Bioeffector-assisted P nutrition of wheat supplied with rock phosphate & placed NH4+

Nkebiwe PM[1], Käfer N[1], Neumann G[2], Müller T[1]

University Hohenheim, Institute of Crop Science ([1]340i, [2]340h), Fruwirtstraße 20, 70599 Hohenheim

Mehdi.Nkebiwe@uni-hohenheim.de

Introduction

Rock phosphate is a cheap P-fertilizer, however, it is less plant-available in neutral to alkaline soils than conventional soluble ammonium phosphate or superphosphate fertilizers. Plant growth-promoting microorganisms (PGPMs, here referred to as microbial bio-effectors or BEs) can increase the availability of sparingly soluble P-fertilizers by improved root and root hair growth via phytorhormones, thus promoting spatial exploitation of P in soil (Lugtenberg and Kamilova 2009; Mohite 2013); and by enhanced solubility of fertilizers by acidification through release of protons and/or low molecular weight organic acids (Altomare et al. 1999; Bashan et al. 2013). The aim of this study was to improve P acquisition and growth of wheat plants supplied with rock phosphate and placed NH4+-fertilizer by inoculating the substrate with various BEs. The effects N-form (NH4+ vs. NO3-) was further investigated for the most promising BE.

Methods

Spring wheat (Triticum aestivum L. Schirocco, KWS, Germany) was grown in a substrate based on 70 % low-P silt loam luvisol (pHCaCL2 6.4; CAL-P, 7mg kg-1; and 30 % sand (moisture: 24 % or70 % Max. WHC; 5.7 kg substrate (5 L pot)-1; 20 plants pot-1). P (150 mg kg-1 soil) was supplied as rock phosphate (RP, 7.6 % P) or as Ca(H2PO4)2 for a positive control (+P). 100 mg N kg-1 soil was placed as stabilized (NH4)2SO4+DMPP or mixed as Ca(NO3)2), ½ at sowing and ½ at 24 days after sowing (DAS). The first set of treatments included five BEs under N supply as NH4+: Control without bio-effector (NoBE), Pseudomonas sp DSMZ13134 Proradix (Pro), Bacillus amayloliquefaciens FZB42 Rhizovital (Rhiz), Paenibacillus mucilagenosus (Paeni) (at 1x109 CFUs or Spores kg-1); Trichoderma harzianum T-22 Trianum-P (T-22, 1x108 spores kg-1). Secondly, NH4+ or NO3- was combined with NoBE or Pro. Three inoculations were conducted at 0, 24 and 34 DAS. There were 5 replicates per treatment arranged in a randomized block design. Plants were grown in greenhouse/outdoors (02. Jun – 04. Sep. 2015; Av. daily temp.: 24°C (min: 8 °C, Max: 51 °C, Light intensity: 400-1200 µmol. photons m-2 s –1). Shoot growth and nutrient status was measured at booting and senescence stage. Root growth and rhozosphere available P level, grain and straw nutrient status was also measured.

Results and Discussion

Inoculation of either Pro or Paeni led to improved grain yield. Application of BE tended to improve root and shoot DM. Under N supply as NH4+, inoculation of Pseudomonas sp. DSMZ 1314 let to higher grain P concentration and each BE inoculation resulted in increased number of grains per pot. Overall, there was a strong negative relationship between residual CAL-extractable P in rhizosphere soil (mg P (100 g soil-1) and shoot P content (mg P plant-1) (P< 0.0001, R2=-0.43, y = -0.0508x + 10.798), indicating P uptake. For biomass formation and biomass nutrient status in general, NH4+ led to higher values than NO3-, and Pro also led to higher values than NoBE. The effect of Pro on P nutrition of wheat was stronger with NH4+ nutrition than NO3-.

Conclusions

Inoculation of Pseudomonas sp. DSMZ 1314 or Paenibacillus mucilagenosus led to increased grain yield. Generally, contents and/or concentrations of nutrients in shoot or grain were higher with NH4+ than with NO3-, and also higher with BE than without. Improvement of nutrient status and yield of wheat plants may be explained by enhanced chemical mobilization/solubilization of nutrients in the rhizosphere and by improved root interception of nutrients in soil.

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