

Ecophysiology of pumpkin cultivars submitted to two soil managements

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Abstract—*In order to obtain subsidies for the establishment of promising management and agricultural sustainability, this study aimed to evaluate the physiological responses of pumpkin cultivars submitted to different agroecological management. The study was carried out on a property located in the municipality of Acarape, Ceara. The experimental design adopted was in split plots, with the plots referring to the two cultivation systems (conventional and in alleys) and the subplots to the three pumpkin cultivars (Jacarezinho, Moranga, and Sergipana), with four repetitions. Biometric and gas exchange variables were assessed in the vegetative and pre-flowering periods. The analysis of variance showed significant responses only for cultivars in which an influence on plant height and stem diameter was observed. Regarding the interaction between environment and cultivars, the variable height exhibited a significant response. The other variables analyzed in this study were not influenced.*

I. INTRODUCTION

In the old societies, the relationship between man and nature was harmonious, where the aim was only to meet the needs of individuals. With the beginning of domestication of plants and animals, humans began to neglect environmental issues, and over the years, the dynamics of the natural environment underwent grand changes as a result of these activities¹.

The expansion of environmental degradation resulting mainly from agricultural practices has occurred exponentially worldwide. This growth is a worrying factor resulting from the negative anthropic action, which alters and modifies the environment². Agriculture activities are one of the factors that contribute to the impoverishment of the soil, modifying its chemical, physical and biological characteristics, which could lead to infertility.

Caatinga biome, which distribution is exclusive to Brazil, covering approximately 800,000 km² of Brazilian territories (11%), has been severely affected by inadequate management and unsustainable use of natural resources³. This biome has been intensively deforested for the introduction and expansion of agricultural products.

The impacts of agricultural production can be minimized according to the techniques and inputs used in cultivation, for that it is necessary to adopt sustainable agriculture practices. To make a better exploit use of the natural potential of soils, it is necessary respecting the local environment characteristics and using practices that provoke as small change as possible, in other words, adopting adequate agricultural management⁴. Based on that, one of the approaches of agroecology is agroecological management, which is based on agricultural sustainability through mainly the conservation of natural resources and the increase of biodiversity in the cultivated fields⁵.

In general, traditional and conventional agricultural methods are considered unsustainable. To promote more sustainable land use planning, given the diversification of existing agricultural and forestry exploitation, one of the alternatives that have been proposed is the use of agroforestry systems⁶. Moreover, the knowledge of the determining factors, resources, and interactions between the components of the agroecosystem may lead to optimizing agricultural production sustainably, even in agroforestry systems. The awareness of the permanent use of forest resources in a given ecosystem is of great importance⁷; such use must be planned based on studies of biological

dynamics and knowledge of natural regeneration processes in the face of human actions.

There are several studies on the scientific literature investigating the physiological processes of plants as a function of environmental changes. Knowing these interactions makes it possible to understand the behavior of the plant in different environments. This type of study is important in agricultural systems and forestry cultivation, as it can contribute to the selection of genotypes, as well as helping to define management practices for cultivated areas⁸.

These investigations generate new knowledge and allow plant species to be cultivated in different types of management. Thus, it is possible to verify which is the most suitable environment for the best development of the plant and also to be able to adopt practices aimed at sustainable development for both agricultural systems and forest crops.

Hence, it is believed that one possibility to practice agricultural sustainability is to carry out the cultivation of vegetables associated with native forests, such as species of the Cucurbitaceae family. Therefore, this study aimed to evaluate the biometric and gas exchange responses of three pumpkin cultivars submitted to different agroecological management, which may lead to subsidies for the establishment of promising management of this vegetable under field conditions.

II. METHODOLOGY

2.1 Experient location

The experiment was carried out in an area located in the municipality of Acarape, Maciço de Baturité – CE, Brazil (04°13'16.2"S, 38°41'55.6"W, and average altitude ranging from 70 to 100 m). The climate in this region is classified by Köppen as Bsh, warm and semi-arid, characterized by shortage and irregularity in rainfall distribution.

2.2 Experimental design and treatments

The experimental design adopted was in split plots, with the plots referring to the two cultivation systems (conventional and in alleys) and the subplots to the three pumpkin cultivars (Jacarezinho, Moranga, and Sergipana), with four repetitions.

Each cultivation system was implemented in an area of 50 x 24 m. The spacing between tree lines was 10 m, with five tree lines per system. The space between two lines of trees was considered as a block. The pumpkin cultivars were sown in a spacing of 2.5 x 0.5 m, with four planting rows eight meters in length each. Each treatment consisted

of four repetitions. The four central meters of the two middle lines of each subplot were considered in the evaluations.

2.3 Floristic survey

Before starting the experiment, vegetative and or reproductive branches 30 cm in length of shrub species belonging to each studied area were collected. For the sample collection, pruning shears were used. The botanical collection was carried out as recommended⁹. The botanical material was used to preparing plant exsiccates (sample of dried and pressed plant in a greenhouse, fixed on a standard size cardboard, properly labeled with information about the plant and the place of collection, for botanical study purposes). Thus, the botanical material was deposited in the Herbarium PriscoBezerra (EAC) of the Federal University of Ceara for proper identification.

2.4 Choosing the area, setting up and conducting the experiment

Initially, two adjacent areas (area 1 and area 2) with dimensions of 50 x 24 m each were separated in the vegetated area of the property. These areas had the same soil and vegetation characteristics.

2.5 Irrigation system

For irrigation of areas 1 and 2, the drip system was adopted. The water used came from a dam located on the property where the experiment was performed. The water flowed from the source to the plants through tubes, eliminating conduction losses and minimizing percolation losses. It is worth mentioning water is only applied in part of the area and upon plant canopy, in micro basins. Another reduction in water losses occurs due to the non-existence of a device at the end of the microtubules to dissipate water and pressure, which would contribute to the evaporation process¹⁰.

2.6 Seedling production and Planting

The seedlings of the three pumpkin cultivars were produced in polystyrene trays having as substrate a mixture of sand and cattle manure in the proportion (2:1). The seedlings arranged on the trays were stored in a greenhouse, made of a wooden frame, and covered with plastic to create a pleasant microclimate to provide better rooting. At 20 days after sowing (DAS), when the seedlings presented a definitive leaf, transplanting to the field was made.

2.7 Crop management

The cultural treatments carried out during the execution of the project were those indicated for the cultivation of pumpkin in the Northeast region¹¹.

2.8 Biometric Variables (Vegetative phase)

At 15, 25, 29, 36, and 41 days after transplanting (DAT), the parameters of plant height and stem diameter were measured using a graduated ruler and a digital caliper, respectively. Leaf area was determined by multiplying the length and width of the leaf by the correction factor.

2.9 Gas exchanges (Vegetative and pre-flowering phase)

At 42 DAT (vegetative development) and 57 DAT (pre-flowering) of pumpkin plants, the parameters of stomatal conductance (gs), transpiration rate (E), and photosynthetic rate (A) were measurements in fully expanded leaves. All measurements were conducted between 8:00 and 12:00 AM using an IRGA (LI 6400XT, Licor, USA).

During the gas exchange measurements, the relative index of chlorophyll (RCI) was determined. A portable meter SPAD 502 (Minolta) was used. Then, the water use efficiency (WUE) (W/gS)/USA was calculated.

2.10 Statistical analysis

Data obtained were submitted to analysis of variance by the F test at the level of 5% probability using the software "ASSISTAT 7.5 BETA". The regression analysis was performed for the data in which there were significant effects.

III. RESULTS AND DISCUSSIONS

3.1 Floristic survey

The floristic survey was carried out for the two areas selected for the cultivation of pumpkins. Area 1, where the conventional cultivation of pumpkins was carried out, was less dense. In this area, 48 specimens of the plant commonly known as "sabiá" (*Mimosa caesalpiniaefolia*) were identified. Whereas, in Area 2, where pumpkins were grown in association with native species, 68 specimens of the same plant were identified. In order to confirm the identification of the plant, the vegetative and reproductive branches of the species were collected. The plant exsiccates was made at the Herbarium PriscoBezerra (EAC) of the Federal University of Ceara, where it remains deposited for possible studies under the code EAC 62604.

3.2 Biometric variables

The results of the analysis of variance are shown in Table 1. The variables plant height (PH), stem diameter (SD), number of leaves (NL), and leaf area (LA) did not present significant responses with regard to the environmental factor (A). Regarding cultivars (C), it is observed that only height and stem diameter exhibited

significant responses at the level of 1% and 5% probability by the F test, respectively. While for the interaction between environment and cultivars (A x C), the variable H

was the unique that showed a significant response at 5% probability.

Table.1: Analysis of variance for plant height (PH), stem diameter (SD), number of leaves (NL), and lead area (LA) of three pumpkin cultivars, cultivated in conventional and alley systems, at 41 days after transplantation.

Sources of Variation	DF	Mean square			
		PH (m)	SD (mm)	NL	LA (cm ²)
Blocks	3	0.23138	3.39458	17.22222 ^{ns}	3204762
Environment (A)	1	0.07763 ^{ns}	0.10667 ^{ns}	433.50000 ^{ns}	22516613 ^{ns}
Residue (a)	3	0.84631	7.67583	245.16667	1327280
Plots	7	-	-	-	-
Cultivars (C)	2	1.57094 ^{**}	10.09969 [*]	345.04167 ^{ns}	4026974 ^{ns}
Int. A x C	2	0.77800 [*]	0.10135 ^{ns}	962.37500 ^{ns}	523412 ^{ns}
Residue (b)	12	0.1273	2.4926	249.48611	1801580
Total	23	-	-	-	-
CV% (A)	-	59.54	26.23	51.06	30.39
CV% (C)	-	23.09	14.95	51.51	35.41

DF = Degree of freedom; CV = Coefficient of variation; ** Significant at the 1% probability level (p<0.01); *Significant at the 5% probability level (p < 0.05); ns not significant (p ≥ .05).

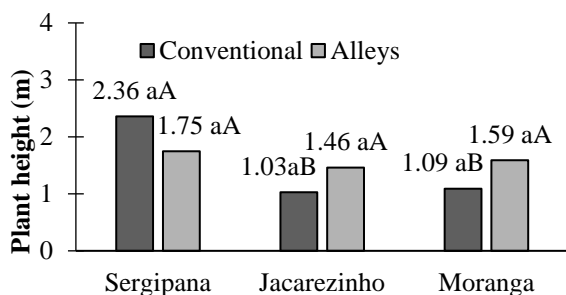


Fig. 1: Plant height of three pumpkin cultivars, cultivated in the conventional system and alleys, at 41 days after transplanting. Lowercase letters represent the environment and uppercase cultivate.

The analyses of Plant height (Figure 1) indicated that there was a significant interaction of Environment x Cultivars, showing that the Sergipana cultivar was superior in the conventional system compared to the other cultivars tested. Statistically, the results were equal in the cultivation in alleys. Also, by comparing the results from the plant height of the Sergipana cultivar to conventional cultivation, an increase of 56.36% and 53.81% on Jacarezinho and Moranga cultivars was observed, respectively. When assessing the cultivation system, it was verified that the Jacarezinho and Moranga cultivars

presented greater plant height when cultivated in the system in alleys.

A conclusion section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

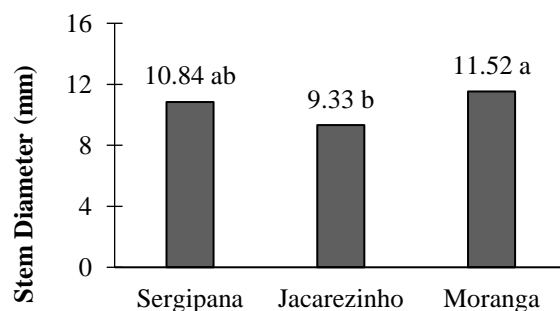


Fig. 2: Stem diameter of three pumpkin cultivars at 41 days after transplanting. Means followed by the same letter do not differ statistically from each other.

Regarding the stem diameter, it can be seen in Figure 2 that the Moranga cultivar had a mean superior to the other

cultivars; however, it did not differ statistically from the Sergipana cultivar, which in turn did not differ statistically from the Jacarezinho cultivar. When comparing the Sergipana cultivar, which had a higher mean, with the Jacarezinho cultivar, which had the worst results for CD, there is a difference of 19.01%.

From the results of stem diameter, it is clear that the analysis of this variable provides practical knowledge and accurate information related to the growth and performance of pumpkin cultivars in different cultivation environments. Such information can be effective for rural producers who can use them to find out which cultivar best adapts to the cultivation environment or even to the region.

The knowledge about the plant's adaptation and new technologies is important for minimizing environmental impacts from agricultural activities. The cultivation system in alleys, presented in this study, is indeed the most suitable for preserving the environment and guaranteeing agricultural production.

Plant growth analysis allows evaluating the plant's behavior adapting to established management conditions. This analysis also allows inferring the contribution of physiological processes to plant growth and productivity. Thus, the growth of plants of horticultural and arboreal species cultivated in an agroforestry system¹². These authors assert that the location of the beds influenced the higher eucalyptus plants' growth and attributed this result to a higher incidence of light, which favored the higher photosynthetic rate and provided greater plant growth.

Although the plant growth process is complex, it is important to evaluate their development and competitive capacity. Growth analysis is a technique that, besides providing such information, allows us to understand the productive potential of specimens and identifies more tolerant and productive cultivars in certain cropping systems¹³.

The increase in leaf area is one of the mechanisms used by the plant to increase the photosynthetic surface¹⁴. As a result, it provides a more efficient photosynthetic

performance in an environment with lower light intensity. Thus, the low photosynthetic rate is compensated for per unit of leaf area, which is a characteristic of shaded leaves. It is worth highlighting that most of the time, the leaf area increases to a maximum, then due to the senescence of the older leaves, it gradually decreases.

By analyzing the results obtained in the evaluation of growth characteristics, both types of management used did not significantly affect the growth of pumpkin plants. Based on that, the cultivation of cucurbits associated with native forest species could work as an important alternative for the pursuit of agricultural sustainability, especially nowadays, in a society with hyper-consumerist habits. Meet the food demands in an unsustainable way implies more damage to ecosystems caused mainly by the removal of natural vegetation in search of new territories for agricultural plantations.

The use of alley cropping systems in tropical regions has gained more prominence since this practice fit out as a proper management alternative for modified areas, especially by small farmers¹⁵. There are several advantages that cultivation in alleys can provide, such as the increase in biodiversity; protection of natural habitats for predators, thus providing ecological balance; biological fixation of C and N for the system; and windbreak function, with improved microclimate¹⁶.

3.1 Physiological variables

3.1.1 Gas exchange in the vegetative and pre-flowering period

Gas exchange analysis in the leaves of the three pumpkin cultivars during the vegetative period was carried out. The results of this analysis showed that the photosynthetic rate (A), the stomatal conductance (gs), and the transpiration were not significant for the analyzed factors (Table 2). A similar response was obtained for the Relative Chlorophyll Index (RCI) and Water Use Efficiency (WUE).

Table. 2: Summary of analysis of variance for photosynthesis (A), stomatal conductance (gs), transpiration (E), water use efficiency (WUE) and relative chlorophyll index (RCI) in pumpkin plants submitted to two managements of soil during the vegetative growth period.

Sources of Variation	DF	Mean Square				
		A	gs	E	WUE	RCI
Blocks	3	2.01168	0.68989	2.86879	1.22720	76.85229
Environment (A)	1	5.64540 ^{ns}	0.28733 ^{ns}	0.17510 ^{ns}	0.82645 ^{ns}	513.00507 ^{ns}
Residue (a)	3	14.54123	0.17743	0.31905	0.58026	62.78973
Plots	7	-	-	-	-	-
Cultivars (C)	2	16.43679 ^{ns}	0.16300 ^{ns}	0.35205 ^{ns}	0.12440 ^{ns}	18.64565 ^{ns}
Int. A x C	2	2.46121 ^{ns}	0.04164 ^{ns}	0.27862 ^{ns}	0.29187 ^{ns}	6.30782 ^{ns}
Residue (c)	12	11.74326	0.12840	0.28343	0.71587	67.84051
Total	23	-	-	-	-	-
CV% (A)	-	18.63	31.65	11.38	18.14	18.88
CV% (C)	-	19.63	16.74	26.92	10.73	20.15

DF = Degree of freedom; CV = Coefficient of variation; ** Significant at the 1% probability level (p<0.01); *Significant at the 5% probability level (p < 0.05); ns not significant (p ≥ 0.05).

Similar effect to vegetative growth period were observed for the flowering period of the pumpkin plants. The results (Table 3) show that the established management conditions have not significantly influenced

the photosynthetic rate (A), stomatal conductance (gs), and transpiration of the plant. Likewise, Water Use Efficiency (WUE) and Relative Chlorophyll Index (RCI) did not exhibit meaning results.

Table. 3: Summary of analysis of variance for photosynthesis (A), stomatal conductance (gs), transpiration (E), Water use efficiency (WUE) and relative chlorophyll index (RCI) in pumpkin plants submitted to two managements of soil during the flowering period.

Sources of Variation	DF	Mean Square				
		A	gs	E	WUE	RCI
Blocks	3	53.88113	0.41317	12.73484*	0.18064	20.83722
Environment (A)	1	63.89607 ^{ns}	0.03840 ^{ns}	2.03584 ^{ns}	1.03368 ^{ns}	45.37500 ^{ns}
Residue (a)	3	7.17522	0.23872	0.55508	0.34665	33,35278
Plots	7	-	-	-	-	-
Cultivars (C)	2	16.97514 ^{ns}	0.33018 ^{ns}	1.13830 ^{ns}	0.47705 ^{ns}	18.01042 ^{ns}
Int. A x C	2	7.66018 ^{ns}	0.38304 ^{ns}	1.47196 ^{ns}	0.04193 ^{ns}	10.57875 ^{ns}
Residue (c)	12	18.25222	0.23902	0.58534	0.64629	34.72958
Total	23	-	-	-	-	-
CV% (A)	-	27.32	118.69	15.24	29.83	19.70
CV% (B)	-	43.57	118.76	15.65	40.73	20.11

DF = Degree of freedom; CV = Coefficient of variation; ** Significant at the 1% probability level (p<0.01); *Significant at the 5% probability level (p < 0.05); ns not significant (p ≥ 0.05).

Photosynthetic activity evaluation is of great importance. As it is known, one of the major processes for

maintaining life on Earth is photosynthesis. Life is powered by sunshine, and photosynthesis is the only

biologically important process that can capture this energy. The sun releases radiant energy that can boost the photosynthetic apparatus of the plants, which produce carbohydrates that will be used in the respiration process¹⁷.

The findings of this study differed from the observations made by the authors in 2005¹⁸. These authors investigated the stomatal conductance rates and observed that the highest rates occurred in leaves grown under full sunlight. The increase in stomatal conductance occurs when, during heat stress, plants cool their leaves through transpiration¹⁹. Whereas, about the photosynthetic rates presented in this study, the highest values were observed in a full sunlight environment.

When the stomata are open, CO₂ absorption is more limited than water loss due to the physical characteristics of the gases²⁰. However, when in low water conditions, the reduction in stomatal temperature causes a greater disadvantage on the water output. Thus, with the stomatal decrease, transpiration decreases faster than photosynthesis since the water loss through transpiration through the stomata depends more on stomatal conductance than on photosynthesis.

Studying gas exchange in eggplant plants, found that stomatic behavior determines the transpiration demand to which the leaves are potentially subject, controlling their loss of H₂O to the environment in the form of water vapor²¹. For these authors, plants submitted to optimal water availability generally have high transpiration rates. However, as the soil water decreases, the plant tends to reduce its transpiration rate as a way to reduce water loss and save water available in the soil.

Although the relative chlorophyll index variable evaluated in this study did not present significant responses to the conditions submitted, it is important to emphasize that chlorophylls are photosynthetic biological pigments found in greater abundance on Earth. The evaluation of chlorophyll contents in leaves is normally one of the methods most used by agricultural producers to monitor crop development. This evaluation provides information on the physiological state, nitrogen contents in leaves, and photosynthetic potential of plants²².

Studying the influence of luminosity on the chlorophyll content of tomato plants, has been verified that the amount of chlorophyll increased as the luminosity increased²³. It occurred because light stimulates the synthesis of chlorophyll by the plant, increasing the light absorption, thus producing a higher amount of photoassimilates.

FINAL CONSIDERATIONS

It is concluded that the planting system did not interfere in the development of pumpkin plants.

The Alleys-cropping system is considered promising agroecological management for pumpkin production under field conditions since it allows for quality and sustainable production.

The planting system in the pumpkin crop did not affect gas exchange in both periods analyzed.

An alley-cropping system presents as a good alternative to eradicate the use of synthetic input and in natural resources' preservation in the Caatinga.

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