POSSIBLE ALLELOPATHIC EFFECTS IN SUCCESIVE SPINACH *(SPINACIA OLERACEA L.)* AND RED BEET *(BETA VULGARIS* L. VAR. *CONDITIVA* ALEF*)* CULTURES

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Abstract. *The causes of mutual partial intolerance were studied in successive cultures of two species of Fam. Chenopodiaceae: spinach (Spinacia oleracea L.) and red beet (Beta vulgaris L.var. conditiva Alef.). In some cases comparisons with small radish (Raphanus sattivus L. convar. sativus) were done. In containers of limited volume of soil collected from previous crops were sown by successive crop, and the springing dynamic and plant weight gain during the first 20-30 days after emergence, were followed. There have been performed several tests cultivating the red beet after spinach, but also the reverse formula, spinach after red beet. In all tests there was registered a marked mutual intolerance, between spinach and red beet, manifested by spring delaying, the decreasing of the proportion of appeared plants, great loss of plants after emergence, clearly caused by the attack of specific ground diseases, slower weight gain after plant emergence, which may be caused by a shortage of nutrients in the soil, given by the presence of the previous plant. In the case of the tests, for which the phytopathological and poor nutrition causes were removed, the emerging delay effects and slower pace of increase in plant weight still remained, in reciprocal sequence cultivation of the spinach and red beet, which lead us to the conclusion of allelopathy phenomenon presence between the two species.*

Keywords: intolerance, successive crops, chenopodiaceae vegetables, allelopathy

INTRODUCTION

Comparative experiences in the field to study the behavior of successive cultures, including the combination of spinach followed by red beet and the reverse sequence, red beet, followed by spinach, showed mutual intolerance phenomena, which have resulted in a decrease or even the disparagement of production. To define the reasons it was necessary a more detailed study of the relations between the two species used in formulas for successive crops. The starting hypothesis was that eliminating the phytopathological factor and mineral nutrition reasons, the other reason could be the allelopathy.

Phenomena of allelopathy in species of the family Chenopodiaceae have been reported by other authors. Thus, in experiments conducted in vegetation pots at the Vegetable Institute of Weihenstephan in Germany it was demonstrated the incompatibility between the Chenopodiaceae species, spinach, red beet, swisschard and orache. (Becker - Dillingen, 1956, Hösslin, 1964) without finding out the reasons. In laboratory experiments were found allelopathy influences of aqueous extract of leaves of wild species of Chenopodiaceae (*Atriplex bunburyana*, *Atriplex*

tomentosa, Maireana georgei şi Enchylaena tomentosa) on lettuce seed germination (*Lactuca sativa*), but also on the germination of their own seeds (Jefferson, Pennacchio, 2003).

Rice (1984) places beets on top of cultivated species with allelopathy effects. In the case of successive crops, allelopathy effects are caused by the allelochemical substances resulted from the decomposition of organic waste of the previous plant and these are more evident at the beginning of decomposition period rather than later (An, M., J. Pratley, T. Haig, 1998).

MATERIAL AND METHOD

To highlight the causes that influence the proportion of germination and plant emergence as well as their dynamic growth in the first 30-40 days after emergence, tests were conducted in containers with limited volume of soil collected from previous crops, in which plant seeds were sown in succession. From spinach was used the Matador variety having 88% germination and for red beet the Detroit variety with 72% germination from the total seeds.

In some tests for the control the soil was the one previously used for the culture of small radish, variety International 2 or of uncultivated state.

There were conducted 2 tests on the behavior of red beet cultivated after spinach and 2 tests for the spinach after red beet.

The important data for the demarcation of the different factors influence were statistically processed and interpreted by the method of variance analysis.

RESULTS AND DISCUSSION

In the first test of red beet crop cultivation after spinach it was observed a germination and emergence delay and a much smaller proportion of emerged plants if compared with a crop on a soil uncultivated previously (Table 1).

Table 1

Red beet plant emergence (out of 60 clusters) for uncultivated soil and previously cultivated with spinach

No. days after sowing	After spinach			Previously untilled soil		
	No. plants	Proportion%		No. plants	Proportion%	
		Of total	Comparing with F.g.		Of total	To F.g.
4 days	-	-	-	6	10,0	13,9
6 days	11	18,3	25,5	39	65,0	90,3
8 days	26	43,3	60,2	57	95,0	131,9
10 days	23	38,3	53,2	60	100,0	138,9

If for the control the proportion of emerged plants exceeds the number of germinable clusters reaching 138.9% due to secondary fruit sprouting from larger clusters, for the variant after spinach the proportion reaches 60.2% after 8 days and decreases slightly

after 10 days after sowing, some plants being attacked and destroyed by specific soil diseases such as those producing the plants falling (*Pythium* sp.).

Emerged red beet plants grown in soil previously cultivated with spinach have a lower growth rate than the control variant (Table 2).

Table 2

Growth dynamics of red beet plants grown in soil previously uncultivated and cultivated with spinach

Previous crop	Mass plant at age:								
	10 days			20 days			30 days		
	FM*		DM*	FM		DM	FM		DM
	g	%	%	g	%	%	g	%	%
Spinach	0,0944^{ooo}	47,1	8,47	0,2172^{ooo}	68,2	8,19	0,2732^{oo}	74,7	8,24
Previously uncultivated	0,2004	100,0	7,92	0,3183	100,0	7,85	0,3470	100,0	8,47

DL(p 5%) =0.04 DL(p 1%) = 0.06 DL(p 0.01%) = 0.08

FM = Fresh matter, DM = Dry matter

Because in the development of germination and plant emergence as well as in growth were involved issues of phytopathological nature, the test of red beet cultivation after spinach was repeated, comparing this version with a formula that has yielded good results in field experiences: red beet in succession after radishes. To remove the bad influence of soil diseases earth was disinfected with a solution of copper sulphate 1% and fertilized regularly with a solution of calcium nitrate 0.5-1%

The data concerning the springing dynamic show in the first test a late springing for the plants cultivated after spinach comparing with radish (Table 3).

Table 3

Red beet plant springing dynamic, FM and DM content after 25 days from sprouting in crops after spinach and radishes

Ground from the culture of	Percentage of emerged plants in relation to no. clusters					Plants' mass		
	5 days	6 days	7 days	9 days	12 days	g/pl	%	DM %
Spinach	6,67	29,3	97,3	150,7	213,3	1,06^{ooo}	86,9	7,78
Radishes	36,0	98,7	144,0	193,3	209,0	1,22	100,0	8,28

DL (p. 0,1%) 0,08

Compared to the percentage of red beet emergence of 38.3% in the first test, after soil disinfection and moderate fertilization the emergence reached 213.3% after spinach and 209.0% after radishes, which means that on average a glomerulus have more than two seeds germinated.

These results clearly show that the proportion of red beet plant emergence is strongly affected by soil diseases that attack and destroy the germination and through soil disinfection this deficiency can be removed. Late emergence as well as

a lower weight of the red beet plant can be attributed to a phenomenon of allelopathy in the case of cultivation after spinach.

To establish the influence of the red beet culture on the spinach one repeated tests were conducted in containers with limited volume of soil, following the emergence and plant growth in the early stages of vegetation.

In a first test of sprouting and emergence of spinach grown in soil previously planted with red beet and radishes, the result was surprising (Table 4).

Table 4

Number of emerged spinach plants, out of the 75 sown, in soil previously cultivated with red beet and radishes

Ground from the culture of	Number of days from sowing					
	4 days		5 days		6 days	
	Plants	%	Plants	%	Plants	%
Red beet	8	10,7	7	9,3	0	0
Radishes	14	18,7	30	40,0	34	45,3

In the soil previously cultivated with spinach, after four days from sowing have sprung up 10.7% of total seeds, for the next day the percentage of plants appeared to fall to 9.3% and after six days they disappear completely presenting symptoms of the disease caused by *Pythium* sp. Spinach after radishes emerged at a rate of 45.3% compared with 88% the germination recorded on filter paper, the ground disease attack being lower than in the case of the former variant.

To remove the unfavorable effect of the phytopathological factors and that of mineral nutrition deficiency, a test was performed with soil disinfected with solution of copper sulphate 1% and regularly fertilized with calcium nitrate solution 0.5-1%, using containers with a larger volume than 4 dm^3 for each variant. There were sown 40 seeds on 6 rows for each variant. At the emergence start, after four days from sowing and within the following 2-3 days of culture, the version of spinach after red beet has the lowest percentage of sprouting (Table 5).

Table 5

Dynamic of springing of spinach plants, grown in soil previously cultivated with red beet, radishes and uncultivated (no plants out from 40 seeds)

Date	Duration from sowing	Plants emerged (out of 40 seeds)					
		After red beet		After radishes		Untilled soil	
		Number	%	Number	%	Number	%
26.09	4 days	1,33	3,33	6,50	16,25	9,67	24,18
27.09	5 days	9,33	23,32	20,50	51,25	27,50	68,75
28.09	6 days	24,83	62,08	31,67	79,18	33,17	82,92
30.09	8 days	28,33	70,83	30,50	76,25	31,83	79,57
2.10	10 days	29,00	72,50	29,34	73,35	30,67	76,68
6.10	14 days	25,33	63,33	25,83	64,58	28,33	70,83

After 10 days from sowing the percentage of sprouting practically is equal for all three variants.

There were found differences in the growth of plants in the three sequence variants (Table 6).

Table 6

Growth dynamic of spinach plants grown in soil previously cultivated with red beet, radishes and untilled (g / plant)

Previous crop	Number of days after emergence								
	10 days			20 days			30 days		
	g/pl	%	SU%	g/pl	%	SU%	g/pl	%	SU%
Red beet	0,1114	72,1	10,86	0,3817	82,4	10,79	1,0692^{oo}	86,4	9,77
Radishes	0,1667	107,8	9,67	0,4443	102,9	10,01	1,4103**	113,8	9,63
Uncultivated	0,1546	100,0	9,12	0,4317	100,0	10,21	1,2397	100,0	9,75

DL (p 5%) = 0,12 DL(p 1%) = 0,16 DL(p 0,1%) = 0,22

Most intense pace of spinach plants growth, expressed through the fresh matter, in dynamic every 10 days, was found for the variant of culture after radishes and the lowest in soil previously cultivated with red beet.

Delays in emerging dynamic of spinach plants, grown in soil previously cultivated with red beet as well as a slower plant growth in the first 30 days after emergence, while the soil was disinfected and fertilized uniformly in all experimental variants, demonstrate the existence of an allelopathical negative influence for the succession red beet - spinach.

CONCLUSIONS

1. Culture of red beet after spinach registers a late emergence, a lower percentage of emergence, greater loss of plants after emergence and dynamics of plant weight gain lower than in formula successive crop after radish or in soil uncultivated with a previous plant.

2. Culture of spinach after red beet presents the same shortcomings: emergence delay, lower percentage of emerged plants, higher losses after plant emergence and slower weight gain during the first 10-30 days after emergence than the control variants (after radish or untilled).

3. The main cause of low percentage of germination and emergence as of the great plants loss during the first 6-10 days after emergence is the ground attack diseases, especially those of the genus *Pythium*, which destroy plants during germination or during the first 8-10 days after emergence.

4. Late emergence and slower dynamics of weight gain in the first phase for the culture in soil disinfected with 1% copper sulphate and fertilized regularly with 0.5-1% calcium nitrate shows that between the two species, spinach and red beet the negative effects of the phenomenon of allelopathy are present.

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