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Article

Total chlorophyll and nutrients content in bean plants and weeds in competition

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Abstract

Plants compete for several resources on soil, including water, light and nutrients which can affect crop yield and also weeds growth. Under the hypothesis that in different densities and weed communities, crops and weeds undergo changes in their nutritional contents of macro and micronutrients, the aim of this study was to quantify the nutritional contents of bean plants and weeds cultivated in increasing densities (0, 74, 147, 221 and 295 plants m-2) and the effect of the association of plants (isolated bean, bean + *Urochloa plantaginea*, bean + *Bidens pilosa* and bean + *Urochloa plantaginea* + *Bidens pilosa*). The contents of macro and micronutrients were evaluated. The increase in plant density promoted a decrease in the total chlorophyll content of bean plants and weeds, as well as a decrease in macronutrients (K and P) and micronutrients (Zn, Fe, Mn and Cu). In the arrangement where the greatest number of species were cultivated simultaneously and in increasing densities, a greater reduction in total chlorophyll content and in macro and micronutrient contents of the three species (crops and weeds) were observed.

Keywords: *Bidens pilosa*, Competitive potential, *Phaseolus vulgaris*, *Urochloa plantaginea*

Introduction

Despite being the world's largest producer of beans (*Phaseolus vulgaris*), Brazil presents low average yield (CONAB, 2016). The inadequate management of weeds is among the several reasons for the low yield in the country. Several studies, such as the ones performed by Salgado et al. (2007) and Borchartt et al. (2011), confirm that weeds can promote losses of up to 93% of bean production.

Bean plants are cultivated in several types of production systems and periods of the year. They suffer interference from a wide variety of weeds (Pereira et al., 2015, Teixeira et al., 2009). This interference represents the sum of negative interactions among plants, including competition and allelopathy (Agostinetto et al., 2008; Sausen et al., 2009). It is necessary to understand the effects of each individual component of the interference to evaluate the best management strategy. Plants compete for a wide variety of soil resources, including water and at least 20 essential nutrients (White, 1995. Therefore, the competition for nutrients can reduce the scarce crop resources (Carvalho et al., 2007).

According to Procopio et al. (2004), although there is great knowledge and technological advances regarding mineral nutrition of cultivated species, the lack of studies in mineral nutrition of weeds undermines the

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understanding of factors that interfere in the competition for nutrients between crops and weeds. *Desmodium tortuosum* (Procópio et al., 2005) and *Nicandra physaloides* populations (Ronchi et al., 2003) were able to accumulate, respectively, up to 10 and 15 times more the relative quantity of phosphorus than weeds. Pereira et al. (2012) observed that cassava plants showed better responses to the increase of phosphorus doses than *Bidens pilosa* and *Urochloa decumbens*.

Several authors report morphophysiological characteristics that may be directly related to the superior competitive ability of crops, such as: shoot dry matter and structure (Barroso et al., 2010), spatial distribution (Dias et al., 2010), germination and emergence (Carvalho & Christoffoleti, 2008), growth habit (Teixeira et al., 2009), soil cover (Braz et al., 2006) and interception of solar radiation (Carvalho & Christoffoleti, 2008). However, the capacity of supply and allocation of nutrients vary with the species involved.

Under the hypothesis that in different densities and weed communities, the crop of interest and weeds undergo changes in their nutritional contents of macro and micronutrients, the aim of this study was to quantify nutritional contents of bean plants and weeds cultivated in increasing densities and the effect of plant association (community).

Materials and Methods

The experiment was performed from August to October 2013, at the Federal University of Vale do Jequitinhonha and Mucuri – Diamantina/MG, in a protected environment under natural light. The experimental units were plastic pots with volume of 10 dm^{-3}, containing samples of Red Latosol.

The soil texture was classified as medium. The chemical analysis showed the following results: pH (water) of 5.0; organic matter content of 4.7 daq kg^{-1}; P, K and Ca of 1.3; 47 and 2.4 mg dm^{-3}, respectively; Mg, Al, H + Al and effective CEC of 1.2; 0.1; 7.1 and 3.8 cmolc dm^{-3}, respectively. The soil sample was corrected and fertilized according to the analysis, incorporating limestone and fertilizing one month before the experiment implantation. 3.0 g dm^{-3} of dolomitic limestone and 3.0 g dm^{-3} of 4-14-8 (N-P2 O5-K2 O) were applied.

Nitrogen supplementation was performed 15 days after crop emergence at the dose of 100 mg dm^{-3} urea previously dissolved in water. Irrigations were performed daily in order to maintain pots close to 70% of field capacity.

Carioca group (IPR Eldorado) was used as bean cultivar with a short cycle and belonging to type II. A 5 x 3 factorial design was used and consisted of a combination of 5 weed infestation densities: 0, 74, 147, 221 and 295 plants m^{-2} (factor A) and two weed species, *Urochloa Plantaginea* (brachiaria or alexandergrass) and *Bidens pilosa* (beggarticks) and the association of both (brachiaria + beggarticks) (factor B).

At 50 days after emergence (DAE) of bean plants and weeds, the total chlorophyll content was evaluated [using Soil Plant Analysis Development (SPAD) Index through Falker CFL 1030 chlorophyllometer] and then they were harvested. The leaf samples were dried in forced air circulation oven at 65 °C until constant weight. All the dry material was ground in a Wiley mill, homogenized and sampled to determine macro and micronutrient contents in the shoot part of the species.

For the analysis of macro and micronutrient contents, the samples were submitted to nitric-perchloric digestion (HNO3 + HClO4, 3:1) for the determination of P, K, Ca, Mg, Zn, Cu, Mn and Fe (EMBRAPA, 1999). P reading was performed using a UV-VIS spectrophotometer. K was measured by flame emission photometry and Ca, Mg, Fe, Zn, Cu and Mn by atomic absorption spectrophotometry.

Data were submitted to analysis of variance, and means, when significant, were compared by Tukey´s test at 5% probability.

Results and Discussion

In bean + brachiaria and bean + beggarticks associations, no difference was observed in chlorophyll content (CHL) with the increment of plant density.

On the other hand, in bean + beggarticks, it was observed that in densities of 147 and 221 plants ha^{-1}, CHL values in bean plant were the highest, not differing from the values observed in the highest plant density (295 plants m^{-2}) (Table 1).

Evaluating the arrangements within each density, it was verified that in densities of 147 and 221 plants ha^{-1}, the mean values for CHL of bean plants were lower in bean + brachiaria and bean + beggartick than in treatments where the three species were used (Table 1).

Table 1. Total chlorophyll content (CHL) in leaves of bean, beggartick and brachiaria cultivated in different arrangements and densities.

		Total Chlorofyll	
Density (plants m^{-2})	B + Br	B + Bt	B + Br + Bt
		Bean (CV%: 23,90)*	
0	41.10 Aa	41.10 Aa	41.10 Ba
74	42.58 Aa	37.53 Aa	38.43 Ba
147	42.28 Ab	40.38 A b	44.25 Aa
221	40.68 Ab	42.73 Ab	44.38 Aa
295	41.75 Aa	40.40 Aa	42.50 ABa
		Beggartick (CV%: 15,85)*	
	Bt + B	Bt + Br	Bt + Br + B
74	40.93 Aa	38.83 Aab	35.68 Ab
147	42.28 Aa	41.93 Aa	36.6 Ab
221	43.73 Aa	39.40 Aa	39.48 Aa
295	43.70 Aa	38.48 Ab	37.28 Ab
		Brachiaria (CV%: 18,46)*	
	Br + B	Br + Bt	Br + Bt + B
74	48.73 Aa	39.83 Ab	35.10 ABb
147	40.25 Ba	35.98 Ab	38.95 Aab
221	41.20 Ba	32.60 Bb	40.75 Aa
295	42.38 Ba	32.35 Bb	34.35 Bb

* Means followed by the same capital letter in the column and lowercase in the row do not differ by Tukey test at 5%. B = Bean, Br = brachiaria, Bt = beggartick. CV = coefficient of variation.

Regarding CHL of beggartick plants cultivated in different arrangements, it was verified that they did not show statistical difference in different plant densities (Table 1). However, evaluating the plant arrangement within each density, there was a reduction in CHL with brachiaria + bean plants (beggartick + brachiaria + bean). In the highest density (295 plants ha^{-1}), CHL of beggartick plants in beggartick + brachiaria and beggartick + brachiaria + bean arrangements was lower than the plots where beggartick was cultivated only with bean plants (beggartick + bean) (Table 1). Brachiarias cultivated with bean (Brachiaria + bean) and in treatments where they were cultivated in competition with beggartick (brachiaria + beggartick) showed a reduction in mean values of CHL from the second density of plants (74 plants ha^{-1}) on. In the arrangement with brachiaria, beggartick and bean plants, CHL difference was observed only in the highest density of plants (Table 1).

Evaluating CHL means of brachiaria plants within each density, it was verified that they showed higher values when they were in competition only with bean (Brachiaria + bean) differing from the other arrangements where it was cultivated with beggartick and in the arrangement where the three species were present (Table 1).

The determination of relative chlorophyll content through chlorophyll meter is used to predict the need for nitrogen fertilization in several crops, including coffee (Godoy et al., 2008; Reis et al., 2006); potato (Coelho et al., 2010) and tomato (Ferreira et al., 2006). The chlorophyll content in the leaf is used to predict the nutritional level of nitrogen (N) in plants, due to the fact that the amount of this pigment correlates positively with N content in the plant (Godoy et al., 2008).

In relation to potassium content (K) in bean leaves, it was observed that when the bean was cultivated alone, the K contents were higher in all arrangements, when compared to treatments where there was an increase in weed density. In the arrangement where the three species were cultivated simultaneously (bean + brachiaria + beggartick), it was observed a reduction in K contents only at the highest weed densities (221 and 295 plants ha^{-1}). A decrease in K content in bean plants was observed for all arrangements (Table 2).

Evaluating K contents of bean plants (arrangements) within weed densities, lower values were observed for bean in the arrangement with brachiaria, at densities of 74 and 147 plants ha^{-1}. In densities of 221 and 295 plants ha^{-1}, K contents were lower in bean + brachiaria and bean + beggartick arrangements in relation to treatments where the three species were cultivated simultaneously (Table 2). Fialho et al. (2012), studying the effect of coffee and weed competition, verified a direct reduction in K concentration in coffee plants: 0.72 and 0.98 g kg^{-1} for each *B. decumbens* and *D. horizontalis* added to the pot.

Table 2. Potassium content (K) in leaves of bean, beggartick and brachiaria cultivated in different arrangements and densities.

	K (dag kg^{-1})		
		Feijoeiro (CV%: 19,80)*	
	Br + B	Bt + Br	B + Bt + Br
0	1.58 A	1.58 A	1.58 A
74	0.99 Bb	1.40 ABab	1.49 Aa
147	1.15 Bb	1.53 ABa	1.46 Aa
221	1.17 Bb	1.17 Bb	1.35 Ba
295	1.15 Ba	1.22 Ba	1.20 Ba
		Beggartick (CV%: 18,73)*	
	Bt + B	Bt + Br	Bt + Br + B
74	1.76 Aa	1.66 Ab	1.50 Ab
147	1.84 Aa	1.44 Ab	1.37 Ab
221	1.80 Aa	1.35 Bb	1.10 Bb
295	1.80 Aa	1.30 Bb	1.26 Bb
		Brachiaria (CV%: 13,59)*	
	Br + B	Br + Bt	Br + Bt+ B
74	1.86 Aa	2.04 Aa	1.30 Ab
147	2.03 Aa	2.18 Aa	1.32 Ab
221	1.90 Aa	2.26 Aa	1.28 Ab
295	2.00 Aa	1.47 Bb	1.26 Ab

* Means followed by the same uppercase letter in the column and lowercase in the row do not differ by Tukey´s test at 5%. B = Bean, Br = brachiaria, Bt = beggartick. CV = coefficient of variation.

The capacity that differentiates weed species regarding nutrient extraction in the soil can be attributed to soil volume explored by the root system, soil fertility and the capacity of nutrient accumulation by the species. However, the advantage of weeds in competition for nutrients is linked to the high density of these plants (Albuquerque et al., 2008).

Beggartick plants cultivated with bean (beggartick + bean) showed no difference in K contents with the increase in weed density. In beggartick + brachiaria and beggartick + brachiaria + bean arrangements, it was observed lower values for K in the two largest weed densities (Table 2).

The levels of K in beggartick plants (when evaluating the arrangements within each density) were higher in all plant densities when this species was cultivated in the arrangments with beggartick + bean and beggatick + brachiaria + bean (Table 2).

Brachiaria plants cultivated through different arrangements did not show variation in K contents with the increment of plant density (Table 2).

In relation to contents of K in brachiaria plants within each density, it was verified that, for all evaluated densities, the arrangement with the three species (Brachiaria + beggartick + bean) showed the lowest mean values to this variable (Table 2).

Phosphorus content (P) in bean plants were lower in the highest density of plants for bean + brachiaria and bean + beggartick arrangements. In the arrangement with three species, the lowest values were observed in the two largest populations evaluated in relation to the other evaluated densities (Table 3). It is possible to infer that the two weed species aggressiveness and the increase of plants density increased the competition, reducing the availability of nutrients to bean plants, probably due to the greater initial development of its roots and the high ability of these species in exploring and capturing nutrients. However, the ability to capture soil resources and the competitive ability of plants are not necessarily correlated (Cury et al., 2013).

Table 3. Phosphorus content in leaves of bean plants, beggarticks and brachiaria cultivated in different arrangements and densities.

	P (dag kg^{-1})		
Density (plants m^{-2})	B+ Br	B + Bt	B + Bt + Br
		Bean (CV%: 23,98)*	
0	0.19 A	0.19 A	0.19 A
74	0.18 Aa	0.17 Aa	0.17 Aa
147	0.18 Aa	0.15 Aa	0.16 Aa
221	0,20 Aa	0,16 Ab	0,12 Bb
295	0,15 Ba	0,14 Ba	0,12 Ba
		Beggartick (CV%: 34,82)*	
	Bt + B	Bt+ Br	Bt + Br + B
74	0.17 Aa	0.12 Ab	0.12 Ab
147	0.15 Aa	0.10 Ab	0.11 Ab
221	0.14 Aa	0.11 Aab	0.09 Ab
295	0.16 Aa	0.07 Bb	0.08 Bb
		Brachiaria (CV%: 24.94)*	
	Br + B	Br + Bt	Br + Bt + B
74	0.20 Aa	0.25 Aa	0.17 Ab
147	0.19 Aa	0.19 ABa	0.16 Ab
221	0.17 Bab	0.19 ABa	0.15 ABb
295	0.16 Ba	0.13 Bb	0.13 Bb

* Means followed by the same capital letter in the column and lowercase in the row do not differ by Tukey test at 5%. B = Bean, Br = brachiaria, Bt = beggartick. CV = coefficient of variation.

No differences were verified in P content in bean plants in the different arrangements within the densities, except in the density of 221 plants ha-1, in which the content of P, in the arrangement with three species, showed lower mean value than the other arrangements (Table 3). Evaluating the effect of plant density on P contents of beggartick plants, it was observed that in beggartick + bean arrangement, there was no difference in mean values of this variable with the increment of plant density. However, in the other arrangements (beggartick + brachiaria and brachiaria + bean), there was a decrease in mean values of P contents in the highest plant density (295 plants ha-1) differing from other densities (Table 3).

In all tested densities, it was verified that mean values of beggartick + bean showed higher mean values of P content when compared to the other arrangements (Table 3).

The highest weed densities (221 and 295 plants ha-1) promoted reduction of P levels in brachiaria compared to other densities for all plant arrangements (Table 3). The arrangement in which the three species were cultivated presented the lowest values of P contents for all densities (Table 3). The nutrient competition is affected by water content in the soil, by specific aspects of the competitors and also by differences in growth habit and nutrient requirement of the species (Ferreira et al., 2013). The ability to remove nutrients from soil and the required amounts vary not only with the cultivar, but also with the degree of competition (Cury et al., 2013).

No statistical difference was observed in calcium (Ca) and magnesium (Mg) contents in the different arrangements and plant densities. The mean values of Ca were 0.22; 0.18 and 0.07 dag kg-1, respectively, for bean, beggartick and brachiaria plants. For Mg, the values were 0.04; 0.05 and 0.04, respectively for bean, beggartick and brachiaria plants.

Evaluating zinc (Zn) levels in common bean plants, it was observed that, in all arrangements, a decrease in the contents of this nutrient was observed in the plots where bean was cultivated in isolation to the arrangements where the plant was cultivated in competition with the weeds (Table 4).

Evaluating the effect of arrangements within each density, it was verified that Zn contents in bean plants were reduced in bean + beggatick and bean + beggatick+ brachiaria arrangements at densities of 147 and 221 ha-1 plants. In other densities, no difference among the arrangements was observed (Table 4).

Evaluating Zn levels in beggartick plants in beggartick + bean and beggartick+ brachiaria + bean arrangements, a reduction of mean values of this variable was observed in densities of 147 to 295 ha-1 plants, differing from the lowest density of plants. In beggartick + brachiaria arrangement, no difference was observed among the densities (Table 4).

Within each density it was observed that Zn content in beggartick were lower in the treatments where the three species were cultivated together (Table 4).

No statistical difference was observed regarding Zn contents in brachiaria plants among the densities and within the arrangements, with mean of 15.09 mg kg^{-1}.

In plots where bean + brachiaria and bean + beggartick + brachiaria arrangements were cultivated, there was a negative effect on iron (Fe) contents in bean plants when they were cultivated under weed competition. However, when bean plants were cultivated with beggartick, no difference was observed among the densities (Table 5).

Table 4. Zinc contents (Zn) in the leaves of beans and beggartick cultivated in different arrangements and densities.

	Zn (mg kg^{-1})		
	Bean (CV%: 19,87)*		
	Br + B	Br + Bt	Br + Bt + B
0	18.71 A*	18.71 A	18.71 A
74	13.78 Ba	16.27 Aa	13.70 Bb
147	15.98 Ba	11.42 Bb	11.39 Bb
221	15.84 Ba	11.13 Bab	9.10 Bb
295	11.99 Ba	9.42 Ba	11.12 Ba
	beggartick (CV%: 16,97)*		
	Bt + B	Bt + Br	Bt + Br + B
74	18.21 Aa	10.24 Aa	10.24 Aa
147	13.67 Ba	13.23 Aa	5.55 Bb
221	15.40 Ba	15.07 Aa	5.98 Bb
295	15.40 Ba	10.26 Ab	4.27 Bc

* Means followed by the same capital letter in the column and lowercase in the row do not differ by Tukey test at 5%. B = Bean, Br = brachiaria, Bt= beggartick. CV = coefficient of variation.

Table 5. Iron contents (Fe) in leaves of bean and beggartick plants cultivated in different arrangements and densities.

Density (plants m^{-2})	B + Br	B+ Bt	B + Bt+ Br
	Fe (mg kg^{-1})		
	Bean (CV%: 23,89)*		
0	95.66 A	95.66 A	95.66 A
74	85.37 ABa	96.96 Aa	79.52 Bb
147	84.63 ABa	94.86 Aa	66.87 Bb
221	89.98 ABa	96.26 Aa	77.85 Bb
295	75.33 Bb	100.32 Aa	72.17 Bb
	Beggartick (CV%: 72,37)*		
74	111.24 Aa	87.52 Bb	79.23 Bb
147	116.60 Aa	100.11 Aab	83.62 Bb
221	117.07 Aa	108.72 Aa	91.96 Ab
295	121.26 Aa	104.66 Ab	104.51 Ab

* Means followed by the same capital letter in the column and lowercase in the row do not differ by Tukey test at 5%. B = Bean, Br = brachiaria, Bt= beggartick. CV = coefficient of variation.

Regarding the evaluation of Fe content in bean plants within each density, a negative effect was observed at all densities in the arrangement where the three species were present (Table 3).

Beggartick plants did not show difference in Fe contents with the increment of density in beggartick + bean arrangement. However, in beggartick + brachiaria and beggartick + brachiaria + bean arrangements, there was an increase in Fe contents from the lowest density to the highest plant densities (Table 3).

Evaluating the levels of Fe in beggartick plants within the arrangements, a negative effect was observed in the values of this variable when the beggartick was cultivated in beggartick + brachiaria + bean arrangement (Table 3).

Regarding Fe contents in brachiaria plants, no statistical difference was observed among the densities and plant arrangements, with overall mean of 51.78 mg kg^{-1}.

Bean plants cultivated in arrangements of bean + beggartick and bean + beggartick + brachiaria showed lower values of Cu contents in densities of 147 to 295 plants ha^{-1} in relation to the lowest density and the control (bean cultivated in isolation). In bean + brachiaria arrangement the values of Cu contents did not vary with the different densities in relation to the control (Table 6).

Table 6. Copper (Cu) content in leaves of bean and beggartick plants and manganese (Mn) content in bean plants cultivated in different arrangements and densities.

		Cu (mg kg^{-1})	
		Bean(CV%: 21,08)*	
0	6.22 A	6.22 A	6.22 A
74	8.75 Aa	7.50 Aa	10.00 Aa
147	2.40 Ab	3.33 Ba	2.50 Ba
221	2.00 Ab	5.00 Ba	2.00 Ba
295	2.10 Ab	2.50 Ba	2.50 Ba
		Beggartick (CV%: 87,28)*	
74	6.66 Aab	2.49 Ab	9.96 Aa
147	4.99 ABa	2.66 Ab	5.00 ABa
221	2.50 Ba	2.50 Aa	2.50 Ba
295	5.00 Ba	2.49 Ab	2.50 Bb
		Mn (mg kg^{-1})	
	Bean (CV%: 36,89)*		
0	633.41 A	633.41 A	633.41 A
74	355.65 Bb	582.14 Ba	364.92 Bb
147	378.15 Bb	547.06 Ba	334.22 Bb
221	366.66 Bb	557.77 Ba	358.71 Bb
295	357.35 Bb	518.07 Ba	356.97 Bb

*Means followed by the same capital letter in the column and lowercase in the row do not differ by Tukey test at 5%. B = Bean, Br = brachiaria, Bt= beggartick. CV = coefficient of variation.

Evaluating the effect of the arrangement within each density, it was verified that mean values of Cu content was lower in the arrangement in which bean was cultivated with brachiaria (bean + brachiaria) at densities of 147 to 295 plants ha-1 (Table 6).

It was observed a difference in Cu contents in beggartick plants cultivated in beggartick + bean and beggartick + brachiaria + bean arrangements, being negatively affected at densities higher than 147 plants ha-1 in relation to the lowest density (74 plants ha -1). In beggartick + brachiaria arrangement, no difference was observed among the densities tested (Table 6).

Beggartick + brachiaria arrangement provided the lowest values of Cu contents within the different densities (Table 6).

No statistical difference was observed regarding Cu contents in brachiaria plants among the different densities and within the arrangements, with an overall mean of 10.02 mg kg -1.

For all evaluated arrangements, a difference was observed in Mn contents of bean plants among the plots where the crop was cultivated in isolation and the plots in which the crop was in competition with weeds at different densities (Table 6).

Evaluating the effect of the arrangements within each density, it was verified that bean plants showed higher values in Mn contents when cultivated in bean + beggar tick arrangement, differing from the other arrangements (Table 6).

The mean values found for Mn contents for beggartick and brachiaria plants were 514.25 and 339.64 mg kg^{-1}, and did not differ significantly in any plant density or arrangement.

In general, the micronutrient contents found in bean and weed (brachiaria and beggartick) were proportional between the crop and the competing plants, with a reduction in micronutrient contents with increasing competition intensity (plant population) and this decrease occurred in the three species studied. It is known that micronutrients are limiting to bean production. This limitation may be due to its unavailability, deficient supply or presence of weeds (Ronchi et al., 2003). Thus, the last two processes may have occurred possibly due to the omission of this nutrient in the substrate suitability for nutrition, and / or the competition of this resource with beggartick and brachiaria.

Ronchi et al. (2003), studying coffee in competition with weeds, verified on average, 13.88 times more micronutrients in *Richardia brasiliensis*, in relation to the content found in coffee. Fialho et al. (2012) studying the coffee crop in competition with weeds concluded that concentrations of macro and micronutrients in young coffee plants were influenced by the presence of weeds that lived in the same environment, with a tendency of lower nutrient contents in the leaves of the crop with the increase of weed density. The same authors emphasized that the weed species showed a higher leaf content of some nutrients, being *D. horizontalis* in P and Fe, *B. plantaginea* in P, Mg, Mn and Zn and *M. aterrima* in N, Ca and Zn, regardless of the density of infestation.

It can be verified that the crop negatively affected the accumulation of nutrients of weeds. Thus, the superiority of weeds in the competition for these resources may be due to the occurrence of high density of these weeds in the area (Santos et al., 2003). The interaction of a single weed species at different densities interferes according to the weed density (Carvalho et al., 2010; Carvalho & Christoffoleti, 2008). The competition also depends on the crop and weed population and it is also important to emphasize that intraspecific competition may represent greater losses to the crop (Dias et al., 2010).

Conclusion

The increase in plant density promoted a decrease in total chlorophyll content of beans and weeds, as well as reduction in the values of macronutrients (K and P) and micronutrients (Zn, Fe, Mn and Cu).

The arrangement in which the highest number of species was cultivated simultaneously and in increasing densities promoted a greater reduction of total chlorophyll, macro and micronutrient contents of the three species.

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