

Soil Detoxication by the Means of Activated Carbon in Breeding Process

Spiridonov Jury J.^{1,a*}, Mukhin Viktor M.^{2,b}, Karpachev Vladimir V.^{3,c},
Gorshkov Vladimir I.^{3,c}, Gorshkova Emma K.^{3,c}, Voropaeva Nadezhda L.^{3,c},
Shachnev Nikolai V.^{3,c}, Figovsky Oleg L.^{4,d}

¹ Federal State-Financed Scientific Institute "All-Russian Scientific and Research Institute of Phitopathology"

² Joint-Stock Company "Electrostal Science and Production Enterprise "Neorganika"

³ Federal State-Financed Scientific Institute "All-Russian Rapeseed Research Institute"

⁴ Polymate Ltd.-INRC, Migdal Ha Emek, Israel

^{a*}spiridonov@vniif.ru, ^binfo@neorganika.ru, ^cbionanotex_l@mail.ru, ^dfigovsky@gmail.com

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Abstract. The paper describes results of vegetative tests of activated carbon as a detoxicant of herbicide remains in soil on eight varieties of summer rapeseed. The tests were performed with the purpose to align soil fertility on different breeding and test sites. The research is based on attempts to apply coal absorbent as a means of soil detoxication to neutralize herbicides remains in the process of oilseed brassica crops breeding. Several summer rapeseed varieties were used as research objects. Similar approaches have not encountered in literature references available.

Introduction

Variety testing (pre-test, competition, ecological) is the essential part and logical outcome of breeding process. The best varieties (productivity- and qualitywise) further pass to State Variety Test Committee according to the results of variety testing.

The tests compare genetically different plants exposed to the same conditions to provide varieties' proper evaluation. The agrotechnical conditions such as soil fertility, cultivation technology, seeding ratio and depth should be identical. The only difference to be considered is the response of different genotypes to the same set conditions. The only subject of testing is a variety (a certain genotype). The test results can be recognized as successful and adequate only in case if all the principles described above are followed [1].

Theory

Aligning soil fertility on the test site is prior to the researcher. Although, the uncontrolled influence of pesticide remains in soil on variety yield evaluation has been recently observed. This occurs when genotypes respond differently to this factor. Varieties with high herbicide tolerance indicate higher yield during breeding tests. At the same time, presence of pollutants in soil create unfavorable vegetation environment for other varieties, suppressing their genetic potential.

It is quite random to come across soils with either systematic or accidental fertility variation. Most likely it is both.

Test results regarding yield and its quality may be different from true figures due to certain failures. Researcher faces 3 kinds of failures while performing tests. Those are accidental, systematic and rough. They may have different causes including presence pollutants in soil.

Systematic failures don't influence comparability of different test options (they vary in the same direction), though may slightly affect tests results. It is true only in case if genotypes' response to this stress factor is the same.

Pesticide remains in soil reduce genotypes' yield capacity and distort the comparison of different varieties (hybrids). While performing breeding tests, only genotypes must differ, though all the other conditions should be identical ("principle of the single difference"). In this regard, only field test results that do not contain one-sided errors should be used for results mathematical processing and making reasonable conclusions.

Soil detoxication with the use of absorbent materials may be applied as the way to counter the impact of herbicide and pesticide remains. The positive impact of activated carbon application for protection of various crops from the affects pesticides and herbicides has been discovered and studied in the world's leading research enterprises. [2-14].

Materials and methods

A mixture of soddy podzolic soils with sand and rotted manure at a ratio of 1: 1: 1 was used as a soil substrate. According to the number of test options, 72 soil samples 3 kg each were placed in plastic bags. 400 ml of tap water were added to each sample because the prepared soil in the bunker had not been hydrated. 24 hours later soil samples were poured into trays and treated with the pollutant (herbicide) on OP-5 unit (central atomizer, liquid volume for spraying 10 ml). The treated soil was stirred thoroughly and placed back into plastic bags.

Zinger herbicide (ZH) was applied as a pollutant at application rates of 2.5 and 5.0 g/ha (ZH-2.5 and ZH 5.0 further in the paper). The pollutant (60% metsulfuron-methyl) was chosen due to the fact that it is a typical representative of the latest generation of herbicides, belonging to sulfonylurea class. Sulfonylurea-based herbicides have unique physiological activity and are widely used in agriculture for weed control in cereal crops. However, they tend to preserve in soil for long and agricultural crops are quite sensitive to their remains. In addition, long-term experiments with herbicides of this class have indicated consistent increase of plant resistance to it (from 0.001% up to 60.5% in 5 years).

"Polluted" samples were treated with activated carbon dozed as 200 and 400 kg/ha (AC-200 and AC-400 further in the paper) in 24 hours after they had been exposed to the herbicide; and the soil mixture was thoroughly stirred. A day later the soil samples were placed in 600-gr vegetation pots (4 samples per each option). The next step was sowing rapeseed test varieties in the pots. 8 test varieties were presented in the experiment: Ratnik, Bulat, Forward, Reef, Altair, Arbalet, Jarilo (LK-935-09), Favorit (SA-063-10) [15-24].

The samples that have been exposed to neither herbicide nor activated carbon were taken as standard. Naturally, samples that have been treated by either herbicide or activated carbon were also presented.

The pots were placed in artificial climate chamber (ACC) for 15 days with day temperature of 20 °C and night temperature of 16 °C and day and night length 16 and 8 hours respectively; illumination of test plants during the day period was 20000 LK. The plants were watered daily to keep humidity level at 60-70%.

In 15 days the plants (6 pieces in each pot) were cut for standard and treated samples to be weighed and compared. Pots with standard and treated plants were photographed before putting results on record (photo 1,2).

Weight loss of treated plants relative to standard ones was calculated by the formula:

$$B = 100 - \left(\frac{A}{K} \cdot 100\% \right),$$

where B - weight loss of treated plants relative to standard ones; A – average treated plant weight; K – average standard plant weight.

Results

Applying of AC-200 and AC-400 to Ratnik and Bulat varieties effectively restrained negative affect of ZH-2.5 on the plants' growth and development. Though herbicide doze increase (applying

HZ-5.0) led to AC-200 and AC-400 activity failure. Applying AC-200 and AC-400 to “unpolluted” soil indicated no influence (identical to standard option) on raw mass accumulation for plants of Ratnik and Bulat varieties. (see Figure 1).

Applying of AC-200 and AC-400 to Forward variety also effectively countered negative affect of ZH-2.5 on the plant's growth and development. Introducing AC-400 suppressed ZH-5.0 activity and decreased raw mass loss by 18%. (83,5% loss when treated with only ZH-5.0, 65,5% after applying AC-400).

Rif variety plants indicated no sensitivity to either AC-200 or AC-400 in all test options. Detoxication activity was not observed.

AC-200 revealed itself ineffective in countering both ZH-2.5 and ZH 5.0 on Altair variety plants. Though, detoxication effect on ZH-2.5 was achieved after applying AC-400.

Applying of AC-200 and AC-400 to Arbalet variety decreased negative effect of ZH-2.5 on the plants' growth and development. AC-400 was effective to reduce the negative impact of ZH-5.0 and raw plant mass appeared to be higher than standard.

AC-200 and AC-400 indicated detoxication activity and reduced the negative impact on both ZH-2.5 and ZH 5.0 on growth and development of Yarilo variety plants.

Applying of AC-200 and AC-400 to Favorite variety twice decreased negative effect of ZH-2.5 on the plants' growth and development, also countering the impact of ZH-5.0.

The results are presented in Table 1, Photo 1 and 2.

Table 1. The effect of pre-sowing application of AC to 8 varieties of summer rapeseed

Variety	Option #	AC doze, kg/ha	ZH doze, g/ha	Mass of test-plants, g					Mass decrease of test plants, % to standard
				Repetitions				average	
				1	2	3	4		
Ratnik	1	200	2,5	2,9	2,4	1,7	2,3	2,3	42,5
	2		5,0	1,1	0,6	0,6	0,8	0,8	80,0
	3	400	2,5	1,9	2,3	1,9	2,9	2,3	42,5
	4		5,0	0,8	2,0	0,6	0,8	1,1	72,5
	5	—	2,5	1,4	2,0	1,6	1,9	1,7	57,5
	6		5,0	1,0	1,0	0,8	0,6	0,9	77,5
	7	200	—	4,6	3,4	4,6	3,8	4,1	-2,5
	8	400		3,8	3,5	4,2	3,8	3,8	5,0
	9	standard		3,8	4,6	3,7	3,7	4,0	0
	LSD ₀₅							0,63	
Bulat	10	200	2,5	1,2	2,7	2,5	0,9	1,8	50,0
	11		5,0	0,6	0,9	0,8	0,8	0,8	77,8
	12	400	2,5	1,4	1,1	1,7	1,9	1,5	58,3
	13		5,0	0,9	0,9	0,8	1,0	0,9	75,0
	14	—	2,5	0,8	0,8	1,0	1,1	0,9	75,0
	15		5,0	0,6	0,9	0,6	0,9	0,8	77,8
	16	200	—	3,3	3,3	3,6	3,8	3,5	2,8
	17	400		3,9	4,0	3,3	2,9	3,5	2,8
	18	standard		4,1	3,3	3,4	3,4	3,6	0
	LSD ₀₅							0,59	
Forward	19	200	2,5	2,9	2,8	3,8	3,1	3,2	47,5
	20		5,0	0,7	0,7	0,7	0,8	0,7	88,5
	21	400	2,5	2,8	3,2	2,9	3,9	3,2	47,5
	22		5,0	2,0	1,0	2,3	2,9	2,1	65,6
	23	—	2,5	1,4	0,8	2,0	1,5	1,4	77,0
	24		5,0	0,9	0,9	0,9	1,2	1,0	83,6
	25	200	—	4,5	3,6	4,1	3,4	3,9	36,1
	26	400		5,1	5,7	4,9	4,5	5,1	16,4
	27	standard		6,4	6,6	4,9	6,6	6,1	0
	LSD ₀₅							0,77	

Variety	Option #	AC doze, kg/ha	ZH doze, g/ha	Mass of test-plants, g					Mass decrease of test plants, % to standard
				Repetitions				average	
				1	2	3	4		
Rif	28	200	2,5	1,4	0,5	0,8	1,1	1,0	77,3
	29		5,0	0,4	0,4	0,4	0,4	0,4	90,9
	30	400	2,5	1,6	1,8	1,4	1,7	1,6	63,6
	31		5,0	1,0	0,8	0,7	0,7	0,8	81,8
	32	—	2,5	1,2	2,1	1,7	1,9	1,7	61,4
	33		5,0	0,6	0,9	1,1	0,5	0,8	81,8
	34	200	—	4,7	3,8	3,9	3,5	4,0	9,1
	35	400		4,3	3,9	4,0	4,0	4,1	6,8
	36	standard	4,3	4,4	4,4	4,3	4,4	0	
	LSD ₀₅						0,41		
Altair	37	200	2,5	1,3	1,4	0,9	0,9	1,1	75,6
	38		5,0	0,7	0,7	0,7	0,8	0,7	84,4
	39	400	2,5	2,8	1,8	2,9	2,9	2,6	42,2
	40		5,0	0,8	0,7	0,6	0,6	0,7	84,4
	41	—	2,5	1,5	1,0	1,5	1,7	1,4	68,9
	42		5,0	0,7	0,7	1,4	1,4	1,1	75,6
	43	200	—	4,6	4,0	5,0	4,8	4,6	-2,2
	44	400		4,3	4,2	5,1	4,5	4,5	0
	45	standard	5,0	3,7	5,3	3,9	4,5	0	
	LSD ₀₅						0,61		
Arbalet	46	200	2,5	2,8	3,2	3,3	2,5	3,0	31,8
	47		5,0	0,8	1,2	1,0	0,9	1,0	77,3
	48	400	2,5	3,1	2,1	3,5	3,2	3,0	31,8
	49		5,0	2,4	2,0	1,8	1,7	2,0	54,5
	50	—	2,5	2,2	1,8	2,1	2,6	2,2	50,0
	51		5,0	1,4	0,9	1,4	1,0	1,2	72,7
	52	200	—	4,0	3,5	4,5	5,4	4,4	0
	53	400		6,1	3,9	4,9	4,7	4,9	-11,4
	54	standard	5,6	4,1	3,8	4,1	4,4	0	
	LSD ₀₅						0,83		
Jarilo	55	200	2,5	2,1	3,0	2,4	2,9	2,6	54,4
	56		5,0	1,0	1,5	2,4	2,3	1,8	68,4
	57	400	2,5	3,4	4,1	2,9	2,9	3,3	42,1
	58		5,0	1,5	1,1	2,1	2,4	1,8	68,4
	59	—	2,5	1,5	2,0	2,5	2,3	2,1	63,2
	60		5,0	0,5	1,0	0,8	1,1	0,9	84,2
	61	200	—	5,9	4,0	4,5	5,3	4,9	14,0
	62	400		4,3	3,8	3,9	5,3	4,3	24,6
	63	standard	5,2	6,1	5,2	6,2	5,7	0	
	LSD ₀₅						0,84		
Favorite	64	200	2,5	3,0	3,7	4,6	3,8	3,8	30,9
	65		5,0	1,5	2,0	0,8	1,3	1,4	74,5
	66	400	2,5	2,6	3,6	3,1	2,7	3,0	45,5
	67		5,0	1,5	2,5	2,1	2,1	2,1	61,8
	68	—	2,5	1,9	1,2	1,7	1,8	1,7	69,1
	69		5,0	1,3	0,8	0,7	1,3	1,0	81,8
	70	200	—	5,0	4,8	5,2	4,4	4,9	10,9
	71	400		5,5	5,2	5,6	5,0	5,3	3,6
	72	standard	6,1	4,7	5,6	5,5	5,5	0	
	LSD ₀₅						0,65		



Photo 1. Applying single Zinger herbicide 5.0 g/ha to eight summer rapeseed varieties

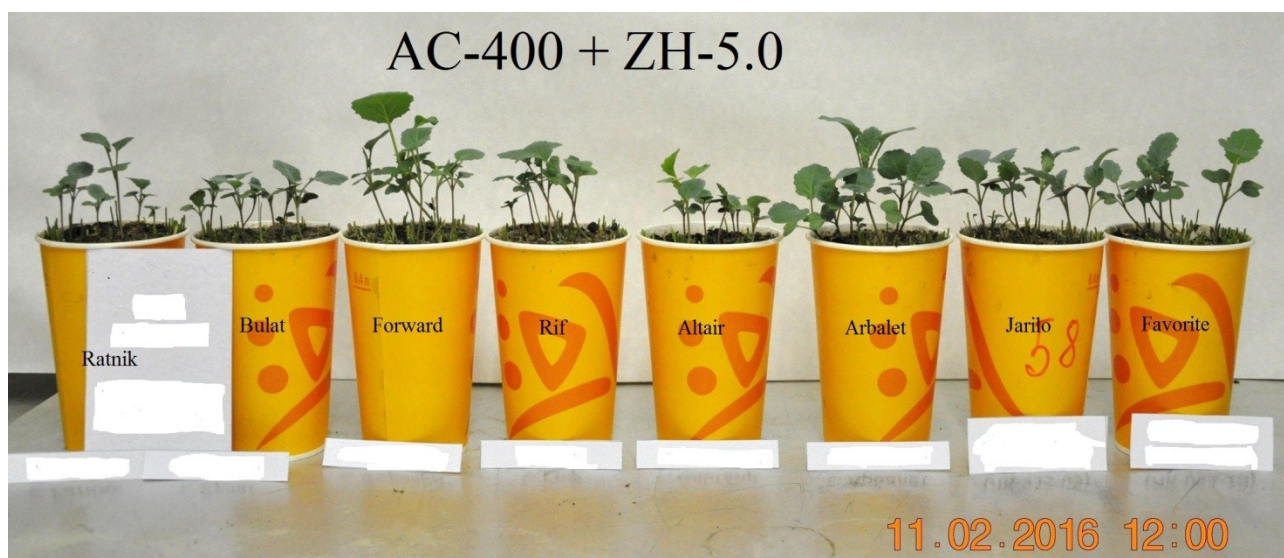


Photo 2. Applying the combination of activated carbon 400 kg/ha and Zinger herbicide 5.0 g/ha to eight summer rapeseed varieties

Discussion

Our research based on applying activated carbon as a means of soil detoxication in the process of oilseed brassica crops breeding indicated the following:

1. AC-200+ZH-2.5 option indicated the highest AC detoxication activity on “Favorite” variety (herbicide affect decreased by 55%). Positive results were also observed on Forward (38%) Arbalet (36%), Bulat (33%), Ratnik (26%), Jarilo (14%).
2. AC-200+ZH-5.0 option revealed absorbent activity on Jarilo (19%) and Favorite (9%) varieties.
3. AC-400+ZH-2.5 option indicated decrease of ZH negative effect on all varieties except Rif. (Altair – by 40%, Forward - by 38%, Arbalet - 36%, Favorit - 35% Yarylo - 33%, Ratnik- 26%, Bulat - by 23%.)
4. At AC-400+ZH-5.0 option the positive effect of absorbent was observed on Arbalet (25%), Favorite (24%), Forward (22%), Jarilo (19%) varieties.

Conclusion

Comparative tests results of activated carbon application as Zinger herbicide detoxicant in several options have revealed variations in response of different summer rapeseed varieties to the negative herbicide impact. Tests results also indicated a relatively high tolerance of Arbalet, Ratnik, Rif and Bulat varieties to the negative herbicide impact. These varieties are preferable to be used in crop rotations with an intensive herbicide application.

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