Bioinoculants for *Zea mays* production in P-deficient agricultural soils

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Aims and Scope

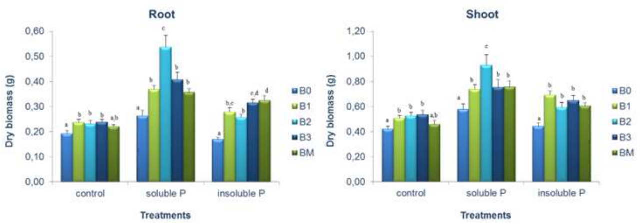
Phosphorus (P) is a limiting factor in crop growth and, due to its low availability, P-deficiency in soils is widespread, and as such the successive application of P-fertilizers to maintain crop production has occurred, leading to severe environmental problems. The development and application of environmentally friendly biotechnological approaches as alternatives to chemical fertilizers has gained considerable interest in agricultural practices worldwide. The harnessing of **P**hosphate **S**olubilizing **B**acteria (PSB) seems to be of utmost importance towards the reverse of the current use of large amounts of P fertilizers, since they can stimulate plant growth in particular through the conversion of bound P in soil into bioavailable P forms. This work aimed to evaluate the ability of PSB to enhance *Zea mays* growth in an agricultural P-deficient soil.

Methodology

- ✓ P solubilizing strains *Rhodococcus* sp. EC35 (B1), *Pseudomonas* sp. EAV (B2) and *Arthrobacter nicotinovorans* EAPAA (B3) were inoculated in maize growing in P-deficient soils without P fertilization and amended with soluble - KH_2PO_4 and insoluble P - $Ca_3(PO_4)_2$
- ✓ Plant dry biomass and P accumulation in plant tissues were determined after 90 days
- ✓ Available P in rhizosphere soils were determined at the end of experiment
- ✓ The persistence of inoculated strains in soils was evaluated by Denaturing Gel Gradient Electrophoresis (DGGE)

Results and Discussion

Effects of PSB inoculation on *Z. mays* growth



PSB inoculation enhanced *Z. mays* biomass production in all P-treatments

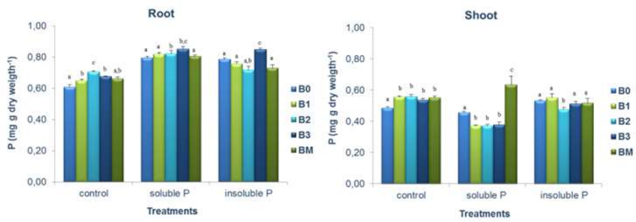
- ✓ Without P fertilization - bacterial inoculation increased plant dry biomass by ca. 20%
- ✓ Addition of soluble P – strains B1, **B2** and B3 promoted root biomass by 41, **104** and 55% and shoot biomass by 27, **60** and 30%
- ✓ Addition of insoluble P - strains B1, B2 and **B3** promoted root biomass by 65, 52 and **86**% and shoot biomass by 54, 34 and **46**%, respectively
- ✓ Mixed inoculation (BM) - increased plant dry biomass of soluble and insoluble P treated plants

P availability in soils

	Available P (mg kg^{-1})		
	Control	**Soluble P**	**Insoluble P**
B0	24.3 ± 0.9^{a}	36.5 ± 1.0^{a}	27.6 ± 0.7^{a}
B1	29.2 ± 0.6^{b}	36.6 ± 0.9^{a}	31.5 ± 0.1^{b}
B2	25.9 ± 0.2^{a}	49.1 ± 0.4^{d}	40.8 ± 0.9^{d}
B3	28.9 ± 1.0^{b}	45.0 ± 0.1^{c}	$29.5 \pm 1.3^{a,b}$
BM	30.3 ± 0.1^{b}	41.0 ± 0.3^{b}	37.2 ± 0.6^{c}

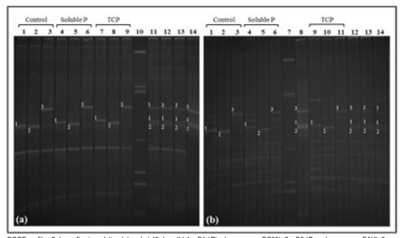
- ✓ **Bioinocula application increased P availability in soils**

P accumulation in *Z. mays* tissues



- ✓ Bacterial inoculation improved P accumulation in roots and shoots of plants growing in soils without P fertilization
- ✓ *A. nicotinovorans* EAPAA (B3) increased P uptake in roots in soluble- and insoluble-P amended soils

Bioinoculants persistence in soils



DGGE profiles 2 days after inoculation (a) and at 45 days (b).1 – B1 (*Rhodococcus* sp. EC35); 2 – B2 (*Pseudomonas* sp. EAV); 3 – B3 (*A. nicotinovorans* EAPAA). Gel (a) lanes 1, 4, 7 – soil inoculated with B1; lanes 2, 5, 8 – soil inoculated with B2; lanes 3, 6, 9 – soil inoculated with B3; lane 10 – marker; lanes 11–13: mixed inoculation (BM) – without P, soluble P and insoluble P (TCP), respectively; lane 14 – pure cultures (B1, B2 and B3). Gel (b) lanes 1, 4, 9 – soil inoculated with B1; lanes 2, 5, 10 – soil inoculated with B2; lanes 3, 6, 11 – soil inoculated with B3; lane 7 – marker; lane 8 – pure cultures (B1, B2 and B3); lane 12–14 – mixed inoculation (BM) – without P, soluble P and insoluble P (TCP), respectively.

The inoculated PSB were detectable in the maize rhizosphere soils after 45 days (half the life cycle of the plant) in all treatments

- ✓ PSB can be used as bioinoculants and significantly promote growth of *Z. mays* in P-deficient soils, especially in early stages of maize growth

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Conclusions

- ✓ PSB significantly enhanced *Z. mays* growth and P uptake in P-deficient soils
- ✓ *Rhodococcus* sp. EC 34, *Pseudomonas* sp. EAV and *A. nicotinovorans* EAPAA may be used as biofertilizers and constituting an interesting alternative to the application of phosphatic fertilizers in P-deficient soils, reducing costs and improving crop yields