

## Original Research Article

<https://doi.org/10.20546/ijcmas.2017.605.320>

## Effect of Inoculation with VAM Fungi at Different P Levels on Dry Matter Production (g plant<sup>-1</sup>) of *Tagetes erecta* L.

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### A B S T R A C T

#### Keywords

Marigold, VAM, phosphorus, *Glomus fasciculatum*, *G. mosseae*, *G. Intraradices*, Dry matter

#### Article Info

##### Accepted:

xx April 2017

##### Available Online:

xx May 2017

A field experiment was conducted to study the response of marigold (*Tagetes erecta* L.) to the inoculation of Vesicular Arbuscular Mycorrhizal (VAM) fungi at different P levels. In this experiment the VAM fungi viz., *Glomus fasciculatum* (Thaxter) Gerd. and Trappe, *Glomus mosseae* (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<sup>-1</sup> were tried. The results brought out that marigold responded well to VAM inoculation under field conditions. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest total dry matter production in marigold (67.40, 123.02, 154.66 and 155.73 g, respectively) than other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants supplied with P at 60kg/ ha (44.97, 87.46, 105.53 and 105.73 g, respectively) at 30, 60, 90 and 120 DAT, respectively.

### Introduction

Marigold (*Tagetes erecta* L.) is one of the most commonly grown commercial flower crops in India. Increased flower production, quality of flowers and perfection in the form of plants are important objectives to be reckoned in commercial flower production (Hemlanaik, 2003). Marigold 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. Mycorrhiza literally means ‘fungus root’. The fungus obtains photosynthesis from plant, while the plant is able to utilize the network of fungal hyphae, (which effectively act as an extended root system). The uptake of inorganic nutrients by plants is influenced by microorganisms in the rhizosphere. Symbiotic endophytes such as mycorrhizae are examples of microorganisms that are involved in the uptake of vital plant nutrient element, phosphorus.

Phosphorus is an important plant macronutrient, making up about 0.2 % of a plant's dry weight. 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 (up to 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).

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

### Materials and Methods

The present investigation was conducted at experimental unit of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur district, Karnataka during the period from October 2013 to February 2014 to know the symbiotic relationship between

marigold and VAM fungi at different phosphorus levels and its effect on dry matter production. A factorial experiment was laid out in Randomised 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<sup>-1</sup>) were tried in all possible combinations. Treatment details are as follows,

### Factor I = Mycorrhizal species

- M<sub>1</sub>- *Glomus fasciculatum* (Thaxter) Gerd. and Trappe.
- M<sub>2</sub>- *Glomus mossea* (Nicol. and Gerd.) Gerd. and Trappe.
- M<sub>3</sub>- *Glomus intraradices* Schenck and Smith.
- M<sub>0</sub>- Uninoculated control

### Factor II = Phosphorus levels 3

- (225kg N + 60kg K<sub>2</sub>O as constant)
- P<sub>1</sub>- 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>
  - P<sub>2</sub>- 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>
  - P<sub>3</sub>- 120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

### Treatment Combination

Treatment No.	Treatment	Combination
T <sub>1</sub>	M <sub>0</sub> P <sub>1</sub>	Uninoculation + 60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>2</sub>	M <sub>0</sub> P <sub>2</sub>	Uninoculation + 90 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>3</sub>	M <sub>0</sub> P <sub>3</sub>	Uninoculation + 120 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>4</sub>	M <sub>1</sub> P <sub>1</sub>	<i>G. fasciculatum</i> + 60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>5</sub>	M <sub>1</sub> P <sub>2</sub>	<i>G. fasciculatum</i> + 90 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>6</sub>	M <sub>1</sub> P <sub>3</sub>	<i>G. fasciculatum</i> + 120 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>7</sub>	M <sub>2</sub> P <sub>1</sub>	<i>G. mosseae</i> + 60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>8</sub>	M <sub>2</sub> P <sub>2</sub>	<i>G. mosseae</i> + 90 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>9</sub>	M <sub>2</sub> P <sub>3</sub>	<i>G. mosseae</i> + 120 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>10</sub>	M <sub>3</sub> P <sub>1</sub>	<i>G. intraradices</i> + 60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>11</sub>	M <sub>3</sub> P <sub>2</sub>	<i>G. intraradices</i> + 90 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>
T <sub>12</sub>	M <sub>3</sub> P <sub>3</sub>	<i>G. intraradices</i> + 120 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>

During nursery stage, four raised seed beds each of 2.0m x 1.0m x 15cm height were prepared with a two feet gap in between beds to avoid contamination. For each species of *Glomus* fungi one bed was used and remaining one was used as uninoculated control. Thirty days old healthy and uniform seedlings were transplanted in an experimental plot of 3.0 m x 3.0 m with spacing of 60 x 45 cm and light irrigation was given immediately after transplantation. Initial root colonization by VAM fungi were recorded on the day of transplantation by staining root system with trypan blue (Phillips and Hayman, 1970).

The fertilizer dose prescribed for marigold in transitional tract is 225:120:60 N: P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O per hectare. Nitrogen and Potassium were applied in the form of urea and murate of potash respectively. Phosphorus was applied according to the treatment levels in the form of rock phosphate. Half the quantity of nitrogen (112.5 kg/ha) and full dose of potassium (60kg/ha) viz., P<sub>1</sub>=60 kg rock phosphate ha<sup>-1</sup>, P<sub>2</sub>=90 kg rock phosphate ha<sup>-1</sup> and P<sub>3</sub>= 120 kg rock phosphate ha<sup>-1</sup> i.e., 50, 75 and 100 % recommended level phosphorus) were applied after two weeks of transplantation by ring method of fertilizer application. Remaining 50 % of nitrogen was applied 30 days after transplantation as top dressing.

### **Dry matter production (g/plant)**

Dry matter production was estimated at three different stages of the plant growth. Three plants were uprooted randomly from the net plot in each treatment. Then leaves, stem, and flowers were separated and oven dried at a temperature of 70 °C, till it reached constant weight. Dry matter accumulation in different parts of the plant at different stages were weighed and recorded in grams. The total dry matter production was calculated by adding dry matter accumulation in leaves, stem,

flowers and roots of respective stages. This data formed the basis for computing crop growth rate.

### **Results and Discussion**

The dry matter production was influenced by inoculation with *Glomus* fungi. Plants inoculated with *Glomus* fungi were recorded more dry matter production than Uninoculated control.

The data on total dry matter (TDM) accumulation in marigold as influenced by inoculation of *Glomus* fungi at different levels of P recorded at 30, 60, 90, 120 DAT are presented in Table 1.

As the growth advanced, TDM accumulation in marigold plant increased significantly with increase in age. The influence of *Glomus* fungi on TDM accumulation in marigold was significant at all stages of growth.

At 30 DAT, the plants inoculated with *G. fasciculatum* recorded significantly highest TDM (60.40 g) and it was statistically on par with *G. mosseae* (60.17 g) and *G. intraradices* showed least TDM production (50.50 g).

At 60, 90, 120 DAT, *G. fasciculatum* recorded significantly highest TDM (112.43, 140.61 and 141.09 g) and least was observed in *G. intraradices* (95.62, 117.49 and 118.10 g).

Application of P influenced the TDM accumulation significantly at all the stages of growth. Among the P levels 90 kg/ ha recorded maximum TDM (45.79, 84.58, 106.16 and 106.76 g, respectively) and minimum was recorded in P level at 60 kg/ ha (37.94, 72.10, 88.91 and 89.43 g, respectively) at 30, 60, 90 and 120 DAT, respectively.

The interaction effect of inoculation of *Glomus* fungi and P-fertilization was

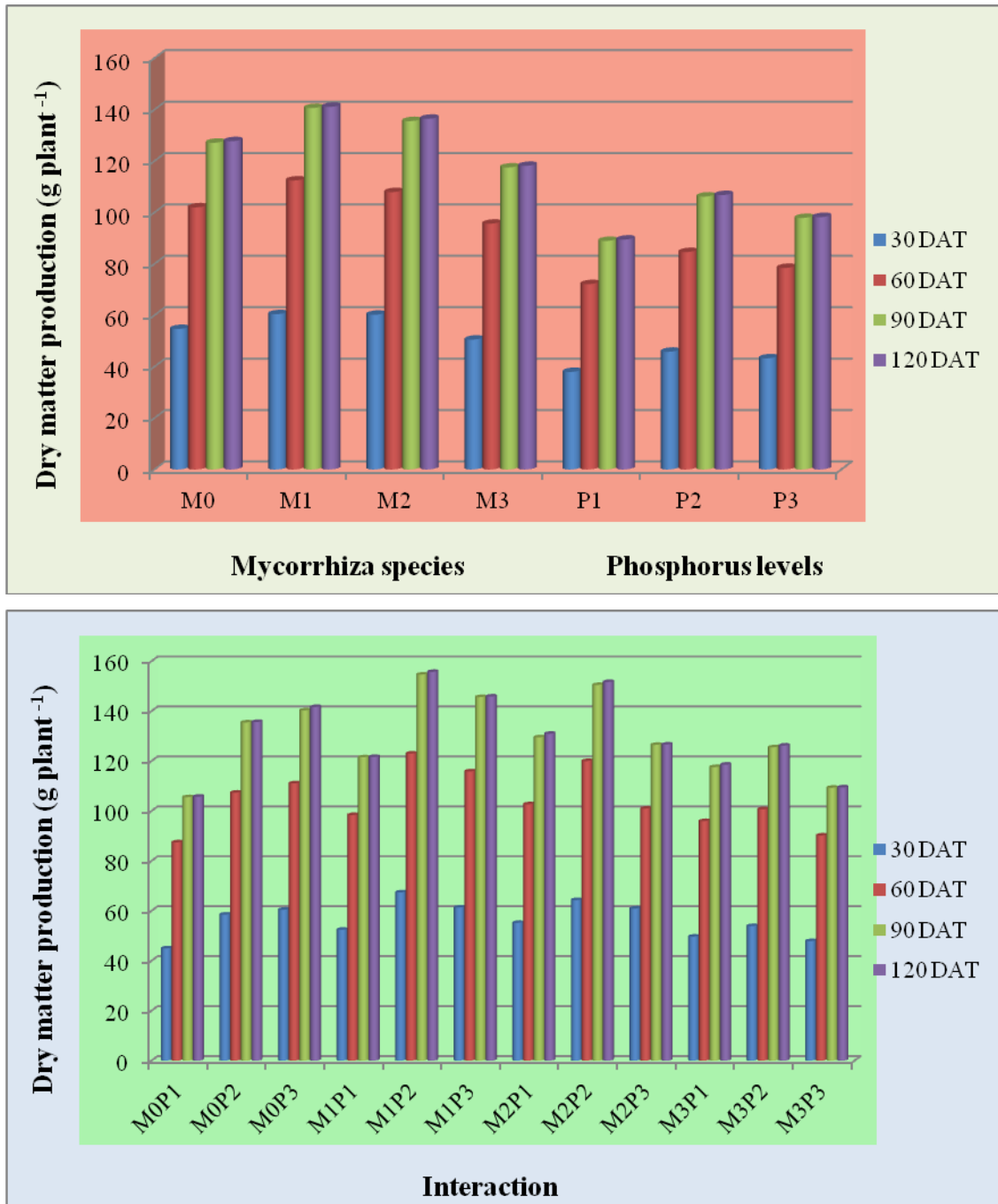
significant at all the stages of growth. The TDM production was increased with the increase in P levels up to 120kg/ ha in uninoculated control plants, whereas in the inoculated plants the TDM production was increased at P level 90 kg/ ha. The plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest TDM production in marigold (67.40, 123.02,

154.66 and 155.73 g, respectively) than other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha and least was observed in uninoculated control plants supplied with P at 60kg/ ha (44.97, 87.46, 105.53 and 105.73 g, respectively) at 30, 60, 90 and 120 DAT, respectively.

**Table.1** Effect of inoculation with VAM fungi at different P levels on dry matter production of *Tagetes erecta* L

Treatment	Dry matter production (g plant <sup>-1</sup> )			
	30 DAT	60 DAT	90 DAT	120 DAT
<b>Mycorrhiza</b>				
M <sub>0</sub> - Uninoculated control	54.66	101.97	127.11	127.70
M <sub>1</sub> - <i>Glomus fasciculatum</i>	60.40	112.43	140.61	141.09
M <sub>2</sub> - <i>Glomus mosseae</i>	60.17	107.90	135.51	136.44
M <sub>3</sub> - <i>Glomus intraradices</i>	50.50	95.62	117.49	118.10
S.Em ±	0.16	0.07	0.03	0.04
C.D. (P=0.05)	0.46	0.21	0.08	0.11
<b>Phosphorus levels (kg/ha)</b>				
P <sub>1</sub> - 60	37.94	72.10	88.91	89.43
P <sub>2</sub> - 90	45.79	84.58	106.16	106.76
P <sub>3</sub> - 120	43.24	78.40	97.84	98.19
S.Em ±	0.12	0.05	0.02	0.03
C.D. (P=0.05)	0.35	0.16	0.06	0.09
<b>Interaction (MXP)</b>				
M <sub>0</sub> P <sub>1</sub> - Uninoculated control + P @ 60	44.97	87.46	105.53	105.73
M <sub>0</sub> P <sub>2</sub> - Uninoculated control + P @ 90	58.53	107.35	135.50	135.68
M <sub>0</sub> P <sub>3</sub> - Uninoculated control + P @ 120	60.47	111.10	140.31	141.68
M <sub>1</sub> P <sub>1</sub> - <i>Glomus fasciculatum</i> + P @ 60	52.48	98.40	121.54	121.66
M <sub>1</sub> P <sub>2</sub> - <i>Glomus fasciculatum</i> + P @ 90	67.40	123.02	154.66	155.73
M <sub>1</sub> P <sub>3</sub> - <i>Glomus fasciculatum</i> + P @ 120	61.33	115.87	145.65	145.89
M <sub>2</sub> P <sub>1</sub> - <i>Glomus mosseae</i> + P @ 60	55.23	102.70	129.52	130.96
M <sub>2</sub> P <sub>2</sub> - <i>Glomus mosseae</i> + P @ 90	64.33	120.03	150.50	151.71
M <sub>2</sub> P <sub>3</sub> - <i>Glomus mosseae</i> + P @ 120	60.93	100.98	126.52	126.65
M <sub>3</sub> P <sub>1</sub> - <i>Glomus intraradices</i> + P @ 60	49.67	95.97	117.61	118.58
M <sub>3</sub> P <sub>2</sub> - <i>Glomus intraradices</i> + P @ 90	53.93	100.71	125.54	126.24
M <sub>3</sub> P <sub>3</sub> - <i>Glomus intraradices</i> + P @ 120	47.90	90.20	109.32	109.49
S.Em ±	0.47	0.22	0.08	0.12
C.D. (P=0.05)	1.38	0.63	0.24	0.34

**Fig.1** Effect of inoculation with VAM fungi at different P levels on dry matter production ( $\text{g plant}^{-1}$ ) of *Tagetes erecta* L.



M<sub>0</sub> - Uninoculated control  
 M<sub>1</sub> - *Glomus fasciculatum*  
 M<sub>2</sub> - *Glomus mossae*  
 M<sub>3</sub> - *Glomus intraradices*

P<sub>1</sub> - 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>  
 P<sub>2</sub> - 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>  
 P<sub>3</sub> - 120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

The dry matter production and its accumulation in flower depend upon photosynthetic capacity of plants during flower development period. The photosynthetic capacity of the plant depends upon leaf area and leaf area index (LAI). The plants inoculated with *G. fasciculatum* recorded significantly higher LA (58.05 dm<sup>2</sup>) at 120 DAT than other species of *Glomus* fungi and uninoculated control (Figure 1). However, the similar trend was observed in the interaction between these *Glomus* fungi and given P at 90 kg/ ha. Which was comparable with the uninoculated control along with the application of P at 120 kg/ ha. Whereas leaf area index was recorded significantly highest in the plants inoculated with *G. fasciculatum* (5.35), as compared to other species of *Glomus* fungi and uninoculated control.

However these characters were found to be significantly highest in the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha (7.34) as compared to other species of *Glomus* fungi and superior over uninoculated control plant and given P at 120 kg/ ha (5.33). Which eventually might have resulted in higher photosynthesis, maximum dry matter production and accumulation in flower development period, similar results were observed by Hemlanaik *et al.*, (1995) in China aster, Farkoosh (2011) in *Matricaria chamomilla* and Rajapakse *et al.*, (1989) in cowpea. Because of increased leaf area per plant at all the stages of growth inoculation of VAM also recorded highest leaf area index. Leaf area duration which is determined by the LAI of the consecutive growth stages denotes the magnitude and persistence of leaf area during the entire crop growth period. The treatment *G. fasciculatum* given P at 90kg/ ha recorded the higher LAD (160.25 days) than other species of *Glomus* fungi and it was comparable with uninoculated control with given P at 120 kg/ ha (107.95 days). The

increased LAD could be attributed to increase in leaf area and LAI in the same treatment.

The increase in leaf area has resulted in the increased dry matter accumulation in the treated plants with *Glomus* fungi and may were found to have higher values for CGR. At the later stages of crop growth, the decreased rate of dry matter accumulation noticed this could be due to the decreased rate of total dry matter accumulation in plant. The higher CGR values at 30-60 DAT, indicates that the rate of increment per unit area and time was more at early stages due to active crop growth and also due to arrangement of leaves in the canopy in such a way avoiding mutual shading. As the crop growth advanced, the number of leaves decreases, the size of the leaves smaller and leaf fall also more and declining the rate of dry matter accumulation in the leaves. These results are in accordance with the results obtained by Brigitta (2011) and Hemlanaik (2003).

In the present study, with the application of *G. fasciculatum* and given P at 90 kg/ ha significantly higher NAR (1.19 g/ m<sup>2</sup>/ day) was observed compared to other *Glomus* species and uninoculated control. Net assimilation rate (NAR), synonymously called as 'unit leaf rate', express the rate of dry weight increases at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory area. These results were supported by Shubha (2006).

In conclusion, the dry matter production of marigold plants inoculated with efficient VAM fungi and supplied with P at 90 kg ha<sup>-1</sup> was comparable even better than the uninoculated plants supplied with P at 120 kg ha<sup>-1</sup>. 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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### How to cite this article:

Swathi, G. and Hemla Naik, B. 2017. Effect of Inoculation with VAM Fungi at Different P Levels on Dry Matter Production (g plant<sup>-1</sup>) of *Tagetes erecta* L. *Int.J.Curr.Microbiol.App.Sci*. 6(5): 2830-2836. doi: <https://doi.org/10.20546/ijemas.2017.605.320>