CIBTech Journal of Biotechnology ISSN: 2319–3859 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/cjb.htm
2014 Vol. 3 (2) April-June, pp.1-5/Shinde and Khanna
Research Article

GROWTH RESPONSES OF POTATO PLANTS TO NATIVE ARBUSCULAR MYCORRHIZAL FUNGI

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ABSTRACT
Arbuscular mycorrhizal fungi have since long been known for their involvement in increasing the yield and growth of plants in their presence. Work on the same has been carried out for numerous cash crops, potato being one of them. Our research includes the study of different growth responses of AM fungi in potato plants grown in their presence and absence. Potato plants were grown in pot culture and field culture conditions. Growth responses including average shoot length, average number of leaves per plant, average number of leaflets per plant, average root length; average number of tubers per plant, average diameter of tubers per plant and average fresh weight per plant were performed. Standard deviation was calculated to check the relevance of our results. Investigatory studies on control and mycorrhizal potato plants from both pot and field conditions allowed us to conclude that mycorrhizal plants grew faster and better than control plants. It was observed that plants growing under field conditions shoed better growth responses than those grown in pot conditions. This indicated positively that AM fungal presence is beneficial for potato growth.

***Keywords*:** *AM Fungi, Potato, Growth Responses*

INTRODUCTION
The word 'Mycorhiza' was coined by Frank (1885). It was first observed and identified by Nageli (1842). The nature of this now known mutually beneficial fungus was vaguely reported earlier. Janse (1897) and Gallaud (1905), detailed out special identifying characters present in it to provide a better understanding. As further research on AM fungi proceeded in its history, the diversified instrumental advantages provided to plants came into picture. Out of many positive effects they had, many reports suggested that they serves as bioprotectant (Vaast *et al*., 1998; Slezack *et al*., 2000), assisted in revegetation of deserted sites (Saito and Marumoto, 2002) and also aided in micro propagated plantlet cultivation (Yano-Melo *et al.,* 1999). Besides this, many scientists also reported increased levels of biochemical parameters in mycorrhizal plants when compared with plants grown in their absence (Koide and Mosse, 2004; Baylis, 1959).
Besides the increased growth rate and higher levels of biochemical contents, plants colonized by AM fungi have many changes that take place within them, even at cellular levels. Since one of the main contributions of AM fungi in nutrient availability to plants it colonizes is phosphate, the enzymes that are known to assist in phosphate availability, phosphatase concentrations, are closely altered with mycorrhization.
Though a substantially large amount of research has till date gone into analysis of AM fungi and its variation in soils of numerous agriculturally important crops, the need to determine the actually effects of the nutrient availability on the growth responses was necessary this is what prompted us to work on the same. Potato is one of the important crops being grown on a large scale in Pune and much can be contributed to its yield, with findings of this research. This research therefore mainly focuses its attention on the changes of growth responses in potato plants grown in the presence and absence of AM fungi and their simultaneous comparison in the two different set of conditions.

MATERIALS AND METHODS
For the current investigation, three sets of potato tubers were planted under pot culture and field culture. Healthy potato tubers possessing sprouted eyes were selected and same were planted in large, similar

sized pots (pot culture) or rowed ridges (field culture) for growth and further investigation. Soil used contained 2:1:1 ratio of sand: manure: soil. Control set of tubers were sowed in sterilized soil. Same was achieved using an autoclave at 121°C for 20 minutes. Mycorrhizal set of tubers were planted in soil collected from potato growing fields that contained naturally growing AM fungi. The AM fungi identified include *Glomus*, *Sclerocystis Acaulospora*, *Scutellospora* and *Gigaspora*. Since potato plants require loose textured soil for growth and development of tubers, soil was mixed and crumbles broken well, stones removed; this helped to reduce all lumps in it to the minimal. Plants were watered daily until harvested at 90 days. Growth responses were analyzed after 30, 60 and 90 days. For field culture, plantation involves the creation of longitudinal, ridged rows of well drained soil plantation of potatoes approximately 5-10cm below the surface with intra and inter row spacing of 20x20 cm (Tantowijoyo and Fliert, 2006). Ridging allows the plant stem to remain upright and the soil to maintain its loose texture. The plant requires a well irrigated soil however it is not adaptable to water logging conditions. At maturity, the plant stem and leaves turn yellow and the tubers are easily separated from the mother plant.

Two main types of responses were studied during the entire period of our study. These included above ground growth a response that is assessment of the aerial system. This included study of average shoot length, average number of leaves per plant, average number of leaflets per plant, average root length. Subterranean growth responses included study of average number of tubers per plant, average diameter of tubers per plant and average fresh weight per plant.

All results obtained were analyzed for the standard deviation to observe the deviation from the mean value.

RESULTS AND DISCUSSION

Results for pot culture and field culture experiments were analyzed and assessed and following is a summative interpretation based on the same.

POT Conditions

Average shoot length after 30 days in control set was 10.33± 1.52753 cm; in Mycorrhizal set was 12.33±1.52 cm. After 60 days, control plants showed 17.67±0.58 cm shoot length and mycorrhizal plants were 25.66±1.52 cm tall.

Average root length after 30 days in the control set was 4.5±0.5 cm and in the mycorrhizal set was 9.56±0.92 cm. On the 90th day, the root length of control plants was 11.1±0.65 cm, while that of mycorrhizal plants was 15.43±0.40 cm (Table No.1).

Average number of leaves for control plants was 0.33±0.57, 5.3±0.57 and 5.33±0.57 after 30th, 60th and the 90th day after plantation respectively. Mycorrhizal plants recorded 4.33±0.57, 10.00±1.00 and 9.66±0.57 average number of leaves on 30th, 60th and the 90th days (Table No. 1).

Table 1: Effect of AM fungi on growth responses in potato plants under pot conditions

Days	Average Shoot length (cm)		Average Root length (cm)		Average No. of Leaves per plant		Average No. of leaflets per leaf	
	Control	Mycorrhizal	Control	Mycorrhizal	Control	Mycorrhizal	Control	Mycorrhizal
30	10.33 ± 1.53	12.33 ± 1.52	04.50±0.50	09.56±0.92	0.33±0.57	04.33±0.57	2.66±0.57	6.00±1.00
60	17.66±1.52	25.66±1.52	08.83±0.76	12.43±0.45	5.30±0.57	10.00±1.00	7.33±1.15	7.66±1.52
90	21.00±1.00	38.67±1.53	11.10±0.65	15.43±0.40	5.33±0.57	09.66±0.57	7.66±1.52	7.66±1.154

Abbreviations: ± = Values obtained for standard deviation

Average number of leaflets in control set of plants after 30 days was 2.66±0.57; 60 days old plants was 7.33±1.15 and 90 days old plants was 7.66±1.52. Mycorrhizal plants possessed 6.00±1.00 leaflets per plant after 30 days, 7.66±1.52 after 60 days and 7.66±1.15 leaflets per plant after 90 days (Table No. 1).

Average number of tubers in control plants was 2.00±1.00 30 days after plantation. After 60 days, the value increased to 5.00±1.00 and finally to 6.33±0.57 after 90 days. Mycorrhizal plants showed 3.66±0.57 average tubers per plant at the 30th day, 7.66±0.57 at the 60th day and 9.00±1.00 at the 90th day. The

average number of tubers per plant was observed to be higher in plants grown in the presence of AM fungi (Table No.2). Mycorrhizal plants showed greater number of tubers with greater diameter at the time of harvest.

Table 2: Effect of AM fungi on growth responses in potato plant tubers under pot conditions

Days	Average No. of Tubers per plant		Average diameter of tubers per plant (cm)		Average fresh weight per plant (g)	
	Control	Mycorrhizal	Control	Mycorrhizal	Control	Mycorrhizal
30	2.00±1.00	3.66±0.57	03.53±0.50	06.56±0.51	00.67±0.58	01.00±1.00
60	5.00±1.00	7.66±0.57	06.23±0.25	12.43±0.40	15.08±2.78	27.66±2.08
90	6.33±0.57	9.00±1.00	12.56±0.51	18.30±0.30	35.60±2.26	55.36±1.27

Abbreviations: ± = Values obtained for standard deviation

Average diameter of potato tubers in control set was 3.53±0.50 cm on 30th day, 6.23±0.25 cm after 60 days and 12.56±0.51 cm after 90 days after plantation. Mycorrhizal plants showed 6.56±0.51 cm average diameter on the 30th day, 12.43±0.40 cm on the 60th day and 18.30±0.30 cm on the 90th day. This shows that there was an average difference of approximately 6 cm in the diameter of tubers produced by plants growing in the presence of AM fungi and those growing in its absence at 90 day (Table No.2).

Average fresh weight of tubers was 00.67±0.58 g in control plants after 30 days, 15.08±2.78 g after 60 days and 35.60±2.26 g after 90 days. Mycorrhizal plant tubers weighed 01.00±1.00 g, 27.66±2.08 g and 55.36±1.27 g on the 30th, 60th and the 90th day respectively (Table No.2).

Field Conditions

Average shoot length after 30 days in control set was 10.33±2.51 cm; mycorrhizal set plants were 19.00±1.00 cm. After 90 days, the average observed was 31.33±2.51 cm, while mycorrhizal set depicted 53.66±3.05 cm (Table No.3).

Table No. 3: Effect of AM fungi on growth responses in potato plants under field conditions

Days	Average Shoot length (cm)		Average Root length (cm)		Average No. of Leaves per plant		Average No. of leaflets per leaf	
	Control	Mycorrhizal	Control	Mycorrhizal	Control	Mycorrhizal	Control	Mycorrhizal
30	10.33±2.51	19.00±1.00	05.33±0.50	07.46±0.41	2.00±1.00	06.66±0.57	3.66±1.15	4.66±0.57
60	25.33±1.53	38.66±2.51	07.13±0.15	11.53±0.50	3.66±0.57	10.66±1.15	6.00±1.00	8.00±1.00
90	31.33±2.51	53.66±3.05	10.53±0.50	17.6±0.53	8.66±0.57	16.00±1.00	6.66±0.57	9.66±0.57

Abbreviations: ± = Values obtained for standard deviation

There was a difference of 14 cm between the average shoot length of mycorrhizal plants raised under field and pot conditions. Potato plants allowed to grow in the presence of mycorrhiza under field conditions depicted the highest value of average shoot length.

Average root length in control plants after 30 days of growth was 5.53±0.503 cm and mycorrhizal plants was 7.46±0.413 cm. At the 90th day, the average root length was 10.53±0.503 cm in control plants and 17.6±0.53 cm in mycorrhizal plants (Table No.3). The maximum average root length of potato plants was observed in mycorrhizal plants both, under pot and field conditions. Mycorrhizal potato plants grown under field conditions depicted higher value of average root length as compared to mycorrhizal plants grown under pot conditions.

Average number of leaves after 30 days of plantation in control set of plants was 2.00±1.00. After 60th day, it increased to 3.66±0.57 and to 8.66±0.57 by the 90th day (Table No.3). Mycorrhizal plants reported 6.66±0.57, 10.66±1.15 and 16.00±1.00 leaves at observations made on the 30, 60 and 90 day respectively.

Average number of leaflets after 30 days was 3.66±1.15, it was 6.00±1.00 and 6.66±0.57 leaflets after 60 and 90 days of growth respectively. Mycorrhizal plants possessed 4.66±0.57 leaflets after 30 days,

8.00±1.00 leaflets after 60 days of growth and 9.66±0.57 leaflets per plant after 90 days of growth (Table No.3).

Average number of tubers in control plants was 3.00±1.00 at the 30th day, 3.66±0.57 at the 60th day and 5.33±0.57 at the 90th day. Mycorrhizal plants showed 5.66±0.57 tubers per plant after 30 days, 6.66±0.57 at 60th day and 8.66±0.57 tubers at 90th day respectively (Table No.4). This shows that there was a marked difference in the average number of tubers produced in mycorrhizal and control plants. It was observed that mycorrhizal plants showed a greater number of tubers being produced per plant as compared to control plants grown in field conditions.

Table No. 4: Effect of AM fungi on growth responses in potato plant tubers under field conditions

Days	Average No. of Tubers per plant		Average diameter of tubers per plant (cm)		Average fresh weight per plant (g)	
	Control	Mycorrhizal	Control	Mycorrhizal	Control	Mycorrhizal
30	3.00±1.00	5.66±0.57	04.33±0.38	08.60±0.62	00.33±0.57	000.66±1.15
60	3.66±0.57	6.66±0.57	08.60±0.65	16.33±0.21	21.00±2.00	130.33±2.51
90	5.33±1.54	8.66±0.57	12.33±0.37	21.20±0.55	46.66±2.51	220.66±2.08

Abbreviations: ± = Values obtained for standard deviation

Average diameter of potato tubers, after 30 days was 04.33±0.38 cm, 08.60±0.65 cm after 60 days and 12.33±0.37 cm after 90 days. Mycorrhizal plants possessed average tuber diameter of 08.6±0.62 cm after 30 days, 16.33±0.21 cm after 60 days and 21.2±0.55 cm after 90 days (Table No.4).

Average fresh weight of potato tuber per plant was 0.33±0.57 g, 21.00±2.00 g and 46.66±2.51 g on the 30th, 60th and 90th day respectively. Mycorrhizal plant tubers were of 0.66±1.15 g, 130.33±2.51 g and 220.66±2.08 g on the 30th, 60th and 90th day respectively (Table No.4).

Our results were concomitant with results obtained by Lenin *et al.,* (2010). Besides this, Sultana and Pindi (2012) studied and reported that cotton plants inoculated with AM fungi depicted increased shoot and root length. Our studies are in corroboration with Wu *et al.,* (2005) who obtained results that suggested that the use of biofertilizer containing *Glomus mosseae* and three bacterial species resulted in the highest biomass and seedling height. Besides this, Wu and Xia (2006) reported that AM fungi influenced growth of *Citrus tangerine* and reported that AM colonization significantly stimulated plant growth.

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