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RESEARCH ARTICLE

AM FUNGI AND PHOSPHATE SOLUBILIZING BACTERIA (*Paenibacillus polymyxa*) AS A POTENTIAL BIOINOCULANT FOR MARIGOLD

***Ramlakshmi, R. and Bharathiraja, S.**

Department of Microbiology, Annamalai University, Annamalainagar, Chidambaram, Tamilnadu, India

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ABSTRACT

Mycorrhizae are symbiotic association between higher plant roots and certain fungi which plays a key role in the mobilization of phosphorus and natural cycling of various nutrients in the ecosystem and also protect plants against environmental stresses and pathogenic organisms. Marigold is an economically important flower crop and it can be cultivated round the year. Marigold flowers has got popularity among gardeners and dealers due to its easy cultivation and wide adaptability. Both leaves and flowers of marigold are equally important in medicine field due to medical properties, the essential oil of marigold also valuable use in perfume industry. Marigolds are ideal for cut flowers especially for making garland. The present investigation was carried out in the pot culture house, Department of microbiology, Annamalai University. The growth and yield of marigold was significantly enhanced by the inoculation of AM fungi + phosphobacteria with 75% of P and 100% N&K fertilizers (T_{10}) it was followed by (T_{13}) which constituting AM fungi (*Glomus fasciculatum)*+ Phosphobacteria (*Paenibacillus polymyxa)* and 50 % P and 100% N&K fertilizers. Based on the above triats, AM fungi (*Glomus fasciculatum)* +Phosphobacteria (*Paenibacillus polymyxa*) were found to be a potential bioinoculant for Marigold to obtain maximum yield with the reduction of 25 percent Phosphatic fertilizers.

INTRODUCTION

India is one of the Asian largest nation in the world and having rich tradition in the cultivation of different types of economically important flower crops. Among which, Marigold is a impartant flower crop and can be cultivated throughout the year. Marigold plant has got much importance in industries and medicinal field due to medical properties and desirable fragrance as well as its adaptability to different environmental conditions (Garrido *et al*., 2010). Marigolds are ideal for making flower garden because of attractive and colorful flowers. In India the area under floriculture are 60487.6 ha. The highest area of under floriculture was found in Karnataka, followed by Tamilnadu (16745.ha). Arbuscular Mycorrhizal Fungi is the most abundant kind of mycorrhizal fungi inhabited in the soil can colonize into cortical cells of roots, thus forming inter cellular structures, vesicle and Arbuscle in the root cortex (Gaude *et al*., 2012). The NPK are the essential nutrients required by plants in which Phosphorus plays a vital rolefrom the germination to harvest of the crop plants. Phosphorus is second only to the nitrogen as an essential nutrient for crop production and is contributing 0.2 percent of plant dry weight, most of the Indian soils contain more amount of phosphorus in unavailable form, and In order to improve the availability of phosphorus, Microbiologists are recommending phosphobacteria to almost all types of crop plants. Apart from phosphobacteria it is an essential need to recommend AM fungi to overcome phosphorus deficiency in all types of crop plants.

The application of inorganic fertilizer alone cannot meet the crop requirements thus there is a renewed interest to the use of bioinoculants that improve the mineral uptake, disease resistant and drought tolerance in Marigold production. The present investigation was therefore aimed study the inoculation of AM fungi and phosphobacteria with the graded leaves NPK fertilizers on the growth and yield of Marigold.

MATERIALS AND METHODS

The present research work has been carried out to find the influence of AM fungi and phosphobacteria with recomented dosage of NPK fertilizers on the growth and yield of Marigold (T*agets erecta. L*) var golden yellow was selected and used for this experiment. The inoculants of AM fungi was isolated and screened based on the efficiency the best isolate was selected and used for field experiments. The culture consists of live arbuscular mycorrhizal fungal spores of single species in root based inoculum in the tissues of previous host and soil. They

Corresponding author:* ***Ramlakshmi, R.*
Department of Microbiology, Annamalai University, Annamalainagar, Chidambaram, Tamilnadu, India.

were maintained at 5^0 c for storage. The soil inoculum was prepared by adding garden land soil and the sand in the ratio of 1:1 the pots were filled with soil and fumigated by using 10% formaldehyde solution. About 50 g of mycorrhizal inoculum was added each pots containing sterilized substrates.

Arbuscular mycorrhizal fungal spores were estimated from the rhizosphere soil by wet sieving and decanting method (Gerdemann and Nicolson 1963). The percent root colonization of AM fungal spores was determined by the methods as described by phillips and Hayman 1970. The biometric observation *viz*., plant height, no. of leaves, no. of flowers, flower yield, Dry matter production, and chlorophyll content was analysed. The experiment was laid out eith the following principles of randomized block design. The plants were subjected to thirteen treatments each one was replicated thrice and in each replication 12 plants were maintained.

TREATMENT DETAILS

T_1 - Control
T_2 - NPK control
T_3 - *Glomus fasciculatum*
T_4 - *Paenibacillus polymyxa*
T_5 - 100% NPK + *Glomus fasciculatum*
T_6 - 100% NPK + *Paenibacillus polymyxa*
T_7 - 100% NPK + *Glomus fasciculatum* + *Paenibacillus polymyxa*
T_8 - 75% P and 100% NK + *Glomus fasciculatum*
T_9 - 75% P and 100% NK+ *Paenibacillus polymyxa*
T_{10} - 75% P and 100% NK + *Glomus fasciculatum* + *Paenibacillus polymyxa*
T_{11} - 50% P and 100% NK +*Glomus fasciculatum*
T_{12} - 50% P and 100% NK + *Paenibacillus polymyxa*
T_{13} - 50% P and 100% NK + *Glomus fasciculatum* + *Paenibacillus polymyxa*

RESULTS AND DISCUSSION

Arbuscular mycorrhizae are ubiquitous in soils that colonize the root and increase the growth and yield of agriculturally important plant species (Jeffries *et al*., 1989). Mycorrhizal infection may affect the mineral nutrients of the host plant directly by enhancing plant growth through nutrient acquisition by fungal mycelium from the surrounding soil, or directly by modifying transpiration rates and the composition of rhizosphere microflora (Marschner and Dell, 1994). (Fester *et al*., 2005) The response of *crossandra* to *Glomus fasciculatum* and Phospobacteria with graded levels of NPK *viz*., 50, 75 and 100% NPK/ha was studied. AM fungal inoculation induced maximum plant height, No. of leaves, and No.of flowers, early flowering in *Crossandra* (Bharathiraja and Tholkappian 2011 b). Inoculation with m Mycorrhizae enhanced plant height, shoot length and fruit yield in Bhendi *Abelmoschus esculentus* (Sivakumar and Tholkappian 2013).

The results on the effect of *Glomus fasciculatum* and *Paenibacillus polymyxa* on plant height of Marigold were recorded 30, 60, 90 days after and are presented in Table 1. All the treatment showed significant increase in plant height when compared with control. However the treatment T_{10} 75% P + 100% N&K + *Glomus fasciculatum* and *paenibacillus polymyxa* recorded maximum plant height of 23.35 cm,43.08 and 63.28 cm on 30, 60, and 90 DAT respectively.

Table 1. Effects of *Glomus fasciculatum* and phosphobacteria with graded levels of inorganic phosphorus on the plant height of Marigold

Treatments	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
T_1 Control	18.00	29.45	49.65
T_2 100% NPK alone	22.45	35.13	54.00
T_3 *Glomus fasciculatum* alone	18.29	29.55	50.39
T_4 *Paenibacillus polymyxa* alone	18.26	29.50	49.73
T_5 100% NPK + *Glomus fasciculatum*	20.23	39.00	57.15
T_6 100% NPK + *Paenibacillus polymyxa*	20.00	38.25	56.15
T_7 100% NPK +*Glomus fasciculatum* +Paenibacillus polymyxa	22.36	40.90	60.23
T_8 75% P and 100% N&K + *Glomus fasciculatum*	21.06	39.90	59.00
T_9 75% P and 100% N&K + *Paenibacillus polymyxa*	20.96	38.59	58.18
T_{10} 75% P and 100% N&K + *Glomus fasciculatum* + *Paenibacillus polymyxa*	23.35	43.08	63.28
T_{11} 50% P and 100% N&K +*Glomus fasciculatum*	19.80	37.25	56.00
T_{12} 50% P and 100% N&K + *Paenibacillus polymyxa*	19.09	36.90	53.33
T_{13} 50% P and 100% N&K + *Glomus fasciculatum* + *Paenibacillus polymyxa*	23.32	41.39	60.63
SE	0.46	0.60	1.52
CD (p=0.05)	0.93	1.23	3.06

Table 2. Effects of *Glomus fasciculatum* and phosphobacteria with graded levels of inorganic phosphorus on the number of flowers per plant in marigold

S.No	Treatments	Number of flowers plant $^{-1}$	Diameter of flower (cm)
1	T_1 Control	15.55	6.40
2	T_2 100% NPK alone	19.00	8.63
3	T_3 *Glomus fasciculatum* alone	16.55	6.60
4	T_4 *Paenibacillus polymyxa* alone	16.35	6.53
5	T_5 100% NPK + *Glomus fasciculatum*	20.49	9.90
6	T_6 100% NPK + *Paenibacillus polymyxa*	20.53	9.53
7	T_7 100% NPK +*Glomus fasciculatum* +*Paenibacillus polymyxa*	24.03	10.96
8	T_8 75% P and 100% N&K + *Glomusfasciculatum*	21.55	9.93
9	T_9 75% P and 100% N&K + *Paenibacillus poliymyxa*	21.43	9.60
10	T_{10} 75% P and 100% N&K + *Glomus fasciculatum* + *Paenibacillus polymyxa*	26.43	11.60
11	T_{11} 50% P and 100% N&K +*Glomus fasciculatum*	19.57	8.90
12	T_{12} 50% P and 100% N&K + *Paenibacillus polymyxa*	19.33	8.70
13	T_{13} 50% P and 100% N&K + *Glomus fasciculatum* + *Paenibacillus polymyxa*	24.63	10.98
	SE	1.21	0.33
	CD (p=0.05)	2.42	0.66

It was followed by T_{13} (50% P +100% N & K) as 23.32 cm, 41.39 cm and 60.63 cm.

It was observed that plant height was significantly improved by the treatments (T_5-T_{13}) receiving *Glomus fasciculatum* and phosphobacteria either individually or in combination along with graded levels (100, 75 and 50 %) of inorganic fertilizers.
The data recording mean performance on the number of flowers per plant due to inoculation of AM fungi and phosphobacteria with graded levels of NPK on 30, 60, 90 DAT are represented in (Table 2). The maximum no. of flowers was noticed in treatment T_{10} 75 % P and

100% N&K + *Glomus fasciculatum* and *Paenibacillus polymyxa* at harvest on 90 DAT compared with control.

The effect of AM fungi and phosphobacteria with graded levels of inorganic phosphorus on the mean diameter of marigold flowers are presented in Table 2. There was significant increase in the diameter of flowers in all the treatments compared to control , where as T_{10} and T_{13} recorded on par values in allmost all growth and yield parameters. Among the treatments, the maximum 11.60 cm mean diameter of flowers recorded in treatment T_{10} (75% P and 100% N & K +*Glomus fasciculatum* + *Paenibacillus polymyxa*). It was followed by T_{13} (50% P +100% N & K) as 10.98 cm. Minimum diameters of flowers were showed in control (6.40 cm).

Conclusion

Based on the above findings, it is clear that the use of AM fungi and phosphobacteria with graded levels of NPK fertilizers, can stimulate the growth and yield of Marigold (*Tagets erecta.L*) with the minimized use of chemical fertilizer and leads to reduction of 25% to 50% cost of chemical fertilizers.

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