Geophysical Research Abstracts
Vol. 17, EGU2015-4588-4, 2015
EGU General Assembly 2015

Intercropping with white lupin (Lupinus albus L.); a promising tool for phytoremediation and phytomining research

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In recent studies root-soil interactions of white lupine (Lupinus albus L.) have drawn special attention to researchers due to its particularly high potential to increase bioavailability of phosphorous (P) and trace nutrients in soils. In mixed cultures, white lupine has the ability to mobilize P and trace nutrients in soil in excess of its own need and make this excess available for other intercropped companion species. While improved acquisition of P and improved yield parameters have mostly been documented in cereal-lupine intercrops, compared to sole crops, only a few recent studies have evidenced similar effects for trace elements e.g. Fe, Zn and Mn. In this preliminary study we tried to obtain more information about the mobilization of trace elements due to intercropping under field conditions. We hypothesize, that processes that lead to a better acquisition of trace nutrients might also affect other trace elements what could be useful for phytoremediation and phytomining research. Here we report the results of a semi-field experiment were we investigated the effects of an intercropping of white lupine with oat (Avena sativa L.) on the concentrations of trace metals in shoots of oat. We investigated the effects on 12 trace elements, including 4 elements with relevance for plant nutrition (P, Fe, Mn, Zn) and 8 trace elements, belonging to the group of metalloids, lanthanides and actinides with high relevance in phytoremediation (Cd, Pb Th, U) and phytomining research (Sc, La, Nd, Ge). The experiment was carried out on a semi-field lysimer at the off-site soil recycling and remediation center in Hirschfeld (Saxony, Germany). To test the intercropping-dependent mobilization of trace metals in soil and enhanced uptake of elements by oat, white lupine and oat were cultivated on 20 plots (4 m^2 each) in monocultures and mixed cultures and two different white lupin /oat-ratios (11% and 33%, respectively) applying various treatments. The geometrical arrangement of plots was randomized and every treatment was fivefold replicated. Soil solution was collected weekly with plastic suction cups. Concentrations of trace metals in shoots of oat and soil solution were measured with ICP-MS. As a result, we found that both, concentrations of trace elements in oat plants, as well as the mobility of P and trace metals in soil solution was increased by an intercropping with white lupine. Mixed culture of oat with 11% white lupin significantly increased the concentrations of the trace nutrients Fe, Mn and Zn, as well as the concentrations of the trace metals Pb, La, Nd, Sc, Th and U in tissues of oat. Surprisingly, mixed cultures with 33 % white lupin did not significantly affect trace metal concentrations in oat, what might be the consequence of an increasing competition of roots of white lupin and oat for nutrients and trace metals.

In conclusion we found that mixed cultures of white lupin with cereals might be a powerful tool for enhanced phytoremediation and phytomining. However, processes involved in the physiochemical mechanism of element uptake as affected by the oat/white lupin co-cultivation remain unknown and further studies on this topic are planned.

These studies have been carried out in the framework of the PhytoGerm project, financed by the Federal Ministry of Education and Research, Germany.

The authors are grateful to students and laboratory assistants contributing in the field work and sample preparation.