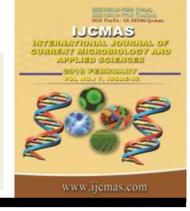
Int.J.Curr.Microbiol.App.Sci (2018) 7(2): 3803-3809

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 02 (2018)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2018.702.450

Impact of Azotobacter and Inorganic Fertilizers on Yield Attributes of Tomato

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Keywords

Growth, Nitrogen, Azotobacter, Tomato, Yield

Article Info

Accepted:
30 December 2017
Available Online:
10 February 2018

A B S T R A C T

A field experiment was carried out at farmers' fields in village wadura (Sopore) of district Baramulla J&K during kharif 2013 and 2014 to study the effect of AZOPHOS and Inorganic fertilizers on growth and yield of Tomato cv. "SHALIMAR-1". The treatments comprised of 3 levels of biofertilizers (control, PSB, VAM) in combination with 4 levels of inorganic fertilizers [0, 25, 50 and 100% recommended dose of fertilizers (RDF) N and P] laid out in a randomized complete block design with each treatment replicated three times. Maximum plant height (207.86 cm), fruit yield (1.50 Kg plant^{-1}), No. of Branches (11.18 plant^{-1}) and Nitrogen in fruit (0.32 %) were recorded in treatment *Azotobacter-3* + PSB (PS6) +100% NPK. The use of *Azotobacter* and PSB in combination with various inorganic levels of fertilizer over control increased the nitrogen content in fruit over control. Maximum nitrogen content (%) in fruit (0.32%) was observed in treatment combination of *Azotobacter-3* + PSB (PS6) +100% NPK.

Introduction

Tomato (*Lycopersicon esculentum*) belongs to family solanaceae having chromosome number (2n=24). It is self-pollinated crop and Peru-equator is the centre of origin. Tomato is one of the popular vegetables of great commercial value and is used in various forms. It contains higher quantity of total sugar (2.5-4.5%), starch (0.6-1.2%) and minerals like potassium, calcium, sodium, magnesium, phosphorus, iron, etc. Apart from this it also contains organic acids such as citric, malic and acetic acid which are known as health acids in fresh tomato fruit. Nearly 144 countries are involved in Tomato production. Among them major production countries are China, EU, India, US and

Turkey, with China accounting for 31% of the total world production followed by India. In India it occupys an area of 791 thousand ha, with production of 17398 thousand tons with an average yield of 22 t/ha (Horticulture statistics data, 2014-15 Government of India). In India it is an introduced crop and in being grown on an area of 882.03 hectare with an annual production of 18735.91 metric tonnes (Indian horticulture data base, 2014). In Jammu and Kashmir states, tomato is grown on an area of 1.7000 ha with an annual production of 37000 metric tonnes. Tomato is a herbaceous sprawling plant growing to 1-3 m in height with weak woody stem. The flowers are yellow in colour and the fruits of cultivated varieties vary in size from cherry tomatoes, about 1–2 cm in size to beefsteak tomatoes, about 10 cm or more in diameter. It is one of the important vegetable crop which contain some important minerals, vitamins. Lycopene, one of nature's most powerful antioxidants, is present in tomatoes. Proper plant growth and its fruits are necessary. This can be achieved to a great extent by the use of optimum levels of fertilizers. The essential elements especially the major nutrients (NPK) are considered the most important among nutrients and factors limiting growth and yield of plant, since plant growth are negatively affected by their deficiency. For enhancing the yield and quality application of adequate quantities of plant nutrients is a pre-requisite which can be met both from organic as well as inorganic sources. Substitution of high analysis fertilizers like urea and di ammonium phosphate for increasing crop productivity or inadequate use of organic manures have rendered Indian soils deficient in macro and micro nutrients. With rapid increase in population, the demand for the crop has significantly increased, leading to extensive use of chemical fertilisers for supply of plant nutrients without any consideration for soil health, which is a critical factor for realising sustainable yield of any vegetable crop. Besides, this the residual effects of chemical fertilizers on environment, underground water, soil microflora, vegetable and vegetable products is a matter of concern, as some of the residues like nitrates enter the human body and are carcinogenic. Thus, there is an urgent need to utilise other sources of plant nutrients for sustainable and safe tomato production. The answer lies in the use of organic manurers which have a potential to provide primary, secondary and micronutrients besides building a strong organic matter base resulting in improvement of soil structure and sustainable vegetable production devoid of most of the harmful residues. But organic sources of plant nutrients supply nutrients in slow manner and thus it is essential to use both organic and inorganic plant nutrients in integrated form which has proved superior than individual sources with respect to growth, yield and quality in different vegetable crops. Organic farming is a production system which avoids or largely excludes the use of synthetically produced fertilizers, pesticides, growth regulators and livestock feed additives. It is well known fact that increased dependence on agro chemicals including fertilizers has led to several ill effects on the environment and also results in decrease of soil fertility. Application of organic manure play an important role on yield and its attributes as well as nutrient uptake and directly increase the soil physical condition. It lowers soil bulk density, increases water holding capacity, CEC, build up beneficial soil microbes, improve good soil structure and enhance stable soil aggregates. Use of biofertilizer and organic manure in agriculture is becoming popular nowadays for not only in order to reduce the cost of chemical fertilizers but also to decrease the adverse effects of chemical fertilizers on soil and plant environment and to ensure more crop productivity. In many situations combination of organic and inorganic fertilizers have produced higher yields than alone (Blackshaw, 2005). *Azotobacter* and

Azospirillum are the two most important non-symbiotic N-fixing bacteria in non-leguminous crops. Under appropriate conditions, *Azotobacter* and *Azospirillum* can enhance plant development and promote the yield of several agricultural important crops in different soils and climatic regions. These beneficial effects of *Azotobacter* and *Azospirillum* on plants are attributed mainly to an improvement in root development, an increase in the rate of water and mineral uptake by roots, displacement of fungi and plant pathogenic bacteria and, to a lesser extent, biological nitrogen fixation. Besides nitrogen fixation, *Azotobacter* synthesizes and secretes considerable amounts of biologically active substances like vitamins, nicotinic acid, pantothenic acid, biotin, heteroxins, gibberelins etc. which enhance root growth of plants (Rao, 1986). Another important characteristic of *Azotobacter* association with crop improvement is secretion of ammonia in the rhizosphere in the presence of root exudates, which helps in modification of nutrient uptake by the plants (Narula and Gupta, 1986). The ability of Azotobacter to produce plant growth regulatory substances along with N_2 fixation stimulate plant growth and there by productivity. The changes that occur in the plant roots help in transport of minerals and water (Sarig *et al.*, 1988). All these factors combined together produce positive effects on crop yield especially for vegetables and cereals. Therefore, the present study was to evaluate the effect of biofertilizers on growth and yield of tomato. Modern day intensive crop cultivation results with the huge application of chemical fertilizers which are not only in short supply but also expensive and pollute the environment, soil and water too. Nitrogen fixing bacteria and Phosphate solubulizers are main bio-fertilizers for horticultural crops. These micro-organisms are either free living in soil or symbiotic with plants and contribute directly or indirectly towards nitrogen and phosphorus nutrition of plants. Microorganisms which are capable of solubilizing insoluble phosphate, also called phosphate solubilizing microorganisms (PSMs).They offer an ecologically acceptable means for converting insoluble phosphate to soluble forms by acidification, chelation and exchange reaction. Several strains of bacteria (*Pseudomonas*, *Bacillus*, *Rhizobium*, *Enterobacter* etc.) and fungi (*Aspergillus* and *Penicillium*) have been recognized as powerful phosphate solubilizers. PSB not only provide sustained P supply for the growth of plants but also stimulate the efficiency of nitrogen fixation and accelerate the accessibility of other trace elements by synthesizing important growth promoting substances like siderophores, antibiotics, etc., produce plant hormones such as auxins, cytokinins, gibberellins and improve crop productivity (Abbas *et al.*, 2013) by solubilizing insoluble phosphorus and providing protection to plants against soil borne pathogens.

Materials and Methods

A field experiment was carried out at farmers‟ fields in village wadura (Sopore) of district Baramulla J&K during kharif 2013 and 2014 to study the effect of AZOPHOS and Inorganic fertilizers on growth and yield of tomato. Four week old seedlings of tomato were transplanted on ridges in the field toward the end of February with a spacing of 60cm x 45cm. The experimental soil was silty clay loam and neutral in reaction with pH 7.6, EC 0.14 dS m^{-1}, medium in available N (272 kg ha^{-1}), available P (14 kg ha^{-1}) and available K (218 kg ha^{-1}). The treatments comprised of 3 levels of biofertilizers (control, PSB, VAM) in combination with 4 levels of inorganic fertilizers [0, 25, 50 and 100% recommended dose of fertilizers (RDF) N and P] laid out in a randomized complete block design with each treatment replicated three times. No

Phosphorus was applied N and K was applied as per treatments in form of urea and muriate of potash. Tomato variety SHALIMAR -1 was used. Roots of tomato seedlings were inoculated as per standard methods with the inoculant of PSB culture @ 1litre per acre of seedling. After inoculation, the seedlings were sown at a spacing of 60 × 45 cm in the last week of May and harvested in the 2nd week of September. All the cultural operations were followed as per the package of practices. Plant height was measured at harvesting from the base of plant to the base of fully opened top leaf with the help of a scale and number of branches were also counted. The fruit yield was recorded at harvest. The fruit samples collected from tomato plant at harvest time were oven-dried, processed and digested with digested with conc. sulphuric acid for estimation of nitrogen (Subbiah and Asija, 1956) in Kjedahl apparatus. Mean of the data was taken of both the years and the data was subjected to the analysis of variance as per the standard method given by Panse and Sukhatme (1967). The data was analyzed by using 'R' software and significance of treatment effects tested by "F" test.

Results and Discussion

Tomato Yield

Fruit yield recorded increase due to application of *Azotobacter* and PSB in combination with various inorganic levels of fertilizer over control (Table 1). The maximum fruit yield (1.50 kg $plant^{-1}$) was recorded with the application of *Azotobacter-3* + PSB (PS6) +100% NPK.Minimum yield (0.28 kg $plant^{-1}$) was recorded from the untreated plants. These findings are in line with the findings of Wange *et al.,* (1998) and Tripathi *et al.,* (2010) in strawberry, who recorded higher yield with *Azotobacter* and PSB application. The increase in yield might be due to increased fruit set per plant, due to the fact that nitrogen fixers and phosphorous solubulizers not only increased the availability of nitrogen and phosphorous to the plants but also increased their translocation from root to flower through plant foliage (Singh and Singh, 2009). Similar results were reported by Mirzakhani *et al.,* (2009) in safflower and Poonia and Dhaka (2012) in tomato.

Plant Height and Number of Branches

Plant height showed increase due to various treatments as compared to control (Table 1).The maximum height (207.86 cm) and number of branches (11.18 $plant^{-1}$) was obtained in treatment *Azotobacter-3* + PSB (PS6) +100% NPK which was significantly over control. This increase in plant height due to the production of more chlorophyll content with the inoculation of nitrogen fixers. The other reason for increased vegetative growth may be the production of plant growth regulators by bacteria in rhizosphere, which are absorbed by the roots. Higher microbial activity in rhizosphere expressed as activity of hydrogenase, phosphates and nitrogenase enzymes was also reported (El- Tantawy and Mohamed, 2009). Therefore increased vegetative growth may be attributed to the increased biological nitrogen fixation (Mohandas, 1987). Better development of root system and the possibly synthesis of plant growth hormones like IAA, GA and Cytokinins (Martinez *et al.,* 1993) and direct influence of bio-fertilizers (Gajbhiye *et al.,* 2003) might have caused increase in plant growth parameters. Also the increase in growth characters might be due to stimulative effect of PSB on P solubilization leading to higher P availability and uptake by plants (Sharma *et al.,* 2007). These results are in conformity with the findings of (Poonia and Dhaka, 2012**).** Similar results were obtained by Marathe and Bharambe (2005) in sweet orange, Nazir *et al.,* (2006) and Tripathi *et al.,* (2010) in strawberry.

Table.1 Effect of Azotobacter and Inorganic Fertilizers on Yield Attributes of Tomato (2013-14)

TREATMENTS	Plant Height (cm)	No. of Branches plant^{-1}.	Fruit yield (Kg plant^{-1})	Nitrogen(%) in fruit
T_0=Control (No bio-fertilizer or NPK)	104.50	5.17	0.28	0.04
T_4 = NPK (Optimum dose)	166.25	8.38	1.20	0.24
T_1=*Azotobacter*-3+PK(Optimum dose)	112.18	6.63	0.412	0.07
T_2=*Azotobacter-3*+50% N+PK(Optimum dose)	146.75	7.24	0.945	0.17
T_3=*Azotobacter-3*+25% N+PK(Optimum dose)	138.46	6.98	0.893	0.12
T_5=Phosphorus solublizing bacteria(PS-6) + NK(Optimum dose)	109.18	6.51	0.736	0.18
T_6= Phosphorus solublizing bacteria (PS-6) +50% P+NK(Optimum dose)	144.27	7.10	0.906	0.21
T_7= Phosphorus solublizing bacteria (PS-6) + 25% P+ NK(Optimum dose)	136.84	6.94	0.840	0.19
T_8 = *Azotobacter-3* + PSB (PS6) +100% NPK (Optimum dose)	207.86	11.18	1.50	0.32
T_9 = *Azotobacter-3* + PSB (PS6) +50% NPK (Optimum dose)	155.26	9.26	1.104	0.18
T_{10} = *Azotobacter-3* + PSB (PS6) +25% NPK(Optimum dose)	124.26	8.12	0.736	0.13
$CD_{(0.05)}$	24.03	0.78	0.27	0.01

Nitrogen (%) in Fruit

Phosphorus content in fruit was markedly influenced by *Azotobacter* and PSB in combination with various inorganic levels of fertilizer over control (Table 1). The highest nitrogen content of 0.32% was recorded by the treatment *Azotobacter-3* + PSB (PS6) +100% NPK and lowest was obtained in control. There was an increase in nitrogen content in fruit due to various treatments as compared to control. The increase in nitrogen content in fruit is because of increase in nitrogen fixation in soil leading to higher N availability and uptake. Similar results were obtained by Sathish *et al.*, (2011) and (Walpola and Yoon, 2013).

The present study revealed that the use of 100% NPK along with *Azotobacter and* PSB influenced the growth and yield of tomato as well as improved nutrient availability. The application of 100% NPK along with *Azotobacter and* PSB appears to be suitable combination for high yield under temperate conditions of Kashmir valley.

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How to cite this article:

Zahoor Ahmad Baba, Sheikh Tahir, Fozia Shafiq Wani, Burhan Hamid, Mudasir Nazir and Basharat Hamid. 2018. Impact of Azotobacter and Inorganic Fertilizers on Yield Attributes of Tomato. *Int.J.Curr.Microbiol.App.Sci.* 7(02): 3803-3809.
doi: https://doi.org/10.20546/ijcmas.2018.702.450