Proceedings of ANAS (Biological Sciences), 65(5-6): 164-167 (2010)

Influence of Agrochemical Countermeasures on Accumulation of ^{90}Sr and ^{137}Cs in Various Agricultural Crops

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It was proved by long-term field experiments that agrochemical countermeasures, i.e. use of an optimal and higher doses of complete mineral fertilizers (NPK) along with significant increase in crop yields leads to appreciable decrease in accumulation of artificial radionuclides (^{90}Sr and ^{137}Cs) in various agricultural crops grown on grayish brown soils of Absheron.

Keywords: *agrochemical countermeasures, radionuclids, biosphere, mineral and organic fertilizers*

INTRODUCTION

As a result of accident at Chernobyl Nuclear Power Plant (NPP), significant number of artificial radionuclides falls out into soils. Significant increase of artificial radionuclides in environment (in soils) after Chernobyl accident along with their existing contents in soils accumulated during the period of intensive nuclear tests, poses a potential threat of radioactive pollution to plant products and whole environment. Among artificial radionuclides the most significant are long-living ^{90}Sr and ^{137}Cs, which are quickly included into biological cycles of migration, accumulated in skeleton and soft tissues, and are one of the major dose-forming radionuclides in living organisms.

Use of countermeasures in agriculture holds one of the central places in system of measures on elimination of the consequences of the Chernobyl accident. One of the significant countermeasures of inflow of artificial radionuclides into the plants is incorporating into the soils various combinations and doses of organic and mineral fertilizers. From all countermeasures this protective measure refers to the most effective and practically realized. Existing literature data on this subject is contradictive (Pavlotskaya and Babicheva, 1973; Marey et al., 1974; Aleksakhin, 1982; Aliyev and Abdullayev, 1983; Prister et al., 1991; Ponikarova et al., 1992; Abdullayev and Aliyev, 1998). Thus, the aim was to study the influence of incorporation of an optimal and higher doses of complete mineral fertilizers (NPK) on accumulation of ^{90}Sr and ^{137}Cs in grain cereals (winter wheat and winter barley) and legumes (soybean and garbanzo) grown on grayish brown arable soils of Absheron.

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MATERIALS AND METHODS

Field researches were carried out on the plot of Absheron Subsidiary Experimental Station of the Research Institute of Crop Husbandry. The soil was grayish brown of loamy mechanical composition. The used fertilizers were: nitrogen - in form of ammonium nitrate, phosphorus - in form of double superphosphate, and potassium - in form of sulfuric potassium. Whole norm of phosphorous and potassium fertilizers and 20% of nitrogen fertilizers were incorporated into the soil just before sowing and other part of nitrogen fertilizers - as dressing in phases of heading and blossoming. Recorded square of test allotments with wheat and barley was 10 m^2, with soybean and garbanzo - 16 m^2. Experiments were repeated 3 times. All rules of agritechnology providing high harvest were followed in experiments. Experiments were carried out with winter wheat variety Vugar, winter barley variety Garabakh-7, garbanzo variety AzNIIZ-304 and soybean variety Beyson.

Sampling for radioactive chemical analysis was made at the end of vegetation period. The plant samples were incinerated at temperature not higher than 450°C. The latter is due to the fact that when incinerated at above shown temperature the possibility of volatilization and mechanical capture with smoke of radionuclides is not excluded (Pavlotskaya and Babicheva, 1973).

^{90}Sr concentration was measured in extract 6N of hydrochloric acid by oxalate method by derived ^{90}Y, and ^{137}Cs activity concentration – by iodime-antimony method. Activity of radionuclides was measured using low background radiation device

Table 1. Influence of mineral fertilizers appilication on different crops productivity (average in 2 years)

Variants	Yield, cwt ha^{-1}		Increase in comparison to control			
	Grain	Straw	Grain		Straw	
			cwt ha^{-1}	%	cwt ha^{-1}	%
Winter wheat						
Control (without fertilizers)	53.7	58.4	-	-	-	-
N160P90K60 (optimal dose)	66.2	69.1	12.5	23.3	10.7	18.3
N240P360K240	78.7	78.5	25.0	46.6	20.1	34.3
N320P720K480	84.2	88.6	30.5	56.8	30.2	51.7
Winter barley						
Control (without fertilizers)	46.6	56.9	-	-	-	-
N90P90K60 (optimal dose)	56.2	70.2	9.6	20.6	13.3	23.3
N135P360K240	63.9	78.7	17.3	37.1	21.8	38.3
N180P720K480	72.7	86.2	26.1	56.0	29.3	51.5
Garbanzo						
Control (without fertilizers)	19.0	25.9	-	-	-	-
N30P60K30 (optimal dose)	21.6	30.3	2.6	13.3	4.4	17.0
N45P240K120	24.8	33.9	5.8	30.5	8.0	30.9
N60P480K240	27.2	38.8	8.2	43.2	12.9	49.8
Soybean						
Control (without fertilizers)	20.2	29.8	-	-	-	-
N90P60K30 (optimal dose)	25.9	41.9	5.7	28.2	12.1	40.6
N135P240K120	30.8	44.4	10.6	52.5	14.6	49.0
N180P480K240	32.9	47.2	12.7	62.9	17.4	58.4

UMF-1500M with SBT-13 scintillation counter and scaler device PP-16.

RESULTS AND DISCUSSION

The obtained results showed that the use of optimal and higher doses of complete mineral fertilizers significantly raises crop productivity of grain cereals and legumes. Thus, the average increase in grain yield due to addition of optimal and higher doses of mineral fertilizers for wheat grain in comparison to non-fertilized variant was 12.5-30.5 cwt ha^{-1} (23.3-56.8%), barley – 9.6-26.1 cwt ha^{-1} (20.6-56.0%), garbanzo – 2.6-8.2 cwt ha^{-1} (13.3-43.2%), soybean – 5.7-12.7 cwt ha^{-1} (28.2-62.9%) and for straw − 10.7-30.2 cwt ha^{-1} (18.3%-51.7%); 13.3-29.3 cwt ha^{-1} (23.3-51.5%); 4.4-12.9 cwt ha^{-1} (17.0-49.8%); 12.1-17.4 cwt ha^{-1} (40.6-58.4%), respectively (Table 1).

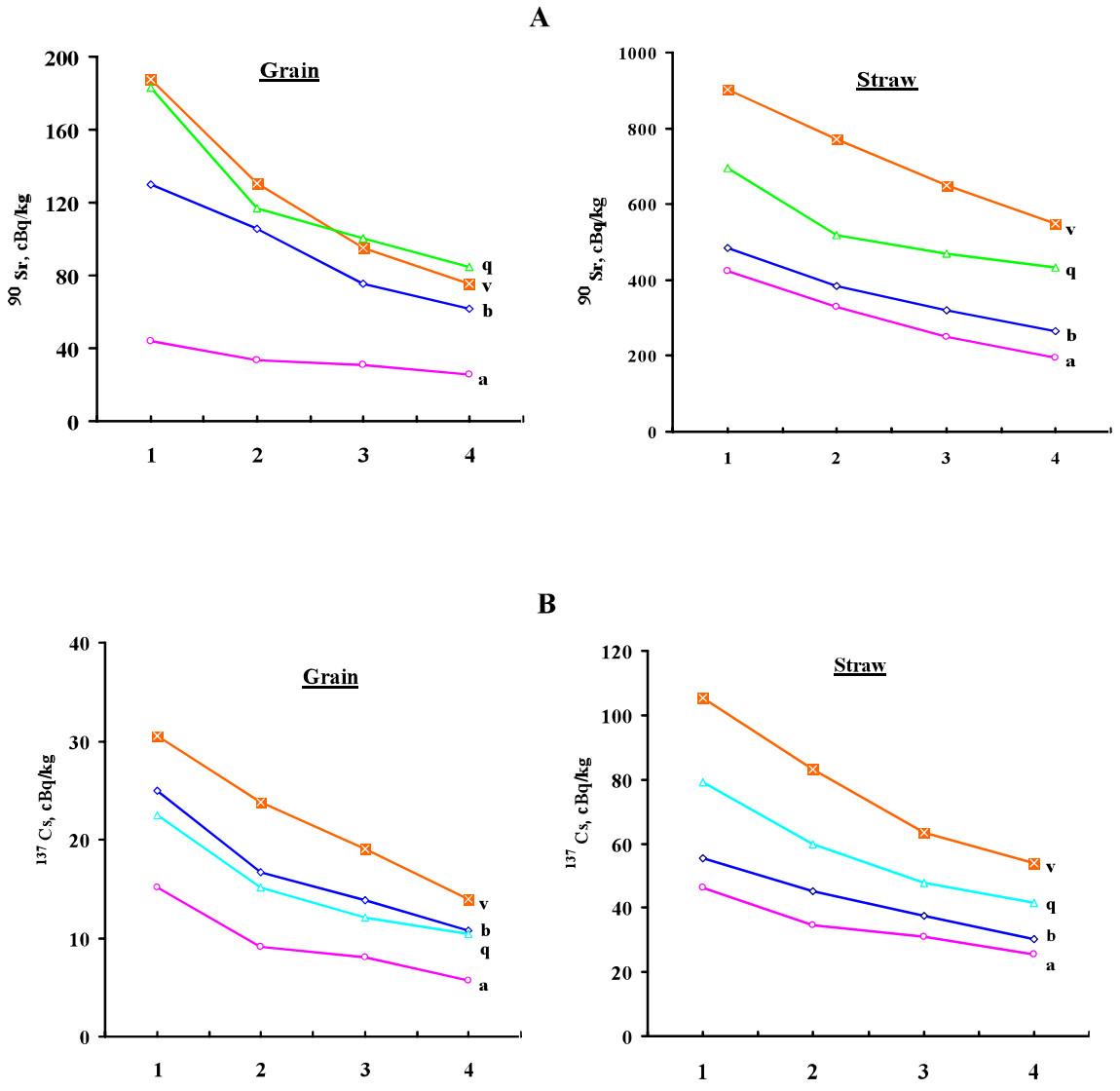
As known, due to use of mineral fertilizers it is possible to limit accumulation of artificial radionuclides in crops (Gulyakin and Yudintseva, 1973). The addition of potassium fertilizers is the most important for decreasing the ^{137}Cs accumulation in plants (Moiseyev et al., 1986). Thus, in area of Chernobyl accident it was possible to decrease the ^{137}Cs content 1.5-2.5-times in plants by limiting the acid soils and incorporation into soils of potassium fertilizers in increased quantities (Korneyev et al., 1988).

In present research use of mineral fertilizers resulted in decreased concentration of ^{90}Sr and ^{137}Cs in vegetative and generative parts of winter wheat, winter barley, garbanzo and soybean plants, and maximum decrease of radionuclides concentration in all crops was observed in samples, where high doses of mineral fertilizers were used (especially phosphorus and potassium). Incorporation into the soil of optimal and higher doses of mineral fertilizers decreased ^{90}Sr concentration in the grain of wheat by 24.0-41.1% (10.5-18.0 cBq/kg), barley - 18.4-52.2% (23.8-67.7 cBq/kg), garbanzo - 36.0-53.8% (65.9-98.4 cBq/kg) and soybean - 30.6-59.7% (57.5-112.0 cBq/kg) on average in two years. Concentration of ^{90}Sr in comparison to non-fertilized samples decreased in straw by 22.2-54.3% (94.2-230.7 cBq/kg), 21.1-45.2% (102.7-220.0 cBq/kg), 25.4-37.7% (176.7-262.1 cBq/kg) and 14.7-39.0 % (132.2-352.0 cBq/kg), correspondingly (Figure 1A).

^{137}Cs accumulation decreased in grain of wheat by 40.1-62.5% (6.1-9.5 cBq/kg), barley - 33.2-56.8% (8.3-14.2 cBq/kg), garbanzo - 32.4-53.8% (7.3-12.1 cBq/kg) and soybean - 20.3-54.1% (6.2-16.5 cBq/kg), and in straw by 25.8-45.4% (12.0-21.1 cBq/kg), 18.7-45.8% (10.4-25.4 cBq/kg), 24.1-47.3% (19.1-37.4 cBq/kg) and 26.6-48.8%, respectively (28.0-51.4 cBq/kg) (Figure 1B).

Thus, incorporation into the soils of mineral fertilizers in optimal and higher doses along with increase of grain yield, also leads to significant decreasing in accumulation of artificial radionuclides in yields (grain and straw) of various crops.

Decrease in ^{90}Sr and ^{137}Cs concentration in plants under influence of mineral fertilizers (especially in high doses) may be as the result of "diluti-



Fiqure 1. Influence of mineral fertilizers on accumulation of strontium-90 **(A)** and caesium-137 **(B)** in grain and straw of various agricultural crops (average data in 2 years).
(a) Wheat: 1 - Control (without fertilizers), 2 - N160P90K60 (optimal dose), 3 - N240P360K240, 4 - N320P720K480;
(b) Barley: 1 - Control (without fertilizers), 2 - N90P90K60 (optimal dose), 3 - N135P360K240, 4 - N180P720K480;
(v) Soybean: 1 - Control (without fertilizers), 2 - N90P60K30 (optimal dose), 3 - N135P240K120, 4 - N180P480K240
(q) Garbanzo: 1 - Control (without fertilizers), 2 - N30P60K30 (optimal dose), 3 - N45P240K120, 4 - N60P480K240.

on" of radionuclides in increasing phytomass, decreasing of radionuclides access for root assimilation as a result of decrease of ^{90}Sr and ^{137}Cs mobility or change in correlation of accessible macro- and microelements for plants (including radionuclides) in soils.

CONCLUSIONS

1. Use of complete mineral fertilizers in optimal and higher doses led to significant increase in productivity of winter wheat, winter barley, garbanzo and soybean. The biggest effect was observed at highest doses of mineral fertilizers.

2. Incorporation into the soil of increasing doses of complete mineral fertilizers along with increase of crops productivity led to significant decrease in ^{90}Sr and ^{137}Cs accumulation in yields of winter wheat, winter barley, garbanzo and soybean, maximum decrease of radionuclides concentration in plants was observed in samples, where highest doses of phosphorous-potassium fertilizers were used.

REFERENCES

Aleksakhin R.M. (1982) Nuclear energy and biosphere. Energoizdat, Moscow: 215 p. (in Russian).

Aliyev J.A., Abdullayev M.A. (1983) Strontium-90 and caesium-137 in soil-plant cover of Azerbaijan. Nauka, Moscow: 104 p. (in Russian).

Abdullayev M.A., Aliyev J.A. (1998) Migration of artificial and natural radionuclides in soil-plant system. Elm, Baku: 239 p. (in Russian).

Prister B.S., Loshilov N.A., Nemets O.F., Poyarkov V.A. (1991) Fundamentals of agricultural radiology. Urozhai, Kiev: 472 p. (in Russian).

Ponikarova T.M., Strukov V.N., Panasov M.N., Drichko V.F., Semyonov Y.I. (1992) Radioactivity of chestnut soils and main agricultural crops of arid zone of Povolzhye. Agrichem. **4:** 96-100 (in Russian).

Pavlotskaya F.I., Babicheva Y.V. (1973) Long-live artificial and natural radioisotopes in grain of agricultural crops in Moscow surroundings. Atomizdat, Moscow: 31 p. (in Russian).

Marey A.N., Barkhudarov R.M., Novikova N.Y. (1974) Global precipitations of caesium-137 and human being. Atomizdat, Moscow: 166 p. (in Russian).

Gulyakin I.V., Yudintseva Y.V. (1973) Agricultural radiobilogy. Kolos, Moscow: 272 p. (in Russian).

Moiseyev I.T., Rerikh L.A., Tikhomirov F.A. (1986) To the question of influence of mineral fertilizers at access of ^{137}Cs from soil of agricultural plants. Agrochem. **2:** 89 p. (in Russian).

Korneyev N.A., Povalyayev A.P., Aleksakhin R.M. et al. (1988) Sphere of agroindustrial production-radiologic consequences at Cernobyl NPP and main protective measures. Nuclear Energy **65(2):** 129 (in Russian).