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Article

Competitive Ability of Canola Hybrids Resistant and Susceptible to Herbicides

Habilidade Competitiva de Híbridos de Canola Resistentes e Suscetível a Herbicidas

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ABSTRACT - This work aimed to compare the competitive ability of canola hybrids susceptible (conventional) or resistant to triazine or imidazolinone group herbicides, with turnip. The experiments were conducted in greenhouse, in a completely randomized design, with four replicates. The hybrids Hyola 571CL (resistant to imidazolinone), Hyola 555TT (resistant to triazine), and Hyola 61 (conventional) were used. The treatments consisted of ratios (100:0; 75:25; 50:50; 25:75; 0:100%) of canola and turnip plants. The evaluation was performed 44 days after emergence, determining the leaf área (AF), dry matter of aerial part (MSPA), and stature (EST) of the plants. The competitiveness analysis was performed through diagrams and interpretation of the competitiveness indexes. For the canola hybrids, the competition occurred by the same mean resources. There was damage to the crop growth in competition with the turnip. The turnip was not benefited only when in competition with Hyola 571CL hybrid, for the EST variable, and with the conventional canola, for the variable AF. There was significance for the competitiveness indexes, demonstrating that turnip is more competitive then the crop. Greater AF, MSPA, and EST occurred for canola plants in the smallest proportions of turnip and, for turnip plants, in the largest proportions of canola. The ability to compete with turnip is similar among hybrids, with injury to the crop and benefit to the weed, when competing. Interspecific competition is more damaging to canola hybrids; and intraspecific competition is more damaging to turnip.

Keywords: *Brassica napus* L., *Raphanus sativus* L., interference, competitiveness.

RESUMO - Este trabalho objetivou comparar a habilidade competitiva de híbridos de canola, suscetível (convencional) ou com resistência aos herbicidas do grupo das triazinas ou das imidazolinonas, com o nabo. Os experimentos foram conduzidos em casa de vegetação, no delineamento inteiramente casualizado com quatro repetições. Foram utilizados os híbridos Hyola 571CL (resistente a imidazolinonas), Hyola 555TT (resistente a triazinas) e Hyola 61 (convencional). Os tratamentos consistiram de proporções (100:0; 75:25; 50:50; 25:75; 0:100%) de plantas de canola e do nabo. A avaliação foi realizada aos 44 dias após a emergência, determinando-se a área foliar (AF), matéria seca de parte aérea (MSPA) e estatura (EST) de plantas. A análise da competitividade foi feita por meio de diagramas e interpretação dos índices de competitividade. Para os híbridos de canola, a competição ocorreu pelos mesmos recursos do meio. Houve prejuízo ao crescimento da cultura em competição com o nabo. O nabo somente não foi beneficiado quando em competição com o híbrido Hyola 571CL, para a variável EST, e com a canola convencional, para a variável AF. Houve significância para os índices de competitividade, demonstrando que o nabo é mais competitivo que a cultura.

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Maior AF, MSPA e EST ocorreu para plantas de canola nas menores proporções de nabo e, para plantas de nabo, nas maiores proporções de canola. A habilidade em competir com o nabo é semelhante entre os híbridos, havendo prejuízo à cultura e benefício à planta daninha, quando em competição. A competição interespecífica é mais prejudicial para os híbridos de canola, e a competição intraespecífica, para o nabo.

Palavras-chave: *Brassica napus* L., *Raphanus sativus* L., interferência, competitividade.

INTRODUCTION

The presence of weeds in canola (*Brassica napus* L. var. *oleifera*) constitutes a barrier to reach high yields, reducing the availability of water, light and nutrients for the crop. Because they belong to the same family as canola (Brassicaceae), turnip (*Raphanus sativus* L. var. *oleiferus* Metzg) and wild radish (*R. raphanistrum* L.) are considered difficult to control species, and there are no products with proven efficiency on such species and selectivity to the crop (Vargas et al., 2011). Thus, the development of canola hybrids with resistance to herbicides is considered an advance for the crop, allowing the management of weeds of difficult control.

Weeds generally present rusticity, allowing them to adapt to the most diverse conditions with ease, which gives them advantage over the cultivated plants. The development of hybrids with herbicide resistance may be associated with an adaptive cost to plants, reducing their ability to compete with weeds. Triazine-resistant plants present three times lower electron flow rate from primary quinone (QA) to secondary one (QB), which is due to the mutation in the D1 protein of photosystem II (FSII) (Jansen and Pfister, 1990). Regarding herbicide resistance of the imidazolinones group, the adaptive cost of mutations in the gene encoding the acetolactate synthase (ALS) enzyme, which is inhibited by the herbicide in susceptible plants, is generally not high, and such resistance is considered to be an advance in being cultivated plants (Tranel and Wright, 2002; Tranel and Horvath, 2009).

The greater competitiveness of the crop or weed can occur due to the greater capacity of apprehension of the resources of the environment, less need of the resource or anticipated emergence in relation to the other species and present population (Agostinetto et al., 2013). When crops are sown in a mixture with weeds, with variation in the proportion of plants, there may be advantage of both the crop and the competing weed - variations that occur in function of the species that are present (Dal Magro et al., 2011). Also, within the same species, cultivars/ hybrids submitted to the breeding process may present differences in the ability to compete with weeds due to changes in physiological processes, such as changes in enzymes or proteins that confer resistance to herbicides.

The hypothesis of this work is that the hybrid of canola resistant to triazine herbicides presents less ability to compete with the turnip, in comparison to the other hybrids. The objective was to compare the competitive ability of susceptible or herbicide resistant canola hybrids from the triazines group or the imidazolinones with the turnip.

MATERIAL AND METHODS

The experiments were conducted in a greenhouse, using a completely randomized design with four replicates. The following canola hybrids were used: Hyola 571CL (resistant to imidazolinones), Hyola 555TT (resistant to triazine) and Hyola 61 (conventional).

To evaluate the competitive ability of the canola hybrids, two experiments were carried out. In both, vessels with volumetric capacity of 9 L and surface diameter of 24 cm were used, and they were filled with soil (humic dystrophic Red Latosol), with the following physical and chemical characteristics: clay: 620 g dm^{-3}; pH_{water}: 6,2; P: 15,6 mg dm^{-3}; K: 166 mg dm^{-3}; organic matter: 20 mg dm^{-3}; base saturation: 79%), and, after sowing, with a 4 cm layer of substrate (peat). When required, thinning or transplanting of seedlings was performed to meet the desired populations. In experiment I, three replications were used, and in experiment II, four replicates were used.

In experiment I, in an additive series, monocultures of the canola hybrids Hyola 61, Hyola 571CL (resistant to imidazolinones) and Hyola 555TT (resistant to triazine) and of turnip, cultivar IPR 116, in the populations of 2, 4, 8, 16, 32, 64 and 128 plants per pot (equivalent to 44, 89, 178, 356, 711, 1,422 and 2,844 plants m^{-2}), respectively, were deployed. This test aimed to determine the population of plants in which the final yield becomes constant. Experiment I was conducted from 6/23/14 to 8/10/14.

At 44 days after emergence (DAE), when the turnip and canola plants were in the leaf development stage, with six open leaves (Canola Council of Canada, 2017), the dry matter of the aerial part (MSPA) was determined by weighing the aerial part of the plants after drying in an oven at 60 °C until constant mass. For the analysis of the data, the reciprocal method of production per plant was used to determine the production of constant MSPA, which was obtained with the population of 889 plants m^{-2} (40 plants/pot) for the crop and weed (data not shown).

Experiment II was carried out in a substitute series, using the plant population determined in the previous experiment, which was 40 plants pot^{-1} (889 plants m^{-2}). The treatments consisted of ratios of canola plants of each hybrid, and of turnip, being 100:0 (stand only with canola), 75:25, 50:50, 25:75 e 0:100% (stand only with turnip). The period of conduction of experiment II was from 8/31/14 to 10/18/14.

The evaluation was performed at 44 DAE, when the canola plants were in the inflorescence emergence stage, with free flower buds and at the level of the youngest leaves (Canola Council of Canada, 2017), while the turnip was in full flowering. The stature of the plants (EST – cm) (with distended leaf blade), leaf area (AF – cm^2) and MSPA (g) were evaluated. The EST of the plants was determined using a graduated ruler; the AF was determined using foliar area meter (brand: LI-COR, model: LI-3100C); and the MSPA was determined as described in experiment I.

For the analysis of the data referring to AF, MSPA and EST of the crop and the competitor, the graphical analysis method of relative productivity was used (Roush et al., 1989; Cousens, 1991). The relative productivity (PR) was calculated as follows: PR = average (AF, MSPA or EST) of the proportion of plants/average (AF, MSPA or EST) of the monoculture. The total relative productivity (PRT) was calculated by the sum of the PR of the competitors, for each proportion of plants.

Diagrams based on PR and PRT were constructed. In these diagrams, the results obtained for PR were compared to a hypothetical line joining the points zero and 100 and representing the absence of interference of one species over the other. The PR that results in higher values in relation to the hypothetical line indicates that there was benefit in the growth of the species in question; and the PR with smaller values in relation to the hypothetical line indicates that there was damage in the growth of such species. The PRT equal to the unit (straight line) shows that there is competition for the same resource(s); PRT greater than 1 represents no competition; PRT lower than 1 indicates that antagonism occurs and, therefore, mutual injury to the growth of the species (Cousens, 1991).

Relative competitiveness (CR), relative clustering coefficient (K) and competitiveness (C) were calculated, where CR represents the growth of species x in relation to species y; K indicates the relative dominance of one genotype over the other; and A indicates which of the genotypes is more aggressive.

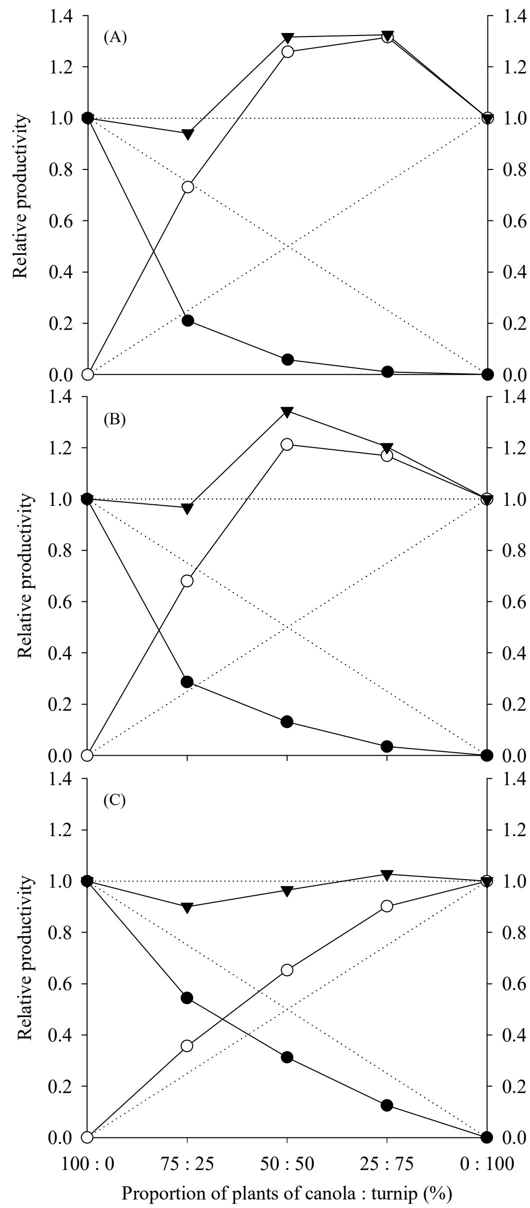
Regarding the statistical analysis, the difference was calculated for the PR (DPR) values obtained in the proportions of 25%, 50% and 75% in relation to the values of the hypothetical line, which correspond to 0.25, 0.50 e 0.75 PR, respectively. To test differences in the DPR, PRT, CR, K and C indices, the t-test was used ($p \leq 0.05$) (Roush et al., 1989). As a null hypothesis, the averages were considered to be zero to test the DPR, C and the differences between K_x and K_y; and, to test the PRT and the CR, it was considered as a null hypothesis that the means were equal to 1.

In order to verify if the PR and PRT curves were different from the hypothetical lines, it was adopted the criterion that at least in two proportions a significant difference occurred by the t test. (Bianchi et al., 2006). For the variables CR, K and C, a difference in competitiveness was considered when at least two of them had a significant difference by the t test.

The results obtained for AF, MSPA and EST of canola and turnip plants, expressed as mean values per plant, were submitted to analysis of variance. When the F test indicated significance (p≤0.05), the means of the treatments were compared by the Dunnett test (p≤0.05), considering the respective monocultures as controls.

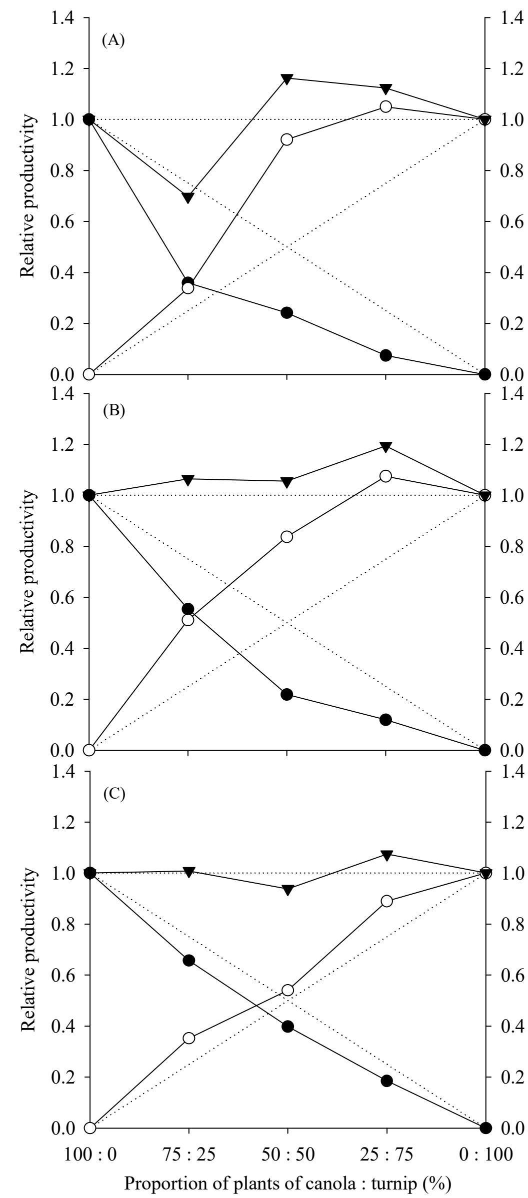
RESULTS AND DISCUSSION

According to the graphical analysis of the results for the combination of turnip and canola plants, Hyola 571CL, Hyola 555TT and Hyola 61 hybrids, PRT did not differ from 1, indicating that the competition was due to the same medium resources between the plants (Figures 1, 2 and 3; Table 1). For all variables, PR of canola presented concave line, and PR of turnip presented convex



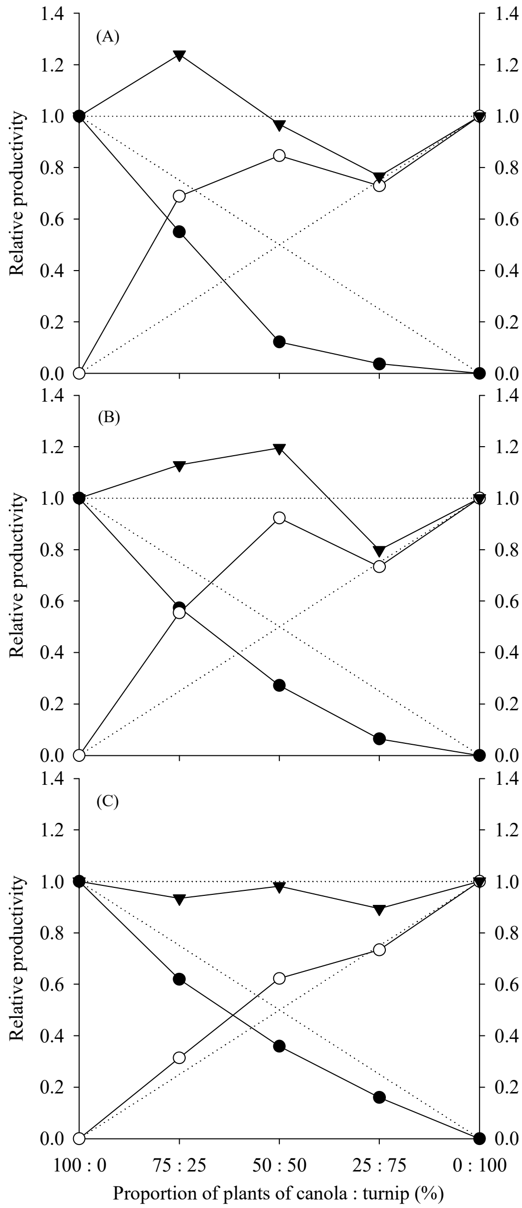
Dashed lines refer to hypothetical relative productivities.

Figure 1 - Relative productivity of canola plants of Hyola 555TT hybrid (●) and turnip (o) and total relative productivity (▼) regarding the leaf area (A), dry matter of aerial part (B) and stature (C), according to the proportions between the species.



Dashed lines refer to hypothetical relative productivities.

Figure 2 - Relative productivity of canola plants of Hyola 571CL hybrid (●) and turnip (o) and total relative productivity (▼) regarding the leaf area (A), dry matter of aerial part (B) and stature (C), according to the proportions between the species.



Dashed lines refer to hypothetical relative productivities.

Figure 3 - Relative productivity of canola plants of Hyola 61 hybrid (•) and turnip (o) and total relative productivity (▼) regarding the leaf area (A), dry matter of aerial part (B) and stature (C), according to the proportions between the species.

line, in relation to hypothetical line, indicating damage to crop growth and benefit to weed (Figures 1, 2 and 3). The PR differences of the crop (canola) for all hybrids and variables analyzed were significant in at least two plant proportions (Table 1).

For the turnip, the relative productivity difference was not significant only when competing with the Hyola 571CL hybrid, for the EST variable, and with the conventional canola, for the AF variable (Table 1). In the other competition trials and for the other variables, turnip PR was superior to the hypothetical line (Table 1).

In an experiment carried out comparing the competitive ability of Hyola 61, Hyola 76, Hyola 433 and Hyola 571CL canola hybrids with the turnip, the authors verified that there was mutual injury to the growth of the crop and weed, being observed concave lines for PR of both (Galon et al., 2015). Still in this trial, the authors found PRT lower than 1, indicating that competition between canola and turnip caused mutual injury. These results were different from those obtained in the present study, due to the different hybrids used.

Regarding the competitiveness indexes, there was significance in at least two of them in all the competition tests between the canola hybrids and the turnip, for all variables evaluated (Table 2). Considering AF and MSPA, in all competition trials, there was difference for the CR and C indexes, where the CR presented values lower than 1 and the C presented values lower than zero, demonstrating that the turnip is more competitive than the culture (Table 2).

For the EST variable, in addition to differences for CR and C, there was also a difference for the K index, where K_{canola} was lower than K_{turnip} (Table 2). The EST results corroborate the results obtained for AF and MSPA, in which turnip is more competitive than canola, regardless of the hybrid.

In a previous study, considering the competitiveness indexes, a higher competitive ability was observed for Hyola 433 hybrids in relation to turnip, both for AF and MSPA, while the other hybrids used in this test (Hyola 61, Hyola 76 and Hyola 571CL) had similar or inferior competitiveness to turnip (Galon et al., 2015).

Generally, in competitive trials, the crop is more competitive than the weed in individual terms, since the weed effect is not due to its greater individual competitive ability, but mainly due to the combined effect of its total population of plants (Vilá et al., 2004). However, in related species, the advantage is not necessarily of the commercial crop (Bianchi et al., 2006). Weeds present greater genetic variability, which gives them greater opportunity to adapt to the competitive environment than the cultivated species, which underwent a selection process by man (Bianchi et al., 2006).

Table 1 - Relative productivity differences (DPR) and total relative productivity (PRT) for leaf area (AF), dry matter of aerial part (MSPA) and stature (EST) variables, in the proportions 75:25, 50:50 and 25:75 of the canola hybrid Hyola 555TT, Hyola 571CL and Hyola 61, in competition with turnip

	Proportion of associated plants		
	75:25	50:50	25:75
AF			
DPR[(1)] (Hyola 555TT)	-0.54 (±0.17) *	-0.44 (±0.03) *	-0.24 (±0.01) *
DPR (turnip)	0.48 (±0.21) *	0.76 (±0.41) *	0.56 (±0.45) ns
PRT[1]	0.94 (±0.36) ns	1.32 (±0.44) ns	1.32 (±0.45) ns
DPR (Hyola 571CL)	-0.39 (±0.08) *	-0.26 (±0.10) *	-0.18 (±0.00) *
DPR (turnip)	0.09 (±0.13) ns	0.42 (±0.14) *	0.30 (±0.10) *
PRT	0.70 (±0.12) ns	1.16 (±0.17) ns	1.12 (±0.10) ns
DPR (Hyola 61)	-0.20 (±0.18) ns	-0.38 (±0.00) *	-0.21 (±0.02) *
DPR (turnip)	0.44 (±0.15) *	0.35 (±0.30) ns	-0.02 (±0.05) ns
PRT	1.24 (±0.32) ns	0.97 (±0.31) ns	0.77 (±0.07) *
MSPA			
DPR (Hyola 555TT)	-0.46 (±0.10) *	-0.37 (±0.05) *	-0.22 (±0.01) *
DPR (turnip)	0.43 (±0.03) *	0.71 (±0.28) *	0.42 (±0.31)ns
PRT	0.97 (±0.13) ns	1.34 (±0.33) ns	1.20 (±0.32) ns
DPR (Hyola 571CL)	-0.20 (±0.11) *	-0.28 (±0.09) *	-0.13 (±0.01) *
DPR (turnip)	0.26 (±0.16) *	0.34 (±0.25) ns	0.32 (±0.14) *
PRT	1.06 (±0.18) ns	1.06 (±0.32) ns	1.19 (±0.15) ns
DPR (Hyola 61)	-0.18 (±0.10) *	-0.23 (±0.08) *	-0.18 (±0.02) *
DPR (turnip)	0.30 (±0.06) *	0.42 (±0.18) *	-0.02 (±0.20) ns
PRT	1.13 (±0.16) ns	1.20 (±0.26) ns	0.80 (±0.22) ns
EST			
DPR (Hyola 555TT)	-0.21 (±0.07) *	-0.19 (±0.04) *	-0.12 (±0.01) *
DPR (turnip)	0.11 (±0.02) *	0.15 (±0.03) *	0.15 (±0.13) ns
PRT	0.90 (±0.07) ns	0.97 (±0.06) ns	1.03 (±0.14) ns
DPR (Hyola 571CL)	-0.09 (±0.11) ns	-0.10 (±0.04) *	-0.07 (±0.02) *
DPR (turnip)	0.10 (±0.02) *	0.04 (±0.05) ns	0.14 (±0.09) ns
PRT	1.01 (±0.12) ns	0.94 (±0.05) ns	1.07 (±0.09) ns
DPR (Hyola 61)	-0.13 (±0.03) *	-0.14 (±0.04) *	-0.09 (±0.02) *
DPR (turnip)	0.06 (±0.03) *	0.12 (±0.06) *	-0.02 (±0.03) ns
PRT	0.93 (±0.06) ns	0.98 (±0.06) ns	0.89 (±0.04) *

(1) DPR and PRT: t test, being considered significant (*) when the values differed ($p \leq 0.05$) from zero and 1, respectively. Values in parentheses represent the standard deviation.

In the present trial, at the time of the evaluation, the canola plants were with the flower buds free and at the level of the younger leaves (Canola Council of Canada, 2017), while the turnip was in full flowering. This is due to the cultivation conditions to which the plants were submitted (relatively high temperatures), because high temperatures favor the early flowering of the turnip. The shortening of the turnip cycle suggests an earlier use of environmental resources, favoring their growth and development to the detriment of the canola crop.

By means of the values of MSPA and mainly EST, presented in Table 3, it is possible to infer that the turnip has a greater ability to compete with the evaluated canola hybrids, since these were generally higher for the turnip in relation to the canola in the respective monocultures.

Table 2 - Competitiveness indexes among canola and turnip hybrids, expressed by relative competitiveness (CR) and relative grouping coefficients (K) and competitiveness (C), for leaf area (AF), dry matter of aerial part (MSPA) e stature (EST) variables of the canola hybrid Hyola 555TT, Hyola 571CL and Hyola 61, in competition with turnip

Hyola 555TT x turnip				
	CR[1]	K_{canola}[2]	K_{turnip}	C[1]
AF	0.04 (±0.02) *	0.07 (±0.04) ns	-0.91 (±3.92)	-1.20 (±0.39) *
MSPA	0.10 (±0.03) *	0.15 (±0.07) ns	-3.35 (±0.67)	-1.08 (±0.23) *
EST	0.48 (±0.06) *	0.46 (±0.09) *	1.89 (±0.23)	-0.34 (±0.04) *
Hyola 571CL x turnip				
AF	0.27 (±0.12) *	0.36 (±0.20) ns	3.43 (±2.23)	-0.68 (±0.16) *
MSPA	0.26 (±0.07) *	0.29 (±0.08) ns	1.80 (±1.44)	-0.62 (±0.19) *
EST	0.74 (±0.12) *	0.67 (±0.11) *	1.19 (±0.24)	-0.14 (±0.07) *
Hyola 61 x turnip				
	CR	K_{canola}	K_{turnip}	C
AF	0.16 (±0.07) *	0.14 (±0.01) ns	3.42 (±2.70)	-0.72 (±0.30) *
MSPA	0.29 (±0.04) *	0.38 (±0.16) ns	4.12 (±1.56)	-0.65 (±0.10) *
EST	0.58 (±0.10) *	0.56 (±0.10) *	1.71 (±0.46)	-0.26 (±0.09) *

[1] CR and C: t test, being considered significant (*) when the values differed ($p \leq 0.05$) from zero and 1, respectively. The difference between K_{canola} and K_{turnip} was compared by the t test, being considered significant (*) when the values differed ($p \leq 0.05$) from zero. Values in parentheses represent the standard deviation.

Higher dry matter yield, as well as higher plant height, generally indicates a higher competitive ability (Bianchi et al., 2011).

When comparing the values of AF, MSPA and EST of the canola in each proportion of the mixture (25%, 50% and 75%) with the values obtained in the monoculture (100%), a greater effect of interspecific competition was observed, since the higher averages of the culture were observed when it was in a larger population than the competitor (Table 3). When considering the weed, turnip, it was observed a greater effect of intraspecific competition, since the highest values were obtained for the largest proportions of canola, with a difference in relation to monoculture (Table 3).

The results regarding the competitive ability of the hybrids of canola with the turnip are important to assist in the selection of the hybrid when there is the presence of the competitor turnip in the crops. In the present study, the hybrids of canola had similar competitiveness among themselves and, in all cases, less competitiveness than the turnip. Therefore, the adaptive cost reported for triazine-resistant canola materials, in the case of the Hyola 555TT hybrid, had no effect on their ability to compete with the turnip, in comparison to the other evaluated hybrids.

Regarding the choice of materials, it is important to point out that, since 2001, there have been biotypes of turnip resistant to ALS inhibitor herbicides (Heap, 2017), besides the existence of cross resistance of turnip biotypes to this mechanism of action (Cechin et al., 2016). Therefore, the use of the hybrid Hyola 571CL in crops infested with resistant turnip is not recommended, since the herbicide selective to the crop will not promote the control of this weed.

Based on these results, it is concluded that the ability to compete with the turnip is similar among the canola hybrids, causing harm to the growth of the hybrids when in competition with the turnip, and causing benefit to the turnip growth when in competition with the canola. Interspecific competition is more damaging to canola hybrids, while intraspecific competition is predominant for turnip.

Table 3 - Response of canola hybrids Hyola 555TT, Hyola 571CL and Hyola 61, and turnip in competition, for leaf area (AF), dry matter of aerial part (MSPA) and stature (EST) variables, in the proportions 75:25, 50:50 and 25:75 (canola:turnip), in competition with turnip in relation to their respective monocultures (100:0 or 0:100)

AF (cm^2 per plant)			
Proportion of plants	Canola hybrids		
Canola:turnip	Hyola 555TT	Hyola 571CL	Hyola 61
100:0 (T[(1)])	103.69 (±10.46)	121.21 (±38.54)	124.79 (±36.81)
75:25	27.01 (±12.57) *	58.02 (±11.23) *	91.58 (±25.47)
50:50	20.53 (±3.31) *	58.60 (±20.99) *	30.59 (±1.17) *
25:75	6.00 (±1.77) *	35.84 (±1.05) *	18.47 (±8.02) *
CV[(2)] (%)	40.63	38.24	39.58
	Turnip		
75:25	153.95 (±38.10) *	71.24 (±24.39)	145.12 (±27.18) *
50:50	132.55 (±37.74) *	96.96 (±12.36) *	89.10 (±27.60)
25:75	92.34 (±27.13)	73.70 (±6.30)	51.20 (±3.20)
0:100 (T)	52.66 (±20.47)	52.66 (±20.47)	52.66 (±20.47)
CV (%)	33.98	27.23	30.01
MSPA (g per plant)			
Proportion of plants	Canola hybrids		
Canola:turnip	Hyola 555TT	Hyola 571CL	Hyola 61
100:0 (T)	0.47 (±0.01)	0.59 (±0.06)	0.42 (±0.02)
75:25	0.18 (±0.03) *	0.44 (±0.07) *	0.32 (±0.05) *
50:50	0.12 (±0.01) *	0.26 (±0.09) *	0.23 (±0.06) *
25:75	0.06 (±0.02) *	0.28 (±0.02) *	0.11 (±0.02) *
CV (%)	40.22	19.61	18.14
	Turnip		
75:25	1.55 (±0.07) *	1.16 (±0.32) *	1.26 (±0.11) *
50:50	1.38 (±0.27) *	0.95 (±0.25)	1.05 (±0.18) *
25:75	0.89 (±0.20)	0.81 (±0.09)	0.56 (±0.13)
0:100 (T)	0.57 (±0.14)	0.57 (±0.14)	0.57 (±0.14)
CV (%)	19.78	28.83	19.31
EST (cm)			
Proportion of plants	Canola hybrids		
Canola:turnip	Hyola 555TT	Hyola 571CL	Hyola 61
100:0 (T)	37.89 (±3.15)	37.87 (±1.88)	36.80 (±2.90)
75:25	27.48 (±3.00) *	33.16 (±4.78)	30.41 (±1.33) *
50:50	23.71 (±2.59) *	30.15 (±2.43) *	26.41 (±2.47) *
25:75	19.04 (±1.59) *	27.98 (±3.12) *	23.57 (±2.40) *
CV (%)	11.34	11.60	9.25
	Turnip		
75:25	90.26 (±3.43) *	89.06 (±3.44) *	79.50 (±7.17) *
50:50	82.62 (±3.22) *	68.33 (±5.82)	78.77 (±6.96) *
25:75	76.09 (±9.62) *	75.07 (±6.83) *	61.88 (±2.01)
0:100 (T)	63.28 (±3.09)	63.28 (±3.09)	63.28 (±3.09)
CV (%)	8.24	7.88	8.68

[(1)] T: control treatment; [(2)] CV: coefficient of variation. *Averages differ from the control treatment by Dunnett's test ($p \leq 0.05$). Values in parentheses represent the standard deviation.

REFERENCES

Agostinetto D, Fontana LC, Vargas L, Markus C, Oliveira E. Habilidade competitiva relativa de milhã em convivência com arroz irrigado e soja. Pesq Agropec Bras. 2013;48:1315-22.

Bianchi MA, Fleck NG, Agostinetto D, Rizzardi MA. Interferência de *Raphanus sativus* na produtividade de cultivares de soja. Planta Daninha. 2011;29(4):783-92.

Bianchi MA, Fleck NG, Lamego FP. Proporção entre plantas de soja e plantas competidoras e as relações de interferência mútua. Cienc Rural. 2006;36(5):1380-7.

Canola Council of Canada. Growth stages. 2017. [accessed on: 14 sept. 2017]. Available at: <http://www.canolacouncil.org/canola-encyclopedia/crop-development/growth-stages/>.

Cechin J, Vargas L, Agostinetto D, Zimmer V, Pertile M, Garcia JR. Resistence of radish biotypes to iodosulfuron and alternative control. Planta Daninha. 2016;34(1):151-60.

Cousens R. Aspects of the design and interpretation of competition (interference) experiments. Weed Technol. 1991;5(3):664-73.

Dal Magro T, Schaedler CE, Fontana LC, Agostinetto D, Vargas L. Habilidade competitiva entre biótipos de *Cyperus difformis* L. resistente ou suscetível a herbicidas inibidores de ALS e destes com arroz irrigado. Bragantia. 2011;70(2):294-301.

Galon L, Agazzi LR, Vargas L, Nonemacher F, Basso FJM, Perin GF et al. Competitive ability of canola hybrids with weeds. Planta Daninha. 2015;33(3):413-23.

Heap I. The international survey of herbicide resistant weeds. [accessed on: 23 Apr. 2017]. Available at: http://www.weedscience.com/Summary/Country.aspx.

Jansen MAK, Pfister K. Conserved kinetics at the reducing side of reaction-center II in photosynthetic organisms; changed kinetics in triazine-resistant weeds. Zeitsch Naturfor. 1990;45:441-5.

Roush ML, Radosevich SR, Wagner RG, Maxwell BD, Petersen TD. A comparison of methods for measuring effects of density and proportion in plant competition experiments. Weed Sci. 1989;37(2):268-75.

Tranel PJ, Horvath DP. Molecular biology and genomics: New tools for weed science. BioScience. 2009;59(3):207-15.

Tranel PJ, Wright TR. Resistance of weeds to ALS-inhibiting herbicides: what have we learned? Weed Sci. 2002;50(6):700-12.

Vargas L, Tomm GO, Ruchel Q, Kaspary TE. Seletividade de herbicidas para a canola PFB-2. Passo Fundo: Embrapa Trigo; 2011. (Documentos, 130).

Vilá M, Williamson M, Lonsdale M. Competition experiments on alien weeds with crops: lessons for measuring plant invasion impact? Biol Invasion. 2004;6:59-69.