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Article

Competitive Relative Ability of Barley Cultivars in Interaction with Turnip

Habilidade Competitiva Relativa de Cultivares de Cevada em Convivência com Nabo

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ABSTRACT - Among the weeds that cause interference with the growth and development of barley the turnip stands out, especially by the high competitive ability for the resources available in the environment. The research objective with the study was to evaluate the competitive ability of barley cultivars to live with a turnip biotype. Experiments were installed in a greenhouse, in the experimental outlining of randomized blocks designed with four repetitions. The treatments were arranged in replacement series, consisting of proportions of barley plants and turnip: 100: 0, 75:25, 50:50, 25:75 and 0: 100% which was equivalent to 20: 0, 15: 5, 10:10, 5:15 and 0:20 plants per pot. The barley was represented by BRS Cauê, BRS Elis and MN 610 and the competitor by turnip. The competitive analysis was made through diagrams applied in replacement experiments, among with use of relative competitiveness indices. The leaf area (AF) and the dry mass of the aerial part (MS) were evaluated at 50 days after the emergence of the species. The results show that there was competition between barley varieties with the turnip with mutual damage to the species involved in the community. Turnip negatively modified the AF and the MS of BRS Cauê, MN 610 and BRS Elis demonstrating higher competitive ability for the means of the resources. The interspecific competition causes greater damage to the AF and the MS species than the intraspecific competition. Thus, the turnip control is recommended the turnip control even when present at low densities of plants infesting the barley.

Keywords: *Hordeum vulgare*, *Raphanus sativus*, competitive interaction.

RESUMO - Entre as plantas daninhas que ocasionam interferência no crescimento e no desenvolvimento da cevada, destaca-se o nabo, em especial por apresentar elevada habilidade competitiva pelos recursos disponíveis no meio. Diante disso, objetivou-se com este trabalho avaliar a habilidade competitiva de cultivares de cevada ao conviverem com um biótipo de nabo. Foram instalados experimentos em casa de vegetação, no delineamento experimental de blocos casualizados com quatro repetições. Os tratamentos foram arranjados em série de substituição, constituídos por proporções de plantas de cevada e do nabo: 100:0, 75:25, 50:50, 25:75 e 0:100%, o que equivaleu a 20:0, 15:5, 10:10, 5:15 e 0:20 plantas por vaso, respectivamente. A cevada foi representada pelos cultivares BRS Cauê, BRS Elis e MN 610, e o competidor, pelo nabo. A análise da competitividade foi efetuada por meio de diagramas aplicados a experimentos substitutivos, mais uso de índices de competitividade relativa. A área foliar (AF) e a massa seca da parte área (MS) foram avaliadas aos 50 dias após a emergência das espécies. Os resultados demonstraram que houve competição entre os cultivares de cevada com o nabo, com prejuízo mútuo às espécies envolvidas na comunidade. O nabo modificou

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negativamente a AF e a MS dos cultivares BRS Cauê, MN 610 e BRS Elis, demonstrando habilidade competitiva superior pelos recursos do meio. A competição interespecífica causa maior prejuízo à AF e à MS das espécies do que a competição intraespecífica. Dessa forma, recomenda-se o controle do nabo mesmo quando estiver presente em baixas densidades de plantas infestando a cevada.

Palavras-chave: *Hordeum vulgare, Raphanus sativus*, interação competitiva.

INTRODUCTION

The brazilian production of barley is concentrated in southern Brazil, and the Rio Grande do Sul (RS) state is responsible for 50% of the total production in the country, with an average yield of 1,800 kg $ha^{-1,}$ this being 30% lower than the national average (Conab, 2016). This winter cereal is important for the crop rotation system or as an alternative crop for farmers in southern Brazil, as properties diversification.

Among the factors that significantly affect the productivity of barley grain in RS, the interference caused by the weeds stands out. Weeds, when not properly controlled, can compromise both the grain yield and the quality of the raw material destined to the industry, causing economic losses for farmers when competing with thcrops for environmental resources (Galon et al., 2011).

Among the weeds that infest the crop of barley the turnip stands out *(Raphanus raphanistrum* and *R. sativus*), since it is very competitive for the resources available in the environment, and in many cases in RS, it presents resistance to herbicides inhibitors of aceto lactate synthase (ALS), thus making it difficult to control when using the chemical method. The turnip has been used also as a plant for ground cover,adoption of no-till system on straw, or as winter forage for animal feed (Costa and Rizzardi, 2015), and this causes the seed bank to increase in each harvest.

Turnip competes with barley for the resources available in the environment, such as water, light, CO_2 and nutrients, and therefore it alters the expression of the potential crop yield, hinders the expansion of the cultivated area, interferes with the growth and development and reduces the yield and quality of the harvested grain (Nunes et al., 2007, Galon et al., 2011, 2012), and, in many cases, it hosts insects and diseases.In the fields of Alto Uruguai Gaúcho, the turnip is widely distributed and is found in high levels of infestation. This fact is aggravated by the high shading ability of the weed species already in the early stages of the cultures, and therefore, in many cases, worsening the damages to neighboring species (Jannink et al., 2000). Another factor that contributes to the turnip highlight when infesting the barley crops is in the low capacity to compete that the culture presents when compared to other species in relation to the weed.

In this context, researches allowing to determine the competitive ability of barley with weeds become relevant for the adoption of more sustainable management methods and alternative to chemical or even the adoption of integrated weed management. Studies to determine the competitive ability of community species stand out, because the population of cultivated plants is generally constant, but the population of weeds varies according to the soil seed bank and the environmental conditions that alter the level of infestation (Agostinetto et al., 2010; Galon et al., 2011, 2015). Thus, it is important to check the influence of variation in the proportion of plants among the species, since the weed density is the factor that most affects the growth and development of crops of agronomic interest.

As for the experiments in replacement series, they are used to study the inter and intraspecific competition (Cousens, 1991). In this type of experiment, the total population is kept constant and the ratio of the two species is variable and, therefore, it is possible to compare the productivity of associations with the monoculture and to indicate which species or cultivar is more competitive (Cousens, 1991).

The hypothesis of this study was that the turnip, even though more adapted to the environment than barley, shows less competitive ability when it occurs at rates equal to the culture of cultivars in appropriate situation resources. Thus, the objective of this work was to compare the competitive abilities of barley cultivars BRS Cauê, BRS Elis and MN 610 in the presence of a turnip biotype.

MATERIAL AND METHODS

The experiments were conducted in a greenhouse at the Universidade Federal da Fronteira Sul (UFFS) campus in Erechim/RS, in the 2014/15 agricultural year. The experimental units consisted of plastic pots with a capacity of 6 $dm^{-3,}$ filled with soil originating from agriculture, characterized by Aluminium-Iron humic Red Lactosoil (Embrapa, 2013). The correction of pH and soil fertilization were performed according to the physicochemical analysis and following the technical recommendations for the cultivation of barley (Indications ..., 2013). The physical and chemical characteristics of the soil were: pH in 4.8 water; MO = 3.5%; P = 4.0 mg dm^{-3}; K = 117.0 mg dm^{-3}; Al^{3+} = 0.6 $cmol_c$ dm^{-3}; Ca^{2+} = 4.7 $cmol_c$ dm^{-3}; Mg^{2+} = 1.8 $cmol_c$ dm^{-3}; CTC (t) = 7.4 $cmol_c$ dm^{-3}; CTC (tph = 7.0) = 16.5 $cmol_c$ dm^{-3}; H + A1 = 9.7 $cmol_c$ dm^{-3}; SB = 6.8 $cmol_c$ dm^{-3}; V = 41%; and clay = 60% .

The experimental design was completely randomized with four replications. The competitors tested included barley cultivars BRS Cauê, BRS Elis and MN 610, which competed with a turnip biotype *(Raphanus sativus).*

Preliminary experiments for the barley and the turnip monocultures were performed, in order to determine the plant population in which the final production becomes constant. For this, populations 1, 2, 4, 8, 16, 24, 32, 40, 48, 56 and 64 plants per pot were used (equivalent to 25, 49, 98, 196, 392, 587, 784, 980 , 1,176, 1,372 and 1,568 plants m^{-2}), respectively. At day 50 after the emergence of the species, aerial parts of barley plants and/or turnip were collected to determine the dry mass of the aerial part (MS), which is quantified by weighing, after being dried in a forced air circulating oven at 65 ± 5 °C until it hits constant mass. By means of the average MS values obtained from the species, an MS constant production was obtained with population of 20 plants per pot, for all barley cultivars and/or turnip biotype, which amounted to 520 plants m^{-2} (data not shown).

After identifying the constant final population, three other experiments were conducted to evaluate the competitiveness of barley cultivars BRS Cauê, BRS Elis and MN 610 in competition with a turnip biotype, all conducted in replacement series in different combinations of cultivars and weed, varying the relative proportions of plants per pot (0:20, 5:15, 10:10, 15:5, 20:0), maintaining the total plant population constant (20 plants per pot). To establish the desired populations in each treatment and to achieve uniformity of seedlings, seeds were sown in trays beforehand, and later transplanted to pots.

At day 50 after emergence of the species, the leaf area (AF) and the dry weight of aerial part (MS) were measured. To determine the AF, a portable foliar area meter Model CI-203 BioScence was used in order to quantify the variable in all plants in each treatment. After determining the AF, the plants were placed in paper bags and placed for drying in a forced air circulating oven at a temperature of 60 ± 5 °C until the material reached a constant weight to measure the MS of the species.

The data were analyzed by the method of graphical analysis of the variation or relative productivity (Roush et al., 1989; Cousens, 1991; Bianchi et al., 2006). This procedure, also known as a conventional method for replacement experiments, consists of the construction of a diagram based on the yield or relative variations (PR) and total (PRT). When the result of the RP is a straight line, it means that the species' skills are equivalent. If the PR results in a concave line, it indicates loss in growth of one or both species. On the contrary, if the PR shows a convex line, there is a benefit of growth of one or both species. When the PRT is equal to 1 (straight line), it occurs competition for the same resources; if it is greater than 1 (convex line), the competition is avoided; and if the PRT is less than 1 (concave line) it occurs mutual loss of growth (Cousens, 1991).

The relative competitiveness index (CR), relative clustering coefficient (K) and aggression (A) of the species were also calculated. The CR represents a comparative growth of barley cultivars

(X) in relation the to turnip competitor (Y); K indicates the relative dominance of a species over the other, and A points which of the species is more aggressive. Thus, the CR, K and A indices indicate which species manifests itself more competitive, and its joint interpretation determines more safely the competitiveness of the species (Cousens, 1991). The X barley cultivars are more competitive than the Y turnip when CR>1, Kx> Ky and A>0; on the other hand, the Y turnip is more competitive than the X barley cultivars when CR<1, Kx<Ky and A<0 (Hoffman and Buhler, 2002).To calculate these indices 50:50 proportions of the species involved in the experiments (barley and/or turnip) were used, with the equations CR = PRx / PRy; Kx = PRx / (1-PRx); Ky = PRy / (1-PRy); A = PRx - PRy according to Cousens and O'Neill (1993).

The statistical analysis procedure of the productivity or relative variation included the calculation of the differences in the PR values (DPR) obtained in proportions of 25, 50 and 75% in relation to the values belonging to the hypothetical stretch in the respective proportions, which are: 0.25, 0.50 and 0.75 for PR (Bianchi et al., 2006; Fleck et al., 2008). The t test was used to test the differences in the DPR, PRT, CR, K and A indices (Roush et al., 1989; Hoffman and Buhler, 2002). It was considered as null hypothesis to test the differences of DPR and A, when the averages were equal to zero (Ho = 0); to PRT and CR when the averages were equal to 1 (Ho = 1); and for K, when the average of the differences between Kx and Ky were equal to zero [Ho (Kx Ky) = 0]. The criterion to consider the PR and PRT curves different from the hypothetical stretch was that, at least in two proportions, it occurred significant difference in the t test (Bianchi et al., 2006; Fleck et al., 2008). Likewise, for the CR, K and A indices, the existence of differences in competitiveness was seen when at least two of them showed a significant difference in the t test.

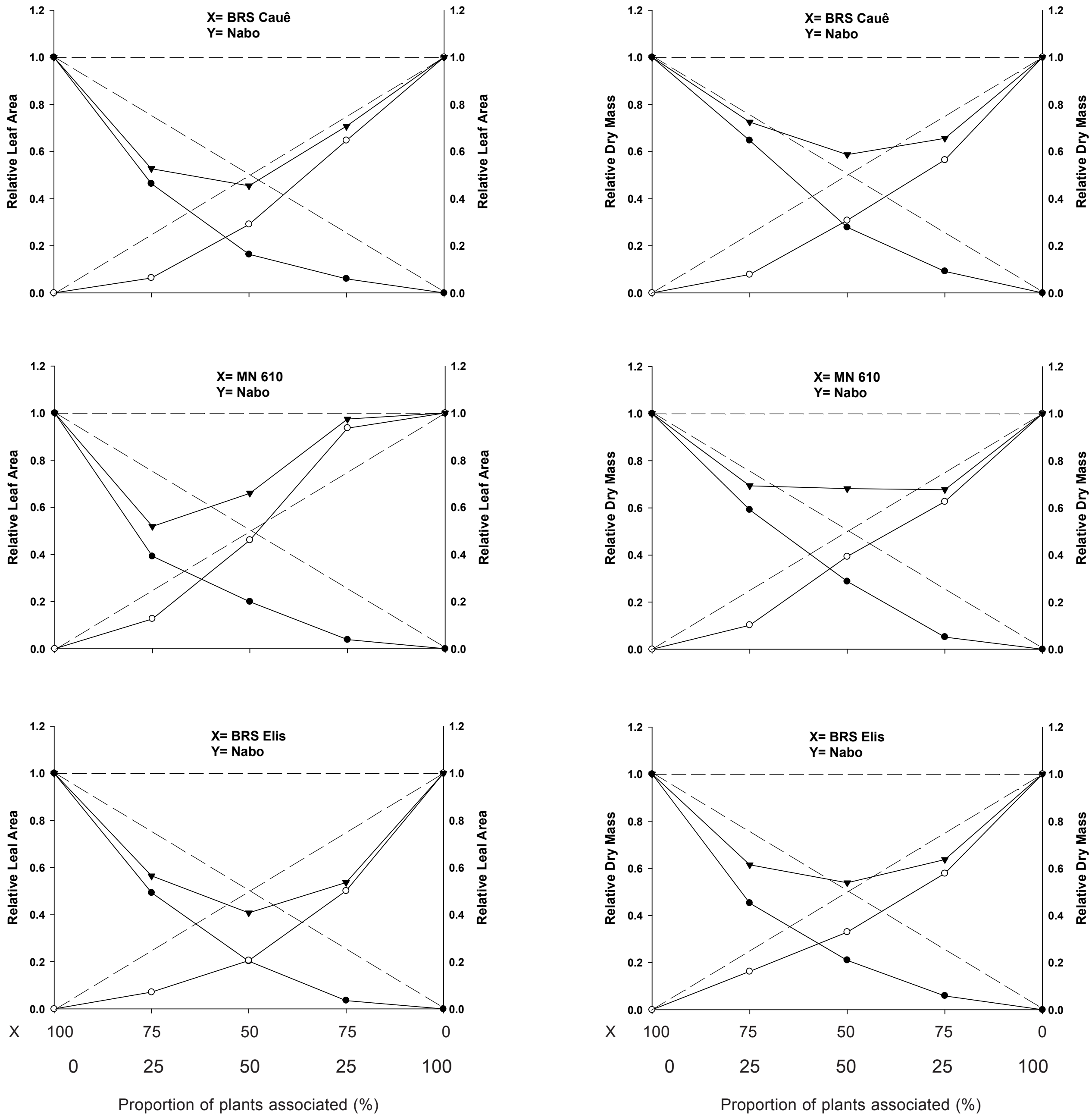
The results for AF and MS, expressed as average values per treatment were subjected to analysis of variance in the F test; being significant, the treatment averages were compared using Dunnett's test, considering monocultures as witnesses in these comparisons. In all statistical analysis the significance of p = 0.05 was adopted.

RESULTS AND DISCUSSION

The data analysis of variance showed that there were significant interactions between the proportions of barley plants or turnip to the AF (leaf area) and MS (dry weight of the aerial part) variables.The graphical results indicate, for the three barley cultivars (BRS Cauê, BRS Elis and MN 610), that they showed similarities regarding the competition with the turnip biotype and significant differences for the AF and MS variables in the proportions of plants evaluated.Significant differences were observed in at least two proportions in relation to the PRT to AF and MS to the BRS Cauê and MN 610 cultivars when competing with the turnip, with concave lines and average values below 1 (Figure 1; Table 1).These concave lines and below 1 PRT results 1 make it possible to infer that there was competition between barley and turnip for the same resources present in the environment as according to Harper (1977), when PRT<1, there is mutual antagonism between the species that are competing for the environmental resources. Results similar to this study were observed by Galon et al. (2011) when evaluating the competitive ability of barley cultivars (BRS Greta, BRS Elis and BRS 225) in competition with ryegrass *(Lolium multiflorum).*

To the AF and MS variables, in all combinations of plants involving BRS Cauê, MN 610 and BRS Elis with turnip biotype, it was observed that the deviations of the stretches of PR in relation to the expected stretches are concave lines (except when the MN 610 cultivar competed with the turnip in the proportion of 25:75 to the AF variable, which presented a convex line), both for the cultures and for the weed (Figure 1).This demonstrates that the culture and the weed compete for the same resources of the environment in which they are inserted, with mutual loss to the growth of the species. When studying the effect of ryegrass on barley, Galon et al. (2011) also observed the occurrence of concave lines for the culture and competitor for the tillering variables, AF and MS, which corroborates what was found in this study.

For there to be significance it is necessary that at least two proportions of plants differ from each other (Bianchi et al., 2006); accordingly, the occurrence of significant differences between the estimated and expected stretches was verified in the studied variables and in all proportions



(•) PR of the barley cultivars BRS Cauê, MN 610 or BRS Elis (X), the PR of the turnip competitor (Y) and (▼) PRT of the species. Dashed lines refer to the hypothetical relative productivity, when there is no competition between one species and the other UFFS, Erechim/RS, 2014.

Figure 1 **-** Relative Productivity (PR) and total productivity (PRT) to the leaf area and/or dry mass of the aerial part of barley and turnip cultivars.

of plants, except for the AF of cultivar MN 610 *versus* turnip involving the turnip PR (Figure 1; Table 1).

When evaluating Figure 1, it was found that there was a decreasing of the AF and MS variables in all proportions, according to the increasing competitor population. In the AF in the same population of the culture with the competitor, in 50:50 proportion, there was a significant difference, with reductions of more than 67, 60 and 59% for BRS Cauê, BRS Elis and MN 610, respectively, when compared to the free witness of turnip. For the MS, using the same comparison, it was observed a decrease of 44, 42 and 58% for the three cultivars in interaction with turnip. This shows that the turnip is very competitive and that when it is present in the same population

Table 1 - Relative productivity differences and total relative productivity to the leaf area and dry mass variables of the aerial part of cultivars BRS Cauê, MN 610 or BRS Elis and of the turnip biotype, 50 days after the plant emergence. UFFS, Erechim/RS 2014

Variables	Proportions of associated plants (barley: competititor)		
	75:25	50:50	25:75
Leaf Area			
BRS Cauê	-0.29 (±0.03)*	-0.34 (±0.01)*	-0.19 (±0.01)*
Turnip	-0.19 (±0.01)*	-0.21 (±0.02)*	-0.10 (±0.07)
Total	0.53 (±0.03)*	0.45 (±0.02)*	0.71 (±0.07)*
MN 610	-0.36 (±0.01)*	-0.30 (±0.01)*	-0.21 (±0.001)*
Turnip	-0.12 (±0.02)*	-0.04 (±0.03)	0.19 (±0.09)
Total	0.52 (±0.01)*	0.66 (±0.02)*	0.97 (±0.09)
BRS Elis	-0.26 (±0.02)*	-0.30 (±0.01)*	-0.21 (±0.001)*
Turnip	-0.18 (±0.00)*	-0.30 (±0.01)*	-0.25 (±0.03)*
Total	0.56 (±0.02)*	0.41 (±0.01)*	0.54 (±0.03)*
Aerial dry mass			
BRS Cauê	-0.10 (±0.03)*	-0.22 (±0.02)*	-0.16 (±0.01)*
Turnip	-0.17 (±0.001)*	-0.19 (±0.02)*	-0.19 (±0.03)
Total	0.72 (±0.03)*	0.54 (±0.01)*	0.66 (±0.04)*
MN 610	-0.16 (±0.02)*	-0.21 (±0.02)*	-0.20 (±0.001)*
Turnip	-0.15 (±0.001)*	-0.11 (±0.02)*	-0.12 (±0.04)*
Total	0.69 (±0.02)*	0.68 (±0.02)*	0.68 (±0.02)*
BRS Elis	-0.30 (±0.04)*	-0.29 (±0.02)*	-0.19 (0.01)*
Turnip	-0.09 (±0.01)*	-0.17 (±0.02)*	-0.17 (0.06)*
Total	0.61 (±0.04)*	0.54 (±0.02)*	0.64 (±0.06)*

* Significant difference by the t test (P≤0.05).Values in parentheses represent the standard error of the average.

as the culture, it causes negative interference in the growth of barley. According to Jannink et al. (2000), plant species when interacting in a community can respond to competition with growth reduction due to the effect of the interference between them, which corroborates what was observed in this study with the negative effect on AF and MS of the barley cultivars.

In general, barley cultivars showed lower growth relative to the turnip in all proportions of plants evaluated for the variables tested, with lower PR to the culture and greater to the weeds, but they showed little contribution to the PRT (Figure 1; Table 1). It is possible to report that the probable cause of the turnip to present a greater relative growth than the barley is related to the plant height, becoming more efficient in the search for solar radiation and imposing shadow to the culture (Almeida and Mundstock, 2001). When a species is more competitive than the other it means that it will have a greater absorption capacity of available resources in the environment and thus the increase of potential growth and development, which leads to increased damage to the competitor, since smaller amounts of resources are available (Agostinetto et al., 2013). It should be noted that in replacement experiments, there is little evidence of qualitative changes due to the increased population, in other words, the dominance of one species over the other rarely changes with the change of the population (Cousens and O'Neill, 1993).

An increase in the PRT of the combinations was observed, as larger were the combinations of proportions of plants competing with each other – a significant situation for all variables (Table 1). This behavior shows that the species are competitive and that one does not contribute more than expected to the total productivity of the other. Because they belong to different botanical families, it was expected that the barley cultivars and the turnip explored different ecological niches and not compete for the same resources of the environment. Thus, they would not present distinction in terms of competitiveness because these differences have been found in many studies using closely related species, for example between barley x ryegrass (Galon et al., 2011), rice x gulf cockspur grass (Galon and Agostinetto, 2009), rice x red rice (Fleck et al., 2008) and cultivated sorghum x *sorghum halepense* (Hoffman and Buhler, 2002).However, some papers report the occurrence of differentiation in the competition of plant from different families, such as wheat x turnip (Rigoli et al., 2008), crabgrass x soybean (Agostinetto et al., 2013) and rice x zigzag jointvetch (*Aeschynomene rudis*) (Galon et al., 2015).

The relative growth of the barley cultivars BRS Cauê, MN610 and BRS Elis showed similar values in the same proportion of plants in competition, for the AF and MS variables (Figure 1; Tables 1 and 2). Thus, even though the cultivars presented different characteristics as height and development cycle (Technical Information..., 2013), there was no differentiation in their competition with the turnip. These results allow us to infer that there is no sharp effect of intrinsic characteristics in growing on the turnips and that the ability of barley cultivars to interfere with the weed was equivalent. The results observed differ from those found by Fischer et al. (1997), Fleck et al. (2008) and Galon et al. (2015), which verified the existence of competitive variability according to the development cycle of each cultivar. However, this may result from the fact that biotic and abiotic factors affect the work undertaken in the field and that this may act differently for each cultivar. Thus, there is greater importance of the development cycle variation and the height of the plants, which is not observed in the greenhouse, because the environment is controlled and there is less pressure from the biotic and abiotic factors.

The AF and MS morphological variables of cultivars BRS Cauê, MN 610 and BRS Elis in general were reduced when competed with the turnip in all analyzed associations, regardless of the proportion of plants in the association (Table 2). The higher the proportion of the competitor in association with the cultivars, the greater were the damages to the variables of the culture. In the turnip, it was verified the same tendency to reduce AF and MS, which was observed for culture. Researches have reported that it may occur damage to the growth of the cultures and weeds when they are competing in a given community (Feck et al., 2008; Rigoli et al, 2008; Galon and Agostinetto, 2009; Agostinetto et al., 2009; Galon et al., 2011).

In general, the results for both AF and MS variables show that the highest average per plant of the culture, or even the turnip, were obtained when they are presented in smaller populations in association in all combinations (Table 2). Therefore, it is observed that interspecific competition is less harmful than intraspecific competition for both species involved. When working with rice and soybean x zigzag jointvetch (*Aeschynomene rudis*) (Agostinetto et al., 2013), wheat x turnip

Table 2 - Barley cultivars (BRS Cauê, MN 610 or BRS Elis) response to the turnip biotype interference for the leaf area and dry weight variables of the aerial part, 50 days after the emergence. UFFS, Erechim/RS 2014

Proportions of plants (Barley: Turnip)	Leaf area (cm^2 per pot)	Dry mass (g per pot)
BRS Cauê		
100: 0 (T)	2035.58	8.33
75:25	1259.19*	7.18
50:50	667.23*	4.64*
25:75	490.70*	3.07*
VC (%)	9.88	11.95
Competitive turnip		
0: 100 (T)	1977.94	16.40
25:75	1705.80	12.33*
50:50	1150.53*	10.11*
75:25	503.70*	5.14
VC (%)	27.87	9.54
Cultivar MN 610		
100: 0 (T)	2454.85	13.17
75:25	1284.05*	10.40*
50:50	978.74*	7.59*
25:75	372.63*	2.71*
VC (%)	14.38	9.36
Competitive Turnip		
0: 100 (T)	1142.93	15.89
25:75	915.66	13.26*
50:50	843.72	12.50*
75:25	464.31*	6.48*
VC (%)	19.23	6.33
Cultivar BRS Elis		
100: 0 (T)	2026.34	12.01
75:25	1331.90*	7.24*
50:50	821.11*	5.04*
25:75	288.35*	2.82*
VC (%)	8.34	14.32
Turnip Competitor		
0: 100 (T)	1937.03	16.62
25:75	1294.41*	12.82*
50:50	793.91*	10.95*
75:25	551.75*	10.82*
VC (%)	8.34	14.17

* Average differs from the witness (T) by the Dunnett test ($p \leq 0.05$).

(Costa and Rizzardi, 2015), rice in competition with zigzag jointvetch (*Aeschynomene rudis*) (Galon et al., 2015) and wheat in the presence of ryegrass (Rigoli et al., 2008), the same effects denoted in this study were also observed.

Competition affects quantitative and qualitative production, because it changes the utilization efficiency of environmental resources such as water, light, CO_2 and nutrients (Bianchi et al., 2006), establishing itself between the culture and plants of other species on site. This competition also occurs between individuals of the same species or between predominant biotypes in the area, as observed by Ferreira et al. (2008), which verified that ryegrass biotypes resistant to glyphosate have lower competitiveness than the susceptible ones. It is also noteworthy that in a community of plants there is benefit in competition for resources for those who are established first, by the intrinsic characteristics of each cultivar in relation to the competitive ability (height, growth rate, number of tillers, etc.), through better use or the need of resources for a particular species within an ecological niche.

The barley X cultivar (BRS Cauê, MN 610 and BRS Elis) is more competitive than the turnip Y, when compared by the coefficients developed by Hoffman and Buhler (2000), CR>1, $K_x > K_y$ and A>0. Thus, the occurrence of significant difference in at least two levels (Bianchi et al., 2006) was adopted as a criterion to prove competitive superiority. In general, the turnip showed higher growth for the AF and MS variables when in competition with barley cultivars BRS Cauê, MN 610 and BRS Elis, as indicated by the CR (less than 1), K (greater than culture) and A (negative) indices. Overall, there were differences among barley cultivars and turnip, which shows that both are not equivalent in terms of competition for environmental resources, highlighting that the weed is more competitive than the culture (Table 3). Using the three indices to determine the competitiveness, it was observed that the cultivated sorghum was more competitive than the Sorghum halepense (Hoffman and Buhler, 2002), the turnip was more competitive than soybean genotypes (Bianchi et al., 2006) and red rice showed greater aggression than the watered rice (Fleck et al., 2008).

When interpreting the graphical analysis in conjunction with the relative variables and their significance in relation to the equivalent values (Figure 1; Table 1), the morphological variables (Table 2) and the competitive indices (Table 3), in general, it was found that there is competition effect of the turnip on barley cultivars BRS Cauê, MN 610 and BRS Elis, demonstrating that this weed presents high competitive ability in relation to the culture. The results found by Galon et al. (2011) corroboratewith the present work, when exhibiting that the ryegrass was also more competitive than the barley cultivars BRS Greta, BRS Elis and BRS 225. By basically exploring the same ecological niche, the barley cultivars and the turnip compete for similar resources in time and/or space. Thus, differences in terms of competitiveness of the tested species may occur due to the fact that they present demands for nutrients, light and water similar to each other. Researches have shown that the same species of the botanical families with different morphological and physiological characteristics present similarities in demand for environmental

Table 3 - Competitiveness indices among barley cultivars (BRS Cauê, MN 610 or BRS Elis) and the compettitor (turnip), expressed as relative competitiveness (CR), groups of coefficients (K) and aggression (A), obtained in experiments conducted in replacement series. UFFS, Erechim/RS, 2014/15

Variables	CR	K_x (barley)	K_y (turnip)	A
Leaf Area				
BRS Cauê x Turnip	0.57 (±0.07)*	0.20 (±0.01)*	0.41 (±0.03)*	-0.13 (±0.02)*
MN 610 x Turnip	0.44 (±0.55)*	0.25 (±0.01)*	0.87 (±0.10)*	-0.26 (±0.04)*
BRS Elis x Turnip	1.01 (±0.11)	0.26 (0.02)	0.26 (±0.02)	-0.002 (±0.02)
Dry mass of the aerial part				
BRS Cauê x Turnip	0.93 (±0.15)	0.39 (±0.05)	0.45 (±0.04)	-0.03 (±0.04)
MN 610 x Turnip	0.74 (±0.06)*	0.41 (±0.04)*	0.65 (±0.05)*	-0.11 (±0.03)*
BRS Elis x Turnip	0.64 (±0.06)*	0.27 (±0.03)*	0.49 (±0.03)*	-0.12 (±0.02)*

* Significant difference by the t test (P≤0.05). Values in parentheses represent the standard error of the average. K_x and K_y are the group coefficients for the cultivation of barley and the competitor turnip, respectively.

resources, such as turnip x soybean (Bianchi et al., 2006), crabgrass x soybean (Agostinetto et al. 2013) and rice x zigzag jointvetch (*Aeschynomene rudis*) (Galon et al., 2015).

The knowledge of the dynamics and competitiveness between plants – especially barley and turnip – is essential for decision-making to control the weed in a given population that will not cause negative interference on the culture, even considering that the turnip can produce up to 17,275 seeds m^{-2} (Reeves et al., 1981) and that this weed is resistant to the herbicides inhibiting ALS (Costa and Rizzardi, 2015), widely used in controlling infesting weed species of barley and wheat.

The results makes it possible to conclude that there was competition for the same environmental resources among barley cultivars BRS Cauê, MN 610 and BRS Elis with the turnip, with mutual loss to the species involved in the community. Turnip negatively modified the leaf area and the dry weight of barley cultivars BRS Cauê, MN 610 and BRS Elis, demonstrating superior competitive ability for the resources available in the environment. The interspecific competition causes bigger losses to the leaf area and to the dry mass of the species than the intraspecific competition. Therefore, the turnip control is recommended even when presented in low density because of the damage it causes to the growth of the barley culture.

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