**Biochar-based inoculum of *Bradyrhizobium* improve plant growth and yield of lupin** (*Lupinus angustifolius* L.) **under drought stress**

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**Abstract**

The legume-*Rhizobium* symbiosis is known as the most efficient system for biological nitrogen fixation (BNF) through nodulation in legume roots. Drought stress is a major abiotic impact on the symbiotic performance of legumes, inhibiting plant growth, and decreasing yields. Biochar is a fine-grained substrate rich in organic carbon that is produced by pyrolysis or by heating biomass in a low oxygen environment and has been used worldwide as a soil amendment to increase soil fertility and plant growth. It is also considered as a suitable carrier material for bacterial inoculants. We have evaluated the potential of a hydrochar (HTC) for suitability as a carrier for *Bradyrhizobium* sp. (Lupinus) under irrigation and drought conditions. The three types of char were used as carrier material for bacteria: (i) hydrochar (HTC) from maize silage (ii) pyrolysis biochar from maize (MBC), and (iii) pyrolysis biochar from wood (WBC). The field experiment was conducted at the Experimental Field Station of Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany. Survival of *Bradyrhizobium* sp. (BR) populations were higher in HTC-char carrier material as compared to pyrolysis biochar from maize (MBC), and pyrolysis biochar from wood (WBC). The HTC based *Bradyrhizobium* sp. inoculant (HTC-BR) significantly enhanced plant growth, uptake of N and P, and nodulation of lupin under drought compared to inoculation withBR strain. The survival of BR was more competent at drought stress condition, when introduced as HTC-based inocula compared to a direct inoculation. Thge result of field experiment showed, that HTC-BR inoculant was effective in lupin growth promotion, pod formation and yield of lupin under both irrigated and drought conditions in comparison to the un-inoculated control. From our study, we conclude in general that HTC as carrier substrate increased survival of *Bradyrhizobium* sp. inoculum. Application of HTC-based formulation of *Bradyrhizobium* sp. is an effective carrier for inocula improving plant growth, nutrient uptake and symbiotic performance of lupin under drought. Our results imply that biochar based microbial inoculants is a promising practical approach to improve growth and yield of legumes under hostile field conditions.

**Keywords**: extreme conditions, grain legumes, hydrochar, inoculation, water scarcity