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Response of Onion to Inoculation with Vesicular Arbuscular Mycorrhiza and Phosphorus Solubilizing Bacteria under Varying Levels of Phosphorus

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A B S T R A C T

A field experiment was carried out to find out the response of onion to individual and combined inoculation of vesicular arbuscular mycorrhiza (VAM) and phosphate solubilizing bacteria (PSB) under different levels of phosphorus (P) at FOA Wadura Sopore, Kashmir. The results revealed that, combined inoculation of onion with VAM and PSB significantly increased all the examined parameters during the study as compared to control as well as to their individual inoculations even when the P inoculation was reduced to 75 and 50 % of the recommended dose. However, the best results were obtained at 75% of P with combined inoculation of VAM and PSB as is evident from 29.2 and 8.5% increase in bulb dry weight and bulb yield respectively. Similarly at the same treatment the quality parameters like total soluble salts (TSS), nitrogen (N), phosphorus (P) and potassium (K) content of the bulbs was increased by 26.6, 42.8, 68.4 and 21.7% as compared to control.

Introduction

Onion is grown as spice and vegetable crop and used for culinary purpose. Raw onion has an antiseptic value, promotes bile production and reduces blood sugar. It is rich source of phosphorus, calcium, vitamin C, protein and carbohydrates. Onion is known to check the deposition of cholesterol in blood vessels, thus protect against heart diseases resulting from blockage of arteries (Barakade *et al.*, 2011).

Phosphorus (P) is an essential macroelement for plants, yet the total concentration of P in soils ranges from 0.02-0.5%. Thus, to increase the availability of phosphorus for plants, large amount of fertilizers are used on a regular basis, yet after inoculation, a large proportion of phosphorus is quickly transferred to an insoluble form (Omar, 1997). But on the other hand the indiscriminate use of chemicals resulted in degradation of soil health, erosion, and loss of organic matter, nitrate pollution and also health hazard for human beings (Ghanti and Sharangi, 2009). Heavy inoculation of inorganic fertilizers degrade the soil health by adversely affecting the microbial biodiversity, physical and chemical environment of soil, water bodies and capital inputs like soil, water and thus overall ecology. In addition, the increasing cost of inorganic fertilizers is making onion production an uneconomical occupation for small and marginal farmers. So for sustainable production of crops alternative technologies that could replace the inoculation of inorganic fertilizers to some extent seem to be the need of hour. In this regard the inoculation of microorganisms like VAM and PSB seems to be an attractive solution that has been actively studied during the last decade so that dependence on inorganic fertilizers can be reduced as they have got the ability to supplement phosphorus, nitrogen, potassium, zinc etc to the plant.

VAM are widespread in nature and are fundamental component of the agro-ecosystem (Bethlenfalvay *et al*., 1997). One of the most dramatic effects of infection by mycorrhizal fungi on the host plant is the increase in P uptake (Roger, 1991), mainly due to the capacity of the mycorrhizal fungi to absorb phosphate from soil and transfer it to the host roots (Asimi *et al*., 1980). PSB are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds. P solubilization ability of rhizosphere microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. It is generally accepted that the mechanism of mineral phosphate solubilization by PSB strains is associated with the release of low molecular weight organic acids, through which their hydroxyl and carboxyl groups chelate the cations bound to phosphate, thereby converting it into soluble forms (Rashid *et al*., 2004).

Materials and Methods

A field experiment was carried out at Faculty of Agriculture, Wadura Sopore (SKUAST-K). The soil of the experimental field is sandy loam with an EC of 0.33 µS/cm and pH 7.3. The experimental area was thoroughly prepared by ploughing the soil three times. Well decomposed farm yard manure (FYM) was applied at the rate of 25 t / ha after ploughing the land. Seven treatments shown in the table 1 were employed which were laid out in a randomized block design and replicated thrice. A recommended dose of N was applied to the plots in two doses, one at the time of transplanting and second in the month of March, whereas the entire P as per the designed treatments and K was applied in a single dose at the time of transplanting. VAM was applied in the root zone at the time of transplanting, whereas seedlings were dipped in a solution of PSB for 45 minutes before transplanting. All the required cultural practices such as irrigation, weeding, pest and disease control etc. were kept constant and given uniformly in all the experimental plots. Ten plants were randomly selected from each plot in such a way that the marginal effect was avoided and data were recorded on

1. Plant height: Plant height was measured with the help of a scale.
2. Bulb fresh weight: bulb fresh weight was measured immediately after harvesting and removing the soil particles adhered to the bulb.
3. Bulb dry weight: Bulb dry weight was measured after keeping the bulbs in oven at 70 ^{0}C till the weight became constant.
4. Bulb diameter: Bulb diameter was measured with the help of caliper.
5. Total soluble solids (TSS): TSS of the bulbs was measured by using the hand refractometer.
6. Estimation of Nitrogen (N): N content from the bulbs was determined by using

the method as proposed by Peoples *et al*. (1989)

7. Determination of Phosphorus (P): P content was estimated from the bulbs as per the method proposed by Koenig and Johnson (1942).
8. Determination of potassium (K): K was estimated by flame photometeric method as proposed by Reed and Scott (1962).

Statistical analysis

The data reported in this study were the mean values based on the three replicates. Differences among treatments were tested by ANOVA and the mean values among the treatments were compared using Duncan's multiple range test at p=0.05.

Results and Discussion

Plant height

The data pertaining to plant height shows that plant height at the harvesting varied at the different treatments. Plant height showed slight increase at T1 and T4 whereas; it recorded a decrease at T2 and T3 treatments. The results were highly significant at T5 with an increase of 11.2% which is at par with T6 where an increase of 8.3% was reported as compared to control (Table 2). The results are in agreement with Naik (2014). The increased growth of onion in terms of plant height by combined inoculation of VAM and PSB at reduced level of P might be due to higher solubilization of P brought about by PSB followed by its increased uptake along with N and K as is evident from table 3 of this study. Inoculation with VAM increases the absorbing capacity of the roots favoring more water uptake by the plants resulting in cell expansion responsible for the increased plant height (Huixing Song, 2005). Since nitrogen is a constituent of chlorophyll, the increase uptake of which might have resulted in increased synthesis of photosynthates leading to better plant growth. The second major nutrient phosphorus is an essential constituent of cellular protein and nucleic acid which might have encouraged the cell division and meristematic activity of plants resulting in increased plant height (Monika *et al*., 2006).

Bulb fresh and dry weight

The variations in bulb fresh and dry weight are evident from table 2 which indicates an increase in both the parameters at all the treatments. However the maximum increase with respect to both the parameters was observed at T5 and T6. Bulb fresh weight recorded an increase of 20.4 and 19.0 % respectively at T5 and T6 whereas at the same treatments the bulb dry weight was increased by 29.2 and 27.1% as compared to control. The results are in accordance with (Naik, 2014). The increase in bulb dry weight can be contributed to increased plant photosynthetic rate achieved by VAM inoculation through increased leaf stomatal conductance as compared to non inoculated plants resulting in more CO_2 uptake (Huixing Song, 2005). K which is an activator of enzymes involved in protein and carbohydrate metabolism plays an important role in the translocation of photosynthates from leaves of bulb which would have been utilized in building up of new cells and tissues leading to increased bulb fresh and dry weight as has been in reported in case of potato by Hans-Eckhard *et al*., (1973).

Bulb diameter and bulb yield

All the treatments differed significantly with each other with respect to bulb diameter and yield. Information made available in table 2 revealed that T5 and T6 once again showed the supremacy among all the treatments in increasing the bulb diameter and yield. A respective increase of 31.6 and 27.8% was recorded in the bulb diameter at T5 and T6 whereas bulb yield recorded an increase of 8.5 and 2.6% respectively at T5 and T6 as compared to control. The results are in conformity with the findings of Tyagi and Yadav (2007). The increase in bulb diameter and bulb yield may be due to the role of bio-fertilizers inoculation on increasing the availability and uptake of nitrogen, phosphorus, potassium, zinc etc by the onion plant. In addition, greater root proliferation and absorbing capacity for water, more photosynthetic area and enhanced food accumulation by the bulbs contribute to their increased yield (Balemi *et al.*, 2007).

Table.1 Treatment details

T0	T1	T2	T3	T4	T5	T6
Control	75% of P+ VAM	50% of P+ VAM	75% of P+ PSB	50% of P+ PSB	75% of P+ VAM+PSB	50% of P+ VAM+PSB

Table.2 Effect of different levels of phosphorus, PSB and VAM on growth and yield of onion

Treatments	Plant height (cm)	Bulb fresh weight (g)	Bulb dry weight (g)	Bulb diameter (cm)	Bulb yield (T/ha)
T0	48.2	75.0	62.1	15.3	14.9
T1	50.1	79.9	69.2	18.4	13.9
T2	47.3	77.5	70.4	17.1	12.1
T3	47.5	84.5	76.3	19.2	13.2
T4	49.4	90.8	84.8	18.6	11.4
T5	54.3	94.3	87.8	22.4	16.3
T6	52.6	92.7	85.2	21.2	15.3
CD P = 0.05	**0.13**	**0.12**	**0.12**	**0.06**	**0.97**

Table.3 Effect of different levels of phosphorus,s PSB and VAM on quality parameters of onion

Treatment	TSS (%)	N	P	k
T0	11.3	2.0	0.06	1.73
T1	10.9	2.4	0.12	1.79
T2	9.8	2.9	0.08	1.82
T3	10.5	2.2	0.16	1.89
T4	9.5	2.5	0.14	1.90
T5	15.4	3.5	0.19	2.21
T6	13.4	3.0	0.17	1.95
CD P = 0.05	**0.9**	**3.2**	**2.7**	**1.8**

Total soluble solids

Total soluble solids were found to decrease when VAM and PSB were separately used with the different levels of P. However table 3 shows that there was a significant increase in TSS when a combined inoculation was made with VAM and PSB at 75% of the P. TSS at T5 was found to be increased by 26.6% whereas at T6 it was increased by 15.6% as compared to control. Same results in this regard have been found by Talwar *et al*. (2017) who found that inoculation with biofertilizers resulted in significantly higher TSS. The increase in TSS can be contributed to increased chlorophyll content which increases the photosynthetic rate of the plant (Mathur and Vyas, 2000). In addition more availability and uptake of K (Table 3) which is having an important role in the translocation of photosynthates also might have contributed to increased TSS of onion by the combined inoculation with VAM and PSB.

Mineral uptake

Combined inoculation with VAM and PSB had a significant effect on the mineral uptake of the onion plant. Table 3 indicates that N, P and K content of the onion bulbs was increased at all the treatments; however the maximum values were recorded at T5 followed by T6. As compared to control N, P and K content showed a respective increase of 42.8, 64.4 and 21.7% at T5 where VAM and PSB were used in combination with 75% of P. Similar results have also been found by Talwar *et al*., (2017) and Hashem (2015).

Microorganisms can increase the solubility of inorganic P by releasing protons, H^+ and organic acid anions such as citrate, malate and oxalate (Yousefi *et al*., 2011) whereas the VAM fungus absorbs the mineral elements like N, P, K, Fe, Zn etc much faster through physical exploration of the soil, modification of root environment, increased movement of various mineral elements into mycorrhizal fungus hyphae and their translocation to the associated plant (Turk, *et al*., 2006).

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