ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.25, n.8, p.522-528, 2021
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v25n8p522-528

# Soursop production under supplementary irrigation and mulching in the semiarid region of Brazil[1]

## Produção de gravioleira sob irrigação suplementar e mulching na região semiárida do Brasil

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*HIGHLIGHTS:*

*Water supplementation in the dry season increases the yield of soursop.*
*Irrigation and mulching increase soursop yield in semiarid regions.*
*The mulch with Agave sisalana residue was more efficient in increasing the yield of soursop.*

**ABSTRACT:** Irregular rainfall in the semiarid region of Brazil and in the world exerts a limiting action on agricultural production, in general, including fruit species. Under these conditions, irrigation is the input that keeps the production system both economically and socially viable. This study was carried out from 2012 to 2014, in the municipality of Remígio, Paraíba State, Brazil, aiming at evaluating the production of 'Morada' soursop cultivated under rainfed and irrigated conditions, in soil with and without mulch, in two harvests. The treatments were distributed in randomized block design with three replicates in a 2 × 3 × 2 factorial scheme, corresponding to non-irrigated plants (0 mm water depth) and plants irrigated weekly (17.2 mm water depth) in soil without mulching, with cover crop residues, and with a sisal bagasse mulch in the 2012/2013 and 2013/2014 crop years. In the soil without mulching, irrigation increased yield from 5.3 to 34.7 t $ha^{-1}$ in the first harvest and from 9.4 to 57.7 t $ha^{-1}$ in the second harvest. The association between irrigation and mulch with sisal residue promoted the highest yield. The use of mulch of sisal residue increased the number and mean mass of fruits, production per plant and yield of 'Morada' soursop compared to the soil without mulch and covered by crop residues.

**Key words:** *Annona muricata* L., *Agave sisalana* residue, water-use efficiency, yield

**RESUMO:** A irregularidade das chuvas na região semiárida do Brasil e do mundo exerce ação limitante na produção agrícola, em geral, inclusive das espécies frutíferas. Nessas condições, a irrigação é o insumo que mantém o sistema produtivo com viabilidade econômica e social. O estudo foi desenvolvido no período de 2012 a 2014, no município de Remígio, Estado da Paraíba, Brasil, com o objetivo de avaliar a produção de gravioleira 'Morada' cultivada em condições de sequeiro e irrigada, no solo sem e com cobertura morta em duas safras. Os tratamentos foram distribuídos em blocos casualizados com três repetições, em arranjo fatorial 2 × 3 × 2, relativos às plantas não irrigadas (lâmina de 0 mm) e irrigadas semanalmente (lâmina de 17,2 mm) no solo sem cobertura, com cobertura a partir de restos de culturas e com bagaço de sisal nas safras agrícolas de 2012/2013 e 2013/2014. No solo sem cobertura a irrigação elevou a produtividade de 5,3 para 34,7 t $ha^{-1}$ na primeira safra e de 9,4 para 57,7 t $ha^{-1}$ na segunda safra. O uso conjunto da irrigação e a cobertura com resíduo de sisal proporcionou as maiores produtividades. O uso do resíduo de sisal como cobertura morta aumentou o número e a massa média de frutos, a produção por planta e a produtividade da gravioleira 'Morada' em relação ao solo sem cobertura e coberto por resíduos culturais.

**Palavras-chave:** *Annona muricata* L., *Agave sisalana* resíduo, eficiência de uso da água, produtividade

• Ref. 237524 – Received 03 May, 2020
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• Accepted 07 Mar, 2021 • Published 29 Mar, 2021
Edited by: Walter Esfrain Pereira

## Introduction

In the semiarid areas of Brazil, the low and irregular rainfall, allied to the high evaporative demand, makes soursop (*Annona muricata* L.) cultivation highly dependent on irrigation (Silva et al., 2013). To reduce the evaporative loss of water in the soil, the use of mulch can benefit crops both with and without irrigation, keeping the soil moist, less heated, and reducing the effects of solar radiation and air temperature on soil water evaporation (Bakshi et al., 2015; Sharma & Bhardwaj, 2017).

The vegetative soil cover has exerted positive effects on the yield of some crops, such as sugar-apple (*Annona squamosa*) (Silva et al., 2007), strawberry (*Fragaria × ananassa*) (Vailati & Salles, 2010), watermelon (*Citrullus lanatus*) (Lima Júnior et al., 2009), and melon (*Cucumis melo*) (Braga et al., 2010). The materials used as soil cover are associated with the availability of crop residues, such as grasses, invasive plants, fine branches, and leaves of the crop being exploited, resulting from cultural practices (Sousa et al., 2017).

Sisal (*Agave sisalana*) fibers can be used as mulch, along with crop residues available in producing or surrounding areas (Cavalcante et al., 2016). These materials exert beneficial effects of a physical nature through the aggregation and infiltration of water in the soil (Prosdocimi et al., 2016), as well as chemical effects on fertility improvement (Barbosa et al., 2013), and biological effects on the population increase and maintenance of biological diversity in the soil (Kader et al., 2017).

The use of sisal residue constitutes an adequate source of soil protection against water loss through evaporation and contributes to soil fertility (Cavalcante et al., 2016). Therefore, the objective of this study was to evaluate the effect of supplementary irrigation and mulch on 'Morada' soursop yield, in the semiarid region of Paraíba state, Brazil.

## Material and Methods

The experiment was conducted in the municipality of Remígio, Paraíba state, from 2012 to 2014, in a commercial orchard of 'Morada' soursop (*Annona muricata* L.) established in 2001 with seminiferous seedlings, spaced by 6 × 6 m, corresponding to a planting density of 278 plants ha$^{-1}$. The experimental area is located in the western Curimataú microregion, semiarid region of the Brazilian Northeast (6° 53' 00" S, 36° 02' 00" W, and 470 m of altitude). The climate is As' type according to Köppen's classification (Alvares et al., 2013), characterized as warm and humid with rainfall in the period from March to July.

The mean monthly values of temperature, relative air humidity, and rainfall in the experimental area for the 2012, 2013 and 2014 crop years are presented in Table 1.

The experimental design was in randomized blocks, with three replicates and six plants per plot. The treatments were distributed in a 2 × 3 × 2 factorial scheme, corresponding to the soil without mulching, covering of the experimental area with crop residues (native grass, invasive plants, leaves, and fine soursop branches), and covering with crushed sisal residue two years ago, with both covers distributed in a crown projection area of 7.0 m$^2$ referring to the crown diameter of 3.0 m during the 2012/2013 and 2013/2014 crop years, in plants without irrigation and irrigated weekly with a 17.2 mm water depth, obtained based on the reference crop evapotranspiration ($ET_0$), by the product of evaporation of class A pan by the factor 0.75.

In the experimental period, when necessary, soursop plants were subjected to cultural practices, such as pruning, phytosanitary management, and control of invasive plants, following the recommendations established for the crop (Pinto et al., 2001).

The soil of the experimental area is a Quartzipsamment. The chemical attributes of the soil in the 0-20 and 20-40 cm layers and the materials used in the mulch were determined before the installation of the experiment using the methodologies contained in EMBRAPA (2017), and are exhibited in Table 2. The soil physical attributes at the two depths were as follows: soil bulk density of 1.43 and 1.42 kg dm$^{-3}$; particle density of 2.72 and 2.73 kg dm$^{-3}$; sand, silt, and clay contents of 915.0 and 908.0 kg$^{-1}$, 55.0 and 61.0 kg$^{-1}$, and 30.0 and 31.0 g kg$^{-1}$, respectively; total porosity of 0.47 and 0.48 m$^3$ m$^{-3}$; and water content of 34.0 and 36.0 g kg$^{-1}$, respectively.

Supplementary irrigation was performed in drought periods using water with the following attributes: ECa = 0.58 dS m$^{-1}$ and SAR = 3.2 (mmol L$^{-1}$)$^{0.5}$, supplied by micro-sprinkler irrigation using one micro-sprinkler per plant, with a flow rate of 60 L h$^{-1}$ and a range of 3.0 m, installed at 30 cm from the stem of each plant and operating at a service pressure of 0.2 MPa.

**Table 1.** Accumulated precipitation (P) and mean values of air temperature (T) and relative air humidity (RH) recorded at the site during the experiment

| Months | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|
| | P (mm) | T (ºC) | RH (%) | P (mm) | T (ºC) | RH (%) | P (mm) | T (ºC) | RH (%) |
| January | 141 | 26.5 | 66 | 38 | 26.7 | 59 | 35 | 25.9 | 58 |
| February | 112 | 24.4 | 56 | 66 | 24.9 | 45 | 117 | 25.1 | 48 |
| March | 8 | 23.9 | 72 | 41 | 24.9 | 68 | 53 | 24.8 | 64 |
| April | 36 | 23.8 | 76 | 135 | 24.7 | 70 | 30 | 24.9 | 72 |
| May | 75 | 23.2 | 79 | 58 | 24.2 | 76 | 100 | 24.1 | 78 |
| June | 195 | 22.3 | 86 | 155 | 22.4 | 80 | 110 | 23.6 | 81 |
| July | 106 | 22.5 | 92 | 118 | 22.0 | 82 | 155 | 22.8 | 83 |
| August | 17 | 21.2 | 86 | 82 | 21.5 | 86 | 37 | 24.6 | 71 |
| September | 4 | 24.4 | 78 | 30 | 24.7 | 78 | 129 | 25.2 | 68 |
| October | 7 | 27.2 | 63 | 13 | 27.4 | 62 | 49 | 28.2 | 62 |
| November | 0 | 27.4 | 54 | 21 | 28.7 | 54 | 20 | 27.6 | 56 |
| December | 0 | 27.3 | 56 | 43 | 28.2 | 56 | 9 | 28.4 | 55 |
| Total/mean | 701 | 24.5 | 72 | 800 | 25.1 | 68 | 844 | 25.4 | 68 |

**Table 2.** Chemical attributes of the soil at the beginning of the experiment, in the 0-20 and 20-40 cm layers, and of soil covering with crop residues and sisal residue

| | Soil | | Mulching | |
|---|---|---|---|---|
| | 0-20 cm | 20-40 cm | Crop residues | Sisal residue |
| pH ($H_2O$) | 7.30 | 6.60 | 7.13 | 9.30 |
| SOM (g kg$^{-1}$) | 8.45 | 4.25 | 380.00 | 392.00 |
| C/N | - | - | 26:1 | 14:1 |
| | | (mg dm$^{-3}$) | | |
| P | 58 | 33 | 235 | 402 |
| $K^+$ | 105 | 89 | 1,307 | 1,426 |
| | | (cmol$_c$ dm$^{-3}$) | | |
| $Na^+$ | 0.24 | 0.17 | 3.15 | 3.25 |
| $H^+ + Al^{3+}$ | 0.54 | 0.87 | 1.24 | 1.24 |
| $Al^{3+}$ | 0.00 | 0.00 | 0.00 | 0.00 |
| $Ca^{2+}$ | 2.03 | 1.18 | 1.75 | 4.70 |
| $Mg^{2+}$ | 0.54 | 0.40 | 2.70 | 6.40 |
| SEB | 3.01 | 1.97 | - | - |
| CEC | 3.62 | 2.85 | - | - |
| V (%) | 83.15 | 71.98 | - | - |

SOM - Soil organic matter; SEB - Sum of exchangeable bases ($K^+ + Ca^{2+} + Mg^{2+} + Na^+$); CEC - Cation exchange capacity [SEB + ($H^+ + Al^{3+}$)]; V - Saturation in exchangeable bases = 100 * SEB/CEC; P and $K^+$ - Phosphorus and potassium - Mehlich-1; $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ - Sodium, calcium and magnesium - 1 mol L$^{-1}$ KCl; $H^+ + Al^{3+}$ and $Al^{3+}$ - Potential acidity and exchangeable aluminum - 0.5 mol L$^{-1}$ calcium acetate - pH 7.0

NPK fertilization was performed in the crown projection area of the soursop plants in a 50 cm wide band, 70 cm away from the stem. Before starting the experiment, at the beginning of the rainy season (March 2012), each plant was fertilized with 300 g of urea (45% N), 250 g of single superphosphate (20% $P_2O_5$), and 140 g of potassium chloride (60% $K_2O$); at the beginning of the experimental phase (end of July 2012), the plants were fertilized with 400, 250, and 180 g of the respective inputs, as recommended by Pinto et al. (2001). In the years 2013 and 2014, at the beginning of the rainy season and beginning of the arid period, the plants were fertilized with the same fertilizers and in the same quantities applied at the beginning of the experimental phase (end of July 2012). Due to the low content of organic matter in the soil, 20 L of bovine manure were applied along with each mineral fertilization (Table 3).

The harvests evaluated corresponded to the periods from September 2012 to March 2013, from September 2013 to March 2014, and from September to December 2014. Soursop fruits were harvested at physiological maturity, evidenced by the increased distance between prickles and the loss of consistency of these structures (Pereira et al., 2011). After harvesting, the fruits were counted to record the number of fruits per plant (NFP) and later weighed to determine the mean fruit mass (MFM), production per plant (PP), and yield (Y).

The results were subjected to analysis of variance and comparison of means by Tukey's test at $p \leq 0.05$ (Banzato & Kronka, 2006), using the Assistat statistical software, version 7.7 (Silva & Azevedo, 2016).

## Results and Discussion

The interaction of irrigation depths × types of mulching × harvests had significant effects on all production components of soursop plants (Table 4).

Supplementary irrigation in the soursop orchard increased the mean number of fruits per plant from 14.3 to 53.7 in the first harvest (2012/2013) and from 21.0 to 84.0 in the second harvest (2013/2014) for plants grown in soil without mulching, representing 3.75 and 4.0 times more fruits under irrigated conditions (Figure 1). This low number of fruits harvested from non-irrigated plants may be a consequence of water deficit, especially in the months from September to December, in which low rainfall and higher temperatures were observed (Table 1). The low availability of water to non-irrigated plants may have induced a reduction in the chlorophyll content and stomatal conductance, as observed in sugar-apple subjected to water stress conditions (Kowitcharoen et al., 2015), limiting the $CO_2$ assimilation and leading to a reduction in biomass production and crop yield.

This situation shows the importance of irrigation in semiarid regions, which have rainfall restrictions both in quantitative terms and in the distribution, a fact evidenced in 2013 and 2014, with a mean rainfall of 800 and 844 mm, respectively, although with high variability over the months (Table 1).

When considering the soil cover, it was verified that the non-irrigated plants obtained 14.3, 22.3, and 26.3 fruits plant$^{-1}$ in the first harvest, and 21.0, 21.7, and 36.0 fruits plant$^{-1}$ in the second harvest, for the plants cultivated in soil without mulching, covered mulching with crop residue, and covered with mulching with sisal residue, respectively (Figure 1). In the irrigated plants, the number of fruits was 53.7, 59.7, and 67.0 fruits plant$^{-1}$ in the first harvest, and 84.0, 69.3, and 74.7 fruits plant$^{-1}$ in the second harvest, considering the same covers. It should be emphasized that, among the covers employed, the mulching with sisal (*Agave sisalana*) residue

**Table 4.** Summary of analyses of variance for number of fruits per plant (NFP), mean fruit mass (MFM), production per plant (PP), and yield (Y) of 'Morada' soursop, as a function of irrigation depths, soil cover, and agricultural harvests evaluated in the years 2012/2013 and 2013/2014

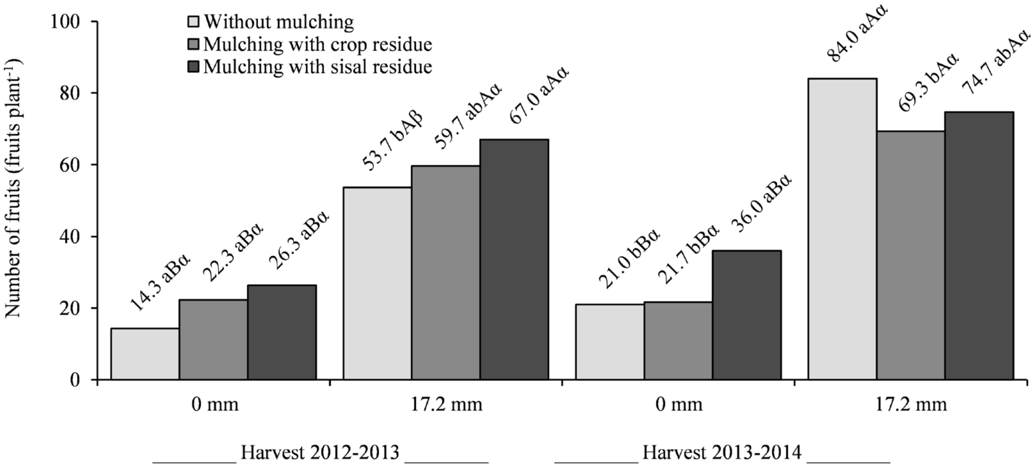
| | NFP | MFM | PP | Y |
|---|---|---|---|---|
| | Mean squares | | | |
| Weekly irrigation depth (ID) | 877.47** | 191.46** | 682.87** | 682.87** |
| Mulching (M) | 9.06** | 24.38** | 21.10** | 21.11** |
| Harvest (H) | 54.13 ** | 63.30 ** | 96.20 ** | 96.20 ** |
| ID × M | 4.47 * | 15.17 ** | 5.72 ** | 5.72 ** |
| ID × H | 11.12 ** | 19.51 ** | 50.60 ** | 50.60 ** |
| M × H | 9.03 ** | 3.32 * | 0.35 ns | 0.35 ns |
| ID × M × H | 5.14 * | 4.53 * | 0.021 * | 0.021 * |
| CV (%) | 11.38 | 9.93 | 16.62 | 16.62 |

CV - Coefficient of variation; ns - Not significant; *,** - Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively

**Table 3.** Chemical characterization of the bovine manure used in the experiment

| pH ($H_2O$) (1:2.5) | C | N | P | S | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | C:N | $Na^+$ | B | $Cu^{2+}$ | $Fe^{2+}$ | $Mn^{2+}$ | $Zn^{2+}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (g dm$^{-3}$) | | (mg dm$^{-3}$) | | (cmol$_c$ dm$^{-3}$) | | | | (mg dm$^{-3}$) | | | | | |
| 8.58 | 187.85 | 10.44 | 2.07 | 6.65 | 2.49 | 4.65 | 5.25 | 18:1 | 130.9 | 0.84 | 1.38 | 21.77 | 44.18 | 4.13 |

pH - Hydrogen potential; C - Carbon; N - Nitrogen; P - Phosphorus; S - Sulfur; $K^+$ - Potassium; $Ca^{2+}$ - Calcium; $Mg^{2+}$ - Magnesium; C:N - Carbon/Nitrogen ratio; $Na^+$ - Sodium; B - Boron; $Cu^{2+}$ - Copper; $Fe^{2+}$ - Iron; $Mn^{2+}$ - Manganese; $Zn^{2+}$ - Zinc




Means with distinct lowercase letters differ statistically by Tukey's test at $p \leq 0.05$ between types of soil cover in the same harvest and water regime; Means with distinct uppercase letters differ between water regimes in the same harvest and type of soil cover; Means with different Greek letters differ between the types of soil cover in different harvests for the same water regime

**Figure 1.** Number of fruits of 'Morada' soursop harvested from plants without and with irrigation as a function of soil mulching in the 2012/2013 and 2013/2014 harvests

was more effective in increasing fruit production in the first harvest, for the irrigated plants, and in the second harvest, for the non-irrigated plants.

The mean fruit mass followed the same trend of the number of harvested fruits, with significantly higher values in the plants irrigated weekly with a 17.2 mm water depth (Figure 2). In plants without mulching, irrigation increased fruit production from 1.3 to 2.3 kg fruit$^{-1}$ in the first harvest, and from 1.6 to 2.5 kg fruit$^{-1}$ in the second harvest, corresponding to gains of 76.9 and 56.2%, respectively (Figure 2). These values are similar to those of 1.76 and 2.35 kg fruit$^{-1}$ obtained by Almeida et al. (2015), in plants of the same cultivar, not irrigated and irrigated, under the same edaphoclimatic conditions.

Regarding the use of mulch in the soil, the sisal residue promoted the highest values of mean fruit mass (3.4 kg fruit$^{-1}$), when associated with irrigation in the second harvest, reaching twice the fruit mass of the condition without mulching and non-irrigated plants (1.3 and 1.6 kg fruit$^{-1}$) obtained in the first and second harvests, respectively (Figure 2). The values of MFM obtained for soursop plants cultivated in soil with mulching with crop residue were statistically similar to those obtained in plants with sisal residue mulching, although surpassing the values of the plants grown in the soil without mulch, in both situations (Table 4). These results, according to Prosdocimi et al. (2016), occurred due to the improvements of soil attributes in terms of water storage, with a reduction in water loss through evaporation caused by mulching, resulting in the production of soursop fruits with higher mean mass per harvest.

Promising results for the use of mulching increasing the mean fruit mass have also been found in other crops, such as yellow passion fruit (*Passiflora edulis* Sims) (Freire et al., 2010) and sugar-apple (Silva et al., 2007). The same was recorded by Vailati & Salles (2010), whose study demonstrated that the use of ground cover (pine and black polyethylene plastic) reached the highest values for the mean mass of strawberry fruits.

The increase in fruit mass promoted by mulching may have occurred due to a greater conservation of soil temperature and moisture and to the degradation and mineralization of crop residues and sisal bagasse, which are rich in essential elements, allowing the plant to absorb more nutrients from the soil solution (Freire et al., 2010; Cavalcante et al., 2016).

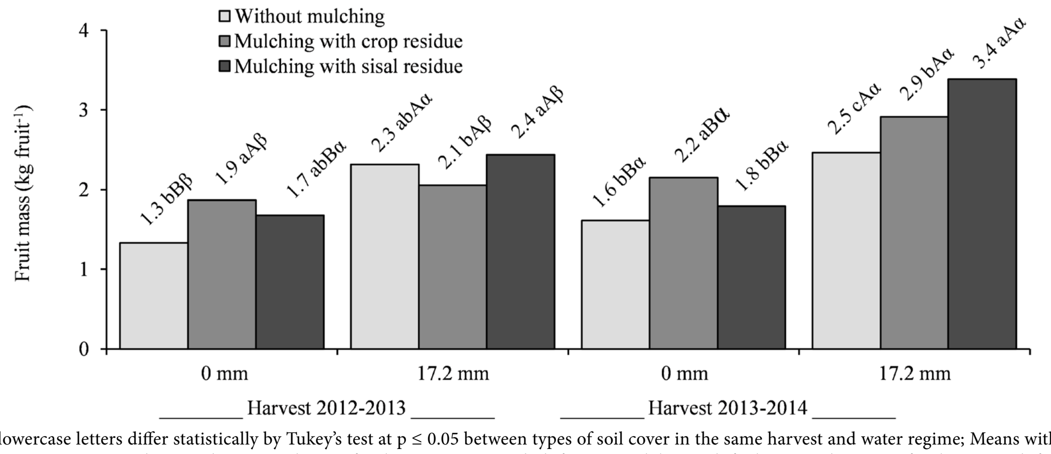



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**Figure 2.** Mean fruit mass in the first (2012/2013) and second (2013/2014) harvests of 'Morada' soursop as a function of soil cover and irrigation depths

Maintaining soil moisture for a longer time is essential for agricultural production in semiarid regions, especially where there is little availability of quality water for irrigation. Moisture, in turn, increases the ion-root contact and nutrient absorption (Sharma & Bhardwaj, 2017). The soil cover also acts as a conditioning factor, improving the microbial activity of the soil and, consequently, the content and availability of nutrients (Kader et al., 2017).

The production per plant obtained in the non-irrigated soursop plants was only 15.2 and 16.2, 32.8 and 22.9, and 26.9 and 25.5% of that obtained in the irrigated plants, in treatment without mulching, mulching with crop residue, and mulching with sisal residue, in the first and second harvests, respectively (Figure 3). The irrigated plants grown in soil with sisal residue obtained the highest PP, with values of 163.9 kg $plant^{-1}$ in the first harvest (2012/2013) and 252.7 kg $plant^{-1}$ in the second harvest (2013/2014). When comparing these values with the 44.1 and 64.4 kg $plant^{-1}$ obtained in non-irrigated plants, using the same soil cover, it is verified that the application of the irrigation depth of 17.2 mm weekly increased the production by 119.8 and 188.3 kg $plant^{-1}$ in both harvests, respectively, representing gains of 271.6 and 292.4% (Table 4 and Figure 3). These values of production per plant are higher than the 17.3 and 24.1 kg $plant^{-1}$ obtained in non-irrigated plants, without mulching and with mulching using sisal residue, respectively (Cavalcante et al., 2016). They are also higher than the 111.4 and 166.6 kg $plant^{-1}$ obtained in the same crop for the same conditions, under irrigation (Cavalcante et al., 2016).

The application of the irrigation depth and soil cover increased the yield of soursop fruits in the two harvests evaluated (Figure 4). In the first (2012/2013) and second (2013/2014) harvests, in the soil without mulching, yield increased from 5.3 to 34.7 t $ha^{-1}$ and from 9.4 to 57.7 t $ha^{-1}$, respectively, without and with the use of irrigation (Figure 4). Under irrigated conditions, fruit yield was increased from 34.7 to 45.6 t $ha^{-1}$ in the first harvest and from 57.7 to 70.3 t $ha^{-1}$ in the second harvest in the soil without mulching and mulching with sisal residues, respectively (Figure 4). These values are higher than the yield of 31.8 t $ha^{-1}$ obtained in irrigated soursop (Silva et al., 2013) and exceed the yields of 31.0 and 46.3 t $ha^{-1}$ obtained in irrigated soursop without mulching and mulching with sisal residue, respectively (Cavalcante et al., 2016).

In the irrigated plants, the yield gains obtained with the use of mulching with sisal (*Agave sisalana*) residue were 31.4 and

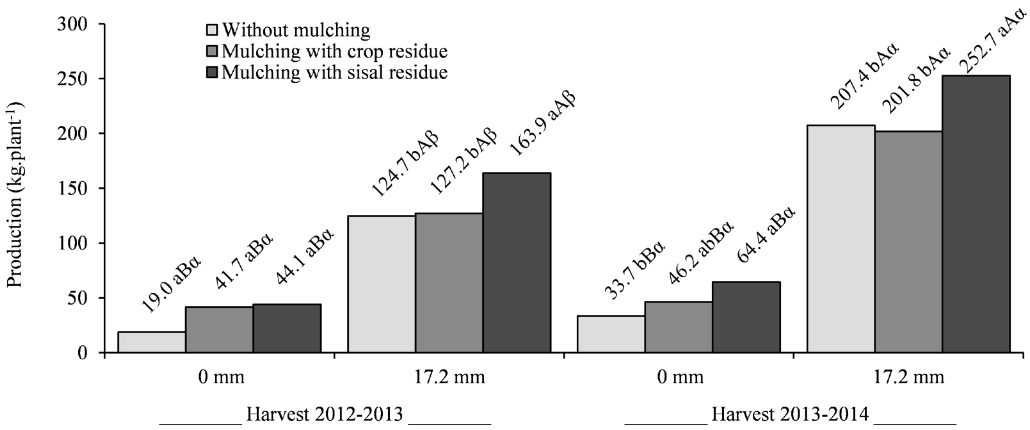


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**Figure 3.** Production per plant in the first (2012/2013) and second (2013/2014) harvests of 'Morada' soursop as a function of soil cover and irrigation depths

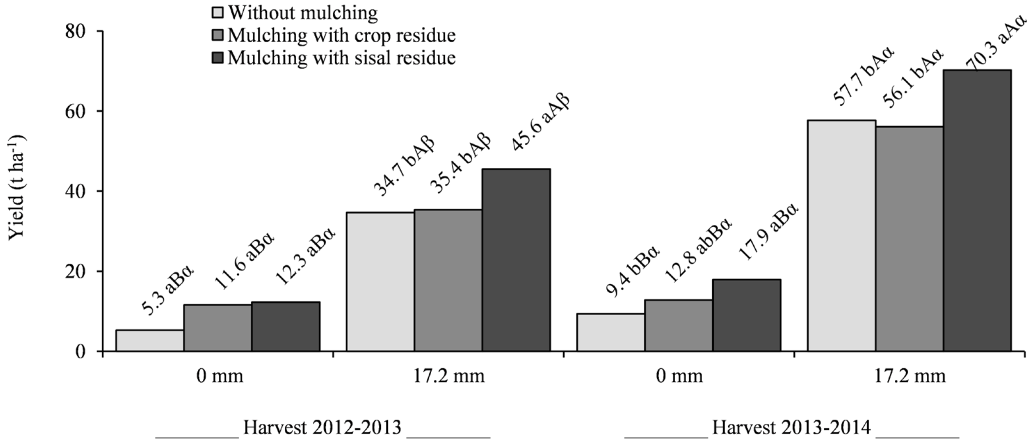


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**Figure 4.** Yield in the first (2012/2013) and second (2013/2014) harvests of 'Morada' soursop as a function of soil cover and irrigation depths

28.8% in the first harvest, and 21.8 and 25.3% in the second harvest, in comparison to plants cultivated in soil without mulching and mulching with crop residue, respectively (Figure 4), indicating that the sisal residue was more effective in providing more favorable conditions for plants.

The combination of irrigation and soil cover techniques resulted in higher yields of soursop fruits. This probably occurred due to the increased availability of water in the soil, which is related to the increased infiltration (reduced runoff) and reduced evaporation rate, which can be three times lower in soils with mulching than in soils without mulching (Bakshi et al., 2015; Sharma & Bhardwaj, 2017).

When comparing different soil covers, Braga et al. (2010) verified the superiority of the cover with organic material (buffel grass straw) in comparison to the uncovered soil. The authors concluded that soil cover with organic materials (coconut husk bagasse, buffel grass straw, and sugarcane bagasse) reduced the soil thermal amplitude. In general, irrigation promoted superior results in all analyzed variables, regardless of cover and harvest. Regarding the type of cover, it was verified that, regardless of irrigation and harvest, the best results were obtained in the plants cultivated with sisal residue mulch.

In the results observed in this study, it is noted that the mulching retarded water deficit in comparison to the crop without its use. However, it was concluded that mulching alone was not sufficient to promote the best yields, which depend on adequate irrigation management. Especially in semiarid regions, which are characterized by rainfall irregularity, making agriculture a risky activity, rainfall-dependent agricultural production systems in the Brazilian semiarid region need to be associated with practices that maintain soil moisture at its maximum level and also mitigate the effects of rainfall irregularity (Almeida et al., 2015; Cavalcante et al., 2016).

Further studies with mulching are recommended to mitigate the effects of water deficit on agriculture in semiarid regions.

## Conclusions

1. Irrigation promotes higher yield, especially when associated with the use of mulching with sisal residue.

2. The use of sisal residue as mulch increases the number and mass of fruits and production per plant of 'Morada' soursop.

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