International Journal of Agricultural Sciences
Volume 17 | Issue 2 | June, 2021 | 220-227
ISSN : 0973-130X
DOI:10.15740/HAS/IJAS/17.2/220-227
Visit us : *www.researchjournal.co.in*

RESEARCH PAPER

Impact of liquid and carrier based biofertilizers on fruit and quality traits in tomato (*Solanum lycopersicum* L.)

K. Lakshmikala*, B. Ramesh Babu[1], M. Ravindra Babu[1] **and** P. Rama Devi[1]
College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem
West Godavari (Andhra Pradesh), India
(Email : kothakadapalakshmikala@gmail.com)

Abstract : The present investigation "Influence of liquid and carrier based biofertilizers on growth, yield and quality of tomato (*Solanum lycopersicum* L.)"was laid out in randomized block design with two factors and three levels comprising of nine treatment combinations in three replications at Horticultural Research Station, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari during *Rabi*, 2018. The application of 80 % recommended dose of fertilizers along with liquid biofertilizers resulted in significant higher differences in number of fruits per cluster (4.90), number of fruits per plant (60.0), fruit set % (98.34), fruit length (5.83 cm), fruit width (5.45 cm), average fruit weight (96.96 g), fruit yield per plant (7.27 kg), TSS (4.67 ^{0}Brix), ascorbic acid content (16.53 mg/100 g), lycopene content (31.72 mg/100g) and titrable acidity (0.53 %) when compared to other treatment combinations.

Key Words : Titrable acidity, Factors, Liquid biofertilizers, Recommended dose of fertilizers, Treatment combinations

View Point Article : Lakshmikala, K., Babu, B. Ramesh, Babu, M. Ravindra and Devi, P. Rama (2021). Impact of liquid and carrier based biofertilizers on fruit and quality traits in tomato (*Solanum lycopersicum* L.). *Internat. J. agric. Sci.*, **17** (2) : 220-227, **DOI:10.15740/HAS/IJAS/17.2/220-227.** Copyright@2021: Hind Agri-Horticultural Society.

Article History : Received : 22.02.2021; **Revised :** 25.02.2021; **Accepted :** 14.03.2021

INTRODUCTION

Tomato (*Lycopersicum esculentum* L.) is a savory, typically red, edible fruit, as well as the plant which bears it and it is one of the important vegetable crops which contains some important minerals and vitamins. Tomato, the world's largest grown vegetable crop known as a protective food occupies an important place in the economy of human societies because of its high nutritive value added products and its wide spread production in different agro climatic conditions. Originating in South America, the tomato was spread around the world following the Spanish colonization of the Americas, and its many varieties are now widely grown, often in greenhouses in cooler climates. Tomato is the most important and remunerative vegetable crop and is grown over an area of 789000 ha with 19759000 MT annual production in India.

Tomato, according to FAO, is the second most cultivated vegetable in the world, after potato while China, USA and Turkey are the leading producers. Studies have shown that high consumption of tomato is consistently

*** Author for correspondence :**
[1]Horticultural Research Station, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India (Email : rameshhort@gmail.com; ravimuvva28@gmail.com; ramadevipuvvada@yahoomail.com)

correlated with a reduced risk of some types of cancer (Franceschi *et al*., 1994) and may account for a low incidence of ischemic heart disease (Gerster, 1997). Tomato fruit quality can be determined by the following parameters, total soluble solid, lycopene, antioxidant activity, vitamins C and E, pH and nutrient contents.

In view of high productivity, the farmers are using chemicals indiscriminately which resulted in deterioration of the soil texture and making the soils sick. The need of the day is to make vegetable farming sustainable, profitable and reduce the use of harmful chemicals by gradually changing inorganic chemicals over to non-chemical methods like organic farming. During the recent years, the use of chemicals for the management of pest and diseases has also been increased. This practice has lead to health hazards, water and environmental pollution and the productivity levels have decreased to a considerable extent. Therefore, several countries around the world including India, demand for organically produced vegetables is increasing among the consumers. The everincreasing costs of chemical fertilizers and pesticides have also emphasized the need for exploitation of bio-fertilizers (Kashyap *et al*. 2014).

Biofertilizers are microbial preparations containing living cells of different microorganisms which have the ability to fix/solubilize the plant nutrients in soil through biological process. They are environmental friendly and play significant role in crop production (Verma *et al*., 2011). Bio-fertigation refers to application of biofertilizer through irrigation and is the efficient and precise use of beneficial micro-organism through micro-irrigation system (Gomathy *et al*., 2008). Liquid biofertilizers are liquid formulations containing the dormant form of desired microorganisms and their nutrients along with the substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to adverse conditions (Verma *et al*., 2011).

The advantages of liquid biofertilizers over conventional carrier based biofertilizers include longer shelf life (12-24 months), no effect of high temperature and no contamination, no loss of properties due to storage at high temperature upto 45^{0}C and high populations can be maintained at more than 109 cells/ml upto 12 to 24 months. It is very easy to use by the farmers, high export potential and recommended dosage is 4 times less than carrier-based biofertilizer. Biofertilizers is known to improve growth, yield as well as productivity of crops. They are low cost, renewable sources of plant nutrients and have the ability to use freely available solar energy, atmospheric nitrogen and water. Use of biofertilizers have positive effects like improving soil fertility and in increasing crop yield. According to Choudhury and Kennedy (2005), biofertilizers are gaining momentum recently due to the emphasis on maintenance of soil health, minimize environmental pollution and cut down the use of chemicals in agriculture.Keeping these facts in view the present study was undertaken to know the influence of liquid and carrier based biofertilizers on growth, yield and quality of tomato.

Material and Methods

The present experiment entitled "Influence of liquid and carrier based biofertilizers on growth, yield and quality of tomato (*Solanum lycopersicum* L.)" was conducted during *rabi*, 2018 was laid out in Factorial RBD with two factors and three replications at Horticultural Research Station, Venkataramannagudem, West Godavari District, Andhra Pradesh. The first factor comprise of three levels of recommended dose of fertilizers (100 %, 80 % and 60 % of RDF) and the second factor consists of three levels of different combinations of biofertilizers (Nitrogen fixing bacteria (NFB) + Phosphate solubilizing bacteria (PSB) + Potassium solubilizing bacteria (KSB) liquid formulation, Nitrogen fixing bacteria (NFB) + Phosphate solubilizing bacteria (PSB) + Potassium solubilizing bacteria (KSB) carrier based biofertilizer and without biofertilizers) comprising nine treatment combinations. The nursery was raised at Centre of Excellence, Dr. Y.S.R. Horticultural university, Venkataramannagudem and seedlings were transplanted after 25 days of sowing at a spacing of 120 cm x 50 cm in main field.

Biofertilizers such as NFB, PSB and KSB were thoroughly mixed with FYM and allowed to multiply for one week under shade, prior to application in the field. Carrier based biofertilizers are applied @ 5 kg/ha and liquid biofertilizer @ 1.25 lt/ha. At the time of final land preparation, recommended dose of farm yard manure (25 t/ha) and phosphorous was applied to the soil. One-forth of the total nitrogen and half of the total potassium was applied basally and remaining three-forth of nitrogen and half of potassium was applied through drip irrigation at weekly intervals as per the schedule recommended by Tamil Nadu Agricultural University. Biofertilizers (both liquid and carrier) were applied in two doses *i.e*., first dose after transplanting and second dose was applied one month after transplanting. Irrigation and other intercultural operations were done as and when necessary. The observations were recorded on the effect of liquid and carrier based biofertilizers along with inorganic fertilizers on growth yield and quality parameters of tomato.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Number of fruits per cluster:

In tomato the application of chemical fertilizers, biofertilizers and their interactions showed significant influence on number of fruits/cluster. Different levels of chemical fertilizers influenced the number of fruits/cluster in tomato and it ranged from 3.38 to 4.44. The significant higher number of fruits/cluster (4.44) was recorded in plants treated with 80 % RDF followed by 100 % RDF application (4.30) while, it was lowest in 60 % RDF application (3.38). NFB, PSB and KSB liquid biofertilizers application recorded 21.73 % higher number of fruits/cluster when compared to control (without biofertilizers) followed by the application of mixture of NFB, PSB and KSB carrier based biofertilizers with an increase of 16.16 %. Application of 80 % RDF along with liquid biofertilizers of NFB, PSB and KSB (F_2B_2) recorded more number of fruits/cluster (4.90) when compared to other interactions followed by 80 % RDF along with NFB, PSB and KSB carrier based biofertilizers (F_2B_1) with 4.70 whereas, the least number of fruits/cluster (3.10) was recorded in 60 % RDF + without biofertilizers (F_3B_3). The similar findings were obtained by Shukla *et al*. (2009) and Singh *et al*. (2017) in tomato.

Table 1 : Effect of biofertilizers in combination with different levels of NPK on number of fruits per cluster in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200: 250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	4.38	4.60	3.93	4.30
	(2.32)	(2.37)	(2.22)	(2.30)
F_2	4.70	4.90	3.73	4.44
	(2.39)	(2.43)	(2.18)	(2.33)
F_3	3.43	3.60	3.10	3.38
	(2.10)	(2.15)	(2.03)	(2.09)
Mean	4.17	4.37	3.59	
	(2.27)	(2.31)	(2.14)	
Factors	F	B	F × B	
S.E. ±	0.01	0.01	0.02	
C.D. (P=0.05)	0.04	0.04	0.06	

(Figures in parenthesis indicates square root transformed values)
F_1- 100 % Recommended dose of fertilizers; F_2- 80 % Recommended dose of fertilizers; F_3- 60 % Recommended dose of fertilizers
B_1- NFB + PSB + KSB (carrier based biofertilizers); B_2- NFB + PSB + KSB (liquid biofertilizers); B_3- Without biofertilizer

Number of fruits per plant:

Different levels of chemical fertilizers influenced the number of fruits/plant and it varied from 40.99 to 51.03. The maximum number of fruits/plant (51.03) was recorded in 80 % RDF application followed by 100 % RDF with 50.01 while, it was least (40.99) in 60 % RDF in tomato. Number of fruits/plant was ranged from 35.44 to 54.35 with the application of biofertilizers in tomato. Significant higher number of fruits/plant (54.35) was obtained with the application of NFB, PSB and KSB liquid biofertilizers followed by the application of NFB, PSB and KSB carrier based biofertilizers (52.25) when compared to control (35.44). Among all the interactions application of 80 % RDF + NFB + PSB + KSB liquid biofertilizers (F_2B_2) recorded significant higher number of fruits/plant (60.00) when compared to other interactions followed by (F_2B_1) 80 % RDF + NFB + PSB + KSB carrier based biofertilizers (58.10) and the lowest (31.33) was recorded in (F_3B_3) 60 % RDF + without biofertilizers. These results might be attributed due to the reason that with the application of biofertilizers, considerable amount of biologically active substances like B vitamins, nicotinic acid, pantothenic acid, biotin,

Table 2 : Effect of biofertilizers in combination with different levels of NPK on number of fruits per plant in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	54.00	56.04	40.00	50.01
	(7.42)	(7.55)	(6.40)	(7.12)
F_2	58.10	60.00	35.00	51.03
	(7.69)	(7.81)	(6.00)	(7.17)
F_3	44.66	47.00	31.33	40.99
	(6.76)	(6.93)	(5.68)	(6.45)
Mean	52.25	54.35	35.44	
	(7.29)	(7.43)	(6.03)	
Factors	F	B	F × B	
S.E. ±	0.06	0.06	0.10	
C.D. (P=0.05)	0.17	0.17	0.29	

(Figures in parenthesis indicates square root transformed values) heteroxins, gibberellins etc., were produced which improves the growth of plants and significantly improves number of fruits/plant. The results were in accordance with Sudhakar and Purushotham (2008) in tomato, Singh *et al.* (2015), *Singh et al.* (2017) and Kamal *et al.* (2018) in tomato.

Fruit set %:

Significant differences in fruit set % was observed due to application of chemical fertilizers, biofertilizers and their interactions in tomato. Fruit set % ranged from 76.00 to 88.47 % was recorded with different levels of chemical fertilizers. Significant higher fruit set % was recorded in F_1 (100 % RDF) and F_2 (80 % RDF) with (88.47 and 87.71) and the lowest (76.00) fruit set % was recorded in F_3 (60 % RDF).

Table 3 : Effect of biofertilizers in combination with different levels of NPK on fruit set % in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200: 250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	90.00	93.40	82.00	88.47
F_2	96.80	98.34	68.00	87.71
F_3	81.00	84.33	62.67	76.00
Mean	89.27	92.02	70.89	
Factors	F	B	F × B	
S.E. ±	1.23	1.23	2.13	
C.D. (P=0.05)	3.72	3.72	6.45	

(Figures in parenthesis indicates square root transformed values)

The plants treated with biofertilizers also showed significant influence on fruit set % and it varied from 70.89 to 92.02 %. The maximum fruit set % was recorded in B_2 (NFB + PSB + KSB liquid biofertilizers) and B_1 (NFB + PSB + KSB carrier based biofertilizers) (92.02 %, 89.27 %) when compared to control (70.89 %). The interaction effect of different levels of chemical fertilizers and biofertilizers showed significant influence on fruit set %. The interaction of 80 % RDF along with NFB + PSB + KSB liquid biofertilizers (F_2B_2), 80 % RDF along with NFB + PSB + KSB carrier based biofertilizers (F_2B_1) and 100 % RDF along with NFB + PSB + KSB liquid biofertilizers (F_1B_2) recorded the highest fruit set % (98.34, 96.80 and 93.40 %) when compared to other interactions while, the least fruit set % (62.67 %) was recorded in (F_3B_3) 60 % RDF + without biofertilizers and the data regarding fruit set % was similar to the findings of Anburani and Manivannan (2002) in brinjal.

Table 4 : Effect of biofertilizers in combination with different levels of NPK on fruit length (cm) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	5.23	5.35	5.06	5.21
F_2	5.63	5.83	4.72	5.40
F_3	4.76	4.84	4.40	4.66
Mean	5.21	5.34	4.73	
Factors	F	B	F × B	
S.E. ±	0.04	0.04	0.07	
C.D. (P=0.05)	0.13	0.13	0.22	

Fruit length (cm):

There was significant difference on fruit length due to application of chemical fertilizers, biofertilizers and their interactions. Chemical fertilizers with different levels influenced the fruit length and it ranged from 4.66 cm to 5.40 cm. The significant higher fruit length (5.40 cm) was recorded with application of 80 % RDF followed by the application of 100 % RDF (5.21 cm) whereas, the lowest (4.66 cm) was recorded with application of 60 % RDF.

Application of NFB, PSB and KSB as liquid formulations resulted significant increase in fruit length by 12.90 % when compared to without biofertilizers (control) followed by the application of NFB, PSB and KSB carrier based biofertilizers with an increase of 10.15 %. Among all the treatments the application of 80 % RDF + NFB + PSB + KSB liquid biofertilizers (F_2B_2) and 80 % RDF + NFB + PSB + KSB carrier based biofertilizers (F_2B_1) recorded significant higher fruit length (5.83 cm and 5.63 cm) when compared to other combinations whereas, the minimum fruit length (4.40 cm) was recorded in (F_3B_3) 60 % RDF + without biofertilizers. The increase in the fruit size might be due

Table 5 : Effect of biofertilizers in combination with different levels of NPK on fruit width (cm) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	5.02	5.14	4.54	4.90
F_2	5.28	5.45	4.30	5.01
F_3	4.53	4.69	4.08	4.44
Mean	4.95	5.09	4.31	
Factors	F	B	F × B	
S.E. (m) ±	0.06	0.06	0.10	
C.D. (P=0.05)	0.17	0.17	0.30	

to the higher uptake of nutrients and more food material synthesis by plant when treated with biofertilizers and the similar findings were obtained by Anburani *et al*. (2003) in brinjal, Gajbhiye *et al*. (2003) and Singh *et al*. (2015) in tomato.

Fruit width (cm):

In tomato significant difference was observed due to different levels of chemical fertilizers in fruit width ranging from 4.44 cm to 5.01 cm. The maximum fruit width was recorded with 80 % RDF and 100 % RDF (5.01 cm and 4.90 cm) while, it was lowest (4.44 cm) in 60 % RDF. Significant higher increase (18.09 %) was recorded with the application of NFB + PSB + KSB liquid biofertilizers over without biofertilizers followed by the application of NFB + PSB + KSB carrier based biofertilizers with an increase of 14.85 %. Different levels of chemical fertilizer and biofertilizer interactions showed significant influence on fruit width. The interaction with 80 % RDF along with liquid biofertilizers of NFB + PSB + KSB (F_2B_2) and 80 % RDF along with NFB + PSB + KSB carrier based biofertilizers (F_2B_1) recorded significant higher fruit width (5.45 cm and 5.28 cm) when compared to other treatment combinations whereas, the minimum fruit width (4.08 cm) was recorded in (F_3B_3) 60 % RDF + without biofertilizers in tomato.

Average fruit weight (g):

There was significant difference on average fruit weight in tomato with the application of chemical fertilizers, biofertilizers and their interactions. Chemical fertilizers with different levels influenced the average fruit weight and it ranged from 70.21 g to 88.77 g. Significant higher average fruit weight (88.77 g) was recorded in F_2 (80 % RDF) followed by F_1 (100 % RDF) with 87.73 g when compared to F_3 (60 % RDF) (70.21 g). Liquid biofertilizers of NFB along with PSB and KSB application recorded an increase (27.87 %) in average fruit weight over control followed by the application of NFB along with PSB and KSB carrier based biofertilizers with an increase of 26.36 % when compared to control.

Among all the interactions the combination of 80 % RDF along with NFB + PSB + KSB liquid biofertilizers (F_2B_2) and 80 % RDF along with NFB + PSB + KSB carrier based biofertilizers (F_2B_1) recorded the significant average fruit weight (96.96 g and 96.71 g) when compared to other interactions whereas, the minimum average fruit weight (61.90 g) was recorded in 60 % RDF + without biofertilizers (F_3B_3) in tomato. These results might be due to essential effects of biofertilizers that enhances the root development, improves the nutrient uptake potential of roots and to some extent ability of nitrogen fixation and these results were similar to the findings of Singh *et al*. (2015) in tomato.

Fruit yield per plant:

Different levels of chemical fertilizers significantly influenced the fruit yield/plant which ranged from 5.79 kg to 6.59 kg. Significant higher fruit yield (6.59 kg/plant) was recorded with the application of 80 % RDF followed by the application of 100 % RDF (6.43 kg) and the lowest (5.79 kg/plant) fruit was recorded in 60 % RDF application. Significant increase (17.89 %) in fruit yield was recorded with the application of liquid biofertilizers (NFB + PSB + KSB) followed by carrier based biofertilizers (NFB + PSB + KSB) with an increase of 12.11 % over control (without biofertilizers). Among all the interactions, application of 80 % RDF in combination with liquid biofertilizers of NFB + PSB + KSB (F_2B_2) recorded significantly higher (7.27 kg/plant) fruit yield followed by (F_2B_1) 80 % RDF in combination with carrier based biofertilizers NFB + PSB + KSB application (6.83

Table 6 : Effect of biofertilizers in combination with different levels of NPK on average fruit weight (g) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	654.33	664.33	523.77	614.14
F_2	676.98	678.72	508.60	624.43
F_3	520.77	531.10	433.33	495.07
Mean	617.36	624.72	488.57	
Factors	F	B	F × B	
S.E. ±	0.84	0.84	1.46	
C.D. (P=0.05)	2.54	2.54	4.40	

Table 7 : Effect of biofertilizers in combination with different levels of NPK on fruit yield per plant (kg) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	6.60	6.80	5.90	6.43
F_2	6.83	7.27	5.67	6.59
F_3	5.73	6.10	5.53	5.79
Mean	6.39	6.72	5.70	
Factors	F	B	F × B	
S.E. ±	0.04	0.04	0.07	
C.D. (P=0.05)	0.11	0.13	0.20	

Table 8 : Effect of biofertilizers in combination with different levels of NPK on TSS (^{0}Brix) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	4.10	4.28	4.00	4.13
F_2	4.47	4.67	3.83	4.32
F_3	3.66	3.74	3.44	3.62
Mean	4.08	4.23	3.76	
Factors	F	B	F × B	
S.E. ±	0.05	0.05	0.08	
C.D. (P=0.05)	0.14	0.14	0.25	

kg/plant) while, the minimum fruit yield (5.53 kg/plant) was recorded in 60 % RDF + without biofertilizers (F_3B_3). Optimum supply of nutrients have led to prolific plant growth and better root development leading to extensive vegetative growth, more number of fruits/ cluster and increased fruit weight thereby resulting in higher fruit yield. Optimum supply of nutrients also lead to better absorption of water and nutrients along with improved physical environment which ultimately leads to increase in fruit yield. The similar findings were obtained by Singh *et al*. (2015) in tomato.

TSS (^{0} Brix):

The data pertaining to TSS, as influenced by chemical fertilizers, biofertilizers and their interactions. Application of different levels of chemical fertilizers significantly enhanced the TSS ranging from 3.62 to 4.32 ^{0}Brix in tomato. The maximum TSS (4.32 ^{0}Brix) was recorded with the application of 80 % RDF followed by 100 % RDF (4.13 ^{0}Brix) and the minimum TSS (3.62 ^{0}Brix) was recorded in 60 % RDF in tomato.

Significant influence on TSS was observed with the application of biofertilizers ranging from 3.76 to 4.23 ^{0}Brix. Significant higher (4.23 ^{0}Brix) TSS was recorded with the application of liquid biofertilizers (NFB along with PSB and KSB) followed by the application of carrier based biofertilizers (NFB along with PSB and KSB) 4.08 ^{0}Brix when compared to control (3.76 ^{0}Brix). Among all the interactions application of 80 % RDF + NFB + PSB + KSB liquid biofertilizers (F_2B_2) and 80 % RDF + NFB + PSB + KSB carrier based biofertilizers (F_2B_1) showed significant higher TSS (4.67 and 4.47 ^{0}Brix) while, it was recorded lowest (3.44 ^{0}Brix) with the application of 60 % RDF + without biofertilizers (F_3B_3). Total soluble solids is an important quality parameter of tomato crop. Accelerated mobility of photosynthates from source to sink, enhanced metabolism of carbohydrates as influenced by growth hormones might have resulted in higher total soluble solids content. Apart from this, potassium favours the conversion of starch into simple sugars during ripening by activating the sucrose synthetase enzyme thus resulting in higher TSS. The results obtained were similar with the findings of Sudhakar and Purushothum (2008), Gajbhiye *et al*. (2010), Gosavi and Kamble (2010), Singh *et al*. (2015) and Kumar *et al*. (2017) in tomato.

Table 9 : Effect of biofertilizers in combination with different levels of NPK on ascorbic acid content (mg/100 g) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250: 250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	15.34	16.03	14.30	15.22
F_2	16.22	16.53	14.30	15.68
F_3	13.51	13.86	13.09	13.49
Mean	15.02	15.47	13.90	
Factors	F	B	F × B	
S.E. ±	0.04	0.04	0.08	
C.D. (P=0.5)	0.13	0.13	0.23	

Table 10 : Effect of biofertilizers in combination with different levels of NPK on lycopene content (mg/100 g) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250:250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	25.46	30.80	14.86	23.71
F_2	26.72	31.72	13.08	23.84
F_3	23.61	24.80	12.37	20.26
Mean	25.26	29.11	13.44	
Factors	F	B	F × B	
S.E. ±	0.07	0.07	0.11	
C.D. (P=0.05)	0.20	0.20	0.34	

Ascorbic acid content (mg/100 g):

Significant difference in ascorbic acid content was observed due to application of different levels of chemical fertilizers ranging from 13.49 to 15.68 mg/100 g in tomato. The maximum ascorbic acid content (15.68 mg/100 g) was recorded in F_2 (80 % RDF) followed by F_1 (100 % RDF) with 15.22 mg/100 g and the lowest (13.49 mg/ 100 g) was in F_3 (60 % RDF). Biofertilizers application also showed significant influence on ascorbic acid content and it varied from 13.90 to 15.47 mg/100 g. Significant higher ascorbic acid content (15.47 mg/100 g) was

Table 11 : Effect of biofertilizers in combination with different levels of NPK on titrable acidity (%) in tomato hybrid Arka Samrat

Recommended dose of fertilizers (200:250:250 kg NPK/ha)	Biofertilizers			
	B_1	B_2	B_3	Mean
F_1	0.48	0.52	0.44	0.48
F_2	0.53	0.53	0.41	0.49
F_3	0.42	0.43	0.39	0.41
Mean	0.48	0.50	0.41	
Factors	F	B	F × B	
S.E. ±	0.004	0.004	0.006	
C.D. (P=0.05)	0.01	0.01	0.02	

recorded in the plants treated with liquid formulations (NFB + PSB + KSB) followed by the application of carrier based biofertilizers (NFB + PSB + KSB) with 15.02 mg/100 over control (without biofertilizers) (13.90 mg/100 g).

The interaction effect of different levels of chemical fertilizers and biofertilizers showed significant influence on ascorbic acid content. Among all the interactions the combination of 80 % RDF along with liquid biofertilizers (NFB + PSB + KSB (F_2B_2) recorded significant higher ascorbic acid content (16.53 mg/100 g) followed by (F_2B_1) 80 % RDF along with NFB + PSB + KSB carrier based biofertilizers (16.22 mg/100 g) whereas, the minimum ascorbic acid content (13.09 mg/100 g) was recorded in (F_3B_3) 60 % RDF + without biofertilizers. In the present study, there was a marginal increase in ascorbic acid content due to combined application of inorganic and bio-fertilizers majorly potassium could have helped to slow down the enzyme system that catalysis the oxidation of ascorbic acid, thus helping plants to accumulate more ascorbic acid content in the fruits. The similar results were obtained by Sudhakar and Purushothum (2008), Gosavi and Kamble (2010), Ordookhani and Zare (2011), Singh *et al*. (2015) and Kumar *et al*. (2017) in tomato.

Lycopene content (mg/100 g) :

Different levels of chemical fertilizers significantly influenced the lycopene content ranging from 20.26 to 23.84 mg/100 g. Significant higher lycopene content in tomato was recorded in 80 % RDF and 100 % RDF application (23.84 and 23.71 mg/100 g) while, the lowest (20.26 mg/100 g) was recorded in 60 % RDF. The tomato plants treated with biofertilizers showed significant effect on lycopene content and it varied from 13.44 to 29.11 mg/100 g. The maximum lycopene content (29.11 mg/100 g) was recorded in NFB + PSB + KSB liquid biofertilizers followed by NFB + PSB + KSB carrier based biofertilizers (25.26 mg/100 g) when compared to control (without biofertilizers) 13.44 mg/100 g.

Different levels of chemical fertilizers and biofertilizers interactions showed significant influence on lycopene content. Application of 80 % RDF + NFB + PSB + KSB liquid biofertilizers (F_2B_2) recorded the maximum lycopene content (31.72 mg/100 g) when compared to other treatment combinations followed by the application of 100 % RDF + NFB + PSB + KSB liquid biofertilizers (F_1B_2) with 30.80 mg/100 g while, it was recorded lowest (12.37 mg/100 g) in (F_3B_3) 60 % RDF + without biofertilizers. The possible reason for this might be that the biofertilizers enhanced the fruit quality by biological nitrogen fixation and producing hormones, vitamins and other growth factors required for better plant growth which affected the fruit quality (Bhattacharya *et al*., 2000). The results obtained regarding lycopene content were similar with the findings of Gajbhiye *et al*. (2010), Gosavi and Kamble (2010) and Ordookhani and Zare (2011) in tomato.

Titrable acidity (%):

There was significant difference on titrable acidity due to application of chemical fertilizers, biofertilizers and their interactions in tomato. Different levels of chemical fertilizers significantly influenced the titrable acidity ranging from 0.41 to 0.49 %. The maximum (0.49 %) titrable acidity was recorded in F_2 (80 % RDF) followed by F_1 (100 % RDF) with 0.48 % when compared to F_3 (60 % RDF) (0.41%). Titrable acidity was influenced by the application of biofertilizers and it ranged from 0.41 to 0.50 %. The application of NFB in combination with PSB and KSB (liquid biofertilizers) showed significant higher titrable acidity (0.50 %) followed by the application of NFB in combination with PSB and KSB (carrier based biofertilizers) with 0.48 % over control (0.41 %). Among all the interactions, the application of 80 % RDF + NFB + PSB + KSB liquid biofertilizers (F_2B_2), 80 % RDF + NFB + PSB + KSB carrier based biofertilizers (F_2B_1) and 100 % RDF + NFB + PSB + KSB liquid biofertilizers (F_1B_2) recorded the maximum titrable acidity (0.53, 0.53 and 0.52 %) whereas, the minimum titrable acidity (0.39 %) was recorded in 60 % RDF + without biofertilizers (F3B3) and the results obtained are similar with the findings of Gosavi and Kamble (2010) and Kumar *et al*. (2017) in tomato.

Acknowledgement:

The work was supported by department of vegetable science, college of horticulture, Venkataramannagudem, West Godavari, Andhra Pradesh, India. I am thankful to my advisory committee and also to the staff of College of Horticulture, Venkataramannagudem.

REFERENCES

Anburani, A., Manivannan, K. and Shakila, A. (2003). Integrated nutrient and weed management on yield and yield parameters in brinjal (*Solanum melongena* L.) cv. Annamalai. *Plant Archives*, **3**(1): 85-88.

Anburani, A. and Manivannan, K. (2002). Effect of integrated nutrient management on growth in brinjal (*Solanum melongena* L.) cv. Annamalai. *South Indian Hort*., **50** (46) : 377-86.

Bhatacharya, P. and Jain, R.K. (2000). Phosphorous solubilizing biofertilizers in the whirl pool of rock phosphate-challenges and opportunities. *Fertilizer News*, **45** : 45-52.

Choudhury, A.T.M. and Kennedy, I.R. (2005). Nitrogen fertilizer losses from rice soils and control of environmental pollution problems. *Communications Soil Science & Plant Analysis,* **36**: 1625-39.

Franceschi, S., Bidoli, E., Vecchia, C.La, Talamini, R., Avanzo, B.D' and Negri, E. (1994). Tomatoes and risk of digestive-tract cancers. *Internat. J. Cancer*, **59**: 181-184.

Gajbhiye, R.P., Sharma, R.R, Tewari, R.N. and Sureja, A.K. (2010). Effect of inorganic and bio-fertilizers on fruit quality of tomato. *Indian J. Hort*., **67**: 301-04.

Gajbhiye, R.P., Sharma, R.R. and Tewari, R.N. (2003). Effect of biofertilizers on growth and yield parameters of tomato. *Indian J. Hort*., **60**(4): 368-71.

Gerster, H., (1997). The potential role of lycopene for human health. *J. American College Nutri.,* **16**: 109- 126.

Gomathy, M., Prakash, D.S., Thangaraju, M., Sundaram, S.P. and Sundaram, P.M. (2008). Impact of biofertigation of Azophosmet on cotton yield under drip irrigation. *Res. J. Agric. & Biological Sci*., **4**(6): 695-99.

Gosavi, P.U. and Kamble, A.B. (2010). Effect of organic manures and biofertilizers on quality of tomato fruits. *Asian J. Hort*., **5**(2): 376-78.

Kamal, S., Kumar, M., Rajkumar and Raghav, M. (2018). Effect of biofertilizers on growth and yield of tomato (*Lycopersicon esculentum* Mill.). *Internat. J. Curr. Microbiol. & Appl. Sci*., **7**(02): 2542-45.

Kashyap, A.S., Thakur, Ashok K. and Thakur, Nitika (2014). Effect of Organic Manures and Biofertilizers on the Productivity of Tomato and Bell Pepper under Mid-Hill Conditions of Himachal Pradesh. *Internat. J. Economic Plants*, **1**(1):036-039.

Kumar, S. and Sharma, S.K. (2006). Response of tomato seed to different bioinoculants at different levels of nitrogen, phosphorus and potassium. *Environment & Ecol*., **24**(2): 327-30.

Ordookhani, K. and Zare, M. (2011). Effect of Pseudomonas, Azotobacter and Arbuscular Mycorrhiza fungi on lycopene, antioxidant activity and total soluble solid in tomato (*Lycopersicon esculentum* F1 Hybrid, Delba). *Adv. Environmental Biol*., **5**(6): 1290-94.

Shukla, Y.R., Thakur, A.K. and Joshi, A. (2009). Effect of inorganic and biofertilizers on yield and horticultural traits in tomato. *Indian J. Hort*., **66**(2): 285-87.

Singh, A., Jain, P.K., Sharma, H.L. and Singh, Y. (2015). Effect of planting date and integrated nutrient management on the production potential of tomato (*Solanum lycopersicon* Mill.) under polyhouse condition. *J. Crop & Weed*, **11**(Special Issue): 28-33.

Singh, R.K, Dixit, P.S. and Singh, M.K. (2017). Effect of bio fertilizers and organic manures on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.) cv. Arka Vikas. *J. Pharmacognosy & Phytochemistry*, **6**(5): 1793-95.

Sudhakar, P.S. and Purushotham, K. (2008). Studies on effect of bio-fertilizer on growth, yield and quality of tomato (*Solanum lycopersicum* L.). *Orissa J. Hort*., **36**(2): 120-25.

Verma, M., Sharma, S. and Prasad, R. (2011). Liquid biofertilizers: Advantages over carrier based biofertilizers for sustainable crop production. *Internat. Society of Environmental Botanists*, **17**(2).

17th Year
★★★★★ of Excellence ★★★★★