Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP3: 501-503

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National conference on "Conservation, Cultivation and Utilization of medicinal and Aromatic plants"
(College of Horticulture, Mudigere Karnataka, 2018)

Effect of plant growth promoting rhizobacteria on growth, yield and quality of shankapushpi (*Clitorea ternatea* L.)" under rainfed situation

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Abstract
A field experiment was conducted to assess the "Effect of Plant Growth Promoting Rhizobacteria on growth, yield and quality of shankapushpi (*Clitoreaternatea* L.)" under rainfed condition at College of Horticulture, UHS campus, GKVK Post, Bengaluru during 2016-2017. The experiments were comprised of ten treatments and were replicated thrice in RCBD. The maximum plant height (13.50,24.08, 46.25 and 60.07 cm at 30,60,90 DAS and harvest, respectively),number of branches (4.55, 6.45, 8.35 and 10.37 at 30,60,90 DAS and at harvest, respectively) and early germination (6.33)were recorded with seed treatment of *Bradyrhizobium japonicum +Pseudomonas fluorescence* with theapplication of full dose of RDF and The maximum number of pods per plant(46.43), length of pod (9.76 cm), test weight(4.11g), seed yield(13.53 Qha^{-1}) and crude protein content(7.47 %) were obtained with same treatment combination.

Keywords: Shankapushpi, *Bradyrhizobium japonicum*, *Pseudomonas fluorescence*

Introduction
India is the largest producer of medicinal herbs and known as the botanical garden of the world. Officially, over 3000 plants were recognized in India for their medicinal value and about 200 native plant species are in wide use for their curative properties. Shankapushpi also known as butterfly pea is one of the important medicinal plant used for boosting memory, improving intellect and also to cure mental illness. It is a perennial leguminous twiner, botanically known as *Clitoria ternatea* L. belonging to the family Fabaceae, originated from tropical Asia and distributed widely in South and Central America. The plant mainly used as a forage as it is highly palatable for live-stock apart from its various medicinal usage.
Butterfly pea is vigorous, strongly persistent and it is long-lived perennial herb with an erect growth habit. The plant is adaptable to a wide range of temperature, rainfall and altitude, but susceptible to frost and doesnot grow well during cold spells in winter. The rainfall requirements ranges from 400mm to 1500 mm per annum, sensitive to water logging and flooding and it is claimed to have some tolerance to salinity. The shankapushpi is considered as Madhya-Rasayana in *Ayurveda* and reported as nervine tonic and laxative. The leaves of shankapushpiconatains glycosides *viz*., kaempferol-3-glucoside, kaempferol-3-rutinoide and kaempferol-3-neohesperidoside.The root contains ternatins, alkaloids, flavonoids, saponins, tannins, carbohydrates, proteins, resins, starch, taraxerol and taraxerone. The seeds have nucleoprotein with its aminoacid sequence similar to insulin, delphinidin-3, 3, 5-triglucoside, essential amino-acids, pentosan and water soluble mucilage (Zingare *et al.*, 2013) [8]. The root powder of *clitorea* is used as one of the ingredients in the preparation of the drug "SULAK" and its ointment to treat leprosy. The flower is also being used traditionally as diuretic, anthelmintic, purgative, demulcentand remedy for rheumatism, bronchitis, urinogenitaldisorderand cancer (Subramanian and Prathyusha, 2011) [6].

Materials and Methods
The field experiment was conducted at College of Horticulture, University of Horticultural Sciences Campus, Gandhi Krishi Vignana Kendra (Post), Bengaluru during June to November

2016-17. Shankapushpi seeds (Local type) were collected from Sanjeevini Vatika, Division of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, and Bengaluru.

The native *Rhizobium* strain was collected from root nodules of shankapushpi and *Pseudomonas fluorescence* was collected from the Department of Agricultural Microbiology, UAS (B) and used for seed treatment of shankapushpi. The experiment comprises of treatements *Viz.*, with three replication by using RCBD design and treatments *viz*. T_1 - Recommended dose of fertilizers (control) T_2 -Recommended dose of fertilizers + *Bradyrhizobium japonicum* T_3 -Recommended dose of fertilizers + *Pseudomonas fluorescens* T_4-Recommended dose of fertilizers +*Bradyrhizobium japonicum*+ *Pseudomonas fluorescens* T_5 -75 % Recommended dose of fertilizers + *Bradyrhizobium japonicum* T_6-75% Recommended dose of fertilizers + *Pseudomonas fluorescens* T_7-75% Recommended dose of fertilizers + *Bradyrhizobium japonicum* + *Pseudomonas fluorescens* T_8 - 50 % Recommended dose of fertilizers + *Bradyrhizobium japonicum* T_9 -50 % Recommended dose of fertilizers +*Pseudomonas fluorescens* T_{10} -50 % Recommended dose of fertilizers+ *Bradyrhizobium japonicum*+ *Pseudomonas fluorescens* nd these were replicated thrice in RCBD.

Results and Discussion

Theseed treatment of *Bradyrhizobium japonicum* + *Pseudomonas fluorescens* and application of full dose of RDF has recorded early germination (6.33 days), maximum germination (70.75%).The early and maximum germination may be due to the effect of PGPR in creating favorable condition through secretions of vitamins and growth promoting substances. The results are in line with those obtained by Abdolshakoor *et al*. (2012) [1] in Isabgol.

The seeds treated with combination of two plant growth promoting rhizobacteria along with the application full dose of NPK has recorded the maximum plant height of 13.50 cm, 24.08 cm, 46.25 cm and 60.07 cm at 30, 60. 90 days after sowing and at harvest, respectively and was followed by seed treatment of *Bradyrhizobium japonicum* and application of full dose RDF (12.92 cm, 23.86 cm, 44.42 cm and 59.10 cm at 30, 60, 90 days after sowing and at harvest, respectively). While, the least plant height was recorded with seed treatment of *Pseudomonas fluorescens* + 50 per cent RDF at all the growth stages. The similar trend was followed with number of branches. The increased plant height may be due to inoculation of plant growth promoting rhizobacteria on the seed before sowing, so that they were able to establish themselves on the roots and directly affect on plant growth and development through the fixation of atmospheric nitrogen, increased phosphorus solubilization and mobilization through the production of plant hormones. Further Rhizobium and *Pseudomonas fluorescens* performed better when the soil is well supplied with nutrients particularly nitrogen through organics, which resulted in increased in cell division and cell elongation which in turn increased the plant height and number of branches. These findings are in line with Abdolshakoor *et al*. (2012) [1] in isabgol.

The seed treatment of *Bradyrhizobium japonicum*+ *Pseudomonas fluorescens* with full dose of RDF has recorded maximum pods per plant (46.43), maximum length of pod (9.76 cm), width of pod of (1.00 cm), pod weight (0.63 g), seeds per pod (8.03), seed weight per pod (0.45 g), seed weight per plant (18.26 g), test weight (4.11 g), seed yield (13.53 Q ha^{-1}) and biological yield (25.90 Q ha^{-1}). The maximum number of pods may be attributed to the role of *Rhizobium* and adequate supply of nutrients might have helped in increased vegetative growth in terms of higher plant height and number of branches. The increased vegetative growth resulted in synthesis of greater amount of food materials, which in turn supported profused flowering and pod setting and resulted in maximum number of pods. The increased pod length and width may be due to better vegetative growth exhibited by plants because of optimum dose of nutrients and role of *Rhizobium* which inturn responsible for vigourous growth and of production of greater amount of photosynthates, which helped in production sizable pods as compared to other treatments. The increased test weight could be due to highernutrients levels leads to accumulation of functional photosynthates which inturn might have resulted in bolder seeds leading to maximum seed weight. These results are in concurrence with Yadav and Kumawat (2003) [7] and Purbey and Sen (2005) [5] in fenugreek. The seed treatment of *Bradyrhizobium japonicum*+ *Pseudomonas fluorescens*and application offull dose of RDF has recorded significantly maximum crude protein content and yield (7.47% and 101.07 kg ha^{-1}, respectively). This might be due to the role of *Rhizobium* helped in fixation of atmospheric nitrogen and optimum dose of nutrient, which in return resulted in translocation and accumulation of secondary metabolites. These results are in agreement with those obtained by Purbey and Sen (2005) [5] in fenugreek.

Table 1: Influence of plant growth promoting rhizobacteria on growth attributes of *Clitorea ternatea* L.

Treatments	Days to Germination	Germination %	Plant height (cm)				Number of branches			
			30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 - RDF (control)	10.00	56.47	11.03	21.88	42.88	56.96	3.23	5.23	7.13	8.76
T_2 - RDF + *Bradyrhizobium japonicum*	7.00	70.30	12.92	23.86	44.42	59.10	4.37	6.35	8.13	9.77
T_3 - RDF + *Pseudomonas fluorescens*	7.67	66.82	12.69	23.77	44.17	58.00	4.20	6.22	7.87	9.62
T_4 - RDF + *Bradyrhizobium japonicum*+ *Pseudomonas fluorescens*	6.33	70.75	13.50	24.08	46.25	60.07	4.55	6.45	8.35	10.37
T_5 - 75% RDF + *Bradyrhizobium japonicum*	8.67	38.63	11.88	22.65	43.65	57.25	3.75	5.82	7.50	9.27
T_6 - 75% RDF + *Pseudomonas fluorescens*	9.00	63.33	11.50	22.25	43.60	57.00	3.62	5.13	7.29	8.95
T_7 - 75% RDF + *Bradyrhizobium japonicum*+ *Pseudomonas fluorescens*	8.00	61.80	12.17	23.01	43.85	57.63	4.03	6.05	7.68	9.48
T_8 - 50% RDF + *Bradyrhizobium japonicum*	10.67	42.83	10.42	21.25	42.13	55.60	2.75	4.91	5.89	8.53
T_9 - 50% RDF + *Pseudomonas fluorescens*	12.00	41.83	10.04	20.99	41.63	52.38	2.50	4.72	6.26	8.33
T_{10} - 50% RDF + *Bradyrhizobium japonicum*+ *Pseudomonas fluorescens*	10.33	55.57	10.74	21.67	42.75	56.04	3.06	5.20	6.78	8.66
F test	*	*	*	*	*	*	*	*	*	*
S.Em±	0.56	0.66	0.27	0.41	0.42	0.69	0.11	0.15	0.23	0.22
CD at 5 %	1.65	1.97	2.81	0.79	1.22	1.25	2.06	0.32	0.45	0.68

DAS – Days After Sowing, RDF – Recommended Dose of Fertiliz

Table 2: Effect of plant growth promoting rhizobacteria on yield and quality of *Clitorea ternatea* L.

Treatments	Number of pods per plant	Length of pod (cm)	Width of pod (cm)	Number of Seeds per Pod	Seed weight per plant(g)	Test Weight (g)	Seed yield (Q ha^{-1})	Biological yield (Q ha^{-1})	Crude protein content (%)	Crude protein yield (Kg ha^{-1})
T_1 - RDF (control)	36.73	8.70	0.80	6.74	15.12	3.59	11.20	21.08	6.09	68.21
T_2 - RDF + *Bradyrhizobium japonicum*	45.50	9.50	0.95	7.97	17.32	3.85	12.83	24.39	7.32	93.92
T_3 - RDF + *Pseudomonas fluorescence*	43.20	9.47	0.92	7.37	17.11	3.83	12.68	23.71	6.9	87.49
T_4 - RDF + *Bradyrhizobium japonicum+ Pseudomonas fluorescence*	46.43	9.76	1.00	8.03	18.26	4.11	13.53	25.90	7.47	101.07
T_5 - 75% RDF + *Bradyrhizobium japonicum*	39.66	8.82	0.87	6.73	15.93	3.63	11.80	22.02	6.34	74.81
T_6 - 75% RDF + *Pseudomonas fluorescence*	38.50	8.80	0.83	6.59	15.52	3.60	11.50	21.42	6.15	70.73
T_7 - 75% RDF + *Bradyrhizobium japonicum+ Pseudomonas fluorescence*	41.50	9.00	0.89	6.80	16.20	3.68	12.00	22.62	6.67	80.04
T_8 - 50% RDF + *Bradyrhizobium japonicum*	34.65	8.37	0.76	6.29	13.02	3.43	9.65	19.18	5.90	56.94
T_9 - 50% RDF + *Pseudomonas fluorescence*	32.32	8.09	0.74	6.07	12.82	3.05	9.50	18.65	5.77	54.82
T_{10} - 50% RDF + *Bradyrhizobium japonicum+ Pseudomonas fluorescence*	34.50	8.57	0.78	6.41	13.52	3.54	10.02	19.82	5.98	59.92
F test	*	*	*	*	*	*	*	*	*	*
S.Em±	0.83	0.15	0.02	0.11	0.44	0.08	0.32	0.45	0.02	2.41
CD at 5 %	2.46	0.43	0.07	0.31	1.30	0.24	0.96	1.34	0.05	7.15

DAS – Days After Sowing, RDF – Recommended Dose of Fertilizers

Conclusion

The present investigation reveals that, the seed treatment with *Bradyrhizobium japonicum* + *Pseudomonas fluorescens* and application of full dose of RDF has resulted in better growth, maximum yield and good qualityshankapushpiseeds under rainfed condition.

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