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Synergistic effect of growth-promoting microorganisms on bio-control of *Fusarium oxysporum* f. sp. *pisi*, growth, yield, physiological and anatomical characteristics of pea plants

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Highlights

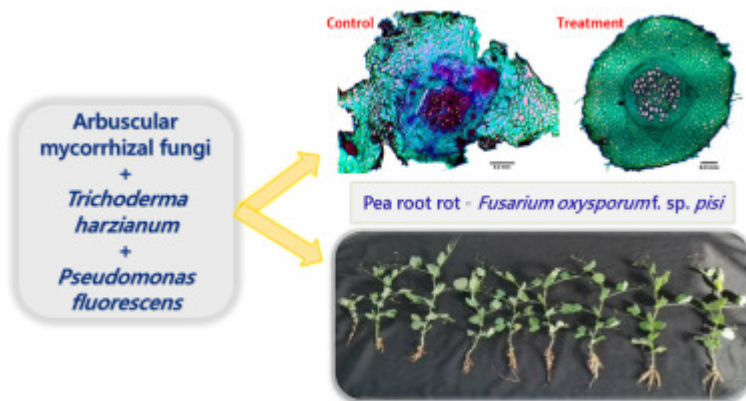
- Treatment of arbuscular mycorrhiza, *T. harzianum*, and *P. fluorescens* was the best.
- This treatment provides great protection against root rot disease of pea.
- The treatment increases the activity of PPO, POX, total phenols, and chlorophyll.
- This treatment decreases the lipid peroxidation and cell membrane permeability.
- The treatment improving the plant growth and increasing the yield

Abstract

FEEDBACK 

Fusarium root rot caused by *Fusarium oxysporum* is an aggressive disease-causing damping-off, root rot, and vascular wilt in all peas growing fields. The disease can cause 100% yield losses under favorable conditions. The present study aims to control *Fusarium* root rot using *Trichoderma harzianum*, *Pseudomonas fluorescens*, and arbuscular mycorrhizal fungi, singly or in combinations. The results showed that all treatments significantly enhanced not only the plant growth, total phenol, activities of antioxidant enzymes, but also, the yield and seed quality. Several changes in the anatomical, physiological, and characteristics of the treated plants were also recorded. Compared to the untreated control treatment, under greenhouse conditions, the maximum reduction of the disease severity (80%) was achieved by the synergistic triple treatment consists of arbuscular mycorrhizal fungi, *Trichoderma harzianum*, and *Pseudomonas fluorescens*, as they gave the best growth and yield parameters. The same combination showed the highest activity of the antioxidant enzyme peroxidase (57.1%), as well as the highest total phenol content (117.7%), over the control. The synergistic triple increased the contents of protein (64.6%), total soluble sugars (48.5%), and total carbohydrate (24.8%) in seeds of pea compared with the control. The synergistic triple treatment led to an increase in the thickness of the root section (25%), the thickness of the cortex (24.8%), the thickness of the vascular cylinder (31.5%), and the diameter of the xylem vessels (81.5%) of the root. Based on their efficiency and eco-safety, this synergistic triple might be very effective for controlling root rot disease of pea caused by *F. oxysporum*, as well as improve the growth, yield, and seed quality.

Graphical abstract



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Keywords

Pisum sativum L.; *Fusarium oxysporum*; Biological control; Arbuscular mycorrhizal fungi; Root rot; Antioxidant enzymes

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