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Research Article

Pantoea spp. Application to Increase the Growth and Yield of Rice 'Pathum Thani 1'

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Abstract

Background and Objective: *Pantoea* sp. SP108 was isolated from the U-thong district, Suphanburi province to promote plant growth. Therefore, this research aimed to study the effect of *Pantoea* sp. on the growth and yield of rice cv. 'Pathum Thani 1'. **Materials and Methods:** Rice seeds were pre-germinated and cultivated in plastic pots (1 seedling/pot). The six treatments were TR1) not soaked with bacteria and application of chemical fertiliser, TR2) rice seed were soaked with a bacterial concentration of 10^8 CFU, TR3) rice seed was soaked with bacteria and chemical fertiliser was applied (30 kg rai^{-1} of 16-16-8 and 20 kg rai^{-1} of 46-0-0), TR4) rice seed was soaked with bacteria and chemical fertiliser was applied (15 kg rai^{-1} of 16-16-8 and 10 kg rai^{-1} of 46-0-0), TR5) rice seed was soaked with bacteria and chemical fertiliser was applied (7.5 kg rai^{-1} of 16-16-8 and 5 kg rai^{-1} of 46-0-0) and TR6) rice seed was soaked with bacteria and were sprayed 25 days after transplanting and panicle initiation. **Results:** The results showed that soaking in *Pantoea* sp. concentration of 10^8 CFU for 30 min with chemical fertiliser applied at a rate of 7.5 kg rai^{-1} of 16-16-8 and 5 kg rai^{-1} of 46-0-0 had a significant effect on the growth and yield of Pathum Thani 1 ($p<0.01$), especially the tillers per clump, canopy width, leaf length, shoot and root fresh weight, filled grain, panicles number per clump and rice yield per rai. **Conclusion:** *Pantoea* sp. solution could be used with ¼ fertiliser to increase yield components of Pathum Thani 1.

Key words: *Pantoea* sp., Pathum Thani 1, yield component, tillers per clump, chemical fertiliser

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Thailand, rice is the most important crop for human food and is an economic crop. Thailand had an area of 1,010.38 million rai for rice harvesting, with 491.52 million tonnes of output. Most consumers are concerned about the health and the environment, therefore, Good Agricultural Practices (GAP) and organic standards for increasing rice production are necessary. The extensive use of chemicals as fertiliser improves plant health and productivity but disturbs the ecological balance of soil and results in nutrient depletion. This has necessitated the search for alternate sources of this element[1]. Organic production is an agricultural system that focuses on natural materials to increase soil fertility, beneficial microorganisms, such as bacteria, fungi and actinomycetes[2] and rehabilitation of rice growth[3]. The application of microorganisms as bioreactors in plant production systems not only offset the high cost of manufacturing chemical fertilisers but also makes insoluble nutrients, such as P and K, available. Research studies on the use of knobs antagonistic microorganisms (mixed strains) in organic rice fields showed that rice yield increased by 21.8%.

Presently, many beneficial microorganisms have been used to decrease the use of chemical fertilisers and pesticides, developing crop production and soil improvement[4]. Prajanban *et al.*[5] reported that the use of *Bacillus megaterium* OriBa-12 can increase the crop growth rate of young corn seedlings of cv. 'KBSC-303'. The dry weight of baby corn, plant weight and stem height increased by 12.01, 14.38 and 21.43%, respectively, compared with the negative control. In addition, *Trichoderma harzianum*, *B. subtilis*, *Pseudomonas fluorescens* and *Acinetobacter baumannii* were used to control disease and increase rice production[4,6-8]. *Pantoea* sp. SP108, isolated from U-thong district, Suphanburi province, is a local bacterium that promotes plant growth, nitrogen and phosphate dissolving properties and produces indole-3-acetic acid. These properties indicate the potential of *Pantoea* sp. SP108 to promote rice growth. Therefore, this research studied the use of *Pantoea* sp. SP108 to promote the growth and yield components of rice production.

MATERIALS AND METHODS

Study area: The study was carried from August, 2019 to March, 2020.

Inoculum and rice seed preparation: Single colonies of *Pantoea* sp. SP108 were transferred to 30 mL glucose yeast extract peptone (GYP) liquid containing 500 μg mL^{-1} of L-tryptophan, colonies were then grown aerobically in flasks on a rotating shaker (150 rpm) for 48 hrs at 35°C. The bacterial suspension was then diluted in sterile distilled water to a final concentration of 10^8 CFU mL^{-1} and resulting suspensions were used to treat rice seeds. Surface sterilised seeds were soaked in separate bacterial suspensions for 30 min before planting.

Pot experiment: The experiment was carried out in a greenhouse located in the Thawi Watthana subdistrict, Sai Noi district, Nonthaburi province, Thailand. The potting soil was obtained from rice fields from Thawi Watthana subdistrict, Sai Noi district, Nonthaburi province. Pots (12-inch without holes) were filled with this soil and saturated with. Chemical fertilizers of 16-16-8 and 46-0-0 were applied at 25 days after transplanting and panicles initiation, respectively, based on the nutrient requirements of rice plants. Pots were arranged in a completely randomised design with three replicates per treatment. The experimental plan was based on six treatments, as shown in Table 1. This study examined the effects of *Pantoea* sp. mixed with fertiliser on the growth of rice cv. Pathum Thani 1. The six treatments were TR1) not soaked with bacteria and application of chemical fertiliser (30 kg rai^{-1} of 16-16-8 and 20 kg rai^{-1} of 46-0-0), TR2) rice seed were soaked with a bacterial concentration of 10^8 CFU, TR3) rice seed was soaked with bacteria and chemical fertiliser was applied (30 kg rai^{-1} of 16-16-8 and 20 kg rai^{-1} of 46-0-0), TR4) rice seed was soaked with bacteria and chemical fertiliser was applied (15 kg rai^{-1} of 16-16-8 and 10 kg rai^{-1} of 46-0-0), TR5) rice seed was soaked with bacteria and chemical fertiliser was applied (7.5 kg rai^{-1} of 16-16-8 and 5 kg rai^{-1} of 46-0-0) and TR6) rice seed was soaked with bacteria and were sprayed 25 days after transplanting and panicle initiation.

Data record: Plant growth parameters, namely plant height, canopy width, plant number/clump, leaf number/clump, ear number/clump, seed number/ear, seeding percentage, seed yield (kg rai^{-1}), seed weight of 100 grains and grain size were recorded.

Statistical analysis: Analysis of variance (ANOVA) was conducted on data obtained for each parameter in each treatment. All analyses were carried out using Statistic software, version 8.0. Duncan's Multiple Range Tests (DMRTs) were calculated at a significance level of 0.05 to test for significant differences among treatments.

Table 1: Treatment for experiment

		Time 1 (25 days after transplanting)		Time 2 (panicle initiation)	
Treatments	Seeds soaked with bacteria	Added bacteria (10^8 CFU)	Fertiliser 16-16-8 (kg rai^{-1})	Add bacteria(10^8 CFU)	Fertiliser 46-0-0 (kg rai^{-1})
1	×	×	30	×	20
2	✓	×	×	×	×
3	✓	×	30	×	20
4	✓	✓	15	✓	10
5	✓	✓	7.5	✓	5
6	✓	✓	×	✓	×

RESULTS AND DISCUSSION

Use of *Pantoea* sp. to promote rice growth: The results showed that management using *Pantoea* sp. mixed with fertiliser had significant effects on plant height, canopy width, tillering number/clump and leaf number/clump of rice cv. Pathum Thani 1 ($p<0.01$). The application of *Pantoea* sp. combined with chemical fertiliser (7.5 and 15 kg rai^{-1} of NPK 16-16-8 at 25 days after transplanting with 5 and 10 kg rai^{-1} of NPK 46-0-0 at panicles initiation) had a significant effect on the tillering number per clump (36.33-37.60 tillers/clump) and leaf number per plant (129.60-135.26 leaves per clump) in Table 2 and Fig. 1.

This might be due to the vermicompost benefits to the ecosystem of the root rhizosphere and the increase in nutrient availability and uptake by rice[9]. Similar results were also observed by the previous study[10]. Nitrogen was the main nutrient affecting vegetative growth, contributing to the number of tillers[11]. The leaf is the source of synthesised carbohydrates.

Use of *Pantoea* sp. to promote rice yield: The use of *Pantoea* sp. with chemical fertilisers at different ratios had a statistically significant effect on the yield of rice cv. Pathum Thani 1. ($p<0.01$) compared to rice cultivated with no bacteria. By evaluating the seeding percentage and number of ears per clump, the use of bacteria *Pantoea* sp. with chemical fertilisers applied at a rate of 15 kg rai^{-1} of 16-16-8 and 10 kg rai^{-1} of 46-0-0 and chemical fertiliser applied at 7.5 kg rai^{-1} of 16-16-8 and 5 kg rai^{-1} of 46-0-0 (TR4 and TR5, respectively) gave the highest seeding percentage and number of ears per clump (80.84±2.10 and 82.06±2.28%, respectively and 18.00±1.00 and 18.00±2.39 ears clump^{-1}, respectively). In terms of yield per rai, the use of *Pantoea* sp. with chemical fertilisers applied at 15 kg rai^{-1} of 16-16-8 and 10 kg rai^{-1} of 46-0-0 (TR4) provided the highest rice yield (507.32±64.4 kg rai^{-1}) in Table 3. In addition, the use of *Pantoea* sp. had a significant effect on rice grain size ($p<0.01$). The use of only bacteria for soaking the rice grain (TR2) gave the longest grain length (105±0.05 mm). The use of only chemical fertiliser (TR1) gave the highest seed width (29±0.01 mm) and the seed thickness was not affected by the use of bacteria *Pantoea* sp. with chemical fertilisers in Table 4.

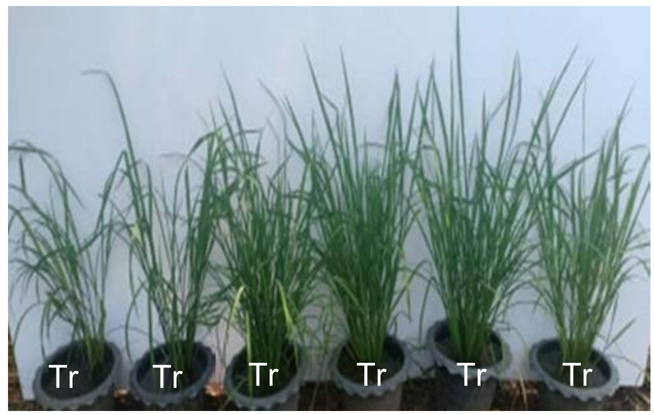

Fig. 1: Growth characteristics of rice varieties Pathum Thani 1

From the experiment, using *Pantoea* sp. at a concentration of 10^8 CFU mL^{-1} increased the growth and yield of rice cv. Pathum Thani 1 grown in 12-inch pots. *Pantoea* sp. with different chemical fertilisers had a statistically significant influence on the growth and yield of rice ($p<0.01$) in plant height, canopy width, number of tillers per clump, number of leaves per clump and yield per rai. The application of *Pantoea* sp. with chemical fertilisers applied at 15 kg rai^{-1} of 16-16-8 and 10 kg rai^{-1} of 46-0-0 and chemical fertiliser applied at 7.5 kg rai^{-1} of 16-16-8 and 5 kg rai^{-1} of 46-0-0 (TR4 and TR5, respectively) were likely to promote the highest growth and rice yield. The *Pantoea* spp. is a bacterium in the IAA capable group, which are plant growth regulators affecting proliferation, cell size, cell division and cell elongation[12]. This may result in rice being more efficient at absorbing nutrients. Similarly, Bakhshandeh *et al*[7]. found that using three phosphate-solubilizing bacteria (PSB), including *Pantoeaananatis* (KM977993), *Rahnellaaquatilis* (KM977991) and *Enterobacter* sp. (KM977992), affects rice (cv. 'Tarom Hashemi') growth in many aspects, such as the increase in plant height, number of roots and rice biomass.

Table 2: Growth of rice varieties Pathum thani 1

Treatments	Plant height (cm)	Canopy width (cm)	Number of tillers/clumps	Number of leaves/clumps
1	122.73±1.44[a]	92.86±5.02[a]	21.20±1.77[c]	83.93±4.81[c]
2	107.93±2.53[a]	82.33±8.78[b]	15.40±1.40[d]	49.00±3.48[d]
3	111.86±5.08[a]	95.26±5.32[a]	29.53±1.02[b]	111.26±4.93[b]
4	96.60±4.81[b]	80.66±1.22[b]	36.33±2.80[a]	135.26±21.1[a]
5	93.40±3.66[b]	73.76±2.70[bc]	37.60±2.80[a]	129.6±6.87[a]
6	83.80±2.74[c]	70.66±1.85[c]	27.13±1.13[b]	90.26±4.88[c]
F-test	**	**	**	**
CV (%)	13.22	12.30	29.56	31.42

Means with the same letter within a column are not significantly different by the DMRT at $p<0.05$, **Significant difference at $p<0.01$

Table 3: Yield component of rice varieties Pathum thani 1

Treatments	Seeding percentage	100 grain weight (g)	Number of ears per clumps	Yield (kg rai^{-1})
1	19.93±4.10[e]	1.57±0.02[c]	10.40±2.97[c]	52.78±15.05[d]
2	26.89±2.96[d]	2.59±0.13[a]	7.80±0.83[d]	92.27±9.89[d]
3	62.66±1.51[c]	2.40±0.06[b]	17.80±1.64[b]	222.56±24.70[c]
4	80.84±2.10[a]	2.44±0.00[b]	18.00±1.00[a]	367.25±20.40[b]
5	82.06±2.28[a]	2.36±0.07[b]	18.00±2.39[a]	507.32±64.42[a]
6	80.84±2.10[b]	2.36±0.07[b]	13.40±1.14[b]	394.26±33.54[b]
F-test	**	**	**	**
CV (%)	44.09	13.42	31.07	62.42

Means with the same letter within a column are not significantly different by the DMRT at $p<0.05$, **Significant difference at $p<0.01$

Table 4: Rice seed characteristics of Pathum thani 1

Treatments	Seed length (mm)	Seed width (mm)	Seed thickness (mm)
1	95±0.02[c]	29±0.01[a]	20±0.01
2	105±0.05[a]	27±0.01[b]	20±0.01
3	97±0.02[bc]	24±0.01[c]	19±0.00
4	102±0.02[ab]	25±0.02[c]	19±0.00
5	97±0.01[bc]	26±0.01[bc]	18±0.01
6	100±0.00[bc]	25±0.01[bc]	19±0.00
F-test	**	**	ns
CV (%)	41.41	7.69	5.26

Means with the same letter within a column are not significantly different by the DMRT at $p<0.05$, **Significant difference at $p<0.01$

Additionally, Efficient K-solubilizing bacteria have been reported to enhance potassium uptake in plants leading to plant growth stimulation under pothouse and field conditions. These K-Solubilizing Bacteria (KSB) could be applied as potential biofertilizers along with the application of rock K materials to provide a continuous supply of available potassium for increasing the crop yield[13]. *Burkhoderia* spp. and *Pantoea dispersa* promotedrice growth by increasing the plant height, the number of leaves, root length and early dry weight. Microorganisms can increase the usefulness of phosphorus elements, such as phosphate dissolving microorganisms. In some countries, such microorganisms have been adopted to increase the usefulness of phosphate rocks. These microorganisms can dissolve rocks, phosphates and other inorganic phosphates by releasing beneficial phosphorus for plant growth. This microorganism contains bacteria, fungi and actinomycetes[14]. Bacterial inoculate have the potential to reinstate the fertility of degraded land through various processes. These microorganisms increase the nutrient bioavailability through nitrogen fixation and mobilization of key nutrients (phosphorus, potassium and iron) to the crop plants while remediating soil structure by improving its aggregation and stability. The success rate of such inocula under field conditions depends on their antagonistic or synergistic interaction with indigenous microbes or their inoculation with organic fertilisers[15]. Therefore, microorganisms are classified as quality microbial fertilisers and are great substitutes for chemical fertilisers. Using bacteria with chemical fertilisation was more effective than using only bacterial or chemical fertilisation. As chemical fertilisers acidify the soil, the nutrient absorption of plants decreases and affect the growth of some types of bacteria in beneficial soils[16].

CONCLUSION

Soaking rice seeds in 10^8 CFU ML^{-1} *Pantoea* spp. for 30 min and applying chemical fertilisers at a rate of 7.5 kg rai^{-1} of 16-16-8 25 days after sowing and 5 kg rai^{-1} of 46-0-0 at the flowering stage (Treatment 5) promoted rice growth and yield of cv. Pathum Thani 1. By measuring the width, canopy, the number of leaves and yield rice is grown with *Pantoea* spp. was more productive than that without.

SIGNIFICANCE STATEMENT

This study discovered the *Pantoea* sp. solution could be used with optimum fertiliser that can be beneficial for yield components of Pathum Thani 1. This study will help the researchers to uncover the critical areas of microorganism useful that many researchers were not able to explore. Thus a new theory on beneficial microorganisms to reduce the amount of chemical fertilizer use in rice fields may be arrived at.

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