ACCUMULATION OF MACRONUTRIENTS IN COWPEA AND WEEDS IN COMPETITION AND UNDER SOIL WATER DEFICIT

ACUMULAÇÃO DE MACRONUTRIENTES EM FEIJÃO-CAUPI E PLANTAS DANINHAS EM COMPETIÇÃO E SOB DÉFICIT HÍDRICO NO SOLO

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ABSTRACT: The ability of a plant species to succeed in colonization of agroecosystem depends on its efficiency in the use of growth resources even in deficient conditions. The present study aimed to evaluate the effects of competition and water deficit in the soil on the accumulation of macronutrients of *Vigna unguiculata* L. Walp., *Commelina benghalensis* L. and *Waltheria indica* L. The study was conducted in a greenhouse, in randomized block design, with four replications. The treatments were arranged in a 5 × 2 factorial, with the first factor corresponding to types of interaction among species (*V. unguiculata* + *C. benghalensis*; *V. unguiculata* + *W. indica*; *V. unguiculata* in monoculture, *C. benghalensis* in monoculture and *W. indica* in monoculture), and the second of water regimes (irrigated and water deficit). The water deficit differently affects macronutrient content on the species, with decreased of K, Ca and Mg in cowpea, and N, P, K and Ca in *W. indica*. For *C. benghalensis*, the water deficit does not reduce the macronutrient contents on the plant. The competition between plants intensifies the effects of water deficit only on *C. benghalensis*, with a decreased on the content of all macronutrients studied. Under irrigated conditions, competition between plants was more damaging the weeds compared to cowpea. The *C. benghalensis* specie, free from interference, has a high potential for nutrient extraction under irrigated and water deficit regimes.

KEYWORDS: *Vigna unguiculata*. *Commelina benghalensis*. *Waltheria indica*. Interference. Water stress. Mineral nutrition.

INTRODUCTION

The cowpea (*Vigna unguiculata* L. Walp.) is one of main food sources of tropical and subtropical regions of world, capable of developing on the most diverse climate and soil conditions. It is one of main components of essential food diet of the poorest populations, has high nutritional value in minerals and proteins, and might be significant source of employment and income (FREIRE FILHO et al., 2011; SOUSA et al., 2015).

In tropical Brazilian conditions, at certain times of year, crop areas are prone to occurrence of periodic droughts, known as "Indian summers", which cause severe socioeconomic losses to rural population, which depends on the production of crops in drought regime for subsistence (SILVA et al., 2010; FREITAS et al., 2017).

The water deficit in soil caused by the "Indian summer" has been one of the main limiting factors for obtaining high productivity, on a regular basis, over the years, influencing almost all the characteristics related to growth and development of cowpea (FREITAS et al., 2014; SOUZA et al., 2017).

Another factor that has contributed to decrease of cowpea productivity is incorrect management of weeds, which can cause up to 90% decreased of crop production (FREITAS et al., 2009). This is due mainly to competition between the cultivated species and the weeds by vegetable growth resources such as water, light, and nutrients (ZANINE; SANTOS, 2004).

The occurrence of competition with weeds by water can anticipate and/or intensify the deleterious effects of water stress due to low availability of water to plants (CRAINE; DYBZINSKI, 2013). Among these effects, it is possible to emphasize the reduction on the nutrient absorption and of quantities required by the plants

Received: 16/05/18
Accepted: 10/12/18

(GONZALEZ-DUGO; DURAND; GASTAL, 2010; LEÃO; FREIRE; MIRANDA, 2011; DODD et al., 2015). Soil water deficit can reduce the absorption, accumulation, partition and nutrient utilization by plants, due to effect on the decrease of root growth, and by the fact that water is the vehicle through which the mineral nutrients move from the solution of soil to roots of plants, especially when this transport occurs by mass flow and diffusion, that is, all mechanisms of transport of nutrients in soil are affected (BARBER, 1974; MARSCHNER, 1995; HU; SCHMIDHALTER, 2005).

The effects of interspecific competition in mineral nutrition of plant were reported in divers crops, such as coffee (RONCHI et al., 2007), maize (CURY et al., 2012; MELO et al., 2015) and common bean (CURY et al., 2013). However, there is little information on the effects of competition when water is a limiting factor for the species, which reinforces the need for their determinations, aiming to improve the understanding of competition relations between plants, especially when interacting species of plants with different competitive ability. This information is essential for optimizing crop yields in agricultural systems.

Based on these considerations, it was hypothesized that competition between plants for water could aggravate the deleterious effects of water deficit, affecting the absorption and the content of macronutrients. The intensity of these effects might vary between the species involved under water competition and their survival strategies under water deficit conditions.

The objective of present study was to evaluate the effects of competition and water deficit in soil on the macronutrients content of cowpea, *Commelina benghalensis*, and *Waltheria indica*.

MATERIAL AND METHODS

The study was undertaken in a greenhouse, in the municipality of Mossoro-RN. The experimental unit was a plastic vessel with a volumetric capacity of 10 dm^{-3}, containing sample of Eutrophic Hapol Plantain (EMBRAPA, 2013), collected in the 0-20 cm surface layer, with the following characteristics: pH (water) = 6.5; organic matter = 1.0 dag kg^{-1}; P, K and Na = 7.2; 64.4 and 3.2 mg dm^{-3}; Ca, Mg, Al, H + Al, and effective CTC = 2.5; 1.8; 0.0; 0.0 and 4.5 $cmol_c$ dm^{-3}, respectively; sand, silt and clay = 820.0; 120.0 and 50.0 g kg^{-1}, respectively; with sand texture. The soil was fertilized based on the recommendations of IPA (2008), with the application in planting of 14.98; 23.66 and 10 mg dm^{-3} of P_2O_5, N and K_2O, respectively.

The experimental design was a randomized block design, with four replications. The treatments were arranged in a 5 × 2 factorial scheme, with the first factor consisting of the types of competition between the evaluated species (competition) [*V. unguiculata* + *C. benghalensis* (V + C); *V. unguiculata* + *W. indica* (V + W); *V. unguiculata* without competition (V); *C. benghalensis* without competition (C); and *W. indica* without competition (W)], and the second of the water regimes (irrigated and water deficit).

The cowpea cultivar was BRS Guariba, with an indeterminate growth habit, semi-erect and cycle of 65-70 days (GONÇALVES et al., 2009). *W. indica* and *C. benghalensis* seeds were collected in a same cowpea crop area and submitted to procedures to overcome dormancy (seeds subjected to cutting the region opposite to the hilum). The seeds underwent preliminary germination and emergency tests to establish the ideal seeding period for the simultaneous emergence of these species.

Thinning was performed 5 days after plant emergence, leaving the same density of weed and crop (one plant per pot). In cases of co-cultivation of cowpea and weed (competition), cowpea and weeds seeds were sown in the center and border of each experimental unit, respectively.

Irrigations were performed daily to maintain moisture of soil above 70-80% of the field capacity. The volumes of water applied to each vessel was calculated by the difference between the vessel weight in its field capacity, that was previously determined, and the weight at the end of each day, following a methodology described by Sousa et al. (2015).

When cowpea plants had grown their second definitive leaf trifolium - (phenological stage V4 - 40 days after emergence), the imposition of water regimes (irrigated and water deficit) was initiated. The irrigated treatment plants continued to receive daily irrigation as described, and those on the water deficit treatment had their irrigation totally suspended, so that stress was the result of the gradual exhaustion of the water of soil. The duration of the water deficit was maintained until the rate of assimilation of CO_2 (A) of cowpea plants reached values close to zero, which occurred after 11 days of irrigation suspension. From that moment, irrigation was reestablished, maintaining the humidity close to the field capacity. A was measured with the aid of an infrared gas analyzer (IRGA, portable model LI-6400, LI-COR Biosciences).

At 21 days of evaluation, when occurred the recovery of the *A* of plants submitted to the water deficit treatment, cowpea and weeds were harvested, fractionated them in leaves, stems, and roots. Then the vegetable material was washed in distilled water and then oven dried with forced air circulation at 65 °C until reaching the constant mass. Then, all the dry mass was milled in a Wiley type mill, homogenized and stored in an airtight container. Samples of this material were used to determination of macronutrient contents in the vegetative components of cowpea and weeds. The nitrogen (N) concentrations were determined by Kjeldahl method in the sulfuric acid digestion extract. After nitric-perchloric acid digestion, the phosphorus (P) contents were determined by colorimetry and potassium (K) by flame photometry, and calcium (Ca) and magnesium (Mg) by atomic absorption spectrophotometry, following the methodology described by Malavolta, Vitti e Oliveira (1997). From the dry mass of each fraction and their respective nutrient contents, the macronutrient contents was calculated.

For interpretation of the results, the data were submitted to analysis of variance using the F test ($p \leq 0.05$) and, in the cases of significance, the averages were compared by Tukey's test at 5% probability level. The statistical software used was SISVAR® 5.6.

RESULTS AND DISCUSSION

The macronutrient accumulation potential of cowpea and weed free from interference and under irrigated conditions can be verified in Table 1. It was observed that, on average, cowpea has higher macronutrient contents in plant compared to weeds. This result is directly related to higher productivity of dry mass of crop (data not shown) and, coincides with those found by Favero et al. (2000), which indicate that the amount of nutrients accumulated is proportional to amount of biomass produced, varying the absorption efficiency among species.

Table 1. Macronutrient content on the vegetative components of cowpea, *Commelina benghalensis* and *Waltheria indica*, cultivated without competition, under irrigated and water deficit regimes

Species	N (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V	166.29aA	172.99aA	80.26aA	77.23bA	24.43aB	46.83aA	270.98aA	297.04aA
C	114.59bA	129.20bA	63.88aB	102.33aA	9.92bA	6.48bA	188.40bA	238.0bA
W	29.43cB	101.99bA	6.66bA	27.40cA	3.63bA	12.95bA	39.72cB	142.34cA
CV (%)	23.72		25.31		25.00		19.91	
Species	P (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V	40.59aA	39.14aA	22.34aA	25.84aA	5.21aA	7.28aA	68.14aA	72.26aA
C	15.64bA	13.43bA	24.39aB	32.32aA	1.96bA	2.51bA	41.99bA	48.27bA
W	8.85bB	30.41aA	3.60bB	10.45bA	1.64bA	3.71bA	14.09cB	44.57bA
CV (%)	24.16		22.76		29.80		23.33	
Species	K (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V	98.08aB	150.55aA	98.94bB	136.73bA	12.14aB	25.93aA	209.16bB	313.21aA
C	123.14aA	135.32aA	134.89aB	170.46aA	11.40aA	7.44bA	269.42aA	313.22aA
W	18.91bB	72.07bA	12.29cA	37.93cA	3.02bA	5.21bA	34.22cB	115.21bA
CV (%)	22.28		21.14		20.90		17.70	
Species	Ca (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V	15.08aB	26.04aA	1.94bB	15.29aA	1.32aB	4.87aA	18.34aB	46.19aA
C	5.30bA	7.77cA	16.30aA	18.37aA	0.83aA	1.24bA	22.42aA	27.38bA
W	5.31bB	14.25bA	1.88bA	5.17bA	0.39aA	1.12bA	7.57bB	20.55bA
CV (%)	27.85		26.16		20.46		26.83	

Species	Mg (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V	3.45aB	7.01aA	2.97aA	4.19aA	0.63aA	0.86bA	7.05aB	12.06aA
C	2.75aA	2.85bA	4.21aA	4.69aA	0.66aA	0.46abA	7.62aA	7.99bA
W	0.96bB	2.42bA	0.28bA	0.84bA	0.05bA	0.23bA	1.29bA	3.50cA
CV (%)	27.69		25.39		28.48		28.83	

V= *Vigna unguiculata*; C= *Commelina benghalensis*; W= *Waltheria indica*; CV= Coefficient of variation; WD= Water deficit; Averages followed by the same lowercase letter (in the column) and upper case (in the line) do not differ for each variable at the 5% probability level by Tukey's test.

The nutrients most absorbed by cowpea were N, K, and P, while the smaller were Ca and Mg (Table 1). Fonseca et al. (2010), in a study with cowpea, cultivar BR3-Tracuateua, cultivated in a dystrophic Xanthic Ferralsol in the northern region of Brazil, recorded that the order of macronutrients extraction by the plant was N> K> Ca> Mg> P.

C. benghalensis was high content of macronutrients compared to *W. indica*. It was observed values, in mg plant^{-1}, of 238.0 to N, 48.3 to P, 313.2 to K, 27.4 to Ca and 8.0 to Mg. (Table 1). Favero et al. (2000) evaluating the performance of spontaneous and leguminous species, including *C. benghalensis*, also observed that K and N are the macronutrients most accumulated by plant, while the smaller was P, Ca and Mg.

As for the species *W. indica*, were verified contents of 142.3; 44.6; 115.2; 20.5 and 3.5 mg plant^{-1} for N, P, K, Ca and Mg, respectively (Table 1). In a study with weed *Sida rhombifolia*, belonging to same family of *W. indica*, Bianco, Carvalho e Bianco (2014) observed, at 77 days after emergence, the following decreasing order of macronutrient accumulation: N> K> P> Ca> Mg.

The difference in total extraction order of P for cowpea and weeds observed by the other researchers mentioned above, in compared to present study, might be related to forms and degree of availability of phosphorus in experimental area, which vary with the soil and climatic conditions and management of fertilization (FINK et al., 2016).

Analyzing the effect of water regime in species without competition (Table 1). The irrigation suspension decreased the contents of K, Ca and Mg, in order of 33, 60 and 42%, compared to irrigated treatment. On the leaves of cowpea, the water deficit treatment decreased the contents of K, Ca and Mg, in order of 34, 41 and 51%, respectively, compared to irrigated treatment plants. On the stem, this reduction was observed for K and Ca, in 27 and 87%, respectively. As for the root, the water deficit decreased the contents of N, K and Ca, in order of 48, 53 and 73%, respectively, compared to irrigated treatment plants (Table 1).

For *C. benghalensis* specie, the water deficit did not change the total content of macronutrients (Table 1). This result can be related the effect of concentration of these nutrients (MAUAD; CRUSCIOL; GRASSI FILHO, 2011), due to limited growth of species on the water deficient conditions (OLIVEIRA et al., 2018). Another probable explanation is that the rehydration and recovery of water status of plant increased the concentrations of macronutrients to values similar to those measured in irrigated plants. Regarding the organs, the irrigation suspension affected only the contents on the stem, which has reduction for N, P and K, in order of 37, 24 and 21%, respectively, compared to irrigated treatment. The decreased on the contents in this compartment might be due to change in partition of these nutrients on the plant in response to water deficit, favoring the contents in leaves and roots to detriment of stem. This increase in proportion of N, P and K translocation to leaves and roots probably is because they are most active organs of plant and the high capacity of remobilization and internal redistribution of these elements (MENGEL; KIRKBY, 1982).

As for *W. indica*, the water deficit decreased the total content of all macronutrients, except for Mg (Table 1). It was observed reductions of 72, 68, 70 and 63% for N, P, K and Ca, respectively, compared to irrigated plants. Evaluating the effect in each organ, on the leaves, water deficit decreased the N, P, K, Ca and Mg contents, in order of 72, 71, 74, 63 and 58%, respectively, compared to irrigated treatment, on the stem, in its turn, the reduction was observed only for P (65%), while on the root, no effect of water deficit was observed. This behavior is a reflection of the root dry mass was not affected by the water deficit (OLIVEIRA et al., 2018).

Possible explanations for reduction of the absorption and content of the macronutrients on the water deficient condition include the limitation of transport of ions to roots, which occur by the diffusion mechanisms (P and K) and mass flow (N, Ca and Mg), which are processes that depend on the moisture content of the soil (HU;

SCHMIDHALTER, 2005); the reduction of root growth and its capacity on the macronutrients absorption and translocation, due possibly to process of root suberization (BARBERON et al., 2016) and the reduction of transpiration caused by the stomata closure in plants to minimize water losses (TANGUILIG et al., 1987); and increased mechanical impediment of dry soil for root growth, which limiting the volume of soil explored for nutrient acquisition (GARG, 2003; LEÃO; FREIRE; MIRANDA, 2011). The water deficit can also reduce the dry mass of plant (OLIVEIRA et al., 2018), and thus reduces the demand for nutrients.

For cowpea plants in the irrigated treatment (Table 2), it was observed that, independently of weed, competition decreased only the total Ca content. This result is due to weeds have a high capacity of extraction of this nutrient, which resulted in a lower nutrient concentration on the soil solution, with a consequent reduction of mass flow, that is the main mechanism of transport of the calcium to roots.

Analyzing the effect of competition in each organ of cowpea, on the leaves, the interference of *W. indica* increased the content of P, in order of 31%, compared to treatment without competition. Similar results were found by Medeiros et al. (2016), which obtained an increase on the concentration of P on the leaves in clones of *Eucalyptus grandis* when submitted to competition with *Ipomoea nil* species. However, competition with *C. benghalensis* decreased Ca and Mg contents in 32 and 23%, respectively. On the stem, the competition decreased only the Ca content, and the higher effects was under interference of *W. indica* specie, which decreased in approximately 84% of total content. For the root, competition with *C. benghalensis* increased the K content, in order of 44%, compared to treatment without competition. The K transport to plant root occurs preferentially by diffusion, owing to a concentration gradient generated on the root surface. Therefore, in competition with cowpea, the *C. benghalensis* specie, owing to its high K extraction capacity, might have decreased the K concentration near the roots of crop, and thus favoring the concentration gradient and, consequently, the diffusive flux and the supply of K to cowpea (OLIVEIRA et al., 2010).

Table 2. Macronutrient content on the vegetative components of cowpea in competition with *Commelina benghalensis* and *Waltheria indica*, under irrigated and water deficit regimes

Species	N (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V[1]	166.29aA	172.99aA	80.26aA	77.23abA	24.42aB	46.83aA	270.98aA	297.04aA
V + C	176.20aA	183.93aA	60.55abA	57.66bA	36.29aA	42.62aA	273.04aA	284.21aA
V + W	172.71aA	176.19aA	51.79bB	83.97aA	33.16aA	38.09aA	257.65aA	298.25aA
CV (%)	12.82		21.28		27.08		13.34	
Species	P (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V[1]	40.59aA	39.14bA	22.34aA	25.84aA	5.21bA	7.28aA	68.14aA	72.26aA
V + C	39.36aA	47.34abA	21.83abA	19.10aA	12.24aA	7.76aB	73.43aA	74.19aA
V + W	28.04bB	51.08aA	14.76bB	23.44aA	6.63bB	11.20aA	49.43bB	85.73aA
CV (%)	17.52		23.43		32.82		14.04	
Species	K (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V[1]	98.08aB	150.55abA	98.94aB	136.73aA	12.14abB	25.93bA	209.16aB	313.21aA
V + C	112.62aB	163.31aA	94.40aB	133.27aA	20.15aB	37.40aA	227.18aB	333.97aA
V + W	110.54aA	124.77bA	85.41aA	112.92aA	11.84bB	27.85bA	207.79aA	265.53aA
CV (%)	19.78		21.87		23.71		17.90	
Species	Ca (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V[1]	15.08aB	26.04aA	1.94aB	15.29aA	1.32bB	4.87aA	18.34aB	46.19aA
V + C	19.21aA	17.67bA	1.72aB	8.83bA	2.81abA	3.45aA	23.73aA	29.94bA
V + W	15.61aA	19.34bA	3.43aA	2.49cA	4.12aA	3.37aA	23.16aA	25.20bA
CV (%)	19.63		32.32		28.32		19.90	
Species	Mg (mg plant^{-1})							
	Leaf		Stem		Root		Total	

	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
V[1]	3.45aB	7.01aA	2.97aA	4.19aA	0.63aA	0.86aA	7.05aB	12.06aA
V + C	4.55aA	5.37bA	2.52aA	3.30aA	0.85aA	1.83aA	7.92aB	12.90aA
V + W	4.03aB	6.78abA	2.23aA	3.11aA	0.79aA	0.77aA	7.05aB	10.66aA
CV (%)	20.87		28.32		27.77		17.48	

[1]*Vigna unguiculata* cultivated without the interference of weeds; V= *Vigna unguiculata*; C= *Commelina benghalensis*; W= *Waltheria indica*; CV= Coefficient of variation; WD= Water deficit; Averages followed by the same lowercase letter (in the column) and upper case (in the line) do not differ for each variable at the 5% probability level by Tukey's test.

In the literature, researchers have demonstrated that the effects of weed competition affect macronutrient contents in other crops, such as maize (CURY et al., 2012; MELO et al., 2015) and common bean (CURY et al., 2013; OLIVEIRA et al., 2017).

Regarding the effect of competition on cowpea under water deficit condition (Table 2), it was verified that the competition did not alter the contents of macronutrients in plant, except for *W. indica*, which decreased by 28% the content total P in cowpea. This behavior is a reflection of higher competitive capacity by the water of this weed under water deficit conditions (OLIVEIRA et al., 2018). As P is transported to roots mainly by diffusion, the reduction of soil moisture decreased the water film thickness inside the pores, increasing the tortuosity of diffusive path, and decreased the value of diffusion coefficient (OLIVEIRA et al., 2010). Concerning the contents between the organs of plant, it was observed that the competition with *W. indica* decreased the P content (in 31%) on the leaves, and the contents on the stem of N and P, in order of 35 and 34 %, respectively. For the root, competition, except for *C. benghalensis*, which resulted in higher P content in cowpea, did not affect the macronutrient content. In a study developed by Cury et al. (2013), the authors observed that *C. benghalensis* was the specie with the smaller competition capacity, because it promoted the lower reduction of nutrient content in common bean.

In general, it was verified macronutrient contents in cowpea were affected in a differentiated way in function of water regime and competition with weeds. These results evidenced the variation on the culture regarding the competitive ability and capacity to extract, accumulate and redistribute these nutrients when under these conditions.

For *C. benghalensis*, under irrigated conditions, competition with cowpea decreased the N, P, K, Ca and Mg total contents, in order of 81, 81, 85, 68 and 72%, respectively, compared to treatment without competition (Table 3). On the leaves, except for Ca, the competition decreased the contents of all macronutrients, in 78, 70, 83 and 63% for N, P, K and Mg, respectively. For the stem, this reduction was 91, 89, 89, 85 and 83% for N, P, K, Ca and Mg, respectively. On the root, no statistical difference was verified for the competition effect.

Evaluating the competition effect under water deficit conditions in *C. benghalensis* (Table 3), it was verified reductions of 82, 82, 85, 77 and 80% for N, P, K, Ca, and Mg, respectively, with the interference of cowpea. These results demonstrated the lowest competitive potential of this species with the culture. In relation to competition effect on the contents between the organs, on the leaves, it was observed a decreased of N, P, K and Mg contents, in order of 82, 84, 85 and 76%, respectively, compared to treatment without competition. As for the stem, the N, P, K, Ca and Mg contents were decreased by 84, 84, 86, 94 and 81%, respectively. On the root, crop interference decreased the N, K, and Mg contents in the order of 73, 71 and 88%, respectively, compared to plants without competition.

In relation to *W. indica* (Table 4), under irrigated conditions, competition with cowpea decreased the N, P, K, Ca and Mg contents on the plant in 89, 91, 90, 96 and 91%, respectively, compared to plants without competition. As for the organs, on the leaves, competition decreased by more than 90% the contents of all macronutrients. On the stem, it was verified the decreased of 87, 88, 90, 99 and 89% for N, P, K, Ca and Mg, respectively. For the root, the competition resulted in estimated losses of 87, 84, 86, 87 and 92% in the N, P, K, Ca and Mg contents, respectively.

Table 3. Macronutrient content on the vegetative components of *Commelina benghalensis* in competition with cowpea under irrigated and water deficit regimes

Species	N (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
C[1]	114.59aA	129.19aA	63.88aB	102.32aA	9.92aA	6.47aA	188.39aB	238.0aA
C + V	20.64bA	27.92bA	10.31bA	8.55bA	2.66bB	8.22aA	33.62bA	44.69bA
CV (%)	24.51		29.92		20.27		19.71	
Species	**P (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
C[1]	15.63aA	13.43aA	24.39aB	32.32aA	1.96aA	2.50aA	41.99aA	48.26aA
C + V	2.45bA	4.07bA	3.83bA	3.56bA	1.40aA	1.65aA	7.68bA	9.29bA
CV (%)	27.72		25.70		22.29		20.11	
Species	**K (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
C[1]	123.13aA	135.32aA	134.89aB	170.46aA	11.39aA	7.44aA	269.42aA	313.22aA
C + V	17.55bA	22.46bA	19.0bA	18.09bA	3.25bA	7.04aA	39.81bA	47.59bA
CV (%)	25.25		22.57		24.47		18.44	
Species	**Ca (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
C[1]	5.29aA	7.77aA	16.30aA	18.36aA	0.82aA	1.24aA	22.42aA	27.38aA
C + V	4.12aA	5.03aA	0.97bA	2.73bA	0.11aA	1.09aA	5.20bA	8.86bA
CV (%)	28.43		20.23		26.47		27.69	
Species	**Mg (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
C[1]	2.74aA	2.85aA	4.21aA	4.69aA	0.66aA	0.45aA	7.61aA	7.99aA
C + V	0.64bA	1.05bA	0.79bA	0.77bA	0.08bA	0.36aA	1.51bA	2.19bA
CV (%)	23.72		22.92		22.58		30.22	

[1]*Commelina benghalensis* cultivated without the interference of cowpea; V= *Vigna unguiculata*; C= *Commelina benghalensis*; CV= Coefficient of variation; WD= Water deficit; Averages followed by the same lowercase letter (in the column) and upper case (in the line) do not differ for each variable at the 5% probability level by Tukey's test.

Table 4. Macronutrient content on the vegetative components of *Waltheria indica* in competition with cowpea under irrigated and water deficit regimes

Species	N (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
W[1]	29.42aB	101.98aA	6.66aB	27.40aA	3.62aB	12.94aA	39.72aB	142.34aA
W + V	11.54aA	9.79bA	3.37aA	3.38bA	2.62aA	1.63bA	17.53aA	14.81bA
CV (%)	28.22		26.88		26.03		24.15	
Species	**P (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
W[1]	8.85aB	30.40aA	3.59aB	10.45aA	1.64aB	3.71aA	14.09aB	44.57aA
W + V	1.28aA	1.86bA	1.19aA	1.26bA	0.37aA	0.57bA	2.86aA	3.70bA
CV (%)	28.25		22.52		29.02		21.64	
Species	**K (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
W[1]	18.91aB	72.07aA	12.28aB	37.93aA	3.02aA	5.21aA	34.22aB	115.21aA
W + V	7.60aA	6.58bA	2.92aA	3.90bA	0.92aA	0.71bA	11.44aA	11.20bA
CV (%)	29.06		26.16		23.84		26.02	
Species	**Ca (mg plant^{-1})**							
	Leaf		**Stem**		**Root**		**Total**	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated

W[1]	5.30aB	14.25aA	1.87aB	5.17aA	0.39aB	1.12aA	7.57aB	20.54aA
W + V	1.22aB	0.59bA	0.09aA	0.04bA	0.07aA	0.15bA	1.40aA	0.78bA
CV (%)	26.54		21.19		26.19		23.99	

Species	Mg (mg plant^{-1})							
	Leaf		Stem		Root		Total	
	WD	Irrigated	WD	Irrigated	WD	Irrigated	WD	Irrigated
W[1]	0.96aB	2.42aA	0.28aB	0.84aA	0.05aB	0.23aA	1.29aB	3.49aA
W + V	0.42aA	0.19bA	0.08aA	0.09bA	0.12aA	0.02bA	0.63aA	0.30bA
CV (%)	20.56		24.92		23.44		25.79	

[1]*Waltheria indica* cultivated without the interference of cowpea; V= *Vigna unguiculata*; W= *Waltheria indica*; CV= Coefficient of variation; WD= Water deficit; Averages followed by the same lowercase letter (in the column) and upper case (in the line) do not differ for each variable at the 5% probability level by Tukey's test.

Despite being considered good competitors, weeds were also negatively affected by effects of crop competition, with decreased macronutrient content. Bianco, Carvalho e Bianco (2014), evaluating the mineral nutrition of the weed *Sida rhombifolia*, recorded that, individually, a plant does not present high competition potential for nutrients, however, the authors comment that in cases if dense populations are established, the extraction of nutrients from the soil can be very intense, and affecting the growth and productivity of agricultural crops. This fact occurs because the weed effect is not caused by its individual competitive capacity, but rather by the total population of the weed community (VILÀ; WILLIAMSON; LONSDALE, 2004; BIANCHI; FLECK; LAMEGO, 2006).

However, when analyzing the effects of competition of the cowpea on the *W. indica* specie under water deficit conditions (Table 4), it was observed that the competition did not affect the total macronutrients contents. In the same way, the competition did not alter the content of macronutrients in any of organs on the plant. This result demonstrates the high competitive capacity of this species by nutrients under water deficient conditions. This behavior is mainly owing to adaptation mechanism to water deficit of this species, which invests on the growth of its roots and the water extraction from the soil in very negative water potentials (OLIVEIRA et al., 2018) and, thus, maintains the absorption and nutrients accumulation on the plant.

CONCLUSIONS

The water deficit differently affects macronutrient content on the species, with decreased of K, Ca and Mg in cowpea, and N, P, K and Ca in *W. indica*. For *C. benghalensis*, the water deficit does not reduce the macronutrient contents on the plant.

The competition between plants intensifies the effects of water deficit only on *C. benghalensis*, with a decreased on the content of all macronutrients studied.

Under irrigated conditions, competition between plants was more damaging the weeds compared to cowpea.

The *C. benghalensis* specie, free from interference, has a high potential for nutrient extraction under irrigated and water deficit regimes.

ACKNOWLEDGMENTS

The Conselho Nacional de Desenvolvimento Científico e Tecnológico – Brasil (CNPq), for the financial support to this research.

RESUMO: A capacidade de uma espécie vegetal para ter sucesso na colonização do agroecossistema depende da sua eficiência na utilização dos recursos de crescimento mesmo em condições deficientes. Objetivou-se avaliar os efeitos da competição e déficit hídrico no solo no conteúdo de macronutrientes de feijão-caupi (*Vigna unguiculata* L. Walp.), trapoeraba (*Commelina benghalensis* L.) e malva-branca (*Waltheria indica* L.). Foi conduzido estudo em casa de vegetação, em delineamento em blocos casualizado, com quatro repetições. Os tratamentos foram arranjados em fatorial 5 × 2, com o primeiro fator correspondente aos arranjos de competição entre as espécies (*V. unguiculata* + *C. benghalensis*; *V. unguiculata* + *W. indica*; *V. unguiculata* em monocultivo; *C. benghalensis* em monocultivo e *W. indica* em monocultivo), e o segundo dos regimes hídricos (irrigado e déficit hídrico). O déficit hídrico afeta de forma diferenciada o conteúdo de macronutrientes nas espécies, com redução de K, Ca e Mg no feijão-caupi, e N, P, K e Ca em *W. indica*. Para *C. benghalensis*, o déficit hídrico não reduz os conteúdos de macronutrientes na planta. A competição entre plantas intensifica os efeitos do déficit hídrico apenas em *C. benghalensis*, com redução do conteúdo de todos os macronutrientes

estudados. Em condições irrigadas, a competição entre plantas foi mais prejudicial as plantas daninhas do que o feijão-caupi. A espécie *C. benghalensis*, livre de interferência, apresenta elevado potencial de extração de nutrientes sob regimes irrigado e de déficit hídrico.

PALAVRAS-CHAVE: *Vigna unguiculata*. *Commelina benghalensis*. *Waltheria indica*. Interferência. Estresse hídrico. Nutrição mineral.

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