doi: 10.1590/S0100-83582016340200005

COMPETITIVE ABILITY OF LETTUCE WITH RYEGRASS[1]

Habilidade Competitiva de Alface com Azevém

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ABSTRACT - The objective of the study was to evaluate the competitive ability of summer crisp and butterhead lettuce types in coexistence with populations of ryegrass. The experimental design was completely randomized in a factorial 2 x 7 scheme, with four replications. On the A factor the lettuce types (summer crisp and butterhead) were allocated and, on B, the densities of ryegrass (0, 2, 4, 8, 16, 32 and 64 plants per pot). The number of leaves, chlorophyll content, leaf area, green mass and dry mass of the lettuce types and ryegrass were evaluated, and the diameter of the culture stem and the tiller number of the weed were determined. Differences in competitive ability between the lettuce types in competition with ryegrass were found, and butterhead was the most competitive when compared with summer crisp for all variables studied. There was an average loss of leaf area in lettuce types of up to 80% when it competed with ryegrass in the populations involved. Ryegrass is a very competitive weed to infect lettuce, and its handling is necessary, even at low densities to avoid productivity losses. The butterhead type of lettuce supports longer competition with ryegrass compared to summer crisp.

Keywords: interference, *Lactuca sativa*, *Lolium multiflorum*.

RESUMO - Objetivou-se neste estudo avaliar a habilidade competitiva dos tipos de alface, crespa e lisa, em convivência com populações de azevém. O delineamento experimental adotado foi inteiramente casualizado, arranjado em esquema fatorial 2 x 7, com quatro repetições. No fator A alocaram-se os tipos de alface (crespa e lisa) e, no B, as populações de azevém (0, 2, 4, 8, 16, 32 e 64 plantas por vaso). As variáveis avaliadas na alface e no azevém, em competição, foram o número de folhas, o índice de clorofila, a área foliar, a massa verde e a massa seca, sendo ainda determinado o diâmetro de caule da cultura e o número de perfilhos da planta daninha. Constataram-se diferenças na habilidade competitiva entre os tipos de alface, em competição com o azevém, sendo a lisa a mais competitiva ao ser comparada com a crespa, para todas as variáveis estudadas. Foram observadas perdas médias de área foliar dos tipos de alface de até 80% quando esta competiu com as populações de azevém envolvidas na competição. O azevém é uma planta daninha muito competitiva ao infestar a alface, sendo necessário o manejo, mesmo em baixas populações de plantas, para evitar perdas de produtividade da cultura. O tipo de alface lisa suporta mais a competição do azevém, se comparada com a crespa.

Palavras-chave: interferência, *Lactuca sativa*, *Lolium multiflorum*.

INTRODUCTION

With the modernization of the agricultural sector, quality, quantity and, mainly, production regularity are demanded from the producer (Costa & Sala, 2005; Sala & Costa, 2012). However, most of the areas where lettuce (*Lactuca sativa*) is cultivated in Brazil are open fields, which causes problems, such as damages caused by solar radiation, attacks by pathogens and competition between the culture and weeds (Sala & Costa, 2012). Oftentimes, lettuce is cultivated on an intercropping with other vegetables

[1] Recebido para publicação em 18.11.2015 e aprovado em 26.1.2016.
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(Negreiros et al., 2002); however, the area designated for cultivation is characterized by intensive soil handling and excessive use of agricultural inputs, fertilizers and irrigation, in addition to the difficulty to control weeds (Oliveira et al., 2004).

The adequate handling of weeds is a determining factor to search for higher productivity in lettuce culture, considering that the competition between plants leads to significant productivity losses (Ferreira et al., 2013). The total period to prevent the interference of weeds that infest lettuce comprehends 21 days after the culture emergence; in case the handling is not conducted during this period, the productivity losses may get to 25% (Giancotti et al., 2010).

Among the weeds that cause productivity losses on cultures, ryegrass is highlighted (*Lolium multiflorum*). It infests virtually all crops in the Southern region of Brazil, since this species has a high seed production and easily spreads out. This weed has a high competitive ability, fighting with the cultures for the environmental resources, such as water, light, CO_2 and nutrients (Agostinetto et al., 2008; Tironi et al., 2014). By competing with barley cultures in several populations and times of emergency, ryegrass caused growth and developmental reductions (Tironi et al., 2014). In addition, when it infested wheat, it caused a loss of approximately 235% in the productivity of grains of the culture (Agostinetto et al., 2008). For barley, the leaf area was reduced as the emergency dates of ryegrass anticipated in relation to the culture, showing that handling strategies for weeds are fundamental to reduce the competitiveness with the cultures (Tironi et al., 2014). However, it is noteworthy that, for lettuce cultures, there are currently no papers that have evaluated the interference of ryegrass, as well as the productivity losses of this culture when infested by the referred weed.

Understanding the interference relationship of weeds on cultivated areas allows the elaboration of strategies that would minimize the use of herbicides and adopting the integrated management of weeds. Considering this, the objective of this study was to evaluate the competitive ability of summer crisp and butterhead lettuce types, in coexistence with ryegrass populations.

MATERIAL AND METHODS

The experiment was installed in a greenhouse with completely randomized experimental design, in a factorial 2 x 7 scheme, with four repetitions. On factor A, the summer crisp and butterhead lettuce types (Mimosa and Rainha de Maio cultivars, respectively) were allocated, and, on factor B, the ryegrass populations were allocated (0, 2, 4, 8, 16, 32 and 64 plants per pot). The referred ryegrass populations were tested to cover the highest likely proportion of observations on the weed that occurs in field, and also for this population to occur with an exponential increase on the establishment of populations, so that treatments were equally spaced on this scale.

In order to evaluate the competitive ability of the species involved on the assay, the treatments were arranged on an additive series (Radosevich et al., 2007), in which a lettuce plant was transplanted in the middle of each experimental unit and, around it, the ryegrass populations were disposed, according to the suggested treatment. The experimental units were constituted by plastic pots with capacity for 8 dm^3 (0.24 m in diameter x 0.20 m high), filled with soil from an agricultural area, classified as humic Aluminoferric Red Latosol (Embrapa, 2013). The soil fertility correction was conducted according to the technical recommendations for lettuce culture.

The experimental units were constituted by a lettuce plant competing with 0, 2, 4, 8, 16, 32 and 64 ryegrass plants per pot, which corresponded to 0; 44.25; 88.50; 176.99; 353.98; 707.96; and 1415.93 ryegrass plants m^{-2}, respectively. 20 days before the transplantation, the different ryegrass populations were sown on the periphery of the experimental units, so that at the time of the transplantation the culture plants and the weed plant had the same height. At the time of the transplantation, the lettuce and ryegrass plants had four completely expanded leafs. The experimental units were kept equidistant, so that the surface area available for the development of the plants corresponded to the area of the experimental unit.

The variables were evaluated 45 days after the lettuce transplantation (DAT), determining, for the lettuce and the competing ryegrass, the number of leafs, the chlorophyll index, the leaf area, the green mass and the dry mass, and the stem diameter of the culture and the number of tillers of the weed were also observed.

The number of leafs (NL) was determined by counting the completely developed leafs on the culture and weed plants. The chlorophyll index (CI) was determined by a portable chlorophyll meter model SPAD 502 – Plus, and the repetition was obtained by the mean across 15 observations on the plants for each experimental unit. The leaf area (LA) was measured using a portable meter model CI-203 Bio Scence, quantifying all the plants in each treatment (cm^2 per pot). The stem diameter (SD) of lettuce was measured with the help of a caliper rule with millimeter scale, measuring it at approximately 1 cm from the soil. The number of ryegrass tillers (TN) was determined by counting. In order to determine the green mass of the aerial part (GM), the plants were cut close to the soil, and the material was then weighted on an analytical scale. Then, the material was kept on paper bags and subject to greenhouse drying with forced air circulation at a temperature of 65±5 ^oC until a constant mass was reached; the results were expressed in g per pot in order to determine the dry mass (DM) of the species involved in the assay.

The data obtained were subject to analysis of variance through the F test, and, when significant, linear and/or non-linear regressions were applied to the quantitative factor, and the choice for the models was based on the statistical significance (F test), on the determination coefficient adjustment (R^2) and the biological meaning of the model; for the qualitative factor, the treatment means were compared through Tukey's test. All tests were conducted at $p<0.05$.

RESULTS AND DISCUSSION

The results showed that there was an interaction between the tested factors (lettuce types x ryegrass populations), except for the chlorophyll index and leaf area variables for the weed. In all comparisons made within each ryegrass population, it was observed that the butterhead lettuce type showed a higher number of leafs (NL) in comparison to the summer crisp type (Table 1).

The competition caused a reduction on the NL of the lettuce according to the increase on the ryegrass population for both types, observing a reduction of 41% on this variable for the butterhead type and 56% for the summer crisp type, for the treatment with 64 plants per pot of ryegrass, in relation to the witness with no weeds (Figure 1A). Probably, this fact is connected to the strategy of the plant to capture more luminosity, which leads to the formation of longer stems, with lower energy investment to develop the leafs, leaf area and dry mass (Galon et al., 2011). It is noteworthy that light is the main limited resource in the community and it has an important role for the initial response of a plant with higher competitive potential (Page et al., 2010). Studying the interference periods in lettuce, Machado et al. (2009) observed a reduction on NL when in competition with weeds during the entire culture cycle.

The NL of ryegrass was lower when it competed with summer crisp lettuce on the populations of two and four plants per pot (Table 2). For the larger ryegrass population (64 plants per pot), the summer crisp lettuce was the one that less interfered on NL; the other populations were not statistically different among each other, both when ryegrass competed against the summer crisp type and the butterhead type. The weed NL, when comparing the ryegrass populations competing with the culture, showed no data adjustment in relation to the tested models, showing means of 59.28 and 66.98 leafs when competing with the summer crisp and butterhead lettuce types, respectively (Figure 1B).

The chlorophyll indices (CI) of the lettuce and ryegrass cultivars did not adjust to the tested model, showing mean values of 13.98 and 17.65 (SPAD) for the summer crisp and butterhead types, respectively (Table 1). Ryegrass in coexistence with the summer crisp lettuce type showed a mean of 25.37

Table 1 - Number of leafs, chlorophyll index, leaf area, stem diameter, green mass and dry mass of the aerial part of the summer crisp and butterhead lettuce types, in competition with ryegrass populations

Ryegrass populations (plants/pot)	Lettuce types	N. of leafs	Chlorophyll index (SPAD)	Leaf area (cm^2)	Stem diameter (cm)	Green mass (g)	Dry mass (g)
0	Summer crisp	13.0 b	15.0 b	931.0 b	1.3 a	89.1 b	7.1 a
	Butterhead	26.2 a	20.7 a	1706.1 a	1.3 a	111.8 a	7.9 a
2	Summer crisp	10.7 b	14.3 b	534.1 b	1.1 b	66.7 b	5.3 b
	Butterhead	26.2 a	20.6 a	1024.3 a	1.3 a	92.4 a	7.5 a
4	Summer crisp	11.2 b	14.9 a	819.6 b	1.2 a	66.8 b	6.3 b
	Butterhead	26.2 a	16.3 a	1528.0 a	1.3 a	149.9 a	9.5 a
8	Summer crisp	10.7 b	14.1 b	792.3 b	1.1 a	59.8 a	4.9 a
	Butterhead	19.2 a	17.6 a	1059.8 a	0.9 a	56.8 a	4.5 a
16	Summer crisp	8.7 b	11.6 b	614.1 b	1.0 a	34.2 b	3.2 b
	Butterhead	23.2 a	15.8 a	1333.9 a	1.2 a	79.9 a	6.6 a
32	Summer crisp	7.5 b	14.8 a	575.9 b	0.8 a	28.0 b	3.0 b
	Butterhead	17.5 a	15.4 a	1181.2 a	0.9 a	51.7 a	4.8 a
64	Summer crisp	5.7 b	13.0 b	186.5 b	0.7 b	10.6 b	1.1 a
	Butterhead	15.5 a	16.7 a	616.0 a	0.9 a	25.7 a	2.6 a
General Mean		15.8	15.8	921.7	1.10	65.9	5.3
CV (%)		15.5	12.5	16.3	12.92	15.1	21.1

Means followed by the same lowercase letter on the column, within each ryegrass population and lettuce types, were not different according to Tukey's test (p>0.05).

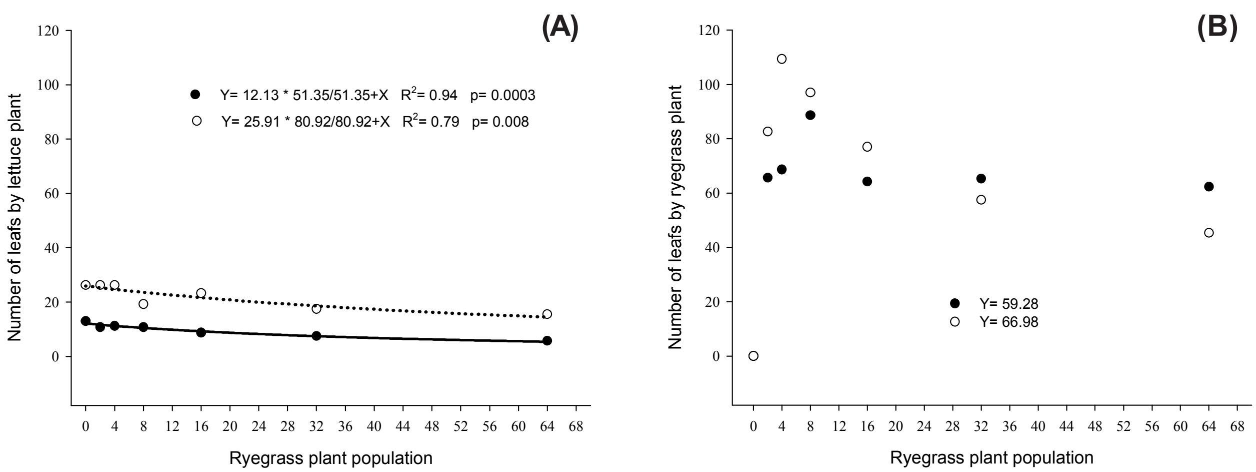

Figure 1 - Number of lettuce leafs (A) and ryegrass leafs (B) according to the types of lettuce, summer crisp (●) and butterhead (○), in competition with ryegrass populations.

(SPAD); in the presence of the butterhead type, the mean CI of the weed was 24.45 (SPAD).

The butterhead lettuce showed higher competitive ability in relation to the summer crisp lettuce for CI in all tested ryegrass populations, except in coexistence with 4 and 32 plants per pot, which were not statistically different. When comparing the CI of the butterhead type without competition with the maximal ryegrass density, a reduction of 20% was observed, and it could be associated with the interspecific competition between the species (Table 1). The CI reduction of the

Table 2 - Number of leafs, chlorophyll index, leaf area, number of tillers, green mass and dry mass of the aerial part of ryegrass according to the populations and types of lettuce

Ryegrass population (plants/pot)	Lettuce types	N. of leafs	Chlorophyll index (SPAD)	Leaf area (cm^2)	N. of tillers	Green mass (g)	Dry mass (g)
2	Summer crisp	65.6 b	34.3^{ns}	421.8 ^{ns}	16.7 a	20.7 a	4.4 a
	Butterhead	82.6 a	31.5	281.9	6.6 b	26.8 a	5.5 a
4	Summer crisp	68.6 b	32.6^{ns}	632.5^{ns}	7.9 b	42.8 a	10.1 a
	Butterhead	109.3 a	31.3	902.7	11.0 a	36.2 a	8.5 a
8	Summer crisp	88.6 a	28.3^{ns}	1392.3^{ns}	8.6 a	38.0 b	8.8 b
	Butterhead	97.0 a	29.6	1315.9	9.7 a	49.5 a	12.1 a
16	Summer crisp	64.2 a	29.5^{ns}	2773.7^{ns}	6.9 a	57.5 a	13.8 a
	Butterhead	77.0 a	27.0	2984.0	6.6 a	37.9 b	8.3 b
32	Summer crisp	65.3 a	27.8^{ns}	4827.0^{ns}	6.3 a	91.1 a	23.3 a
	Butterhead	57.5 a	28.3	5399.3	6.4 a	53.0 b	13.6 b
64	Summer crisp	62.3 a	24.9^{ns}	8888.9^{ns}	6.6 a	86.9 a	24.1 a
	Butterhead	45.3 b	23.2	9298.4	5.8 a	82.8 a	22.3 a
General Mean		63.1	24.9	2794.2	7.1	44.4	11.1
CV (%)		17.9	9.4	20.2	27.1	17.6	16.6

Means followed by the same lowercase letter on the column, within each ryegrass population and lettuce types, were not different according to Tukey's test ($p<0.05$). ^{ns} não significativo ($p<0.05$).

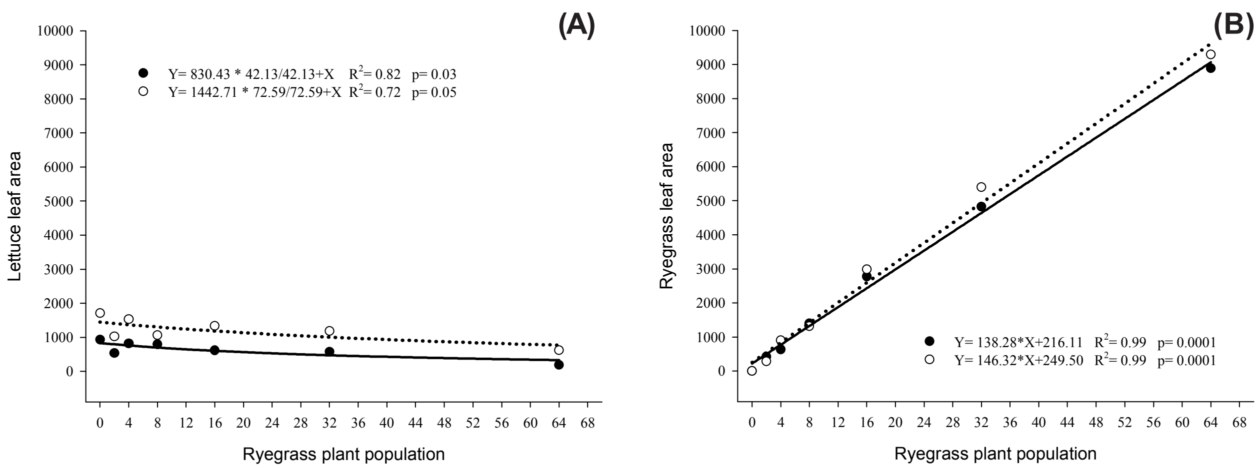

Figure 2 - Leaf area (cm^2 per pot) of the lettuce types (A), summer crisp (●) and butterhead (○), and ryegrass (B), in competition with ryegrass populations.

lettuce plants with the increase of the ryegrass population is due to the interspecific competition, especially for the light resource (Bezerra Neto et al., 2006). The competition for light among plants in communities begins very early, affecting the apical dominance (Almeida & Mundstock, 2001) and, consequently, leading to a reduced growth of the plants involved in the process, as already explained.

It is noteworthy that, among the direct interactions, the competition for solar radiation is one of the most important ones, since this resource is considered a raw material for the metabolic activity of plants (Zanine & Santos, 2004).

In relation to the leaf area (LA) of lettuce, a reduction was observed when the ryegrass population increased for both types (Figure 2A). An opposite effect was observed for ryegrass, that is, with the increase of the weed population, the LA was linearly increase (Figure 2B). According to Melhorança Filho et al. (2008), when lettuce coexists for longer periods with weeds, a LA reduction occurred for the Lucy Brown cultivar. When comparing the lettuce types within each population, the results showed that in all simulations the butterhead type showed higher LA than the summer crisp type (Table 1). The LA losses for plants cultivated in competition with ryegrass were reported by Tironi et al. (2014), working with barley coexisting with ryegrass in different populations and emergency times of the weed and the culture. There was no statistical significant when comparing the lettuce types within each population for the ryegrass LA (Table 2), showing that lettuce is not much competitive in comparison with the weed.

The competition with ryegrass caused the reduction of the stem diameter (SD) of the lettuce plants, considering that a reduction of 29% for the butterhead type and 49% for the summer crisp type was observed, on the population of 64 plants per pot of ryegrass, in relation to the witness with no weed (Figure 3). SD is an important variable to be determined, since, the lower it is, the higher will be the competition between the culture and the weed for the light resource, that is, lettuce etiolates in search for light when it is infested by ryegrass. According to Ballaré & Casal (2000), the effects of the light signals perceived by photoreceptors may be different for the culture and the weeds when in competition. This fact may be explained by the fact that the plant invests energy for the growth of the aerial part and the radicular system, showing, consequently, a considerable reduction on its growth and development, and one of the main morphological changes observed is the stem etiolation (Merotto Jr. et al., 2009). According to the authors, this symptom may be explained as a scape mechanism and a search for luminous radiation of good quality and sufficient quantity to reestablish the energetic balance of the plant.

No statistical difference was observed between the lettuce types for SD, except

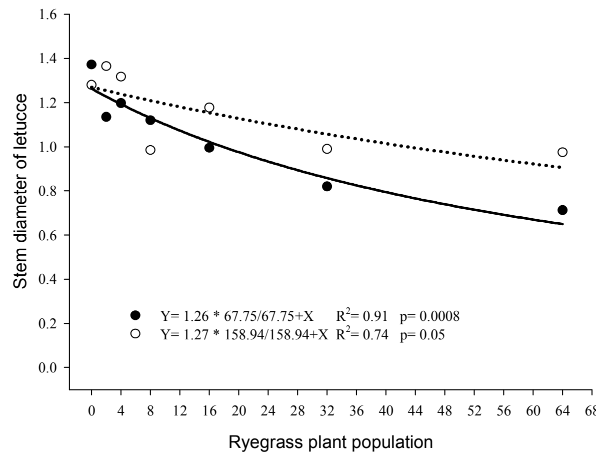

Figure 3 - Stem diameter (mm) of the summer crisp (●) and butterhead (○) lettuce types, according to the ryegrass plant population.

when subject to the populations of 2 and 64 plants per pot of ryegrass, in which the butterhead lettuce was more competitive than the summer crisp lettuce (Table 1). It is noteworthy that differences occur between the cultures and the cultivars when in intra or interspecific competition, and this fact may be related to their genetic differences. Corroborating with this paper, Negreiros et al. (2002), when testing five lettuce cultivars (Babá de Verão, Elisa, Great Lakes, Regina and Tainá) cultivated in coexistence with carrots, observed that Babá de Verão had a larger stem diameter than the others.

The number of tillers (NT) per ryegrass plant, in general, was not influenced by the presence of the lettuce types (butterhead or summer crisp), regardless of the weed population in the competition (Table 2) and none of the tested regression models were adjusted (Figure 4). It is noteworthy that NT showed, in average, 7.60 and 6.60 tillers per plant in competition with the summer crisp and butterhead lettuce types respectively.

Competition caused a reduction of 73% of the green mass (GM) of lettuce plants for the butterhead type, and 85% for the summer crisp type, in the presence of a population of 64 plants per pot of ryegrass, in relation to the no weed witness (Figure 5A). When estimating the GM accumulation loss of the summer crisp and butterhead lettuce types competing with

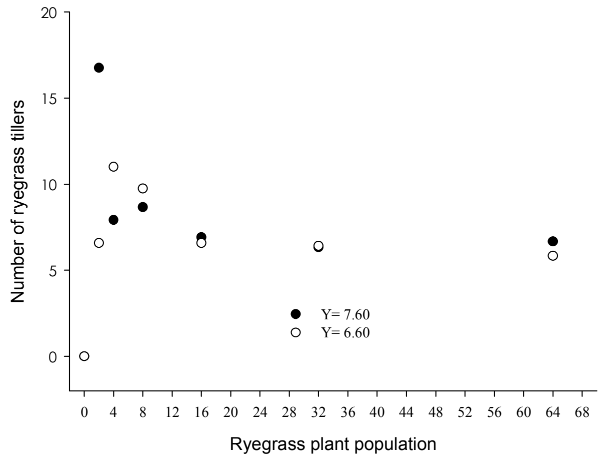

Figure 4 - Number of ryegrass tillers with the presence of summer crisp (●) and butterhead (○) lettuce types, according to the ryegrass plant population.

4 and 64 ryegrass plants, it was observed that summer crisp lettuce lost 453.94 and butterhead lettuce lost 315.34%, respectively. It is noteworthy that butterhead lettuce had a higher capacity to compete with ryegrass in comparison to the summer crisp lettuce, and it was superior to the latter at 138.6%. Results show that, in general, butterhead lettuce had a higher GM accumulation in comparison to the summer crisp lettuce, within each ryegrass population tested (Table 1). The productivity losses are a result of the high aggressiveness that ryegrass shows in relation to agricultural cultures, when competing for the environmental resources available, as reported by Agostinetto et al. (2008) and Tironi et al. (2014). Negreiros et al. (2002) also observed productivity losses of lettuce due to the interspecific competition occurred when this culture lived in coexistence systems with carrots. The population increase of ryegrass plants caused a higher GM accumulation up to the population of 32 plants per pot; after that, the studied variable was stabilized, and this fact may be related to the intraspecific competition for the environmental resources (Figure 5B). A reduction of the ryegrass GM was also observed when in competition with the summer crisp lettuce type for the population of 8 plants per pot and, for the butterhead type, for the 16 and 32 plants per pot populations (Table 2).

With the growth reduction of the lettuce culture, the total fresh mass accumulation is consequently reduced, when in competition with weeds (Melhorança Filho et al., 2008). In addition, Giancotti et al. (2010) observed a reduction of 25% on the fresh mass of summer crisp lettuce plants with an increase of the dry mass of weeds on the seed bank of the soil.

Similarly than for GM, a reduction on the dry mass (DM) accumulation was observed for the lettuce plants with the increase of the ryegrass plant population; the butterhead type had lower losses in comparison to the summer crisp type (Figure 6A), showing that it is more competitive. The ryegrass DM showed a high accumulation increase up to the population of 32 plants per pot. From this point on, it

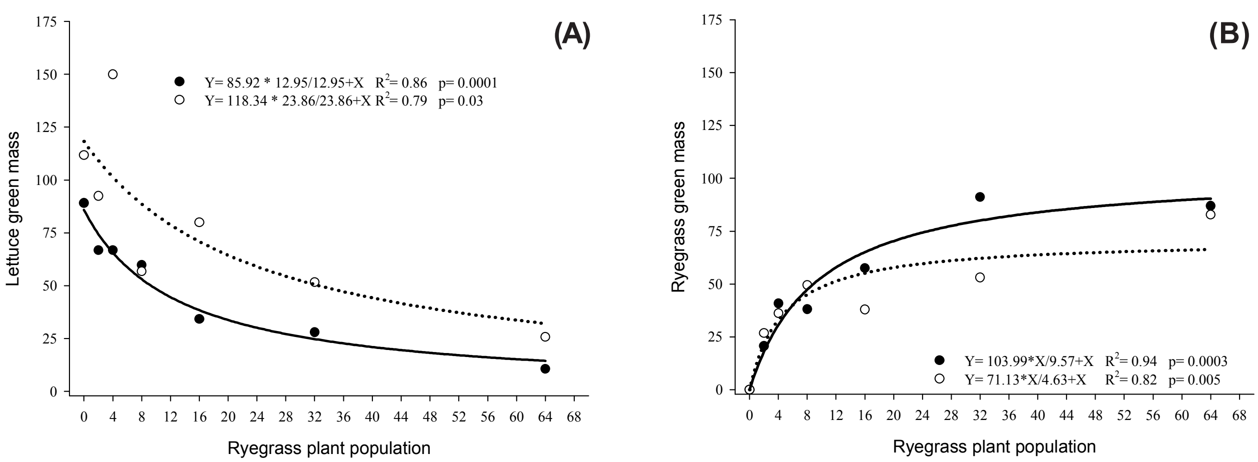

Figure 5 - Green mass (g per pot) of the summer crisp (●) and butterhead (○) lettuce types (A) and ryegrass (B), according to the ryegrass plant population.

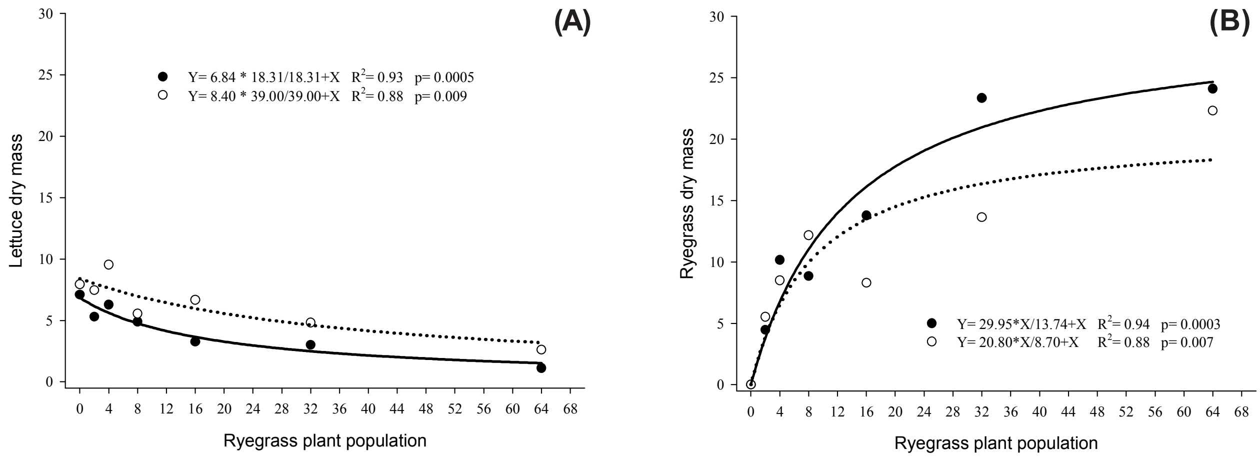

Figure 6 - Dry mass (g per pot) of the summer crisp (●) and butterhead (O) lettuce types (A) and ryegrass (B) according to the competition with ryegrass plant populations.

tended to get stable, probably due to the intra- and interspecific competitiveness among the plants in community (Figure 6B). A gain on the DM accumulation was estimated at approximately 76% for the butterhead lettuce type in comparison to the summer crisp population of 64 plants per pot (Figure 6B).

By comparing the lettuce types within each ryegrass plant population, it was observed that the summer crisp type showed lower DM accumulation for the populations of 2, 4, 16 and 32 plants per pot (Table 1); on the other populations, there were no statistical differences between the lettuce types. Resembling to what occurred for GM, for DM, it was also observed that for the populations of 16 and 32 plants per pot, ryegrass accumulated more DM in the presence of the butterhead type of lettuce, and, for the population of 8 plants per pot, the summer crisp type stood out in the competition (Table 2). For the other tested populations, no effects were observed in relation to the lettuce types on the accumulation of DM of the weed. The results are in agreement with the ones obtained by Machado et al. (2009), who verified that there was a reduction on the fresh and dry mass of lettuce plants when subject to competition with weeds during the entire culture cycle. Similarly, Ferreira et al. (2008) observed a reduction of the dry mass of the aerial part, of the number of tillers and the height of weight plants in competition with different ryegrass biotypes in densities of up to 50 plants m^{-2}.

The butterhead lettuce type showed higher competitive ability in relation to the summer crisp type in competition with ryegrass, for all tested variables. The ryegrass population increase negatively influenced the analyzed variables for both lettuce types. The lettuce productivity in competition with ryegrass showed a reduction of up to 80%, depending on the lettuce type in coexistence and the population in the community. The butterhead lettuce green mass was reduced at 73%, and for the summer crisp type, at 85%, upon the presence of 64 plants per pot of ryegrass, in comparison to the no weed witness. The butterhead lettuce accumulated approximately 76% more dry mass than the summer crisp lettuce, when competing with 64 plants per pot of ryegrass.

ACKNOWLEDGEMENTS

To CNPq and FAPERGS, for the financial assistance concessions and grants to conduct the research.

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