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Toxic Effects of Aluminum on Wheat Decay in its Early Growth and Development

D. Đokić

Faculty of Agronomy, Čačak, Yugoslavia

Jovanka Stojanović, M. Jelić, S. Lomović

Agricultural Research Institute "SRBIJA" Beograd, Centre for Small Grains, Kragujevac, Yugoslavia

Abstract: The contents of Al in the plants and mobile Al in the soil were analysed as the possible reasons for wheat depression and its eventual decay in the spring. The analysis showed that both dried plants and soil sampled from their roots had markedly higher levels of Al and mobile Al, respectively.

Key words: aluminum, mobile aluminum, disorders in wheat growth

Introduction

In Serbia, many disorders take place in the spring vegetation of wheat from its emergence till death, as an eventual consequence of a disturbed growth. The crops get markedly thinned, and even empty points with no plants at all may be encountered. In addition to differences in crop growth, those in colour are also high so that plants turn into yellowish-green and pale-yellow from green. An expressed crop thinning and decreased yields appeared to be the main consequences of such disorders.

Although these disorders were detected three decades ago, no information about their causes has been provided yet.To mention only few of their high number, such as mineral nutrition imbalances, toxicity of nitrogen, aluminum and heavy metals (Kostić et al. 1990, 1991, 1993, 1994; Kosraei et al.

1994; Foy, Burns 1964; Foy 1975; Pavlov, 1990; Nikitišen et al. 1991, Anofrina, 1990).

The objective of this study was to analyse plant and soil Al, which brought about wheat dying in its early growth and development in the spring.

Material and methods

The Center for Small Grains in Kragujevac was provided with plants, for which agricultural producers needed some recommendations to maintain their healthiness. Of these plants, the samples consisting of normal and withered plants were taken from mid-December in 1994 to mid-May in 1995 and analysed for Al content. The soil, taken from plant roots, was analysed for mobile Al content. The levels of Al in the plants and mobile Al in soil were determined colorimetrically, employing aluminon method.

Results and Discussion

Description of diseased plants

The diseased plants in the sample taken from the village Opornice were in 3-leaf, and healthy ones in 4-leaf stage. The former were withered, lower leaves dried and brownish, without secondary shoots. The tips of active leaves were rolled, green or pink-green. The latter had thicker stems, somewhat wider leaves, of which 50 % accounted for secondary shoots. Barley crops were highly densed, with highly expressed tillering except dwarfed plants, appearing only on the surfaces with poor sprouting, i.e. where the plants had much shorter stems, short light-green leaves with dried tips and withered blades whose colour abruptly turned into yellow and dark-brown from green. Fertilization with phosphorus prior to sowing was omitted on this surface.

Wheat crops from the village Pajsijevići were in the 5-6 leaf stage, tillering almost absent, no indications of anthocyanin. The soil underneath plants was hard, cold and sodden. Phosphorus fertilization prior to sowing was omitted.

The first symptoms of N deficiency could be seen on the crops from the villages Bunar and Prnjavor. The crops were first green, then turned yellow-green and yellow, the oldest leaves found dead and withered, but unrolled. The depressed plants from the village Vujetinci jutted out, noticeably differing in height, with rolled leaves either entirely or partly dried. Initially, these plants did well with 3-4 secondary shoots. Later disorders probably resulted from a rather slowed down root development due to P deficiency and soil acidity. The way plants looked suggested no promising yield. In the surveyed samples, the differences in yield between dry and fresh matter amounted to 0.5, i.e. twice as much in favour of the healthy plants.

Al content

Al content amounted to 800-1360 ppm per 1 kg of air dry matter in the diseased, and to 80-880 ppm in the healthy plants (Tab.1). The highest

differences in Al content existed between the healthy and diseased plants, sampled in the village Vujetinci (17 times), whereas the slightest ones were indicative of the crops, sampled in the village Bunar (2.5 times). Al content was rather high in the healthy plants, without any visible symptoms of a disturbed growth. Even higher differences were manifest in the content of soil mobile Al. Thus, its level was 1.0-21.5 ppm in the diseased, and 0.0-1.0 ppm in the healthy plant roots. The diseased plant roots sampled from the villages Vujetinci and Pajsijevići had the highest, and those from the village Bunar the lowest content of mobile Al..

Tab.1. Al content of plants and soil

Locality	Date	Plant growth	Al-ppm content	
			plants	soil
Opornica	15. 12. 1994.	Normal	580	0.0
		Slowed down	1100	11.5
Centre for Small Grains*	20. 02. 1995.	Normal	880	0.0
		Slowed down	1240	1.5
Pajsijević	03. 04. 1995.	Normal	-	-
		Slowed down	940	18.0
Bunar	12. 04. 1995.	Normal	640	0.0
		Slowed down	800	1.0
Prnjavor	13. 04. 1995.	Normal	-	-1.0
		Slowed down	1320	
Vujetinci	19. 05. 1995**	Normal	80	0.0
		Slowed down	1360	21.5

*barley
**sample taken from the surrounding plot consisting of wheat crops with healthy plants

Discussion

It is well-known that young plants, particularly their rooting may be highly impeded in their growth due to a deficit in phosphorus (Đokic, Kostic, 1974., Kostic et al., 1990). During draughts, P deficiency increased, hence a much slowlier plant growth even on those plots, where plants otherwise do well under good humidity conditions. P deficiency combined with increased or common N fertilizer amount can cause an even more disturbed growth that is manifested by a stronger tillering, but a weaker rooting. The root was poorly branched and unable to supply plants with necessary water and mineral matter amounts. Plant growth was obviously slackened, with scarcely rooted plants that were found dead. Empty parts with no crops at all were often encountered. The other plants either continued to grow normally or were heavily damaged and prone to death.

Therefore, the main reasons for such a slow plant growth or even death are high air humidity, P deficiency as well as enough or too much of N fertilization. Moreover, the high air humidity in combination with low soil

temperature markedly reduced aeration and microbial activity. Under these conditions, anaerobic degradation of organic matter led to increased concentrations of organic acids and carbon dioxide, thereby inducing higher soil acidity. Hence, a higher level of mobile Al and an abundance of active heavy metals in soil with a highly toxic impact on plants. The level of P was reduced and N metabolism slowed down in plants, resulting in higher nitrogen soluble fractions that exhibited high toxic effects on the crops. Such a disturbed growth was accompanied by an array of adverse effects, such as the desiccation of leaves, shoots and entire plants. Chlorophyl synthesis was also slowed down, thus, the youngest leaves turned pale-yellow or even white. The crops gave the impression of being cooked.

Not only did Al contents increase in the plants and roots, but also their toxic impact on the plants that died sooner or later. Although lower in the healthy than in diseased plants, Al content of the healthy ones was also hazardous, approximating the limit of toxicity (Grundon et al., 1987). That the symptoms of toxicity may as well take place in the healthy plants in their later growing stages, cannot be denied.

Conclusion

On the basis of everything done, several conclusions may be inferred:

- The disturbances in wheat growth occurring all through to stalking were accompanied by chlorosis, the desiccation of leaves, secondary shoots and entire plants;
- Al content was higher by 0.25 - 17 times in the diseased than in the healthy plants;
- Soil content of mobile Al ranged from 1.0 to 21.8 ppm in the diseased, and from 0-1.0 ppm in the healthy plants;
- The results clearly showed that Al toxicity was responsible for plant death throughout spring growing season.

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TROVANJE ALUMINIJUMOM KAO JEDAN OD UZROKA PROPADANJA PŠENICE U RANIM FAZAMA PORASTA I RAZVIĆA

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D. Đokić

Agronomski fakultet, Čačak

Jovanka Stojanović, M. Jelić, S. Lomović

Institut za Istraživanja u poljoprivredi "Srbija" Beograd
Centar za strna žita, Kragujevac

Rezime

Poremećaji u rastenju i propadanje biljaka u prolećnom delu vegetacije pšenice na kiselim zemljištima su česta pojava. Posledica toga je proređivanje useva i smanjenje prinosa. U moguće uzroke ove pojave ubraja se i trovanje aluminijumom. U ovom radu analiziran je sadržaj aluminijuma u biljci i zemljištu na površini korena depresiranih i zdravih biljaka. Nađene su povećane koncentracije aluminijuma u biljci i zemljištu sa korena depresiranih biljaka. Koncentracije aluminijuma u zdravih biljaka, iako niže nego u obolelih, bile su visoke i blizu toksičnih.