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# Organic compost and irrigation on weight and protein content of *Pereskia aculeata* leaves

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## Abstract

The *Pereskia aculeata* Mill. plant, known in Brazil as Ora-pro-nobis, is a non-conventional vegetable with high leaf protein content, however studies on the crop system of this leaf vegetable are scarce. Therefore, the objective of the present work was to evaluate the effect of organic compost (OC) rates and irrigation depths (ID) on leaf dry weight (LDW) and leaf protein content (LPC) for *P. aculeata* plants. The experiment consisted of five OC rates (0, 15%, 30%, 45%, and 60% of the substrate volume) and three ID (50%, 75%, and 100% of the reference evapotranspiration - $Et_0$), with four replications. The analysis of variance by the F test ($\alpha = 5\%$ and 1%) and the interpretation of the interaction between the factors by response surface demonstrated the increase of ID from 50% to 100% $Et_0$ is more significant for the increasing in LDW than the increases in OC rates. The highest LDW accumulation was found by combining 33% OC in the substrate with ID of 100% $Et_0$. The lowest LDW resulted from the combination of 60% OC and ID of 50%. The highest LPC was found with the use of 52% OC and ID of 69%, and the lowest with the ID of 100% and absence of OC in the substrate.

**Keywords**: Nutritional supplementation. Waste management. Non-conventional vegetable. Barbados gooseberry. Ora-pro-nobis.

## Introduction

The Brazilian policy for solid waste (BRASIL, 2010) defines composting as destination of organic solid waste, resulting from a controlled biological decomposition process of it carried out by a diverse population of organisms under aerobic and thermophilic conditions, resulting in a stable material (BRASIL, 2017).

The use of organic compost obtained from the composting of agro-industrial and urban solid wastes is a form to reuse these materials and avoid their concentrated and inadequate deposition in the nature. This process allows the elimination of pathogens from organic waste at a low cost (COSTA et al., 2009; ORRICO JÚNIOR; ORRICO; LUCAS JÚNIOR, 2009; ORRICO JÚNIOR; ORRICO; LUCAS JÚNIOR, 2010) and is one of the most efficient ways to recycle organic waste for agricultural purposes, besides making it possible to recycle solid material with relatively low cost (TAIWO, 2011).

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The use of organic composts for plant production can significantly reduce production costs; they increase nutrient supply, improve soil chemical (KIEHL, 2008) and physical properties by generating better soil aggregation, and affect soil water infiltration and retention capacities, drainage, aeration, temperature, and root penetration (PEREIRA; WILSEN NETO; NÓBREGA, 2013). They also promote the recycling of nutrients, contributing to the nutritional improvement of the soil-plant system (SILVA et al., 2012).

In a review paper on long-term effects of the addition of organic waste on soil fertility, Diacomo and Montemurro (2010) report such additions increase soil carbon content and, consequently, cation exchange capacity. This effect is due to the high negative charge of organic matter and it is important for nutrient retention and a balanced and gradual availability of macro and micronutrients to plants throughout the crop cycle, favoring nutrient availability from chemical fertilizers (SEDIYAMA et al., 2009; OLIVEIRA et al., 2010).

*Pereskia aculeata* Mill*.* is known as Ora-pro-nobis in Brazil. This species is native to the American tropics and its leaves have high protein content and absence of toxicity associated with high fiber content, making it a promising source of good quality food (TAKEITI et al., 2009; ALMEIDA et al., 2014). It has low cost, easy cultivation, and high nutrition value, and it can be consumed fresh and as processed food products, such as breads and cakes (MARTINEVSKI et al., 2013). Unconventional leaf vegetables, such as *P. aculeate*, are good alternative sources of protein (KINUPP; BARROS, 2008); furthermore, *P. aculeata* is popularly known as a medicinal plant (PINTO et al., 2012).

The growing of crops in protected environments avoids damages to plants caused by hail, frosts, rains, pest attack, and diseases (CALVETE et al., 2008). Therefore, in studies in which the effects of applying different water depths are analyzed, cultivation in protected environments can prevent or minimize the external effects of rains, and comparisons between treatments can be more accurate when considering the volumes of water received by the plants.

*Pereskia aculeata* is a leaf vegetable whose cultivation for economic purposes is still incipient. Few studies found in technical-scientific literature provide results on the response of this plant to different water irrigation depths. Queiroz et al. (2015) evaluated the growth of *P. aculeata* subjected to different soil matric potential (-10 kPa, -30 kPa, -50 kPa, and -70 kPa), the author controlled intermittent variation of these levels through application of manually controlled irrigation.

Using a water management that defines irrigation intervals and depths to be applied is important to meet the water needs of the plants, optimize the use of agricultural inputs, and obtain higher economic returns (BEZERRA et al., 2009).

Irrigation management under protected environment conditions can be based on soil, climate, and plant factors (FIGUEIRÊDO, 1998). However, agro-climate monitoring inside protected environments is difficulty due to the small space for the installation of measuring equipments (FERNANDES; CORÁ; ARAÚJO, 2004) and the high cost for the acquisition of precise sensors. These difficulties can be minimized by using data from nearby official climatological stations, with calibrated sensors, to estimate crop water requirements under protected environments.

In this context, the objective of this work was to evaluate leaf dry matter and protein content accumulation in *P. aculeata* plants subjected to different irrigation depths and organic compost rates mixed to the soil.

## Material and methods

The experiment was developed in the seedling nursery in the Federal Institute of the Triângulo Mineiro, Uberlândia, Minas Gerais, Brazil (18º45'48''S, 48º17'20''W, and altitude of 633 m). The seedling nursery facility had height of 2.6 m to 3.7 m, length of 27.2 m, width of 3.8 m, and north--south longitudinal projection. Its top and side walls were covered with a 150-$\mu$m transparent plastic film, and the front and back walls were covered with 50% shade screen. This place was used to create a protected environment to enable total control of the irrigation depths applied to the treatments.

The experiment was conducted in a completely randomized design with a 5×3 factorial arrangement (5 substrates rates and 3 irrigation depths) consisted of 15 treatments, with four replications and two plants per replication.

The substrates were composed of a mixture of soil, medium-size sand, and organic compost (TABLE 1).

**Table 1**. Percentage and volumetric composition of the substrates used for planting the cuttings of *Pereskia aculeata* Mill.

| Substrate | Organic compost | | Medium-size sand | | Soil[a] | |
|---|---|---|---|---|---|---|
| | (%) | Volume ($cm^3$) | (%) | Volume ($cm^3$) | (%) | Volume ($cm^3$) |
| S1 | 0 | 0 | 60 | 1020 | 40 | 680 |
| S2 | 15 | 255 | 45 | 765 | 40 | 680 |
| S3 | 30 | 510 | 30 | 510 | 40 | 680 |
| S4 | 45 | 765 | 15 | 255 | 40 | 680 |
| S5 | 60 | 1020 | 0 | 0 | 40 | 680 |

[a] typical dystroferric Red Latossolo (Oxisol) (EMBRAPA, 2009).

**Source**: Andrade (2012).

The organic compost used in the substrate was produced by composting of solid organic residues from agro-industries of Uberlândia, MG, Brazil. The medium-size sand from a river was washed and shade dried on a cemented clean surface for 120 hours. The soil used was from the 0 to 20 cm layer; it was shade dried under the same conditions and time as the sand. Before mixing these materials according to the proportions defined in Table 1, each component was separately sieved in a 4-mm mesh sieve, and soil and organic compost samples were collected for soil physical and chemical analysis and organic compost chemical analysis, including its potentially toxic elements (TABLE 2).

**Table 2**. Chemical properties of the organic compost (OC) and chemical and physical properties of the soil used in the experiment.

| Chemical properties | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH ($H_2O$) | D g $cm^{-3}$ | K | Ca | Mg | Al | H+Al | SB | t | T | V | m |
| | | | .............$cmol_c$ $dm^{-3}$.............. | | | | | | | | .....%..... | |
| Soil | 5.9 | 1.27 | 0.21 | 2.4 | 1.3 | 0 | 4.0 | 3.9 | 3.9 | 7.9 | 49 | 0 |
| OC | 6.7 | 0.69 | 34.3 | 109 | 36 | --- | --- | --- | -- | --- | --- | --- |
| | MO g $dm^{-3}$ | B | Cu | Fe | Mn | Zn | Na | P | S | N | C/N | |
| | | ……..…………mg $kg^{-1}$…………………… | | | | | | mg $kg^{-1}$ | | g $kg^{-1}$ | | |
| Soil | 24 | 0.13 | 3.0 | 23 | 30.8 | 0.8 | --- | 6.3 | --- | --- | --- | |
| OC | 398 | 18 | 200 | 34134 | 706 | 284 | 2746 | 19800 | 6200 | 9.6 | 15/1 | |

| Physical properties | | | | | Potentially toxic elements | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Soil | Clay | Silt | Fine sand | Coarse sand | OC | Ni | Pb | Cd | Cr |
| | | …………………. g $kg^{-1}$………………….. | | | | mg $kg^{-1}$ | | | |
| | 791 | 147 | 49 | 13 | | - | - | - | 10.5 |

D = density; H + Al = potential acidity; SB – sum of bases; t = effective cation exchange capacity (CEC); T = CEC at pH 7.0; V = base saturation; m = aluminum saturation; OM = organic matter; C/N = carbon to nitrogen ratio.

**Source**: Andrade (2012).

The substrates were prepared in the proportions presented (TABLE 1) for each treatment and individually placed in plastic bags with 2.66 g of the 4-14-8 NPK fertilizer ($N:P_2O_5:K_2O$) (TOFANELLI; RESENDE, 2011) and dolomitic limestone (100 % total neutralizing power) at sufficient quantity to raise soil base saturation to 70 %. The addition of fertilizer to all treatments made possible to compare the effect of OC rates on the development of plants.

The substrates were then homogenized and placed into pots with a capacity of 1,700 $cm^3$, and 630, 620, 660, 690, and 695 mL of water were added to the S1, S2, S3, S4, and S5 substrates, respectively, considering these mean water volumes as the pot capacities of each treatment. These water volumes were obtained by calculating the means of the differences between the volumes added until the beginning of drainage of the excess water in the pot bottom and the volume drained after this beginning in 3 pots of each treatment. The volumes added and drained were measured with test tubes.

The surfaces of the pots were covered with filter paper and the water was manually dispensed on it using test tubes for a uniform water distribution and infiltration over the whole surface of the substrate in the pots. The pots were then covered with plastic films with two holes—for gas exchange—fixed with rubber bands and incubated for 11 days. After incubation, the substrates were analyzed for chemical characteristics (TABLE 3).

**Table 3**. Chemical properties of the substrates after incubation.

| OC (%) | pH | P | K | Ca | Mg | Al | H + Al | SB | t | T | V | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ($H_2O$) | mg dm$^{-3}$ | | ------------------------- cmol$_c$ dm$^{-3}$ ------------------------- | | | | | | | % | |
| 0 | 6.0 | 17.1 | 0.26 | 2.7 | 1.2 | 0 | 2.0 | 4.16 | 4.16 | 6.16 | 68 | 0 |
| 15 | 6.4 | 151.0 | 1.40 | 7.8 | 3.2 | 0 | 1.8 | 12.30 | 12.38 | 14.18 | 87 | 0 |
| 30 | 6.5 | 208.4 | 3.51 | 8.5 | 4.1 | 0 | 1.7 | 16.00 | 16.05 | 17.75 | 90 | 0 |
| 45 | 6.4 | 238.0 | 4.89 | 16.3 | 3.3 | 0 | 1.8 | 24.40 | 24.41 | 26.21 | 93 | 0 |
| 60 | 6.5 | 248.5 | 6.76 | 34.8 | 2.4 | 0 | 1.9 | 43.80 | 43.85 | 45.75 | 96 | 0 |

H + Al = potential acidity; SB = sum of bases; t = effective cation exchange capacity (CEC); T = CEC at pH 7.0; V = base saturation; m = aluminum saturation.

**Source**: Andrade (2012).

The irrigation was performed manually, using irrigation depths corresponding to 50% ($ID_{50}$), 75% ($ID_{75}$), and 100% ($ID_{100}$) of the reference evapotranspiration ($Et_0$) and 3-day irrigation shifts. $Et_0$ was estimated daily, using the Penman-Monteith equation, according to the FAO-56 model (ALLEN et al., 2006). The $ID_{100}$ corresponded to the accumulated $Et_0$ in the 3-day interval between two consecutive irrigations. Meteorological data external to the protected environment were used, which were obtained from an official automated station of the Brazilian Institute of Meteorology (INMET) at the Federal University of Uberlândia (18°54'59''S, 48°15'W, and altitude of 869 m) at 17.3 km from the experiment area. The accumulated $Et_0$ every 3 days ranged from 2.09 to 6.32 mm during the experiment, corresponding to the ID of 100% $Et_0$ ($ID_{100}$). This value was used to calculate the percentages of 50% ($ID_{50} = 0.5ID_{100}$) and 75% ($ID_{75} = 0.75ID_{100}$) of $Et_0$.

The planting of the seedlings was performed using 120 stem cuttings with diameters ranging from 10.2 to 14.0 mm from a single *Pereskia aculeata* plant. These cuttings were disinfected by immersion in a sodium hypochlorite solution (0.5%) for 5 minutes, washed in running water for 5 minutes, and individually planted in the pots. The pots were randomly distributed in four rows on a 1.2 m by 10.0 m wooden bench, with spacing of approximately 0.20 × 0.25 m. The pots were rotated (tip, line, and axis) every 6 days to reduce possible shading, wind, and temperature differences.

The plants were cut at 122 days after planting (DAP) and washed, and the leaves were dried at 65 °C for 84 hours in a forced air-circulation oven to evaluate their dry weight (LDW). Total nitrogen concentration in the leaves were determined according to the Kjeldahl method (IAL, 2008), and the results were multiplied by 5.75 to obtain the protein content, according to the resolution RDC nº 360 of December 23, 2003 of National Agency of Sanitary Vigilance - ANVISA (BRASIL, 2003). The results were subjected to analysis of variance by the F test ($\alpha$ = 5% and 1%) and the interaction between the factors was evaluated by response surface.

The temperature and relative air humidity in the indoor environment where the plants were grown were measured using a digital thermohygrometer (Inconterm®), whose sensors register temperatures from -50 to +70 °C, with a 0.1 °C resolution and precision of ±1 °C, and relative air humidity from 25% to 98% with a resolution of 1% and accuracy of ±5%. The minimum and maximum temperatures were 5.5 to 18.1 °C and 26.7 to 46.9 °C, with averages of 11.8 and 41.1 °C, respectively; the minimum and maximum relative air humidity were 13% to 76% and 68% to 99%, with averages of 22.2% and 87.2%, respectively.

## Results and discussion

The leaf dry weight (LDW) and leaf protein content (LPC) of the *Pereskia aculeata* plants were affected by the organic compost (OC) rates in the substrate and irrigation depths (ID) ($p<0.01$). However, the effect of these factors on LDW and LPC cannot be analyzed independently since these variables responded significantly ($p<0.05$) to the interaction between OC and ID (TABLE 4). Lopes, Guerrini and Saad (2007) evaluated eucalyptus seedlings and found similar results, with effect of the substrates and irrigation depths on the shoot dry weight of the plants.

**Table 4**. Analysis of variance for the dry weight and protein content in leaves of *Pereskia aculeata* Mill. at 122 days after planting the cuttings.

| Sources of variation | [a] Dry weight | Protein content |
|---|---|---|
| | F | F |
| Organic compost (OC) | 9.04** | 8.14** |
| Irrigation depths (ID) | 43.80** | 86.24** |
| OC x ID | 2.38* | 2.41* |
| [b] CV (%) | 6.56 | 4.77 |

[a] Results transformed into log (x+5); [b] Coefficient of variation; ** and * = significant at 1% and 5% probability, respectively, by the F test.

**Source**: Andrade (2012).

The interpretation on the effects of the interaction between OC and ID was based on the response surface model. The results were applied to this model and it was possible to interpolate the behavior of the interaction between the values of the pre-established treatments. The interaction was significant ($p<0.01$) for LDW, according to Equation (1) (TABLE 5); the highest LDW was obtained with the combination of 33% OC in the substrate and ID of 100% $Et_0$, whereas the lowest was found from the combination of the highest OC rate (60%) with the lowest ID (50% $Et_0$).

**Table 5**. Statistics, response surface model Equation (1), maximum and minimum values and respective combinations between the percentage of organic compost in the substrate (x – compost - %) and irrigation depths (y – depth - %$Et_0$), for the leaf dry weight (LDW) of *Pereskia aculeata* Mill. at 122 days after planting the cuttings.

| Regression | F | p | $R^2$ |
|---|---|---|---|
| Fitted model | 7.79** | 0.0043 | 0.81 |
| Equation (1) | | | |

$$LDW = 0.683393+0.003943x+0.00226y-0.000104x^2+0.000030101xy-0.000002576y^2 \quad (1)$$

| Estimated data by equation (1) Maximum | | | Maximum | | Minimum | |
|---|---|---|---|---|---|---|
| | Minimum | Compost (%) | Irrigation (% $ET_0$) | Compost (%) | Irrigation (% $ET_0$) | |
| Transformed z = Log (MSF + 5) | 1.05 | 0.76 | 33 | 100 | 60 | 50 |
| [@] LDW (g plant$^{-1}$) | 6.25 | 0.69 | | | | |

[@] converted value: LDW = $10^Z - 5$.

**Source**: Andrade (2012).

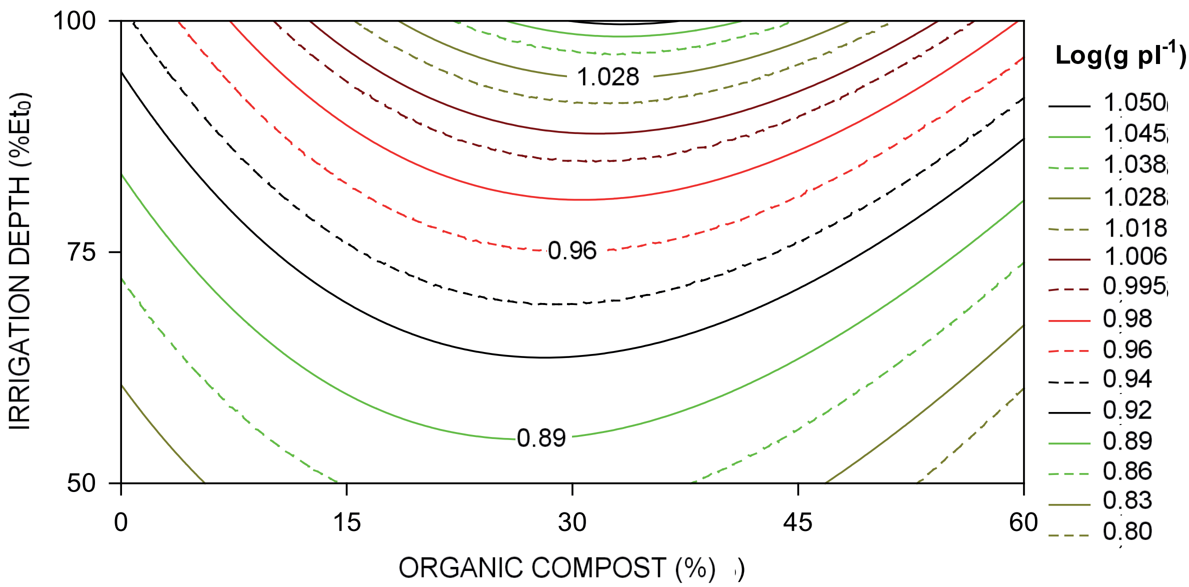
The LDW accumulation responded positively to the increase in ID from 50% to 100% $Et_0$ in all OC rates in the substrate, while increasing the OC rate within each ID increased the LDW until the OC rates of 30% to 33%; OC rates higher than these decreased LDW (FIGURE 1).

This was also found by Lui, Galbiatti and Malheiros (2008) who evaluated irrigation with 50%, 75%, 100%, and 130% $Et_0$ interacting with urban waste rates (20% to 100%) added to two soil types for growing eucalyptus seedlings and found an inverse relation of increasing waste rates and growth, number of leaves, and number of surviving plants.

Lopes, Guerrini and Saad (2007) evaluated eucalyptus using ID of 6 to 14 mm and substrates containing pine bark, charcoal, peat, and vermiculite and found that ID of 12 mm and 14 mm contributed the most to the development of *Eucalyptus grandis* seedlings, which presented optimum quality at 108 days after sowing.

Queiroz et al. (2015) also found effect of increasing irrigation depths on *Pereskia aculeata* grown with substrate composed of soil, medium-size sand, and bovine manure at 6:3:1 volume ratio, from pre-rooted cuttings. They found a linear increased in the LDW ($p<0.01$) by 120 days after planting with a 60% increase in the water irrigation volume, due to the decrease of potassium in the substrate from -10 kPa to -70 kPa, when using a decreasing intermittent water deficit.

**Figure 1**. Response surface for leaf dry weight (LDW) accumulation in *Pereskia aculeata* Mill. as a function of organic compost rates in the substrate (%) and irrigation depths (% $Et_0$), at 122 days after planting of the cuttings. Data transformed into log (LDW + 5).




**Source**: Andrade (2012).

The application of Equation (1) (TABLE 5) showed the LDW percentage increases with increasing ID, within each OC rate in the substrate, were greater from 50% to 75% $Et_0$ (from 61.2% with 15% OC to 236.2% in 60% OC) than from 75% to 100% $Et_0$ (from 47.3% in 15% OC to 93.4% in 60% OC). Regarding the percentages of OC, the highest LDW percentage increases occurred from 0% to 15% CO for all ID, with decreasing additions for increasing ID (from 67.7% to 50% $Et_0$ to 48.7% for 100% $Et_0$).

However, from 15% to 30%, the percentage increases of the LDW increased with increasing ID; and from 30% or 33%, LDW presented decreases, which were smaller with increasing ID. The greatest LDW decreases occurred from 45% to 60% OC, which were, in decreasing order, from 63% to 50% $Et_0$, from 36% to 75% $Et_0$, and from 24% to 100% $Et_0$.

Regarding the leaf protein content, the response surface model was significant ($p<0.01$) and resulted in Equation 2 (TABLE 6). The application of this equation and the interpretation of the isolines (FIGURE 2) showed the combination of 52% OC in the substrate with ID of 69% $Et_0$ resulted in the maximum leaf protein content (24.4%), while the minimum (16.6%) resulted from 0% OC with the ID of 100% $Et_0$.

**Table 6**. Statistics and regression equation for response surface (2), maximum and minimum values, and respective combinations between organic compost percentage in the substrate (x - compost - %) and irrigation depths (y - depth - $\%Et_0$), for leaf protein content in *Pereskia aculeata* Mill., at 122 days after planting the cuttings.

| Regression | F | p | $R^2$ |
|---|---|---|---|
| Degree 2 | 34.56** | <0.0001 | 0.95 |

Equation (2)

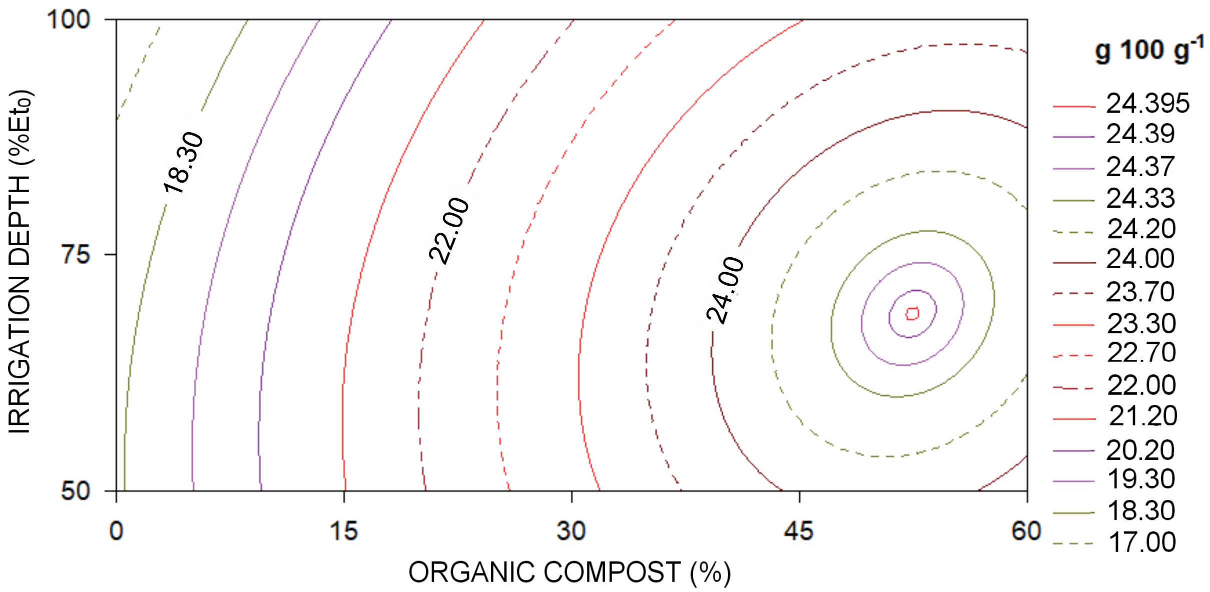
Protein = $15.724807 + 0.209154x + 0.092724y - 0.002349x^2 + 0.00054xy - 0.00088y^2$ (2) z=-0.115417+0.005564x+0.00652y-0.00013x²+0.000032333xy-0.0000308y²0.0000308y²0.0000308y²

| Variable | Content (g 100 $g^{-1}$) | | Maximum | | Minimum | |
|---|---|---|---|---|---|---|
| Maximum | Minimum | Compost (%) | Irrigation (% $Et_0$) | Compost (%) | Irrigation (% $Et_0$) |
| 24.4 | 16.2 | 52 | 69 | 0 | 100 |

**Source**: Andrade (2012).

Increasing the OC percentage in the substrate up to 52% for each ID increased the leaf protein content; and the percentage increase in all ID occurred with the increase in OC from 0% to 15% (16.6% in ID from 50% to 21.1% in ID of 100%). After 15%, the increases in OC expanded by a less percentage the leaf protein content until no more changes occurred after 45% OC. Considering the increase in ID within each OC rate in the substrate, there was a gradual decrease in leaf protein content with increasing ID for all OC rates. The greatest percentage reductions always occurred with increasing ID from 75% to 100% $Et_0$. Similar results on the effect of increasing ID on leaf protein content in *P. aculeata* were found by Queiroz et al. (2015), who found a linear decrease ($p<0.01$) in leaf protein content with an increase of 60% in the water irrigation depth, resulting from increasing the substrate matric potential from -70 kPa to -10 kPa, in *P. aculeata* plants grown for 120 days in a substrate consisted of soil, medium-size sand, and cattle manure at 6:3:1 volume ratio.

**Figure 2**. Response surface for leaf protein content in *Pereskia aculeata* Mill. as a function of organic compost rates in the substrate and irrigation water depths at 122 days after planting the cuttings.




**Source:** Elaborated by the authors (2019)

According to the isolines (FIGURE 2), the leaf protein content was more strongly affected by the OC percentage in the substrate than by the ID within the percentages of the two treatments evaluated in this experiment.

The positive effect of increasing OC percentage was also found by Souza et al. (2005) in lettuce; the crude protein content of lettuce shoots was affected only by the organic compost rates and not by the mineral fertilization; crude protein contents increased linearly with increasing rates of organic compost up to 160 Mg ha$^{-1}$; for each increase of 1 Mg ha$^{-1}$ of organic compost there was a 0.02% increase in the shoot crude protein content of the lettuce plants.

## Conclusions

Irrigation water depths and organic compost rates inversely affect leaf dry weight and protein content accumulation in *Pereskia aculeata* plants. The combination of 33% organic compost on the substrate with an irrigation depth of 100% $Et_0$ provides the greatest leaf dry weight accumulation. The maximum leaf protein content is achieved with 52% organic compost combined with an irrigation depth of 69% $Et_0$.

## Composto orgânico e irrigação influenciando a massa e o teor proteico em folhas de Ora-pro-nóbis

## Resumo

O manejo dos resíduos orgânicos e da irrigação e a presença de hortaliças na alimentação são demandas atuais, a Ora-pro-nóbis (*Pereskia aculeata* Mill.) é uma hortaliça não convencional com alto teor de proteína nas folhas, entretanto estudos sobre o cultivo sistematizado dessa hortaliça

folhosa são praticamente inexistentes. Em vista do exposto, o objetivo deste trabalho foi estudar o efeito da utilização de composto orgânico (CO) e de lâminas de irrigação (LI) na produção de massa seca (MSF) e no teor de proteínas (TPF) nas folhas. Para isso, realizou-se experimento com cinco doses de CO (0, 15%, 30%, 45% e 60% do volume do substrato) e três níveis de LI (50%, 75% e 100% da evapotranspiração de referência - $Et_0$), com quatro repetições. A variância analisada pelo Teste F ($\alpha$ = 5% e 1%) e a interpretação dos resultados da interação entre os fatores por superfície de resposta permitiram verificar que o aumento da LI de 50% para 100% da $Et_0$ é mais importante para o ganho de MSF do que o aumento das doses do CO. Assim, o maior acúmulo de MSF foi conseguido por meio da combinação de 33% de CO no substrato com LI de 100% da $Et_0$. O menor acúmulo resultou da combinação de 60% de CO com a LI de 50% da $Et_0$. O máximo TPF foi alcançado com 52% de CO e LI de 69% da $Et_0$ e o mínimo com a LI de 100% da $Et_0$ e ausência de CO no substrato.
**Palavras-chave**: Complementação nutricional. Gestão de resíduos. Hortaliça não convencional. *Pereskia aculeata* Miller.

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