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Short Communication

The Effect of Drought Stress on the Growth and Yield of Onions (*Allium cepa* L.) by the Application of AM Fungi to Field Conditions

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Onion (*Allium cepa* L.) also known as bulb onion is a worldwide major crop of vegetables and spices. The onion bulb consisting of shortened, compressed underground stem protected by modified fleshy scales that surround a central bud at the stem's tip. Drought suppresses plant growth substantially and reduces net primary productivity in arid and semi-arid grasslands [1], [2]. In both amply watered and drought-stressed host plants, vesicular-arbuscular mycorrhizal fungi can influence the water balance. Nonetheless, soil microbes such as mycorrhizal fungi, also control the response of plant growth to drought stress. The effects of soil microbes on the resistance to plant drought are not well known to date.

Arbuscular mycorrhizal fungi (AMF) are one of the most common soil microbe classes and act as mycorrhizal symbionts with the roots of about 72 per cent of terrestrial plants [3]. Many studies have shown that AMF can improve host plant growth by promoting nutrient and water absorption to reduce abiotic stresses, such as drought [4], [5], [6]. AM fungal hyphae can penetrate soil pores that can't be accessed by the root fur, accessing sources of water and nutrients not accessible to non-AM plants. Hence, AMF can improve plant efficiency, change the relationship between plant and water, and increase plant productivity under drought stress [7]. The improved growth in cotton plants documented the potential of mycorrhizal inoculation for the effects of drought stress and being useful for improved production under stress conditions [8]. Among the species of *Allium*, garlic and onion are the most commonly distributed vegetables in the world and have a high nutritional value and beneficial impact on human health. The purpose of this study was to evaluate the effect of arbuscular mycorrhizal fungi on the growth and yield of Onions at different water intervals.

Field tests were completed in Dongargaon, Niphad tehsil, Nasik District of Maharashtra, India, during two back to back years 2018 and 2019. Onion (*Allium cepa* L. var. N-2-4-1 Niphad) seedlings supplied to nursery beds in the area. Seeds purified for 20 minutes in 1 per cent sodium hypochlorite and planted in autoclave sandy loam soil to create seedling. About 15 grams of inoculum (spores, hyphae, root sections of AM along with rhizosphere soil) blended to the 1 kg of the medium. The inoculum of three species of arbuscular mycorrhizal fungi (*Glomus fasciculatum, G. mosseae* and *G. etunicatum*) grown on maize and sorghum plants from a pure culture. The same amount of sterilized inoculum had been added to the control. The planting media was held in the nursery at 29/16°C (day/night) temperature and relative humidity of 45 to 76 per cent. Consistently, three seedlings from each procedure were tested at random (up to transplantation) for 50 days. The underlying foundations of tested seedlings were thoroughly washed and cut into a bit of cm. Such root sections cleared with 10 per cent KOH and stained with 0.05 per cent trypan blue and installed the technique of examining mycorrhizal contamination in PVLG as per [9]. Rate root colonization was acquired by the gridline intersect method [10]. Root colonization in seedlings reached over 60 per cent during transplantation (two months after planting).

At a separation of 12 cm between plants and 24 cm between columns, onion seedlings were then transplanted in the primary region, each plot measurement being 3 m in length and 2 m in width. Four mycorrhizal treatments (including 3 AM fungi and non-mycorrhizal plants) and three interim water systems (6, 9 and 12 days) were used in a factorial randomized square structure including 3 replicates used. After the transplantation, interim medications of the water system were started; in any case, all plots flooded at regular intervals for 6 days before the start of the interim water system for the better foundation of seedlings.

The dirt's key attributes were pH 7.9; EC 0.32 ds / m; natural carbon 0.10%; P_2O_5 12 kg/ac, K_2O 200 kg/ac, Zn 0.24 ppm, Cu 0.68 ppm, Fe 3.98 ppm and Mn 14.49 ppm. The plants were given 50 mg/kg of nitrogen as urea-based on the standard soil check. Weeds without the use of synthetic herbicides were regulated. In the wake of the seedling system managed intact plants. Leaf region was estimated during the process of bulb production. Fresh weight and diameter estimated at bulb maturation stage and dry bulb weight resolved at 72°C after drying. Data were statistically analyzed using the MSTAT-C variance tool. Significant difference at P=0.01 was acquired using a separate test set from Duncan.

All mycorrhizal fungal species have been found to have increased the survival rate of onion seedling significantly from 60 (control) to more than 76 (Table 1). With an increase in water stress interval from 6 to 9 days, the survival rate of seedling increased but decreased significantly in both AM

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inoculated and non-inoculated seedlings at 12 days of water stress interval plants (Table 2). The relationship between Arbuscular mycorrhizal fungi (AMF) colonization and intervals of water stress on seedling survival was important. Onion seedling survival rate was higher in the mycorrhizal plants than control in all three water stress treatments. In mycorrhizal colonization therapy, the survival rate of micro propagated oil palms improved during the acclimatization phase [11]. The amount of water which was optimal for the growth of the plants resulted in the largest development of fungal spores [12]. A decrease in fungal spore mass in onion plants with an increase in drought stress [13], on the other hand, reported that mycorrhizal fungi enhance water uptake by increasing onion hydraulic conductivity.

Table 1 Effect of AMF colonization on onion seedling survival, leaf area, single bulb weight and diameter and total yield

Treatment	Seedling survival (%)	Leaf area (cm^2)	Single bulb weight (g)	Bulb diameter (cm)	Yield (t/ha)	Marketable yield (t/ha)
Control	$60.00_{b\#}$	378.4_{c}	65.72_{b}	4.9_{b}	10.87_{b}	10.154_{b}
Glomus fasciculatum	76.32_{a}	548_{a}	126.69_{a}	6.7_{a}	32.92_{a}	31.57_{a}
Glomus mosseae	71.44_{a}	472_{b}	119.86_{a}	6.4_{a}	30.16_{a}	29.34_{a}
Glomus etunicatum	73.13_{a}	512_{b}	110.12_{a}	6.6_{a}	27.8_{a}	27.42_{a}
LSD 1%	13.86	26.24	35.32	0.848	5.63	5.27

in each column means labelled with the same letter are not significantly different at p= 0.01

Table 2 Effect of Water stress interval on onion seedling survival, leaf area, single bulb weight and diameter, total and marketable yield

Water stress (Days interval)	Seedling survival (%)	Leaf area (cm^2)	Single bulb weight (g)	Bulb diameter (cm)	Yield (t/ha)	Marketable yield (t/ha)
6	$69.5_{ab\#}$	530.2_{a}	139.5_{a}	6.9_{a}	33.5_{a}	33.12_{a}
9	79.6_{a}	501.7_{b}	105.4_{b}	6.6_{a}	27.91_{b}	27.6_{b}
12	63.2_{b}	421.6_{c}	67.6_{c}	5.4_{b}	14.8_{c}	14.63_{c}
LSD 1%	11.48	22.26	30.31	0.41	4.6	4.66

in each column means labelled with the same letter are not significantly different at p= 0.01

Table 3 Interaction of AMF and water stress intervals on leaf onion leaf area, bulb dry weight, total and marketable yield

Treatment	Water stress (Days interval)	Leaf area (cm^2)	bulb weight dry (g)	Yield (t/ha)	Marketable yield (t/ha)
Control	6	$418.20_{ef\#}$	12.80_{bc}	10.20_{cd}	9.03_{cd}
	9	406.80_{f}	12.80_{bc}	14.80_{bcd}	14.56_{cd}
	12	307.80_{g}	14.30_{ab}	6.20_{d}	6.08_{d}
Glomus fasciculatum	6	558.80_{b}	13.40_{bc}	40.10_{a}	39.75_{a}
	9	634.90_{a}	13.50_{abc}	38.25_{a}	37.97_{a}
	12	480.60_{cd}	11.90_{c}	19.01_{bc}	18.75_{bc}
Glomus mosseae	6	557.40_{b}	12.90_{bc}	42.90_{a}	42.45_{a}
	9	475.60_{cd}	12.50_{c}	35.60_{a}	35.20_{a}
	12	430.30_{def}	15.60_{a}	14.30_{cd}	14.05_{cd}
Glomus etunicatum	6	584.10_{b}	13.10_{bc}	44.10_{a}	42.85_{a}
	9	483.20_{c}	13.20_{bc}	24.70_{a}	23.75_{b}
	12	460.80_{cde}	12.30_{c}	17.30_{bc}	16.85_{bc}
LSD 1%		45.44	1.76	9.39	9.29

in each column means labelled with the same letter are not significantly different at p= 0.01

Colonization with AMF and interval of water stress greatly affects the area of the onion leaf (Table 1-2). There is significant interlinking on the area of the leaf between colonization with AMF and treatment with water stress intervals (Table 3). Plants treated with *Glomus fasciculatum* at a water stress interval of 9 days and non-mycorrhizal plants at a water stress interval of 12 days provided the highest and lowest area of the leaves (634.9 cm^2 vs. 307 cm^2). Leaf area reduced in all treatments except the treatment with *Glomus fasciculatum* by increasing the interval of water stress (Table 3). Leaf area at all water intervals was higher in AMF treated plants than normal.

The index of the leaf area is a prime feature of plant growth. The result denoted that AMF treatment not only increased plant growth in standard water treatment (6 days of water stress treatment) but also in extended water stress conditions (9-12-day water stress interval). All of the AMF was effective, but the most effective was *Glomus fasciculatum*. The mycorrhizal colonization improves the absorption of water, helps the plant to withstand water deficit stress and enhances the size of the plant [14]. The inoculation of AM fungi in Bt cotton enhanced drought tolerance [15].

Arbuscular mycorrhizal fungi (AMF) and water stress treatment significantly affected the weight and diameter of the bulb, but the interlinkage between water stress interval and AMF treatment was not important in bulb weight and diameter (Table 1-2). Mycorrhizal treated plants produced larger bulbs than control plants. The bulb 's weight decreased dramatically with an increase in the water stress cycle, but the bulb 's diameter was approximately the same at 6 and 9 days of water stress treatment and reduced in 12 days of water stress treatment.

The complete and marketable yield of onion was significantly controlled by mycorrhizal inoculation and intervals of water tension, and their interdependence effect was important (Table 1). Non-mycorrhizal plants treated with all water stress recorded the lowest total and marketable bulb yield. Arbuscular mycorrhizal fungi (AMF) *Glomus etunicatum* inoculated onion plants under 6 days of water an interval, as well as *Glomus fasciculatum* at 9 days of water stress, produced the greatest total and marketable bulb yields. At 12 days of water stress, onion yield decreased significantly; however, at 12 days of water stress interval, onions treated with *Glomus fasciculatum* and *Glomus etunicatum* provided greater marketable and total yield than non-mycorrhizal treatment at 6 and 9 days of water stress intervals. The colonization of mycorrhizal fungi increased the size and yield of onion bulbs [16]. The *Glomus* species have the capacity for altitude colonization in *Allium* [17]. The mycorrhizal colonisation enhances plant growth by encouraging mineral nutrition and improving the relationship between water, leading to greater plant size and higher yield [18]. Overall, mycorrhizal colonization improved seedling survival, bulb development and higher onion yield. Plants inoculated with *Glomus fasciculatum* and *Glomus mosseae* were more tolerant of excessive water stress interval (9 days) and produced comparable water stress interval yield with 6 days.

SUMMARY

Currently, great attention has been given to the use of arbuscular mycorrhizal fungi for sustainable agriculture to modify plant performance, mineral feeding and water uptake. For two consecutive years, three species of mycorrhizal fungi (*Glomus fasciculatum*, *G. mosseae* and *G. etunicatum*) were examined under three irrigation intervals. Onion seedlings inoculated with mycorrhiza and non-mycorrhizal seedlings were transplanted to $4m^2$ plots. After the establishment, the plants were irrigated every 6, 9 and 12 days. Results showed that mycorrhizal colonization substantially increased seedling survival at all irrigation intervals and mycorrhizal colonization increased seedling establishment by more than 16.32 per cent. Onions that were colonized by *G. fasciculatum* had the highest leaf area at bulbing stage (634.9 cm^2) at a 9-day irrigation interval and non-mycorrhizal plants had the lowest leaf area at a 12-day irrigation interval (307.8 cm^2). Mycorrhizal colonization increased the yield of onion bulbs by about 3 folds relative to control plants. Onions that were colonized by *G. fasciculatum* and *G. mosseae* with irrigation cycles of 6 and 9 days, and *G. etunicatum* produced the highest marketable bulb at 6-day irrigation intervals (more than 35 t / ha), and non-mycorrhizal plants had the lowest marketable yield at 12-day irrigation intervals.

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