were observed low average concentrations of exchangeable aluminum and low acid exchangeable. Similar results were observed by Bonini et al. [2] when observing that the use of organic matter for oxisol recovery did not influence the increase in the pH of the soil.

With regard to the contents of organic matter, significant values were observed in the treatments with *Brachiaria brizantha, humidicola* and *brizantha* MG5 both without fertilization, which presented lower values than the control (Table 1). This fact can be explained by the low fertility of the soil, of this experiment, since the grasses, require the nutrients from the soil for its development, intensifying the activity of the microorganisms, Santos et al. [19] and consequently higher consumption of organic matter available in the soil. In the areas studied under the direct planting system, due to the cover of the soil by the straw in a direct planting system promoted an increase of the organic matter in the surface layers of the soil, Silva et al. [20].

The use of grasses of the genus Brachiaria, increased the fertility of the Oxisol, even did not Interfering significantly (table 1). These results are associated with rapid soil coverage by grasses and rapid nutrient recycling, Marchini et al. [21]. The use of grasses in the recovery of degraded areas is highlighted, because since it has the root system fasciculated is able to form infiltration channels, improving the storage of water, as well as decompression of the soil, Genro Júnior et al. [22].

The values obtained for soil bulk density and particle density and porosity, for the analyzed treatments, depths and absence and presence of mineral fertilization in the different Brachiarias analyzed, are presented in Table 2. It is observed that for the values relating to soil bulk density there was significant difference when the fertilization associated with *B. decumbens* and *B. rizuziensis* was carried out. However, no significant values were presented between particle density and total porosity by the Dunnet test at 5%. Soil and particle density were significant by the Tukey test at 5% for depth, regardless of the type of *Brachiaria* used and the presence or absence of fertilization, so that the superficial layer differed from the others (Table 2).

**Table 2.** Soil bulk density, particle density and total soil porosity values for evaluated treatments

| | Properties determined | | |
|---|---|---|---|
| Treatments | Bulk density | Particle density | Total porosity |
| | ---------------- g $cm^{-3}$ ---------------- | | % |
| Control | 1.45 | 2.65 | 45.4 |
| *B. decumbens* SA | 1.41 | 2.66 | 47.1 |
| *B. decumbens* CA | 1.40* | 2.68 | 47.8 |
| *B. brizantha* SA | 1.42 | 2.65 | 46.4 |
| *B. brizantha* CA | 1.40 | 2.66 | 47.2 |
| *B. humidicola* SA | 1.40 | 2.69 | 48.0 |
| *B. humidicola* CA | 1.42 | 2.65 | 46.4 |
| *B. briznatha* MG 5 SA | 1.42 | 2.68 | 47.1 |
| *B. briznatha* MG 5 CA | 1.42 | 2.68 | 47.0 |
| *B. ruziziensis* SA | 1.41 | 2.66 | 47.0 |
| *B. ruziziensis* CA | 1.36* | 2.65 | 48.7 |
| Depth | | | |
| 0 – 5 cm | 1.38 b | 2.63 b | 47.5 a |
| 5 – 10 cm | 1.40 a | 2.67 a | 47.6 a |

| | | | |
|---|---|---|---|
| 10 – 20 cm | 1.41 a | 2.67 a | 47.2 a |
| 20 – 30 cm | 1.42 a | 2.67 a | 47.0 a |

* Significant and superior to the control, by the Dunnett test, at a level of 5% probability; WoutF (without fertilization), WF (with fertilization). Averages followed by the same lowercase letter in the column, do not differ from each other by the Tukey test at 5% probability.

In the results obtained in Table 2, the lowest bulk and particle density values were found in the depths 0-5 cm, thus showing that the root systems of the grasses influence positively, due to the greater amount of roots in the surface layer. On the other hand, as the analyzed depth increases, the soil tends to become denser. Lower density in the superficial layer was also observed by Genro Júnior et al. [22] a typical clay red Oxisol.

According to Reinert et al. [23], the smallest density observed in the most superficial layer may be related to the higher density of roots of the crops used and to the higher content of organic matter. These results are in accordance with those observed by Custódio et al. [24] who observed an increase in the density of the soil in depth in which the treatment, with the smallest average, was found in the soil with pasture. These authors agree that this lower soil density, in the more superficial layers, may be due to the higher deposition of organic matter.

In relation to the species of Brachiarias, there was a difference when comparing the average values obtained for the bulk density (Table 2). According to Imhoff et al. [25], the use of grass with growth in clump favors the compaction of the soil, for facilitating more its exposure to the animal trampling. However, as the *Brachiaria* presents prostrate habit, the soil cover becomes more expressive and consequently favoring its protection. The same was verified when compared the average soil bulk density values for the treatments with and without fertilization. The particle density values were not influenced by the grasses (Brachiarias) or fertilization (table 2), being affected only in terms of the depth analyzed, differing from the superficial layer of the others, precisely the one with the highest levels of organic matter (Table 1). Particle density is a physical attribute of the soil that is not affected by the soil texture, being only affected by the source material and the organic matter content of the soil, Santos et al. [26].

As noted in the research, Rosales et al. [27] agree to verify that variability in organic matter content in Oxisol can reduce particle density values. Higher particle density values were observed in the surface layer of the soil by Silva et al. [28] due also to the highest organic carbon content on the surface. In relation to the total porosity in function of the grasses used in the research, the values are very similar for the different grasses, for the condition of fertilization and for the depths analyzed and, therefore not presenting differences Significant ($P < 0.05$). However, it is observed that among the grasses there was a variation of 47.6% (*Brachiaria decumbens*) to 46.6% (*Brachiaria brizantha* MG5) and that the total porosity values decreased with the evaluated depth, ranging from 47.5% (0-5 cm layer) to 47.0% (layer of 20-30 cm). This may indicate, according to Bonini et al. [29] that small changes in particle density, can reduce the pore space of the soil, even not in a meaningful way.

The values obtained for the weighted average diameter of dry aggregates (DMPAs) and Damp (DMPAu) and stability of the soil aggregates under the different grasses (DMPAu/DMPAs), for the analyzed treatments, depths and fertilization levels are presented in Table 3.

**Table 3.** Values of the weighted average diameter of dry aggregates (DMPAs) and Damp (DMPAu) and of aggregate stability (DMPAu/DMPAs) for the different grasses analyzed without and with fertilization NPK

| Treatments | Determinations | | |
|---|---|---|---|
| | DMPAs | DMPAu | DMPAu/DMPAs |
| | --------------mm--------------- | | |
| Control (S. Gram.) | 2.09 | 1.03 | 0.49 |
| *B. decumbens* SA | 3.00* | 2.02* | 0.67* |
| *B. decumbens* CA | 3.38* | 2.31* | 0.68* |
| *B. brizantha* SA | 3.02* | 2.14* | 0.76* |
| *B. brizantha* CA | 3.15* | 2.18* | 0.69* |
| *B. humidicola* SA | 3.14* | 2.01* | 0.64* |
| *B. humidicola* CA | 3.16* | 2.21* | 0.70* |
| *B. brizantha* MG5 SA | 2.96* | 2.04* | 0.69* |
| *B. brizantha* MG5 CA | 3.16* | 2.23* | 0.71* |
| *B. ruziziensis* SA | 2,98* | 2.17* | 0.73* |
| *B. ruziziensis* CA | 3.07* | 2.61* | 0.85* |

* Significant and superior to the control, by the Dunnett test, at a level of 5% probability; WoutF (without fertilization), WF (with fertilization)

Of these results, it is observed that for the values concerning the DMPAs and DMPAu there was a significant difference when compared to the value of the control treatment (without grass and without fertilization) by the test Dunnett to 5%.

According to the averages obtained it can be observed that there was an improvement in the aggregate of the soil, whether it is DMPA obtained by dry or wet via and stability of the aggregates (table 3). Although the treatments are being compared statistically with the control, the presence of mineral fertilizer influences those without fertilization and exception made only for the stability of the aggregates using the *Brachiaria Brizantha.*

The average obtained for the DMPAu/DMPAs ratio was very low for the grass-free treatment (control), thus showing the low stability of the soil aggregates under this treatment (Table 3). Silva et al. [13] affirmed that grasses can be used as recovering plants of soil structure in degraded areas, because they have a higher density of roots and better distribution of the root system in the soil, favouring the link of the contact points between mineral particles and aggregates, which contributes to the formation and stability of the aggregates. They also added that the greater the relationship DMPAu/DMPAs (near 1) the greater is the stability of the aggregates of the soil in water and, those with values closest to zero, represent aggregates highly susceptible to destruction in the presence of water. By the values of the DMPAu/DMPAs relationship obtained in the treatments with the use of grasses (Brachiarias) for five years, independent of the mineral fertilization (table 3), there were elevations in the values when compared with that of the control.

## 4- CONCLUSIONS

The greatest values DMPAu and DMPAs and the DMPAu/DMPAs relationship for treatments with Brachiarias indicate that grasses favor the formation of aggregates and contribute to their stability. *Brachiaria ruziziensis* reduces soil bulk density values. The *Brachiaria brizantha* is the most suitable for raising the organic matter content of an Oxisol without mineral fertilization.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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