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RESEARCH ARTICLE :

Effect of inoculation with VAM fungi at different P levels on flower yield, petal meal yield, mycorrhizal spore count in the root- zone soil and percentage root colonization (PRC) of *Tagetes erecta* L.

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Marigold, VAM, Phosphorus, *Glomus fasciculatum*, *G. mosseae*, *G. Intraradices*, Yield, Petal meal, Mycorrhiza, Spore count

SUMMARY : In this experiment the VAM fungi *viz.*, *Glomus fasciculatum* (Thaxter) Gerd. and Trappe, *Glomus mossea* (Nicol. and Gerd.) Gerd. and Trappe, *Glomus intraradices* Schenck and Smith. with an un-inoculated control was maintained and three P levels *viz.*, 60, 90, 120 kg ha^{-1} were tried. The results brought out that the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest number of flowers per plant (117.80) and least was observed in uninoculated control plants with given P at 60kg/ ha (80.53). Similarly, the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly maximum flower yield (626.73 g/ plant, 17.83 t/ ha) and it was statistically on par with *G. mosseae* (618.73 g/ plant, 17.73 t/ ha) at the same level of P and least was observed in uninoculated control plants with given P at 60kg/ ha (446.73 g/ plant, 11.61 t/ ha). Petal meal yield per kilogram of fresh flower (87.83 g), petal meal yield per hectare (15.66 q), were significantly higher with the inoculation of *G.fasciculatum* and given P at 90 kg/ ha followed by *G. mosseae* (83.83g and 14.85 q, respectively) at the same level of P than the other species of *Glomus* fungi and uninoculated control. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest spore count (279.67 and 407.67, respectively) and highest PRC (85.33 and 93.67, respectively) which was found to be superior as compared to other species of *Glomus* fungi.

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BACKGROUND AND OBJECTIVES

Marigold (*Tagetes erecta* L.) is one of the most commonly grown commercial flower crops in India. In India marigold ranks first among the loose flowers followed by chrysanthemum, jasmine, tuberose, crossandra and barleria (Bhattacharjee *et al*., 2002). Marigold (*Tagetes erecta* L.) belongs to the family Asteraceae and genus *Tagetes*. The two main popularly grown species in marigold are *Tagetes erecta* L. and *Tagetes patula* L.

which have their origin in Mexico and South Africa, respectively. *Tagetes erecta* L. is popularly known as "African marigold" while *Tagetes patula* L. as "French marigold". There are several other important species *viz.*, *Tagetes tenuifolia* L. (the striped marigold), *Tagetes lucida* L. (the sweet scented marigold), *Tagetes minuta* L. and *Tagetes lacera* L.

Compared to any other flowering annuals, marigold is easily adaptable to various conditions of growing and has fairly good keeping quality. It is propagated by seeds and comes up well in all types of soil. The flowers of these species are generally large in size with bright shades, ranging from yellow to orange and are the best for combination in any flower arrangement. Marigold is grown for cut flowers, making garlands, decoration during pooja and several religious functions, besides its use in landscape gardening. Apart from its significance in ornamental horticulture, it has been valued for other purposes too. The aromatic oil extracted from marigold, is called as "tagetes oil". It is used in preparation of high grade perfumes and also as an insect fly repellant.

Marigold is a heavy feeder of nutrients, at present these nutrients are supplied through chemical fertilizers. The indiscriminate and continuous use of chemical fertilizers in intensive cropping system has led to an imbalance of nutrients in soil which has an adverse effect on soil health. The balanced use of chemical fertilizers improves the physico-chemical properties of soil besides increasing the efficiency of applied fertilizers.

The symbiosis of plant roots with arbuscular mycorhizal fungi is known to be one of the most ancient and widespread plant strategies to enhance nutrient acquisition and to cope with environmental stress (Brachmann and Parniske, 2006). The intra-radical mycelium of these soil fungi proliferates in the root cortex of the host plant. Extra radical AM hyphae spread in the soil around the root and provide the surface area by which the VAM fungus absorbs nutritional elements such as phosphorus (P), nitrogen (N), zinc (Zn) or copper (Cu) for transport and transfer to the host plant (Smith and Read, 2008). Many workers have reported the enhancement of phosphate uptake and growth of leguminous plants by vesicular arbuscular mycorhizal fungi (VAM) (Atimanav and Adholeya, 2002). Therefore, the main aim of this study was to investigate the effects of different mycorrhizal species on marigold at different P levels. Mycorrhizae are important for plant P acquisition, since fungal hyphae greatly increase the volume of soil that plant roots explore (Smith and Read, 1997). In certain plant species, root clusters (proteoid roots) are formed in response to P limitations. These specialized roots exude high amounts of organic acids (upto 23% of net photosynthesis), which acidify the soil and chelate metal ions around the roots, resulting in the mobilization of P and some micronutrients (Marschner, 1995). Studies have indicated that inoculation of pepper with VAM significantly increased plant growth and yield compared to uninoculated control (Thanuja, 2002).

Considering its importance as commercial flower crop, the study on effect of VAM fungi on marigold at different phosphorus levels was initiated.

RESOURCES AND METHODS

A factorial experiment was laid out in Randomized Block Design. There were 12 treatment combinations each three replications. In the present experiment VAM fungi (*Glomus fasciculatum, G. mosseae, G. intraradices* with an uninoculated control) and three levels of phosphorus (60, 90, 120 kg ha^{-1}) were tried in all possible combinations.

Treatment details are as follows.

Factor I = Mycorrhizal species :

M_1- *Glomus fasciculatum* (Thaxter) Gerd. and Trappe.
M_2- *Glomus mossea* (Nicol. and Gerd.) Gerd. and Trappe.
M_3- *Glomus intraradices* Schenck and Smith.
M_o- Uninoculated control.

Factor II = Phosphorus levels : 3

(225kg N + 60kg K_2O as constant)

Treatment combination:		
Treatments No.	Treatments	Combination
T_1	M_0P_1	Uninoculation + 60 kg P_2O_5/ ha
T_2	M_0P_2	Uninoculation + 90 kg P_2O_5/ ha
T_3	M_0P_3	Uninoculation + 120 kg P_2O_5/ ha
T_4	M_1P_1	*G. fasciculatum* + 60 kg P_2O_5/ ha
T_5	M_1P_2	*G. fasciculatum* + 90 kg P_2O_5/ ha
T_6	M_1P_3	*G. fasciculatum* + 120 kg P_2O_5/ ha
T_7	M_2P_1	*G. mosseae* + 60 kg P_2O_5/ ha
T_8	M_2P_2	*G. mosseae*+ 90 kg P_2O_5/ ha
T_9	M_2P_3	*G. mosseae* + 120 kg P_2O_5/ ha
T_{10}	M_3P_1	*G. intraradices*+ 60 kg P_2O_5/ ha
T_{11}	M_3P_2	*G. intraradices* + 90 kg P_2O_5/ ha
T_{12}	M_3P_3	*G. intraradices* + 120 kg P_2O_5/ ha

P_1- 60 kg P_2O_5/ ha
P_2- 90 kg P_2O_5/ ha
P_3- 120 kg P_2O_5/ ha

Observations on yield and its attributes :

Number of flowers per plant:

Number of flowers from each harvest was counted till the final harvest in the tagged plants and the average number of flowers per plant was worked out.

Flower yield per plant (*g*):

After recording the number of flowers per plant all the flowers were weighed separately at every harvest till the final harvest and the average flower yield per plant was calculated.

Flower yield per hectare (*t/ ha*):

Flowers from plants other than tagged ones in net plot area were harvested separately and weighed treatment-wise. To this, flower weight of tagged plants was added to get net plot yield. Based on total net plot yield, yield per hectare was calculated.

Petal meal yield per kilogram of fresh flower (*g*):

One kilogram of fresh flower taken treatment wise at peak flowering stage and kept for shade drying in laboratory for 20 days. Then the dried petals were separated from calyx and seed part of each flower and made into fine powder with the help of grinder mixture. The ground fine powder was weighed treatment wise and recorded as petal meal in grams per kilogram of fresh flower.

Petal meal yield per hectare (*q*) :

Petal meal yield per hectare was estimated based on the petal meal yield obtained per kilogram of fresh flower weight and it was multiplied by using the total flower yield per hectare and expressed as quintals per hectare.

Observations onVAM parameters :

Mycorrhizal spore count in the root zone soil:

Extra metrical clamydospores produced by VAM mycorrhizal fungi were determined by using wet sieving and decanting method given by Gerdemann and Nicolson (1963).

50g of representative soil samples drawn from each plot of rhizosphere after 60 and 90 days after transplanting were suspended in sufficient quantity of water and stirred thoroughly. It was allowed to stand for one minute undisturbed before decanting on to the sieves. The suspension was passed through a set of sieves with mesh size 1000, 300, 250, 105 and 45 µm arranged in the descending order. The spores collected in the last two sieves were transferred on to a nylon mesh with pore size of 45 µm. Spore count was done by using stereomicroscope.

Per cent root colonization (*PRC*):

The percentage mycorrhizal colonization of the plant roots was determined after 60 and 90 days after transplanting (pre blossoming and peak blossoming stage, respectively) according to the method followed by Phillips and Hayman (1970).

Root samples were cut into one cm pieces and fixed in FAA (Formalin: acetic acid: alcohol, 5:5:90) for two hours. Roots were then cleared by autoclaving with 10 per cent KOH at 1.1 kg cm^{-2} pressure for 15 minutes. The alkalinity due to KOH was neutralized by one per cent HCl for 5 minutes. Staining was done by simmering the roots in 0.05 per cent tryphan blue in lactoglycerol (Lactic acid 400 ml: glycerol 500 ml and distilled water 100 ml) for 10 minutes. Excess stain was removed and roots were kept in lactoglycerol. The stained root bits were arranged on slides, covered with cover slips and observed under microscope for VAM mycorrhizal mycelium, vescicles and arbuscles. Then per cent colonization was calculated by the following formula.

$$\text{Per cent root colonization} = \frac{\text{Number of root bits positive for colonization}}{\text{Number of root bits observed}} \times 100$$

In the investigation 100 stained root bits were observed in each replicate sample.

OBSERVATIONS AND ANALYSIS

The data on number of flowers per plant, flower yield per plant and flower yield per hectare as influenced by inoculation of *Glomus* fungi at different levels of P is presented in Table 1. The data on petal meal yield per kilogram of fresh flower and petal meal yield per hectareas influenced by inoculation of *Glomus* fungi at different levels of P is presented in Table 2. The data on spore count as influenced by inoculation of *Glomus* fungi at different levels of P recorded at 60 and 90 DAT and

data on per cent root colonization (PRC) as influenced by inoculation of *Glomus* fungi at different levels of P recorded at 90 and 120 DAT are presented in Table 3.

Number of flowers per plant :

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was significant. It was increased with the increase in P levels upto 120kg/ ha in uninoculated control plants, whereas in the inoculated plants the number of flowers was found to be highest at P level 90 kg/ ha. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest number of flowers per plant (117.80) and it was found to be superior as compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants with given P at 60kg/ ha (80.53).

Flower yield per plant (g) :

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was significant. It was increased with increase in P levels upto 120kg/ ha in uninoculated control plants, whereas in the inoculated plants the flower yield was increased at P level 90 kg/ ha. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly maximum flower yield (626.73 g) and it was statistically on par with *G. mosseae* (618.73 g) at the same level of P which was found to be superior as

Table 1: Effect of inoculation with VAM fungi at different P levels on number of flowers per plant, flower yield per plant, flower yield per hectare of *Tagetes erecta* L.

Treatments	Number of flowers per plant	Flower yield per plant (g)	Flower yield per hectare (t)
Mycorrhiza			
M_0 - Uninoculated control	89.71	513.53	14.37
M_1 - *Glomus fasciculatum*	104.80	555.64	15.56
M_2 - *Glomus mosseae*	102.62	556.64	16.17
M_3 - *Glomus intraradices*	84.71	472.67	12.57
S.E.±	0.40	1.16	0.03
C.D. (P=0.05)	1.18	3.40	0.09
Phosphorus levels (kg/ha)			
P_1 - 60	64.28	351.60	9.48
P_2 - 90	76.69	423.01	11.90
P_3 - 120	73.83	405.79	11.63
S.E. ±	0.30	0.87	0.02
C.D. (P=0.05)	0.88	2.55	0.07
Interaction (MXP)			
M_0P_1 - Uninoculated control + P @ 60	80.53	446.73	11.61
M_0P_2 - Uninoculated control + P @ 90	89.40	521.60	14.94
M_0P_3 - Uninoculated control + P @ 120	99.20	572.27	16.56
M_1P_1 - *Glomus fasciculatum* + P @ 60	85.93	491.67	12.97
M_1P_2 - *Glomus fasciculatum* + P @ *90*	117.80	626.73	17.83
M_1P_3 - *Glomus fasciculatum* + P @ 120	110.67	548.53	15.89
M_2P_1 - *Glomus mosseae* + P @ 60	92.73	474.87	13.44
M_2P_2 - *Glomus mosseae* + P @ 90	113.67	618.73	17.73
M_2P_3 - *Glomus mosseae* + P @ 120	101.47	576.33	17.35
M_3P_1 - *Glomus intraradices* + P @ 60	83.60	461.93	12.54
M_3P_2 - *Glomus intraradices* + P @ 90	88.13	489.00	12.95
M_3P_3 - *Glomus intraradices* + P @ 120	82.40	467.07	12.21
S.E.±	1.21	3.49	0.09
C.D. (P=0.05)	3.53	10.21	0.26

compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants with given P at 60kg/ ha (446.73 g).

Flower yield (t/ ha) :

The interaction effect of inoculation of *Glomus* fungi and P-fertilization on flower yield was significant. The flower yield was increased with increase in P levels up to 120kg/ ha in uninoculated control plants, whereas in the inoculated plants the flower yield was increased at P level 90 kg/ ha. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly maximum flower yield (17.83 t/ ha) and it was statistically on par with *G. mosseae* (17.73 t/ ha) at the same level of P which was found to be superior as compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants with given P at 60kg/ ha (11.61 t/ ha).

Petal meal yield per kilogram of fresh flower (g) :

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was significant. The petal meal yield was increased with the increase in P levels upto 120kg/ ha in uninoculated control plants, whereas in the inoculated plants the petal meal yield was increased at P level 90 kg/ ha. The plants inoculated with *G.*

Table 2: Effect of inoculation with VAM fungi at different P levels on petal meal yield per kilogram of fresh flower and petal meal yield per hectare of *Tagetes erecta* L.

Treatments	Petal meal yield per kilogram of fresh flower (g)	Petal meal yield per hectare (q)
Mycorrhiza		
M_0 - Uninoculated control	68.33	9.98
M_1 - *Glomus fasciculatum*	78.89	12.43
M_2 - *Glomus mosseae*	72.78	11.93
M_3 - *Glomus intraradices*	70.44	8.86
S.E.±	0.40	0.06
C.D. (P=0.05)	1.16	0.19
Phosphorus levels (kg/ha)		
P_1 - 60	46.50	5.89
P_2 - 90	60.34	9.63
P_3 - 120	56.53	8.78
S.E.±	0.30	0.05
C.D. (P=0.05)	0.87	0.14
Interaction (MXP)		
M_0P_1 - Uninoculated control + P @ 60	58.00	6.73
M_0P_2 - Uninoculated control + P @ 90	70.83	10.58
M_0P_3 - Uninoculated control + P @ 120	76.17	12.61
M_1P_1 - *Glomus fasciculatum* + P @ 60	69.00	8.94
M_1P_2 - *Glomus fasciculatum* + P @ *90*	87.83	15.66
M_1P_3 - *Glomus fasciculatum* + P @ 120	79.83	12.68
M_2P_1 - *Glomus mosseae* + P @ 60	61.67	8.28
M_2P_2 - *Glomus mosseae* + P @ 90	83.83	14.85
M_2P_3 - *Glomus mosseae* + P @ 120	72.83	12.64
M_3P_1 - *Glomus intraradices* + P @ 60	59.33	7.44
M_3P_2 - *Glomus intraradices* + P @ 90	79.33	10.28
M_3P_3 - *Glomus intraradices* + P @ 120	72.67	8.87
S.E.±	1.19	0.19
C.D. (P=0.05)	3.49	0.57

fasciculatum and given P at 90 kg/ ha recorded significantly highest petal meal yield in marigold (87.83 g), which was found to be superior as compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants with given P at 60kg/ ha (58.00 g).

Petal meal yield per hectare (q) :

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was significant. The petal meal yield was increased with the increase in P levels upto 120kg/ ha in uninoculated control plants, whereas in the inoculated plants the petal meal yield was increased at P level 90 kg/ ha. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest petal meal yield in marigold (15.66 q/ ha) and it was closely followed by *G. mosseae* (14.85 q/ ha) at the same level of P which was found to be superior as compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants with given P at 60kg/ ha (6.73 q/ ha).

Spore count (50 g $^{-1}$ rhizosphere soil):

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was significant spore count. The spore count increased with increase in P levels upto 90 kg/ ha

Table 3: Effect of inoculation with VAM fungi at different P levels on mycorrhizal spore count in the root- zone soil and percentage root colonization (PRC) of *Tagetes erecta* L.

Treatments	Mycorrhizal spore count		Percentage of root colonization (PRC)	
	60 DAT	90 DAT	60 DAT	90 DAT
Mycorrhiza				
M_0 - Uninoculated control	44.00	75.67	36.11	40.67
M_1 - *Glomus fasciculatum*	249.33	352.89	79.11	84.56
M_2 - *Glomus mosseae*	261.44	358.11	81.22	86.00
M_3 - *Glomus intraradices*	210.67	300.89	72.56	77.00
S.E.±	0.50	0.92	0.30	0.30
C.D. (P=0.05)	1.47	2.70	0.89	0.89
Phosphorus levels (kg/ha)				
P_1 - 60	133.81	190.06	48.44	52.06
P_2 - 90	154.13	221.06	52.75	57.06
P_3 - 120	142.63	200.63	50.13	53.00
S.E.±	0.38	0.70	0.23	0.23
C.D. (P=0.05)	1.10	2.02	0.66	0.67
Interaction (MXP)				
M_0P_1 - Uninoculated control + P @ 60	47.67	81.33	39.00	43.67
M_0P_2 - Uninoculated control + P @ 90	44.67	77.00	37.67	41.00
M_0P_3 - Uninoculated control + P @ 120	39.67	68.67	31.67	37.33
M_1P_1 - *Glomus fasciculatum* + P @ 60	211.00	306.67	71.67	75.33
M_1P_2 - *Glomus fasciculatum* + P @ *90*	279.67	407.67	85.33	93.67
M_1P_3 - *Glomus fasciculatum* + P @ 120	257.33	344.33	80.33	84.67
M_2P_1 - *Glomus mosseae* + P @ 60	247.00	340.00	76.67	82.67
M_2P_2 - *Glomus mosseae* + P @ 90	266.33	361.33	83.00	88.00
M_2P_3 - *Glomus mosseae* + P @ 120	271.00	373.00	84.00	87.33
M_3P_1 - *Glomus intraradices* + P @ 60	208.00	285.67	71.00	76.00
M_3P_2 - *Glomus intraradices* + P @ 90	231.33	333.00	75.33	81.67
M_3P_3 - *Glomus intraradices* + P @ 120	192.67	284.00	71.33	73.33
S.E.±	1.51	2.78	0.90	0.91
C.D. (P=0.05)	4.42	8.10	2.66	2.67

in both the inoculated plants and uninoculated control plants. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest spore count (279.67 and 407.67, respectively) as compared to other species of *Glomus* fungi and least spore count was observed in uninoculated control plants with given P at 120 kg/ ha (39.67 and 68.67, respectively) at 60 and 90 DAT, respectively.

Per cent root colonization (PRC):

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was significant on PRC. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest PRC (85.33 and 93.67, respectively) followed by *G. mosseae* (83.00 and 88.00, respectively) at the same level of P which was found to be superior as compared to other species of *Glomus* fungi and least PRC was observed in uninoculated control plants with given P at 120 kg/ ha (31.67 and 37.33, respectively) at 60 and 90 DAT, respectively.

Inoculation of VAM fungi alone increased the flower yield significantly (Fig. 1). The flower yield per hectare with the inoculation of *Glomus mosseae* (16.17 t / ha) and *G. fasciculatum* (15.56 t / ha) were significantly maximum as compared with the other VAM fungi and uninoculated control (14.37 t/ha). The flower yield was increased with increase in P level @ 120 kg P in uninoculated control. However, in the inoculated plants it was increased at 90 kg P. But in inoculation with *G. fasciculatum* and 90 kg of P recorded significantly maximum flower yield (17.83 t/ ha) followed by *G. mosseae* (17.73 t/ ha) at the same level of P as compared to the other VAM fungi and uninoculated control (16.56 t/ ha) at 120 kg of P.

M_0 - Uninoculated control
M_1 - *Glomus fasciculatum*
M_2 - *Glomus mossae*
M_3 - *Glomus intraradices*

P_1 – 60 kg P_2O_5/ ha
P_2 – 90 kg P_2O_5/ ha
P_3 – 120 kg P_2O_5/ ha

Fig. 1: Effect of inoculation with VAM fungi at different P levels on flower yield per hectare (t) of *Tagetes erecta* L.

Similar results were supported by Daft and Okusanya (1973) in petunia flower production and by Sreenivasa *et al*. (1993) in chilli. These results clearly indicates that the potential of saving of 25 per cent phosphatic fertilizer with the use of an efficient VAM fungus.

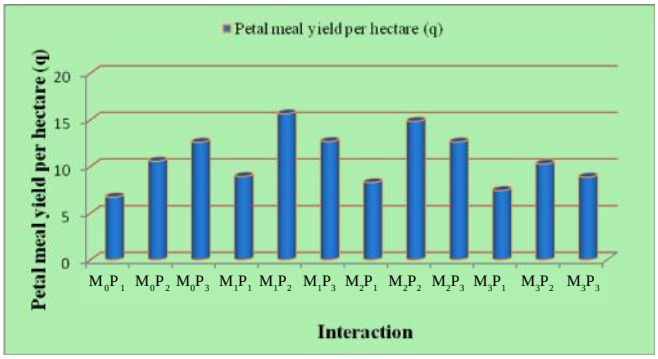
Flower yield is a manifestation of yield contributing characters like number of flowers per plant, flower size and flower yield per plant. Flower yield per plant also followed the similar trend as that of flower yield per hectare. Here also inoculation with *G. fasciculatum* and given P at 90 kg/ ha recorded maximum flower yield (626.73 g /plant) per plant followed by *G. mosseae* (618.73 g/ plant) at the same level of P compared to other species of *Glomus* fungi and uninoculated control (572.27 g) with full dose of P (120 kg/ ha). The present results are in conformity with the research findings of Hemla Naik *et al*. (1995) and Suneel *et al*. (2013) and Long *et al*. (2010).

Further, the yield per plant is determined by number of flowers per plant and flower size. Here also the plants inoculated with *G. fasciculatum* recorded maximum number of flowers (104.80) per plant as compared to other VAM fungi and uninoculated control. And it was significantly highest in inoculations with *G. fasciculatum* and given P at 90 kg/ ha (117.80) as compared to other VAM fungi and uninoculated control plants (99.20) applied with P at 120 kg/ ha. Similar trend was observed in flower size. Graham *et al*. (1981) observed increased the number of tubers in potato, similarly Kale *et al*. (1987) in aster and salvia in worm cast amended soils with VAM inoculation.

The difference in yield components could be attributed to the physiological characters, both in vegetative and reproductive phases of crop growth. Difference in dry matter production and its distribution into different plant parts (leaf, stem and flower) with the inoculation of VAM at various growth stages were mainly responsible for the increased in flower yield, number of flowers and flower size.

The difference in the petal meal yield per hectare in the treatments may be inturn attributed to the corresponding differences in yield components *viz*., petal meal yield per kilogram of fresh flower weight, flower yield per plant, number of petals per flowers, ten fresh

flowers and ten dry flowers weight (Fig. 2). The present results are in conformity with the research findings of Hemla Naik (2003) and Anuradha *et al*. (1990) in marigold, who also observed higher number of petals per flower, flower as well as petal meal yield and higher carotenioid contents.



M_0 - Uninoculated control
M_1 - *Glomus fasciculatum*
M_2 - *Glomus mossae*
M_3 - *Glomus intraradices*

P_1 – 60 kg P_2O_5/ ha
P_2 – 90 kg P_2O_5/ ha
P_3 – 120 kg P_2O_5/ ha

Fig. 2: Effect of inoculation with VAM fungi at different P levels on petal meal yield per hectare (q) of *Tagetes erecta* L.

The VAM parameters *i. e*., per cent root colonization and extramatricular chlamydospore number (sporulation) were significantly highest in the inoculated plants compared with these characters produced by native endophytes in the uninoculated control plants. The extent of root colonization and spore number varied with different VAM fungi. The highest root colonization and spore number makes more fungal-host contact and more exchange of nutrients and hence better plant growth.

Inoculation of *G. mosseae* (86.00 %) and *G. fasciculatum* (84.56%) recorded significantly highest PRC than other species of *Glomus* fungi and uninoculated control (40.67%). However, inoculation with the *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest PRC (93.67 %). The lowest was recorded in the uninoculated control plants with given p at 120 kg/ ha (37.33%). Regarding spore number the plants inoculated with G. *fasciculatum* and given P at 90 kg/ ha than higher P level (407.67). This might be due to higher levels of P depressed VAM development (Bagyaraj and Powell, 1985). The mechanism of P inhibition of mycorrhizal formation may be associated with membrane mediated root exudation (Hemla Naik *et al*., 1995; Graham *et al.*, 1981 and Sreenivasa and Bagyaraj, 1988).

It may suggest that the reduction of mycorrhizal infection in presence of added phosphorus is owing to a self regulatory mechanism of plant discarding the mycorrhizal fungus when its phosphorus requirement is more than that satisfied (Hayman, 1982 and Gazey *et al*., 2006). A general declining trend of VAM PRC and sporulation with application of higher levels of P has been found out by many authors (Sreenivasa *et al*., 1993).

Conclusion :

The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest number of flowers per plant (117.80), maximum flower yield (626.73 g/ plant, 17.83 t/ ha), Petal meal yield per kilogram of fresh flower (87.83 g) and petal meal yield per hectare (15.66 q), highest spore count (279.67 and 407.67, respectively at 60 and 90 DAT)and highest PRC (85.33 and 93.67, respectivelyat 60 and 90 DAT).

This indicates the possibility of reducing P fertilizer application by 25 % of the recommended dose to marigold by inoculation with a suitable strain of VAM fungi, *i. e.*,*G. fasciculatum* and *G. mosseae*.

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REFERENCES

Anuradha, K., Pampapathy, K. and Narayana, N. (1990). Effect of nitrogen and phosphorus on flowering, yield and quality of marigold. *Indian J.Hort.*, **47**: 353-357.

Atimanav, G. and Adholeya, A. (2002). AM inoculations of five tropical fodder crops and inoculum production in marginal soil amended with organic matter. *Biol. Fertil. Soil,* **35** : 214–218.

Bagyaraj, D.J. and Powell, C.L. (1985). Effect of VAM inoculation and fertilizer application on the growth of marigold. *New Zealand J. Agric. Res.*, **28**: 169-173.

Bhattacharjee, S.K., Suchitra, P. and Naveenkumar, P. (2002). Floriculture in India and its potential. *Floriculture Directory*, Indian Agricultural Research Institute, NEW DELHI, INDIA.

Brachmann, A. and Parniske, M. (2006). The most important symbiosis on earth. *PLoS Biol*., **4** : 239.

Daft, M.J. and Okusanya, B.O. (1973). Effect of Enodogone mycorrhizae on plant growth. VI. Influence of infection on the anatomy and reproduction. *New Phytol*., **72**: 1333-1339.

Gazey, C., Abbott, L.K. and Robson, A.D. (2006). Indigenous and introduced arbuscular mycorrhizal fungi contribute to plant

growth in two agricultural soils from south-western Australia. *Bioresource Technol*, **97**(6): 809-818.

Gerdemann, J.W. and Nicolson, T.H. (1963).Spores of mycorrhiza endogone species extracted from soil by wet sieving and decanting. *Transac. British Mycological Society*, **46**: 235-244.

Graham, J.H., Leonard, R.J. and Menge, J.A. (1981). Membrane mediated decrease in root exudation responsible for phosphorus inhibition of VA mycorrhizal formation. *Plant Physiol.*, **58**: 548-552.

Hayman, D.S. (1982). *Endomycorrhizae*, In interactions between nonpathogen soil microorganisms and plants. Ed. Elseveir. Amsterdam, pp. 401- 442.

Hemla Naik, B., Nalawadi, U.G., Sreeenivasa, M.N. and Patil, A.A. (1995). Field responses of China aster [*Callistephus chinensis* (L.) Nees.] cv. 'OSTRICH PLUME' to the inoculation of vesicular-arbuscular mycorrhizal fungi at different phosphorus levels. *Scientia Hort.*, **62**(1–2): 129–133.

Hemla Naik, B. (2003). Stability analysis and standardization of production technology for flower and xanthophylls yield in marigold (*Tagetes* spp.). Ph.D. Thesis, University of Agricultural Sciences, Dharwad, KARNATAKA (INDIA).

Kale, R.D., Bano, K., Sreenivasa, M.N. and Bagyaraj, D.J. (1987). Influences of worm cast on the growth and Mycorrhizae of two ornamental plants. *South Indian J. Hort.*, **35**: 433-437.

Long, L., Yao, Q., Yong-Heng, H., Yang, R., Guo, J. and Zhu, H. (2010). Effects of arbuscular mycorrhizal fungi on zinnia and the different colonization between Gigaspora and Glomus. *World J. Microbiol. & Biotechnol.*, **26**: 1527-1531.

Marschner, H. (1995). Mineral nutrition of higher plants. 2nd Ed. Academic Press, San Diego. pp.889.

Phillips, J.M. and Hayman, D.S. (1970). Improved procedures for clearing roots and staining parasitic and VA mycorrhizal fungi for rapid assessment of infection. *Transac. British Mycological Society*, **55**: 158-161.

Smith, S.E. and Read, D.J. (1997). *Mycorrhizal symbiosis.* London: Academic Press; 1997. Vesicular-arbuscular mycorrhizas; pp. 9–160.

Smith, S. and Read, D. (2008). Colonization of roots and anatomy of arbuscular mycor-rhiza. In: *Mycorrhizal symbiosis.* Academic Press, London, pp. 42–90.

Sreenivasa, M.N. and Bagyaraj, D.J. (1988). *Chloris gayana* (Rhodes grass), a better host for the mass production of *Glomus fasciculatum* inoculums. *Plant soil*, **106**: 289-290.

Sreenivasa, M.N., Krishnaraj, P.U., GAngadhara, G.A. and Manjunathaiah, H.M. (1993). Response of chilli (*Capsicum annuum* L.) to the inoculation of an efficient VA mycorrhizal fungus. *Scientia Hort.*, **53**: 45- 52.

Suneel, D., Sharma, S.D. and Pramodkumar (2013). Arbuscular mycorrhizas and Zn fertilization modify growth and physiological behaviour of apricot (*Prunus armeniaca* L.). *Scientia Hort.*, **155** : 97-104.

Thanuja, T.V. (2002).Induction of rooting and root growth in black pepper cuttings (*Piper nigrum* L.) with the inoculation of arbuscular mycorrhizae. *J. Sci. Hort.*, **92** (3-4) : 339-346.