2014 International Conference on Agricultural and Biosystem Engineering

Resistance of Winter Wheat Genotypes to Heavy Metals

R.A Alybayeva, S.S. Kenzhebayeva, S.D. Atabayeva

Department of Biology and Biotechnology
Kazakh National University named after al-Farabi, Ministry of Education and Sciences
Almaty, Republic of Kazakhstan

Abstract

The aim of this study was to identify wheat germplasm resistant to heavy metals (lead, copper, zinc and cadmium), which are important to eastern Kazakhstan region and identification of donors for breeding and promising forms of wheat that are resistance to heavy metals and destined for agricultural production. Different genotypes of winter wheat, the world's collection (Kazakh, Russian, a collection of CIMMYT cultivars and lines of winter wheat, wild species of wheat) were studied. Field studies carried out for the determination of physiological parameters. Heavy metals in soil and plant samples were determined by atomic absorption spectrophotometry. Genotypic differences in the accumulation of copper, lead, cadmium and zinc were established. The smallest number of studied heavy metals accumulates in the seeds of varieties of winter wheat Mironovskaya-808 and Krasnovodopadskaya-25. The highest yield from plots has winter wheat Mironovskaya-808. A crop yield of plants is connected with their ability to quickly enter to the tillering stage, successfully overwinter, preserve during the summer vegetation. Variety of winter wheat Mironovskaya-808 can be recommended for cultivation in the technologically disadvantaged regions, with soil contamination by heavy metals, as they accumulate not much heavy metal, they have good indicators of development, overwintering, yield.

© 2014 Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).
Selection and peer review under responsibility of Information Engineering Research Institute

Keywords: Physiological parameters; promising winter wheat varieties; resistance to heavy metal accumulation; wheat genotypes

Introduction

In Kazakhstan, the development of a powerful industry was based on its rich natural resources. However, the industrial centers are the areas of highest contamination by heavy metals. Sound environmental technologies are crucial to address heavy metal pollution. Development and use of plant varieties...
characterized by minimal accumulation of heavy metals can provide one such environmental solution. Plants grown in contaminated soils exhibit significant interspecies and intervarieties differences in responses to pollution [Molchan I.M., 1996]. The available literature data showed that a significant positive correlation between the concentration of heavy metals in the grain and genotypes, indicating the possibility of breeding varieties with a low potential for accumulation of heavy metals [Wu Feibo, Zhang Guoping 2002]. Characterization of heavy metal accumulation in wheat and identification of germplasm resistance to influence of heavy metals is an important step towards the creation and use of wheat varieties resistant to heavy metal pollutions in agricultural production systems. This requires the study of the gene pool of cultivated plants and their wild relatives, and the selection of donors that accumulate minimum amount of heavy metals and varieties that are promising for cultivation in areas contaminated with heavy metals.

The aim of this study was the identification of wheat germplasm resistant to lead, copper, zinc and cadmium and the identification of promising wheat forms destined for implementation into the agricultural production and breeding process.

1. Objects and methods

The experiment studied the genotypes of winter wheat world collection: Mironovskaya 808 and Kupava - Russian varieties of winter wheat, Krasnovodopadskaya 25 - Kazakhstan variety of winter wheat, MK-3745 - a promising winter wheat line of SIMMIT, triticale - a variety of Taza, Triticum compactum Host., Triticum timopheevii Zhuk., Triticum monococcum L., Triticum triunciale L., Triticum dicoccum Schuebl. - wild relatives of wheat.

Plants were grown for scientific test site, under natural environmental pollution, in the suburban area of Ust-Kamenogorsk city, East Kazakhstan region. The content of heavy metals in plants were determined by atomic absorption on the device 300 from AAnalyst "Perkin Elmer". Experimentation and determination of physiological parameters was conducted by the method of field experience [Dospechov BA, 1985].

2. Results and discussion

Our research has shown that the concentration of heavy metals in the soil of root zone of winter wheat genotypes is not equal. In relation to Maximum Permissible Concentrations (MPC) the exceeding of concentration level of lead is not observed, but the exceeding of the concentrations of zinc, copper and cadmium is shown (Figure 1).

![Fig.1. The content of zinc, copper (a), cadmium and lead (b) in the root zone soil of different genotypes of winter wheat grown in their natural environment pollution](image-url)
The study of the accumulation of heavy metals in components of different genotypes of winter wheat in conditions of natural pollution has shown that zinc is accumulated in all plant’s components, copper mostly in the roots and leaves, lead mainly in the leaves, cadmium in different organs, depending on the genotype. The large genotypic differences in the accumulation of zinc, copper, cadmium and lead in plant components were revealed.

Study of content of zinc, copper, cadmium and lead in the seeds of winter wheat genotypes are the most important, because wheat corn is used in the food industry. Our studies of zinc accumulation in the seeds of genotypes of the world collection showed that the metal accumulates in large quantities and its content exceeds the MPC for corn in all genotypes and only in seed of variety triticale Taza no such exceeding is observed (Figure 2). The greatest number of zinc is accumulated by plant seeds of variety Kupava, average number – by genotypes: Tr. compactum, Krasnovodopadskaya 25, MK-3745, Mironovskaya 25, the smallest number – by varieties of triticale Taza (Figure 2).

The copper content in the seeds of different genotypes of worldwide collection does not exceed the MPC in any variant of the experiment. The greatest amount of copper is accumulated by seeds of variety Mironovskaya 808, less accumulated by genotypes: MK-3745, Kupava, Krasnovodopadskaya 25, Tr. compactum, the least accumulated by - Taza.

In respect of cadmium there is not only significant accumulation of cadmium in the seeds, but also remarkable differences between the studied genotypes. Cadmium content exceeds the MPC for grain in almost all variants of the experiment, only in the seeds of such genotypes as Krasnovodopadskaya 25 and Mironovskaya 808 the content of cadmium does not exceed the MPC. The greatest amount of cadmium far exceeding MPC have seeds of triticale Taza, smaller amount but well above MPC - Kupava, Tr. compactum and MK-3745. Greater accumulation of cadmium in seeds than in other organs of wheat was observed by other authors as well. As a rule, the content of microelement in wheat grain is higher than in stems and leaves of plants [Medvedev P.V., Fedotov V.A., 2009]. According to some researchers, the level of heavy metal cadmium in products is the problem of food security. Reduction of cadmium in the grain is one of the priorities of breeding programs [RE Knox, CJ Pozniak, FR Clarke, JM Clarke, S. Houshmand, and AK Singh RE., 2009].

![Fig. 2. The content of zinc, copper, cadmium and lead in the seeds of different genotypes of winter wheat grown in their natural environment pollution](image)

The greatest amount of lead is accumulated in plant seeds of variety Kupava, the content of lead exceeds MPC of this metal in wheat grain. Other genotypes accumulate lead in small amounts not exceeding the MPC, the smallest amount of lead is found in seeds of the type Tr. compactum.
The results from the study showed that heavy metal accumulation in winter wheat varieties of Mironovskaya 808 and Krasnovodopadskaya 25 were the least among the world collection. Since zinc is not a toxic element and toxic metals such as cadmium and lead are insignificantly accumulate in the seeds of these varieties, it can be recommended for further research in breeding for metal resistance.

Also the physiological parameters of the studied wheat genotypes were investigated. The study of the quantity of plants under growth phases of the world collection genotypes showed that the wild relatives of wheat T. monococcum, T. dicoccum, T. timofeevi, T. triunciales have the smallest quantity of sprouted plants. The best germination showed genotypes Mironovskaya 808 and T. compactum (Figure 3). The study of quantity of plants preserved before overwintering showed that the largest number of surviving plants has genotypes Mironovskaya 808 and variety of triticale Taza, the smallest number of plants have variety of winter wheat T. monococcum. Winter wheat variety Mironovskaya 808 overwintered better than the other genotypes and has the highest percentage of surviving plants before harvesting. This indicates that this variety is the most resistant to adverse environmental conditions during the summer growing season. Some types of wheat could not stand overwintering conditions: T. monococcum, T. timofeevi, T. triunciale, T. dicoccum (Figure 3).

The biggest harvest from the plots has winter wheat Mironovskaya 808, this can be connected to successfully overwinter, preserve during the summer growing season. In addition, the variety Mironovskaya 808 goes faster the phases of development than other varieties. The genotype triticale Taza is also characterized by relatively high yield compared with other studied forms of wheat (Figure 4).

Winter wheat variety Mironovskaya-808 is recommended for cultivation in the East Kazakhstan region with soil contamination with heavy metals, as it accumulates little heavy metals, has a good development, overwintering, yield.
Fig. 4. Harvest from plots (g/cm²) of different genotypes of winter wheat grown in their natural environment pollution.

3. Conclusions

1) Varieties of winter wheat Mironovskaya 808 and Krasnovodopadskaya 25 are more resistant to the accumulation of studied heavy metals. They can be recommended for the use in breeding for metal resistance.

2) Varieties of winter wheat Mironovskaya 808 can be recommended for the cultivation in technologically disadvantaged regions, with soil contaminated by heavy metals, as they accumulate not much heavy metals, they have good indicators of development, overwintering and yield.

References