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Impact of Arbuscular Fungi Inoculation at Different P Levels on Benefit: Cost Ratio of Flower Production and Xanthophyll Production of Marigold

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ABSTRACT

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. mosseae and given P at 90 kg/ ha recorded significantly highest cost: benefit ratio in marigold (1: 5.39) followed by G. fasciculatum (1: 5.35) 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 (1: 3.26). Similarly, the plants inoculated with G. fasciculatum and given P at 90 kg/ ha recorded significantly highest cost: benefit ratio of xanthophylls production in marigold (1: 11.57) followed by G. mosseae (1: 9.67) 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 (1: 1.69).

Key words: *Marigold, Mycorrhiza, Xanthophylls, B: C ratio.*

INTRODUCTION

Marigold is a plant of the genus *Tagetes* of the family Asteraceae, mostly cultivated as garden flower that is one of the natural sources for achieving yellow color. Marigold flowers are used at many religious ceremonies and festivals, strung together they make colourful garlands. Increased flower production, quality of flowers and perfection in the form of plants are important objectives to be reckoned in commercial flower production[3]. In India marigold ranks first among the loose flowers followed by chrysanthemum, jasmine, tuberose, crossandra and barleria[2]. Today, there is huge demand for natural colours of marigold, *Calendula, Hibiscus, Gomphrena, Petunia* etc., in the international market. Marigold is one such potential flower crops for natural colour extraction.

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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. 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 repellent. Besides, marigold is growing today as a commercially important source of carotenoid pigments. The principal pigment present in the flowers is xanthophyll, particularly lutein accounts for ~ 80-90 per cent and is present in the form of esters of palmitic and myristic acids[1]. Marigold carotenoids are the major source of pigment for poultry industry as a feed additive to intensify the yellow colour of egg yolks and broiler skin[6]. The ground blossom meal (petal meal) or the extract, usually saponified for better absorption, is added to the poultry feed. These products are traded as 'Aztec marigold' or marigold extract as 'Adoptinal' marigolds can be cultivated easily and their petals are the most concentrated source of xanthophylls, which can be extracted either from fresh or dried petal meals[4].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 fertilizersMycorrhiza 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 rhizospere. Symbiotic endophytes such as mycorrhizae are examples of microorganisms that are involved in the uptake of vital plant nutrient element, phosphorus. There are many reports providing evidence that most of taxonomically higher order plants are infected with mycorrhizal fungi which assist in the uptake of nutrients like phosphorus, sulphur, potassium and micronutrients like Zn, Cu, Mn, Fe etc[8]. Phosphorus is an important plant macronutrient, making up about 0.2% of a plant's dry weight. It is a component of key molecules such as nucleic acids, phospholipids, ATP and consequently, plants cannot grow without a reliable supply of this nutrient. P is also involved in controlling key enzyme reactions and in the regulation of metabolic pathways[9]. After N, P is the second most frequently limiting macronutrient for plant growth. This update focuses on P in soil and its uptake by plants, transport across cell membranes and compartmentation and redistribution within the plant. Mycorrhizae are also important for plant P acquisition, since fungal hyphae greatly increase the volume of soil that plant roots explore[7]. 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[5].

MATERIALS AND METHODS

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^{-1}) were tried in all possible combinations.

Treatment details are as follows,

Factor I = Mycorrhizal species

M_1- *Glomus fasciculatum.*
M_2- *Glomus mossea*.
M_3- *Glomus intraradices*.
M_o- Uninoculated control

Factor II = Phosphorus levels : 3

(225kg N + 60kg K_2O as constant)
P_1- 60 kg P_2O_5/ ha
P_2- 90 kg P_2O_5/ ha
P_3- 120 kg P_2O_5/ ha

1. Treatment Combination

Treatment No.	Treatment	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

Economics

In order to assess the effects of each treatment with the combination of VAM and P fertilizer, the cost of cultivation was worked out. This included the cost of fertilizer *i. e.*, Urea (Rs. 6.5/ kg), Rock phosphate (Rs. 6/ kg) and Murate of Potash (Rs.13/ kg) and the cost of FYM, was taken. The VAM fungi cost (Rs. 40/ kg) was also included. The labour cost, including fertilizer application, irrigation and plant protection, weeding *etc*., during the cropping period were worked out. The average market price of Rs. 15.00 per kilograms of flower and Rs. 6000 per kilogram of xanthophyll was taken for calculating gross return. The yields obtained under individual treatment during the crops were taken into consideration for working out the economics (Appendix-III). Based on the total cost of cultivation and gross return obtained, the net return and benefit cost ratio (BCR) were worked out and was computed per hectare.

Cost of cultivation

The prices of all inputs prevailing at the time of their use and the labour cost were used to work out the cost of cultivation and expressed in Rupees per ha.

Gross return

The gross income was worked out based on the prevailing market of the flower and xanthophyll produce and expressed in Rupees per ha.

Net return

The net income per hectare was calculated on the basis of gross income and cost of cultivation per ha and expressed in Rupees per ha.

Benefit: cost ratio

$$\text{Benefit: Cost Ratio} = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

RESULTS AND DISCUSSION

The data on economics of marigold as influenced by inoculation of *Glomus* fungi at different levels of P are presented in Table 1 and 2.

Result

The plants inoculated with *G. mosseae* and given P at 90 kg/ ha recorded significantly highest net returns in marigold (Rs.225655/ hectare) followed by *G. fasciculatum* (Rs. 224005/ hectare) 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 (Rs. 133361). Similarly, the plants inoculated with *G. mosseae* and given P at 90 kg/ ha recorded significantly highest cost: benefit ratio in marigold (1: 5.39) followed by *G. fasciculatum* (1: 5.35) 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 (1: 3.26).

Whereas, for xanthophyll production, the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest net returns in marigold (Rs. 539695/ ha) followed by *G. mosseae* (Rs. 451125/ 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 (Rs. 77432.7). Similarly, the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest cost: benefit ratio of xanthophylls production in marigold (1: 11.57) followed by *G. mosseae* (1: 9.67) 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 (1: 1.69).

Discussion

The economic analysis revealed that, the maximum benefit to cost (B:C) ratio (1: 5.39) was observed in the treatment where the plants inoculated with *G. mosseae* and given P at 90 kg/ ha followed by *G. fasciculatum* (1: 5.35) 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 (1: 3.26). The flower yield was maximum in the above said treatment. Hence, the net returns were increased. Similarly, the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest cost: benefit ratio of xanthophyll production in marigold (1: 11.57) followed by *G. mosseae* (1: 9.67) at the same level of P as compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha. The xanthophyll yield was more in the above said treatments (34.49 kg/ ha, 29.28 kg/ ha, respectively) than other treatments Hence, the net returns were increased. The present results are in conformity with the research findings of Hemlanaik[3].

Table 1: Economics of flower production in African Marigold (*Tagetes erecta* L.)

Sl. No.	Particulars	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
1	Land preparation	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
2	Seed cost (200 g/ha @ Rs.1000/kg)	200	200	200	200	200	200	200	200	200	200	200	200
3	Nursery raising	850	850	850	850	850	850	850	850	850	850	850	850
4	inocula	-	-	-	-	100	100	100	100	100	100	100	100
5	Transplanting (12 labourers @ Rs.120/labour)	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
6	Gap filling (3 labours @ Rs.120/lb)	300	300	300	300	300	300	300	300	300	300	300	300
7	Manures (20 t/ha @ Rs. 300/t)	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
8	Fertilizers	6186.9	7026.9	7866.9	6186.9	7026.9	7866.9	6186.9	7026.9	7866.9	6186.9	7026.9	7866.9
9	Irrigation (5 labourers @ Rs.120)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
10	Intercultivation and weeding	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
11	Plant protection chemicals	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
12	Harvesting (30 labourers @ Rs.120)	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600
13	Transportation and marketing	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
14	Land rent (@ Rs.3500/acre)	8750	8750	8750	8750	8750	8750	8750	8750	8750	8750	8750	8750
15	Miscellaneous	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
16	Total expenditure (Rs.)	38486.9	39326.9	40166.9	38486.9	39426.9	40266.9	38586.9	39426.9	40266.9	38586.9	39426.9	40266.9
17	Bank interest (@7%pa)	2302.08	2360.88	2419.68	2308.08	2367.88	2426.68	2309.08	2367.88	2426.68	2309.08	2367.88	2426.68
18	Total cost of cultivation (Rs.)	40789	41687.7	42586.6	40789	41794.8	42693.6	40896	41794.8	42693.6	40896	41794.8	42693.6
19	Flower yield (t/ha)	11.61	14.93	16.56	12.96	17.72	15.89	13.43	17.83	17.35	12.54	12.95	12.2
20	Gross return (@ Rs.1500/q of fl.)	174150	223950	248400	194400	265800	238350	201450	267450	260250	188100	194250	183000
21	Net returns (Rs.)	133361	182262	205813	153611	224005	195656	160554	225655	217556	147204	152455	140306
22	Benefit to cost ratio (B:C)	3.26	4.37	4.83	3.76	5.35	4.58	3.92	5.39	5.09	3.59	3.64	3.28

Table 2: Economics of xanthophyll production in African marigold (*Tagetes erecta* L.)

Sl. No.	Particulars	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
1	Total cost of cultivation	40789	41687.7	42586.6	40789	41794.8	42693.6	40896	41794.8	42693.6	40896	41794.8	42693.6
2	Total cost for extraction of xanthophyll	5028.4	4829.3	4919.2	4739.5	4840	4929.9	4750.2	4840	4929.9	4750.1	4840	4929.9
3	Gross returns	123250	286790	379610	200430	586330	371450	228310	497760	396780	172550	270980	174760
4	Net returns	77432.7	240272.9	332104	154902	539695	323827	182664	451125	349157	126904	224345	127137
5	B:C ratio	1.69	5.16	6.99	3.4	11.57	6.79	4	9.67	7.33	2.78	4.81	2.66

Table 3: Effect of inoculation with VAM fungi at different P levels on benefit: cost ratio of *Tagetes erecta* L.

Treatment	Total cost of cultivation (Rs)	Flower yield (t/ha)	Gross returns (Rs.)	Net returns (Rs)	Benefit to cost ratio
M_0P_1 - Uninoculated control + P @ 60	40789.00	11.61	174150.00	133361.00	3.26
M_0P_2 - Uninoculated control + P @ 90	41687.70	14.93	223950.00	182262.00	4.37
M_0P_3 - Uninoculated control + P @ 120	42586.60	16.56	248400.00	205813.00	4.83
M1P1 - *Glomus fasciculatum* + P @ 60	40789.00	12.96	194400.00	153611.00	3.76
M_1P_2 - *Glomus fasciculatum*+ P @ *90*	41794.80	17.72	265800.00	224005.00	5.35
M_1P_3 - *Glomus fasciculatum* + P @ 120	42693.60	15.89	238350.00	195656.00	4.58
M_2P_1 - *Glomus mosseae* + P @ 60	40896.00	13.43	201450.00	160554.00	3.92
M_2P_2 - *Glomus mosseae* + P @ 90	41794.80	17.83	267450.00	225655.00	5.39
M_2P_3 - *Glomus mosseae* + P @ 120	42693.60	17.35	260250.00	217556.00	5.09
$M3P_1$ - *Glomus intraradices* + P @ 60	40896.00	12.54	188100.00	147204.00	3.59
M_3P_2 - *Glomus intraradices* + P @ 90	41794.80	12.95	194250.00	152455.00	3.64
M_3P_3 - *Glomus intraradices* + P @ 120	42693.60	12.20	183000.00	140306.00	3.28

*Price of flowers = Rs. 1500/ q

Table 4: Effect of inoculation with VAM fungi at different P levels on benefit: cost ratio of xanthophyll production in *Tagetes*

Treatment	Total cost of cultivation (Rs)	Total cost for extraction of xanthophyll (Rs)	Gross returns (Rs.)	Net returns (Rs)	Benefit to cost ratio
M_0P_1 - Uninoculated control + P @ 60	40789.00	5028.35	123250.00	77432.70	1.69
M_0P_2 - Uninoculated control + P @ 90	41687.70	4829.33	286790.00	240272.90	5.16
M_0P_3 - Uninoculated control + P @ 120	42586.60	4919.21	379610.00	332104.00	6.99
M1P1 - *Glomus fasciculatum* + P @ 60	40789.00	4739.45	200430.00	154902.00	3.40
M_1P_2 - *Glomus fasciculatum*+ P @ *90*	41794.80	4840.03	586330.00	539695.00	11.57
M_1P_3 - *Glomus fasciculatum* + P @ 120	42693.60	4929.91	371450.00	323827.00	6.79
M_2P_1 - *Glomus mosseae* + P @ 60	40896.00	4750.15	228310.00	182664.00	4.00
M_2P_2 - *Glomus mosseae* + P @ 90	41794.80	4840.03	497760.00	451125.00	9.67
M_2P_3 - *Glomus mosseae* + P @ 120	42693.60	4929.91	396780.00	349157.00	7.33
$M3P_1$ - *Glomus intraradices* + P @ 60	40896.00	4750.15	172550.00	126904.00	2.78
M_3P_2 - *Glomus intraradices* + P @ 90	41794.80	4840.03	270980.00	224345.00	4.81
M_3P_3 - *Glomus intraradices* + P @ 120	42693.60	4929.91	174760.00	127137.00	2.66

*Price of the xanthophyll = Rs. 6000/ kg

CONCLUSION

The maximum benefit to cost (B:C) ratio (1: 5.39) was observed in the treatment where the plants inoculated with *G. mosseae* and given P at 90 kg/ ha followed by *G. fasciculatum* (1: 5.35) 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 (1: 3.26). Similarly, the plants inoculated with *G. fasciculatum* and given P at 90 kg/ ha recorded significantly highest cost: benefit ratio of xanthophyll production in marigold (1: 11.57) followed by *G. mosseae* (1: 9.67) at the same level of P as compared to other species of *Glomus* fungi and uninoculated control plants applied with P at 120 kg/ ha.

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