UDC: 633.11:631.524.86
original scientific paper

Acta Agriculturae Serbica

Acta Agriculturaae Serbica, Vol. II, 4 (1997) 67-71

Effect of Different Materials on Mobile Aluminum (Al^{3+}) Neutralization With Maize Growing

M. Bojić, N. Bokan, Rakočević-Bosković Ljiljana, V. Stevović

Faculty of Agronomy, Čačak, Yugoslavia

Abstract: The experiment was conducted in the western Serbia on a highland soil with extremely high content of mobile aluminum (36 mg/ 100 g of soil) and low pH (3.1).

Aiming at Al^{3+} neutralization, the application of bentonite, CaO, MgO, zeolite and crude phosphates was made in different treatments, each designed as a block replicated 3 times plus control. As a test plant, an early vegetation maize hybrid NSSC 201 was used.

The key goal of this study was to find out the extent to which these materials effected changes in Al^{3+}, pH and maize yield.

The treatment with bentonite (45 t/ha) showed the best effect, since Al^{3+} was reduced to 2.52 mg/100 g of soil and pH increased to 4.16., whereas the treatment with crude phosphates indicated the poorest effect, with Al^{3+} decreased to 25-30 mg/100 g of soil and pH increased to 3.4.

In general, all the treatments except the control greatly favoured maize yield, with the highest one reported to be 11.93 t/ha on the treatment with 3.0 t/ha CaO, and the lowest one of 8.63 t/ha established on the treatment with crude phosphates.

Key words: mobile aluminum, soil acidity, neutralizing materials, maize, yield

Introduction

Plant production has been made rather difficult on soils of unsuitable chemical, physical and biological properties for over many years. In Serbia, 50% account for acid soils, of which 30% account for extremely acid ones, with production of many plants made almost impossible (Stevanovic, 1986). This

problem becomes even more serious when such a low pH of soil is associated with high concentration of an active Al in soil solution so that even weeds fail to grow under such conditions. It is well-known that free Al ions with pH reduced in the rhizosphere along with unsuitable environmental conditions may largely inhibit root growth as well as the uptake of P, N and other nutrients (Riley and Barber, 1971; Pavlov, 1982; Marschner et al., 1987). In addition, allowing for the fact that increases in Al accumulation in the plant and in free Al in soil are caused by an excessive use of N fertilizer (Jelic et al., 1993), it is clear how much attention should be paid to this issue.

The results on Al toxicity impairing plant root in extremely acid soils have been reported by many authors. Durman et al., 1990; Okiljevic, 1982; Foy, 1984; Jakovljevic et al., 1990, Wagatsuma et al., 1987 reported about Al ions degrading epidermal cells and root crust in the form of deep surficial cracks. Foy (1984) also pointed to the symptoms of P deficiency frequently appearing on the foliage and roots. As regards maize hybrids, they show a differing resistance to poor soil conditions, while the application of lime can help to efficiently increase soil pH and P availability (Dugalic et al., 1997).

The methods and materials required need to be applied as appropriately as possible in order to make these soils capable of normal plant production.

Materials and methods

A study on the effect of different materials on mobile Al^{3+} neutralization with maize cultivation was conducted on a hilly area with already existing symptoms of partly dead wheat, oats and maize plots.

A high content of mobile aluminum (>30 mg/100 g of soil) and a very low pH (pH in nKCl 3.1) were established in soil samples taken for chemical analyses. The experiment was set up using different materials for neutralizing high content of Al and low pH of soil. For this purpose, bentonite, CaO, MgO, zeolite and crude phosphates were applied in the following treatments:

1. control (∅)
2. bentonite (45 t / ha)
3. CaO (3.0 t / ha)
4. MgO (1.5 t /ha)
5. zeolite (2 t /ha)
6. crude phosphates (1.2 t / ha)

Prior to setting up of the trial, soil samples were taken for chemical analyses.

The experiment of a split-plot design with randomized blocks, replicated 3 times, was carried out in field conditions. Of an early vegetation maize hybrid from FAO maturity group, 200-NSSC 210 was grown for 2 years.

An application of neutralizing materials over the soil surface along with use of rotary tiller permitting their mixing with soil, was broadcast one month prior to sowing.

Sowing was performed at the beginning of May in both study years with concomitanly applied 600 kg /ha NPK 15:15:15, with the addition of 250 kg/ ha KAN in mid-June.

Harvesting took place by the end of October. Zoromat was used for weed control.

After the removal of crops, soil samples were taken from each treatment for chemical analyses. The content of mobile aluminum was analysed according to the method of A. Sokolov, and pH in nKCl following potentiometric method

LSD- test and an analysis of variance were employed for statistical processing of the data obtained.

Results

The results obtained suggest that of all the treatments, used for Al^{3+} neutralization, that with bentonite (45 t/ha) was the most efficient one (Tab. 1) causing mobile Al to considerably reduce (2.52 mg), in relation to the previous state (35.6 mg/100 g) and pH to increase from 3.10 to 4.16.

Tab. 1. The content of mobile aluminum (Al^{3+}) and pH value in soil

Treatment	pH (nKCl-u)		Al (mg/100 g of soil)	
	1995.	1996.	1995.	1996.
Control	3,10	3,18	35,60	34,8
Bentonite (45 t/ha)	3,86	4,16	6,12	2,52
CaO (3,0 t/ha)	3,61	3,81	13,52	8,88
MgO (1,5 t/ha)	3,40	4,02	17,41	14,77
Zeolite (2 t/ha)	3,48	3,70	16,92	14,04
Crude phosphates (1,2 t/ha)	3,35	3,40	31,22	30,19

In contrast, the treatment with crude phosphates (1.2 t/ha) had barely beneficial effect on mobile Al neutralization, with its slight decrease (30.19 mg) in relation to the preeceding state (35.6 mg/100 g of soil) and pH increase from 3.10 to 3.40 units .

All the remaining materials more or less efficiently reduced Al^{3+} content, with its concentration in the soil brought to the level being non-toxic or tolerant of maize, which favoured its growth.

Though not so visible as in the case of Al, the change in pH ranging from 0.40 to 0.70 units was also due to materials applied.

So neutralized Al^{3+} and partly increased pH value in soil favoured increase in maize yield to a great extent, compared with the control (Tab.2). Notably, different materials differently effected maize yield.

For example, the application of lime (CaO) increased maize yield more efficiently in relation to the remaining materials used. Then, the use of MgO benefited yield increase much more than bentonite and crude phosphates did, whereas zeolite caused slight and the rest of materials almost no differences in maize yield.

The years of studies had a negligible effect on the yield in that, as can be seen in the Table 1., the average maize yield of the second year was somewhat lower, which might have resulted from less convenient environmental conditions of the second vegetation season of maize. However, an interaction between

materials applied and study years was found to exceptionally favour yield increase, compared with the control. The use of lime efficiently improved yield increase throughout both years of studies, whereas all the reamining materials caused minor statistical differences in yield.

Tab. 2. Maize yield (t/ha)

Year (B)	Materials applied (A)						
	Control	Bentonite 45 t/ha	CaO 3,0 t/ha	MgO 1,5 t/ha	Zeolite 2 t/ha	Crude phosphates 1,2 t/ha	☒
1995.	7,06	9,02	11,93	9,37	9,14	8,63	9,19
1996.	6,80	8,69	11,73	9,66	8,74	8,84	9,08
☒	6,93	8,86	11,83	9,52	8,94	8,74	9,14

		A	B	AB
LSD	0,05	0,628	0,363	0,889
	0,01	0,854	0,493	1,208

Discussion

Considering fairly adverse soil conditions of the highlands of the western Serbia (50 % account for acid, of which 30 % account for extremely acid soils not to mention extremely high content of mobile Al), more attention has been paid to these issues in recent years. In this regard, two methods have been applied. First, a range of remedying measures with calcification as the most preferable one. Second, the selection of the plants that are genetically resistant, particularly on heavily acid soils where too much of lime is wasted (Foy et. al., 1987).

In his research on maize grown on soil with pH amounting to 3.8, Brocic (1994) came to conlusion that with the aim of reducing acidity, the use of CaO in the rate of 4 t/ha proven the most efficient, an allowance being made for pH increase by 0.7 units in relation to the control and for Al content by its decline below the level being toxic of maize, ranging from 1.53 to 8.10 mg/100 g of soil. This is in agreement with results of Jakovljevic et. al.,(1991) and Foy (1974) suggesting that the rate of mobile Al exceeding 10 mg/100 g of soil may be toxic of maize. The results of this study also benefit the fact that Al content, decreased to the limit being non-toxic of maize, favours its growth and yield.

Furthermore, Brocic (1994) reported that maize yield increased about 4 t/ha thanks to the application of CaO (4 t/ha) + manure, being also in compliance with results of the present study.

In addition, Foy (1974) noticed that, due to an excess of mobile Al in the plough layer, root fails to develop deep enough to take up sufficient amounts of nutrients and water from deeper layers of the soil. As a result, shoot growth has been largely slowed down, obviously leading to lower yield. This is strongly supported by our results, indicating that the yields resulting from the application of materials for neutralizing mobile Al definitely proven much higher than those obtained in the control with Al content exceeding even 30 mg/ 100 g of soil.

Conclusion

Based on the objective and results of this study, several conclusions may be drawn:

1. The best effect on Al^{3+} neutralization was observed on the treatment with bentonite used in the rate of 45 t/ha allowing mobile Al to be reduced from 35.6 mg to 2.52 mg/100 g of soil;

2. The poorest effect was however reported on the treatment with crude phosphates used in the rate of 1.2 t/ha, with neither Al^{3+} nor pH changing visibly (Al - 30.19 mg/100, pH 3.40) in relation to the previous state (Al - 35.6 mg, pH 3.10);

3. All the materials applied for Al^{3+} neutralization led to significant increase in maize yield, compared with the control (6.93 t/ha);

4. In both years of studies, the highest average maize yield of 11.83 t/ha of grains was achieved using 3 t/ha CaO.

5. Finally, the lowest average maize yeald of 8.74 t/ha of grains was reported on the treatment with crude phosphates used in the amount of 1.2 t/ha.

References

Broćić, Z. (1994): Uticaj organskih i mineralnih djubriva i vremena obrade na fizičke i hemijske promene u zemljištu i prinos kukuruza. Doktorska disertacija. Poljoprivredni fakultet, Zemun.

Dugalić, G., Stevanović, D., Ognjanović, R., Veskoović, M., Jovanović, Ž. (1997): Povećanje prinosa različitih hibrida kukuruza neutralisanjem kiselosti pseudoglejnog zemljišta, Zbornik Zimske škole za agronome, 35-43, Čačak.

Durman, T., Hadžiselimović, S., Nikolić, S. (1990): Reziste-ntnost nekih autohtonih materijala ozime pšenice na povećanu koncentraciju aluminijuma u tlu ($Al^{+}3$). Savremena poljoprivreda, Vol. 38, No. 3-4, 245-258, Novi Sad.

Foy, C.D. (1974): Aluminium Toxicity in Plants. Agron. J., 66, 715-719.

Foy, C.D., Lafever, H.N., Schwartz J.W. and Fleming, A.L. (1984): Aluminium tolerance of wheat cultiovars related to region of origin. Agron. J. 66, 751-758.

Foy C.D., Smith D.H., Briggle, L.W. (1987): Tolerances of oat cultivars to an acid soil high in exchangeable aluminium. Journal of Plant Nutrition, Vol. 10, No 9-16, 1163-1174.

Jakovljević, M., Stajković, M. I Blagojević, S. (1990): Some negative chemical properties of acid soils. 10th World Fertilizer Congres of CIEC (Proc.), 21 Đ 27 oct., Nicosia, Cyprus, 1-5.

Jakovljević, M., Mišović, M., Broćić, Z. (1991): Uticaj primene organskih i mineralnih djubriva na hemijska i biološka svojstva pseudo-gleja. Zbornik radova Polj. fak. God. 36, sv. 596, Beograd, 171-180.

J e l i ć, M., K o s t i ć, M. A., S t e v a n o v i ć, D., J a k o v l j e v i ć, M.,L o m o v i ć, S. (1993): Neadkvatno đubrenje kao uzrok povećanja sadržaja nitrata, pojave toksičnih koncentracija Al i smanjenja produktivnosti pšenice. Savremena poljoprivreda, vol. 1, broj 6, 366-367.

M a r s c h n e r, H., R o m h e l d, V. and C a k m a i, I. (1987): Root induced changes of nutrient availability in the rhiozosphere. J. of Pl. Nutr., 10 (9-16), 1175-1184.

O k i l j e v i ć, V. (1982): Toksično dejstvo Al na neke sorte pšenice i ječma na pseudogleju Bosanske Krajine. Zemljište i biljka, 31, 45-54.

P a v l o v, A. N. (1982): O mineralnom pitanij rastenij v zaslušlivih uslovijah. Seljhazj. Biologija, Tom 17, No 2, 189-195.

R i l e y, D., and Barber, S. A. (1971): Effect of ammonium and nitrate fertilization on phosphorus uptake as related to root induced pH changes at the root soil interface. SSS Am. Proc., v. 34, No 2, 301-306.

S t e v a n o v i ć, D. (1986): Problemi korišćenja i povećanja produktivne sposobnosti kiselih zemljišta u Srbiji. Glasnik poljoprivredne proizvodnje, prerade i plasmana, god. XXXV, br. 9, 18-22, Beograd.

W a g a t s u m a, T., K a n e k o, M. and H a y a s a k a, Y. (1987): Destruction proces of plant root cells by Aluminnium. Soil Sci. Plant Nutr., 33, 161-175.

NEUTRALIZACIJA MOBILNOG ALUMINIJUMA PRI GAJENJU KUKURUZA

-originalni naučni rad-

M. Bojić, N. Bokan, Rakočević-Bošković Ljiljana, V.Stevović

Agronomski fakultet, Čačak

Rezime

Ogled je izveden u brdsko-planinskom području Zapadne Srbije, u poljskim uslovima, gde je predhodno utvrđen visok sadržaj mobilnog aluminijuma (36mg/100gr zemljišta) i veoma nizak pH (3,1).

Za neutralizaciju Al^{3+} korišćena su sledeća sredstva: Bentonit, CaO, MgO, Zeolit i Sirovi fosfati.

Primena ovih sredstava izvršena je kroz različite varijante. Svaka varijanta je izvedena u tri ponavljanja uz kontrolnu varijantu. Kao test biljka korišćen je hibrid kukuruza rane vegetacije NSSC 201. Ogled je trajao dve godine. Cilj proučavanja je bio da se utvrdi u kojoj meri primenjeni materijali utiču na promenu Al^{3+}, pH i prinos kukuruza.

Najbolji efekat utvrđen je na varijanti sa Bentonitom gde je Al^{3+} sveden na 2,52mg/100g zemljišta, a pH povećan na 4,16. Najslabiji efekat utvrđen je na varijanti sa Sirovim fosfatima, gde je sadržaj Al^{3+} iznosio 25-30mg/100g zemljišta, a pH povećao do 3,5.

Prinos kukuruza na svim ispitivanim varijantama bio je znatno veći nego na kontroli. Najveći prinos u odnosu na kontrolu postignut je na varijanti sa 3t/ha CaO, 11,93t/ha, a najmanji na varijanti sa sirovim fosfatima 8,63t/ha.