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The Effect of Mycorrhiza and PGPR Application on Pest and Disease Incidence and the Yield of Purple Waxy Mays (*Zea mays L. ceratina*)

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Abstract:
The low productivity of glutinous mays is caused by several factors, including infertile soil conditions and its high susceptibility to pests and diseases. These conditions hinder optimal plant growth and significantly reduce crop yields. Therefore, alternative environmentally friendly control measures are needed, one of which involves using biological agents such as Plant Growth-Promoting Rhizobacteria (PGPR) and mycorrhizae. This study aimed to analyze the effect of PGPR and mycorrhizal treatments on pest infestation intensity and the production yield of glutinous mays. The research was conducted from June to September 2024 in Duko Kembang Village, Bondowoso District, Bondowoso Regency, East Java Province. The experimental design used was a non-factorial Randomized Complete Block Design (RCBD) consisting of four treatments :(100% anorganic fertilizer), (50% anorganic fertilizer + PGPR), (50% anorganic fertilizer + mycorrhiza), and (50% anorganic fertilizer + PGPR + mycorrhiza). The observed parameters included: (1) agronomic parameters such as plant height, stem diameter, time to male and female flowering, cob weight, cob diameter, and cob length, and (2) pest infestation intensity by grasshoppers, armyworms, and downy mildew. Data were analyzed using ANOVA and followed by the DMRT test at a 5% significance level. The results showed that the treatments had no significant effect on either the agronomic parameters or the intensity of pest infestation.

Keywords:
agronomic traits, glutinous maize, mycorrhiza, pest infestation, plant growth-promoting rhizobacteria

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INTRODUCTION

Mays (Zea mays L.) ranks second among carbohydrate sources after rice and plays a vital role in Indonesia's food security. Among various types cultivated, glutinous mays—locally known as "jagung ketan" or "jagung pulut"—have recently garnered attention for their industrial potential due to their unique starch characteristics. Introduced under the name "Pulut URI (Untuk Rakyat Indonesia)" in 2013, this variety contains a waxy endosperm whose starch shares similar properties with cassava tapioca, making it suitable as an alternative raw material for adhesives, paper, textiles, and even as a partial rice substitute for people with dietary restrictions such as diabetes (Maulana et al. 2018).

Despite these advantages, the productivity of glutinous mays remains relatively low. Studies have shown that its yield potential is under 2 tons per hectare, largely due to poor soil fertility and

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vulnerability to diseases such as downy mildew (Peronosclerospora spp.). Soil fertility is a critical factor influencing crop performance, and while conventional fertilization often relies on chemical inputs, the growing concern for sustainable and eco-friendly agriculture has shifted interest toward biofertilizers (Subaedah et al. 2023).

Plant Growth Promoting Rhizobacteria (PGPR) and mycorrhizae are two types of biological fertilizers known to improve plant growth, nutrient uptake, and resistance to biotic stress. PGPR enhances plant development through hormone regulation, nutrient solubilization, and disease suppression, while mycorrhizal fungi form mutualistic associations with roots, extending hyphal networks that improve water and nutrient absorption. When applied synergistically, PGPR and mycorrhizae can reinforce each other's effects, increasing crop resilience and productivity (Weng et al. 2022).

Previous research has demonstrated the separate effectiveness of PGPR and mycorrhizae on sweet mays, but studies on their combined impact, particularly on glutinous mays, remain limited. Therefore, this study aims to evaluate the influence of PGPR and mycorrhizal inoculation—individually and in combination—on the growth, yield, and pest-disease intensity in glutinous mays under suboptimal soil conditions.

METHOD

This research was conducted from June to September 2024 in Duko Kembang Village, Bondowoso Sub-district, Bondowoso Regency, East Java, at coordinates (7°56'19.5"S 113°47'59.6"E). The tools used included a measuring tape, raffia string, stakes, a hoe, a hand weeder, a planting stick, a bucket, a watering can, a knapsack sprayer, scissors, a weighing scale, calipers, stationery, a notebook, and a mobile phone. The materials used were Jantan F1 purple glutinous mays seeds, PGPR, mycorrhizal fertilizer, compost, botanical pesticide, KCl, urea, and NPK fertilizer. Mays was planted with a spacing of approximately 70 cm x 25 cm and a planting depth of 2–3 cm per hole using one seed per hole. Maintenance activities included replanting at 7 Days After Planting (DAP), fertilization twice using 300 kg/ha of urea and 350 kg/ha of NPK, and hilling at 21 and 36 DAP. The mays were harvested between 63 and 65 days after planting.

The experimental design used was a non-factorial Randomized Complete Block Design (RCBD) consisting of 4 treatments and 6 replications, as follows: K = Control (100% anorganic fertilizer), P = PGPR 100 ml + 50% recommended dose of anorganic fertilizer, M = Mycorrhiza 30 grams + 50% anorganic fertilizer, PM = PGPR 100 ml + Mycorrhiza 30 grams + 50% anorganic fertilizer. The observed parameters included: Plant height (cm) measured from the soil surface to the shoot tip, Stem diameter (mm) measured at the second lower internode using a digital caliper, Cob diameter measured with a caliper at 65 DAP, Cob length (cm) measured using a measuring tape at harvest, Days to male and female flowering, Cob weight without husk (g) measured using an analytical balance at harvest, Pest infestation intensity for grasshoppers, armyworms, and downy mildew.

RESULT

Effect of Treatments on Agronomic Parameters

Statistical analysis indicated that the application of PGPR and mycorrhiza had no significant effect on agronomic parameters. Likewise, chemical fertilizer treatments did not produce significant differences. Average values for each parameter are presented in Tables 1 and 2.

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Table 1. Summary of Research Results

Observation Variable	Treatment Type			
	100% Chemical Fertilizer	50% Chemical Fertilizer + 100 ml PGPR	50% Chemical Fertilizer + 30 grams Mycorrhizae	50% Chemical Fertilizer + 100 ml PGPR + 30 grams Mycorrhizae
Plant height	ns	ns	ns	ns
Stem diameter	ns	ns	ns	ns
Male flowers appear	ns	ns	ns	ns
Female flowers appear	ns	ns	ns	ns
Cob weight	ns	ns	ns	ns
Cob length	ns	ns	ns	ns
Cob diameter	ns	ns	ns	ns

ns = not significantly different

Table 2. Effect of Treatment Type on Observed Variable Types

Observation Variable	Treatment Type			
	100% Chemical Fertilizer	50% Chemical Fertilizer + 100 ml PGPR	50% Chemical Fertilizer + 30 grams Mycorrhizae	50% Chemical Fertilizer + 100 ml PGPR + 30 grams Mycorrhizae
Plant height (cm)	151.94	150.08	145.58	155.28
Stem diameter (mm)	22.5	22.62	23.05	22.13
Male flowers appear (DAP)	50.61	49.28	50.28	49.84
Female flowers appear (DAP)	54.81	52.5	53.81	53.21
Cob weight (gram)	178.1	187.84	180.73	189.38
Cob length (cm)	16.65	16.51	16.21	16.275
Cob diameter(cm)	45.74	46.98	45.71	47.11

Effect of Treatments on Grasshopper Infestation Intensity

The infestation intensity data for each treatment can be seen in Table 3 and Figure 2, showing the grasshopper infestation intensity on may plants throughout the observation period (2–6 weeks after planting (WAP). The PGPR treatment resulted in the highest infestation rate at the 4th week after planting (WAP), reaching 4.76%, which was slightly higher than the other treatments but still categorized as light. Meanwhile, the mycorrhiza and combined PGPR-mycorrhiza treatments showed relatively lower infestation levels, peaking at 4.63% and 4.05% respectively at the 4th WAP observation. After the 4th WAP, the infestation intensity across all treatments tended to decrease, with values at the 6th WAP ranging from 3.12% to 3.78%. Overall, these treatments maintained grasshopper infestation intensity in the light category throughout the observation period.

Table 3. Intensity of Grasshopper Pest Damage to Mays Plants

Treatment	Observation to Mays (DAP)					Category
	2	3	4	5	6	
Control	1.90*	2.03*	4.28*	3.69*	3.12*	Light*
PGPR	1.64*	1.83*	4.76*	4.44*	3.78*	Light*
Mycorrhizae	1.53*	1.39*	4.63*	3.94*	3.45*	Light*
PGPR + Mycorrhizae	1.57*	0.61*	4.05*	3.59*	3.13*	Light*

Note: * Light; ** Medium; *** Heavy; **** Puso

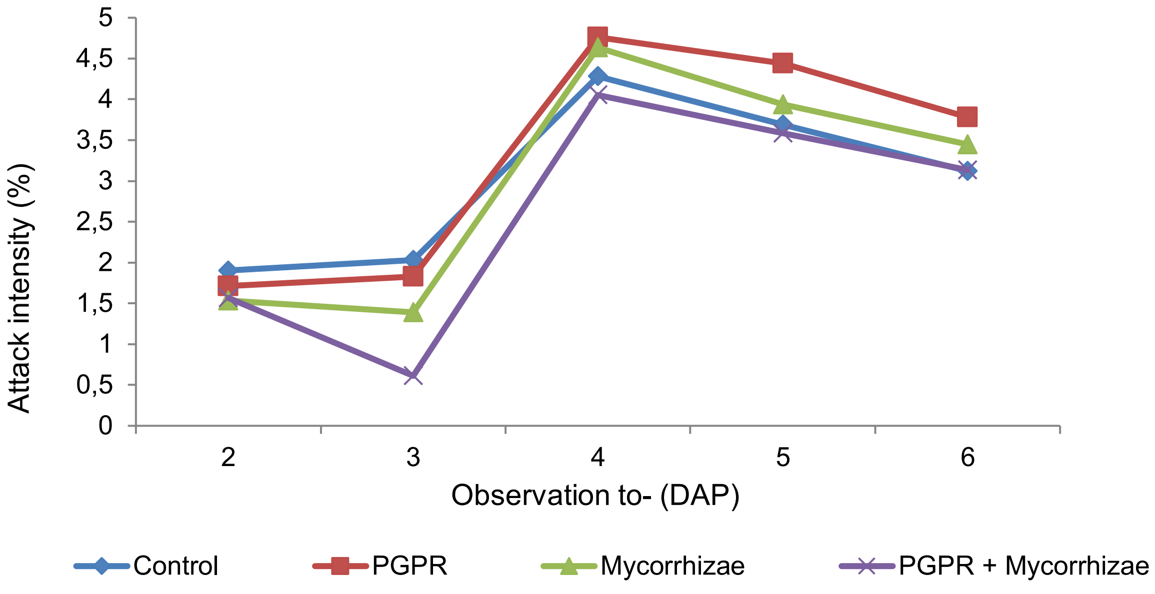

Figure 2. Intensity of Grasshopper Pest Attacks on Mays

Effect of Treatments on Fall Armyworm Infestation Intensity

The infestation intensity data for each treatment are shown in Table 4 and Figure 3, which show the fall armyworm (Spodoptera frugiperda) infestation intensity on mays plants throughout the observation period (2–6 WAP). The PGPR treatment recorded the highest infestation level at the 4th WAP at 4.76%, slightly higher than the other treatments but still within the light category. Meanwhile, the mycorrhiza and PGPR-mycorrhiza treatments showed relatively lower infestation levels, peaking at 3.92% and 4.63%, respectively, at the 4th WAP observation. After the 4th WAP, infestation intensity in all treatments tended to decrease, with values at the 6th WAP ranging from 3.11% to 3.78%. Overall, these treatments kept the fall armyworm infestation in the light category throughout the observation period.

Table 4. Intensity of Armyworm Pest Damage to Mays Plants

Treatment	Observation to Mays (DAB)					Category
	2	3	4	5	6	
Control	0*	2.03*	4.28*	3.69*	3.11*	Light*
PGPR	0*	1.82*	4.76*	4.44*	3.78*	Light*
Mycorrhizae	0*	1.39*	4.63*	3.93*	3.44*	Light*
PGPR + Mycorrhizae	0*	0.57*	3.92*	3.58*	3.13*	Light*

Note: * Light; ** Medium; *** Heavy; **** Puso

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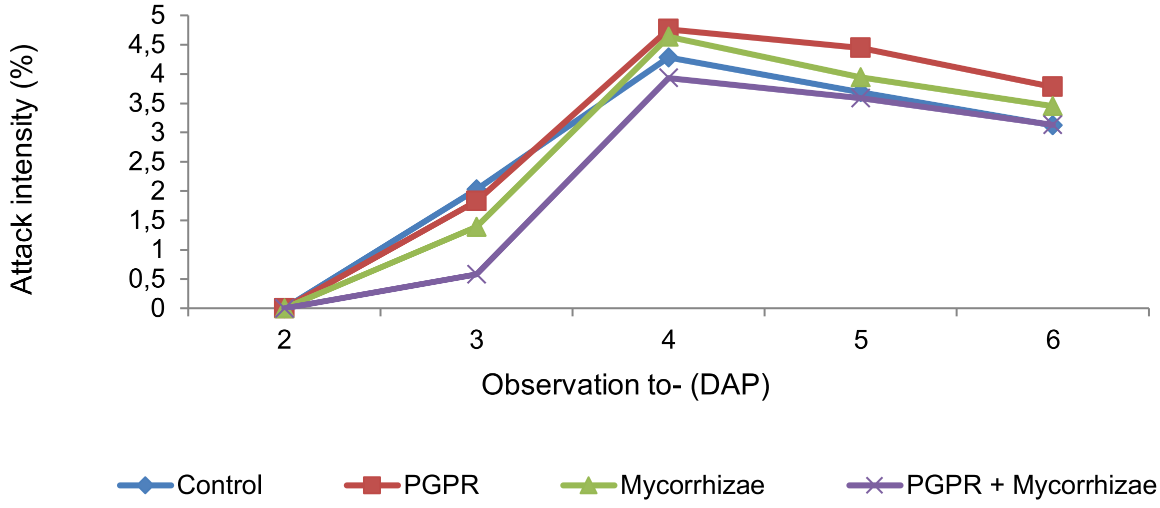

Figure 3. Intensity of Armyworm Pest Attacks on Mays

Effect of Treatments on Downy Mildew Infestation Intensity

The infestation intensity data for each treatment can be seen in Table 5 and Figure 6, showing the downy mildew infestation intensity on mays plants throughout the observation period (2–9 WAP). At the beginning of the observation period, the highest damage intensity occurred in the mycorrhiza treatment at 7.64%. In contrast, the PGPR treatment showed the lowest damage intensity at 5.56%. By the end of the 9th WAP observation, the highest damage intensity was observed in the PGPR treatment at 5.48%, while the combined PGPR and mycorrhiza treatment showed the lowest damage intensity at 4.15%.

Table 5. Intensity of Downy Mildew Disease Damage in Mays Plants

Treatment	Observation to Mays (DAB)								Category
	2	3	4	5	6	7	8	9	
Control	0	0	6.20*	3.04*	4.70*	4.08*	4.13*	4.54*	Light*
PGPR	0	0	5.56*	3.99*	5.13*	4.63*	4.93*	5.48*	Light*
Mycorrhizae	0	0	7.64*	4.72*	5.38*	4.65*	4.87*	5.25*	Light*
PGPR+Mycorrhizae	0	0	7.04*	4.41*	4.75*	4.10*	4.15*	4.15*	Light*

Note: * Light; ** Medium; *** Heavy; **** Puso

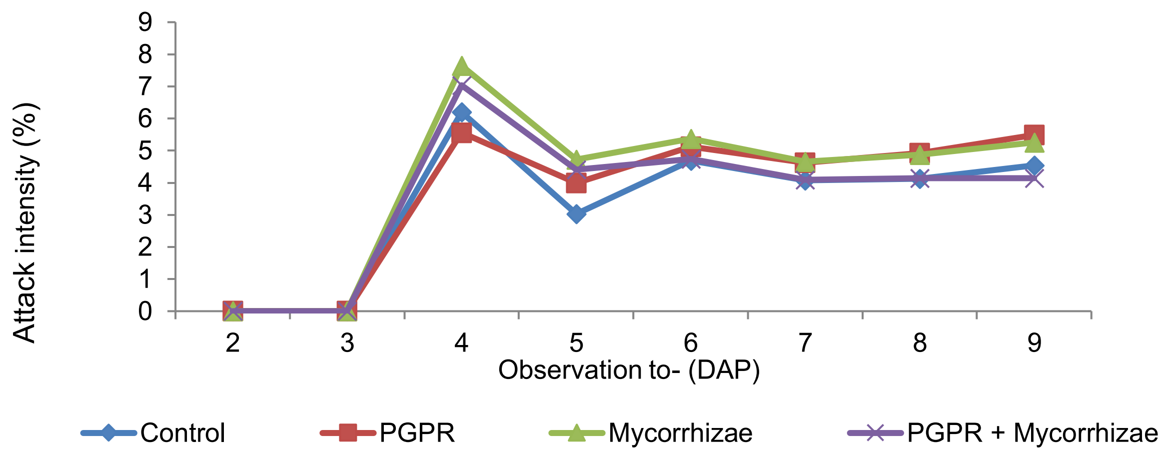

Figure 4.6 Intensity of Downy Mildew Attack on Mays

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DISCUSSION

Although statistical analysis showed no significant effect, the mean values indicated that the mycorrhiza treatment resulted in the greatest stem diameter, while PGPR had the highest plant height. PGPR acts as a biofertilizer and biostimulant by enhancing nutrient availability (N, P, K, Zn, Fe), and regulating plant hormones (auxins, cytokinins, gibberellins, abscisic acid, and ethylene) (Basu et al., 2021). Mycorrhiza, on the other hand, improves nutrient and water absorption and promotes root growth via hormone production, which mays enhance height and leaf number (Nurbaity et al., 2023). PGPR and mycorrhiza showed no significant effect on flowering time. This could be due to genetic factors, as flowering is more influenced by genotype and environment than early vegetative treatment (de Andrade et al., 2023).

Regarding yield, while not statistically significant, the highest cob weight and diameter were observed in the PGPR + mycorrhiza treatment. This suggests that these biofertilizers mays substitute 50% of anorganic fertilizer. PGPR enhances nutrient uptake, especially phosphorus, essential for kernel and cob development, and improves stress resistance (Hartono et al., 2024). Mycorrhiza expands the root system via hyphae and improves phosphate and water uptake (Weng et al., 2022). Their synergy mays enhance overall growth and yield.

The combination of PGPR and mycorrhiza showed the lowest average infestation rates for grasshoppers and armyworms. This can be attributed to the induced systemic resistance (ISR) triggered by these microbes, which stimulates the production of defense-related compounds such as peroxidase, polyphenols, and phytoalexins (de Andrade et al., 2023). Additionally, enhanced nutrient uptake helps produce healthier plants with stronger resistance. PGPR and mycorrhiza had no significant effect on downy mildew intensity. Interestingly, PGPR treatment alone showed a slightly higher average infestation. This could be due to rapid plant growth induced by PGPR, creating softer, more susceptible tissues (Sari et al., 2023). Also, the microenvironment created by PGPR activity mays favor certain pathogens. Hence, PGPR use should be complemented with effective disease control strategies to mitigate downy mildew.

CONCLUSION

The application of PGPR and mycorrhiza did not significantly affect plant growth, yield, or pest and disease infestation intensity. However, mean values indicate that the combination of PGPR + mycorrhiza resulted in the highest cob weight and diameter. PGPR and mycorrhiza can potentially replace up to 50% of anorganic fertilizer usage.

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