ISSN: 0976-1675

www.rjas.org

Research Journal of Agricultural Sciences

© Centre for Advanced Research in Agricultural Sciences

Research Paper

DI: 6256-1307-249

Consequence of Arbuscular-Mycorrhizal *Glomus* Species on Drought Tolerance of Garlic (*Allium sativum* L.)

Sanjay Shinde
Department of Botany,
Arts Commerce and Science College Lasalgaon, Nashik - 422 306, Maharashtra, India

Received: 05 May 2020; Revised accepted: 14 August 2020

A B S T R A C T

An experiment was conducted to determine the effect of mycorrhizal fungi inoculation on growth of garlic grown under well-watered and water stressed pot culture conditions. Garlic (*Allium sativum* L.) cloves were planted in furrows. The data was collected at an interval of 15 days. Colonization of root with Arbuscular Mycorrhizal (AM) fungi occurred in under water-stressed and well-watered conditions, but the extent of AM fungi root colonization was higher under well-watered than under water stressed conditions. Regarding length of leaves, root, weight of bulb and diameter of garlic after 45, 60, 75 and 90 days, data was collected. The AMF-inoculated plants had higher fresh bulb yield and mean bulb weight than uninoculated plants However, inoculation with AM fungi has improved garlic bulb yield. The result indicates from AM fungi inoculation benefited more than that of especially under water-stressed conditions.

Key words: *Allium sativum*, AM fungi, Inoculation, Watered, Water stressed, Root colonization

The garlic (*Allium sativum* L.) which belongs to family Liliaceae is one of the important horticultural crops cultivated in India. Arbuscular Mycorrhizal fungi are important in sustainable farming because they improve plant water relations and thus increase the drought resistance of host plants (Allen and Allen 1986). They improve disease control (Bolandnazar *et al*. 2007), as well as they increase mineral uptake, which reduces the use of fertilizers. The capabilities of specific fungus-plant associations to tolerate drought are of great curiosity. Mycorrhizal inoculation with *Glomusaggregatum*, and *Glomusdeserticola* was found to improve garlic growth by enhancing the leaf area index, length of leaf, bulb yield, and water use efficiency, under both well-watered and water-deficit conditions (Bolandnazar 2009). Garlic as an irrigated crop, but in famine conditions limit of crop productivity, on applying different skills in cropping systems that would enable plants to better resist drought stress. It is helpful to improve crop production under arid conditions. The Allium species, garlic is the most widespread vegetables and show a high nutritional value on human health and beneficial to our cardiovascular system by reducing blood pressure. It is helpful to reduce the severity of cold and flu. Garlic is one of the most popular ingredients in cooking. Under drought conditions Arbuscular Mycorrhizal (AM) fungi associated with plant roots enhanced growth of crop as well as productivity by improving the mineral nutritional status. By increasing the surface area of soil explored via fungal hyphae, it can be accomplished (Mushen 2018). Arbuscular Mycorrhizal fungi also improve soil aggregation and water-holding capacity both by producing external hyphae. Mycorrhizal plants have better capacity to overcome unfavorable conditions of environment and thus produce more benefit. If tolerance of the plants to drought differs with Arbuscular Mycorrhizal fungi isolate with which plants are associated (Gupta and Routaray 2009). The main aim of this study was to grasp effects Arbuscular Mycorrhizal fungi on bulb yield of garlic. It has been observed that both sterilized and non-sterilized soil, the inoculation with Arbuscular Mycorrhizal fungi can cause magnificent increase in root length, leaf and diameter as well as weight of bulb garlic. Nelsen and Safir (1982) testified that mycorrhizal garlic was more tolerant to water deficit stress than non-mycorrhizal one.

***Corresponding author:** Dr. Shinde Sanjay Kacharu, Assistant Professor, Arts Commerce and Science College Lasalgaon, Nashik - 422 306, Maharashtra

e-mail: sanjayshinde70@yahoo.com | **Contact:** +91- 9011669279

MATERIALS AND METHODS

An experiment was conducted during 2015-16 to determine the effect of arbuscular mycorrhizal fungi inoculation on growth of garlic grown under well-watered and water stressed pot culture conditions. The data was collected at an interval of 15 days i.e. after 45, 60, 75 and 90 days. The factors were irrigation intervals (2, 4 and 8days), Arbuscular Mycorrhizal Fungi (AMF) species, (*Glomus aggregatum* and *Glomus deserticola*) and Non-mycorrhizal (NM) as control plants. Garlic (*Allium sativum* L.) the cloves (seeds) were disinfected for15 min in 1% sodium hypochlorite and sown in sandy loam Fifteen grams of inoculum (spore, hyphae, AM root fragment and soil) were mixed to one kg of the medium. The control received the same amount of sterilized inoculum. After seedling emergence, their roots were washed, cut into 1cm long pieces and mixed thoroughly. The fragments then were cleared with 10% KOH and stained with 0.05% (w/v) trypan blue in lactoglycerol (Phillips and Hayman 1970). Percentage of mycorrhizal colonization was determined by gridline intersect method (Furlan and Fortin 1973). At transplanting (8weeks after sowing) root colonization occurs in seedlings.

RESULTS AND DISCUSSION

Effect of water stress on length of leaves and root of garlic after 45, 60, 75 and 90 days

The effect of water stress on growth response of garlic was studied with and without AM fungi after 45, 60, 75 and 90 days. The growth parameters like root length, and leaf length was recorded in control and mycorrhizal plants. The water stress was given at 2, 4 and 8 days interval in mycorrhizal plants whereas the control plant was watered with 2 days interval. The length of leaf recorded after 45 days was 26 cm in control plants whereas it was 33, 32 and 31cm in mycorrhizal plants watered with 2, 4 and 8 days interval respectively. After 60 days the length of leaf recorded was 34, 33 and 32cm in mycorrhizal plants watered with 2, 4 and 8 days interval respectively whereas it was28 cm in control plants. The length of leaf recorded after 75 days was 29 cm in control plants whereas it was 38, 37 and 36.50cm in mycorrhizal plants watered with 2, 4 and 8 days interval respectively. The length of leaf recorded was 29cm in control plant whereas it was recorded 41, 40 and 38cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days (Table 1). The length of root recorded after 45 days was 7 cm in control plant whereas it was 8, 9 and10cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively. After 60 days the length of root recorded was 11.00, 11.50 and 12.50 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively whereas it was9 cm in control plant. The length of root recorded after 75 days was11.00 cm in control plant whereas it was 12.60, 15.00 and 16.50 in mycorrhizal plant watered with 2, 4 and 8 days interval respectively. The length of root recorded was 13.00cm in control plant whereas it was recorded 14.55, 16.00 and15.80cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days (Table 1). The mycorrhizal plant showed better growth after 45, 60, 75 and 90 days as compared to control plant. The results were significant at $P \leq 0.05$ level.

Table 1 Effect of water stress on length of leaf and root of garlic after 45, 60, 75 and 90 days

No. of days	Parameter	C	E	E4	E8
45 days	Leaf length cm	26.00 ± 1.83	33.00 ± 1.83	32.00 ± 1.83	31.00 ± 1.83
	Root length cm	07.00 ± 1.83	8.00 ± 1.83	9.00 ± 1.83	10.00 ± 1.83
60 days	Leaf length cm	28.00 ± 1.83	34.00 ± 1.83	33.00 ± 1.83	32.00 ± 1.83
	Root length cm	9.00 ± 1.83	11.00 ± 1.83	11.50 ± 1.86	12.50 ± 1.77
75 days	Leaf length cm	29.00 ± 1.83	38.00 ± 1.83	37.00 ± 1.83	36.50 ± 1.75
	Root length cm	11.00 ± 1.83	12.60 ± 1.83	15.00 ± 1.83	16.50 ± 1.75
90 days	Leaf length cm	29.00 ± 1.83	41.00 ± 1.83	40.00 ± 1.83	38.00 ± 1.83
	Root length cm	13.00 ± 1.83	14.55 ± 1.83	16.00 ± 1.83	15.80 ± 1.79

C- Control, E-Experimental, watered after 2 days, E4- watered after 4 days, E8- watered after 8 days ±=SE

After 45 days the diameter of garlic bulb recorded was 10.10 cm in control plant whereas it was 12.20, 11.30 and 10.70 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively. The diameter of garlic bulb after 60 days recorded was 10.80 cm in control plant whereas it was 12.80, 11.90 and 11.40 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively. The diameter of garlic bulb recorded after 75 days was 13.90, 13.20 and 12.80 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively whereas it was 11.20 cm in control plant. After 90 days diameter of garlic bulb recorded was 11.40 cm in control plant whereas it was recorded 15.00, 14.30 and 13.70 cm in mycorrhizal plant watered with2, 4 and 8 days interval respectively (Table 2). The mycorrhizal plant showed better growth after 60 and 90 days as compared to control plant. The results were significant at $P \leq 0.05$ level. The weight of garlic bulb recorded after 45 days was 59.50 gm in control plants whereas it was 71.00, 67.00 and 62.00 gm in mycorrhizal plants watered with 2, 4 and 8 days interval respectively. After 60 days the weight of garlic bulb recorded was 75.40, 69.30 and 63.50 gm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively whereas it was 61.50 gm in control plant. After 75 days the weight of garlic bulb recorded was 65.70 gm in control plant whereas it was 77.50, 72.70 and 67.20 gm in mycorrhizal plant watered with 2, 4 and 8 days interval

respectively. Weight of garlic bulb recorded was 69.40 gm in control plant whereas it was recorded 90.00, 75.80 and 71.60 gm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days (Table 2). The mycorrhizal plant showed better growth after 60 and 90 days as compared to control plant. The results were significant at P≤ 0.05 level.

Table 2 Effect of water stress on diameter and weight of garlic bulb after 45, 60, 75 and 90 days

No. of days	Parameter	C	E	E4	E8
45 days	Diameter of bulb (cm)	10.10 ± 1.96	12.20 ± 1.87	11.30 ± 1.87	10.70 ± 1.77
	Weight of bulb (gm)	59.50 ± 1.97	71.00 ± 1.83	67.00 ± 1.83	62.00 ± 1.83
60 days	Diameter of bulb (cm)	10.80 ± 1.90	12.80 ±1.79	11.90 ± 1.83	11.40 ± 1.94
	Weight of bulb (gm)	61.50 ± 2.01	75.40 ± 1.87	69.30 ± 1.87	63.50 ± 1.94
75 days	Diameter of bulb (cm)	11.20 ± 1.94	13.90 ± 1.83	13.20 ± 1.97	12.80 ± 1.87
	Weight of bulb (gm)	65.70 ± 2.01	77.50 ± 1.94	72.70 ± 1.87	67.20 ± 1.87
90 days	Diameter of bulb (cm)	11.40 ± 2.01	15.00 ± 1.83	14.30 ± 1.97	13.70 ± 1.87
	Weight of bulb (gm)	69.40 ± 2.01	90.00 ± 1.83	75.80 ± 1.87	71.60 ± 1.87

C- Control, E-Experimental, watered after 2 days, E4- watered after 4 days, E8- watered after 8 days ±=SE

Effect of water stress on number of propagules per 100 gm of soil and percent root colonization of garlic after 45, 60, 75 and 90 days

The number of propagules per 100 gm of rhizosphere soil of garlic plants watered with two days interval was recorded 304, 352, 391 and 502 after 45, 60, 75 and 90 days respectively. The percent root colonization reported in these plants was 47, 52, 61 and 69 after 45, 60, 75 and 90 days respectively. The number of propagules per 100 gm of soil of garlic plants was recorded 240, 295, 347 and 479 after 45, 60, 75 and 90 days respectively in plants watered with four days interval. The percent root colonization reported in plants watered at the interval of 4days was 44, 49, 58 and 64 after 45, 60, 75 and 90 days respectively. The plants watered at the interval of eight days showed minimum number of AM propagules and lowest root colonization. It was 205, 256, 308 and 426 after 45, 60, 75 and 90 days respectively. The number of propagules decreased as the water stress was increased. The percent root colonization reported in plants watered at the interval of 8 days was 40, 46, 57 and 60 after 45, 60, 75 and 90 days respectively (Table 3). The results are significant at P≤0.05 level.

Table 3 Effect of water stress on percentage root colonization and number of propagules per 100 gm of soil of garlic after 45, 60, 75 and 90 days

Treatment	45 days		60 days		75 days		90 days	
	NAMP	RC	NAMP	RC	NAMP	RC	NAMP	RC
C	-	-	-	-	-	-	-	-
E	304 ± 1.83	47 ± 1.83	352 ± 1.83	52 ± 1.83	391 ± 1.71	61 ± 1.83	502 ± 1.83	69 ± 1.83
E4	240 ± 1.83	44 ± 1.83	295 ± 1.83	49 ± 1.83	347 ± 1.15	58 ± 1.83	479 ± 1.83	64 ± 1.15
E8	205 ± 1.83	40 ± 1.83	256 ± 1.83	46 ± 1.83	308 ± 1.83	57 ± 2.94	426 ± 1.83	60 ± 1.83

Values are significant at P≤0.05 level

NAMP = Number of AM propagules RC = % root colonization C- Control E -Experimental, Watering after 2 days, E4-Watering after every 4 days, E8- Watering after 8 days. ± = SE AMF colonization (Table 3) improved the leaf length, root length, (Table 1) as well as diameter and weight of bulb ratio significantly (Subramanianet *at al*. 2006). Water stress had significantly reduced bulb yields in un-inoculated plants (Mushen and Ali 2015). However, inoculation with AM fungi has upgraded garlic bulb yield. The length of leaf recorded after 75 days was 29 cm in control plants whereas it was 38, 37 and 36.50 cm in mycorrhizal plants watered with2, 4 and 8 days interval respectively. The length of leaf recorded was 29cm in control plant whereas it was recorded 41, 40 and 38 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days The length of root recorded was 13.00 cm in control plant whereas it was recorded 14.55, 16.00 and 15.80 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days (Table 1). The mycorrhizal plant showed better growth after 45, 60, 75 and 90 days as compared to control plant. After 90 days diameter of garlic bulb recorded was11.40cm in control plant whereas it was recorded15.00, 14.30 and 13.70cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively (Table 2). The mycorrhizal plant showed better growth after 60 and 90 days as compared to control plant. Weight of garlic bulb recorded was 69.40gm in control plant whereas it was recorded 90.00, 75.80 and 71.60gm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days. The plants watered at the interval of eight days showed minimum number of AM propagules and lowest root colonization. It was 205, 256, 308 and 426

after 45, 60, 75 and 90 days respectively. The number of propagules and root colonization arise with decreased as the water stress was increased (Ruiz-Lozano and Azcon 1996). The symbiotic association between plant-mycorrhiza has seen increased interest and evidenced for direct recycling of nutrients from organic matter to plants by mycorrhizal fungi. The plant mycorrhiza association is mostly studied for many crop plants for enhancement in plant growth and yield due to increased supply of phosphorous to the host plants. Therefore, present investigation was undertaken to find out the exact interrelationship between AM fungi and yield of garlic. Arbuscular mycorrhizal fungi improved garlic growth and development in comparison with non-mycorrhizal ones. This improvement resulted from increasing plant height which led to greater leaf area and probably photosynthesis capacity both leading to greater larger bulb. Increasing plant size and yield (Charron *et al*. 2001a); and enhancing chlorophyll content by AMF colonization. Mycorrhizal garlic had greater size of bulb than control plants at first harvest, implying that bulb initiation and bulbing process occurred earlier and produced faster in mycorrhizal plants than non-mycorrhizal ones (Table 1). In control plants, bulbing occurred 10-15 days late. Our results agree with findings of Charron et al.(2001b), who reported that mycorrhizal garlic reached to marketable size 2-3 weeks earlier than non-mycorrhizal garlic.

The mycorrhizal colonization improves garlic seedling endurance and establishment that increased its growth and development which led to producing bigger bulb and greater yield. Hence, it indicates that the presence of arbuscular mycorrhizal association affects the growth and development of garlic plant.

Acknowledgement

The author is thankful to the management of N.V.P. Mandal and the Principal of Arts, Science and Commerce College, Lasalgaon District Nasik for permitting to complete the undertaken research work in the authorized research laboratory and providing the facilities during conducting research work.

LITERATURE CITED

Allen E B and Allen M F. 1986. Water relations of xeric grasses in the field: interactions of mycorrhizas and competition. *New Phytology* **104**: 559-571.

Bolandnazar S, Aliasgharzad N, Neishabury M R and Chaparzadeh N. 2007. Mycorrhizal colonization improves onion (*Allium cepa* L.) yield and water use efficiency under water deficit condition. *Scientia Horticulturea* 114.

Bolandnazar S. 2009. The effect of mycorrhizal fungi on onion (*Allium cepa* L.) growth and yield under three irrigation intervals at field condition. *Journal of Food Agriculture and Environment* **7**: 360-362.

Charron G, Furlan V, Bernier-Carou M and Doyon G. 2001a. Response of garlic plants to arbuscular mycorrhizae, 1. Effects of inoculation method and phosphorus fertilization on biomass and bulb firmness. *Mycorrhiza* **11**: 187-197.

Charron G, Furlan V, Bernier-Carou M and Doyon G. 2001b. Response of garlic plants to arbuscular mycorrhizae, 2. Effects nitrogen fertilization on biomass and bulb firmness. *Mycorrhiza* **11**: 145-150.

Furlan V and Fortin J A. 1973. Formation of endomycorrhizae by Endogonecalospora on Allium sativum under three temperature regimes. *Le Naturaliste Canadien* **100**: 467-477.

Gupta N and Routaray S. 2009. Effect of water stress on performance of maize inoculated with *Glomus* sp. isolated tea garden of Keonjhar, Orissa. *Maize Genetics Corporation News Letter (USA)* **83**: 5-6.

Hunt R. 1982. *Plant Growth Curves*. Edward Arnold, London, UK.

Mushen T A A. 2018). Evaluation of the effect *Giagaspora Margarita*, *Glomus Desriticola* fungi in stimulating the resistance of the *Capsicum annutum* L. plant towards chromium and lead. *Journal of Global Pharma Technology* **10**(5): 181-192.

Mushen T A and Ali B Z. 2015. Evaluation of the efficiency of arbuscular mycorrhizal fungi in enhancing resistance of *Lycopersicon esculentum* roots against *Fusarium oxysporum* wilt disease lbn. *Al-Haitham Journal for Pure and Applied Science* **28**(2): 292-306.

Nelsen C E and G R Safir. 1982. The water relation of well-watered, mycorrhizal and non-mycorrhizal garlic plants. *Journal of American Society of Horticultural Science* **107**: 271-274.

Phillips J M and Hayman D S. 1970. Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection. *Transactions of British Mycological Society* **55**: 158-161.

Ruiz-Lozano J M and Azcon R. 1996. Mycorrhizal colonization and drought stress as factors affecting nitrate reductase activity in lettuce plants. *Agricultural Ecosystem and Environment* **60**: 175-181.

Subramanian K S, Santhanakrishnan P and Balasubramanian P. 2006. Responses of field grown tomato plants to arbuscular mycorrhizal fungal colonization under varying intensities of drought stress. *Scientia Horticulturae* **107**: 245-253.