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Rhizobacterial Inoculation Effect On Yield Contributing Parameters Of Maize (Zea Mays)

Muhammad Arshad khan[1*] , Haroon Shahzad[2] , Muhammad Waheed[3] , Fawad Anwar[4] , Muhammad Adil[5] , Imran Qazi[1] , Muhammad Jazib[6] , Ejaz Ullah Khan[6]

[1] PARC-Arid Zone Research Centre, Dera Ismail Khan.

[2] Department of Soil & Environmental Sciences, The University of Agriculture, Faisalabad.

[3] Directorate of Soil Survey, Khyber Pakhtunkhwa.

[4] Rangeland Research Institute, National Agriculture Research Centre, Islamabad.

[5] Department of Agronomy, The University of Agriculture, Peshawar.

[6] Department of Soil & Environmental Sciences, Gomal University, Dera Ismail Khan.

[1*] Muhammad Arshad Khan, Arid Zone Research Centre, Dera Ismail Khan.

Abstract

Increasing prices of synthetic fertilizers are posing a grave threat to world's agriculture. The use of alternate ways to minimize the use of synthetic fertilizers without compromising yields is the fundamental objective of today's research. Use of beneficial microbes in agriculture is among the methods to minimize the risk. To address the problem two trials were conducted to investigate the effects of plant growth-promoting rhizobacteria (PGPR) on percent germination, vigour, and other parameters of pot-grown maize. In these trials, four bacterial strains, including P. aeruginosa, P. putida, E. mori, and E. asburiae. P. aeruginosa, P. putida, E. mori, and E. asburiae were the microorganisms used. The results of the first investigation revealed that seed Inoculation greatly increased the germination of maize seed and the vigour of maize seedlings. In the second experiment, bacterial inoculation followed by a considerable rise in the dry weight of the shoots, as well as the surface area of the leaves. The findings revealed that inoculating seeds with rhizobacteria had an additional encouraging influence on the growth and development of the plants than other treatments. Seeds Inoculation with rhizobacterial strains resulted in considerable increase in plant height, fresh biomass, dry biomass, and leaf area of the maize plants in this experiment, as demonstrated in results.

Introduction

PGPR are bacteria that colonise plant roots and stimulate the development and outcome of the plants they are colonising (Singh, 2013). It is possible to find them in a wide variety of plant species. Qureshi et al. (2013) proposed a number of mechanisms for the promotion of plant growth by rhizobacteria that have capability to produce phytohormones (Qureshi et al., 2019), fix N_2 asymbiotically (Qureshi et al., 2019), siderophore production to protect plants from phytopathogens (Shahzad, 2020), the antibiotics synthesis (Alori et al., 2017). Agronomically important crops have shown significant gains in growth and yield following the inoculation of the PGPR into their plants (Gholami et al., 2009). Bacteria like Azospirillum, Pseudomonas, and Azotobacter have an eloquent effect on seed germination and seedling growth in a variety of ways (Reed et al., 2013). Researchers discovered that Azotobacter inoculation can improve wheat production by up to 30 percent and Bacillus inoculation can increase wheat yield by up to 43 percent, respectively, when applied to wheat (Albdaiwi et al., 2019). The bacteria strains P. putida and P. fluorescens have proved to enhance root and shoot extension in canola (Pallai et al., 2012), wheat (Albdaiwi et al., 2019), and potato plants (Frommel et al., 1991), among other things. In cereals, inoculation with Azospirillum has been shown to improve biomass of plant body, tissue nitrogen and uptake of nutrients (Baset et al., 2010). It has been demonstrated that both Pseudomonas and Azospirillum are capable of being utilised as natural fertilisers in agriculture and that they may be gathered for this purpose (Ferreira et al., 2019). The impact of these rhizobacteria on the growth and yield of specific crops, on the other hand, have been the subject of past research. It was not able to study the impact of PGPR on all growth indicators at the same time, from germination through harvest, because of the time constraints. The major goal of this investigation was to identify whether or not PGPRs had an effect on seed germination, seedling growth characteristics, and maize grain output.

Methodology

In this experiment, four rhizobacterial strains were utilised to test the hypotheses in 2020 at the Arid Zone Research Center in DI Khan, Pakistan. The inoculum used in this investigation were of Pseudomonas putida, Pseudomonas aeruginosa, Enterobacter mori and Enterobacter asburiae.

Bacterial strains were used to treat maize seedlings. Maize seeds were surface sterilised for 2 minutes in 0.02 percent sodium hypochlorite solution before being rinsed in sterile distilled water to remove any leftover impurities. The seeds were glazed with 20% gum Arabic and wrapped in perlit before being rolled into a culture medium containing 1 x 10^8 cfu/ml of bacteria.

The most effective germination test was using a paper towel. The studies were conducted in a growth chamber maintained at 28°C with 25 seeds per treatment (CRD). Each treatment had three replications in the growth chamber. The number of seeds that germinated after seven days determined viability. Vigor was valued by calculating the root and shoot lengths of every sapling and utilizing the subsequent computation formula:

$$\text{Vigor index (\%)} = (\text{Mean root length} + \text{Mean shoot length})\text{x \%Germination}$$

The capacity of the aforementioned bacterial strains to boost maize seedling growth by applying PGPRs to soils in 2020 was explored. The soil had 9.3 and 173 ppm of readily available P and K. This soil was clay loam with a pH of 8.1. Organic carbon content was 0.57 percent, with 0.03% nitrogen. The 15-centimeter-diameter plastic pots that could hold 2 kg of soil were used for this experiment. Each treatment got bacterial inoculation and replicated three times to formulate a 15 pots experiment, with a double seed per pot. No chemical fertiliser was used, and the plants were watered regularly to ensure their growth. To calculate the dry weight, the plants were dried in an oven at 75°C for a length of time until the weight gets constant. The area of each larger leaf was calculated using a formula that computed the leaf's overall area.

$$\text{Expanded Leaf Area} = \text{K x Length x Width}$$

Where K = 0.75

ANOVA F-test determined that there was a statistically substantial difference between treatment means, so the LSD test was employed to distinguish between them at a confidence level of 0.05.

Results

Seed inoculation considerably heightened the germination of maize seeds and the vigour of maize seedlings when compared to the untreated seeds (Figure 1). The rate at which augmentation occurred, on the other hand, varied according on the bacterial strain used. When compared to nontreated control seeds, all bacteria increased seed germination in P. aeruginosa-treated seeds by up to 42 percent when compared to nontreated control seeds (Fig.1). In this trial, the extremely substantial upsurge in vigour indexes was accomplished by P. aeruginosa, which was followed by E. mori and E. asburiae, respectively. These bacteria recorded 1377.95, 1184.86, and 1054.86 vigour indexes, respectively, which were all considerably higher than the control.

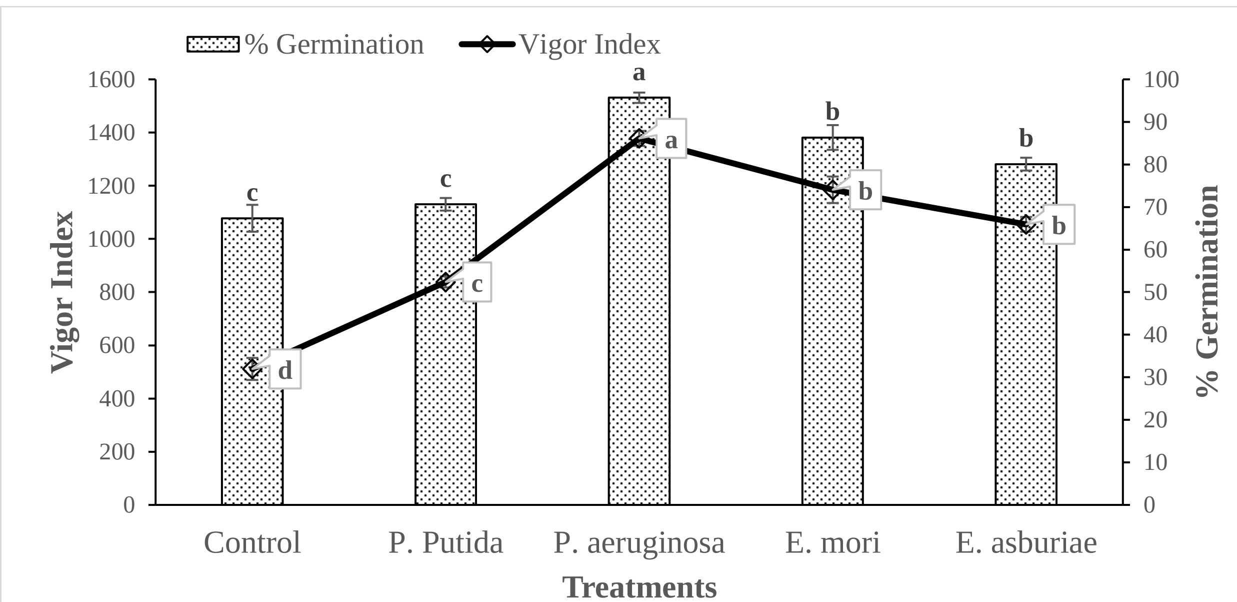

Figure 1. Seed germination and maize vigour index 7 days after bacterial inoculation under in vitro conditions

This research has shown that inoculating plants with bacteria treatments had a greater stimulating influence on the growth and development of the plants than did using any other therapy. P. aeruginosa strain fared much better than other strains in the pot experiment when it comes to boosting plant development when compared to the other strains tested. Using all of the bacterium strains, maize seeds were inoculated, and the plant height increased considerably (16.16-34.50%) as compared to untreated control (Figure 2).

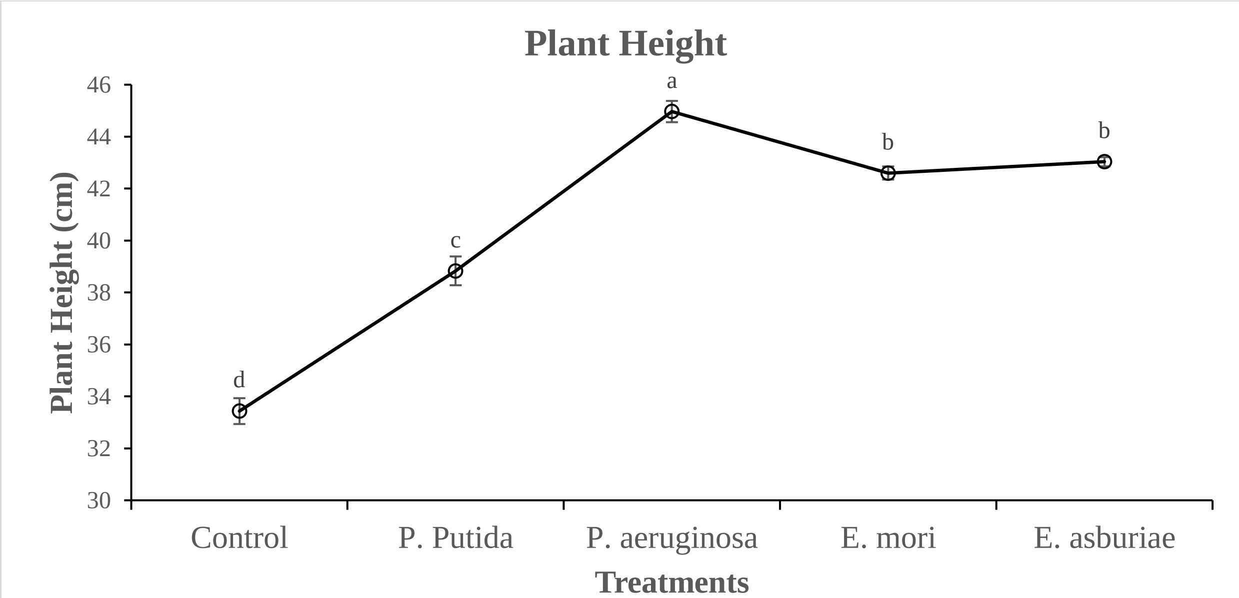

Figure 2. Effect of Rhizobacterial inoculation on plant height

Following the completion of the pot study, it was discovered that inoculating maize seeds with bacterial strains has a significant impact on the fresh weight and dry weight of the seedlings (Figure 3, 4). P. aeruginosa produced the highest total fresh weight (48.43 g) among the treated plants, which was statistically equal to the findings obtained from E. mori and E. asburi treated plants but was substantially greater than the results obtained from the untreated control plants. When it came to total fresh weight, the P. aeruginosa plant had the highest value (19.23 g), which was a statistically significant difference from the E. mori and E. asburi treated plants but was not significantly different from the untreated control plant, which was not statistically significant difference from the E. mori and E. asburi treated plants.

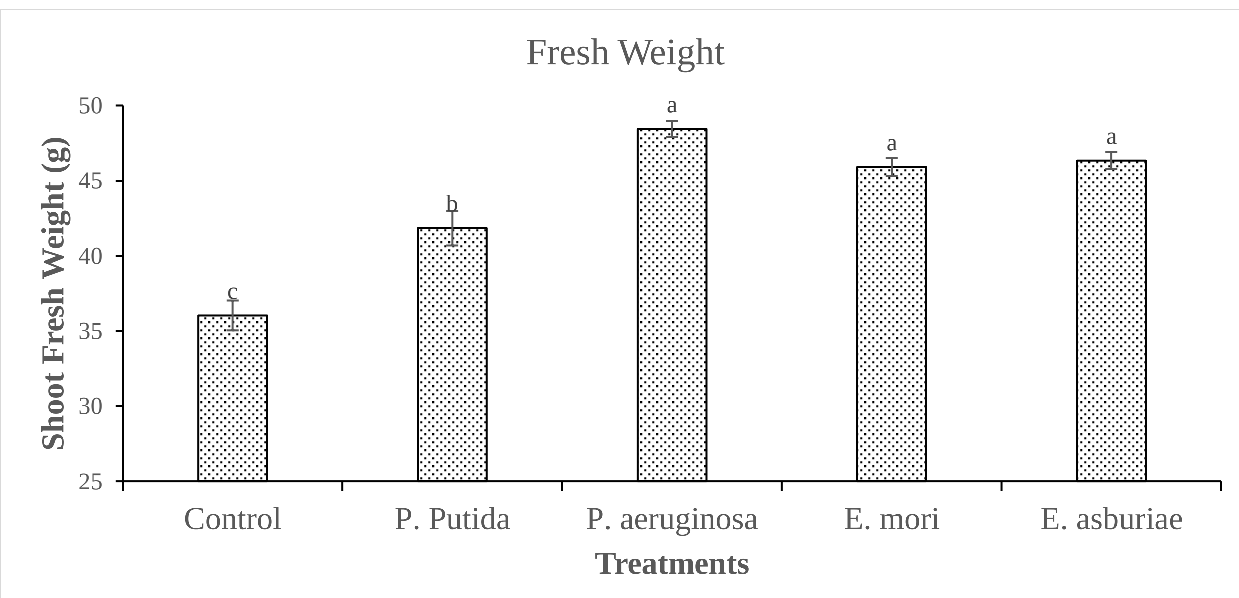

Figure 3. Effect of Rhizobacterial inoculation on Plant Fresh Weight

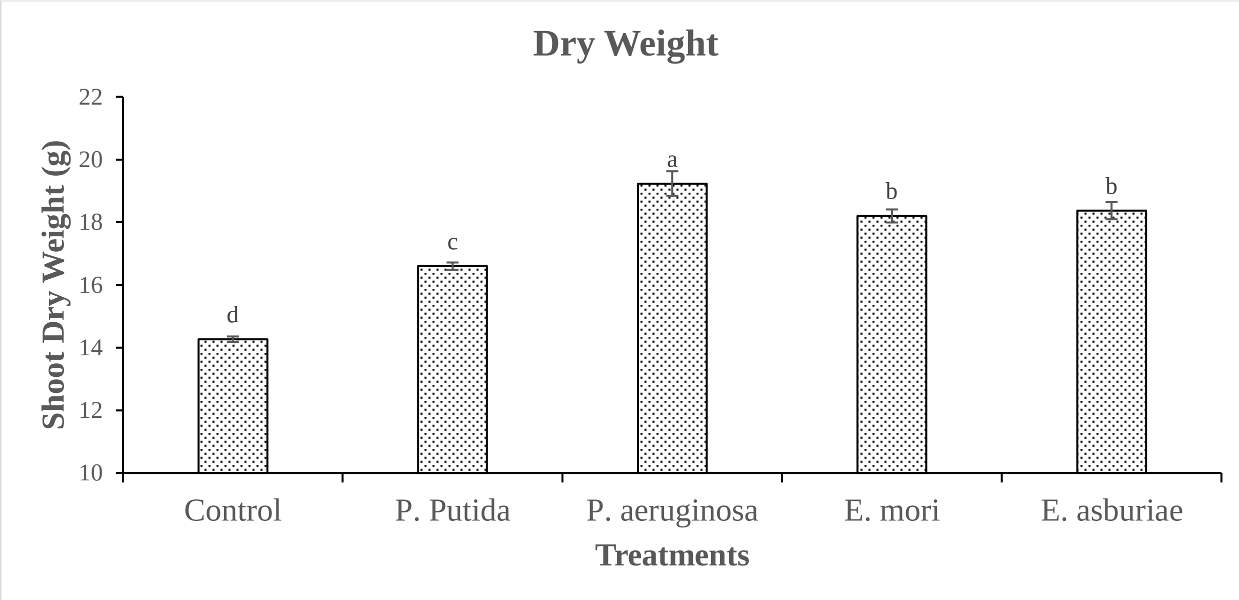

Figure 4. Effect of Rhizobacterial inoculation on Plant Dry Weight

Additionally, bacterial augmentation had a considerable impact on the quantity of surface area present on the leaves of the plants after they were transplanted. When comparing the results of the trial to a nontreated control group, the researchers discovered that P. aeruginosa caused a 41 percent increase in leaf area. The leaf area of plants treated with P. aeruginosa was significantly bigger than the leaf area of all other plants treated with the same bacteria, and this difference was statistically significant.

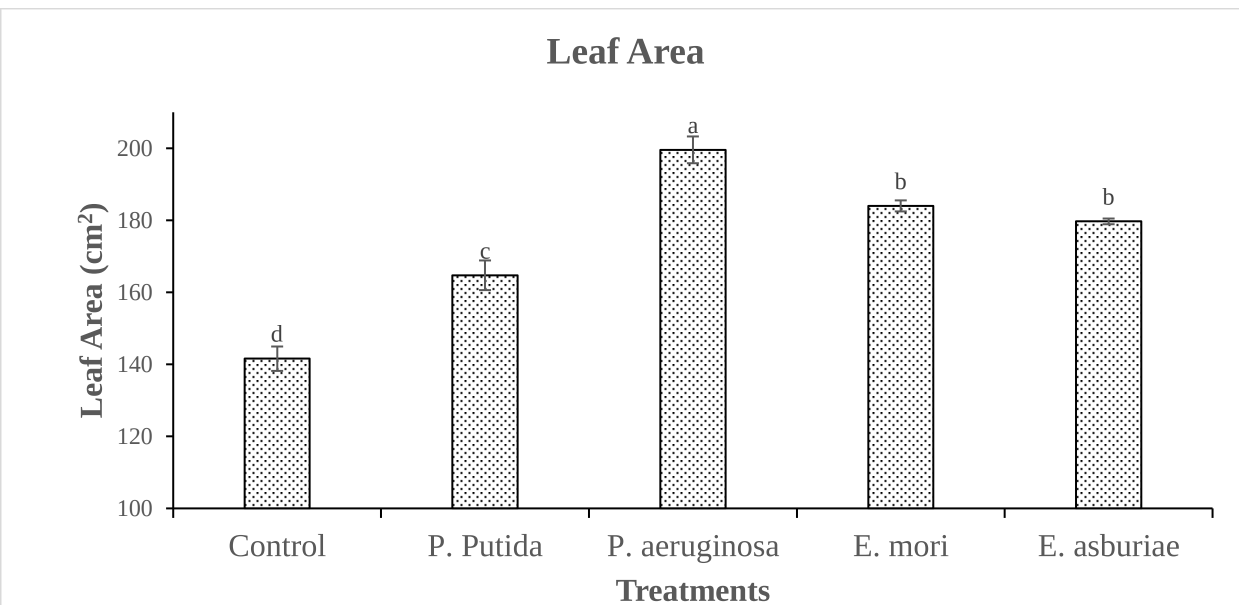

Figure 5. Effect of Rhizobacterial inoculation on Leaf Area

Discussion

This study convincingly established the benefits of PGPR strains in improving plant development in several crops. Botanical inoculants, such as bacteria, can boost plant growth and germination, better seedling emergence, improve plant reactions to stress, and shield plants from disease. The new study's conclusions are consistent with earlier research (Bhattacharyya and Jha, 2012). Seed inoculation with PGPRs enhanced seedling growth, viability, emergence, and seedling count in vitro when compared to the control treatment.

In other cereals, such as sorghum and pearl millet, rhizobacteria have been demonstrated to improve seed germination parameters in a similar way to that described here (Raj et al., 2003). In trials with wheat and sunflower, it was discovered that some PGPR generated increases in seed emergence, with some PGPR induced increases in seed emergence reaching levels up to 100% higher than control values (Saleemi et al., 2017). The researchers in this study hypothesised that increased synthesis of hormones like gibberellins, which would have triggered the activity of specific enzymes that promote early germination, such as amylase, which would have increased the availability of starch assimilation, may have contributed to the findings. Aside from that, increased auxin production would have increased seedling vigour significantly (Ullah et al., 2017).

Inoculating seedling maize with PGPR strains greatly enhanced seedling growth across a variety of soil conditions, according to a pot experiment. Inoculation resulted in the early development and growth of seedlings in general. These findings are similar to those of Dobbelaere et al. (2002), who looked into the effect of PGPR Azospirillum brasilense on spring wheat growth after inoculation with the bacteria. Inoculated plants had more germination, development, and flowering, and the dry weight of both the root system and the upper plant sections rose as a result of the infection, according to the findings. Inoculation with the PGPR has improved the growth characteristics and yields of several crop plants, according to other researchers. When maize seeds were inoculated with Azospirillum strains in experimental conditions versus Pseudomonas strains, the Azospirillum infection resulted in a more evident increase in shoot development, particularly during the establishment of the plant (Bhashan et al., 2010).

According to the current experiment's findings, seed inoculation with all microorganisms increased plant height and leaf area. According to the findings, plant height and leaf area rose in a similar manner across a variety of crops infected with Pseudomonas, Azospirillum, and Azotobacter strains. According to Burd et al. (2000), plant growth promoting rhizobacteria can increase plant height and productivity by synthesising phytohormones, increasing local nutrient availability, facilitating nutrient uptake by the plants, decreasing heavy metal toxicity in the plants, and antagonising plant pathogens. Plants infected with PGPRs have a higher dry weight on average than plants not inoculated with PGPRs, according to the findings. The increase in dry weight was caused by an increase in the length and number of leaves generated by each plant in most cases. According to Yasari and Patwardhan (2007), Azotobacter and Azospirillum strain treatment increased canola yield (21.17 percent), pods per plant (16.05 percent), number of branches (11.78 percent), and weight of 1000 grain seed (all of which were higher than previously) (2.92 percent). Several studies have shown that seed inoculation with rhizobacteria improves the dry weight and yield of maize shoots after planting. The bacteria's ability to fix N2 and solubilize phosphate, as well as their ability to produce growth-promoting chemicals, could explain this improvement.

Conclusion

The results of the study advocate that screening of promising rhizobacteria for growth and yield promotion in a pot and field experiment is a supportive strategy for categorising effective PGPR for biofertilizer production and biotechnology.

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