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Article

INFLUENCE OF WEEDS ON YACON INITIAL GROWTH AND DEVELOPMENT

Influência de Plantas Daninhas no Crescimento e Desenvolvimento Iniciais de Yacon

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ABSTRACT - The consumption of yacon has been increasing around the world due to the nutritional and pharmaceutical properties of this plant. The growing commercial interest in yacon (*Smallanthus sonchifolius*) generates a demand for crop management research studies, including the effect of weed competition on yacon, which was not yet studied. Thus, this study was performed with the objective of evaluating the effects of weed competition on yacon development and growth. The experimental design was completely randomized with four treatments and seven replicates. Treatments were yacon with the interference of four weed species: *Cyperus rotundus* L. (nutgrass), *Commelina benghalensis* L. (tropical spiderwort), *Amaranthus viridis* L. (slender amaranth) and *Bidens pilosa* L. (hairy beggarticks). The experiment was conducted in a greenhouse, using 10 dm^3 pots. Plant height, number of leaves, number of stems, leaf area, fresh and dry mass weight (total and partial), and chlorophyll A, B and total were evaluated. The weed competition resulted in a decrease in the yacon development (height, number of leaves, number of stems, leaf area), photosynthetic rate (decreased chlorophyll content A, B and total) and yield, as also decreased the accumulation of fresh and dry biomass of tuberous roots. *C. benghalensis* L. and *A. viridis* L. were the weeds most affecting the development and growth of yacon.

Keywords: *Smallanthus sonchifolius*, *Commelina benghalensis*, *Amaranthus viridis*, *Cyperus rotundus*, *Bidens pilosa*, competition.

*RESUMO - O consumo da batata yacon tem sido cada vez mais difundido pelo mundo devido às suas propriedades nutricionais e farmacêuticas. Em razão do crescente interesse comercial pela yacon, há demanda por estudos sobre o seu manejo agrícola, entre os quais estão os efeitos da competição de plantas daninhas com a yacon, fato ainda pouco conhecido. Assim, realizou-se este trabalho com o objetivo de avaliar os efeitos da convivência das plantas daninhas no desenvolvimento e crescimento da yacon. O delineamento experimental foi inteiramente casualizado, com tratamentos constituídos pela convivência com quatro espécies de plantas daninhas: tiririca (**Cyperus rotundus** L.), trapoeraba (**Commelina benghalensis** L.), caruru (**Amaranthus viridis** L.) e picão-preto (**Bidens pilosa** L.), além da testemunha (yacon ausente de daninhas), com sete repetições. O experimento foi conduzido em casa de vegetação, em vasos de 10 dm^3. Foram avaliados altura das plantas, número de folhas, número de hastes, área foliar, acúmulo de massa fresca e seca (total e por partes) e clorofila A, B e total. A convivência com as plantas daninhas provocou diminuição no desenvolvimento da yacon (altura, número de folhas, número de hastes e área foliar), na capacidade fotossintética (redução dos teores de clorofilas A, B e total) e na produção, pois também diminuiu o acúmulo em biomassa fresca e seca das raízes tuberosas.*

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A trapoeraba e o caruru foram as plantas daninhas que mais prejudicaram o desenvolvimento e crescimento da yacon.

Palavras-chave: *Smallanthus sonchifolius, Commelina benghalensis, Amaranthus viridis, Cyperus rotundus, Bidens pilosa*, competição.

INTRODUCTION

Yacon (*Smallanthus sonchifolius*), which is an Andean species belonging to the Asteraceae family, is mainly produced in some South American countries, such as Colombia, Ecuador, and Peru. This plant has reserve roots, where high concentrations of fructooligosaccharides (FOS) are present, including from the inulin type, charactering yacon as a functional food and increasing the interest of food and pharmaceutical industry to use this plant (Gusso et al., 2015).

With regard to health benefits, expectations were opened about its cultivation as a new product to be explored and applied at social, agricultural, technological and scientific levels, in Brazil and worldwide (Santana and Cardoso, 2008). Yacon has been entering the market gradually, but there are no commercial studies or exact sales figures due to its relative novelty in the consumer market, which in turn reflects the low level of knowledge of the product. In addition, yacon production is still predominant in family agriculture, and is cultivated as an innovative non-conventional vegetable, mainly from a nutraceutical point of view. It is based on the concept of healthy food, setting the agronomic importance of its study (Oliveira et al., 2013).

One important research topic to be explored is the effect of weeds on yacon cultivation, since this crop has a relatively long cycle, up to 11-12 months, and slow initial growth (Silva et al., 2018b), the crop performance may be affected by weed interference (Seminario et al., 2003).

Weeds represent one of the biotic factors of horticultural cropping systems, affecting the growth, development, and productivity of these crops. When not properly managed, weeds can interfere in the plant development, competing for resources such as water, light, nutrients, and also releasing allelopathic substances, affecting crops and reducing yield and quality, interfering in crop management and harvest (Soares et al., 2003; Medeiros et al., 2016) .

Experiments with tuberous roots and tubers, such as cassava, carrot and potato, suggests that weed interference and inadequate management, especially in the initial development stage, contribute significantly to reduced yield (Silva and Silva, 2007; Blanco, 2008), demonstrating the demand of weed interference studies in yacon, to support decision making when managing this crop. The objective of this study was to evaluate the yacon initial growth and development under weed interference.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse, located in the city of Alegre, Espírito Santo state, Brazil, with geographic coordinates of -20.761833º S and 41.537026º W, during the months of April, May and June 2017. The climate of Southern Espírito Santo is classified, according to Köeppen, as type "Aw", with two well defined seasons during the year, hot and rainy between the months of October and March, and cold and dry between April and September, with average annual temperature of 23 ºC and rainfall of 1,200 mm (Pezzopane et al., 2012).

The experiment was conducted in a completely randomized design, with five treatments and seven replicates. The treatments were yacon growing under the interference of four weed species: *Cyperus rotundus* L. (nutgrass), *Commelina benghalensis* L. (tropical spiderwort), *Amaranthus viridis* L. (slender amaranth) and *Bidens pilosa* L. (hairy beggarticks); and control (weed-free yacon). Rhizomes were used as propagules for nutgrass (*C. rotundus* L.) and stolons for tropical spiderwort (*C. benghalensis* L.). Seeds were used for slender amaranth (*A. viridis* L.) and hairy beggarticks (*B. pilosa* L.).

In each pot, 50 seeds of slender amaranth and hairy beggarticks were randomly planted. Five nutgrass rhizomes, with a diameter of 1.0 cm, were planted arranged in a circle, and four stolons with four axillary buds were planted in "X", for tropical spiderwort. Plants were thinned 30 days after planting, reducing the weed population to 4 plants per pot, following a uniform and quantitative distribution of the plants. Weeds were then pruned (single time) at 10 cm from the soil, to simulate a mowing. Spontaneous plants not related to the study were removed weekly in all the pots throughout the study period.

Yacon rhizophores were transplanted right after the weed pruning. Rhizophores with 4 to 5 buds were previously sanitized using a sodium hypochlorite solution the 2% for 10 minutes to prevent contamination and planted at 5cm depth in plastic boxes (70 x 50 x 20 cm) filled with 20 kg of washed sand, where they remained for 15 days for conservation. Black plastic pots with 10 dm^3 of volume were filled with 20.0 kg of a mix of soil and composted bovine manure, in a ratio of 3:1 (v/v). Subsequently, two rhizophores were transplanted in each pot at 5 cm of depth.

The soil was classified as red-yellow latosol, medium texture (Santos et al., 2013), collected at depth 0-20, air dried and sieved in a 5 mm mesh. The soil sample (0-20 cm) was submitted to chemical analysis, resulting in the following: pH 6.64 in water, 17.79 mg dm^{-3} of P, 229 mg dm^{-3} of K, 7.0 Na dm^{-3}, 2.70 $cmol_c$ dm^{-3} Ca, 1.12 $cmol_c$ dm^{-3} Mg, 0.00 $cmol_c$ dm^{-3} Al, base saturation of 75%. The composted manure was also analyzed, presenting the following results: 13.019 g kg^{-1} N; 2.756 g kg^{-1} of P; 9.129 g kg^{-1} K; 6.193 g kg^{-1} Ca and 4.563 g kg^{-1} Mg.

The evaluations started at 30 days after transplanting and included, for agromorphological parameters: plant height, number of leaves, number of stems, leaf area, chlorophyll A, chlorophyll B and total chlorophyll (clorofiLOG; Falker, Porto Alegre, RS, Brazil). To estimate the leaf area, the leaf length was measured along the leaf midrib, from the base to apex without the petiole; and leaf width was measured perpendicular to the midrib from one end of the leaf to the other. These readings were then used to estimate the leaf area by applying the equation developed by Erlacher et al., 2016.

$\hat{A}fLW = -27.7418 + (3.9812\ LW / \ln LW)$; where L is the leaf length and W is the width.

After the end of the greenhouse experiment, yacon plants were collected, fractionated and weighed to obtain a fresh weight for thin and tuberous roots, rhizophores, stems and leaves. Roots and rhizophores were washed previously in running water. The plant fractions were oven dried until reaching a constant weight, to determine the dry biomass of rhizophores, tuberous roots, thin roots, stem, and leaves. Roots with a diameter larger than 0.5 cm were classified as tuberous and the remaining were considered thin roots (Machado et al., 2004).

The data were submitted to analysis of variance using the F test ($p>0.05$), and when significant, means were separated using Tukey test ($p>0.05$).

RESULTS AND DISCUSSION

Yacon (*Smallanthus sonchifolius*) initial growth (90 days) was affected by weed interference, with *Commelina benghalensis* and *Amaranthus viridis* as the most competitive species reducing yacon development, decreasing plant height, leaf area, number of stems and leaves. *Bidens pilosa* and *Cyperus rotundus* less affected the crop comparing to the other weeds (Table 1).

Table 1 - Plant height, number of shoots, number of leaves and leaf area (LA) in yacon 90 days after planting under weed interference

Weed	Yacon growth			
	Height (cm)	NS	NL	LA (cm^2)
Hairy beggarticks	26.85 b	2.61 b	17.52 b	192.10 b
Tropical spiderwort	21.38 c	2.14 bc	12.95 c	148.27 c
Nutgrass	33.23 a	2.66 b	19.09 b	284.76 a
Slender amaranth	22.57 c	2.04 c	14.57 c	147.08 c
Control (weed-free)	34.80 a	3.76 a	24.33 a	299.74 a
CV (%)	12.55	24.08	15.14	15.32

Means followed by the same letter in the same column do not differ by Tukey's test ($p > 0.05$). CV: coefficient of variation. Number of shoots (NS), number of leaves (NL) and leaf area (LA).

These results demonstrate the yacon sensibility to competition with some weeds in the early crop cycle stages, indicating the requirement of management techniques for these plants, since this crop has a long cycle plant (8-12 months) and slow initial growth (Silva et al., 2018a), providing a favorable growth window for the weeds and allowing them to compete for resources, mainly water and nutrients.

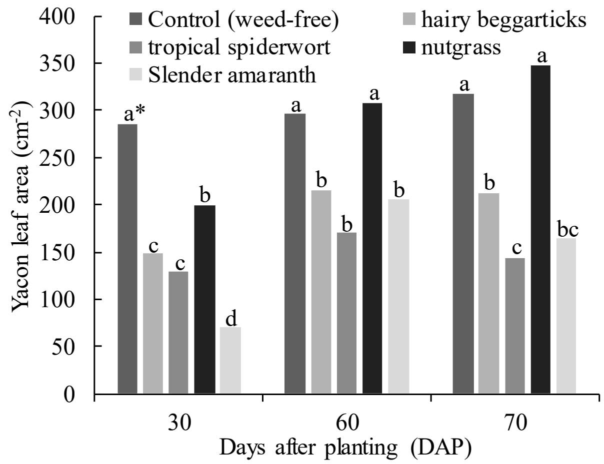
It is important to highlight that the significant effects of weed competition on yacon were observed along the crop cycle, resulting in plant leaf area reduction, with *C. benghalensis* and *A. viridis* L. (slender amaranth) as the weeds causing more interference in the development of yacon. Additionally, one important result was *C. rotundus* always being the least prejudicial to yacon (Figure 1).

The higher competitive ability observed for *A. viridis*, *C. benghalensis* may be explained for the more efficient growth of these species, since both accumulated more shoot biomass, and *A. viridis* also presented higher biomass for the root system, whereas *C. rotundus* was the weed with lower biomass accumulation (Table 2).

Table 2 **-** Dry mass of weed shoots (WS) and roots (WR)

Weed	Weed growth (g per pot)	
	WS	WR
Hairy beggarticks	18.25 c	3.00 b
Tropical spiderwort	26.71 a	3.42 b
Nutgrass	2.00 d	2.71 b
Slender amaranth	24.57 b	4.71 a
CV (%)	6.21	29.0

Means followed by the same letter in the same column do not differ by Tukey's test (p>0.05). CV: coefficient of variation.



* Means followed by the same letter in the same column do not differ by Tukey's test (p>0.05).

Figure 1 **-** Foliar area of yacon plants under weed interference in three evaluation time points.

In addition to the fact of competition, certain weed species have the allopathic potential, with the release of substances by means of exudates from roots, and or leachate. These substances impair growth and hamper the normal development of established plants (Trezzi and Vidal, 2004). For nutgrass, *Cyperus rotundus*, for example, the allelopathic effect from extracts obtained from its rhizomes is known (Andrade et al., 2009).

The effects of weed interference may also be demonstrated by the leaf chlorophyll content of yacon plants. The weeds, with exception to *C. rotundus*, led to a decrease in the total chlorophyll content in relation to control, with emphasis again for *C. benghalensis* and *A. viridis*, since these species resulted in more substantial decreases. For chlorophyll A in yacon leaves, only *C. benghalensis* and *A. viridis* affected it negatively. Relatively to chlorophyll B, once again the *C. benghalensis* and *A. viridis* most affected this parameter, but *B. pilosa* also reduced the yacon chlorophyll concentration (Table 3).

The biomass accumulation in the initial phase of the yacon cycle (90 days after transplanting) was reduced by weed competition, and from the studied weeds, *A. viridis* caused more reduction in plant growth, since less fresh biomass weight was observed for all plant sections, including stem, leaves, rhizophores, fine roots and tuberous roots (Table 4).

When the results for fresh biomass of tuberous roots are analyzed, becomes evident how weeds are capable of interfering in plant development and commercial production of yacon, since the tuberous roots are main plant part to be consumed. The effect of competition on yacon yield varies for each weed, but in some situations, the yield reduction may reach 67%, as observed for *A. viridis* (Table 4). Other weed species were less competitive to yacon, resulting in less reduction, such as *C. rotundus* which resulted in 6% of yield loss (Table 4).

The more efficient competition of *A. viridis* is related to its faster plant development, especially for the root system (Table 2), providing to the plant more ability to compete more aggressively for

Table 3 **-** Chlorophyll A, chlorophyll B and total chlorophyll of yacon plants under weed interference

Weed	Chlorophyll in yacon		
	Chlorophyll A	Chlorophyll B	Total Chlorophyll
Hairy beggarticks	26.47 a	7.09 bc	33.42 bc
Tropical spiderwort	23.85 b	6.33 c	30.19 cd
Nutgrass	26.71 a	8.23 ab	34.76 ab
Slender amaranth	23.61 b	6.00 c	29.47 d
Control (weed-free)	27.80 a	9.14 a	36.85 a
CV (%)	9.26	16.68	9.54

Means followed by the same letter in the same column do not differ by Tukey's test (p>0.05). CV: coefficient of variation.

Table 4 **-** Fresh biomass of stem, leaves, rhizophores, thin and tuberous roots in yacon plants under weed interference

Weed	Yacon fresh biomass (g per plant)				
	SFB	LFB	RIZFM	TRFB	TRFB
Hairy beggarticks	38.52 c	57.91 c	35.28 b	26.28 c	45.88 d
Tropical spiderwort	35.28 c	54.71 c	36.04 b	28.90 c	58.07 c
Nutgrass	59.00 b	110.00 b	35.42 b	39.00 b	104.28 b
Slender amaranth	21.28 d	47.28 d	28.00 c	17.28 d	36.42 e
Control (weed-free)	73.11 a	126.14 a	47.85 a	43.31 a	111.82 a
CV (%)	7.13	4.63	8.37	6.10	6.19

Means followed by the same letter in the same column do not differ by Tukey's test (p>0.05). CV: coefficient of variation. Fresh biomass of stems (SFB), leaves (LFB, rhizophores (RIZFM), thin roots (TRFB) and tuberous roots (TRFB).

water and nutrients, reducing the formation of tuberous roots in yacon. Similar results were observed for the potato crop, where the production of tubers was negatively affected by weed interference, leading to losses varying between 6.0 and 60%, and this variation was related to the presence of weeds with different competitive capacity (Costa et al., 2008).

The results for dry biomass production in the different parts of the yacon plants were similar to the trends observed before and already discussed, where the weed competition affected the yacon crop, with *A. viridis* leading to more intense reduction in the accumulation of dry biomass for all parts of the yacon plant, and the *C. rotundus* being the species that least affected, with results for rhizophores and thin roots not differing from the control (weed-free yacon) for dry biomass of rhizophores and fine roots (Table 5).

Plant dry biomass production responds to efficient vegetative growth and adequate formation of shoots and leaves since these parts have an essential function for optimal photosynthesis. Thus, it is observed that yacon was negatively affected by weed competition in different levels, according to the aggressiveness of each specie, since weeds may limit crop production when not correct managed (Pitelli, 1985).

Table 5 **-** Dry biomass of stem, leaves, rhizophores, thin and tuberous roots in yacon plants under weed interference

Weed	Yacon dry biomass (g per plant)				
	SDB	LDB	RIZDM	TRDB	TRDB
Hairy beggarticks	4.14 c	7.40 c	4.42 c	3.14 bc	5.14 d
Tropical spiderwort	2.85 d	5.71 d	5.00 bc	2.57 c	7.57 c
Nutgrass	6.00 b	14.00 b	6.42 ab	4.85 a	12.00 b
Slender amaranth	2.75 d	5.71 d	5.00 c	2.57 c	4.28 d
Control (weed-free)	8.00 a	17.85 a	7.28 a	4.00 ab	14.57 a
CV (%)	21.01	8.92	15.68	25.62	11.42

Means followed by the same letter in the same column do not differ by Tukey's test (p>0.05). CV: coefficient of variation. Dry biomass of stems (SDB), leaves (LDB), rhizophores (RIZDM), thin roots (TRDB) and tuberous roots (TRDB).

The development and initial growth of yacon (*Smallanthus sonchifolius*) were affected by weed interference, with *A. viridis* as the most competitive and *C. rotundus* less affecting the yacon crop.

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