ROCZNIKI GLEBOZNAWCZE T. XXVI, Z. 2, WARSZAWA 1975

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EFFECT OF CLAYING LIGHT SOIL AND ADDING HERBICIDES ON THE SOIL MICROFLORA

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More and more frequent use of chemicals for weed control calls for a permanent checking the action of these preparations on soil microflora. The negative influence of herbicides on different groups of microorganisms has been pointed out by several authors [2, 3, 8, 9, 10, 11, 12]. They draw attention to the fact of decreasing number of respective physiological groups under the influence of higher herbicide doses, and to morphological, cytological and physiological changes in the microorganisms examined.

The phytotoxic activity of herbicides, applied into soil, changes, according to the soil type, its mechanical composition as well as the content of organic matter and mineral colloids [4, 17]. In case of light soils, characterized by a low content of humus, silt and clay, the effect of relatively low herbicide doses is stronger and the danger of undesirable phenomena greater.

However, the herbicide application conditions on light soils change considerably if the latter were clayed. Introduction of a larger amount of clayey particles into light soil can change its physical properties [7] and living conditions of microorganisms as well as exert an influence on the persistence of the weed-killing preparation effectiveness [16].

The activity of herbicides in soil may depend not only on the soil conditions, but the plants growing on it can contribute as well to inactivation of weed-killing preparations [1, 5, 13, 18]. In our study carried out in conditions of short vegetation experiments, we tried to observe the effect of clayey materials added to light soil, the growth of plants on it and the activity of herbicides towards the soil microflora.

MATERIAL AND METHODS

For the experiments light soil (coarse sandy soil) and post-flotation silica neutralized with serpentinite were used. Some physico-chemical properties of the soil materials used in the experiment are presented in Table 1.

Table 1

Some physico-chemical properties of materials applied in the experiment

Materials	Per cent of fraction of 0.02 mm	P_2O_5	K_2O	Mg soluble	pH	
		mg/100 g of soil acc. to Egner			In H_2O	In KCl
Light soil	5	5.8	1.2	3.2	5.2	4.3
Silica	40	9.5	12.3	15.0	6.6	6.0
Soil + silica	10	6.7	3.0	12.5	6.2	5.5

The experiment was carried out in small plastic pots containing 500 g of air-dry soil, or a mixture of 455 g of soil and 45 g of silica. NPK fertilization and microelements were applied in forms and quantities generally adopted in such type of experiments [16].

The following herbicides produced by Geigy-Ciba A.G., Basel Switzerland, were used:

Gesaprim — containing 50% active substance of atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine)

A-1798 — containing 50% of active substance being a mixture of 2/3 atrazine and 1/3 prometrine,

Gesagard — containing 50% active substance of prometrine (2-methyl-thio-4,6-diisopropyloamino-s-triazine)

All these preparations were introduced into soil in the form of aqueous suspension, at 0.5 mg per pot, corresponding approximately to the field dose of 3 kg/ha. The experimental plants were maize, oats and white mustard. The experiments were carried out in a glasshouse, keeping the humidity of the substrate at 60% maximum water capacity of the soil.

The scheme of the experiment was as follows:

1. soil
2. soil + Gesparim
3. soil + A 1798
4. soil + Gesagard

5. soil + silica
6. soil + silica + Gesaprim
7. soil + silica + A 1798
8. soil + silica + Gesagard

Each experimental plant was cultivated for four weeks. Ten days after the harvest of maize the pots were sown with oats twice in succession, and then with white mustard. After the harvest of the experimental plants the weight of fresh and dry matter of the aboveground parts was determined, and soil samples were taken for the following microbiological determinations:

Standard determinations:
— total quantity of bacteria on soil extract,
— total quantity of actinomyces,
— total quantity of fungi,
— total quantity of cellulose-decomposing bacteria;

Additional determinations:

10 g soil from each treatment were inoculated with *Azotobacter, Bacillus cereus* and bacterial strain No. 22 isolated from light soil. After 1 and 4 weeks of incubation the number of inoculated microorganisms was determined.

Standard determinations were made three times in the course of growing season, namely after the harvest of maize, after the harvest of oats II, and after the harvest of mustard, i.e. 1, 3 and 5 months after introduction of herbicides. Additional determinations were made in soil samples taken after the harvest of maize.

RESULTS

In the course of growing season fresh and dry matter of aboveground parts of the experimental plants were taken four times. The results are shown in Table 2.

No negative response of maize to the action of herbicides used in the experiment has been noticed, while oats I revealed a high susceptibility to the action of Gesaprim. The response of the first sowing of oats to the presence of silica in the soil was distinctly positive, while the second sowing of oats on the same medium showed only a minimal effect of A-1798 and Gesagard. The last experimental plant, mustard, showed a negative response to the presence of A-1798 in the medium without silica, and inhibitory action of Gesaprim and Gesagard in that with silica.

The results of microbiological analyses are shown in Figs 1-4 and in Table 3.

Table 2

Effect of claying and addition of herbicides on yelds of fresh and dry weight of examined plants
Yelds in g/pot

Treatments	I sowing maize		II sowing oats I		III sowing oats II		IV sowing white mustard	
	Weight		Weight		Weight		Weight	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
Soil	6.29	0.88	2.53	0.61	3.06	0.57	3.18	0.43
Soil + Gesaprim	6.60	0.88	1.43	0.17	3.68	0.60	2.81	0.39
Soil + A 1798	7.18	0.74	2.43	0.30	3.30	0.62	2.47	0.31
Soil + Gesagard	7.13	1.00	2.63	0.43	3.00	0.54	3.38	0.40
Soil + silica	7.99	1.28	3.52	0.97	3.20	0.55	3.07	0.41
Soil + silica + Gesaprim	8.50	1.05	2.94	0.39	3.13	0.54	2.70	0.39
Soil + silica + A 1798	6.79	1.00	3.17	0.42	2.99	0.54	3.60	0.47
Soil + silica + Gesagard	7.12	1.12	3.37	0.59	2.71	0.55	2.41	0.39

Table 3

Effect of claying and addition of herbicides on number of examined bacteria strains
/in thousands/g of soil/

Treatments	I term			II term		
	Azotobacter	Bacillus cereus	Strain 22	Azotobacter	Bacillus cereus	Strain 22
Soil	32	460	80	66	250	140
Soil + Gesaprim	47	450	60	38	350	130
Soil + A 1798	68	390	60	8	790	60
Soil + Gesagard	35	360	70	8	640	130
Soil + silica	97	500	350	105	400	600
Soil + silica + Gesaprim	56	470	360	90	520	310
Soil + silica + A 1798	83	500	190	87	860	380
Soil + silica + Gesagard	78	450	270	89	780	420

The addition of herbicides to the soil alone had a negative effect on number of bacteria (Fig. 1), particularly in case of Gesaprim and A-1798. Silica added to the soil always increased the number of bacteria, and in case of herbicide treatments — except the first term of analyses — it almost completely eliminated the inhibitory effect of the weed-killing preparations.

In the medium without silica some herbicides had a stimulating effect on the number of actinomyces (Gesagard more than A-1798, Fig. 2), while Gesaprim obviously inhibited their development. This group of microorganisms was favourably influenced by an addition of silica. Despite this increase in number, in the soil with silica all the herbicides showed some inhibitory effect on actinomyces.

All herbicides used in the experiment brought about a decrease of the number of fungi (Fig. 3). The most negative effect was that of Gesaprim, then A-1798, while Gesagard appeared to be least toxic to this group of microorganisms. The addition of silica alone to the medium decreased also the number of fungi, while with simultaneous use of herbicides it slightly weakened the inhibitory effect of the weed-killing preparations.

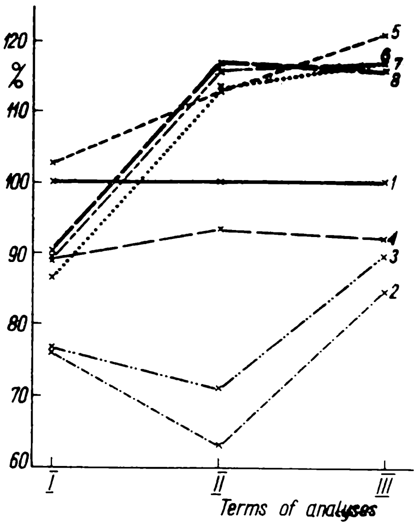

Fig. 1. Effect of claying and addition of herbicides on the number of bacteria in soil. Results are given in relative values — treatment 1 (soil alone) = 100

1 — soil; *2* — soil+Gesaprim; *3* — soil+A 1798; *4* — soil+Gesagard; *5* — soil+silica; *6* — soil+silica+Gesaprim; *7* — soil+silica+A 1798; *8* — soil+silica+Gesagard

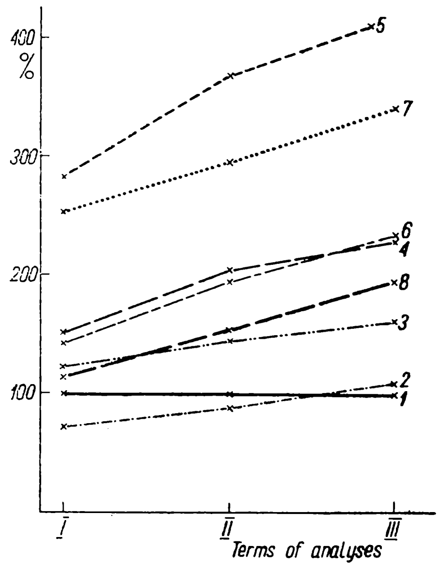

Fig. 2. Effect of claying and addition of herbicides on the number of actinomyces in soil. Results are given in relative values — treatment 1 (soil alone) = 100; explanation as in Fig. 1

The effect of all the herbicides used in the experiment on the number of cellulose-decomposing bacteria was negative (Fig. 4), the strongest being that of Gesagard, and then Gesaprim and A-1798. The addition of silica alone had a positive effect on the number of this group of microorganisms, and in case of simultaneous use of herbicides it considerably weakened the inhibitory effect of these preparations.

The results of inoculation tests (Tab. 3) showed a stimulating effect of herbicides on the growth of *Azotobacter* in the first term, while in the second they contributed to a considerable decrease of its number.

Addition of silica resulted in almost threefold increase of the number of the microorganisms in the first term of analysis, and twofold one in the second term. Herbicides used together with silica showed also in this case a negative effect, though inhibition was weakened by claying. In comparison with soil alone, the addition of silica contributed to an increase of the number of *Azotobacter* even at application of herbicides.

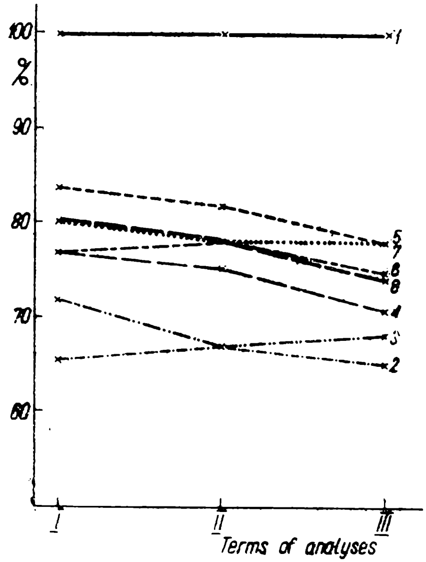

Fig. 3. Effect of claying and addition of herbicides on the number of fungi in soil. Results are given in relative values — treatment 1 (soil alone) = = 100; explanation as in Fig. 1

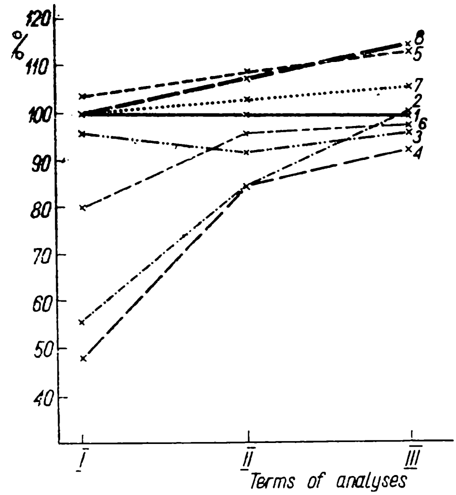

Fig. 4. Effect of claying and addition of herbicides on the number of a cellulose-decomposing bacteria in soil. Results are given in relative values — treatment 1 (soil alone) = 100; explanation as in Fig. 1

Similar results were obtained at inoculation of the soil with *Bacillus cereus*. In the first term the addition of herbicides brought about a slight drop in the number of this microorganism, while in the second — an increase. The addition of silica resulted in an increase of the number of *Bacillus cereus* in both terms, and the effect of herbicides with silica was similar to that of herbicides without silica. It was very interesting to find out a stimulating effect of all the tested herbicides on *Bacillus cereus* in the second term of determinations.

Strain No. 22 responded to the addition of herbicides with a decrease of its number in both terms, while an addition of silica distinctly stimulated its development. Claying did not eliminate entirely the inhibitory effect of herbicides on these microorganisms.

CONCLUSIONS

In the experiment there was observed, on the one hand, a direct effect of silica on the experimental plants and soil microflora, and on the other — an indirect effect of this clayey material through some decrease of the toxicity of herbicides. Apart from that, the effect of herbicides alone could be inhibitory, or sometimes even stimulating.

The addition of silica alone influenced favourably the yields of oats I and contributed to an increase of the number of actinomyces and bacteria. Contrary to both those groups of microorganisms, fungi responded to introduction of silica into soil with a decrease of their number. Just such a response of the respective groups of microorganisms can suggest that changes in the number of those organisms would be brought about by higher pH value of clayed soil and higher content of magnesium.

The action of triazine preparations used in the experiment was toxic to oats and mustard, and they almost always decreased the number of the microorganisms tested. The introduction of silica and clayey substances into soil often weakened, and sometimes even entirely eliminated, the inhibitory effect of herbicides. In some cases there appeared even a stimulating effect of these preparations to some plants and respective groups of microorganisms; only fungi showed no positive response to introduction of silica in the presence of herbicides. In the latter case the effect of silica — most probably unfavourable to fungi — increased similar effect of herbicides.

A decrease of the inhibitory effect of herbicides in the presence of silica can be explained by more or less constant adsorption of triazines by clayey particles, which has been proved by Friesel [6] and other authors [14]. The favourable action of silica might be caused by the fertilizing action of this material. Most probably the amount of herbicides contained in the soil solution was gradually decreasing with time; this led to surpassing of determined thresholds of concentration and — in some cases — to the phenomenon of stimulation. Such changes might be caused not only by the mentioned adsorption of the preparations on soil colloids, but also by their phytodetoxication and uptake by plants.

Thus introduction of clayey substances into light soil can essentially change the effect of herbicides on soil microflora, these changes depending certainly on both the kind of the clayey material and the herbicides introduced into soil. This question requires further, more detailed investigations.

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WPŁYW IŁOWANIA GLEBY LEKKIEJ I DODATKU HERBICYDÓW NA MIKROFLORĘ GLEBOWĄ

Zakład Uprawy Roli i Roślin IUNG w Laskowicach Oławskich

Streszczenie

Autorzy w krótkotrwałych doświadczeniach wegetacyjnych badali wpływ dodatku krzemionki do gleby lekkiej na zmiany aktywności herbicydów trójazynowych w stosunku do mikroflory glebowej. W badaniach zastosowano herbicydy o nazwach fabrycznych Gesaprim, preparat A 1798 i Gesagard.

W ciągu sezonu wegetacyjnego, oprócz określania plonów świeżej i suchej masy części nadziemnych roślin testowych, wykonano jeszcze oznaczenia ogólnej ilości bakterii, grzybów i promieniowców w glebie oraz przeprowadzono testy z *Azotobacter, Bacillus cereus* i ze szczepem bakteryjnym wyodrębnionym z gleby lekkiej, a oznaczonym nr 22.

Stwierdzono, że zastosowana w doświadczeniu krzemionka korzystnie wpłynęła na liczebność badanych grup drobnoustrojów glebowych, z wyjątkiem grzybów. Szczególnie korzystnie oddziaływała krzemionka na promieniowce. Wszystkie użyte do badań herbicydy ujemnie działały na badane grupy drobnoustrojów oraz były toksyczne dla owsa i gorczycy. Wprowadzenie do gleby krzemionki w warunkach doświadczenia osłabiało intensywność toksycznego działania herbicydów zarówno w stosunku do mikroflory glebowej, jak i poszczególnych roślin doświadczalnych. Uprawiane po sobie rośliny doświadczalne działały detoksykująco na znajdujące się w glebie herbicydy.

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ВЛИЯНИЕ ДОБАВКИ ИЛА К ЛЕГКОЙ ПОЧВЕ И ПРИБАВКИ ГЕРБИЦИДОВ НА ПОЧВЕННУЮ МИКРОФЛОРУ

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Резюме

Авторы в краткосрочных вегетационных опытах исследовали влияние прибавки кремнезема к легкой почве на изменения активности триазинных гербицидов по отношению к почвенной микрофлоре. В исследованиях применяли гербициды с фабричными названиями Гесаприм, А 1798 и Гесагард.

В течение вегетационного периода, наряду с определением величины урожая свежей и сухой массы надземных частей подопытных культур, определяли общее количество бактерий, грибов и актиномицетов в почве, а также производили тесты с применением азотобактера, *Bacillus cereus* и бактерийного штамма изолированного из легкой почвы и обозначенного № 22.

Обнаружено, что примененный в опыте кремнезем оказывал положительное влияние на численность исследуемых групп почвенных микроорганизмов, за исключением грибов. Особенно положительно влиял кремнезем на актиномицеты. Все примененные в исследовании гербициды отрицательно влияли на исследуемые группы микроорганизмов, а также оказались токсическими для овса и горчицы. Внесенный в почву кремнезем в условиях опыта снижал интенсивность токсического действия гербицидов как по отношению к почвенной микрофлоре так и к отдельным подопытным культурам. Обрабатываемые поочередно подопытные культуры влияли антитоксически на содержащиеся в почве гербициды.