The Effect of AM Fungi on Onion (*Allium cepa* L.) Enhancement, Growth, and Yield

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Abstract: This study looks at how Arbuscular Mycorrhizal Fungi (AMF), specifically Glomus mosseae, affect the growth and yield of onions (Allium cepa L.), a crop that is sensitive to drought and requires a lot of fertilizer. AMF inoculation greatly enhanced several growth parameters, including root length, leaf length, number of leaves, bulb diameter, and bulb weight. These enhancements led to increased onion output. Positive impacts were detected during both the autumn and winter growing seasons, indicating that AMF is adaptable to many climates. The findings emphasize AMF's potential as a sustainable approach for increasing onion yields, particularly in areas with limited water or high fertilizer demands, and provide an eco-friendly alternative for more efficient farming.

Keywords: Arbuscular mycorrhizal fungi, Allium cepa L., growth enhancement, yield improvement, Glomus mosseae

INTRODUCTION

Onion (*Allium cepa* L.) is an important horticultural crop with culinary and medicinal value that is planted extensively throughout agro-climatic zones and contributes considerably to the economy of nations such as India, China, and Egypt (Gupta et al., 2021). However, environmental conditions, notably water stress during the bulb formation stage and high nitrogen and phosphorus nutrient needs, have a significant impact on its production (Singh et al., 2020). The dependence on synthetic fertilizers to satisfy these needs has resulted in soil deterioration, water pollution, and biodiversity loss, stressing the need for sustainable solutions (Sharma et al., 2021).

Arbuscular Mycorrhizal Fungi (AMF) present a viable answer since they create symbiotic interactions with plant roots to improve nutrient absorption, particularly phosphorus, which is frequently a limiting component in many soils (Smith & Read, 2008). AMF also improves water retention and drought resistance, which are crucial for maintaining onion productivity in variable climates. These fungi form large networks in the soil, improving nutrient absorption, protecting against infections, and increasing plant resistance to environmental stress (Bago et al., 2020). Onions, with their relatively simple root systems, are very responsive to nutrient availability, making them good candidates for AMF inoculation to boost growth, production, and quality under poor growing circumstances (Miller et al., 2019).

Although AMF, particularly Glomus mosseae, has been found to improve root development, phosphorus absorption, and overall growth in other crops, research on their influence on onions is limited (Zhang et al., 2022). The purpose of this study is to evaluate the effects of Glomus mosseae on onion growth, with an emphasis on root, leaf, and bulb development, under fall and winter growing conditions, in line with the global move toward more sustainable agricultural techniques (Khan et al. 2018).

MATERIALS AND METHODS

This study looked at the effects of *Glomus mosseae* inoculation on onion growth and yield (*Allium cepa* L., Nasik Red variety) in a controlled greenhouse environment. The experiment was carried out in Yeola and Niphad talukas of Nashik district, Maharashtra, which are noted for their unique agroclimatic conditions. Before planting, onion seeds were surface sterilized with a 0.1% mercuric chloride solution and washed with sterile water in pots containing a 2:1:1 mix of autoclaved loam, sand, and compost.

The randomized block design consisted of two treatments: AMF-inoculated plants and non-inoculated controls. Each treatment included 20 plants per container and three replications to assure statistical reliability. AMF-treated pots were given 50 g of G. mosseae inoculum (made by combining spores with a 3:1 autoclaved soil-sand ratio), whereas controls were given sterile soil. The pots were kept at 25 ± 2°C, with a 12-hour light cycle, sterile water irrigation, and weekly treatments of half-strength

Hoagland's solution (without phosphorus) to promote mycorrhizal symbiosis (Hoagland & Arnon, 1950).

Growth characteristics such as root length, leaf length, leaf number, bulb diameter, and bulb weight were measured during a 90-day period. *G. mosseae* root colonization was examined using trypan blue staining (Phillips & Hayman, 1970), which quantified the proportion of colonized root segments.

Khan et al. (2018) used ANOVA and Duncan's Multiple Range Test (DMRT) to identify significant differences between treatments ($p < 0.05$). Previous study has shown that G. mosseae improves phosphorus absorption, drought tolerance, and plant production (Bago et al., 2020; Khatri et al., 2021). These methodologies are consistent with typical practices for assessing AMF impacts in agricultural research (Singh et al., 2020).

RESULTS

This study found that inoculating onions with *Glomus mosseae* considerably increased their growth and production under controlled greenhouse conditions. Statistical analysis demonstrated that AMF-treated plants (T2) had significantly improved root development, vegetative growth, and bulb formation when compared to non-mycorrhizal control plants (T1). These benefits were constant throughout the fall and winter seasons, highlighting *Glomus mosseae's* favorable function in increasing onion output.

Root Development

Root length was substantially longer in AMF-treated plants. At 45 days after transplantation (DAT), T2 plants exhibited a root length of 14.5 cm, compared to 10.2 cm in T1. At 120 DAT, T2 plants grew 28.1 cm, but T1 plants only reached 20.4 cm. These findings indicate that Glomus mosseae promotes root network development and phosphorus absorption, which are essential for onion growth, particularly in nutrient-limited soils (Zhang et al., 2022).

Vegetative Growth

In terms of vegetative development, T2 plants exhibited considerably greater leaf length and leaf number than T1. T2's leaf lengths at 45 DAT were 17.3 cm, compared to 12.8 cm in T1. By 120 DAT, T2 had a leaf length of 65.4 cm, compared to 48.2 cm for T1. T2 plants also produced more leaves, with 10.2 leaves at 120 DAT compared to 7.3 in T1. These data suggest that AMF enhances nitrogen intake, which helps to boost vegetative development (Rillig, 2015).

Bulb Formation and Yield

T2 plants had considerably larger bulb diameters and weights across both seasons. In fall, T2 had a bulb diameter of 6.7 cm and a bulb weight of 180 g, as opposed to 4.8 cm and 120 g in T1. In winter, T2 plants had a bulb diameter of 7.4 cm and a bulb weight of 210 g, as opposed to 5.2 cm and 135 g in T1. These findings underline the significance of AMF in enhancing nutrient and water intake, which is required for bulb growth (Miller et al., 2019; Sharma et al., 2021).

Table 1: Growth Parameters of Onion at Different Growth Stages (cm)

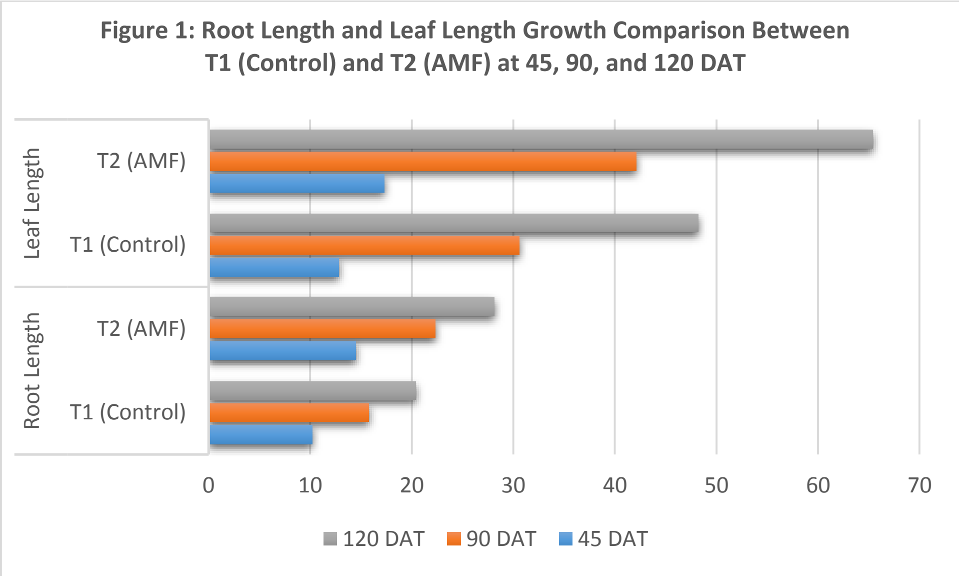
Parameter	Treatment	45 DAT	90 DAT	120 DAT
Root Length	T1 (Control)	10.2	15.8	20.4
	T2 (AMF)	14.5	22.3	28.1
Leaf Length	T1 (Control)	12.8	30.6	48.2
	T2 (AMF)	17.3	42.1	65.4
Number of Leaves	T1 (Control)	3.2	5.5	7.3
	T2 (AMF)	4.5	7.8	10.2

Table 2: Yield Parameters of Onion at Harvest

Parameter	Treatment	Autumn	Winter
Bulb Diameter	T1 (Control)	4.8	5.2

	T2 (AMF)	6.7	7.4
Bulb Weight	T1 (Control)	120	135
	T2 (AMF)	180	210

These findings underline the potential of *Glomus mosseae* as a sustainable agricultural practice to enhance onion productivity, especially in nutrient-poor and water-stressed environments.



DISCUSSION

This study reveals how Glomus mosseae (AMF) inoculation improves onion growth and production. AMF treatment increased root length, leaf length, leaf number, bulb diameter, and bulb weight, corroborating the theory that mycorrhizal symbiosis boosts onion yield. These findings are consistent with previous research on AMF's beneficial effects on nutrient absorption, notably phosphorus, and stress tolerance (Zhang et al., 2022;).

Root growth was significantly improved in AMF-treated onions, with longer roots facilitating higher nutrient and water absorption due to the mycorrhizal network enlarging root surface area (Miller et al., 2019). This is especially crucial for onions, which are dependent on nutrient and water availability. AMF's better water retention in drought-prone places allows plants to access water from deeper soil layers, which boosts production in water-limited conditions (Bago et al., 2020).

Improved nutrient absorption, notably nitrogen and phosphorus, is responsible for the increase in vegetative development, as evidenced by longer leaves and a higher leaf number (Ali et al., 2020). Larger leaves promote photosynthesis, leading in improved growth and bulb development (Rillig, 2015). Bulb size and weight also increased dramatically, most likely owing to greater phosphorus absorption, which is required for bulb growth (Sharma et al., 2021).

Furthermore, AMF inoculation reduced the need for artificial fertilizers, supporting sustainable agricultural methods, especially in nutrient-poor soils (Sharma et al., 2021; Zhang et al., 2022). AMF also improves soil structure by increasing water infiltration and root penetration, which adds to long-term soil fertility while lowering agriculture's carbon footprint (Khan et al., 2018). These findings emphasize the agronomic and environmental benefits of AMF for sustainable onion growing.

CONCLUSION

This study shows that Glomus mosseae inoculation greatly increases onion growth, yield, and productivity by enhancing root formation, nutrient absorption, and drought tolerance. AMF improves plant resilience, decreases the need for artificial fertilizers, and promotes sustainable farming. These findings emphasize mycorrhizal fungi's potential in resource-efficient agriculture, opening up new avenues for future study, particularly in the face of climate change and resource scarcity.

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