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Effect of Drip Fertigated and Soil Drenched Liquid Organic Manures on Productivity and Quality of Tomato

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Abstract To study the influence of liquid organic manures viz., humic acid, fulvic acid, vermiwash and jeevamiritham on productivity and qualities of tomato, a factorial experiment in a randomized block design with 3 replications was conducted in Tamil Nadu Agricultural University, Coimbatore during summer 2017 and 2018. The treatment consists of 2 factors namely irrigation methods and fertilization methods. Soil application of liquid organic manures followed in conventional irrigation method and venturi fertigation used in drip irrigation method. The results showed that highest yield were obtained from treatment which received drip irrigation with inorganic fertilizers but resulted in decreased quality parameters of total soluble solids and ascorbic acid content. Among all the liquid organic manures used in this study, humic acid along with fulvic acid (both @ 3 kg ha^{-1}) resulted significantly higher yield and qualities of tomato fruits.

Keywords Humic acid, Fulvic acid, Total soluble solids (TSS), Titrable acidity (TA), Ascorbic acid content (AA).

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Introduction

Tomato is the leading vegetable crop grown throughout the world and ranks first as a processing crop. In India, it occupies an area of 773.9 Mha with a productivity of 24.2 t ha^{-1}. Increased use of imbalanced fertilizer application resulted an adverse effect on soil and crop ecosystem. Cost of inorganic fertilizers increasing to an extent that they are out of reach of many small farmers. In such a situation, role of organic manures leads an important role in sustainable crop production.

The use of liquid organic manures such as humic acid, fulvic acid, vermiwash and jeevamiritham results in higher growth, yield and quality of tomato crop. Different humic acid from forest soil mixed with nutrient solution in a hydroponic culture resulted enhanced net photosynthesis by 68—436% during the vegetative stages and increased fruit sugar content in tomato (Haghighi and Teixeira 2013). Vermiwash of different combinations of animal, agro and kitchen waste have enhanced the growth and productivity of tomato plants. It also works well in inhibiting the growth of *Alternaria alternata* at 10% dilution (Jaikishun et al. 2014).

The individual and combined applications of 0.4% Humic acid, 4% Fulvic acid and 0.25% chelated calcium solutions increased vegetative growth, yield, ftuit quality in tomato fruits (Husein et al. 2015). Therefore, the main objective was to study the effect of soil drenching and drip fertigated liquid organic manures on the productivity of tomato.

Materials and Methods

The experiment was conducted in the Eastern Block fields of Tamil Nadu Agricultural University (TNAU), Coimbatore in 2017 and 2018 to analyze the response of tomato productivity under drip and conventional irrigated conditions to various liquid organic manures. The experiment consisted of 2 factors namely irrigation methods and fertilization methods, with 3 replications in a factorial randomized block design. The tomato F_1 hybrid Shivam was used in the experiment. Following are the treatment details.

Factor 1. Irrigation methods (I)

I_1 : Drip irrigation, I_2 : Conventional irrigation.

Factor 2. Fertilization methods (F)

F_1 : Humic acid 3 kg ha^{-1}, F_2 : Fulvic acid 3 kg ha^{-1}, F_3 : Vermiwash 5%, F_4 : Jeevamiritham 5%, F_5 : Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}, F_6 : Vermiwash 5% + Jeevamiritham 5 %, F_7 : Inorganic fertilizers.

The soil physical and chemical properties of the experimental area in 2017 and 2018 were presented in Table 1. The tomato seedlings were transplanted in the experimental plot @ one seedling hill^{-1} at a spacing of 75 × 65 cm in the paired row system . In conventional method, ridges and furrows were formed and tomato seedlings were transplanted at a spacing of 60 × 80 cm.

In the case of drip irrigation (I_1) treatments, the fertilizers NPK were applied through drip fertigation (Table 2) using Urea as N source, mono ammonium phosphate (MAP) for P and muriate of potash (MOP) for K. Considering the nutrient uptake pattern, at phenological growth stages, 75% of recommended dose (RD) of P was applied on basal application with single super phosphate (Portal TNAU Agritech 2014). The fertigation schedule for remaining 25% was furnished in Table 2. For conventional irrigation (I_2) treatments, soil drenching of organic liquid manures and conventional method of application of fertilizers were done. The RD of fertilizers for tomato 200 : 250 : 250 kg of NPK per ha were applied as indicated in Table 3. Further fertilizer sources used for supplying NPK were urea, single super phosphate (SSP) and MOP respectively. All other standard cultural practices of TNAU for field crops was followed uniformly for all the treatments.

Table 1. Physico-chemical characteristics of the experimental fields.

Particulars	Values Field No. 36 E Year 2017	Values Field No. NA5 Year 2018
Clay (%)	34.5	35.9
Silt (%)	19.8	21.8
Fine sand (%)	19.4	17.3
Coarse sand (%)	26.3	25.0
Textural class	Sandy clay loam	Sandy clay loam
Bulk density (g cc^{-1})	1.31	1.33
Particle density (g cc^{-1})	2.23	2.31
Porosity (%)	41.25	42.42
pH	8.34	8.10
EC (dS m^{-1})	1.16	0.78
Organic carbon (%)	0.45	0.39
Available nitrogen (kg ha^{-1})	198.0	336.0
Available phosphorus (kg ha^{-1})	19.5	17.5
Available potassium (kg ha^{-1})	648.0	468.0

Table 2. Stage of fertigation schedule for drip irrigated (I_1) treatments of tomato crop.

Crop stages	Quantity (%) N	 P	 K
Transplanting to seedling establishment stage (1—10 days)	10	5	10
Flower initiation to flowering stage (11—40 days)	40	10	40
Flowering to fruit set stage (41—70 days)	30	5	30
Alternate day from picking	20	5	20
Total	100	25	100

Table 3. Fertilization schedule for conventional irrigated (I_2F_7) treatment of tomato crop.

Crop	Basal	I top dressing (25 DAS)	II top dressing (45 DAS)
Tomato	33 % N 100 % P_2O_5 50 % K_2O	33 % N 50 % K_2O	33 % N

Total soluble solids (TSS) was determined by a hand refractometer. Fruits were homogenized in a blender and portions of the homogenate were taken to determine the titrable acidity (TA) and ascorbic acid (AA) contents. The TA was determined by the titration of sample (20 g) with 0.1 N NaOH (AOAC 1975). The AA was measured by classical titration method using 2, 6-dichlorophenol indophenols solution, and expressed as mg/100 ml (AOAC 1975).

Results and Discussion

The data of the 2 years were pooled and statistically analyzed for different parameters. The number of fruits per plant of tomato was furnished in Table 4. Drip irrigation (I) significantly influenced the number of fruits per plant. Application of inorganic fertilizers (F_7) recorded significantly highest number of fruits per plant (30.97) but comparable with the treatment Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1} (F_5). In the case of interaction, the inorganic fertilization in drip irrigated treatment (I_1F_7) produced comparatively the highest number of fruits (34.81). The increase in yield was due to the performance of all crop growth and yield attributing characters due to better availability of soil moisture environment and availability of plant nutrients throughout the crop growth period under drip fertigation system. Shedeed et al. (2009) reported that increase in fruit yield per plant could be related to significantly higher number of fruits per plant in drip irrigation (14.5) over furrow irrigation (12.4) and in 100% NPK fertigation (16.8) over drip irrigation.

Regarding the fruit weight (Table 5) there is no significant difference between irrigation methods. But fertigation have prominent effect on the fruit weight. Application of RDF through drip fertigation (I_1F_7) recorded highest fruit weight (89.52 g) and this was at par with combined application of Humic acid and Fulvic acid (F_5) (82.81 g). It may be due to the biostimulant effects of humic substances (HS), characterized by both structural and physiological changes in roots and shoots related to nutrient uptake, assimilation and distribution (Canellas et al. 2015). The interaction between the irrigation methods and fertigation methods was not prominent.

The data on the yield of fresh fruits of tomato are furnished in Table 6. Both irrigation methods and fertilization had profused influence on yield of fresh fruits of tomato. Among the methods of irrigation, drip irrigation (32,432 kg ha^{-1}) showed profused superiority over the conventional irrigation (27,680

Table 4. Number of fruits per plant of tomato in response to fertilization and irrigation methods.

Treatments	Pooled mean		
	I_1 Drip	I_2 Conventional	Mean
F_1 -Humic acid 3 kg ha^{-1}	20.30	18.51	19.40
F_2 -Fulvic acid 3 kg ha^{-1}	18.25	17.52	17.89
F_3 -Vermiwash 5%	15.28	12.47	13.88
F_4 -Jeevamiritham 5%	15.55	15.70	15.62
F_5 -Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}	29.55	26.18	27.87
F_6 -Vermiwash 5% + Jeevamiritham 5%	24.94	23.87	24.40
F_7 - Inorganic fertilizers	34.81	27.12	30.97
Mean	22.67	20.20	
	I	F	I × F
SEd	0.593	1.109	1.568
CD (0.05)	1.203	2.251	3.183

Table 5. Fruit weight (g) of tomato in response to fertilization and irrigation methods.

Treatments	Pooled mean		
	I_1 Drip	I_2 Conventional	Mean
F_1 -Humic acid 3 kg ha^{-1}	63.95	59.54	61.74
F_2 -Fulvic acid 3 kg ha^{-1}	68.29	59.70	63.99
F_3 -Vermiwash 5%	56.03	53.94	54.99
F_4 -Jeevamiritham 5%	58.31	48.32	53.31
F_5 -Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}	81.80	83.83	82.81
F_6 -Vermiwash 5% + Jeevamiritham 5%	76.77	68.90	72.84
F_7 -Inorganic fertilizers	86.47	92.57	89.52
Mean	70.23	66.69	
	I	F	I × F
SEd	2.288	4.281	6.055
CD (0.05)	NS	8.691	NS

Table 6. Yield (kg ha^{-1}) of tomato in response to fertilization and irrigation methods.

Treatments	Pooled mean I_1 Drip	I_2 Conventional	Mean
F_1 -Humic acid 3 kg ha^{-1}	25456	21508	23482
F_2 -Fulvic acid 3 kg ha^{-1}	23462	20069	21765
F_3 -Vermiwash 5%	16361	12571	14466
F_4 -Jeevamiritham 5%	17589	14678	16134
F_5 -Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}	47011	42772	44891
F_6 -Vermiwash 5% + Jeevamiritham 5%	37461	32595	35028
F_7 - Inorganic fertilizers	59683	49565	54624
Mean	32432	27680	
	I	F	I × F
SEd	1283.65	2401.50	3396.23
CD (0.05)	2605.82	4875.05	NS

kg ha^{-1}). In the case of fertilization methods, yield of tomato were comparable among each other I_1F_7 (59,683 kg ha^{-1}) and I_2F_7 (49,565 kg ha^{-1}). Application of inorganic fertilizers recorded significantly the highest fruit yield (54,624 kg ha^{-1}). It is obvious that higher number of fruits, fruit weight as reported earlier caused higher yield in tomato plants. Among the organic fertilization treatments, combined application of HS (Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha $^{-1}$) registered superiority in the fruit yield (44,891 kg ha^{-1}). Vaccaro et al. (2009) demonstrated that the hydrophilic fraction of HS isolated stimulated nitrate reductase (NR), nitrite reductase (NiR), glutamine synthetase (GS), glutamate synthase (GOGAT) and aspartate aminotransferase (AspAT), enzymes that are linked to nitrogen uptake and assimilation; the same fraction affected nitrogen use efficiency. The increase in yield might be due to the increased nitrogen uptake and assimilation by the effect of HS. There was no interaction between the irrigation methods with fertilization.

The effect of treatment on quality characteristics of tomaco fruits were summarized in Table 7—9. In general TSS is an important quality factor which influences the palatability and acceptability of fruits. It was influenced both due to irrigation methods and fertilization but not in their interaction. Among the irrigation methods, drip irrigation treatment showed superiority over conventional irrigation. In the case of fertilization, the application of Humic acid 3 kg

Table 7. TSS (°Brix) of tomato in response to fertilization and irrigation methods.

Treatments	Pooled mean I_1 Drip	I_2 Conventional	Mean
F_1 -Humic acid 3 kg ha^{-1}	5.27	4.89	5.08
F_2 -Fulvic acid 3 kg ha^{-1}	5.19	4.75	4.97
F_3 -Vermiwash 5%	4.55	4.38	4.46
F_4 - Jeevamiritham 5%	4.89	4.66	4.77
F_5 - Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}	5.45	5.31	5.38
F_6 -Vermiwash 5% + Jeevamiritham 5%	5.18	4.65	4.91
F_7 - Inorganic fertilizers	4.21	4.07	4.14
Mean	4.96	4.67	
	I	F	I × F
SEd	0.070	0.132	0.186
CD (0.05)	0.143	0.268	NS

ha^{-1} with Fulvic acid 3 kg ha^{-1}, recorded potential impact on the TSS over all the treatments (5.38 °Brix). Whereas in the inorganic fertilization it was only 4.14 °Brix. This was in agreement with the findings of Pieper and Barrete (2009).

With respect to the quality parameter of TA there was significant impact only due to the fertilization and not in irrigation methods and in the interaction. The highest TA was observed in inorganic fertilization (0.75%) but it was comparable with individual and combined application of Humic acid 3 kg ha^{-1} and Fulvic acid 3 kg ha^{-1}.

Table 8. TA (%) of tomato in response to fertilization and irrigation methods.

Treatments	Pooled mean I_1 Drip	I_2 Conventional	Mean
F_1 -Humic acid 3 kg ha^{-1}	0.68	0.72	0.70
F_2 -Fulvic acid 3 kg ha^{-1}	0.68	0.77	0.72
F_3 -Vermiwash 5%	0.57	0.67	0.62
F_4 -Jeevamiritham 5%	0.65	0.65	0.65
F_5 -Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}	0.67	0.75	0.71
F_6 -Vermiwash 5% + Jeevamiritham 5%	0.69	0.60	0.64
F_7 -Inorganic fertilizers	0.75	0.74	0.75
Mean	0.67	0.70	
	I	F	I × F
SEd	0.022	0.041	0.058
CD (0.05)	NS	0.083	NS

Table 9. AA (mg 100 ml^{-1}) of tomato in response to fertilization and irrigation methods.

Treatments	Pooled mean I_1 Drip	I_2 Conventional	Mean
F_1 -Humic acid 3 kg ha^{-1}	30.19	28.41	29.30
F_2 -Fulvic acid 3 kg ha^{-1}	28.15	21.03	24.59
F_3 - Vermiwash 5%	18.14	16.31	17.23
F_4 - Jeevamiritham 5%	25.24	18.19	21.71
F_5 -Humic acid 3 kg ha^{-1} + Fulvic acid 3 kg ha^{-1}	34.64	29.87	32.26
F_6 -Vermiwash 5% + Jeevamiritham 5%	22.54	22.25	22.40
F_7 - Inorganic fertilizers	20.63	21.05	20.84
Mean	25.65	22.44	
	I	F	I × F
SEd	0.708	1.324	1.873
CD (0.05)	1.437	2.689	3.802

In the case of AA, both the factors of irrigation methods and fertilization as well as their interaction showed significance. Among the irrigation, drip remarkably increased AA (25.65 mg 100 ml^{-1}) over the conventional (22.44 mg 100 ml^{-1}). Fertigation of Humic acid 3 kg ha^{-1} in combination with Fulvic acid 3 kg ha^{-1} improved AA content significantly (32.26 mg 100 ml^{-1}) over all the fertilization methods. In the interaction also the drip irrigation with combined application of Humic acid 3 kg ha^{-1} and Fulvic acid 3 kg ha^{-1} registered the superiority (34.64 mg 100 ml^{-1}) over the rest of the treatments. Similar results were reported by Selim et al. (2010) who showed that HS application through drip irrigation system enhance the yield quantity of potato tubers under Egyptian sandy soil conditions. Osman and Ewees (2008) reported that positively significant differences in quality paramters (TSS and AA content) as affected by amended saline irrigation water with Humic acid at the applied rates added through the drip irrigation system.

To conclude, drip irrigation with organic fertilizers increase the yield but not to the quality of TSS and AA. Whereas drip irrigation with combined fertilization of Humic acid 3 kg ha^{-1} and Fulvic acid 3 kg ha^{-1} improved the yield as well as the quality.

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