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Research Article

Yield and Quality of Tomato Influenced by Different Sources of Fertilizers and Levels of Fertigation

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Abstract

Tomato (*Lycopersicon esculentum* Mill) belongs to Solanaceae family is one of the most important vegetables from nutritive as well as consumption point of view. Tomato is one of the most popular and widely grown vegetable crops in the world. Applying of fertilizers through fertigation can reduce fertilizer wasting and increased plant uptake nutrients. A greenhouse and open field experiments were conducted to know the influenced of different sources of fertilizers (NPK: Nitrogen, Phosphorus, Potasium) and levels of fertigation on yield and quality of tomato. The study consisted of two supplied through fertigation and soil application at three levels (100, 125 and 150 per cent recommended dose of fertilizers where recommended dose of fertilizers (RDF) is 250:250:250 Kg NPK ha^{-1}) of nutrient. Application of 125% of water soluble fertilizers (18:18:18) with recommended dose of (250:250:250 Kg/ha) through fertigation decreased the number of days (31.33 days) taken for 50 per cent flowering, number of days taken (50.33 days) from first flower emergence to fruit maturity and increased number of inflorescence and flowers per inflorescence per plant (14.60 inflorescences and 53.20 flowers respectively). It also increased fruit setting percentage (88.44%), number of fruit per plant(75.13), fruit per m^2 (300.53), mean weight of fruits per plant (346.12g), yield per plant (3.92 kg), yield per m^2 (15.70 kg) and yield per hectare (159.30 t) respectively. It showed around 279.13 per cent increasing of yield per hectare under greenhouse condition compared to other control under open field condition.

Keywords: Tomato; Fertilizer; Fertigation; Yield; Quality

Introduction

Vegetables are perhaps the most intensively irrigated crops all over the world and more so is tomato. It is a high value crop and technologies that need high investment can be adopted in this crop. Tomato (*Lycopersicon esculentum* Mill) belongs to Solanaceae family is one of the most important vegetables from nutritive as well as consumption point of view. Tomato is one of the most popular and widely grown vegetable crops in the world. Tomato fruits being rich in vitamins and minerals such as C, A, potassium and calcium. Several tomato products like juice, paste, puree, ketchup, sauce have larger domestic use and have better avenues for export and the maximum use of tomato fruit is in fresh form [1,2].

The ripened tomato fruits have medicinal values like anti cancer property of mouth, stimulates torpid liver and useful in chronic dyspepsia. Greenhouse protect the crop from excess solar radiation, extreme temperature value and low volume crops like flowers and vegetables in greenhouse during off- season or round the year is possible with improved productivity and quality of the produce, thereby fetching additional returns. Fertigation means fertilizers

combined with irrigation is one of the most effective and convenient means of supplying nutrients and water, according to specific requirement of the crop, whenever required, resulting in higher productivity of better quality produce. Despite the widespread use of high frequency irrigation system and fertigation elsewhere, in India, not much information is available on different methods of planting and on several aspects of fertigation on closely spaced crops like tomato [3].

Efficient use of fertilizers and water is highly essential for sustainable horticulture and agriculture, in the context of declining per capita land, dwindling water resources, receding water table, increasing ecological disturbances and cost escalation of fertilizers. Pressure on agriculture is increasing due to population growth, necessitating efficient utilization of all inputs in agriculture. India needs to produce about 300 million tonnes by 2020 to feed its growing population. Fertigation has a bright promise in high value vegetable crop production and is becoming more popular because of availability of high-grade completely water-soluble fertilizers. Therefore, there is a need to study the influence of different methods of planting at different levels of irrigation and fertigation involving the sources of fertilizer, rate of fertilizer and methods of fertilizer application. In addition, sizeable amount of nutrients are left over after tomato, which can support a short duration crop. A study carried out with the following objectives.

- To know the effect of different sources of fertilizers on yield and quality of tomato under greenhouse and open conditions.
- To study the effect of different levels of nutrients through fertigation on yield and quality of tomato.
- To work out the economics of cultivation of tomato with fertigation under naturally ventilated greenhouse and open conditions.

Material and Methods

The study was carried out at the Precision Farming Development Center, Division of Horticulture, Gandhi Krushi Vignana Kendra (G.K.V.K), University of Agricultural Sciences, Bangalore, which is situated at an altitude of 930 meter above mean sea level and latitude and longitude of 12^0 58' North and 770 35' East respectively. The four weeks old seedlings of tomato variety Allrounder were planted on raised beds at spacing of 45cm x 60 cm in open field and greenhouse conditions. There were eighteen treatments (no water-soluble and water-soluble (WSF) fertilizers (nitrogen, phosphorus and potassium (NPK)) through fertigation and soil application, with 250:250:250 Kg/ha at 100, 125 and 150 percent of recommended dose of fertilizers (RDF)). Treatments were replicated four times in Factorial Randomized Complete Block Design. The fertilizers application through fertigation was done at 15 days after transplanting, half dose of N and full of P, K was done 15 days after transplanting, and the remaining dose applied 45 days after transplanting through soil. Observations were recorded on yield parameter.

Fertilizers description

- Nitrogen: Urea
- Phosphorus: Single superphosphate
- Potassium: Muriate of potash.

Fertilizers ratio

- Normal fertilizers NPK (46:16:60) through fertigation (250:250:250 kg/ha)
- Water soluble fertilizers (18:18:18) through fertigation (250:250:250 kg/ha)
- Normal fertilizers NPK (46:16:60) through Soil application (250:250:250 kg/ha).

Treatments details

- T_1,T_{10}: Urea, SSP, MOP (100% RDF through fertigation)
- T_2,T_{11}: Urea, SSP, MOP (125% RDF through fertigation)
- T_3,T_{12}: Urea, SSP, MOP (150% RDF through fertigation)
- T_4,T_{13}: 100% RDF of WSF Through fertigation
- T_5, T_{14}: 125% RDF of WSF Through fertigation
- T_6, T_{15}: 150% RDF of WSF Through fertigation
- T_7, T_{16}: Urea, SSP, MOP (100% RDF of NPK through Soil application)
- T_8, T_{17}: Urea, SSP, MOP (125% RDF of NPK through Soil application)
- T_9, T_{18}: Urea, SSP, MOP (150% RDF of NPK through Soil application).

Results and Discussion

Days taken for first flower emergence and 50 per cent flowering

There was no significant difference between open field and greenhouse conditions for days taken for first flower emergence.

Among the treatments in greenhouse and open field condition, significantly less number of days (31.33 days) was taken for 50 per cent flowers at 125 per cent of recommended dose of water-soluble fertilizers through fertigation. Maximum days (36.33 days) recorded in open field condition when 100 per cent of recommended dose of normal fertilizers applied through soil (table 1 and 2). This may be due to the increased levels of potassium given to the plants in the water-soluble form through out the crop growth stage, which might have enhanced the productive development of plant.

Factor	No. of inflorescence/plant			No. of flower/ inflorescence			Fruit setting (%)		
	Field	GH		Field	GH		Field	GH	
A. Conditions									
Open Field	6.39			30.65			54.21		
Greenhouse	10.66			42.73			78.18		
B. Sources of fertilizers									
NF	6.53	10.73		30.03	42.83		49.44	79.18	
WSF	6.47	12.43		35.40	50.84		65.00	84.22	
SANF	6.17	8.80		26.51	34.50		48.18	71.15	
C. Levels of fertigation									
100%	5.87	9.77		26.77	37.93		56.14	75.15	
125%	7.17	12.17		31.40	48.37		89.22	82.44	
150%	6.13	10.03		40.25	41.88		57.26	76.96	
	F test	SEm±	CD	F test	SEm±	CD	F test	SEm±	CD
A	*	0.04	0.11	*	0.52	1.50	*	0.61	1.76
B	*	0.05	0.14	*	0.64	1.83	*	0.75	2.16
C	*	0.05	0.14	*	0.64	1.83	*	0.75	2.16
AxB	*	0.07	0.20	*	0.90	2.59	*	1.06	3.05
AxC	*	0.07	0.20	*	0.90	2.59	*	1.06	3.05
BxC	*	0.08	0.24	*	1.10	3.17	*	1.30	3.73
AxBxC	*	1.25	3.47	*	0.90	2.50	*	1.06	2.94

Table 1: Effect of different sources of fertilizers and levels of fertigation on number of inflorescence, flower/ inflorescence per plant and Fruit setting (%) of tomato at 60 DAT.

*Significant at 5%

NF: Normal fertilizers NPK (46:16:60) through fertigation (250:250:250 kg/ha)

WSF: Water soluble fertilizers (18:18:18) through fertigation (250:250:250 kg/ha)

SANF; Normal fertilizers NPK (46:16:60) through Soil application (250:250:250 kg/ha)

GH: Greenhouse

Treatment No. of inflorescence/plant		No. of inflorescence/plant, No. of flower/inflorescence and fruit setting(%) at 60 DAT		
		No. of flower/ inflorescence	Fruit setting (%)	
Open field	T_1	5.60	19.40	30.55
	T_2	7.40	41.40	59.22
	T_3	6.40	29.30	58.55
	T_4	5.50	28.30	59.7
	T_5	7.80	40.60	71.44
	T_6	7.30	37.30	63.77
	T_7	4.50	20.30	45.44
	T_8	7.30	31.60	53.44
	T_9	5.70	27.63	45.66
Green house	T_{10}	8.30	34.50	69.00
	T_{11}	14.50	50.60	85.44
	T_{12}	9.30	43.40	83.11
	T_{13}	11.40	48.70	76.22
	T_{14}	14.60	53.20	88.44
	T_{15}	13.40	50.63	88.00
	T_{16}	7.40	30.60	66.11
	T_{17}	9.50	41.30	73.89
	T_{18}	9.40	31.60	73.44

Table 2: Effect of different sources of fertilizers and levels of fertigation on number of inflorescence, flower/inflorescence per plant and fruit setting (%) of tomato at 60 DAT.

T_1,T_{10}: Urea, SSP, MOP (100% RDF through fertigation)

T_2,T_{11}: Urea, SSP, MOP (125% RDF through fertigation)

T_3,T_{12}: Urea, SSP, MOP (150% RDF through fertigation)

T_4,T_{13}: 100% RDF of WSF Through fertigation

T_5,T_{14}: 125% RDF of WSF Through fertigation

T_6,T_{15}: 150% RDF of WSF Through fertigation

T_7,T_{16}: Urea, SSP, MOP (100% RDF of NPK through Soil application)

T_8,T_{17}: Urea, SSP, MOP (125% RDF of NPK through Soil application)

T_9,T_{18}: Urea, SSP, MOP (150% RDF of NPK through Soil application).

Number of inflorescence and flowers per inflorescence per plant

Number of inflorescence and flowers per inflorescence per plant at 60 and 90 days (14.60 inflorescences and 53.20 flowers, respectively) after transplanting significantly were increased with application of 125 per cent of recommended dose of water-soluble fertilizers through fertigation in greenhouse condition compared to other treatments and open condition (table 1 and 2). This increased in number of inflorescence per plant and flowers per inflorescence per plant may be relate to higher availability of NPK nutrients and uptake when produced through fertigation, which render easy accessibility as required by the crop. The least number of inflorescence per plant and flowers per inflorescence per plant, with soil application in open condition resulting in inefficient fertilizers used and low number of inflorescence per plant and flowers per inflorescence per plant. Further, fertigation might have increased the number of inflorescence and flower in two ways, i) By increasing the number of primary branches and ii) increasing shoot growth and number of secondary branches and hence the ultimate size of the plant thereby, increasing the number of potential sites where flowers could develop.

Fruit setting (%)

Fruit setting percentage significantly increased at 125 per cent of recommended dose of water-soluble fertilizers through fertigation compared to other treatments (table 1 and 2). This may be due to effect of potassium that is given in form of water-soluble and effect of greenhouse condition, which controlled the temperature and humidity during the growth stages of tomato.

Number of days taken from flower emergence to fruit maturity

Number of days taken (50.33 days) from first flower emergence to fruit maturity decreased by application of 125 per cent of recommended dose of water soluble fertilizers through fertigation in greenhouse condition over open field condition and other treatments, and days taken increased (66.33 days) by supplying normal fertilizers through soil application (table 1 and 2). The result may be due to effect of NPK for fruit maturity when supplied in the form of water-soluble fertilizers with better absorbance of nutrients by roots of tomato crop.

Number of fruits per plant, fruits per m^2 and mean weight of fruits per plant (g)

Number of fruit per plant, fruit per m^2 and mean weight of fruit per plant significantly increased when applied with 125 per cent of recommended dose of water-soluble fertilizers through fertigation in greenhouse condition compared to other treatments and open condition. These may due to maximum number of clusters per plant, fruit sitting percentage per plant and efficient use of NPK nutrients in form of water soluble fertilizers through fertigation and more number of fruits per plant (71.53 fruits), hence, more number of fruits per m^2 (286.13 fruits) and maximum mean weight (332.82 g) of fruits per plant with 166.35% increasing of number of fruits per plant as well as yield per plant under greenhouse condition compared to control and soil application (table 3 and 4). Hebbar., *et al*. [3] has also reported that application of water-soluble fertilizers through fertigation recorded significantly higher number (56.9) of fruits per plant.

Factor	No. of fruit/plant			No. of fruit/m^2			weight of fruit/plant(g)		
	Field	GH		Field	GH		Field	GH	
A. Conditions									
Open Field	51.32			205.60			234.02		
Greenhouse	60.64			241.99			265.82		
B. Sources of fertilizers									
NF	46.72	60.56		186.89	242.24		236.04	248.72	
WSF	61.47	62.47		246.76	250.51		243.54	305.94	
SANF	44.86	59.90		179.60	239.60		222.49	241.19	
C. Levels of fertigation									
100%	43.30	59.63		174.38	238.53		223.79	224.46	
125%	57.44	61.32		229.78	244.76		241.97	304.04	
150%	53.21	60.97		212.85	242.53		236.30	267.27	
	F test	SEm±	CD	F test	SEm±	CD	F test	SEm±	CD
A	*	0.07	0.18	*	0.69	1.98	*	0.32	0.93
B	*	0.08	0.23	*	0.85	2.43	*	0.40	1.14
C	*	0.08	0.23	*	0.85	2.43	*	0.40	1.14
AxB	*	0.11	0.32	*	1.19	3.43	*	0.56	1.61
AxC	*	0.11	0.32	*	1.19	3.43	*	0.56	1.61
BxC	*	0.14	0.39	*	1.46	4.20	*	0.68	1.97
AxBxC	*	0.14	0.31	*	1.19	3.31	*	0.56	1.55

Table 3: Effect of different sources of fertilizers and levels of fertigation on number of fruit/plant, per/m2 and weight of fruits per plant full harvest of tomato.

*Significant at 5%

NF: Normal fertilizers NPK (46:16:60) through fertigation (250:250:250 kg/ha)

WSF: Water soluble fertilizers (18:18:18) through fertigation (250:250:250 kg/ha)

SANF: Normal fertilizers NPK (46:16:60) through Soil application (250:250:250 kg/ha)

GH: Greenhouse.

Treatment No. of fruit/plant		No. of fruit per plant, per m^2 and weight of fruit (g) per plant full harvest		
		No. of fruit/m^2	Weight of fruit/plant(g)	
Open field	T_1	43.00	172.00	202.13
	T_2	52.13	208.53	280.33
	T_3	45.03	180.13	225.65
	T_4	53.20	215.80	229.44
	T_5	69.20	276.80	270.27
	T_6	64.73	258.93	230.89
	T_7	31.67	127.20	198.98
	T_8	55.47	221.87	252.35
	T_9	47.43	189.73	216.13
Green house	T_{10}	52.50	206.00	198.99
	T_{11}	71.53	286.13	332.82
	T_{12}	58.13	226.67	234.92
	T_{13}	54.30	217.20	270.90
	T_{14}	75.13	300.53	346.12
	T_{15}	54.97	222.53	300.79
	T_{16}	51.27	209.07	220.91
	T_{17}	71.27	285.07	278.49
	T_{18}	56.67	224.67	224.31

Table 4: Effect of different sources of fertilizers and levels of fertigation on number of fruit/plant, per/m2 and weight of fruits per plant full harvest of tomato.

T_1,T_{10}: Urea, SSP, MOP (100% RDF through fertigation)

T_2,T_{11}: Urea, SSP, MOP (125% RDF through fertigation)

T_3,T_{12}: Urea, SSP, MOP (150% RDF through fertigation)

T_4,T_{13}: 100% RDF of WSF Through fertigation

T_5,T_{14}: 125% RDF of WSF Through fertigation

T_6,T_{15}: 150% RDF of WSF Through fertigation

T_7,T_{16}: Urea, SSP, MOP (100% RDF of NPK through Soil application)

T_8,T_{17}: Urea, SSP, MOP (125% RDF of NPK through Soil application)

T_9,T_{18}: Urea, SSP, MOP (150% RDF of NPK through Soil application).

In a trial carried out in tomato, the yield parameters (fruit $plant^{-1}$, weight $fruit^{-1}$ and yield ha^{-1}) were significantly greater with fertigation than solid fertilizer application [4]. Malik and Kumar [5] reported that the yields and fruit size of tomato were greatest when the supplementary fertilizer was supplied through the drip fertigation system compared to soil application. The drip fertigation with 100 per cent of NPK recommended dose increased yield and quality of tomato [6].

Yield per plant, per m^2 (kg) and per hectare (t)

Results show significantly highest yield per plant (3.98 kg), yield per m^2 (15.93 kg) and yield per hectare (159.30 t) with 125 per cent of WSF through fertigation in greenhouse condition and minimum yield (51.07 t) was recorded in open field condition with 100 per cent of RDF of NF through soil. It showed around 279.13 per cent increasing of yield per hectare under greenhouse condition compared to control and open field condition. This increase in fruit yield was reflected on improved yield parameter as evident from number of fruits (71.53 fruits) per plant and fruit yield (3.98 kg) per plant (table 5 and 6). Increase in fruit yield per plant, per m^2 and per hectare could be related to significantly higher number of fruits per plant at full harvest. Effects of nitrogen fertilizer that applied through fertigation on the performance of summer tomato were studied by Kunita., *et al*. [1] and the results of the study indicated that the yield of tomato increased by fertigation by up to 10 per cent compared with control. A case study reported by Tu., *et al*. [2] revealed that drip irrigation and drip fertigation significantly increased tomato yield compared with the untreated control.

Conclusion

The present investigation evaluated that the application of 125 per cent of recommended of water soluble fertilizers through fertigation under greenhouse condition resulted in maximum growth, yield (around 166.35%) and quality parameters of tomato compared to application of NPK through soil application and control under field condition.

Factor	Yield/plant (kg)			Yield/m^2 (kg)			Yield(t/ha)		
	Field	GH		Field	GH		Field	GH	
A. Conditions									
Open Field	2.13			8.50			81.29		
Greenhouse	3.28			13.10			131.02		
B. Sources of fertilizers									
NF	1.99	3.30		7.96	13.22		79.57	132.16	
WSF	2.45	3.41		9.79	13.64		86.77	136.36	
SANF	1.94	3.11		7.75	12.46		77.52	124.56	
C. Levels of fertigation									
100%	1.80	3.13		7.18	12.53		71.84	125.30	
125%	2.44	3.39		9.76	13.55		97.64	135.48	
150%	2.14	3.31		8.55	13.23		74.39	132.30	
	F test	SEm±	CD	F test	SEm±	CD	F test	SEm±	CD
A	*	0.003	0.01	*	0.01	0.03	*	2.62	7.52
B	*	0.003	0.01	*	0.01	0.04	NS	3.21	-
C	*	0.003	0.01	*	0.01	0.04	*	3.21	9.21
AxB	*	0.004	0.01	*	0.02	0.05	*	4.53	13.03
AxC	*	0.004	0.01	*	0.02	0.05	*	4.53	13.03
BxC	*	0.010	0.02	*	0.02	0.06	*	5.55	15.96
AxBxC	*	0.004	0.01	*	0.02	0.05	*	4.53	12.57

Table 5: Effect of different sources of fertilizers and levels of fertigation on yield per plant (kg), per m2 (kg) and per hectare (t) of tomato.

*Significant at 5%

NS: Non significant

NF: Normal fertilizers NPK (46:16:60) through fertigation (250:250:250 kg/ha)

WSF: Water soluble fertilizers (18:18:18) through fertigation (250:250:250 kg/ha)

SANF: Normal fertilizers NPK (46:16:60) through Soil application (250:250:250 kg/ha)

GH: Greenhouse.

Treatment		**Yield/plant (kg), Yield/m^2 (kg) and Yield(t/ha))**		
Yield/plant (kg)		**Yield/m^2 (kg)**	**Yield(t/ha)**	
Open field	T_1	1.43	5.71	57.07
	T_2	2.66	10.65	106.51
	T_3	1.89	7.52	75.15
	T_4	2.17	8.67	77.40
	T_5	2.77	11.07	96.24
	T_6	2.41	9.62	86.67
	T_7	1.77	7.06	70.63
	T_8	2.25	9.02	90.17
	T_9	1.79	7.18	71.77

Green house	T_{10}	2.83	11.32	113.17
	T_{11}	3.92	15.76	157.60
	T_{12}	3.16	12.63	126.33
	T_{13}	3.21	12.85	128.47
	T_{14}	3.98	15.93	159.30
	T_{15}	3.23	12.93	129.28
	T_{16}	2.79	11.14	111.40
	T_{17}	3.53	14.13	141.28
	T_{18}	3.03	12.10	121.00

Table 6: Effect of different sources of fertilizers and levels of fertigation on Yield per plant (kg), per m2 (kg) and per hectare (t) of tomato.

T_1,T_{10}: Urea, SSP, MOP (100% RDF through fertigation)

T_2,T_{11}: Urea, SSP, MOP (125% RDF through fertigation)

T_3,T_{12}: Urea, SSP, MOP (150% RDF through fertigation)

T_4,T_{13}: 100% RDF of WSF Through fertigation

T_5,T_{14}: 125% RDF of WSF Through fertigation

T_6,T_{15}: 150% RDF of WSF Through fertigation

T_7,T_{16}: Urea, SSP, MOP (100% RDF of NPK through Soil application)

T_8,T_{17}: Urea, SSP, MOP (125% RDF of NPK through Soil application)

T_9,T_{18}: Urea, SSP, MOP (150% RDF of NPK through Soil application).

Suggestions

- Applying fertilizers along with fertigation will increase plant growth and development and quality and quantity of the products
- It is recommended to add 125% water soluble fertilizers to the crops at different stages of growth especially after transplanting, flowering stage, fruit sitting and during harvesting at appropriate rate.
- Irrigation through drip system along mulches will help to preserve water, control weeds and improve fruits quality and quantity.

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