GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

# EVALUATION OF TWO VARIETIES OF MAIZE INTERCROPPED WITH PIGEONPEA IN THE SEMI-ARID REGION OF BRAZIL

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## ABSTRACT

The consortium of grasses and legumes have been widely used as a mean of improving the soil fertility for forage production. This work at the University of Alagoas, Santana do Ipanema, Alagoas, Brazil, aimed to evaluate the vegetative growth in two cropping systems, sole maize and maize intercropped with pigeonpea for two maize varieties. The statistical design was a randomized block design in a split plot design. The test consisted of two cropping systems (S.C. I - monoculture corn and S.C. II - consortium of corn with pigeonpea) and two regional varieties of maize (var. I - Jalapão and VAR II - Batité), totaling 4 treatments with 5 blocks, making up 20 experimental units. In the plots of farming systems and the plots maize varieties were allocated. After experimenting for a period of 84 days, when there was stabilization of plant growth, it was found that the two maize varieties studied Jalapão and Batité, possessed similar behavior in its vegetative growth and cropping systems of sole maize and intercropped, also possessed similar behaviors.

***Keywords-*** *Intercropping; Zea mays; Creole corn.*

## I. INTRODUCTION

A great strategy for the semi-arid soils is the intercropping, such as maize (Zea mays L.) with the pigeon pea (Cajanus cajan (L.) Millsp) for both increased quality in food production to the animals in the form of hay or silage, but also to the soil nitrogen fixation, and with increase in soil organic matter, since the semi-arid soils are mostly poor in organic matter.

According Provazi et al. (2007), pigeon pea is a legume with their center of origin and genetic diversity in India. It is often cited as a specie of multiple use and their tolerance to adverse conditions such as water stress caused by long periods of drought and low soil fertility.

The pigeonpea has adapted very well in Brazil, resisting to various weather soils, climate, among other factors, mainly being accepted by small producers as a good source of protein and absorption of nutrients due to the breakdown of the compacted layers soil with its strong root system (Calvo, 2010).

Another important factor to be considered is its resistance to drought, adapting well in poor soils and the most diverse climatic conditions, with good results as a supplier of green mass, and is used in crop rotation and as green manure for degraded soils.

The reclamation is therefore a consequence of incorrect use of the landscape and fundamentally soil, with only a limited attempt to remedy damage which in most cases could have been avoided (Ceconi, 2010).

This problem brings negatives financial, where most producers are coming up not knowing what to do, where has disrupted agricultural production and consequently productivity in general, especially in semi-arid to be a dry season from the region and temperatures well high in most of the year.

Once the corn crop is quite demanding in terms of soil fertility, the use of areas with shrub legumes may be efficient alternative and within the reach of small farmers to increase crop productivity (Queiroz et al, 2007).

Intercropping is the simultaneous culture of two or more species with different vegetative cycles and architectures are operated simultaneously in the same area and the same time, and have not necessarily been sown simultaneously (Busato; Peil, 2006; Pinto et al, 2011; Rezende et al, 2011).

However, studies performed in pigeonpea culture are still scarce and insufficient, so the increasing need of study and compare these varieties to enable greater performance. The objective of this study was to evaluate the green mass production, food science and soil quality for maize in consortium with pigeonpea.

## II. MATERIAL AND METHODS

This work was conducted in the experimental area of the State University of Alagoas - UNEAL, Campus II, the city of Santana do Ipanema, Alagoas State, Brazil, from June 28 to September 28, 2012.

The statistical design was a randomized complete block in a split plot design. The test consisted of two cropping systems (SC I - corn monoculture and SC II - corn consortium with pigeon pea) and two varieties of maize (VARIETY I, Jalapão and VARIETY II, Batité), totaling 4 treatments with 5 blocks, making up 20 experimental units, the plots were allocated the cultivation and the subplots the varieties of maize systems.

The area of each sub-plot was 6.00m$^2$ containing 5 corn crop rows spaced 0.80m and 1.50m in length for each row containing six plants with 0.25m between themselves, eliminating the plant and the boundary line of each end, and analyzed 4 plants of the three central rows. For the pigeon pea was used 0,40m distance between the plants, which was planted between the rows of corn.

The planting was done manually with the aid of hoes; seed, either as corn pigeonpea, started about 3 hours submerged in water, to accelerate germination. Was not performed tillage, just cleaning the area and opening of graves. Before the beginning of the experiment and at the end of the research chemical analysis of soil were carried out.

At 18 days after germination occurred thinning of corn plants leaving only two per hole. Also held two hoeings during the experiment.

The collections of plant height data, comprised the plant from the base to the apex without extending the apical leaf, is held weekly with the aid of a tape measure, from 7 to 84 days after emergence (DAE), as described methodology As (Alvarenga et al, 2008).

At the end of the cycle, 90 day, was heavy production of green matter of each treatment, with a digital balance accurate to 0,001g, separating the stem and leaves, with the sum of the weights of each part calculated the total production.

The chemical analyzes were performed at the Laboratory of Animal Nutrition of Agricultural Sciences Center of the Federal University of Paraíba, in Areias, which analyzed the dry matter content (DM), mineral matter (MM), crude protein (CP), Fiber Neutral detergent fiber (NDF), acid detergent fiber (ADF), and digestibility "in vitro".

The vegetative development and food science data were submitted to analysis of variance by F test and the means were compared by Tukey's test at 5% significance using the statistical software SISVAR 5.3 (Ferreira, 2011).

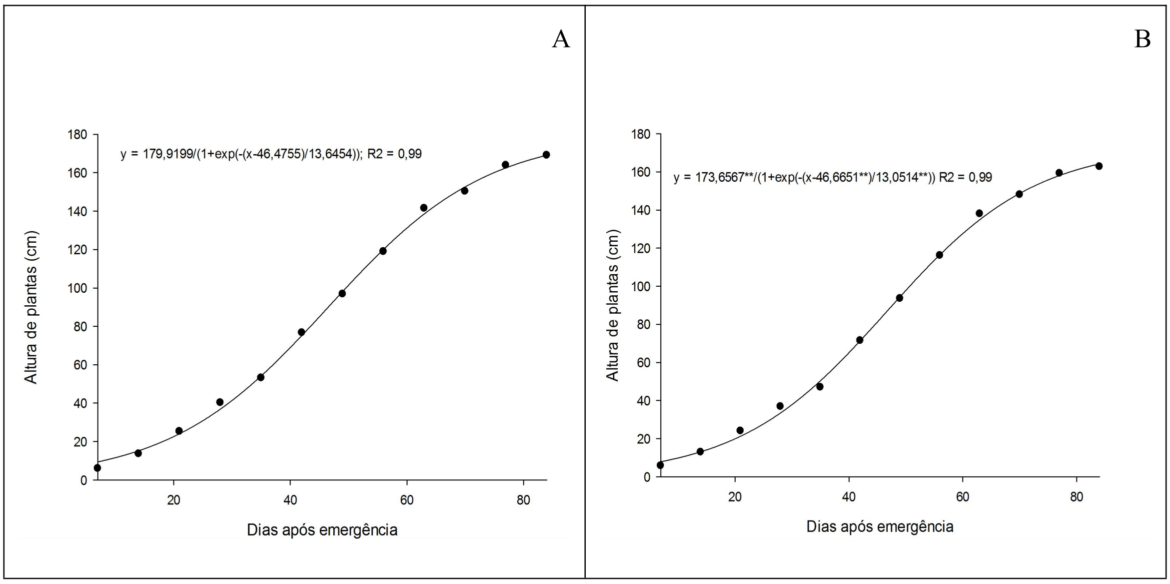
## III. RESULTS AND DISCUSSION

Significant effects of cropping systems under variable plant height, only at 28 DAE ($p < 0.05$), plants grown intercropped with pigeonpea reached height of 42.08 cm, while the single system height plants was 34.80 cm, and this superiority equivalent to 17.30%, as shown in Figure 2.

For those varieties of corn, these were statistically different in two evaluation periods (14:28 DAE). With 14 DAE plant height of Jalapão variety and Batité was 13.52 and 12.87 cm, respectively. The same happened at 28 DAE variety Jalapão remained with greater height compared to Batité, whose values were, respectively, 40.09 and 36.79 cm (Figure 1). Looking at the same table it appears that there was no interaction effect between the factors studied in any of the evaluation times.

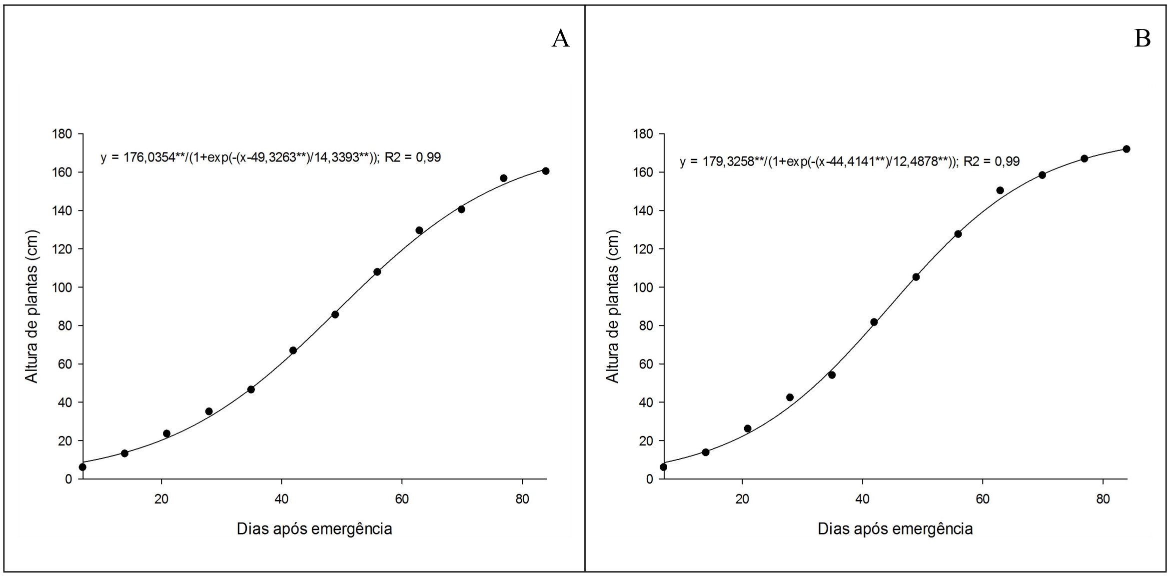
Analyzing the sigmoidal equations contained in Figure 1a and 1b, for Jalapão and Batité varieties, respectively, it appears that both varieties possessed similar behavior. Until about 20 DAE plants had slow growth, between 26 and 27 DAE was reaching the maximum rate of growth and 72-73 DAE reached the stabilization of plant height.

**Figure 1. Height of maize plants, variety Jalapão (A) and Batité (B) over time**




**DAE days after emergency** **DAE days after emergency**

**Figure 2. Height of maize plants, single system (A) and in association with pigeonpea (B) over time**




**DAE days after emergency** **DAE days after emergency**

In the study by Silva (2011), who observed the yield of maize and cowpea in single and intercropping system in the southern state of Tocantins region, scores a plant height of 178 and 175 cm for cropping systems respectively, differing significantly.

Queiroz et al (2007), evaluating species of legumes intercropped with maize in Piracicaba-SP, observed similarly in the first year of cultivation, corn yield was not influenced by intercropping with legumes, although they reported that corn yield was improved by the consortium in the second year of cultivation.

According to Queiroz et al (2007), the addition of the dry weight of legumes in the first year is insufficient to positively affect the characteristics evaluated, possibly by low organic matter mineralization, associated with the short trial period.

Another factor that could be observed is that this grass species has a rapid growth over the pigeonpea, and be planted in the same period, there was the shadow of this legume, preventing their development and consequently of its root system, inhibiting the absorption and nitrogen fixation and the transport of nutrients from the lower to the upper layers of the soil.

According to Barreto and Fernandes (2010), after you harvest the corn, pigeonpea plants should be pruned at the height of one meter and the dry biomass produced, which is 1.5 to 2.5 t ha-1, is left on the soil surface, for best results in subsequent years.

Research shows that there was no significant difference between the monoculture and the pigeonpea crop intercropping with maize, however, visually were no differences in growth throughout development stage.

However, at 14 days of age, there was a small statistical difference for the varieties used, and 28 days other differences were observed between the results for both cropping systems as to the varieties.

After 28 days, perhaps because of that corn, with its faster growth has excelled covering the legumes (pigeonpea) in its development, which leads to not understand the significance of most of the results.

These findings may be related to the age of pigeonpea, because its root system was not developed enough to promote nitrogen fixation in the soil and also to adduce nutrients from the lower layers to the upper.

Once the corn crop is quite demanding in terms of soil fertility, the use of alleys with leguminous trees can be efficient alternative and within the reach of small farmers to increase productivity of maize (Queiroz et al, 2007).

To understand the advantages given to the soil through the legume was done soil analysis before and after the experiment which demonstrate some chemical and biological differences observed in the results (**Table 2**).

In Table 3, relating to the experimental area before and after planting can be seen as decreased pH levels, namely a small level of acidification factor to be investigated in further experiments; decreased sodium, phosphorus and potassium, which indicates that the legume has proposed a good CTC as can be seen immediately afterwards, which took a good absorption of the main macronutrients essential to plants; there was also a small increase in aluminum levels, cause to be studied in the future.

Comparing the studied farming systems, it is noticed that the corn consortium with pigeon pea has advantages as aluminum, where he had a small decrease in their levels than the monoculture, there was little difference between the sum of the bases.

Has also been a considerable increase in soil organic matter, which is very important especially for semi-arid soils, increasing the microbial layer, which in turn enriches the whole chain, thus increasing the nitrogen content, and consequently improving all kinds of production, continually increasing the productivity of nearby cultures.

To carry out the chemical analyzes samples of each variety of corn related to the split plot excluding only the borders were collected. The main components studied were: dry matter (DM), mineral matter (MM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and digestibility "in vitro", where the results are shown in **Table 3** as a percentage.

Observing the **Table 3**, which exhibits different results analyzed in order that corn was used in two different varieties, one can say that the factor for this significant difference of 1% is from the plant physiology by are of different varieties, which shows not be such a significant difference, since there was not a result of changes in acid detergent fiber.

## IV. CONCLUSION

In view of the results, make themselves understand that most nitrogen fixation both atmospheric N2 way through the soil nutrients by legumes, occurs according to the age of the plant, where its roots are more developed and fixed, thus decompressing the soil for better root development of other cultures.

The semi-arid soils mostly are low in organic matter and are also acidic soils, which hinders the growth and development of plants grown in general, the Pegeonpea is a great alternative in providing organic matter, as can be seen an increase mean in their contents after the experiment, formed by the decomposition of its aerial part, bringing increased microbial layer, thus improving the soil generally, since the microorganisms are a major factor in the development of all chain that nourishes the plants, and unpack causing soil clod breaking in their profiles with their root development by increasing the availability to other cultures capture water and nutrients.

The use of pigeonpea as a consortium can also assist on the development of forage crops increasing the amount of nutrients consumed by animals, causing quick profit to the producer, where well-fed animals has its high health, and consequently, greater weight gain and certain market.

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**Table 1. Review of the statistical average of the weekly length development (cm) of the corn crop in the rainy season, subject to 90 days of age, the monoculture (SC I) and the consortium with pigeonpea crop (SC II) two varieties of maize.**

| F.V | Mean square (Days after emergence - DAE) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 | 84 |
| Blocks (B) | 0,913 | 4,285 | 36,55 | 174,70 | 379,56 | 1000,45 | 2024,22 | 3643,73 | 5682,11 | 6439,46 | 5489,87 | 4889,01 |
| S.C. | 0,015$^{ns}$ | 1,404$^{ns}$ | 33,90$^{ns}$ | 264,84* | 286,07$^{ns}$ | 1098,90$^{ns}$ | 1916,09$^{ns}$ | 1946,56$^{ns}$ | 2165,69$^{ns}$ | 1607,60$^{ns}$ | 514,90$^{ns}$ | 653,68$^{ns}$ |
| Res (a) | 0,195 | 0,550 | 6,537 | 26,99 | 45,26 | 266,29 | 649,37 | 1093,94 | 1564,92 | 2039,47 | 2747,36 | 3248,63 |
| V | 0,228$^{ns}$ | 2,151* | 6,339$^{ns}$ | 54,45* | 190,09$^{ns}$ | 132,25$^{ns}$ | 50,30$^{ns}$ | 37,67$^{ns}$ | 58,89$^{ns}$ | 23,65$^{ns}$ | 106,81$^{ns}$ | 198,57$^{ns}$ |
| V x A | 0,0001$^{ns}$ | 0,343$^{ns}$ | 0,420$^{ns}$ | 1,693$^{ns}$ | 16,45$^{ns}$ | 5,756$^{ns}$ | 6,138$^{ns}$ | 2,401$^{ns}$ | 13,12$^{ns}$ | 102,83$^{ns}$ | 85,03$^{ns}$ | 781,00$^{ns}$ |
| Res (b) | 0,165 | 0,342 | 1,562 | 9,120 | 51,31 | 42,41 | 61,08 | 133,31 | 177,65 | 148,46 | 324,71 | 310,54 |
| C.V. (a) % | 7,61 | 5,62 | 10,40 | 13,51 | 13,45 | 22,06 | 26,78 | 28,15 | 28,32 | 30,29 | 32,45 | 34,36 |
| C.V. (b) % | 6,99 | 4,43 | 5,08 | 7,85 | 14,32 | 8,80 | 8,21 | 9,83 | 9,54 | 8,17 | 11,16 | 10,62 |
| Averages for cropping systems | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S.C. I** | 5,79a | 12,93a | 23,28a | 34,80b | 46,23a | 66,57a | 85,35a | 107,62a | 129,27a | 140,13a | 156,45a | 160,15a |
| **S.C. II** | 5,84a | 13,46a | 25,89a | 42,08a | 53,79a | 81,40a | 104,93a | 127,35a | 150,08a | 158,06a | 166,59a | 171,58a |
| **d.m.s.(5%)** | 0,549 | 0,921 | 3,174 | 6,451 | 8,353 | 20,262 | 31,641 | 41,068 | 49,119 | 56,075 | 65,083 | 70,771 |
| **Averages for varieties** | | | | | | | | | | | | |
| **VAR. I** | 5,71a | 13,52a | 25,15a | 40,09a | 53,09a | 76,56a | 96,73a | 118,86a | 141,39a | 150,18a | 163,83a | 169,01a |
| **VAR.II** | 5,92a | 12,87b | 24,02a | 36,79b | 46,92a | 71,41a | 93,56a | 116,11a | 137,96a | 148,00a | 159,21a | 162,71a |
| **d.m.s.(5%)** | 0,419 | 0,603 | 1,289 | 3,114 | 7,387 | 6,716 | 8,059 | 11,907 | 13,745 | 12,565 | 18,583 | 18,173 |

Means followed by the same lower case letter in the column do not differ statistically among themselves by Tukey test at 5% level of probability. SC - cropping systems, VAR - varieties, SCI - single corn cropping system, SCII - intercropping maize cropping system with pigeonpea, VAR I - variety Jalapão and VAR II - variety Batité.

**Table 2. Analysis of the samples regarding the total area of the experiment before planting and in two different tillage systems SC I (single corn) and CS II (corn in consortium with *Cajanus cajan* L., pigeonpea).**

| ***Chemical analysis*** | ***Before planting*** | ***After planting*** | |
|---|---|---|---|
| | ***Total area*** | **S.C. I** | ***S.C. II*** |
| **pH (in water)** | 6,6 | 6,2 | 5,8 |
| **Na (ppm)** | 44 | 13 | 14 |
| **P (ppm)** | 12 | 10 | 10 |
| **K (ppm)** | 117 | 61 | 57 |
| **Ca + Mg (meq/100 mL)** | 5,5 | 4,4 | 4,9 |
| **Ca (meq/100 mL)** | 4,0 | 3,2 | 3,6 |
| **Mg (meq/100 mL)** | 1,5 | 1,2 | 1,3 |
| **Al (meq/100 mL)** | 0,01 | 0,06 | 0,05 |
| **H + Al (meq/100 mL)** | 1,4 | 2,1 | 2,1 |
| **S (Some of bases)** | 5,99 | 4,61 | 5,11 |
| **C.T.C. Efetiva** | 6,00 | 4,67 | 5,16 |
| **C.T.C. (Cap. Troc. de Cátions pH-7,0)** | 7,39 | 6,71 | 7,21 |
| **%V(Ind. de Sat. de Bases)** | 81,1 | 68,7 | 70,9 |
| **%M(Ind. Sat. de Al)** | 0,2 | 1,3 | 1,0 |
| **%Na (PST)** | 2,7 | 0,8 | 0,9 |
| **Sat. em K (%)** | 4,2 | 2,3 | 2,0 |
| **Org. Matter Total (%)** | 0,58 | 1,43 | 1,77 |

**Table 3. Components studied in chemical analysis on 100% dry matter of two varieties of corn used in monoculture (SC I) and consortium (SC II).**

| F.V | Mean square (Bromatological Samples) | | | | | |
|---|---|---|---|---|---|---|
| **Samples** | **D.M.%** | **M.M.%** | **C.P.%** | **F.D.N.%** | **F.D.A%** | **Digestibility "in vitro" %** |
| **Blocks (B)** | 0,360 | 2,422 | 25,39 | 14,97 | 6,078 | 34,13 |
| **Cropping System (C.S.)** | 2,151 ns | 0,278 ns | 1,925 ns | 1,579 ns | 0,015 ns | 0,438 ns |
| **Res (a)** | 0,565 | 1,508 | 1,857 | 1,794 | 0,601 | 24,71 |
| **VAR. (V)** | 0,677 ns | 0,005 ns | 0,011 ns | 6,475 ns | 28,56** | 5,140 ns |
| **V x A** | 0,192 ns | 0,655 ns | 0,666 ns | 2,464 ns | 0,297 ns | 13,44 ns |
| **Res (b)** | 0,241 | 0,159 | 0,298 | 1,644 | 1,994 | 10,08 |
| **C.V. (a) %** | 0,81 | 19,48 | 14,38 | 1,95 | 2,20 | 10,31 |
| **C.V. (b) %** | 0,53 | 6,33 | 5,76 | 1,87 | 4,01 | 6,59 |
| **Averages for cropping systems** | | | | | | |
| **S.C. I** | 92,47a | 6,18a | 9,16a | 68,79a | 35,16a | 48,35a |
| **S.C. II** | 93,12a | 6,42a | 9,78a | 68,23a | 35,22a | 48,05a |
| **d.m.s. (5%)** | 0,933 | 1,524 | 1,692 | 1,663 | 0,962 | 6,172 |
| **Averages for varieties** | | | | | | |
| **Var. I** | 92,98a | 6,32a | 9,50a | 69,08a | 34,00a | 48,71a |
| **Var.II** | 92,61a | 6,28a | 9,45a | 67,94a | 36,39b | 47,70a |
| **d.m.s. (5%)** | 0,506 | 0,411 | 0,563 | 1,322 | 1,456 | 3,274 |

* Means followed by the same lower case letter in the column do not differ in at Tukey test at the 5% level of probability, occurring only a small significant difference of 1% in average for varieties on the detergent acid fiber variable (FDA).