Effect of lateral spacing on marketable yield and irrigation production efficiency on tomato crop

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Abstract

The experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar during the winter crop growing period in order to examine the effect of lateral spacing on marketable yield and irrigation production efficiency of tomato. The soil of the experimental field was fertile clay loam, (35.5% sand, 35.8% silt and 38.6% clay) with average bulk density of 1.31 g cm³. The moisture content at field capacity (-13 bar) and wilting point (-15 bar) was 1.95% and 9.1 % on an oven dry sight loss basis respectively. The plant available soil moisture was 136.2 mm/m. The experiment consist two lateral spacing viz. 0.5m for every row and 1.0 m for alternative rows. The lateral spacing of 0.5m gave higher marketable yield and irrigation production efficiency as compared with 1.0m lateral spacing.

Keywords: Lateral spacing, marketable yield, irrigation, production efficiency, tomato crop.

Paper cited: Rana, M. and Monu (2015). Effect of lateral spacing on marketable yield and irrigation production efficiency on tomato crop. *South Asian Journal of Food Technology and Environment*, 1(3&4): 266-273.

Received: 30/09/2015 Revised: 09/09/2015 Accepted 1/10/2015

Introduction

India is basically a semi-arid country with limited surface and sub-surface water source. Due to increasing population and rapid industrialization the demand of water is increasing considerably. For every growing population, water for Irrigation is becoming both search and expensive (Ayars *et al.*, 1995). Due to fast depletion of surface and sub-surface water resource, caused by over exploitation and erratic rain fall, it is therefore essential to formulate and adopt an efficient and reliable water application method and other techniques of crop production like lateral spacing etc. therefore efficient and economically variable irrigation water and other Input management strategies in order to irrigate more land area with existing water resources for crop production is required (Doss *et al.*, 1980). The use of irrigation methods or system that requires low labor and energy input has become more popular in recent year these conditions and readily

satisfied by means of drip (micro) irrigation system the means to deliver water to the soil in small and frequent quantities at a relatively low cost compared to other pressurized system therefore, water more efficient than in other irrigation methods. (Breslur, 1978).

In addition, economic and environment reasons increasing irrigation costs and decreasing sources of irrigation have encouraged farmer to use drip irrigation. Drip irrigation can apply water more precisely and uniformly, potentially reducing subsurface drainage controlling soil salinity and measuring yield. Drip irrigation is characterized by localized, frequent application of water and such regime restricts the fluctuations in soil water potential within a narrow range high maintains a favorable soil water regimes, leading to high yields (Breslur, 1977). In some cases the advantage of drip irrigation over other methods was related to a variety of factors such as, water logging and management deficiencies (Sammis, 1980).

Low soil permeability (Grimes *et al.*, 1976) and the different criteria followed to determine the amounts of applied water by the various irrigation methods.

Drip or trickle irrigation may be used to overcome these concerns (Bucks *et al.*, 1982). Irrigation volumes erosion and addition to ground water can be reduce with the more controlled water application that is characteristics of drip irrigation scheduling is defined as deeding when to irrigative and how much water to apply several types of irrigations scheduling as belonging to one of two broad soil water balance computations and soil crop monitoring technique (Farah *et al.*, 1997). The management of water resource in irrigation is a fundamental aspect for their sustainability (Hanson *et al.*, 1970). Optimal water management is essential in irrigated and region to sustain productivity conserve water resource and protect ground water quality (Imtiyaz *et al.*, 2000; Sivanappam *et al.*, 1987 and Wanjura, 1990).

Tomato is one of the important vegetable crop grown in India and is regarded as a cash crop. Researchers have shown that higher tomato yields are obtained by drip irrigation (Parihar, 1974). Tomato required warm weather and plenty of sunshine with proper irrigation for its best development, tomato of a variety or soil ranging from sandy

loam to heavy clay, soil with a pH of 6-7 is idea. Jadhav *et al.*, (1990) tested drip and furrow method for tomatoes. Tomatoes yield were 36 t/ha for drip irrigation systems and 32 t/ha when furrow irrigation was used. The total production of tomato crop in India is approximately 5.3 million tonnes in Uttar Pradesh. Tomato Crop occupies 36,682 ha producing about 1,14,200 tonnes annually. Productivity of tomato in UP is 2120 tonnes/ha.

Material and Methods

The field experiment was conducted during the winter crop growing period in order to examine the effect of variable irrigation on economic return of tomato. The climate in this part of country has been classified as semi-arid with cold winter and hot summer. The soil of the experimental field was fertile clay loam, (35.5% sand, 35.8% silt and 38.6% clay) with average bulk density of 1.31 g cm³. The climatic parameters during the crop growing periods are summarized in Table1. The moisture content at field capacity (-13 bar) and wilting point (-15 bar) was 1.95% and 9.1 % on an oven dry sight loss basis respectively. The plant available soil moisture was 136.2 mm/m.

Table 1: Climatic parameters during the crop growing period of 2011-2012.

Months	Mean wind velocity (km/hr)	Mean sunlight (hours)	Mean humidity (%)	Mean Max temp (°C)	Mean min temp (°C)	Mean evaporation (mm)
Nov.	7.1	1.97	71.18	26.4	9.1	2.29
Dec.	4.01	—	73.75	21.1	8.5	1.55
Jan.	4.70	—	71.14	18.3	8.4	1.75
Feb.	8.37	—	57.16	21.8	7.56	3.22
Mar.	8.74	—	44.94	26.2	9.3	5.18

The experiment was laid out in a two factor complete randomized block design with three replications. It comprises of 10 treatments with five water levels and two lateral spacing. The area of each experimental plot was 9 m². Tomatoes seed was shown on 24th November 2010 in the nursery at a depth of 0.05m with spacing of 10 cm between rows. The seed bed was irrigated regularly and converted with dry straw of 6 cm thickness and treated with gamaxene in order to facilitate good emergence. The seedlings were transplanted on 25th Dec 2010 at a spacing of 0.5m x 0.5m. A butter zone spacing of 0.5 m was provided between the plots. Before plotting experimental field of tomato it was well irrigated, properly ploughed well pulverized and leveled to provide good filth. Prior to transplanting, the experimental field of tomato received 66kg/ha N, 94.3kg/ ha P₂O₅ and 62 kg/ha K₂ O.

The experiment consisted of two lateral spacing. The details of the treatments are as follows:

Lateral Spacing

- LS₁ = 0.5m (laterals in every rows).
- LS₂ = 1.0 m (laterals in alternative rows).

Irrigation Levels

- I₁ Irrigation at 25% of pan evaporation replenishment
- I₂ Irrigation at 75% of pan evaporation replenishment
- I₃ Irrigation at 125% of pan evaporation replenishment
- I₄ Irrigation at 175% of pan evaporation replenishment
- I₅ Irrigation at 225% of pan evaporation replenishment

The layout of the experiment is presented in Fig.1. The daily evaporation data from USWB class A open pan for a

period of five year (2004-2009) were collected. Crop was irrigated when the sum of the daily mean (3 years) of pan evaporation reached approximately to a predetermined value of 16.3mm (rooting depth in m x plant available soil moisture in mm/m x readily available soil moisture in fraction).

Fig. 1: Schematic Layout of Field Experiment.

The irrigation water was pumped directly from borehole to the concrete tank. The irrigation water was lifted from the concrete tank with the help of electric motor to the drip irrigation system. Screen liter was installed on the main line to minimize dripper blockage. PVC pipes of 50mm and low density polyethylene (LDPE) pipes of 12mm diameter were used for sub main and lateral line respectively. The lateral line was laid to each crop rows as well as in alternative row. Plants of tomato were watered by 4 l/h non pressure compensated on line dippers. The space between dippers was 0.5 m. The sub main line was connected to a water meter and

a control valve in order to deliver the desired amount of water to the respective treatments.

In order to assess the economic viability of drip irrigation system under variable irrigation and lateral spacing, both fixed and operation costs were included. Total cost of production, gross return and net return under different irrigation levels was estimated on the following assumption,

Salvage value of the deponents	= 0
Useful life of tube well, pump, motor and pump house	= 25 years
Useful life of drip irrigation systems	= 8 years
Useful life of weeding and spraying equipment	= 7 years
Interest rate	= 12.5%
Repair & maintenance	= 2.5%
No. of Crops/year	= 2

The fixed cost including water development (tube well, pump, motor, pump house and irrigation system etc.). Poly vinyl chloride (PVC) and low density polyethylene (LDPE) pipe for main and laterals, filters, fertilizer units pressure gauges, water meter, drippers, spraying and weeding equipment and other accessories were calculated by the approach.

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where,

CRF = Capital Recovery factor
i = Interest rate, Fraction
N = Useful life of the components (year)

Annual fixed cost/ ha = CRF × fixed cost /ha

$$\frac{\text{Annual fixed cost/ ha/season} = \text{Annual fixed cost/ha}}{2}$$

The operating cost including labor (system installation, fertilizer /chemical application and harvesting etc.), land

preparation, seeds, fertilizer/chemical, water pumping were estimated. The gross return was calculated taking into consideration the marketable yield and current wholesale price of tomato. Subsequently the net return for tomato was calculated considering in total cost of producing and gross return.

Gross return = marketable yield (kg/ha) × market price of tomato (Rs./kg)

Net return (Rs/ha) = Gross return (Rs/ha) - Total cost of production (Rs/ha)

The benefit cost ratio B/C was calculated as follows:-

$$B/C = \frac{\text{Gross return (Rs/ha)}}{\text{Total cost of production (Rs/ha)}}$$

Total cost of production = fixed cost + operating cost.

Results and discussion

Yield and irrigation production efficiency

The effect of irrigation schedule and lateral spacing on marketable yield and irrigation production efficiency of tomato are shown in Table 2. The marketable yield of tomato under different irrigation level range from 28.19 t/ha. The marketable yield of tomato increased significantly with an increase in irrigation level up to 175% of pan evaporation replenishment. It produced highest marketable yield of 57.66 t/ha. A further increase in irrigation level up to 225% of pan evaporation replenishment reduced the marketable yield as 53.61 t/ha. This is due to the excessive vegetative growth and reduction in number of fruits or plants which resulted in loss of mean fruit weight induced by excessive soil moisture condition. Marketable yield of tomato for two lateral spacing are presented in Fig. 2. The seasonal water applied for different irrigation levels ranged from 98 mm to 882 mm whereas the marketable yield for LS₁ (0.5) and LS₂ (1.0) m lateral spacing 49.23 t/ha and 43.50 t/ha respectively.

The irrigation production efficiency decreased significantly with an increase in irrigation levels from 25% Ep to 225% Ep (Table 2). This is because of the ratio of seasonal water application and marketable fruit yield was high as compare with other irrigation levels their marketable yield. The irrigation at 25% of pan evaporation replenishment resulted in significantly maximum irrigation production efficiency of (28.81 kg/in³). The irrigation at 225% evaporation replenishment resulted at significantly minimum irrigation production efficiency (6.07kg/m³). Because it increased the seasonal water applied but at the same time decreased the marketable yield. Irrigation production efficiency of tomato for two lateral spacing is presented in Fig 3. The seasonal water applied for different irritation levels

ranged from 98 mm to 882 mm whereas the irrigation production efficiency for LS₁ (0.5) and LS₂ (1.0) m lateral spacing 14.22 kg/m³ and 12.74 kg/m³ respectively.

Irrigation production efficiency and lateral spacing relationship as 0.5m lateral spacing was more as compare to 1.0m lateral spacing. The overall results presented in Table1 clearly reveled that irrigation at 175% of an evaporation replenishment resulted in higher yield (57.66 t/ha) but irrigation production efficiency was higher at 25% of pan evaporation replenishments reported the higher marketable yield (28.81 kg/m³) and irrigation production efficiency at 175% of pan evaporation replenishment under agro climatic condition of northwestern.

Table.2. Effect of irrigation schedules and lateral spacing on marketable yield and irrigation production efficiency to tomato.

Treatment	Mean marketable Yield (t/ha)	Mean irrigation production efficiency (kg/m ³)
Pan evaporation Replenishment (%)		
25	28.19	28.81
75	44.77	15.19
125	47.60	9.70
175	57.66	8.38
225	53.61	6.07
LSD (0.05)	1.52	0.80
Lateral spacing		
0.5 m	49.23	14.22
1.0m	43.50	12.74
LSD (0.05)	0.96	0.50
Interaction		
LSD (0.05)	2.15	1.13

The seasonal water applied and marketable yield to tomato for 0.5 m (R =0.9546) and 1.0m (R² = 0.9436) lateral spacing exhibited a strong quadratic relationship. The marketable yield of tomato increased with an increase in seasonal water applied up to 685mm and 732 for 0.5 and 1.0m lateral spacing respectively and there after yield tended to decline (Fig. 2).

The relationship between pan evaporation replenishment and marketable yield of tomato for two lateral spacing are presented in Fig.3. The pan evaporation replenishment for different irrigation levels ranged from 25% to 225% whereas the marketable yield for 0.5m and 1.0 lateral spacing ranged from 30.27 t/ha to 61.05 t/ha and 26.12 t/ha to 54.27 t/ha respectively. The

pan evaporation replenishment and marketable yield to tomato for 0.5m ($R^2 = 0.9546$) and 1.0 m ($R^2 = 0.9436$) lateral spacing exhibited a strong quadratic relationship. The marketable yield of tomato increased with an increase in

pan evaporation replenishment up to 166% and 212% for 0.5m and 1.0m lateral spacing respectively and there after yield tended to decline.

Fig.2: Relationship between seasonal water applied and marketability yield of tomato

Fig.3: Relationship pan evaporation replenishment and market ability yield of tomato

The relationship between seasonal water applied and gross return of tomato for two lateral spacing are presented in Fig.2. The seasonal water applied for different irrigation levels ranged from 98 mm to 882 mm whereas the gross return for 0.5m and 1.0m lateral spacing ranged for Rs.151350/ha to Rs.3305250/ha and Rs.130600/ha to Rs.271350/ha respectively. The seasonal water

Conclusion

Irrigation at 0.5m lateral spacing and 175% of pan evaporation in replenishment resulted in significantly higher marketable yield of tomato, whereas irrigation production efficiency was higher with irrigation at 25% of pan evaporation replenishment. A further increase in irrigation level resulting from 225% of pan evaporation replenishment reduces both marketable yield and irrigation production efficiency. The lateral spacing of 0.5m gave higher marketable yield and irrigation production efficiency as compared with 1.0 m lateral spacing.

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