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Full Research Article

Effect of Different Levels of Irrigation and Nutrient Management Practices on the Performance of Tomato (*Lycopersicon esculentum* L.)

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Abstract

To study the effect of different levels of irrigation and nutrient management practices on yield and water use efficiency of tomato (cv. Utkal Kumari) a field experiment, with three irrigation schedules and four nutrient management practices, was conducted in the Regional Research Technology and Transfer Station (RRTTS),Chiplima, Sambalpur for three years. Three years pooled mean of tomato fruit yield indicated that highest fruit yield of 18.48 t ha^{-1} was observed with IW:CPE of 1.2 irrespective of different nutrient management practices. Highest pooled mean fruit yield of 19.07 t ha^{-1} was recorded with application of 25% organic+75% inorganic which was significantly superior to 50% organic+50% inorganic (18.26 t ha^{-1}), 100% organic (16.01 t ha^{-1}) and 100% inorganic (17.21 t ha^{-1}) irrespective of different irrigation levels. Highest mean water use efficiencies of 533.45 kg ha^{-1} cm^{-1} and 469.47 kg ha^{-1} cm^{-1} were observed with IW:CPE of 0.8 and application of 25% organic+75% inorganic fertilizer respectively. Among the irrigation treatments highest net return (₹ 56,136/-) and benefit-cost ratio (2.03) were observed with 1.2 IW:CPE, whereas the highest net return (₹ 61,560/-) and benefit-cost ratio (2.16) were observed with 25% organic+75% inorganic fertilzer . Thus, integrated use of 25% organic along with 75% inorganic fertilizer as per recommended dose of nutrient with an irrigation scheduling at 1.2 IW:CPE produced highest fruit yield of tomato as compared to other treatments. The fruit yield per hectare was significantly correlated to all other yield attributing parameters except days to first harvest.

1. Introduction

Tomato (*Lycopersicon esculentum* Mill) is one of the most popular vegetable crop grown in almost all parts of India due to its wider adaptability to various agro climatic conditions. It is one of the most important vegetable crops of India as well as Odisha in respects to its production and cultivated area. Application of required dose of fertilizer and water increase the yield and quality of tomato. Improper irrigation management practices not only waste scarce and expensive water resources but also decrease crop yield (Tiwari et al., 1998). Similarly fertilizers played a key role in increasing crop productivity and quality .The practice of indiscriminate and continious use of inorganic fertilizers affected the soil health and soil microbial activity. Thus, application of farmyard manure (FYM) increased the total microbial population in the soil (Senapati et al., 2011). The integrated nutrient use of organic and inorganic fertilizers has assumed great significance in recent years. Vermicompost is a stable organic manure, which can be applied alone or in combination with organic and inorganic fertilizer for better yield and quality product of different crops (Arancon et al., 2006 and Jack et al., 2011). Being a heavy feeder it can removed 80 kg nitrogen, 20 kg phosphorus and 130 kg potassium for 37 tonnes of fruit production (Premnath et al., 2008). Tomato is an exhaustive crop which responded well to higher amount of organic and inorganic fertilizers. The integrated use of biofertilizers and recommended dose of fertilizers had positive effect on stability and sustainability of crop production of tomato (Chaurasia et al., 2001) and Gajbhiye et al., 2003). Information relating to interaction effect of organic as well as inorganic fertilizer along with irrigation levels are scarce on tomato .Therefore, an experiment was conducted to study the effect of irrigation along with both organic and inorganic fertilizers on yield and water use efficiency in tomato.

2. Materials and Methods

An experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Sambalpur in the year 2009, 2010 and 2011 during the *rabi* season. The latitude, longitude and altitude of the study area are 20°21′N, 80°55′E and 178.8 m above mean sea level, respectively. The soil of the experimental field was sandy loam with acidic in reaction (pH 5.5), organic carbon content was 0.43% and available N, P and K content was 227, 11.0 and 158 kg ha^{-1}, respectively. The percentage of nitrogen, phosphorus and potassium of FYM (0.53, 0.30 and 0.63), neem cake (4.8,1.0 and 1.5) and vermicompost (1.2,0.4 and 0.6), respectively. The moisture content at field capacity and permanent wilting point was 19.4 and 8.4%, respectively. Sixteen treatments comprised of four irrigation levels (IW:CPE=0.8; IW:CPE=1.0; IW:CPE=1.2; IW:CPE=1.4) as the main plots and four levels of nutrients (N_1:100% organic (FYM 12.5 t ha^{-1}+Vermicompost 2.5 t ha^{-1}+Neem cake 500 kg ha^{-1}) ; N_2:100% inorganic (RD-120:50:100 of N:P_2O_5:K_2O); N_3:25% organic+75% inorganic; N_4:50% organic+50% inorganic as sub-plots in split plot design with four replications. The irrigation water of 5 cm was applied when cumulative pan evaporation reached 62.5, 50, 41.6 and 35.7 mm for IW:CPE of 0.8, 1.0, 1.2 and 1.4, respectively. The total rainfall during the crop growth period were 7.2 mm, 27.8 mm and 65.5 mm received in 1,3 and 9 rainy days during 2009, 2010 and 2011 respectively. Tomato cv. BT-10 (Utkal kumari) was treated with vitavax (2 g kg^{-1} seed) sown in nursery on 1st week of November. and twenty eight days old healthy seedling were transplanted in the main field at a spacing of 60×45 cm^2 in each year. The FYM was applied at the time of land preparation where as full dose of phosphorus and potassium along with half dose of nitrogen were applied at the time of transplanting as per treatment plan. Rest nitrogen was top dressed after fourty days of transplanting. Recommended cultural practices were followed during experiment. At the initial stage of crop, first two light common irrigation were applied for proper establishment of the plants. The volume of irrigation water in each plot was calculated by multiplying the depth of irrigation and area of the plot. Irrigations were given as per treatments when CPE reached at required level and measured quantity of irrigation water was applied with the help of 90^0 V-notch. Ten plants were selected randomly from each net plot area for taking observations on growth and yield components. Fruit yield was calculated on the net plot basis. Water requirement (WR) was calculated by adding effective rainfall during crop growth period, amount of irrigation water applied and soil profile contribution. Water use efficiency (WUE) was calculated by dividing fruit yield (kg ha^{-1}) with the total water requirement (cm) of the crop. Economics for different treatment was calculated on the basis of prevailing market price of the produce and inputs used in the experiment. The recorded data for various parameters were statistically analyzed (Panse and Sukhatme, 1978).

3. Results and Discussion

3.1. Yield attributing arameters

Effect of irrigation scheduling irrespective of nutrient management on yield attributing parameters of tomato was presented in Table 1. Maximum plant height (43.28 cm) and days to first harvest (74.58 days)were recorded with IW:CPE of 1.4 , which was at par with IW:CPE of 1.2. But it was significantly superior to that of other irrigation levels. Maximum number of branches $plant^{-1}$ (12.17) was recorded with IW:CPE of 1.4, which was at par with that observed with IW:CPE of 1.2 and 1.0 but significantly superior to the value observed with IW:CPE of 0.8 irrigation levels. Maximum leaves $plant^{-1}$ (67.25) , retention of fruit $plant^{-1}$ (24.83), average fruit weight (37.83) and fruit yield $plant^{-1}$ (0.981 kg) were recorded with IW:CPE of 1.2, which was significantly superior to all other irrigation levels.

Effect of nutrient management on the yield attributing parameters of tomato for three years irrespective of irrigation levels was presented in Table 1. The poled mean of all three years showed that the yield attributing parameters were positively influenced by the nutrient management practices (Table 1). Application of 25% organic+75% inorganic fertilizer was recorded maximum plant height (43.35 cm) and leaves $plant^{-1}$ (65.10) which was significantly superior to 100% organic and 100% inorganic applied plot. But it was statistically at par with the fruit yield due to application of 50% organic+50% inorganic. The maximum number of branches $plant^{-1}$, average weight of fruit and fruit yield $plant^{-1}$ (0.862 kg) were recorded due to the application of 25% organic+75% inorganic which was significantly superior to that of 100% organic only but the value was at par with 50% organic+50% inorganic as well as 100% inorganic fertilizer. Highest fruit retention $plant^{-1}$ was recorded due to the application of 25% organic+75% inorganic which was significantly superior to all other nutrient management practices, wheras maximum days required to first harvest was observed with 100% inorganic fertilizer which was significantly superior to all other nutrient management practices,

3.2. Fruit yield

The pooled mean fruit yield of tomato in all three years (Table 1) was statistically significant due to imposition of different irrigation treatments. The pooled mean value indicated that, highest fruit yield was obtained at IW:CPE of 1.2 (18.48 t ha^{-1}) which was significantly superior to IW:CPE of 1.4 (17.50 t ha^{-1}) ,IW:CPE of 1.0 (17.38 t ha^{-1}) and IW:CPE of 0.8 (17.20 t ha^{-1}). The irrigation scheduled at IW:CPE of 1.4, 1.0 and 0.8 were

not differed significantly from each other. The crop receiving of irrigation scheduled at IW:CPE of 1.2 increased the grain yield over IW:CPE of 1.4, IW:CPE of 1.0 and IW:CPE of 0.8 by 5.60, 6.33 and 7.44% ,respectively.The better performance of tomato crop under IW:CPE of 1.2 might be due to the favorable soil water environment in the rhizosphere, which indirectly helped the plants for efficient utilization of water as well as nutrients. This result confirms the result of Chatterjee and Mallick (2008).They reported that wetter moisture regimes (IW:CPE of 1.2) increased the fruit yield of tomato by 12.39 and 26.89% over drier moisture regimes at IW:CPE of 1.0 and IW:CPE of 0.8, respectively.

The pooled mean fruit yield of tomato for all three years indicated was statistically significant due to imposition of nutrient management practices.The maximum fruit yield of 19.07 t ha^{-1} was obtained due to the application of 25% organic+75% inorganic, but it was significantly superior to that of 50% organic+50% inorganic (18.26 t ha^{-1}), 100% inorganic (17.21 t ha^{-1}) and 100% organic (16.01 t ha^{-1}). All the nutrient management practices differed significantly from each other. The increase in grain yield owing to application of 25% organic+75% inorganic over 50% organic+50% inorganic, 100% inorganic and 100% organic were 4.43, 10.80 and 19.05%, respectively. This confirms the significance of conjunctive use of organic and inorganic fertilizers than that of individual one. This effect might be due to more availability of different plant nutrients because of the activity of microorganisms present in FYM. This result corroborates the findings of Kumaran et al. (1998) where they observed higher fruit yield of tomato by the application of NPK with FYM and vermin compost. Bahadur et al. (2004) also reported that application of organic manures combined with recommended dose of inorganic fertilizers showed superior performance in tomato. Kumar and Sharma (2004) reported that application of organic manures with NPK were found best in obtaining higher values for yield and available macronutrients (NPK) in both tomato *(Lycopersicon esculentum)* and carrot. Chatterjee and Bandhyopadhyay (2014) reported that application of four tonnes vermicompost per hectare supplemented with 75% recommended inorganic fertilizer inoculated with Azophos resulted maximum uptake of macronutrients and subsequently helped for achieving higher yield of tomato with sustainable soil health.The interaction effect of both irrigation schedules and nutrient management practices on fruit yield from the three years pooled mean was not statistically significant. However, irrigation schedule at IW:CPE of 1.2 and nutrient management of 25% organic+75% inorganic produced highest fruit yield among different interaction.

3.3. Seed yield and its attributes

Effect of irrigation scheduling irrespective of nutrient management on seed yield attributing parameters as well as

Table 1: Effect of different irrigation levels and nutrient management practices on growth and yield attributing characters in tomato crop (pooled mean of 3 years)

Treatments	Plant height (cm)	Branches $plant^{-1}$	Leaves $plant^{-1}$	Days to first harvest (days)	Fruit retention $plant^{-1}$	Average fruit weight (g)	Fruit yield $plant^{-1}$ (kg)	Fruit Yield (t ha^{-1})	Seed recovery (%)	100 seed weight (g)	Seed yield $plant^{-1}$ (g)	Seed yield (kg ha^{-1})
Effect of irrigation schedules												
IW:CPE=0.8	35.65	9.33	58.45	71.66	17.33	32.41	0.586	17.20	0.41	0.272	2.40	70.00
IW:CPE=1.0	40.18	11.58	61.85	73.08	21.00	34.4	0.707	17.38	0.43	0.291	3.04	73.78
IW:CPE=1.2	43.08	12.08	67.25	73.25	24.83	37.83	0.918	18.48	0.47	0.330	4.33	83.70
IW:CPE=1.4	43.28	12.17	63.79	74.58	22.67	35.33	0.807	17.50	0.45	0.313	3.61	80.90
SEm±	0.87	0.39	0.71	0.40	0.59	0.64	0.020	0.21	0.005	0.007	0.11	2.29
CD (*p*=0.05)	3.02	1.34	2.28	1.41	2.04	2.20	0.063	0.62	0.02	0.023	0.34	7.32
Effect of nutrient management												
N_1:100% organic	36.83	9.41	59.88	70.50	19.08	31.85	0.653	16.01	0.42	0.286	2.75	65.00
N_2:100% inorganic	40.18	11.50	62.71	75.25	21.04	35.16	0.743	17.21	0.43	0.299	3.30	75.47
N_3:25% organic+ 75% inorganic	43.35	12.50	65.10	73.75	24.60	37.41	0.862	19.07	0.46	0.314	3.96	87.34
N_4:50% organic+ 50% inorganic	41.85	11.75	63.65	72.83	21.08	35.56	0.761	18.26	0.45	0.305	3.43	80.66
SEm±	0.90	0.40	1.00	0.31	0.81	1.12	0.016	0.14	0.007	0.006	0.09	2.03
CD (*p*=0.05)	2.63	1.18	2.89	0.91	2.37	3.29	0.045	0.38	0.02	0.016	0.25	5.83

seed yield of tomato were presented in Table 1. Irrigation regimes with IW:CPE of 1.2 were recorded maximum seed recovery percent (0.47),100 seed weight (0.330 g) and seed yield (83.70 kg ha^{-1}) were recorded with IW:CPE of 1.2. It was at par with IW:CPE of 1.4. and significantly superior to that of other irrigation levels .But in seed yield plant^{-1} (4.33 g) was maximum recorded with IW:CPE of 1.2 which was significantly superior to that of other irrigation levels.

The results showed that the seed yield attributing parameters as well as seed yield were positively influenced by the nutrient management practices (Table 2). Application of 25% organic+75% inorganic fertilizer was recorded seed recovery percent (0.46) ,100 seed weight (0.314 g), seed yield plant^{-1} (3.96 g) and seed yield (87.34 kg ha^{-1}. The value of seed recovery percent (0.46) and 100 seed weight (0.314 g) owing to application of 25% organic+75% inorganic fertilizer was significantly superior to 100% organic and 100% inorganic applied plot. But it was statistically at par with the fruit yield due to application of 50% organic+50% inorganic. Whereas seed yield plant^{-1} (3.96 g) and seed yield (87.34 kg ha^{-1}were recorded due to the application of 25% organic+75% inorganic which was significantly superior to that of 100% organic only, 50% organic+50% inorganic as well as 100% inorganic fertilizer.

3.4. Water requirement and water use efficiency

Water requirement and water use efficiency for different treatments were presented in Table 2. Irrespective nutrient management practices, highest water requirement of 46.82 cm was observed with IW:CPE of 1.4 where as lowest value of 32.24 cm was observed with IW:CPE of 0.8 among different irrigation levels. Water requirement irrespective of irrigation levels was highest with 100% inorganic (42.43 cm) and lowest under 100% iorganic (39.52 cm) among different nutrient management practices. The treatment that received irrigation at IW:CPE of 0.8 registered a highest mean water use efficiency of 533.45 kg ha-cm^{-1} and return per cm water use (₹ 1,549/), where as lowest value of 373.77 kg ha-cm^{-1} and (₹ 1,075/-) were observed irrigation at IW:CPE of 1.4 Irrespective of

Table 2: Effect of different irrigation levels and nutrient management practices on yield, water requirement, water use efficiency and economics in tomato crop (average mean of 3 years)

Treatments	Water requirement (cm)	Water use efficiency (kg ha-cm^{-1})	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio	Return cm water use^{-1} (₹)
Effect of irrigation schedules							
IW:CPE=0.8	32.24	533.45	53,260	1,03,200	49,940	1.93	1549
IW:CPE=1.0	36.20	480.11	53,920	1,04,280	50,630	1.94	1398
IW:CPE=1.2	41.73	442.84	54,744	1,10,880	56,136	2.03	1345
IW:CPE=1.4	46.82	373.77	54,640	1,05,000	50,360	1.92	1075
Effect of nutrient management							
N_1:100% organic	39.52	405.11	48,880	90,060	41,260	1.75	1044
N_2:100% inorganic	42.43	405.60	50,560	1,03,260	52,700	2.04	1242
N_3:25% organic+75% inorganic	40.62	469.47	52,860	1,14,420	61,560	2.16	1301
N_4:50% organic+50% inorganic	40.06	455.81	53,282	1,09,560	56,278	2.05	1404

Table 3: Coefficients of correlation among yield and yield attributing parameters of tomato

	Height of the plant (cm)	Branches plant^{-1}	Leaves plant^{-1}	Days to first harvest (days)	Fruit retention plant^{-1}	Mean fruit weight (g)	Fruit yield plant^{-1} (kg)	Mean fruit yield (t ha^{-1})
Height of the plant (cm)	1.000	0.972**	0.928**	0.692^{NS}	0.932**	0.915**	0.930**	0.766*
Branches plant^{-1}		1.000	0.881**	0.783*	0.894**	0.911**	0.872**	0.776*
Leaves plant^{-1}			1.000	0.572^{NS}	0.963**	0.963**	0.990**	0.774*
Days to first harvest (days)				1.000	0.576^{NS}	0.650^{NS}	0.567^{NS}	0.461^{NS}
Fruit retention plant^{-1}					1.000	0.942**	0.985**	0.762*
Average fruit weight (g)						1.000	0.952**	0.893**
Fruit yield plant^{-1} (kg)							1.000	0.760*
Mean fruit yield (t ha^{-1})								1.000

**Correlation is significant at 1% level; *Correlation is significant at 5% level; ^{NS} Non-significant correlation

irrigation levels, highest water use efficiency of 469.47 kg ha-cm^{-1} was observed with application of 25% organic+75% inorganic and lowest was with 100% organic (405.11 kg ha-cm^{-1}) .Whereas, highest return per cm water use of ₹ 1,044/- was observed with application of 50% organic+50% inorganic and lowest was with 100% organic (₹ 1,044/-) Similar findings obtained by Chatterjee and Mallick (2008) .They reported that IW:CPE of 1.2 irrigation regime produced and more crop water use than IW:CPE of 1.0 and IW:CPE of 0.8 irrigation regimes, respectively.

3.5. Economics

Among the irrigation treatments highest gross return, net return and benefit-cost ratio (₹ 1,10,880/-, ₹ 56,136/- and 2.03) were recorded at 1.2 IW:CPE. The lowest gross and net return was recorded with 0.8 IW:CPE whereas, the lowest benefit-cost ratio was found with 1.4 IW:CPE .The highest gross return,net return and benefit-cost ratio of ₹ 1,14,420/-, ₹ 61,560/- and 2.16 respectively were recorded (Table 3) with 25% organic+75% inorganic followed by 50% organic+50% inorganic and 100% inorganic and the lowest value was recorded with 100% organic (₹ 90,460/-, ₹ 41,260/-, 1.75).

3.6. Correlation analysis

The correlation among the yield attributing parameters and fruit yield of tomato were computed using the standard procedure (Gomez and Gomez, 1984) and are presented in Table 3. The positive correlation among yield and yield attributing characters in Table 4 indicate that none of the parameter affect adversely (negatively) to any of the parameters. Further, it is evident from the table that the days to first harvest is not significantly correlated to most of the other parameters. However, the mean fruit yield is significantly correlated to average fruit weight which in turn is highly correlated to other yield attributing characters except days to first harvest. This indicates that the fruit yield per hectare is significantly correlated to all other yield attributing parameters except days to first harvest.

4. Conclusion

Application of 25% RDF through organic matter along with 75% of RDF through inorganic fertilizer along with irrigation scheduling at 1.2 IW:CPE can produce significantly higher fruit yield of tomato with highest gross return, net return and B:C ratio. The highest mean water use efficiency was observed with irrigation scheduling at 0.8 IW:CPE and the application of 25% organic along with 75% inorganic fertilizer recorded higher water use efficiency.

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