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Interference of weeds on Barbados gooseberry initial development

Ariany G Teixeira ¹; Mateus O Cabral ¹; Fábio Luiz de Oliveira ¹; Leandro P Dalvi ¹; Luciano Menini ²; Leonardo F Rocha ³

¹Universidade Federal do Espírito Santo (UFES), Alegre-ES, Brasil; arianyteixeira@yahoo.com.br; mateus.cabrall@hotmail.com; fabio.oliveira.2@ufes.br; leandropin@yahoo.com.br; ²Instituto Federal do Espírito Santo (IFES), Alegre-ES, Brasil; lmagini@ifes.edu.br; ³School of Agricultural Sciences, Southern Illinois University, Carbondale, Illinois, USA; leonardo.rocha@siu.edu

ABSTRACT

The Barbados gooseberry crop has agricultural potential, but little information is available regarding cropping practices. More information on weed interference in Barbados gooseberry will support growers to take weed management decisions. The objective of this work was to study initial growth and development of Barbados gooseberry under the interference of weeds. The experiment was conducted in a completely randomized design, with five treatments, composed of Barbados gooseberry in competition with four weed species: slender amaranth (*Amaranthus viridis*), hairy beggarticks (*Bidens pilosa*), Benghal dayflower (*Commelina benghalensis*), purple nutsedge (*Cyperus rotundus*), and a weed-free control, with six replicates. Weed competition led to a decrease in growth and development of Barbados gooseberry reflected in a reduction of up to 40% in yield and 23% in protein content. Additional work must be conducted evaluating these findings under field conditions, using different seedling production and planting techniques potentially affecting these results.

Keywords: *Pereskia aculeata*, non-conventional vegetable, competition, proteins.

RESUMO

Interferência de plantas daninhas no desenvolvimento inicial do ora-pro-nobis

Atualmente o ora-pro-nobis é apontando como cultura de potencial agrícola, porém com poucas informações sobre seu manejo agrônomico. Uma das informações a ser buscada é quanto aos prejuízos que o convívio com plantas daninhas causa. Objetivou-se com este trabalho estudar o crescimento e desenvolvimento inicial do ora-pro-nobis em convivência com plantas daninhas. O delineamento experimental utilizado foi inteiramente casualizado, com cinco tratamentos, ora-pro-nobis em convivência com caruru (*Amaranthus viridis*), picão preto (*Bidens pilosa*), trapoeraba (*Commelina benghalensis*) e tiririca (*Cyperus rotundus*) e a testemunha ausente de plantas daninhas, com seis repetições. A convivência com as plantas daninhas diminuiu o crescimento e desenvolvimento do ora-pro-nobis assim como a produção de folhas em até 40% e 23% do teor de proteínas, respectivamente. Porém, novos trabalhos devem ser realizados em ambientes de plantio a céu aberto, bem como a utilização de técnicas diferenciadas para a produção de mudas e seu transplante para as condições reais de campo.

Palavras-chave: *Pereskia aculeata*, hortaliça não convencional, competição, proteínas.

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The Barbados gooseberry plant (*Pereskia aculeata*), included in the Cactaceae family, is native to South America and well adapted to low elevations. In Brazil, this crop is widely distributed, from Bahia to Rio Grande do Sul state (Pinto *et al.*, 2015). This plant is a climbing cactus and conducted as a vine. Its succulent leaves are a substantial source of protein and have a significant concentration of minerals, dietary fibers, vitamins A and C, and folic acid (Souza *et al.*, 2016). Barbados gooseberry leaves are added to salads, soups, omelets, and pies, while the leaf flour is used as a nutritional enriching ingredient when preparing bread, cakes,

and pasta. The fruits are used for juices, jellies, mousses, and liqueurs, whereas their seeds can be germinated to produce edible sprouts (Garcia *et al.*, 2019).

In Brazil, this plant is commonly referred to as “green meat” or “vegetable meat” because of its high protein and mineral content. Barbados gooseberry has traditional cultural relevance in some regions of Minas Gerais and Goiás states, especially in historic colonial cities. In Diamantina city, Minas Gerais, for example, nearly 80% of the population consumes this vegetable regularly, being less common in other parts of Brazil (Garcia *et al.*, 2019). Despite the restriction of

Barbados gooseberry consumption to specific regions, the adaptability of this plant to different environments, high production of leaf biomass, and data showing the nutritional significance of leaves have been stimulating the use of this plant in other areas. Moreover, added demand for Barbados gooseberry by the food industry highlights the agricultural potential of this plant (Queiroz *et al.*, 2015a; Madeira *et al.*, 2016) and demanding improved crop management practices.

As this plant is adapted to large scale production systems, management practices must be optimized to achieve higher yields, including optimized

weed management methods, as weeds are a major biotic factor interfering with plant growth and development, and therefore reducing yield. When not properly managed, weeds can interfere with plant growth mainly by competing for resources such as water, light, and nutrients, and potentially releasing allelopathic substances, reducing yield and quality of crops (Demétrio *et al.*, 2008; Galon *et al.*, 2013).

Weed species are characterized by having competitive features, such as producing a high number of viable seeds, easily adapting to new environments, which facilitates plant dispersion. Furthermore, weeds often carry seed traits such as dormancy and uneven germination, maintaining field populations even under not optimal conditions (Oliveira Júnior, 2011). Among different weed groups, specific characteristics may offer a further competitive capacity to certain species. Nutsedge and slender amaranth have C4 metabolism, which promotes fast growth rates and biomass production due to efficient CO₂ assimilation (Brighenti, 2001), while hairy beggarticks can absorb high amounts of soil nutrients, including nitrogen, phosphorus, and micronutrients (Santos & Cury, 2011). Purple nutsedge's competitive ability is a result of its perennial life cycle and herbaceous size, with reproduction both sexually (aerial and underground seeds) and through vegetative tubers referred to as "nutlets", which facilitate weed dispersion (Ronchi & Silva, 2004).

Thus, since Barbados gooseberry is a perennial plant with slow initial growth (Madeira *et al.*, 2016), its ability to compete with weeds, especially during initial growth stages, will potentially have a significant impact on yield. As competition with weeds can affect this crop in the initial stages, Madeira *et al.* (2016) recommend using mulching in the first weeks after transplanting seedlings, to reduce weed emergence in fields. However, additional manual weed picking and mowing are required during the crop cycle.

The objective of this work was to study the interference of purple nutsedge, hairy beggarticks, Benghal dayflower, and slender amaranth on

the initial development of Barbados gooseberry.

MATERIAL AND METHODS

Trials were conducted in a greenhouse, in the city of Alegre, Espírito Santo state, Brazil (21°S, 42°W), from August 2018 to October 2018. The climate of Southern Espírito Santo is classified, according to Köppen, as type "Aw", with two well-defined seasons during the year, hot and rainy from October to March, and cold and dry from April to September, with 23°C average annual temperature, and around 1,200 mm rainfall (Pezzopane *et al.*, 2012).

The experiment was conducted in a completely randomized design, with five treatments and six replicates. Treatments were composed of Barbados gooseberry in competition with four weed species: slender amaranth (*Amaranthus viridis*), hairy beggarticks (*Bidens pilosa*), Benghal dayflower (*Commelina benghalensis*), purple nutsedge (*Cyperus rotundus*), and a weed-free control (check).

Weeds were planted in 5 L plastic pots using rhizomes as propagules for purple nutsedge, stolons for Benghal dayflower, and seeds for both slender amaranth and hairy beggarticks. Four rhizomes were used for purple nutsedge, five-node stolons for Benghal dayflower, and 50 seeds for each hairy beggarticks and slender amaranth. Weeds were thinned 30 days after planting, reducing weed populations to four plants per pot. Right after thinning, weeds were trimmed to a height of 10 cm from the soil, and Barbados gooseberry was planted in these pots using stems.

Barbados gooseberry was planted directly in the soil using stem cuttings. Stems comprised mature branches collected from the middle canopy of a single healthy and fully developed plant and standardized to 15 cm length and 0.5 cm diameter, with five budding nodes, always keeping leaves attached to stems. Stems were planted at 7.5 cm depth in 5 L pots where weeds were already grown as before described. Pots were filled with a 2:1 soil:potting mix

blend and positioned in 1 m x 1 m pattern between pots.

The soil mixed with potting mix was classified as Red-Yellow Latosol, medium texture (Santos *et al.*, 2018), collected at 20-30 cm depth. A soil sample was submitted to chemical analysis, resulting in pH 5.46 in water, 3.57 mg dm⁻³ of P, 20.00 mg dm⁻³ of K, 55.00 mg dm⁻³ Na, 0.14 cmolc dm⁻³ Ca, 0.30 cmolc dm⁻³ Mg, 0.00 cmolc dm⁻³ Al, 0.74 cmolc dm⁻³ of total cations, 2.47 cmolc dm⁻³ of cation exchange capacity at pH 7, and 29.86% of base saturation. The soil was collected, air-dried, and sieved through a 5 mm mesh. The pH was corrected by elevating base saturation to 60% using limestone (90 ENV). Fertilization was based on the recommendation of Madeira *et al.* (2016) and adapted to pot volume. Pots were watered daily, by adding 15 mm per pot.

All ratings were performed 90 days after crop planting when plants exhibited uniform growth and development, which shows the beginning of the harvesting stage (Brasil, 2016). To analyze plant vegetative growth and assess the influence of weed competition on leaf size along the stem, the following variables were evaluated: number of leaves (NL); number and length of secondary branches (NSB and LSB) with a minimum length of 5 cm; length and width of proximal leaves (LPL and WPL) (5th leaf at the base of canopy); length and width of medial leaves (LML and WML) (central leaf of middle canopy); and length and width of distal leaves (LDL and WDL) (5th leaf in the upper canopy). Chlorophyll a, chlorophyll b, and total chlorophyll were estimated using a digital chlorophyll meter clorofiLOG (CFL 1030 - Falker, Porto Alegre, RS, Brazil), that uses photodiodes for three wavelengths: two detecting red bands close to the peaks of each type of chlorophyll ($\lambda = 635$ and 660 nm), and a third detecting near-infrared ($\lambda = 880$ nm). Using data from chlorophyll readings, the device estimates a value designated as Falker chlorophyll index (FCI) that is proportional to chlorophyll absorbances (Barbier *et al.*, 2012).

Fresh weight of leaves (FWL) and

dry weight of leaves (DWL), branches (DWB), and roots (DWR) were assessed for Barbados gooseberry 90 days after planting. For each weed species, dry weight of shoots (DWS) and dry weight of roots (DWR) were also estimated at 90 DAP. To measure dry weight, all fresh samples were dried in a forced-air circulation oven at 65°C until reaching constant weight.

Total nitrogen (TN) and crude protein (CP) in leaves were estimated 90 days after planting using the Kjeldahl method, following the procedure described by Galvani & Gaertner (2006), using protein-nitrogen distiller (TE-0363-Tecnal, Piracicaba, SP, Brazil). Crude fiber (CF) was estimated using a commercial fiber analyzer (TE-149 - Tecnal, Piracicaba, SP, Brazil) following Van Soest's method (1967). Total ash (TA) was estimated via the calcination of 1 g digested samples in a muffle oven at 600°C for four hours.

The data were submitted to analysis of variance, using the F test at 5% probability, and when significant, means were separated using Tukey test at 5% probability. All statistical analyses were performed using Sisvar 5.0 (Ferreira, 2014).

RESULTS AND DISCUSSION

Weed competition affected growth and development of Barbados gooseberry during the initial 90 days after planting in greenhouse conditions. Purple nutsedge affected plant growth by reducing the length of secondary branches and number of leaves by 74% and 85%, respectively, followed by Benghal dayflower, slender amaranth and hairy beggarticks (Table 1). Weed competition with Barbados gooseberry and other crops is due to factors such as competition for space, water, light, and nutrients, and potential negative allelopathic effects (Andrade *et al.*, 2009; Silva & Silva, 2012). Weeds reduced shoot growth of Barbados gooseberry, where structures used for commercialization, such as leaves, may have reduced development due to decreased nutrient availability, and/or by allelopathic compounds (Albuquerque

et al., 2008).

Leaf dimensions of Barbados gooseberry (length and width) were also reduced by weed competition with Benghal dayflower and purple nutsedge (Table 2), leading to the production of leaves under sizes commonly reported, which are from seven to ten centimeters in average length (Brasil, 2016). Variations in leaf dimensions drive leaf size and therefore, are directly correlated with leaf area, which will reflect in the photosynthetic capacity of a plant. Similar results were found by Cabral *et al.* (2020) where weed competition reduced the leaf area of yacon plants. Therefore, decreases in leaf dimensions of Barbados gooseberry can lead to a reduction in the production of photoassimilates in these plants and, consequently, reduced leaf biomass (González-Sanpedro *et al.*, 2008). In the case of Barbados gooseberry, a reduction in leaf size would also lead to losses in yield, considering that leaves are the plant structure used for consumption and therefore, the focus to increase profitability in this crop.

The elevated competitive capacity of these weed species is derived from their growth biology and the superior capacity to use and compete for resources, leading to elevated absorption of soil nutrients in addition to aggressive characteristics (Pitelli, 1987). Purple nutsedge is quite aggressive due to its fast initial growth and rapid development of vegetative reproductive structures (Nishimoto, 2001). Benghal

dayflower's competitive ability comes from the ability to propagate both vegetatively and via seeds, associated with vigorous and dense growth, covering the soil and limiting the availability of resources to growing crops (Isaac *et al.*, 2007). Due to reduced leaf growth, Barbados gooseberry displayed reduced production of fresh and dry biomass in leaves, branches, and roots, when competing with weeds. Overall, data show reduced production of fresh and dry biomass of leaves and roots compared to weed-free control, regardless of weed species treatments. However, purple nutsedge had a stronger effect on Barbados gooseberry fresh and dry weight of leaves compared to other weed species.

Regarding the potential to produce leaves (fresh), which is the plant part most consumed and therefore has economic importance, data show that competition with weeds leads to decreases of nearly 40% in Barbados gooseberry production, with the strongest reduction when competing with purple nutsedge (Table 3). These results demonstrate that, in commercial production fields focusing on the production of leaves for fresh consumption, weed competition will significantly compromise the yield of Barbados gooseberry, as it is measured by the production of leaves. These results highlight the importance of implementing weed management practices during the initial development stages of Barbados gooseberry, as well as producing seeds in the greenhouse for

Table 1. Effect of the interference of different weeds on the number of leaves, number, and length of secondary branches of Barbados gooseberry. Alegre, UFES, 2018

Weed treatments	Growth variables		
	NL	NSB	LSB
	(cm ⁻¹)		
Weed-free (control)	54.66a*	2.16a	27.08a
<i>A. viridis</i>	18.83c	1.83a	17.33b
<i>B. pilosa</i>	34.66b	2.00a	21.08b
<i>C. benghalensis</i>	13.00d	2.15a	9.86c
<i>C. rotundus</i>	8.00e	1.66a	7.08c
CV (%)	22.05	31.89	21.03

*Means followed by the same letter in the same column do not differ using Tukey's test at 5% probability. CV= coefficient of variation. NL= number of leaves; NSB= number of secondary branches; LSB= length of secondary branches.

Table 2. Effect of the interference of different weeds on the length and width of proximal, medial and distal leaves of Barbados gooseberry. Alegre, UFES, 2018.

Weed treatments	Leaf variables in Barbados gooseberry					
	LPL	WPL	LML	WML	LDL	WDL
	(cm ^l)					
Weed-free (control)	9.91a*	3.66a	10.16a	3.66a	9.00a	3.41a
<i>A. viridis</i>	8.00ab	3.58a	8.50a	3.25a	7.16ab	2.58bc
<i>B. pilosa</i>	7.50ab	3.75a	9.00a	4.00a	8.00a	3.25a
<i>C. benghalensis</i>	5.83bc	2.91ab	5.83b	2.91bc	5.83b	2.91ab
<i>C. rotundus</i>	5.00c	2.08b	5.00b	2.08c	5.16b	2.08c
CV (%)	23.00	25.26	18.21	17.91	17.06	12.57

*Means followed by the same letter in the same column do not differ using Tukey's test at 5% probability. CV= coefficient of variation. LPL= length of proximal leaves; WPL= width of proximal leaves; LML= length of medial leaves; WML= width of medial leaves; LDL= length of distal leaves; WDL= width of distal leaves.

later transplantation to production fields.

The competitive capacity of purple nutsedge is related to its accelerated plant growth, as this species accumulated the highest amount of biomass, both in shoots and roots (26.83 g and 47.16 g per pot, respectively). Additionally, from tested species, hairy beggarticks caused higher growth reduction to Barbados gooseberry, which may be linked to the growth rate of this weed, as it presented the second largest shoot weight (23.16 g per pot) (Figure 1). The expressive growth and competitive capacity of hairy beggarticks were also reported by Cabral *et al.* (2020) competing this weed with yacon plants. The highly competitive capacity of purple nutsedge is due to accelerated initial growth and development, especially of the root system, providing advantages when competing for water and nutrients (Pitelli, 1987). Other weed species had reduced competitive potential (Figure 1) and these results may be linked to mutual competition effects, allowing better development of Barbados gooseberry, as competition is a biological relationship occurring in both directions between crops and weeds. Competitive and fast-growing crops can suppress the growth of some weed species (Albuquerque *et al.*, 2008).

Data shows that Barbados gooseberry was not significantly affected by Benghal dayflower nor slender amaranth, common weeds affecting horticultural crops, as these weeds displayed lower dry weight of shoots and roots compared to other species in this study (Figure

Table 3. Effect of the interference of different weeds on the dry weight of leaves, branches, and roots and fresh weight of leaves of Barbados gooseberry. Alegre, UFES, 2018.

Weed treatments	Fresh and dry weight of Barbados gooseberry			
	DWL	DWB	DWR	FWL
	(g plant ⁻¹)			
Weed-free (control)	2.50a*	3.83ab	2.16a	4.64a
<i>A. viridis</i>	0.42bc	4.66a	0.24b	0.79bc
<i>B. pilosa</i>	0.76b	3.50ab	0.19b	1.41b
<i>C. benghalensis</i>	0.44bc	3.33c	0.16b	0.82bc
<i>C. rotundus</i>	0.23c	4.33ab	0.14b	0.43c
CV (%)	33.69	19.25	32.28	28.13

*Means followed by the same letter in the same column do not differ using Tukey's test at 5% probability. CV= coefficient of variation. DWL= dry weight of leaves; DWB= dry weight of branches; DWR= dry weight of roots; FWL= Fresh weight of leaves.

1). These results indicate these weeds have a reduced ability to interfere with Barbados gooseberry growth, information relevant to growers, and extension programs when selecting weed management practices for this crop.

In addition to growth and morphological variables, weed competition affected the photosynthetic capacity of Barbados gooseberry as well, by decreasing chlorophylls a, b, and total chlorophyll in leaves (Table 4). Weed competition for resources such as water and nutrients, especially nitrogen (Argenta *et al.*, 2001), diminishes the initial establishment of Barbados gooseberry. Based on bromatological analyzes, concentrations of total nitrogen and crude fiber in leaves of Barbados gooseberry were not significantly

affected by weed interference. However, crude protein concentrations were decreased by competition with purple nutsedge, Benghal dayflower, and hairy beggarticks, resulting in reductions of 23%, 15%, and 10% in the protein content, respectively (Table 4), lower than average values observed in the literature (Takeiti *et al.*, 2009). The competition for nutrients by weeds species may be linked to their adapted roots system. In fact, Benghal dayflower has a root system with a large number of roots that allow increased nutrient absorption surface of the soil (Martins *et al.*, 2007). Thus, weed competition compromises leaf nutrient accumulation and consequently Barbados gooseberry' nutritional quality, which is mainly characterized by being a protein-rich food.

Table 4. Effect of the interference of different weeds on the chlorophyll a, b, total chlorophyll, total nitrogen, crude protein, crude fiber, and total ash in Barbados gooseberry. Alegre, UFES; IFES, 2018.

Weed treatments	Foliar concentrations in Barbados gooseberry						
	CA	CB	TC	TN	CP	CF	TA
	(g kg ⁻¹)						
Weed-free (control)	28.5a*	7.5a	35.9a	22.7a	141.8ab	80.5a	6.1d
<i>A. viridis</i>	23.1e	4.7d	28.0d	24.6a	154.1a	75.6a	9.6ab
<i>B. pilosa</i>	27.3ab	6.5b	34.0b	19.3a	121.0cd	81.1a	7.4bc
<i>C. benghalensis</i>	25.8d	5.5c	31.5c	20.3a	127.3bc	79.6a	10.6a
<i>C. rotundus</i>	27.0bc	6.0bc	33.1bc	19.5a	109.4d	84.9a	10.7a
CV (%)	9.60	17.18	9.89	10.35	8.39	8.52	16.09

*Means followed by the same letter in the same column do not differ using Tukey's test at 5% probability. CV= coefficient of variation. CA= chlorophyll a; CB= chlorophyll b; TC= total chlorophyll; TN= total nitrogen; CP= crude protein; CF= crude fiber; TA= total ash.

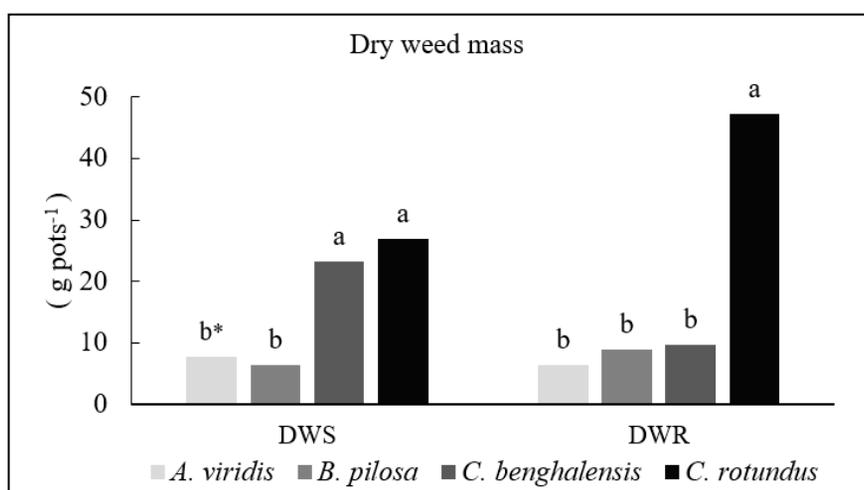


Figure 1. Dry weight of shoots (DWS) and roots (DWR) of weed species 90 days after Barbados gooseberry planting. *Means followed by the same letter in the bars do not differ using Tukey's test at 5% probability. Alegre, UFES, 2018.

In contrast, purple nutsedge and hairy beggarticks led to an increase in total inorganic materials (ash), also described as a mineral residue (sodium, potassium, magnesium, calcium, iron, phosphorus, and other mineral compounds). Therefore, higher concentrations of total ash observed in Barbados gooseberry under influence of weeds (Table 4), could be a result of changes in plant adaptive metabolism in competitive environments, allowing boosted crop absorption and accumulation of minerals (Queiroz *et al.*, 2015b).

Among weeds evaluated in this study, purple nutsedge and hairy beggarticks affected Barbados gooseberry growth and development the most. Therefore, adopting management practices to

effectively control these weeds are recommended and should be adopted when establishing production systems. These weeds, when not properly managed, can become a limiting factor in the development of Barbados gooseberry, especially during the growth and initial establishment of the crop, when plants are less competitive and more susceptible to weed pressure (Pitelli, 1987; Silva & Silva, 2012).

Barbados gooseberry initial growth and development in a greenhouse condition, as well as its crude protein content, was reduced due to weed interference, remarkably by purple nutsedge. Additional work must be conducted evaluating these findings under field conditions, using different seedling production and planting

techniques potentially affecting these results.

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