Microbial BIOFECTORS in alternative Plant Nutrition Strategies for sustainable Maize Production

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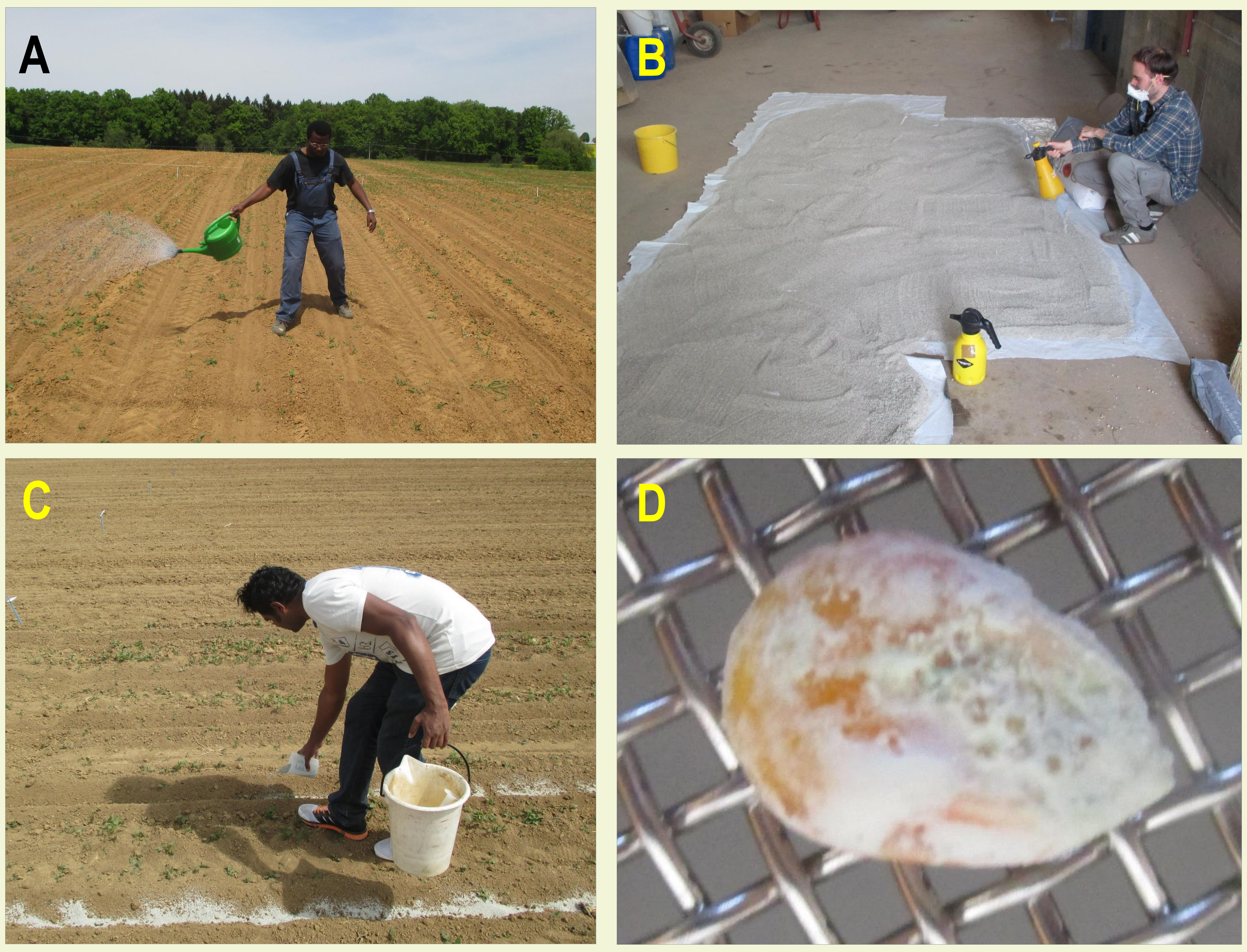
Innovative Plant Nutrition Strategies

Microbial bio-effectors are of interest for sustainable agriculture, as they can improve the growth and nutrition of plants by biological modes of action, such as increased root growth and mycorrhization, mobilization of sparingly available minerals, enhanced stress resistance, and suppression of pathogens.

For their successful application, persistent rhizosphere colonization at sufficient population densities is regarded as a key prerequisite. Yet, variable environmental factors and a lack of knowledge concerning adequate application strategies hamper the expression of beneficial effects under field conditions.

Objective: During recent 5 years, the BioFector project aimed to improve the agronomic effectiveness of microbial bio-effector applications at the field level by developing innovative formulation and application strategies in combination with alternatives to the current practice of mineral fertilization.

Experimental Approaches



Application of bio-effectors by broadcast with subsequent soil incorporation before sowing (A), charging of pumice stone granules (B) for banding along intended maize rows (C), and alginate microbeads with encapsulated inoculum attached to a maize kernel for seed treatment in field experiments.

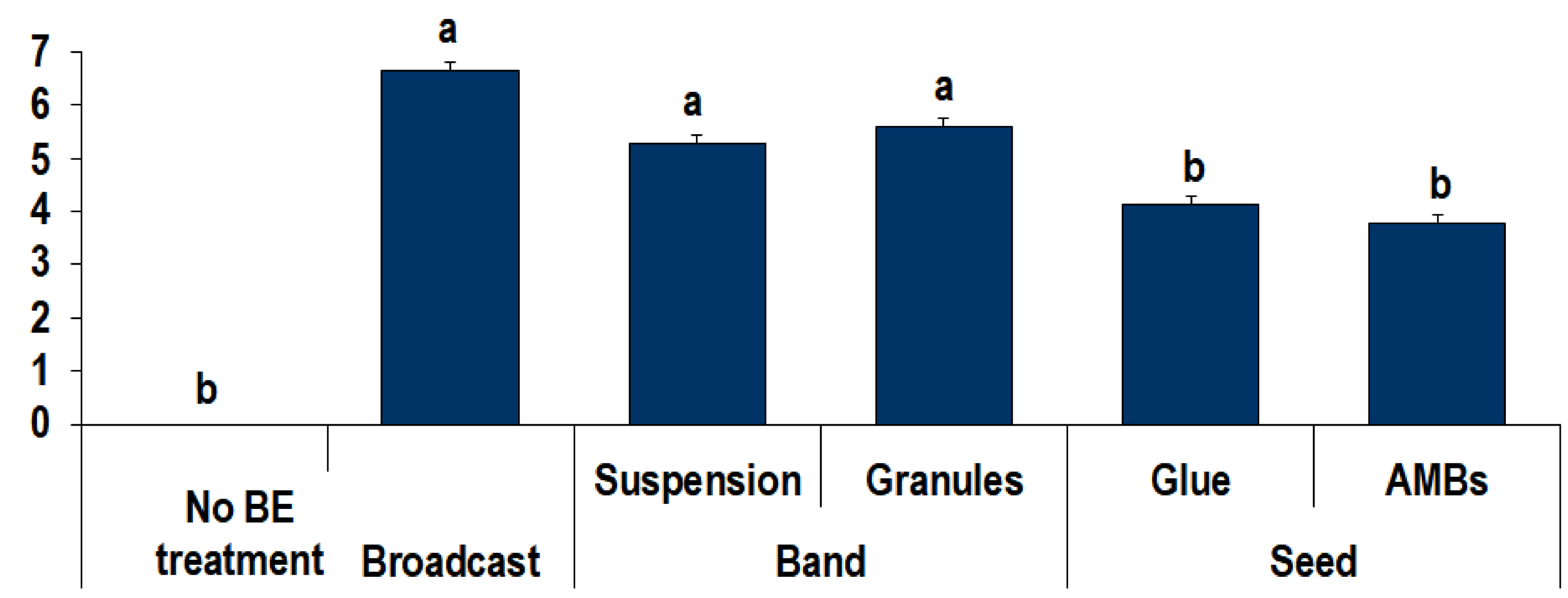
Microbial bio-effector: A rifampicin resistant (RIF) selectant of the commercially available *Bacillus amyloliquefaciens* strain FZB42 (ABiTEP, Berlin, Germany) was tested.

Formulation and application: Delivery strategies such as broadcast or near to the seed banding in suspension or granule formulation with incorporation to the to 10 cm soil layer before sowing (10^9 cfu kg^{-1} soil) were compared with seed treatments (10^8 cfu $kernel^{-1}$) by use of glue or alginate microbeads (AMBs) formulations (Bashan et al. 2002, Biol Fertil Soils 35:359-368).

Fertilization: The maize crop was fertilized by underfoot placement of diammonium phosphate (DAP; applied at a rate of 29 kg N and 32 kg P ha^{-1} before sowing) and placement of stabilized ammonium sulfate (NovaTec solub 21, COMPO; applied at a rate 161 kg N – 32 kg N_{min} ha^{-1}) between rows at the 5 leaves stage of maize according the CULTAN (Controlled Uptake Long Term Ammonium Nutrition) method, described by Sommer 2008 (Getreide Magazin 2/2008, 2-4) as an alternative to conventional N fertilization.

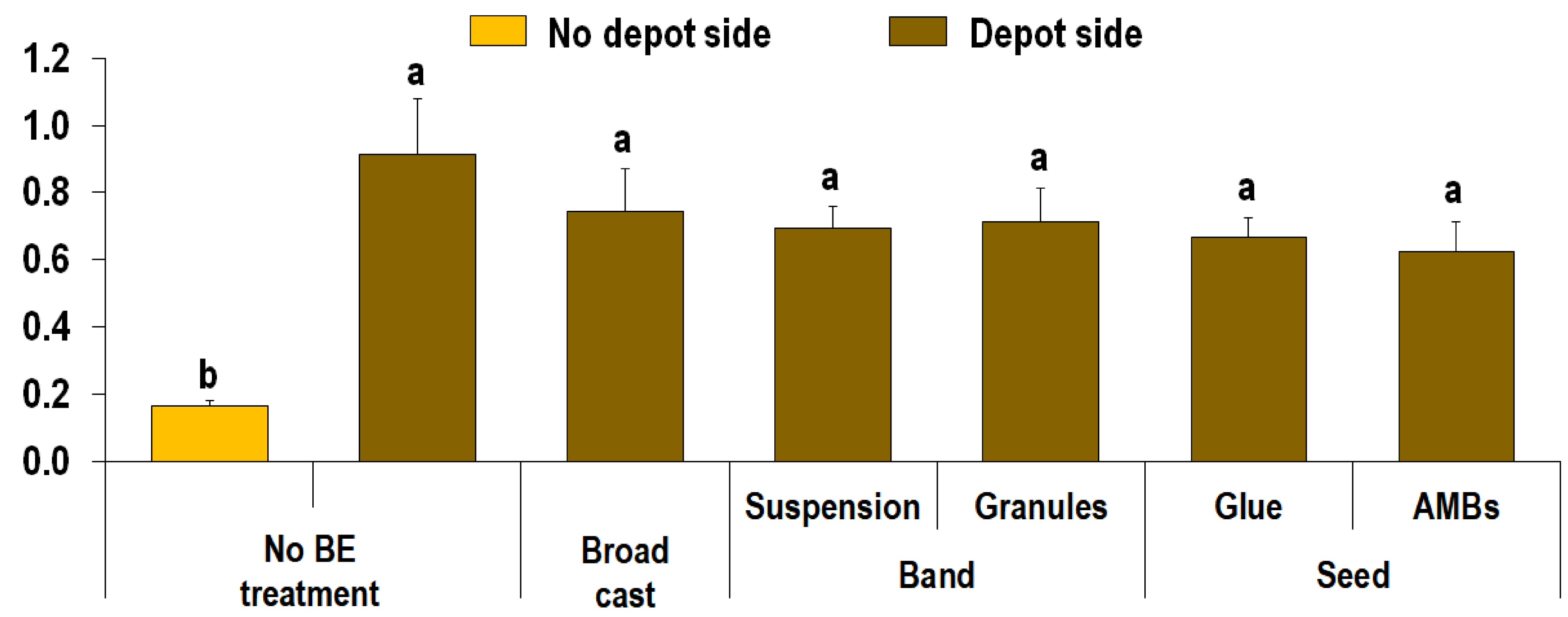
Results and Discussion

Root colonization by FZB42 like bacilli at 8 weeks after sowing, as re-isolated on selective medium [log cfu g^{-1} root dry matter]



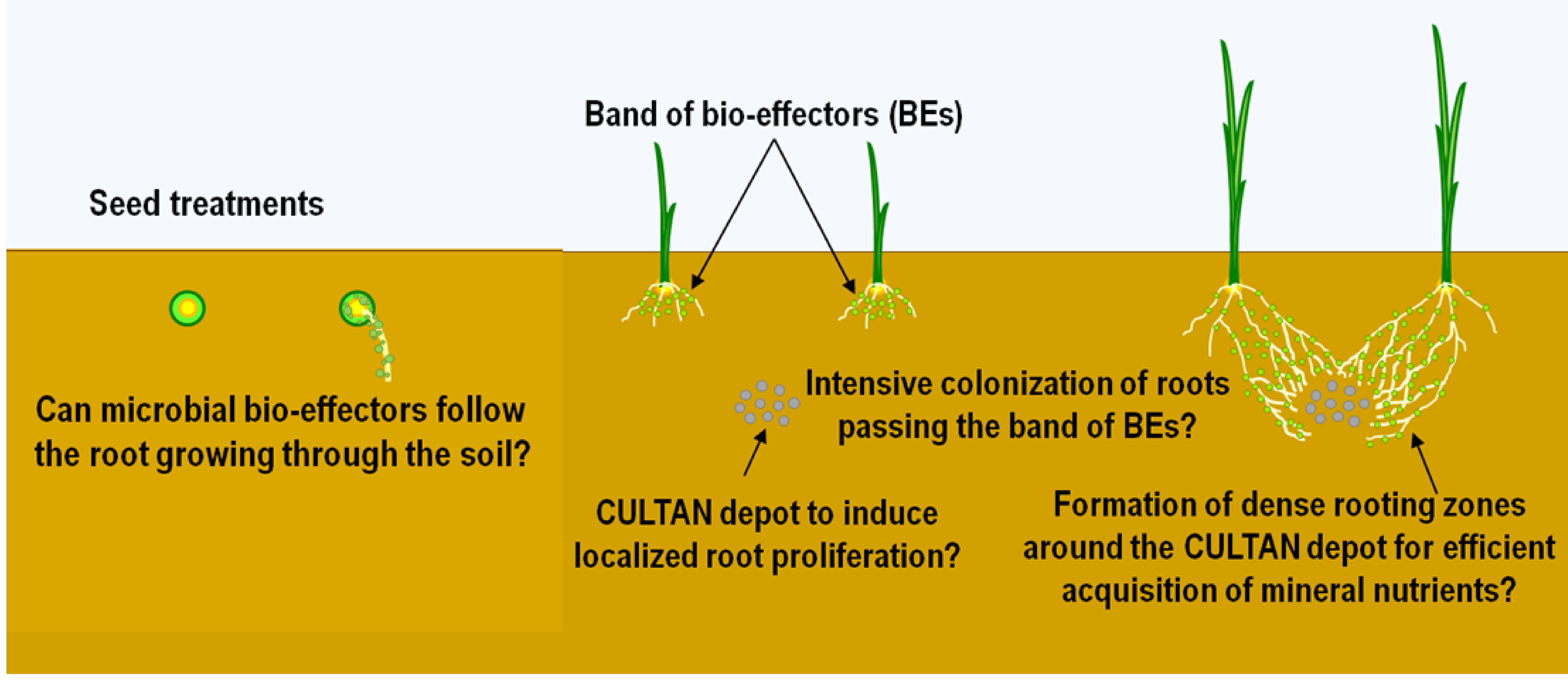
The results of tracing analyses indicated that the intensity of root colonization decreased in the order broadcast > band > seed application of microbial bio-effectors (Tukey test; $p < 0.05$; data not normally distributed).

Root length per soil volume at 9 weeks after sowing, 7 weeks after CULTAN application [cm cm^{-3}]



The application of FZB42 RIF by different strategies did not alter the root length density per soil volume explored by maize plants for mineral nutrient acquisition (Tukey test; $p < 0.05$) or the silage yield of maize under field conditions (data not shown; Tukey test; $p < 0.05$). Pot experiments, in contrast, showed that even low colonization densities of $4*10^6$ cfu g^{-1} root dry matter in response to seed treatments with this Bacillus strain were associated with increases in rooting density from 2.7 to 3.9 cm cm^{-3} compared to the control without bio-effector (BE) treatment.

Research questions concerning the strategic combination of bio-effector and fertilizer placements



Conclusions and Outlook

Adequate inoculum densities and application strategies need to be further investigated with respect to the influence of environmental factors, crop management, and economic aspects for the successful implementation of bio-effector treatments under field conditions.

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