American Journal Of Agriculture And Horticulture Innovations

VOLUME Vol.05 Issue05 2025
PAGE NO. 33-36
DOI 10.37547/ajahi/Volume05Issue05-09

Phosphate-Mobilizing Rhizobacteria As Biocontrol Agents Against Wheat Diseases Caused by Bipolaris Sorokiniana

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Received: 31 March 2025; **Accepted:** 29 April 2025; **Published:** 31 May 2025

Abstract: Bipolaris sorokiniana are a destructive hemibiotrophic pathogen causing root and crown rot, leaf spot and black mold of cereal crops, which significantly reduces grain yield and quality worldwide. This study investigated the antagonistic activity of 20 strains of phosphate-mobilizing wheat rhizobacteria from the genera Rahnella, Enterobacter, Bacillus, Paenibasillus and Pseudomonas against wheat diseases caused by B. sorokiniana. It was found that out of 20 strains of rhizobacteria 5 strains (Enterobacter clocae 7, Bacillus cereus 23, Pseudomonas kilonensis 24, P. kilonensis 26, P. kilonensis 30) 100% inhibited the growth of phytopathogen B. sorokiniana.

Keywords: Bipolaris sorokiniana, phosphate-mobilizing rhizobacteria, wheat, antagonistic activity, biological control.

Introduction: Wheat (Triticum aestivum) is one of the most widely grown crops in the world. In 2018, its production exceeded 734 million tons on an area of 214 million ha [1]. Wheat production is constrained by biotic stresses, chief among which are yield-limiting diseases worldwide. Out of more than 200 wheat diseases, about 50 cause significant economic losses [2-7]. Diseases cause approximately 20% yield loss annually. Rust, spot blight, root rot, parsha, septoriosis, powdery mildew, fusarium and other viral, nematode and bacterial diseases are considered the most damaging [8-11].

Wheat has been a key food crop in the world for thousands of years. However, its yield is often reduced by various biotic stresses [12]. Among the most dangerous pathogens that affect the leaves, stems and grain of wheat is Bipolaris sorokiniana. This fungus has been repeatedly associated with the occurrence of spotting on wheat, leading to yield losses ranging from 16 to 43%, especially in regions with a warm and humid climate [13].

One of the important soil diseases of wheat is common root rot, caused by Bipolaris sorokiniana (Sacc. in Sorok.) Shoem. The micromycete Bipolaris sorokiniana is a globally distributed pathogen of common root rot, leaf spot, seedling blight, bunt blight and black spot on wheat and barley. This fungus is one of the most serious leaf spot diseases in both crops in warm growing regions and causes significant yield losses. High temperature and high relative humidity favor the spread of the disease, especially in intensive irrigated wheat and rice production systems in South Asia. B. sorokiniana can develop endophytically, epiphytically, persist for long periods of time in soil and on plant debris. The chemical mechanisms of such good adaptability of this fungus to different environments are still poorly understood [14-19].

Among the various diseases caused by B. sorokiniana, leaf spots of wheat and barley are the most important, especially under the high temperature and humidity conditions typical for some agricultural regions [20]. This phytopathogen poses a serious threat to more than a thousand plant species, including the major cereal crops wheat, barley, rye, maize, rice, and millet [21]. Moreover, in 2021, B. sorokiniana was reported for the first time on lentil cultivar Syria 229, expanding the potential host range of this pathogen [22].

In recent years, attention to the search for biocontrol agents has increased, and it is important to identify antagonistic strains that can complement cultural and chemical defense methods under field conditions.

Therefore, the aim of this study was to investigate the antagonistic activity of phosphate-mobilizing rhizosphere bacteria of wheat against the phytopathogen B. sorokiniana.

METHODS

The objects of research were 20 local strains of phosphate-mobilizing rhizobacteria of wheat. Rhizobacterial strains were cultured at t=28±2ºC for 5 days under aerobic conditions on peptone liquid nutrient medium with glucose. The fungus was cultivated in liquid Czapeka nutrient medium (20 g glucose, 2 g $NaNO_3$, 1 g KH_2PO_4, 0.5 g $MgSO_4 \cdot 7H_2O$, 0.5 g KCl, water up to 1 l, pH 6) [23]. Phytopathogenic fungi of B. sorokiniana were obtained from the collection of microorganisms of the Institute of Genetics.

The antagonistic activity of rhizobacterial cultures was tested using the well method [24]. The magnitude of antagonistic activity was measured by the diameter of fungal growth inhibition zones around the wells after incubation at 28°C for 3-5 days. Repetition of the experiment was three times. Statistical analysis of the results was carried out using Excel software package.

RESULTS AND DISCUSSION

In a previous study, we isolated rhizobacteria from the rhizosphere of wheat and screened them for their phosphate-mobilizing capabilities, identifying the most efficient strains based on their ability to solubilize inorganic phosphates [25]. In the present study, we further evaluated the biocontrol potential of these phosphate-mobilizing rhizobacteria by assessing their antagonistic activity against Bipolaris sorokiniana, a major fungal pathogen responsible for spot blotch disease in wheat.

A total of 20 phosphate-mobilizing rhizobacterial strains, taxonomically affiliated with the genera Rahnella, Enterobacter, Bacillus, Paenibacillus, and Pseudomonas, were selected for antagonism assays against B. sorokiniana. The antagonistic activity of phosphate-mobilizing rhizobacteria against the phytopathogenic fungus Bipolaris sorokiniana was evaluated in vitro using well method on Czapeka (Figure 1 and 2).

Out of the 20 tested strains, 11 exhibited varying degrees of antagonistic activity against the phytopathogen. Notably, five strains - Enterobacter cloacae 7, Bacillus cereus 23, Pseudomonas kilonensis 24, P. kilonensis 26, and P. kilonensis 30 showed complete inhibition (100%) of fungal mycelial growth, indicating strong antagonistic potential. These strains formed clear inhibition zones and demonstrated rapid colonization around the fungal growth area, likely due to the secretion of antifungal metabolites, lytic enzymes, or siderophores.

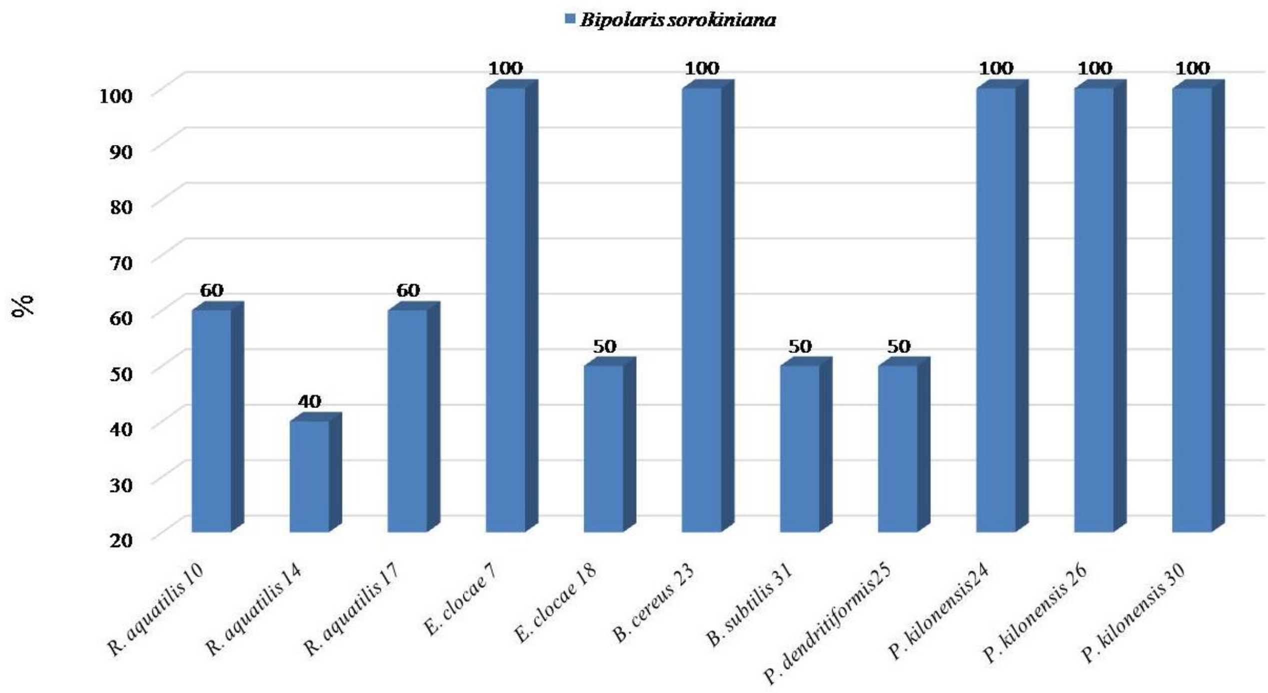

Figure 1. Effect of rhizobacterial strains belonging to the genera Rahnella, Enterobacter, Bacillus, Paenibacillus and Pseudomonas on the growth of the wheat phytopathogen Bipolaris sorokiniana (%)

Moderate inhibition was observed for Rahnella aquatilis strains 10 and 17, which suppressed fungal growth by 60%. E. cloacae 18, B. subtilis 31, and Paenibacillus dendritiformis 25 inhibited the pathogen by 50%, whereas R. aquatilis 14 demonstrated a comparatively lower inhibition rate of 40%. The remaining nine strains did not exhibit any noticeable antagonistic effect against B. sorokiniana, suggesting either the absence of antifungal activity or insufficient production of inhibitory compounds under the experimental conditions.

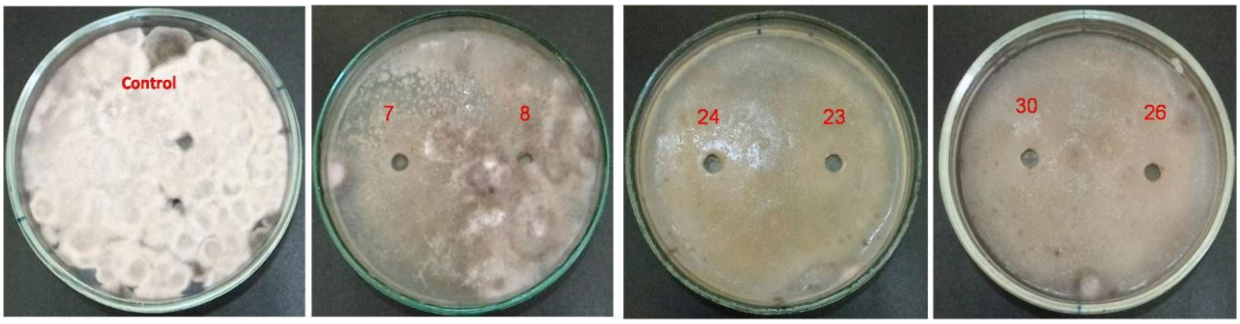

Figure 2. Antagonistic activity of phosphate-mobilizing rhizobacteria against Bipolaris sorokiniana: E. cloacae 7, E. cloacae 8, B. cereus 23, P. kilonensis 24, P. kilonensis 26, P. kilonensis 30

These findings highlight the diversity in biocontrol capacity among phosphate-mobilizing rhizobacteria. The strong antifungal activity exhibited by strains such as P. kilonensis and E. cloacae suggests their potential utility in the development of bioinoculants for integrated disease management in wheat cultivation. The dual functionality of these strains - phosphate solubilization and pathogen suppression - positions them as promising candidates for sustainable agricultural practices aimed at enhancing crop productivity and reducing dependence on chemical fertilizers and fungicides.

Further studies are warranted to elucidate the specific mechanisms of antagonism, including the identification of secondary metabolites and their modes of action, as well as the performance of these strains under greenhouse and field conditions. Thus, of the 20 local phosphate-mobilizing rhizobacterial strains studied, 11 showed antagonistic activity against B. sorokiniana. The strains E. cloacae 7, B. cereus 23, P. kilonensis 24, P. kilonensis 26 and P. kilonensis 30 demonstrated the highest activity, inhibiting the growth of B. sorokiniana by 100%, respectively.

CONCLUSION

B. sorokiniana is a dangerous pathogen that affects the roots, crown, stems, leaves, and grains of wheat, leading to significant yield losses. Effective management strategies should focus not only on limiting the fungus in the above-ground parts of the plant but also on reducing its presence in the soil.

Based on the obtained results, it can be concluded that local rhizobacterial strains exhibit antagonistic and antifungal activity against B. sorokiniana. As a result, rhizobacterial cultures showing high activity can be recommended as starter cultures for developing biofungicides to protect wheat from B. sorokiniana, and effective bioproducts can be created on this basis. An alternative method for combating pathogenic fungi that cause diseases in agricultural plants is the introduction of bacteria with high biofungicidal properties into the soil and the rhizosphere of plants.

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