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# Competitive interaction between guava and weeds: Effect on initial growth

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**Abstract**

Guava (*Psidium guajava* L.) is one of the 50 most consumed fruits in the world. However, weed competition compromises fruit production in cultivation areas. Thus, this work aimed to evaluate the competitive interaction between guava plants and common infesting species on initial growth. Guava seedlings were cultivated during 60 days with *Bidens subalternans* DC., *Waltheria indica* L. or *Commelina benghalensis* L. in a randomized block design with four replicates. The experiment was conducted under greenhouse condition from February to May 2017 in Mossoró city, Brazil. The following variables were analysed: number of leaves; shoot and root length; stem diameter; root, stem, shoot and total dry mass; and leaf area. As a result, only guava plants suffered negative effects on growth due to the competition. *W. indica* and *C. benghalensis* were the most competitive species, reducing the number of leaves, leaf area and total dry matter of guava plants. However, guava and *W. indica* produced more root biomass when in competition. In contrast, *B. subalternans* and *C. benghalensis* was not affected by the presence of guava. In conclusion, competition with *W. indica* or *C. benghalensis* reduces the growth of guava after transplanting.

*Keywords:* Crop-weed competition, fruit tree, interspecific competition, *Psidium guajava* L.

## 1 Introduction

Guava (*Psidium guajava* L.) is a fruit crop of commercial importance in more than 50 countries, and 46.5 million tons of fruits are produced annually around the world (TRIDGE, 2019). In Brazil, fruits yield more than R$ 500 million per year, mainly from the Northeast and Southeast regions (IBGE, 2016). The fruits, leaves, and roots are highly appreciated for their nutritional and medicinal characteristics, presenting a great number of bioactive compounds, vitamins, minerals, and fibres, as well as antioxidant, anti-inflammatory and antimicrobial properties (Singh, 2011; Gill, 2016). In addition, guava plants have hardy nature, high production, and remuneration under low cost, and employs many people, directly and indirectly, mainly familiar farmers, that contribute to keeping people in the field (Rajan & Hudedamani, 2019).

In commercial cultivation, guava plants are usually propagated by cuttings, and, at the time of transplanting to the field, the seedlings need conditions that offer low stress, such as adequate soil moisture and adequate fertilisation of the pits, so that a vigorous plant can establish itself and be more productive (Pereira *et al.*, 2017). However, these conditions, associated with the low initial soil shading, also favour the development of weeds (Fahad *et al.*, 2015; Chauhan *et al.*, 2017).

When crops and weeds establish in the same area, negative interactions will occur, such as competition and allelopathy. Weeds consume the same growth resources available to the crop, such as water, light, and nutrients. Thus, when some of these resources become limited, competition establishes and will stand out the species with the highest competitive capacity. In addition, weeds can release allelopathic compounds to the environment causing damage to crop growth (Mommer *et al.*, 2011; Lowry & Smith, 2018).

*Commelina benghalensis* L., *Waltheria indica* L., and *Bidens subalternans* DC. are weed species that commonly infest areas of guava cultivation in Brazil. These species are aggressive because of their easy propagation and dis-

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semination, ability to grow and develop under low amounts of resources (water and nutrients), and resistance to herbicides (Saunders, 2011; Santos *et al.*, 2015; Hayden & Fagan, 2016; Lima *et al.*, 2016; Pellegrini & Forzza, 2017). Depending on the environmental conditions, these species are annual or perennial and reproduce in several cycles during the guava growth period. These characteristics point to these weeds as potential competitors with guava plants by the growth resources, which may limit the crop development and productivity.

Furthermore, crop-weed competition may be more intense in the initial growth after the transplanting of guava seedlings. In this phase, in addition to the slower growth compared to weeds, guava plants have superficial roots, which explore the same area of soil explored by weed roots (Kareem *et al.*, 2013; Pereira *et al.*, 2017), which may reduce growth and, consequently, the future quantity, size, fruit weight and productivity.

Similarly, agricultural crops can reduce weed growth and development, since competition may cause negative effects for all plants in coexistence. However, competition for growth resources varies according to the morphology, physiology, nutritional need and growth habits of the coexisting species. Therefore, understanding the relationships among plants living in the same environment is important for the development of agricultural management and weed control. Thus, the objective of this work was to evaluate the effects of interspecific competition on the initial growth of guava plants, *C. benghalensis*, *W. indica*, and *B. subalternans*.

## 2 Materials and methods

The experiment was conducted under greenhouse condition from February to May 2017 in Mossoró city, Rio Grande do Norte State, Brazil (05° 11' 15" South, 37° 20' 39" West, 16 m a.s.l, 35.1-21.1 °C temperature, and 96-31 % relative humidity). Polyethylene pots with 8 litres capacity were filled with six litres of Red-Yellow Latosol (Santos *et al.*, 2018) that had the following physical-chemical attributes, according to the soil analysis: nitrogen ($1.19\,g\,kg^{-1}$ soil); phosphorus, potassium and sodium (2.2, 434.6, and $49.3\,mg\,dm^{-3}$ soil, respectively); calcium, magnesium, sum of bases, effective cation exchange capacity (CEC) and total CEC (11.3, 2.1, 14.73, 14.73, and 14.73 $cmolc\,dm^{-3}$ soil, respectively); base saturation, aluminium saturation and percentage of exchangeable sodium (100, 0, and 1 %, respectively); pH (7.2); electrical conductivity ($0.14\,ds\,m^{-1}$); soil organic matter ($8.1\,g\,kg^{-1}$ soil); sand, fine sand, total sand, silt and clay content (0.36, 0.21, 0.57, 0.1, and $0.33\,g\,kg^{-1}$ soil, respectively); and silt / clay ratio (0.3). Fertilisers were added to supply the nutritional need of guava according to Cavalcanti (2008).

The 140-day-old guava seedlings cv. Paluma, propagated by cuttings, were obtained from a company that produces certified seedlings. The *B. subalternans* and *W. indica* seeds, and *C. benghalensis* cuttings were obtained from spontaneous plants in the experimental region. Emergency tests were carried out with the seeds so that the emergency coincided with the guava seedlings transplanting. Guava and weed species were cultivated under competition (guava + *B. subalternans*, guava + *W. indica*, guava + *C. benghalensis*) and single (guava, *B. subalternans*, *W. indica*, *C. benghalensis*) for 60 days, constituting seven treatments. In the competition treatments, the guava seedlings were transplanted to the centre of the pot and *B. subalternans* seeds were sown around the guava seedling. This same procedure was carried out with *W. indica* seeds. After the emergency, a thinning was carried out maintaining one weed seedling per pot. Similarly, *C. benghalensis* cuttings were transplanted into the pot, simulating the vegetative propagation of this species, and one seedling was maintained per pot. The experimental plot was represented by a pot containing the plants in competition or single.

The substrate field capacity was determined by the filter method (Lucas *et al.*, 2011). A 0.5 kg soil sample was placed in a pot containing a paper filter. Then, the pot was filled with water. Subsequently, the water was drained through the filter, and after 72 hours the moist soil mass was weighed. The difference between dry and wet soil mass was used to calculate the amount of water to be added in the pot. Thus, irrigation was performed daily maintaining the substrate with humidity of 60 to 70 % of field capacity. The volumes of water applied were obtained from the difference between the pot weight in its field capacity and the pot weight on the day of irrigation.

After 60 days, all plants were removed from the pots, and the following variables were evaluated: the number of leaves per plant, shoot and root length, and stem diameter. The length was measured from the neck to the apex by millimetric ruler and the results were expressed as centimetres (cm). The stem diameter was measured by an electronic digital caliper (Economy Digital Caliper, Model 54-100-000-2 6"/150 mm, Fowler, EUA) and the results were expressed as millimetres (mm). The plants were then separated into leaves, stems, and roots, and each organ was packed separately in paper bags and dried in a forced circulation oven (65 ± 1 °C, 72 h). Then, the dry mass content of each organ was measured in analytical balance and the total dry mass (leaves + stem + root) was expressed in g per plant. The dry mass of each organ was also expressed as a percentage ( %) of the total dry mass. The leaf area (LA) of guava, expressed in cm² per plant, was determined by the leaf disc method (Lucena *et al*., 2011). Ten 3.95 $cm^2$ discs were removed from the leaves, then packed in paper bags and dried in a forced circulation oven (65 ± 1 °C, 72 h). The leaf area was determined by the formula:

$$LA = (LDM * DA)/DDM$$

where LDM is the leaf dry mass in g per plant, DA is the disc area in $cm^2$, and DDM is the disc dry mass in g. Then, the leaf area ratio (LAR), expressed in $cm^2\ g^{-1}$, was determined by the ratio between leaf area and total dry mass (Benincasa, 2003).

The experiment was conducted in a randomized complete block design with four replicates. The data were submitted to one-way analysis of variance by the F test ($p < 0.05$). Means from guava plants were compared by the Scott-Knott test ($p < 0.05$). And means from each weed species in competition and isolated treatment was compared by the t-test ($p < 0.05$). The analyses were performed using the SAS software program (SAS Institute, 2008).

## 3 Results

### 3.1 Effect of competition on initial growth of guava plants

Competition did not affect the stem diameter (5.0 mm, p>0.05) and the shoot (30.4 cm, p>0.05) and root (22.7 cm, p>0.05) length of guava plants. However, competition with *W. indica* and *C. benghalensis* reduced 32.7 % of the number of leaves (Fig. 1A) and 25.4 % of the total dry matter (Fig. 1B). Moreover, guava plants accumulated 18.2 % more dry matter in their roots when in competition with *W. indica*, compared to the other treatments (Fig. 1C). The presence of *B. subalternans* did not alter the total dry matter (Fig. 1B) but reduced 15.3 % of the leaf dry matter of guava plants (Fig. 1C).

Moreover, competition with *W. indica* and *C. benghalensis* reduced the leaf area (47.0 %) and leaf area ratio (39.3 %) of guava plants (Fig. 2).

### 3.2 Effect of competition on initial growth of weed species

*W. indica* presented more root length (187.9 %, Fig. 3A) and more total dry matter (203.0 %, Fig. 3B) when in competition with guava plants than under single condition. In addition, this species invested more dry matter in roots than in leaves in the presence of guava plants (Fig. 3C). However, root length, total dry matter accumulation and dry matter partition of *B. subalternans* and *C. benghalensis* were not affected by the presence of the guava plants (Fig. 3A-C). The presence of guava plants did not affect shoot height (33.9, 31.7, 31.6 cm, p>0.05), stem diameter (2.6, 3.5, 3.1 mm, p>0.05) and number of leaves (12, 12, 67 leaves per plant, p>0.05) of *B. subalternans*, *W. indica*, and *C. benghalensis*, respectively.

## 4 Discussion

### 4.1 Effect of competition on initial growth of guava plants

Reduction in the number of leaves of guava plants under weed competition may be due to the water competition among species since the same water content was provided to the single species and competition treatments. Thus, in the

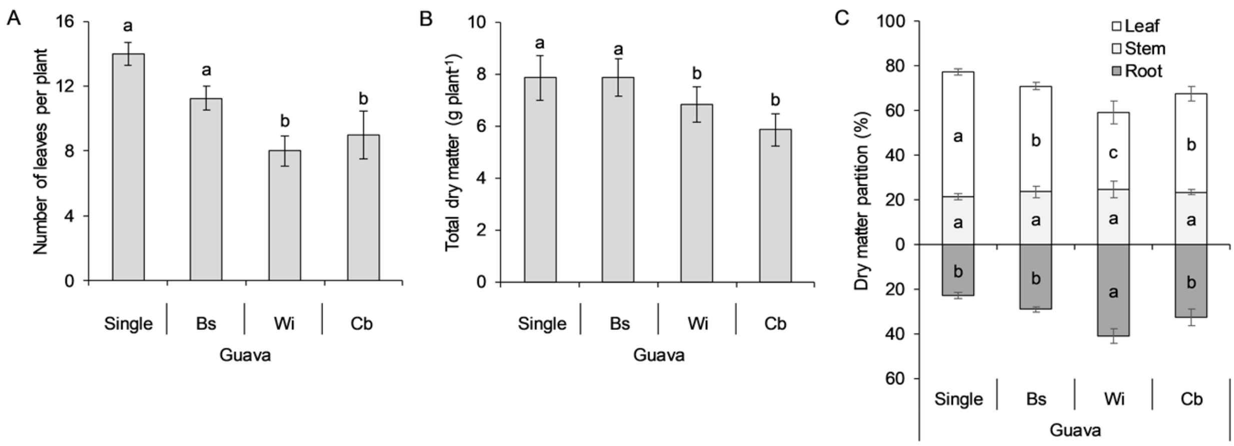


**Fig. 1:** *Effect of competition on the number of leaves (A), dry matter accumulation (B), and dry matter partition (C) of guava plants (Psidium guajava) cultivated single or in competition with Bidens subalternans (Bs), Waltheria indica (Wi) or Commelina benghalensis (Cb) for 60 days after transplanting. Error bars indicate standard error of four replicates. Different letters indicate significant difference according to the Scott-Knott test at 5 % probability.*

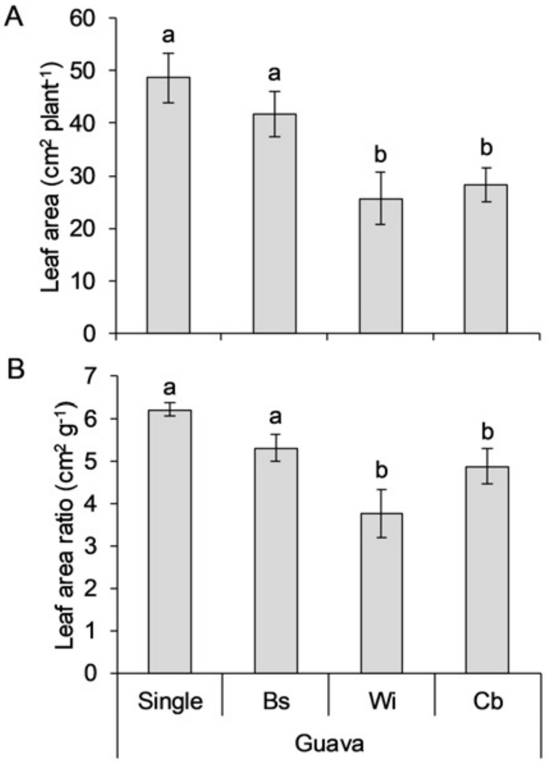


**Fig. 2:** *Effect of competition on the leaf area (A) and leaf area ratio (B) of guava (Psidium guajava) cultivated single or in competition with Bidens subalternans (Bs), Waltheria indica (Wi) or Commelina benghalensis (Cb) for 60 days after transplanting. Error bars indicate standard error of four replicates. Different letters indicate significant difference according to the Scott-Knott test at 5 % probability.*

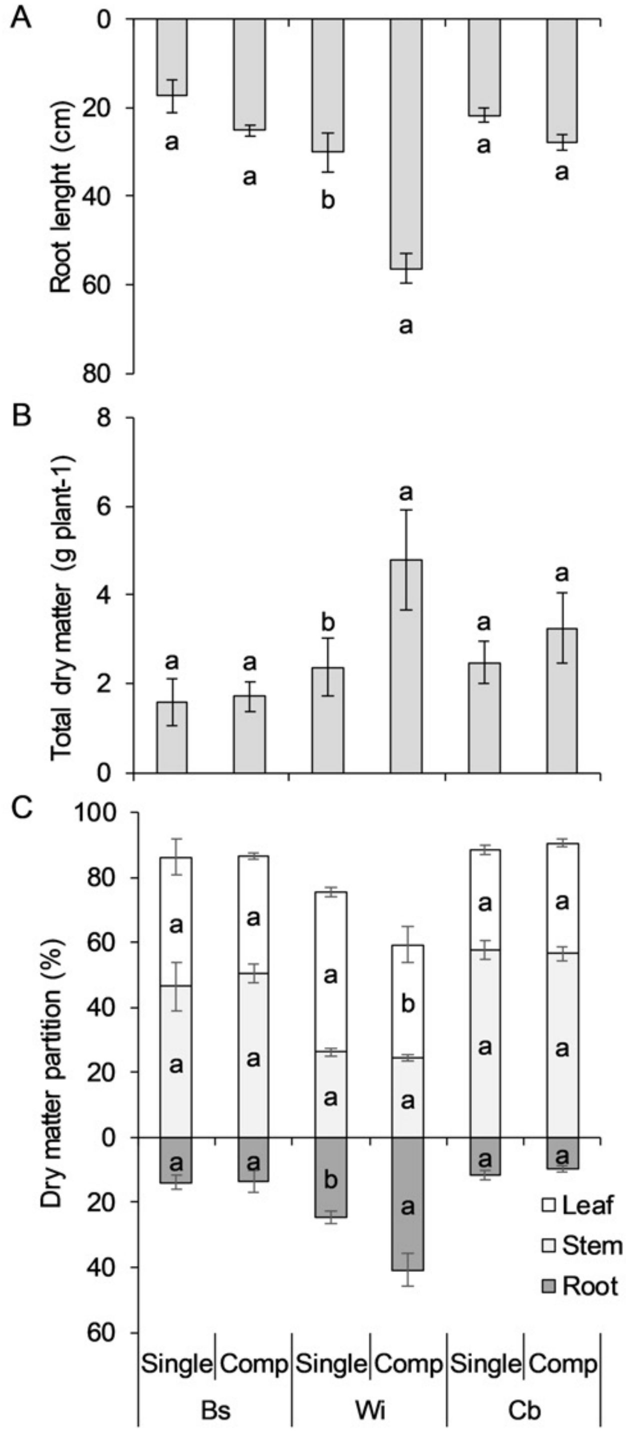


**Fig. 3:** *Effect of competition on the root length (A), dry matter accumulation (B), and dry matter partition (C) of Bidens subalternans (Bs), Waltheria indica (Wi), and Commelina benghalensis (Cb) cultivated single or in competition (Comp) for 60 days with guava plants (Psidium guajava). Error bars indicate standard error of four replicates. Different letters indicate significant difference according to the t-test at 5 % de probability.*

competition treatments, the water resource exhausted faster than in isolated ones. Plants present mechanisms to reduce leaf transpiration under conditions of soil water deficit. In addition to stomatal closure (Boyle *et al.*, 2015) and accumulation of solutes in the root (Barcia *et al.*, 2014), leaf loss may be an alternative to reduce transpiration (Wolfe *et al.*, 2016). Therefore, the reduction of the number of leaves in guava plants in competition with *W. indica* and *C. benghalensis* may be an alternative to this crop species to reduce the loss of water by transpiration. Other species such as *Apoplanesia paniculata*, *Caesalpinia coriaria*, *C. eriostachys*, *Ceiba aesculifolia*, *Cordia eleagnoides, Gliricidia sepium, Ipomoea wolcottiana, Lonchocarpus constrictus, Mimosa arenosa, Senna atomaria* and *Piptadenia constricta* also lose their leaves (up to -80 %) under reduction of water potential as an attempt to maintain water in the tissues (Pineda-García *et al.*, 2013).

Reduction in total dry matter of guava plants in competition with *C. benghalensis* may be due to the planting system of this species in this experiment. The planted stems contained pairs of leaves, and thus, the initial growth rate of this species was higher than those species planted via seed. In addition, the root length and root dry matter of *W. indica* were higher ( 200 %) in the plants in competition treatment than in isolated one. These responses have been observed in this species under competitive conditions (Lima *et al.* 2016). Therefore, both species were able to compete more aggress-ively for water and nutrients in relation to *B. subalternans*, reducing the total dry matter of guava plants.

The total dry matter (Fig. 2A) and shoot and root dry matter partition (Fig. 2B) in guava plants were not affected by the presence of *B. subalternans*. Although the root length of this species was the same of guava plants (20 cm), the dry matter content in this organ was nine times lower in relation to the other weed species, denoting the lower capacity to explore the soil volume. This fact resulted in the nonoccurrence of competition since similar values for total, shoot and root dry matter was observed in guava plants cultivated isolated and in the presence of this weed species.

Guava plants accumulated more dry matter (+18.2 %) in the roots when they were cultivated in the presence of *W. indica*, compared to the other treatments (Fig. 2C). The root dry matter partition is directly related to soil water reduction. Some plants recognise the reduction of soil water potential, and through signals (mainly hormones), these plants can reallocate photoassimilates to the root in order to increase the volume of soil explored and to absorb more water from the soil (Álvarez & Sánchez-Blanco, 2013; Benjamin *et al.*, 2014). *W. indica* is considered an investor species because, under water deficit conditions in the soil, this plant maintains open stomata and gas exchange continues as well as the absorption of water even under declined soil water potential (Lima *et al.*, 2016). Thus, this weed probably reduced the amount of water available to the guava plants to levels enough to stimulate the reallocation of resources.

Root length of guava plants did not alter, thus, the high dry matter accumulation in this organ may be associated to more production of root hairs, in order to explore more soil volume and, therefore, to increase absorption capacity (Faquin, 2005). Although the height of guava plants and weeds were the same at the end of the experiment (30 cm), they were not able to shade them. Therefore, the greater investment in roots to the detriment of the aerial part indicates that there was competition for water and nutrients.

Reduction in leaf area and leaf area ratio is a result of the reduction of the number of leaves and the mobilisation of the photoassimilates to the roots. The smaller leaf area reduces the total photosynthesis and, consequently, decreases the amount of photoassimilates available for the full crop growth and development (Reis *et al.*, 2013; Ghanizadeh, 2014; Xu *et al.*, 2014), directly reducing the productivity of fruits in plants living with *W. indica* and *C. benghalensis*.

Results indicated that *W. indica* and *C. benghalensis* were more aggressive in competition with guava after transplanting when compared to *B. subalternans*. Other species such as *Cyperus rotundus, Parthenium hysterophorus, Rumese dentalis, Anagalis arvensis*, and *Phalaris minor* also showed a high capacity to reduce the components of guava growth on initial periods (Boora *et al.*, 2014). The greater damage caused by these species suggests that the control method adopted should focus mainly on the control of these plants, which cause a greater reduction in the guava growth components.

### 4.2 *Effect of competition on initial growth of weed species*

Although weeds reduce crop growth and development by competition, an opposite effect also occurs, since, in certain situations, competition may be a negative event for all plants in competition. As shown in this work, the greatest accumulation of total dry matter by *W. indica* in competitive condition was a result of higher root growth (Fig. 5A-B), showing that this species, when detecting the limitation of soil resources (water and nutrients) due to competition with other species, invests in root growth as a strategy to increase its competitive capacity. Other species such as *Cleome affinis* and *Tridax procumbens* also invest in root growth under competitive conditions (Vivian *et al.* 2013; Lima *et al.* 2016). This characteristic was not observed for the other weeds studied in this work. As *B. subalternans W. indica* was propagated via seed, but it was able to negatively affect the growth components of guava in the early stages after transplanting. The difference in the aggressiveness of root growth between these species may explain the results observed in guava plants. The greater volume of soil explored by *W. indica* can increase the total absorption of water and nutrients, limiting these resources to the crop.

We can conclude that the competition with *Waltheria indica* or *Commelina benghalensis* reduces the growth of the newly transplanted guava plants and induces more dry matter accumulation in the root than in the shoot. Bidens subalternans does not affect the growth components of guava plants in the initial periods after transplanting. Guava plant does not affect the growth and dry matter accumulation of *C. benghalensis* and *B. subalternans*. However, *W. indica* accumulates more biomass in roots under competitive conditions.

Knowing the species of weeds that cause interference in crop growth is important because it reduces the unnecessary application of herbicides, in addition to reducing costs, and reducing environmental impact.

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*Conflict of interest*

Authors state they have no conflict of interests.

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