

## Optimization of carbon-to-nitrogen ratios and assessing salinity tolerance in *Metarhizium* spp. for biofertilizer development in *Vigna unguiculata* cultivation

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This study investigates the optimization of growth media for *Metarhizium* spp. as a multifunctional biocontrol agent and plant growth-promoting agent by examining the effect of carbon concentration and carbon-to-nitrogen (C:N) ratios on fungal growth and sporulation. The research addresses key knowledge gaps by evaluating how varying C:N ratios influence growth dynamics and spore yield, assessing its potential to alleviate salinity stress at 0, 4, 6, 8, and 10 dS m<sup>-1</sup> salinity levels using media tailored to Sri Lankan soil conditions. Additionally, the impact on cowpea (*Vigna unguiculata*) seed germination, and seedling growth was assessed under normal conditions via seed coating. Fungal growth was evaluated through radial growth, dry biomass, and spore counts. Experimental findings revealed that optimized nutrient composition, achieved by regulating C:N ratios and balanced mineral supplementation significantly influenced fungal growth and sporulation. Herein a C:N ratio of 20:1 combined with 8 g L<sup>-1</sup> carbon concentration was identified as optimal, yielding the highest spore production (327 x 10<sup>6</sup> spores ml<sup>-1</sup>). Seed coatings with spores produced under optimized conditions (8 g L<sup>-1</sup> carbon, C:N 20:1) significantly improved seed germination (100% vs. 60% with Xanthum gum, 40% with distilled water), shoot length (19 cm vs. 6 cm and 4 cm), root length (24 cm vs. 8 cm and 6 cm), and seedling vigour indices (SVI-I: 4300 vs. 880 and 400; SVI-II: 38,000 vs. 3200 and 1500), demonstrating substantial improvement over untreated controls. The findings demonstrated that C:N optimization boosts both the growth and sporulation efficiency of *Metarhizium* spp. as well as its functional efficacy as a plant growth promoter. This study supports the development of cost-effective and eco-friendly biofertilizers that enhance crop resilience and productivity, promoting long-term sustainable agricultural practices.

**Keywords:** Carbon concentration, Carbon to nitrogen ratio, *Metarhizium* spp., Sustainable agriculture, *Vigna unguiculata*