Cation specific exchange capacity of cell wall material isolated from roots of plant species differing in Al resistance

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Introduction

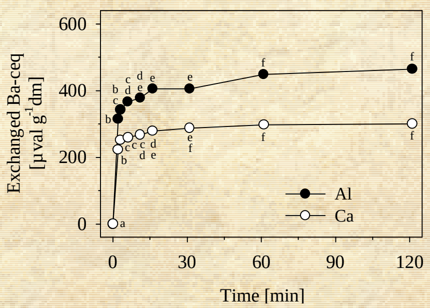
Since many years controversy has surrounded the importance of cation-exchange capacity (CEC) of roots in the Al resistance of plants. In most of the investigations high CEC was associated with Al sensitivity, but several authors reported a reverse relationship or they found no significant differences in root CEC between species/cultivars differing in Al resistance. We investigated the adsorption of several cations to isolated cell wall material (CWM) which was prepared from the roots of 4 plant species differing widely in Al resistance (barley < field bean << rye ≤ yellow lupin) .

Materials and methods

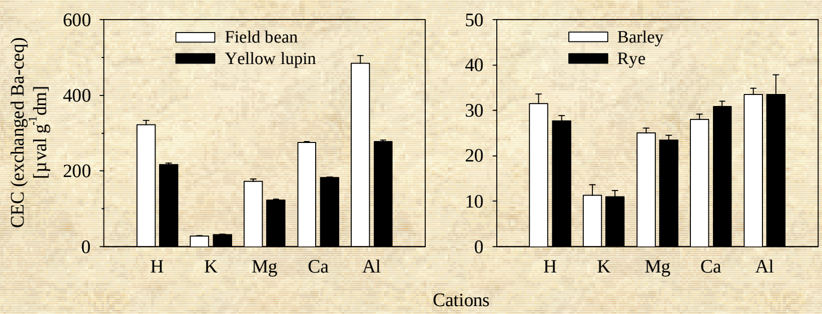
Plants of barley (*Hordeum vulgare* L. cv Baronesse), rye (*Secale cereale* L. cv Kustro), field bean (*Vicia faba* L. cv Herz Freya) and yellow lupin (*Lupinus luteus* L. cv Topaz) were cultivated in nutrient solution. After 4 –6 weeks, CWM was prepared from the whole root system and from root tip fractions (0 - 5 and 5 - 20 mm) by a non-destructive method. CEC was determined separately for H^+, K^+, Mg^{2+}, Ca^{2+} and Al^{3+}, respectively, by shaking small aliquots of the Ba^{2+}-pretreated CWM in solutions containing these cations in the same concentration of charge equivalents (600 µval L^{-1}, pH 4,3). Cation contents of the CWM and the incubation solution were determined by AAS. CEC is expressed as amount of cation charge equivalents in the CWM and as displaced Ba^{2+} charge equivalents in the treatment solution (ceq [µval]).

Results

Cation exchange in CWM took place rapidly. After 2 minutes already 74% and 86% of the exchangeable Ba^{2+} was displaced by Al^{3+} and Ca^{2+}, respectively.



Whole root CWM from the leguminosae showed a much higher CEC for all cations tested than CWM from the gramineae. Within one family CEC differences were only obvious between yellow lupin and field bean. Ba^{2+} replacement pattern of the cations was consistent for all species ($CEC_K << CEC_{Mg} < CEC_{Ca} < CEC_H < CEC_{Al}$).



CWM from the apical root region (0 - 5 mm) of barley and field bean showed a significantly higher adsorbility for Al^{3+} than CWM from their respective reference species with a higher Al resistance. CEC_{Al} of CWM prepared from the more basal region (5 - 20 mm) was similar for both species within one family.

	CEC_{Al} (adsorbed Al-ceq) [µval g^{-1} dm]	
	Root zone	
	0 - 5 mm	5 - 20 mm
Barley	106,8a	59,1a
Rye	63,1b	65,5a
Field bean	491,0a	543,7a
Yellow lupin	422,0b	527,4a

Conclusions

Consistent differences in cation adsorption corresponding to differences in Al-resistance could only be found with CWM from the apical root zone. The results indicate that CEC_{Al} of this sensitive area can characterise Al resistance of plant species, but only within the same family. A lower Al concentration in vicinity to damageable structures such as cell membrane or symplast could be part of an Al resistance mechanism. Although cation exchange properties measured with non-living portions of the apoplast probably have a secondary role in Al resistance, they might modulate other more important processes.