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Response of *Oryza sativa, Solanum lycopersicum, Coriandrum sativum* and *Trigonella foenum* to a photosynthetic bacterial biofertiliser

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Abstract
In the present study, *Rhodopseudomonas palustris* a proteolytic purple non sulphur bacterium was used as biofertiliser and its effect on the root and shoot lengths of four plants have been investigated. To study its potential as biofertiliser, it was primarily screened by seed germination and roots and shoot length growth. In our study, we have observed significant change in the growth of *Oryza sativa, Solanum lycopersicum, Coriandrum sativum and Trigonella foenum*. On inoculation of nitrogen and photosynthetic bacterium, the rice HMT variety was observed to be more responsive compared to Poojalu variety. Increased shoot length was found in both the varieties. Even in the plants like *Solanum lycopersicum, Coriandrum sativum* and *Trigonella foenum* the rate of growth is more when the photosynthetic bacterium was inoculated. The role of Nitrogen on the growth of leaves, roots, stem and vegetative parts of plants is seen in this work. Nitrate contaminations in ground water, eutrophication of aquatic ecosystems etc. are some of the environmental hazards occurring due to excess amounts of chemical fertilizers (Carpenter, 2005; Diaz and Rosenberg, 2008). This paper also includes the study of Eldin and Elbanna (2010) demonstration of the beneficial effects of another purple non sulphur bacteria namely *Rhodobacter capsulatus*. They concluded that these bacteria enhanced the growth and yield of rice in both pots and lysimeter. It was, also concluded the use of old seeds leads to high rate of growth promotions. The increase in height and dry weight of the roots and stem by *Rhodopseudomonas palustris* and Nitrogen is seen initially. The growth is more when both the Nitrogen and bacteria are used in the cultivation.

Keywords: phototrophic purple non sulfur bacteria, *Rhodopseudomonas palustris*, eutrophication, *Poojalu, Oryza sativa*, nitrogen source, plant growth

Introduction

Rhodopseudomonas palustris belongs to the group of the phototrophic purple non sulfur bacteria. It belongs to the class Alpha-Proteobacteria (Imhoff, 2006) [11]. In sediments, moist soils, paddy fields and in various natural wetlands, this bacterium is distributed. *R. palustris* was used earlier as biofertiliser (Hiraishi and Kitamura, 1984, Oda *et al.*, 2002, Roper and Ladha, 1995) [10, 15, 17]. In a previous study *R. palustris* KN122 was inoculated into rice (Oryza Sativa) seedlings with basal fertilizers. Results showed that the grain yield was 9% higher in the inoculated pots than in the non-inoculated pots which proved that *R. palustris* has the ability to fix nitrogen (Harada *et al.*, 2001) [8]. Photosynthetic bacteria play a major role in plant growth. Sun is used as a source of energy by Photosynthetic bacteria. Plants use a substance called chlorophyll to absorb the rays of sun and turn in to nutrients needed for everyday maintenance and growth. Bacteria contain a similar compound called bacteriochlorophyll, which allow them to photosynthesize. The biological properties of the soil seemed to change tremendously in terms of increase in beneficial macro and micro soil biota. Food quality along with better growth is brought by nitrogen (Ullah, 2010). Nitrogen rate increases area of leaf, process of photosynthesis and also rate of assimilation (Ahmad *et al.*, 2009) [2]. Many plants like oilseeds, sugar, fiber, cereals needs nitrogen for effective developmental process and growth. Wheat, rice, sugarcane and cotton have shown incredible production by the application of nitrogen. Rice is one of the major grain crop that is cultivated worldwide (Rafiq *et al.*, 2010) [16]. Nitrogen helps in promoting growth of leaves, stem and other vegetative parts of a plant. Nitrogen helps in increasing the growth of leafy vegetables. In fodder crops, it increases the protein content (Ali *et al.*, 2000, Bloom, 2005) [3, 3]. Nitrogen application should be optimum for proper growth and development of plants. Very little inoculation decreases crop yield whereas excess inoculation causes unnecessary effects on the plants (Magistad, *et al.*, 1945) [13]. Mass flow, root interception and diffusion are the three ways by which the plants uptake the nitrogen. But mass flow is normally used to supply nitrogen to the plants (Hemerly, 2016) [9]. Roots stem and leaves are the three principal organs of plants. Roots first absorb nitrogen followed by leaves (Bollard, 2016) [4]. Earlier studies by one of the authors have also confirmed the nitrogen fixing ability of photosynthetic bacteria. Hence, this work was envisaged and the results are communicated.

Materials and Methods

Oryza sativa (HMT, Poojalu), *Solanum lycopersicum*

(Namdhari 2535) seeds, *Coriandrum sativum* seeds (Dhinkar) and *Trigonella foenum* seeds (24 Mantra Organicare) collected from local market in Nalgonda, Telangana. The grains are kept in a small jute bag and sprinkled with water twice a day. This is followed until the sprouts are observed out of the jute bag. The sprouted grains are separated carefully. Three bottles are prepared for each i.e., 3 bottles for control, 3 bottles for only nitrogen, 3 bottles for nitrogen and photosynthetic bacteria. Soft soil is taken in to the bottles. The growth is recorded after regular intervals. Finally the plants are removed carefully and washed. The plants are removed at seedling stage. The shoot and root measurements of the plants were calculated. The bacterium was earlier isolate of our laboratory which was characterized and used in this study.

Results

Gradual increase in the shoot as well as root length of both the rice varieties, Poojalu and HMT was seen. Inoculation with nitrogen and photosynthetic bacteria brought showed increase in the root and shoot lengths of both the rice varieties shown in the table 1. In case of *Solanum lycopersicum* (Namdhari 2535) seeds, *Coriandrum sativum* seeds (Dhinkar) and *Trigonella foenum* seeds both root and shoot length was observed in these plants after inoculation with nitrogen and photosynthetic bacteria (Table 2,3,4). Earlier studies with photosynthetic bacterium *Rhodopseudomonas palustris* inoculation on *Stevia rebaudiana* showed that this organism neutralizes the effect of chemical fertilizers and promotes the growth of microbial communities near the root of the plant. Eldin and Elbannastudies concluded that these bacteria *Rhodobacter capsulatus* enhanced the growth and yield of rice in both pots and lysimeter studies. Growth beneficial effects of *Rhodopseudomonas palustris* PS3 strain on *Brassica rapa chinensis* growth with less chemical fertilizer supplementation was also reported.

Table 1: Effect of Photosynthetic Bacteria along with Nitrogen on Shoot Length and Root Length in *Oryza Sativa*:

Inoculation	POOJALU		HMT	
	Ht (cm)	Dry Wt (mg plant)	Ht (cm)	Dry Wt (mg plant)
Shoot length				
U	9.2	4.2	10.3	4.6
I(With Nitrogen)	9.8	5.4	12.4	6.9
I(With Nitrogen+Bacteria)	11.5	7.6	13.9	7.5
I(Bacteria)	10.2	6.8	12.8	7.2
Root length				
U	6.3	5.7	9.1	5.2
I(With Nitrogen)	8.9	6.6	11.5	6.8
I(With Nitrogen+Bacteria)	12.3	8.4	14.3	8.1
I(Bacteria)	11.5	8.1	13.1	7.9

U = Uninoculated; I = Inoculated;

Table 2: Effect of Photosynthetic Bacteria and Nitrogen on Root and Shoot Length of *Solanum lycopersicum*

Inoculation	*Solanum lycopersicum*	
	Ht (cm)	Dry Wt (mg plant)
Shoot length		
U	4.0	3.0
I(With Nitrogen)	6.0	3.7
I (With Nitrogen+Bacteria)	8.0	6.0
I(Bacteria)	6.1	4.1
Root length		
U	1.2	4.2
I (With Nitrogen)	1.8	4.5
I (With Nitrogen+Bacteria)	5.0	5.4
I(Bacteria)	2.5	4.9

U = Uninoculated; I = Inoculated;

Table 3: Effect of Photosynthetic Bacteria and Nitrogen on Root and Shoot Length of *Coriandrum sativum*

Inoculation	*Coriandrum sativum*	
	Ht (cm)	Dry Wt (mg plant)
Shoot Length		
U	1.5	4.1
I(With Nitrogen)	2	4.6
I(With Nitrogen+Bacteria)	4	6.4
I(Bacteria)	3	4.4
Root Length		
U	2	3.6
I(With Nitrogen)	4	4
I(With Nitrogen+Bacteria)	7	5
I(Bacteria)	3.2	4.3

U = Uninoculated; I = Inocssulated;

Table 4: Effect of Photosynthetic Bacteria and Nitrogen on Root and Shoot Length of *Trigonella foenum*

Inoculation	*Trigonella foenum*	
	Ht	Dry Wt
	(cm)	(mg plant)
Shoot length		
U	2	2.7
I(With Nitrogen)	3.5	3.4
I(With Nitrogen+Bacteria)	5	6
I(Bacteria)	3.8	4.7
Root length		
U	2.5	4.3
I(With Nitrogen)	5	6.1
I(With Nitrogen+Bacteria)	9	7.3
I(Bacteria)	5.9	6

U = Uninoculated; I = Inoculated;

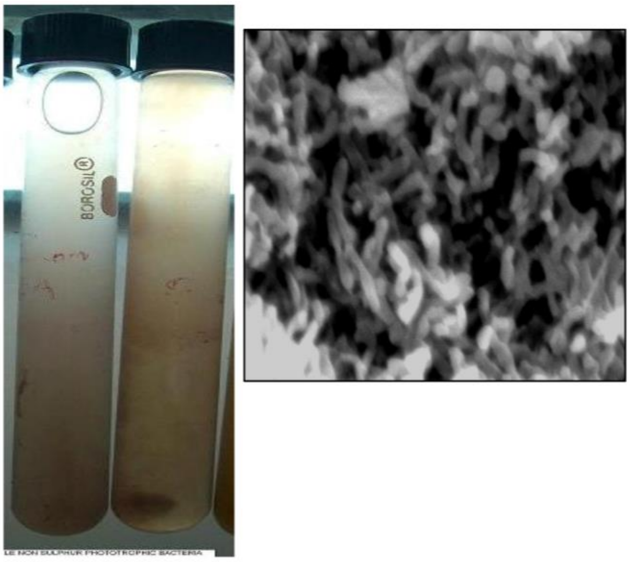

Fig 1: SEM image of the organism [purple non sulphur bacteria consortium]

Discussion

The proteolytic bacterial biofertiliser *Rhodopseudomonas palustris* undergo the Nitrogen fixation and promote the growth by supplying the nutrients to the plant. These photosynthetic bacteria using sun as source is very useful for the growth of the plants. HMT variety was more responsive compared to Poojalu rice variety. Inoculation with nitrogen and photosynthetic bacteria showed a difference compared to inoculation with only nitrogen. Even the dry weight of the rice variety inoculated with nitrogen and photosynthetic bacteria was observed to be more compared to others. The quantity of the component is mandatory as the less quantity leads to low growth and excess leads to unnecessary growth. The authors have also concluded that the bacteria interfered with the effect of chemical fertilizer on the enzyme activities of dehydrogenase and urease of beneficial plant growth promoting bacteria (Jiangbing, 2018). Eldin and Elbanna (2010) in another study have effectively demonstrated the beneficial effects of another purple non sulphur bacteria namely *Rhodobacter capsulatus*. The employment of the low resolution technique Eg denaturing gradient gel electrophoresis (DGGE) fail to present the variations in bacterial components after the root inoculation of *Rhodopseudomonas*.

Conclusion

Gradual increase in the shoot as well as root length of both the rice varieties, Poojalu and HMT was seen. In case of *Solanumlycopersicum* (Namdhari 2535) seeds, *Coriandrumsativum* seeds (Dhinkar) and *Trigonellafoenum* seeds both root and shoot length was observed in these plants after inoculation with nitrogen and photosynthetic bacteria (Table 2, 3, 4). The growth of roots and shoots is seen more in the inoculated nitrogen and bacteria than in the Uninoculated bottles. Earlier studies with photosynthetic bacterium *Rhodopseudomonas palustris* inoculation on *Stevia rebaudiana* showed that this organism neutralizes the effect of chemical fertilizers and promotes the growth of microbial communities near the root of the plant. Eldin and Elbannastudies concluded that these bacteria Rhodobacter capsulatusenhanced the growth and yield of rice in both pots and lysimeter studies. Growth beneficial effects of *Rhodopseudomonas palustris* PS3 strain on *Brassica rapachinensis* growth with less chemical fertilizer supplementation was also reported. The growth of roots and shoots is seen more in the inoculated nitrogen and bacteria than in the uninoculated bottles.

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Conflict of interest: Authors declare that there are no conflicts of interest.

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