W. J. Horst et al. (Eds.), Plant nutrition – Food security and sustainability of agro-ecosystems. 520~521, 2001

Effects of heterogeneous Al and P supply on root growth and screening of maize cultivars differing in Al resistance

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Key words: aluminium, avoidance, compensatory growth, maize, split-root, *Zea mays*

Abstract

Nine day-old seedlings of two maize (*Zea mays* L.) cultivars differing in Al resistance were exposed to a spatially varied Al (0, 10 µM) and P supply (1, 25 µM) for 4 days using a split-root system. Only in the roots exposed to Al did Al supply lead to a decrease in elongation, a reduction in dry matter production, and enhanced callose formation. The response to Al was independent of whether Al was applied to the entire or only half of the root system and of the P supply. A compensatory growth reaction was found for the Al-sensitive cultivar Lixis only in terms of root dry matter but not for the Al-resistant BR201M. The results indicate that assessment of Al resistance based on root elongation was not limited by an Al avoidance reaction.

Introduction

Plant roots are characterised by a very high adaptability enabling them to respond to the heterogeneous soil environment by improving root growth in more favourable pockets. This is described as a plastic response of the root system (Fitter, 1996). For velvet bean (*Mucuna pruriens*) grown in hydroponics with a split-root system, Hairiah *et al*. (1993) showed that *Mucuna* was Al-resistant when the whole root system was exposed to homogeneous Al supply. However, when Al was supplied to only one part of the root system the roots avoided Al by preferential development of those roots not in contact with Al, accompanied by a marked growth inhibition of roots exposed to Al. This reaction was only observed at low P supply. Since screening for Al resistance using young seedlings is conducted in nutrient solution with homogeneous Al distribution (Horst *et al*., 1997) a possible Al-avoidance mechanism might be misleading in the classification of cultivars for Al resistance. The objective of this study was to determine, if an Al-avoidance reaction is expressed by maize seedlings when only a part of the root system is exposed to Al.

Materials and methods

Two experiments were conducted with 9 day-old seedlings of the maize (*Zea mays* L.) cultivars Lixis (Al-sensitive) and BR201 M (Al-resistant), precultured for 5 days at a sub-optimal P concentration of 1 µM. At the start of the experiment two P concentrations (1, 25 µM) and two Al concentrations (0, 10 µM) were applied using a split-root system at pH = 4.3 (Fig. 1). After 4 days, root elongation and root dry weight were determined. Callose in root tips was analysed as described by Horst *et a1*. (1997). Comparisons of means were conducted for each level of P supply separately using the Tukey-test *at* $P< 0.05$.

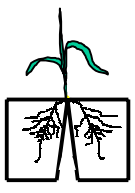

Figure 1. Split-root system.

Results and discussion

Root elongation was enhanced at a low P supply compared to high P supply. Aluminium application decreased root elongation irrespectively of the P supply (Fig. 2). The Al-sensitive cultivar Lixis was more affected than the Al-resistant cultivar BR201M. Regardless of P levels, neither an Al-avoidance reaction nor compensatory root elongation for either cultivar was found.

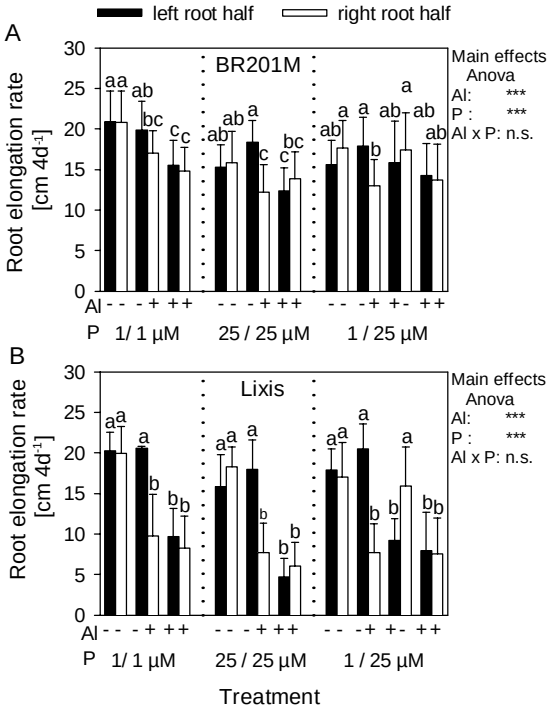

Figure 2. Influence of a varying Al and P supply on root elongation of an (A) Al-resistant (BR201M) and (B) Al-

sensitive (Lixis) maize cultivar.

Callose formation, a marker for Al injury (Horst *et al*. (1997) was enhanced up to 12-fold in Al-exposed root apices of the Al-sensitive and 3-fold in the root tips of the Al-resistant cultivar (Fig. 3). Callose formation in Al-exposed root tips of the Al-resistant cultivar BR201M did not reveal an enhanced Al sensitivity when the other part of the root system was not exposed to Al.

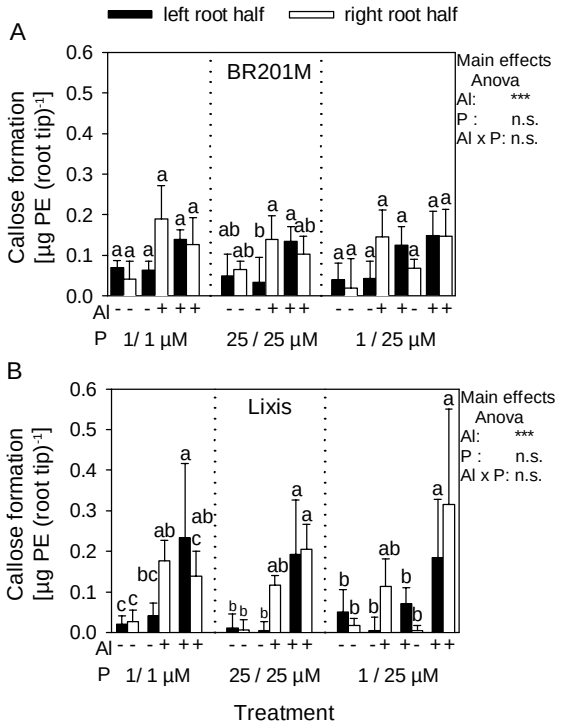

Figure 3. Influence of varying Al and P supplies on callose formation of an (A) Al-resistant (BR201M) and (B) Al-sensitive (Lixis) maize cultivar.

A significant effect of the heterogeneous Al supply was observed for the Al-sensitive cultivar Lixis for root dry matter (Fig. 4). The root dry matter was enhanced on the Al-free side, especially at the high P supply, indicating a compensatory growth reaction. This additional root growth might be accounted for by increased lateral root growth as described for Cu toxicity (Adalsteinsson, 1994) and for a localised nutrient supply (Robinson, 1994). Such a reaction was not found for the Al-resistant cultivar BR201M at any of the P levels. Contrasting the findings of Hairiah *et al.* (1993) with *Mucuna*, no Al avoidance reaction occurred even at low P supply (shoot-P content < 0.3 %).

The results clearly show that an assessment of Al resistance in maize based on root elongation is not altered by a heterogeneous exposure of roots to Al. Screening for Al resistance in maize seedlings in hydroponics is, therefore, not limited to applying Al homogeneously to the root system. Compensatory growth might be more important for Al-sensitive than Al-resistant cultivars and might explain why some Al-sensitive cultivars perform better on acid soils than in nutrient solution.

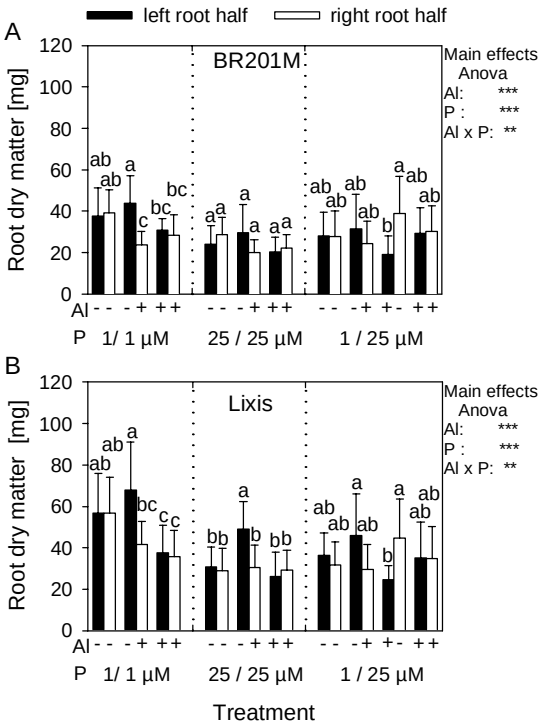

Figure 4. Influence of Al and P supply on root dry matter of an (A) Al-resistant (BR201M) and (B) Al-sensitive (Lixis) maize cultivar.

Acknowledgement

The financial support by BMZ and EU-INCO is highly acknowledged.

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