Research Article

Response of Various Strains of Arbuscular Mycorrhizal Fungi (AMF) vis-à-vis Biochemical Enhancement in Onion (*Allium cepa* L.) cv. Agrifound Light Red

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Abstract

Mycorrhiza refers to the symbiotic association between a fungus and plant root. The arbuscular mycorrhizal (AM) symbiosis augments the plant resistance to biotic and abiotic stresses by enhancement through certain nutritional, biochemical, physiological as well as morphological plant responses thus it has gained a high degree of impetus in recent years. Taking into account the significance of producing crops in a non-chemical approach with high nutritional value, an experiment was designed and conducted to observe the effect of mycorrhizal fungi on the biochemical attributes of onion (*Allium cepa* L.) cv. Agrifound Light Red. Plants were inoculated with different mycorrhizal strains, viz., Bolt SP, NZBBA48, NZBBA49, and NZBBA50 each with the concentrations of 200, 400, and 600 g/ha alongside the control (uninoculated). The analysis of various mycorrhizal inoculations in onion revealed that quality parameters recorded in this investigation programme depicted a significant increase in almost all the traits, viz., sugar, protein, chlorophyll, and thiosulphate contents. Maximum dry weight (g), TSS (ºBrix), and minimum moisture (%) were recorded in the treatment T_6-NZBBA9048 @ 600 g/ha with maximum value for all these traits, total chlorophyll content, total sugar content, and protein content were noticed maximum in the treatment T_6-NZBBA9048 @ 600 g/ha. Thiosulphate was also increased significantly in succession with the research trial and treatment T_3-Bolt SP @ 600g/ha was observed to have the maximum thiosulphate content whereas minimum acid content was recorded in T_9-NZBBA9049 @ 600 g/ha.

Keywords: *Allium cepa* L., arbuscular mycorrhizal fungi, symbiosis, biochemical attributes

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Introduction

Onion (*Allium cepa* L.) is one of the most extensively grown commercial vegetables cum spice crops in India and consumed by almost all the sections of the society throughout the year. Onion contains a wide variety of free radical scavenging molecules, including phenolic compounds, nitrogen compounds, vitamins, terpenoids, and some other endogenous metabolites, which have protective effects against the development of cardiovascular and neurological diseases, cancer, and other disorders that are caused by oxidative stress [1]. VAM (Vesicular Arbuscular Mycorrhizae) improves nutrient uptake [2], photosynthesis [3], and water relations and increase the drought resistance of host plants [4]. Improved productivity of VAM plants was attributed to enhanced uptake of immobile nutrients such as phosphorous, zinc, and copper. Onion *(Allium cepa* L.*)* has a sparse rooting system without root hairs, which makes the crop reliant on for water and nutrient acquisition on arbuscular mycorrhizal fungi [5, 6]. This dependency is especially true in case of cultivation under soil conditions poor in nutrients as is frequently the case in low input and organic agriculture. The mycorrhiza based products have significant potential with respect to superior yield and quality parameters [7]. Arbuscular mycorrhizal fungi enlarge the soil volume from which nutrients can be taken up via an extensive mycelium network, enabling host plants to access more resources [8].

Materials and Methods

An investigation was carried out at the vegetable research farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *rabi* season of 2015-2016. The experiment was conducted in Randomized Complete Block Design (RCBD) in three replications comprising of 13 treatments involving various mycorrhizal formulations, viz., NZBBA9048, NZBBA9049, NZBBA9050 along with Bolt SP at three concentrations of 200 g/ha, 400 g/ha, and 600 g/ha each, applied at 20 days after transplanting. Characterization of different biochemical attributes were undertaken on a promising onion cv. Agrifound Light Red, released from National Horticultural Research and

Development Foundation (NHRDF), Nashik during the growth period as well as after harvesting. During the investigation, the observations were recorded on several biochemical attributes, viz., TSS (ºBrix), dry weight (g), moisture (%), total sugar (reducing and non-reducing sugar in mg g^{-1} fresh weight), total chlorophyll content as well as chlorophyll ‘a’ and chlorophyll ‘b’ in mg g^{-1} fresh weight (taken at 45, 60, and 90 days after transplanting), protein (mg g^{-1} fresh weight), thiosulphate (mg g^{-1} fresh weight), and acid content (mg g^{-1} fresh weight).

Results and Discussion

Mycorrhiza boosts up the plants through providing more nutrients by increasing root surface area, supplying water even on drought conditions, escalates the photosynthetic rate, and accumulation of carbohydrates in abundant to the plants, and also protects the plant from the biotic and abiotic stresses. Ultimately all these circumstances build up a healthy environment for the plants for the production of better quality produce. Accumulation of more carbohydrates due to increased photosynthetic rate is the principal reason to increase the dry bulb weight. The effect of various mycorrhizal formulations on biochemical attributes of onion has been illustrated in **Table 1**. Minimum moisture per cent was recorded in the treatment T_6-NZBBA9048 @ 600 g/ha (84.34) which was statistically at par with the treatment T_4-NZBBA9048 @ 200 g/ha (85.70). This result was in agreement with the works of Singh et al. (2002) [9] and Bolandnazar (2009) [10]. The maximum dry weight was recorded for the treatment T_6-NZBBA9048 @ 600 g/ha (13.27 g) which was statistically at par with the treatment T_4-NZBBA9048 @ 200 g/ha (11.62 g). Similar findings were recorded by Suhail and Mahdi (2013) [11] and Shinde et al. (2013) [12].

Table 1 Effect of various mycorrhizal formulations on biochemical attributes of onion

Treatments	Characters																	
	1	2	3	4	5	6	7	8	9	10			11			12		
										45 DAT	60 DAT	90 DAT	45 DAT	60 DAT	90 DAT	45 DAT	60 DAT	90 DAT
T_1	89.75	8.15	10.62	3.05	4.53	7.58	18.58	20.32	0.26	1.84	2.09	1.79	0.76	0.88	0.71	2.60	2.97	2.50
T_2	91.92	6.17	8.55	3.09	4.69	7.78	18.77	19.97	0.26	1.72	2.14	1.80	0.73	0.94	0.69	2.45	3.08	2.50
T_3	88.02	9.81	10.42	3.14	5.26	8.40	18.91	22.83	0.27	1.77	2.10	2.05	0.69	0.78	0.72	2.46	2.88	2.77
T_4	85.70	11.62	12.22	3.10	4.96	8.06	18.59	20.13	0.25	1.73	2.08	1.84	0.70	0.67	0.66	2.43	2.75	2.51
T_5	86.09	11.57	11.80	2.99	5.17	8.17	18.77	20.43	0.27	1.82	2.13	1.73	0.70	0.81	0.71	2.52	2.93	2.45
T_6	84.34	13.27	12.94	3.15	5.63	8.78	18.78	22.68	0.27	1.74	2.21	2.07	0.64	0.93	0.76	2.38	3.14	2.83
T_7	86.94	10.33	11.20	2.96	5.42	8.39	18.83	20.37	0.27	1.78	2.14	1.92	0.72	0.83	0.75	2.49	2.97	2.67
T_8	88.68	9.27	10.53	3.03	5.23	8.26	18.20	19.80	0.26	1.72	2.09	1.67	0.75	0.78	0.62	2.47	2.87	2.29
T_9	90.69	5.62	10.58	3.02	5.25	8.27	18.88	19.54	0.25	1.60	1.98	1.75	0.52	0.65	0.55	2.12	2.63	2.30
T_{10}	90.12	8.45	10.07	2.96	4.94	7.90	18.70	20.02	0.25	1.71	2.00	1.87	0.65	0.79	0.55	2.36	2.79	2.42
T_{11}	91.22	6.63	9.87	2.88	5.13	8.01	18.20	20.44	0.27	1.79	2.10	1.89	0.75	0.76	0.63	2.54	2.86	2.52
T_{12}	89.15	9.36	9.43	2.80	4.91	7.71	18.38	19.91	0.26	1.78	2.01	1.90	0.60	0.78	0.64	2.38	2.79	2.54
T_{13}	92.93	4.60	8.30	2.84	4.66	7.50	17.21	18.52	0.28	1.73	1.95	1.91	0.70	0.80	0.65	2.43	2.74	2.56
SE (d)	1.14	0.91	0.73	0.10	0.30	0.31	0.37	0.51	0.01	0.07	0.07	0.09	0.06	0.08	0.06	0.10	0.10	0.12
CD at 5%	2.35	1.89	1.51	0.21	0.62	0.64	0.76	1.05	0.01	0.15	0.14	0.18	0.12	0.16	0.12	0.20	0.21	0.24

Treatments: T_1-Bolt SP @ 200 g/ha, T_2-Bolt SP @ 400 g/ha, T_3-Bolt SP @ 600 g/ha, T_4-NZBBA9048 @ 200/ha, T_5-NZBBA9048@ 400g/ha, T_6-NZBBA9048 @ 600 g/ha, T_7-NZBBA9049 @ 200 g/ha, T_8-NZBBA9049 @ 400 g/ha, T_9-NZBBA9049 @ 600 g/ha, T_{10}-NZBBA9050 @ 200 g/ha, T_{11}-NZBBA9050 @ 400 g/ha, T_{12}-NZBBA9050 @ 600 g/ha, and T_{13}-Control (Uninoculated).

Characters: 1-Moisture (%), 2-Dry weight (g), 3-TSS (°Brix), 4-Reducing sugar (mg g^{-1} fresh weight), 5-Non-reducing sugar (mg g^{-1} fresh weight), 6-Total sugar (mg g^{-1} fresh weight), 7-Protein (mg g^{-1} fresh weight), 8-Thiosulphate (mg g^{-1} fresh weight), 9-Acid content (mg g^{-1} fresh weight), 10-Chlorophyll ‘a’ content in leaves (mg g^{-1} fresh weight), 11-Chlorophyll ‘b’ content in leaves (mg g^{-1} fresh weight), and 12-Total chlorophyll content in leaves (mg g^{-1} fresh weight).

A total soluble solid (TSS) is an important constituent of the onion quality and a significant increase was recorded in all the treatments except the control. The maximum TSS was found in the treatment T_6-NZBBA9048 @ 600 g/ha (12.94ºBrix) which showed significant relation with the treatment T_4-NZBBA9048 @ 200 g/ha (12.22ºBrix). These results were in confirmation with the earlier works of Mahmoud and El-Hefny (1999) [13] and Kashappanavar and Sreenivasa (2000) [14]. At 45 days after transplanting (DAT), treatment T_1-Bolt SP @ 200 g/ha (1.84 mg g^{-1} fresh weight) was found best among all the treatments in terms of chlorophyll ‘a’ content. However, at later stages, i.e., 60 DAT and 90 DAT, best results were found by the treatment T_3-Bolt SP @ 600 g/ha (2.21 mg g^{-1} fresh weight) and T_6-NZBBA9048 @ 600 g/ha (2.07 mg g^{-1} fresh weight), respectively. These findings are in accordance with Patharajan and Raaman (2012) [15] in garlic and Shuab et al. (2014) [16].

At 45 DAT, maximum value for chlorophyll ‘b’ content was found for the treatment T_1-Bolt SP @ 200 g/ha (0.76 mg g^{-1} fresh weight) whereas at 60 and 90 DAT, treatment T_2-Bolt SP @ 400 g/ha (0.94 mg g^{-1} fresh weight) and T_6-NZBBA9048 @ 600 g/ha (0.76 mg g^{-1} fresh weight) were found to be best, respectively. This finding was supported by the research works of Patharajan and Raaman (2012) in garlic [15] and Shuab et al. (2014) [16]. Treatment T_1-Bolt SP @ 200 g/ha (2.60 mg g^{-1} fresh weight) was found best among all the treatments in terms of total chlorophyll content at 45 DAT which showed a significant at par relation with the treatment T_{10}-NZBBA9050 @ 200 g/ha with 2.52 mg g^{-1} fresh weight. However, at later stages, viz., 60 and 90 DAT, treatment T_6-NZBBA9048 @ 600 g/ha was found best among treatments with a value of 3.14 and 2.83 mg g^{-1} fresh weight, respectively. These results are in accordance with the findings of Patharajan and Raaman (2012) in garlic [15] and Shuab et al. (2014) [16]. Both the components of sugar, i.e., reducing and non-reducing were reported to increase significantly with all the treatments used in the investigation. Maximum reducing, non-reducing, and ultimately total sugar content were noticed in the treatment T_6-NZBBA9048 @ 600 g/ha with the values of 3.15, 5.63, and 8.78 mg g^{-1} fresh weight, respectively. The total sugar content value of treatment T_6-NZBBA9048 @ 600 g/ha (8.78 mg g^{-1} fresh weight) was statistically at par with the value of T_2-Bolt SP @ 400 g/ha (8.40 mg g^{-1} fresh weight). These results were in confirmation with the earlier works of Patharajan and Raaman (2012) in garlic [15] and Rafiq et al. (2015) [17]. All the treatments elucidated a significant increase in the protein content (mg g^{-1} fresh weight) of the plant. The treatment T_3-Bolt SP @ 600 g/ha (18.91 mg g^{-1} fresh weight) was noticed as the best performer among all the treatments and was also statistically at par with treatment T_9-NZBBA9049 @ 600 g/ha (18.88 mg g^{-1} fresh weight). This investigation result was supported by work of Rafiq et al. (2015) [17]. The present investigation report showed that a significant increase in thiosulphate content of onion with the use of different treatments. The treatment T_3-Bolt SP @ 600 g/ha (22.83 mg g^{-1} fresh weight) showed maximum thiosulphate content and this treatment was statistically at par with treatment T_6-NZBBA9048 @ 600 g/ha (22.68 mg g^{-1} fresh weight). The present finding is in agreement with the work of Mollavali et al. (2016) [18]. Among all the treatments the minimum acid content was reported in the treatments like T_9-NZBBA9049 @ 600 g/ha, T_{10}-NZBBA9050 @ 200 g/ha, T_4-NZBBA9048 @ 200/ha each with the value of 0.25 mg g^{-1} fresh weight while the maximum acid content was reported in the treatment T_{13}-Control (0.28 mg g^{-1} fresh weight). The result showed a significant effect on the acidity content of the plant. This finding is in accordance with the work of Mollavali et al. (2016) [18] and Rozpadek et al. (2016) [19]. The treatment without mycorrhizal inoculation, i.e., T_{13}-Control, showed minimum value for almost all the attributes. These findings should be followed by more studies to understand formation of biochemicals such as sugar and chlorophyll in onion plants in response to the mycorrhizal fungi association.

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