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Effect of Mycorrhizal Inoculation (VAM) and Phosphorus Levels on Growth and Yield Attributes of Sunflower

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Abstract- The field experiment was conducted at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu during July – October 2015 to study the effect of my corrhizal inoculation (VAM) and different levels of phosphorus on growth, yield attributes and yield of hybrid sunflower cv. Sunbred. The experiment was conducted by factorial randomized block design with two replications. The treatments of experiment consisted of 5 levels of P_2O_5 (0, 25, 50, 75 and 100kg/ha) applied in the presence or absence of VAM inoculates. The results revealed that growth, yield attributes and yield was significantly influenced by various P levels in the presence and absence of VAM inoculations. The growth and yield of sunflower was highest under mycorrhizal inoculated plants than non micorhizal inoculation. Among the various phosphorus levels tried, P_2O_5 at 100 kg ha^{-1} recorded maximum values for growth and yield, while P_2O_5 at 0kgha^{-1} registered minimum values for growth and yield of sunflower. Among the treatment combinations tried, mycorrhizal inoculation with P_2O_5 @ 100 kg ha^{-1} recorded maximum values for growth and yield attributes and yield of sunflower (2153 kgha^{-1}) but it was on par with M_2 P_3 (mycorrhizal inoculation with P_2O_5 @ 75 kg ha^{-1}). The lowest values of growth and yield attributes and yield were recorded by non-mycorrhizal inoculation with P_2O_5 @ 0 kg ha^{-1}.

Keywords: sunflower, VAM growth and yield.

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I. Introduction

Sunflower (*Helianthus Annuus* L.) belongs to the family Asteraceae, a new world plant, native of southern parts of United States of America and Mexico has been developed into a valuable source of edible oil and meal, with almost 20-27 percent protein and 40-47 percent oil (Saleem *et al*., 2003). It is easy to cultivate and grown in different conditions and soils. Sunflower oil has excellent nutritional properties, and has a relatively high concentration of linoleic acid (Seiler, 2007). It is also a wealthy source of vitamins A and D. The sunflower seed cake used for cattle feed which is a good source of protein (Gandhi *et al*., 2008). Indian soils are deficient in phosphorus. P is generally a limiting factor in sunflower growth and yield because P deficiencies reduce the accumulation of crop biomass (Zubillaga *etal*., 2002). P is an essential plant nutrient required for higher and sustained productivity of oil from sunflower. Its influence on seed yield, oil yield and oil quality has been well established (Bahl and Toor, 1999). Phosphorus is one of the most essential element for plant growth after nitrogen. It plays a significant role in several physiological and biochemical plant activities like photosynthesis, transformation of sugar to starch and transporting of the genetic traits. A great advantage of feeding the plants with phosphorus is to create deeper and more abundant roots. Phosphorus causes early ripening in plants, decreating grain moisture, and improving crop quality. However, the availability of this nutrient for plants is limited by different reactions. A great proportion of phosphors in chemical fertilizer becomes unavailable to the plants after its application in the soil and further, the mobility of this element is very slow in the soil and cannot respond to its rapid uptake by plants. This causes the creation and development of phosphorus depleted zones near the contact area of roots and soil in rhizosphere. Therefore, the depletion zones and helps to absorb the phosphorus from a wider area by developing an external network around root system. Mycorrhiza hassymbiotic association between the soil fungi and roots of higher plants (Smith *et al*., 2010). These fungi enhance the plant growth through making availability of mineral nutrients such as P, Zn and Cu (Phiri *et al*., 2003). Colonization of AM fungi in cortical tissues of sunflower increased the growth parameters of sunflower (Jalaluddin and Hamid, 2011).

The current trend is to explore the possibility of supplementing chemical fertilizers with organic ones, more particularly biofertilizers of microbial origin. In this context, VAM fungi are receiving greater attention in their beneficial effects on plant growth. Vesicular-arbuscular mycorrhizae (VAM) are widespread in soils, and often the growth of mycorrhizal plants will be higher in comparison to non-mycorrhizal plants. This beneficial effect on plant growth has largely been attributed to higher phosphorus (P) uptake and consequently better P nutrition of mycorrhizal plants (Antunes *et al*. (2007). The beneficial effects of VAM inoculation on P uptake, growth and yield of sunflower have not been carried out. Hence, the present study was taken up to find out the

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effect of mycorrhizal inoculation andphosphorus on the growth and yield attributes of hybrid sunflower.

II. Materials and Methods

Field experiment was conducted during July – October 2015 at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University. The experimental soil was clay loam with pH 8.1, OC 5.0g kg^{-1}, available N (235 kg ha^{-1}), P (22.1 kg ha^{-1}) and K (356 kg ha^{-1}). The experiment consisted of ten treatments and was laid out in factorial randomized block design with two replications. The treatments imposed in the experiment are M_1-Non inoculated and M_2-inoculated *Glomus intraradices* were tried along with different phosphorus levels (P_0-0, P_1-25, P_2-50, P_3-75 and P_4-100 kg P_2O_5 ha^{-1}) through SSP. Recommended dose of 60:60 kg of N&K ha^{-1} was applied in the form of Urea and MOP respectively. Half the dose of N and entire dose of K were applied basally. The remaining quantity of N was applied at 30 DAS. P was applied as per treatment schedule. The mycorrhizal inoculum was applied near the root zone of sunflower. 2gm VAM was applied per plant by placement method. At harvest, plant height was recorded from the first node at the bottom of the plants to the bottom of the head and expressed in cm. The leaf area index (LAI) was calculated by dividing the total leaf area of the plant by the land area occupied. To estimate dry matter production (DMP) the selected plant samples were collected washed, air dried and kept in an oven at 80°C till constant weight was obtained and expressed in Kg ha^{-1}.The yield parameters and yield were recorded at harvesting stage of plant. The head samples for yield were also dried to constant weight and threshed mechanically. Seed yield was adjusted to a 10% moisture basis. Filled seeds and empty hulls were separated by hand. Hereafter, grain number head-1 refers to filled grains only. Data collected were subjected to statistical analysis of variance according to Gomez and Gomez (1989).

III. Results and Discussion

a) Growth Attributes

Mycorrhizal inoculated plants significantly influenced the growth attributes *viz.,* plant height, LAI, DMP and CCI (Table 1). Mycorrhizal inoculation recorded the highest plant height at harvest (147.0 cm), leaf area index at flowering (4.26), dry matter production at harvest (4994 Kg ha^{-1}) and chlorophyll content index (23.43) at flowering stagethan non - mycorrhizal inoculation. This might be due to the formation of external mycelium around the roots by AM fungi which possibly helped to increase the availability of nutrients to the surface of the roots and thereby increased the nutrient uptake andgrowth of the plant. Similar finding was earlier reported by Kavitha and Nelson (2014).

Table 1: Effect of Mycorrhizal Inoculation (VAM) and Phosphorus Levels on Growth and Yield Attributes and Yield of Sunflower

Treatments	Plant Height (cm) at Harvest	LAI at Flowering	DMP at Harvest (kg ha^{-1})	Chlorophyll Content Index	Head Diameter (cm)	Number of Filled Seeds Head^{-1}	100 Seed Weight (g)	Seed Yield (kg ha^{-1})	Stalk Yield (kg ha^{-1})
VAM									
M_1	133.1	3.65	4485	20.39	15.7	514	5.31	1438	3570
M_2	147.0	3.91	4994	23.43	17.7	660	5.83	1845	4069
SEd	1.09	0.016	25.11	0.19	0.09	8.02	0.016	28.46	20.75
CD(P=0.05)	2.34	0.034	53.86	0.41	0.20	17.19	0.034	61.05	44.51
Phosphorus Levels(kg ha^{-1})									
P_0	98.3	2.91	3645	16.21	11.12	321	4.81	973	2692
P_1	126.0	3.48	4101	18.49	14.4	428	5.02	1197	3179
P_2	134.1	3.67	4491	21.03	15.8	528	5.39	1477	3589
P_3	146.3	3.92	5051	23.38	17.8	661	5.81	1843	4129
P_4	153.8	4.05	5316	24.73	18.9	730	6.06	2048	4379
SEd	1.54	0.023	35.51	0.27	0.13	11.34	0.022	40.25	29.35
CD(P=0.05)	3.30	0.049	76.18	0.58	0.29	24.32	0.048	86.34	62.95

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Among the different levels of phosphorus, application of P2O5 at 100 kg ha-1 significantly recorded highest plant height at harvest (153.8 cm), leaf area index at flowering (4.05), dry matter production at harvest (5316 Kg ha^{-1}) and chlorophyll content index (24.73) at flowering stage. This might be attributed to the P stimulating effect on root growth and expansion by increasing crop growth rate. The lowest values for growth attributes were recorded in the treatment which did not receive phosphorus.Similar findings were earlier reported by Adebayo *et al*. (2010) and Abubaker Ali *et al.* (2014).

The interaction effect between the mycorrhizal inoculation and phosphorus was significant (Table 2). The treatment combination of mycorrhizal inoculation along with P_2O_5 at 100 kg ha^{-1} recorded maximum values for growth attributes, but it was on par with mycorrhizal inoculation along with P_2O_5 at 75 kg ha^{-1}. The highest values under these treatments might be due to mycorrhizal inoculation, because this bio fertilizer can enhance absorption of phosphorus by plant. The lowest growth attributes was recorded in the treatment combination of non mycorrhizal inoculation with 0 kg P_2O_5 ha^{-1}. This could be due to inadequate availability of nutrients. This result is in conformity with the findings of Khirood Doley and Paramjit Kaur Jite (2012).

Table 2: Interaction Effect between VAM and Phosphorus on Growth and Yield Attributes of Sunflower

Treatments	Plant Height (cm) at Harvest	LAI at Flowering	DMP (kg ha^{-1}) at Harvest	Head Diameter (cm)	No. of Filled Seeds $Head^{-1}$	Test Weight (g)	Seed Yield (Kg ha^{-1})	Stalk Yield (Kg ha^{-1})
M_1P_0	98	3.11	3521	11.1	298.1	4.31	880	2712
M_1P_1	121	3.58	3883	13.6	366.1	4.78	1019	2946
M_1P_2	126	3.78	4175	14.4	435.1	5.07	1219	3271
M_1P_3	137	4.04	4697	16.5	563.1	5.47	1571	3795
M_1P_4	149	4.36	5184	18.4	692.4	5.94	1942	4268
M_2P_0	109	3.24	3689	11.9	328.6	4.69	996	2968
M_2P_1	131	3.90	4319	15.2	490.6	5.26	1376	3412
M_2P_2	142	4.15	4807	17.2	621.8	5.71	1735	3908
M_2P_3	156	4.48	5403	19.1	758.4	6.16	2114	4464
M_2P_4	159	4.50	5448	19.3	768.2	6.18	2153	4491
SEd	2.18	0.035	50.22	0.19	16.03	0.032	56.9	41.5
CD (P = 0.05)	4.65	0.075	107.73	0.40	34.39	0.068	122.1	89.03

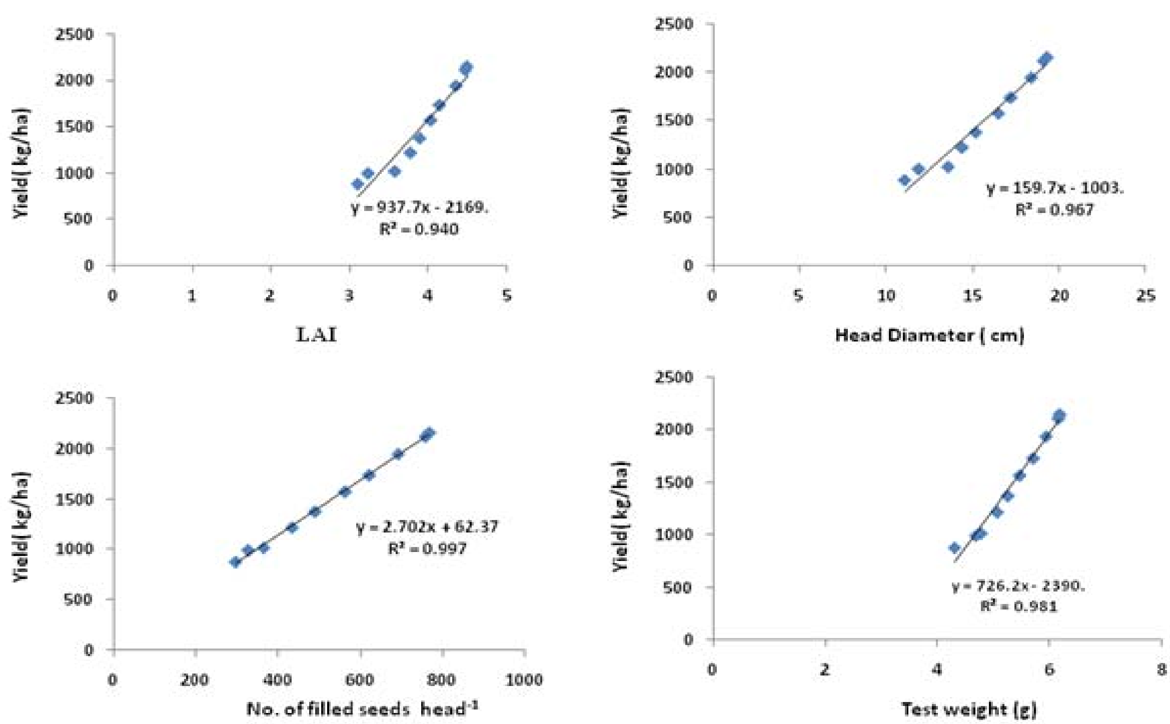

Fig. 1: Linear Relationship between Seed Yield with a) LAI, b) Head Diameter, c) No. of Filled Seeds / Head, d) Test Weight

b) Yield Attributes and Yield

Mycorrhizal inoculated plants showed significant influence on yield attributes and yield (Table 1). Mycorrhizal inoculation recorded the maximum head diameter (17.7cm), number of filled seeds head-1 (660), 100 seed weight (5.83 g) and seed yield (1845 kg ha-1) and stalk yield (4069 kg ha-1) than non-mycorrhizal inoculation. The per cent increase in seed and stalk yield due to mycorrhizal inoculation was 28.3 and 13.9 over non-mycorrhizal. Many researchers suggested that VAM symbiosis increased the units of photosynthesis, and so as to increase the rate of photosynthetic storage and export at the same time (Auge, 2001).

Phosphorus levels significantly influenced the yield attributes and yield (Table 1). Among the different levels, P_2O_5 at 100 kg ha^{-1} produced maximum head diameter (18.9 cm) number of filled seeds $head^{-1}$ (730), 100 seed weight (6.06 g) and seed yield (2048 kg ha^{-1}) and stalk yield (4379 kg ha^{-1}). The best treatment caused 53 and 38 per cent increase in seed and stalk yield over control. The lowest value for yield attributes and yield was recorded in the treatment P_2O_5 at 0 kg ha^{-1}. This might be due to the role of phosphorus in cell division and cell enlargement, photosynthesis, which ultimately affect the yield attributes. Similar finding was earlier reported by Ghazanfar Ullah Sadozai (2013).

The interaction effect between the mycorrhizal inoculation and phosphorus was not significant (Table 2). The treatment combination of mycorrhizal inoculation along with P_2O_5 at 100 kg ha^{-1} recorded higher values for yield attributes and yield but it was on par with mycorrhizal inoculation along with P_2O_5 at 75 kg ha^{-1}. The mycorrhizal inoculation caused a saving of 25 kg P_2O_5/ha. This might be due to more availability of phosphorus and other nutrients at both vegetative and reproductive stages. Similar findings were earlier reported by Hossein Soleimanzadeh (2012) and Khirood Doley and Paramjit Kaur Jite (2012). The lowest values of yield attributes and yield were recorded under the treatment combination of non mycorrhizal inoculation with 0 kg P_2O_5 ha^{-1}.This might be due to the absence of mycorrhiza resulted in reduced growth and yield attributing characters and seed and stalk yield. The effect due to different treatments on yield was confirmed by significant positive linear relationship noticed between seed yield with LAI, Head diameter, number of filled seeds per head and test weight (Fig. 1). The present result was in harmony with earlier reported by Ultra Jr *et al*. (2007) and Mostafa Heidari and Vahid Karami (2014).

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