Spatial root interaction of maize and two important weed species

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ABSTRACT

Roots are essential for growth, survival and fitness of plants. Most often roots of different plants share a certain soil volume, for example when weeds establish within a crop canopy. The study of the co-location of roots in such plant mixtures is, however, not trivial, because it is not easy to assign single roots to the respective plants. To overcome this limitation, we conducted an experiment in which one transgenic line of maize (*Zea mays* L.) expressing the green fluorescent protein (GFP) was grown together with either redroot amaranth (*Amaranthus retroflexus* L.) or lambsquarters (*Chenopodium album* L.). We used minirhizotrons (i.e. transparent tubes installed in the soil) and a suitable imaging system to detect those roots which are fluorescing, to screen the roots of the plant species being grown in each mixture and to classify them as maize or weed roots. The approach was suitable for studying how maize and the selected weed species interact in a shared soil volume. Preliminary results indicate that the number of roots of maize was significantly reduced by the presence of weeds. Furthermore, the effect of maize on the number of roots of the weeds was the opposite of that on shoot biomass; it increased for lambsquarters, whereas it decreased for redroot amaranth. The results suggest a different competition strategy of redroot amaranth than maize and lambsquarters.

1. INTRODUCTION

Plants sharing the same space interact above and belowground. While aboveground competition is basically for light, belowground competition involves several elements (i.e. water and all nutrients). Therefore, the occupation of the soil volume is of primary importance for belowground competition and depends on various root characteristics such as architecture, morphology, biomass allocation and growth rate, which will together define root density, root surface area and root distribution (Casper and Jackson, 1997). Furthermore, the root system forms a complex array of single roots entangled with each other, hidden in the soil, and distributed irregularly. The arrangement of these roots in the soil ultimately determines how plants access the soil resources.

In this study we used a recently developed method to distinguish roots of two plants (Faget et al. 2009). The objectives of the study were to investigate i) whether the presence of weeds affect the root growth of maize, and ii) whether these effects depend on the weed species. Our research was conducted with two of the most important weed species (Holm et al., 1997) for maize cultivation; *Amaranthus retroflexus* L. and *Chenopodium album* L. The ability to germinate at lower temperatures than many other weed species, an aggressive growth habit, as well as a prolific seed production, allow those species to compete strongly with crops for light, water, and nutrients (Knezevic et al., 1997). Several studies have been made to investigate the interaction of maize with *Chenopodium album* as well as with *Amaranthus retroflexus*. However, these studies were mainly focused on the crop yield loss of maize (e.g. Fischer et al., 2004)

2. MATERIAL AND METHODS

The study was conducted at the Experimental Field Station of the Institute of Plant Sciences, Swiss Federal Institute of Technology (ETH Zurich) in Lindau. Boxes with minirhizotrons were placed in greenhouse cabinets. The maize (*Zea mays* L.) genotype ETH-M72 GFP (GFP maize) was planted in mixture with *Chenopodium album* L. (C) and *Amaranthus retroflexus* L (A). One row of GFP maize, located in the center of the experimental plot, flanked on each side by rows of either C or A were grown in the plots. The orientation of the plant rows was parallel to the minirhizotrons. For control purposes, plots with either a single maize row or two weed rows were also established. Root images were recorded at the minirhizotron – soil interface using a special camera system for the quantification of GFP roots (see paper by Faget et al.). This imaging system is based on the use of two cameras: one type of camera captures images to detect all roots while the second type of camera captures images to detect only the fluorescent roots of GFP maize.

3. RESULTS AND DISCUSSION

The presence of weeds, independently of the species, reduced the biomass yield and the number of roots of maize. Compared to the plots where maize grew alone, its biomass yield decreased drastically (~74%) in plots with C and less (~35%) in plots with A. The effect of competing with maize on the shoot biomass yield of the weeds depended on the weed species. A produced 30% more shoot biomass growing alone than with maize while the shoot biomass production of C was not significantly affected by the presence of maize. The effect of maize on the number of roots of the weeds was the opposite of that on shoot biomass yield; it increased for C growing with maize, whereas it decreased for A growing with maize. The number of roots of maize growing with weeds was also less than of maize growing alone. In conclusion, preliminary results suggest a different competition strategy of *Amaranthus retroflexus* than maize and *Chenopodium album.*

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