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INFLUENCE OF DRIP IRRIGATION AND NITROGEN FERTIGATION ON YIELD AND WATER PRODUCTIVITY OF GUAVA

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ABSTRACT

A field experiment was carried out during 2009-2010 to 2011- 2012 at the Gangetic alluvial soils of West Bengal, India to assess four irrigation schedules (surface irrigation at IW/CPE 1.0, drip irrigation at 60%, 80% and 100% of crop evapotranspiration) and three nitrogen fertigation levels (80%, 100% and 120% of recommended dose of N) on the yield and water productivity of guava (cv. *Psidium guajava* L). The results showed that fruit yield of guava increased consistently and significantly with increasing ETc and nitrogen fertilization. However, the highest fruit yield of 18.7 t/ha was obtained with drip irrigation at 100% ETc, whereas the lowest yield of 11.0 t/ha was recorded under drip irrigation at 60% ETc. Similarly, maximum fruit yield of 16.9 t/ha was registered at 100% of recommended dose of N. The interaction between irrigation schedules and N fertigation levels revealed that maximum fruit yield of 21.6 t/ha and water productivity of 17.8 kg/ha-mm was demonstrated under drip irrigation at 100% ETc with 120% of recommended dose of N. Alternatively, surface irrigation scheduled at IW/CPE 1.0 could also be used advantageously if the initial investment for laying the drip irrigation system is likely to be an impediment to the resource poor farmers for guava cultivation.

INTRODUCTION

Guava (*Psidium guajava* L.) is one of the leading fruit crops in India due to wide adaptability to varying soil and climatic conditions. In the Indo-Gangetic alluvial soils of West Bengal, the crop has immense potential in increasing productivity and yield sustainability. However, limited availability of irrigation water during the dry season is a major constraint in increasing area under guava cultivation. Even the unscientific water management practices coupled with lack of proper water saving technologies can lead to the reduction in crop yield. Judicious application of water and plant nutrients in guava is prerequisite to achieve the targeted yield and quality of fruits (Singh and Singh, 2007). Drip irrigation is undoubtedly the most efficient and advanced technology in India and offers a great promise due to its higher water and nutrient use efficiency by crops against lower amounts of water applied and avoids moisture stress throughout the growing period by providing available moisture at critical crop growth stages (Kumar *et al.*, 2005; Raina *et al.*, 2011). This system could invariably save about 40-70% of water and increase crop productivity by 10-55% depending upon soils and climatic conditions (Berad *et al.*, 1998; Deshmukh and Sen, 2000). The conventional nitrogen fertilization especially in light textured soils may cause huge losses of nitrogen through leaching, ammonia volatilization and denitrification. Drip fertigation (application of fertilizer with drip irrigation), on the other hand, has proved its superiority over conventional method of fertilizer application to ensuring the right amounts of irrigation water and plant nutrients available at the root zone and nourishes the crop requirements for stabilizing yield and quality of produce (Mohammad and Said, 2003; Prasad *et al.,* 2003; Patel and Rajput, 2004). Drip-fertigation also increases the nutrient use efficiency of crop by permitting timely application of fertilizers in small quantities in the vicinity of root zone matching with the plants' nutrient need, besides substantial saving in fertilizer usage and reducing nutrient losses ((Veeraputhiram *et al*., 2005; Kumar *et al*., 2007). The information on the feasibility of drip irrigation and nitrogen fertigation as compared to conventional surface irrigation and nitrogen fertilization on yield and water productivity of guava in this region is lacking. In this backdrop, it was thought worthwhile to develop an appropriate irrigation and nitrogen fertilizer schedules through drip fertigation vis-à-vis surface irrigation and nitrogen fertilization on the yield and water productivity of guava in the Gangetic alluvial soils of West Bengal.

MATERIALS AND METHODS

A field experiment was conducted during 2009-2010 to 2011-2012 at the Gangetic alluvial soils of West Bengal, India to assess the different drip irrigation schedules and nitrogen fertigation levels vis-à-vis surface irrigation and nitrogen fertilization on the yield and water productivity of guava (*Psidium guajava* L.). The site lies at 23^0 N latitudes and 89^0 E longitudes at an elevation of 9.75 m above mean sea level. The soil is sandy loam in texture (Fluvaquent) with pH 6.7, EC 0.37 dS/m and organic carbon 5.9 g/kg. The available N, P and K were 182.4, 18.9 and 135.6 kg/ha, respectively. The treatments consisted of four irrigation schedules (surface irrigation at IW/CPE 1.0, drip irrigation at 60, 80 and 100% ETc) and three N-fertigation schedules (80, 100 and 120% of recommended dose of nitrogen) was laid out in a split plot design with three replications. Healthy, vigorous and disease-free seedlings of guava (cv. Khaja) were planted on 23rd June 2007 with a spacing of 5 m x 5 m. Every plant received about 2 kg wood ash, 500 g bone meal and 15 kg farm yard manure during planting. The recommended doses of fertilizers per plant was 200 g N, 160 g P_2O_5 and 260 g K_2O applied in the form of urea, single superphosphate and muriate of potash, respectively. Phosphorus and potassium were applied in two equal splits broadcasted in mid-January and mid-August every year. Nitrogen as per treatment was applied through drip fertgation in 10 equal splits, whereas in surface irrigation, nitrogen was top-dressed in three equal splits. Crop was harvested in several pickings between July to November each year and data were added to calculate the total fruit yield.

In drip system, irrigation water was lifted by hand pump to a 200 L capacity over head tank installed at 3 m above the ground level. Nitrogen fertilizer was dissolved in the tank and applied through drip irrigation using the gravity flow. The volume of water required for crop was computed on daily basis following the equation as suggested by Vermeiren and Jobling (1980):

$$V = Ep \times Kp \times Kc \times Sc \times Wp$$

Where, V = Volume of water (cm^3/day/plant), E_p = open pan evaporation (mm/day), K_p = pan factor or pan coefficient, K_c = crop coefficient (0.8), S_c = crop spacing (cm x cm) and W_p = wetted area (1.0). The effective rainfall was calculated by balance sheet method from the actual rainfall received and was used for daily water requirement of crop. The crop factor values used for different crop stages were computed based on the existing relative humidity and wind velocity (Doorenbos *et al*., 1984). The pan factor value was 0.8 as suggested for USDA class A-Pan. The plot size for two plants was 50 m^2. Irrigation water was applied biweekly through drip system. Average depth of water applied through drip system at 60, 80 and 100% ETc was 432, 576 and 720 mm, respectively. The water application in surface irrigation scheduled at IW/CPE 1.0 with 50 mm depth was 850 mm. The water use efficiency was computed by dividing fruit yield of guava with total water used including effective rainfall, soil profile contribution and irrigation water. A separate lateral line (12 mm) was laid for each treatment. There were two drippers for each plant located at 30 cm distance on either side of plants each having a discharge of 2 lph.

RESULTS AND DISCUSSION

Fruit yield

The data depicted in figure 1 showed that drip irrigation at 100% ETc, irrespective of nitrogen levels, recorded significantly the higher fruit yield over surface irrigation and other drip irrigation schedules in all the years and their average values. Drip irrigation at 100% ETc, on an average, increased the fruit yield by 69.7, 16.9 and 9.0 % over drip irrigation at 60% ETc, 80% ETc and surface irrigation at IW/CPE 1.0, respectively. This variation in yields under surface and drip irrigation system was mainly due to the differences in wetting patterns, water distributions in soil and relative water use by crop. The results are in agreement with findings with Ramniwas *et al*. (2012) who observed maximum fruit yield of guava at 100% irrigation water through drip system. The increase in yield under drip irrigation might be ascribed to the better water utilization (Raina *et al.,* 1999), higher absorption and accumulation of nutrients by crop (Rumpel *et al*., 2003) and maintenance of excellent soil-water-air relationship with higher oxygen concentration in the root zone (Bangar and Chaudhary, 2004). Surface irrigation, on the contrary, resulted in considerable wastage of water and plant nutrients in deep percolation below root zone and set a chain of undesirable hazards such as poor soil aeration, water logging, imbalanced soil water-nutrient environment and weed infestation leading to the declined fruit yield (Raina *et al.,* 2011). Similarly, the fruit yield increased significantly with increase in levels of nitrogen in all the years. However, application of 100% recommended dose of N registered the highest fruit yield, which was at par with 120% of recommended dose of N, but inferior to 80% of recommended dose of N (Fig. 2). The interaction between irrigation schedule and nitrogen level on fruit yield was found to be significant (Table 2). However, drip irrigation at 100% ETc with 120% of recommended dose of N fertigation recorded maximum yield of 21.6 t/ha, but it was at par with drip irrigation at 100% ETc with 100% recommended dose of N fertigation (21.2 t/ha). This may be ascribed to the timely supply of water and nitrogen in the root zone matching with

Table 2: Interaction effects of irrigation schedules and nitrogen fertilization on fruit yield of guava (pooled over 3 years)

Treatments	Fruit yield (t/ha)			
	80% of RDN	100% of RDN	120% of RDN	Mean
Drip at 60% ETc	9.60	11.80	12.20	11.20
Drip at 80% ETc	14.90	16.70	17.10	16.23
Drip at 100% ETc	16.30	21.20	21.60	19.70
Surface irrigation	15.90	19.10	19.40	18.13
Mean	14.18	17.20	17.58	-
CD at 5%	I 1.7	N1.1	I × N 1.4	

Table 1: Effect of irrigation schedules on water use, water productivity and water saving by guava (pooled over 3 years)

Irrigation schedule	Profile water contribution (mm)	Effective rainfall (mm)	Irrigation water (mm)	Water use (mm)	Water productivity (kg/ha-mm)	Water saving (%)
Surface irrigation at IW/CPE 1.0	41.8	452.7	850	1344.5	12.7	-
Drip at 60% ETc	48.3	452.7	432	933.0	11.8	30.6
Drip at 80% ETc	45.6	452.7	576	1074.3	14.9	20.1
Drip at 100% ETc	42.7	452.7	720	1215.4	15.4	9.6

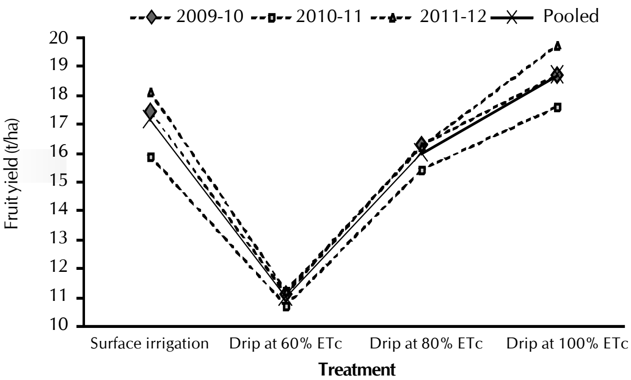

Figure 1: Effect of different irrigation schedules on fruit yield of guava

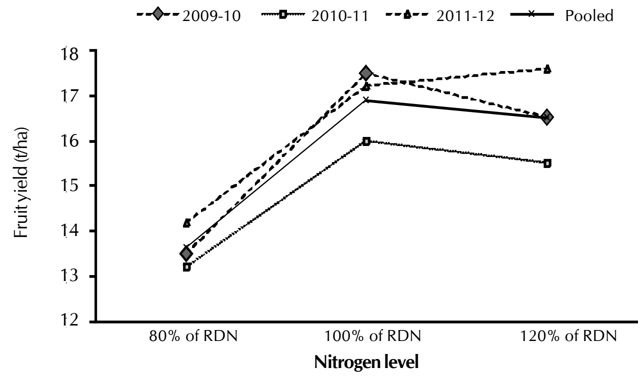

Figure 2: Effect of different nitrogen levels on fruit yield of guava

the water and nutrient demands of crop, which in turn promoted the fruit yield. These results corroborated to the findings of Singandhupe *et al*. (2003) and Mandal *et al*. (2007) who observed that split application of N through drip irrigation enhanced yield and nitrogen economy of crop.

Water productivity and water saving

During cropping season of 2009-2010 to 2011-2012, average values of effective rainfall, soil water contribution from profile and depth of irrigation water applied are given in Table 1. Drip irrigation at 100% ETc registered the highest water productivity of 15.4 kg/ha-mm with water saving of 9.6% as compared to surface irrigation which exhibited water productivity of 12.7 kg/ha-mm. The corresponding values of water productivity and water saving for drip irrigation at 80% ETc and 60% ETc were 14.9 kg/ha-mm and 20.1% and 11.8 kg/ha-mm and 30.6%, respectively. The lower water productivity, but higher water saving was observed at 60% ETc due to decreased fruit yield as a consequence of lower amount of water application through drip system. The interaction values showed that drip irrigation at 100% ETc with 120% of recommended dose of N fertigation recorded maximum water productivity of 17.8 kg/ha-mm. The relatively higher water productivity under drip irrigation as compared to surface irrigation was due to the higher water uptake by crop as a result of direct application of small amount of water in several splits into root zone without wetting the entire area and higher water distribution efficiencies in the soil profile (Bangar and Chaudhary, 2004).

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