EFFECT OF FERTIGATION SCHEDULING AND COST ECONOMICS IN THREE CULTIVARS OF GUAVA (*PSIDIUM GUAJAVA* L.) UNDER ULTRA HIGH DENSITY PLANTING IN CHHATTISGARH

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Abstract: Field experiment was carried out during the year 2014-15 in winter season at research field of Precision Farming Development Centre (PFDC) of Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) to study the effect of drip irrigation and fertigation scheduling on performance of three cultivar of guava (*Psidium guajava* L.) in ultra high density planting. The experiment was conducted with three varieties (Lalit, Allahabad Safeda and L-49) along with three levels of fertigation scheduling (60% RDF, 80% RDF and 100% RDF). The benefit-cost (B: C) ratio was evaluated. Benefit-cost analysis was carried out to determine the economic feasibility of using drip irrigation. The cost of drip irrigation system includes depreciation, prevailing bank interest rate, repair and maintenance of the system. The interest rate and repair and maintenance cost of the system were 12 and 1% per annum of the fixed cost respectively. The useful life of drip system was considered to be 10 years. The cost of cultivation includes expenses incurred in field preparation, cost of seedlings, fertilizer, weeding, crop protection measures, irrigation water and harvesting with labour charges. The B: C ratio was found maximum (2.78) in Lalit cultivar with (80% RDF).

Keywords: Fertigation, Guava, UHDP, B: C ratio

INTRODUCTION

Guava (*Psidium guajava* L.) is a very popular fruit in India and has been under cultivation in India since early 17th century. It belongs to family "Myrtaceae" and an important commercial fruit crop of tropical and sub-tropical region of India. It is known as "Apple of tropics" and rich in vitamin "C" and pectin content besides being a good source of other vitamins and minerals. Fruits are fair source of vitamin A (about 250 mg/100 g) and contain appreciable quantities of thiamine, niacin and riboflavin. The ascorbic acid content ranges from 75-260 mg/100 g, which varies with cultivar, season, location and stage of maturity. The fruit also contains considerable amount of calcium, phosphorus and iron. However, 80% of iron remain in the seed and is not utilizable. Moreover, guava fruits are rich source of pectin which ranges between 0.5 and 1.8% (Adsule and Kadam, 1995). The area under guava in India is 235.6 thousand ha and production is 3198.3 thousand metric tonnes with a productivity of 13.6 metric tonnes/ha. The highest area under guava cultivation is in Maharashtra (39.00 thousand ha). Madhya Pradesh is the leading state of guava production (801.00 thousand metric tonnes), as well as productivity (37.6 metric tonnes/ha). Whereas, in Chhattisgarh, the area of guava is 17119 ha and production is 140908 metric tonnes (Anonymous, 2013). Fruit production is undergoing a change where emphasis is being given to higher production per unit area. High density planting or meadow orchard system is the fastest way of reducing the gestation period and simultaneously increasing the productivity of the orchards. Accommodation of the maximum number of precocious plants per unit area to get the maximum profit per unit of the tree volume without impairing the soil fertility status is called the high density planting. The meadow orchard is a modern method of fruit cultivation using small or dwarf tree with modified canopy. Better light distribution within tree canopy increases the number of well illuminated leaves. Drip irrigation proved efficiently in providing irrigation water and nutrients to the roots of plants, while, maintaining high yield production. Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of the impact sprinkler, which replaced flood irrigation. This is because high water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface runoff, as well as minimal deep percolation. Moreover, a drip irrigation system can easily be used for fertigation, through which crop nutrient requirements can be met accurately. Due to the way the water is applied in a drip system, traditional surface applications of timed-release fertilizer are sometimes ineffective, so drip systems often mix liquid fertilizer with the irrigation water. Basin irrigation is the conventional method widely used to irrigate most of the fruit crops grown in Rajasthan state of India. However, this method uses more water compared to other high tech water saving irrigation methods such as sprinkler, drip etc. Many researchers have reported the higher application efficiency of drip irrigation systems over the conventional basin irrigation systems (Salvin *et al.,* 2000; Bharambe *et al.,* 2001; Agrawal and

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Agrawal, 2007) compared to drip and basin irrigation systems in fruits and found that there was savings of 40-60% more irrigation water than basin irrigation methods. Singh *et al.* (2006) reported that irrigation requirement met through drip irrigation along with polythene mulch gave the highest yield of guava (37.70 t/ha) with 164% greater yield as compared to ring basin irrigation. Fertigation enables adequate supplies of water and nutrients with precise timing and uniform distribution to meet the crop nutrient demand. Further, fertigation ensures substantial saving in fertilizer usage and reduces leaching losses (Kumar *et al.,* 2007). Similar to frequent application of water, optimum split applications of fertilizer improves quality and quantity of crop yield than the conventional practice.

MATERIAL AND METHOD

A Field experiment was carried out during the year 2014-15 in winter season at research field of Precision Farming Development Centre (PFDC), Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Raipur is situated in the central part of Chhattisgarh at latitude 21.16 ^{0}N and longitude 81.36 ^{0}E at an altitude of 289.56 meters above the mean sea level. Raipur comes under dry, sub-humid agro-climatic region. The source of rainfall is South-West monsoon. It receives an average annual rainfall of 1200-1400 mm, most of which (about 85%) is received from third week of June to mid September and very little (rest of 15%) during October to February. May is the hottest and December is the coolest month of the year. The pattern of rainfall, particularly during June to September months has a great variation from year to year. The maximum temperature goes as high as 46 ℃ during summer and minimum as below as 6 ℃ during winter months. The atmospheric humidity is high from June to October. The Meteorological data *viz.*, temperature, sunshine hours, relative humidity, wind velocity and evaporation. The weekly maximum and minimum temperature was 34.4 ℃ and 8.6 ℃, respectively. The maximum temperature during the experimentation varied between 28.3 ℃ to 33.4 ℃ from September 2014 to December 2014 whereas, minimum temperature varied between 8.3 ℃ to 25.1 ℃. The total rainfall during the period of experimentation was 236.4 mm, relative humidity throughout the crop season varied between 27-95%. The average maximum relative humidity for different months varied from 84-95%, while, monthly average minimum relative humidity varied between 27-83%. The average values of open pan evaporation ranged from 1.7-4.1 mm/day, whereas average sunshine values varied from 0.5-9.0 hrs/day, maximum wind velocity during crop period was 6.9 km/hrs and minimum was recorded 1.9 km/hrs.
The experimental plots were irrigated by using drip irrigation system as per water requirement of the crop. Crop water requirement was calculated daily with the help of meteorological data recorded by meteorological observatory of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The plants were irrigated daily by drip irrigation systems. The irrigation water requirement was estimated and irrigation schedule was developed by various methods. However, the most commonly adopted method was Pan "A" evaporation method where the daily water requirement was calculated using the formula:
Daily water requirement = A x B x C x D x E litre/day/plant
Where,
A = Pan evaporation
B = Pan factor
C = Crop factor
D = Per cent wetted area
E = Spacing between row to row and plant to plant
The water requirement of the crop was computed on daily basis by using the following equation as suggested by Shukla *et al.*, (2001). V = Ep.Kp.Kc.Sp.Sr.Wp Where, V = Volume of water required (litre / day / plant) Ep = Pan evaporation as measured by Class-A pan evaporimeter (mm /day) Kc = Crop co-efficient (co-efficient depends on crop growth stage) Kp = Pan co-efficient Sp = Plant to plant spacing (m) Sr = Row to row spacing (m) Wp = Fractional wetted area, which varies with different growth stage (0.3 to 1.0) The values of pan coefficient and crop coefficients were taken from (Doorenbos and Pruitt, 1977). The water requirement of guava crop was estimated on daily basis for all months considered under study. Daily time to operate drip irrigation system was worked out taking the application rate per plant. Drip system was scheduled on alternate days; hence total quantity of water delivered was cumulative water requirement of two days. Observations on water requirement, growth character and yield of capsicum were recorded and analyzed statistically following the standard procedures (Panse and Sukhatme, 1985). The water use efficiency (WUE) of the crop was determined by dividing the yield with water requirement of the crop. Each plant was provided with 2 emitter 10 cm away from plants, drip irrigation scheduling was done at 100% of open pan evaporation. In drip irrigation scheduling was done based on irrigation depth/cumulative pan evaporation (IW/CPE) = 1 to 4 cm depth.

Time required to run the system =
Quantity of water required/per plant/per days
        Drip discharge 26

Treatment-wise cost of cultivation was worked out. The total expenditure on cultivation and management of crop was recorded in terms of rupees and per hectare cost of cultivation was calculated. The gross monetary returns per hectare was worked out

considering the average prevailing price for guava as Rs. 20 per kg and the net returns were calculated by subtracting the cost of cultivation from gross returns and B: C ratio was worked out by using following formula:

Benefit: cost ratio = $\dfrac{\text{Net returns}}{\text{Cost of cultivation}}$

RESULT AND DISCUSSION

The maximum plant height (135.22 cm) was found under the treatment combinations of 80% RDF (131.07 cm) in the cultivar Lalit followed by Allahabad Safeda (127.07 cm) with the same treatment combinations depicted in table (1). The minimum plant height (125.95 cm) was observed in the cultivar L-49 with the treatment combinations of 60% RDF (128.22 cm). The taller plant height with 80% water through drip irrigation might be due to the optimum availability of moisture which facilitated for production of better root biomass resulting better nutrient uptake from the soil. Plant girth was maximum (8.86 cm) in Lalit cultivar with treatment combinations of 80% RDF (8.77 cm) followed by Allahabad Safeda (8.36 cm) with the same treatment combinations However, it was minimum in L-49 cultivar with treatment combinations of 60% RDF (7.86 cm). 75% (IW/CPE) ratio and maximum dose of fertigation level resulted in maximum plant girth in guava under drip irrigation system. The maximum plant canopy spread (160.80 cm) was found in the treatment combinations of 80% RDF (161.44 cm) in the cultivar Lalit followed by Allahabad Safeda (160.32 cm) with the same treatment combinations. The minimum plant canopy spread (156.81 cm) was observed in the cultivar L-49 with the treatment combinations of 60% RDF (156.09 cm). The above findings are in accordance with the report of present investigation. Plant canopy spread was significantly better under alternate day irrigation scheduling and higher levels of fertigation doses (Chandra and Jindal, 2001). The results are in accordance with the findings (Shukla *et al.,* 2000) in aonla, (Shirgure *et al.,* 2004) in acid lime, (Sulochanamma *et al.,* 2005) and (Agarwal and Agrawal, 2007) in pomegranate. The maximum number of fruits per plant (46.65) were found in the treatment combinations of 80% RDF (44.14) in the cultivar Lalit followed by L-49 (43.63) with the same treatment combinations. The minimum number of fruits per plant (39.23) was observed in the cultivar Allahabad Safeda with the treatment combinations of 60% RDF (42.12). Drip irrigation is being widely adopted in the orchards for improving fertilizer and water use efficiency through

drip in the orchards. Irrigation scheduling at 80% of ETc and 75% of recommended dose of fertilizer was found to be more effective than other treatments over the control for fertigation in guava (Singh *et al.,* 2012).

The maximum number of V_1-Lalit, V_2-Allahabad Safeda, V_3-L-49, F_1-60% recommended dose of fertilizer, F_2-80% recommended dose of fertilizer, F_3-100% recommended dose of fertilizer fruits per plant might be due to the higher fruit set which ultimately increased the number of fruits per plant. The above results are in agreement with the finding of Maji and Das (2008) in guava. The maximum fruit yield per plant (8.37 kg) was found in the treatment combinations of 80% RDF (7.97 kg) in the cultivar Lalit followed by L-49 (7.77 kg) with the same treatment combinations. The minimum fruit yield per plant (6.67 kg) was observed in the cultivar Allahabad Safeda with the treatment combinations of 60% RDF (7.16 kg). Highest yield in irrigation scheduling at 80% of ETc and 75% of recommended dose of fertilizer was found to be more effective than other treatments over control for fertigation in guava (Singh *et al.,* 2012). Drip irrigation is being widely adopted in the orchards for improving fertilizer and water use efficiency through drip in the orchards.

Drip irrigation provides appropriate moisture at field capacity, better root development in terms of number and spread of roots, which facilitated luxuriant growth of plant due to better nutrient uptake resulting better fruit growth and development, ultimately achieving higher yield. Significantly, the maximum fruit yield per hectare (41.82 t/ha) was found in the treatment combinations of 80% RDF (39.82 t/ha) in the cultivar Lalit followed by L-49 (38.84 t/ha) with the same treatment combinations. The minimum fruit yield per plant (33.43 t/ha) was observed in the cultivar Allahabad Safeda with the treatment combinations of 60% RDF (35.81 t/ha). 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.

Table 1. Effect of fertigation scheduling on crop growth, yield attributes and yield of guava

Treatment	Plant height (cm)	Plant girth (cm)	Plant canopy spread (cm)	Number of fruits/plant	Fruit yield/plant (kg)	Fruit yield/ha
Varieties						
Lalit	135.22	8.86	160.80	46.65	8.37	41.82
Allahabad Safeda	127.07	8.36	160.36	39.23	6.67	33.43
L-49	125.95	7.86	156.81	43.63	7.77	38.84
Fertigation levels						
60% RDF	128.22	7.86	156.09	42.12	7.16	35.81
80% RDF	131.07	8.77	161.44	44.14	7.97	39.82
100% RDF	128.96	8.44	160.40	43.24	7.68	38.46

RDF-recommended dose of fertilizer

Table 2. Effect of physico-chemical changes in guava cultivars

Treatment	Fruit weight (g)	Number of seeds/fruit	Seed weight (g)	TSS	pH	Acidity (%)
Varieties						
Lalit	183.62	216.04	6.64	14.99	4.94	.64
Allahabad Safeda	169.32	213.34	5.57	13.84	4.15	.56
L-49	178.59	215.23	4.08	12.53	3.94	.55
Fertigation Levels						
60% RDF	175.30	212.94	4.52	12.89	4.09	.56
80% RDF	178.42	216.82	6.17	15.00	4.57	.60
100% RDF	177.81	214.84	5.60	13.47	4.37	.58

RDF-recommended dose of fertilizer

Table 3. Cost analysis of guava

Treatment	Cost of cultivation	Gross return	Net return	Benefit : Cost
Varieties				
V_1	221000	836483.69	615283.69	2.78 : 1
V_2	221200	668577.78	447377.78	2.02 : 1
V_3	221400	776711.11	555511.11	2.51 : 1
Fertigation Level				
F_1	221000	716140.74	495140.74	2.24 : 1
F_2	221200	**796377.78**	**575177.78**	**2.60 : 1**
F_3	221400	769254.06	547854.06	2.47 : 1

The maximum fruit weight (183.62 g) was found in the treatment combinations of 80% RDF (178.42 g) in the cultivar Lalit with followed by L-49 (178.59 g) with the same treatment combinations. The minimum fruit weight (169.32 g) was observed in the cultivar Allahabad Safeda with the treatment combinations of 60% RDF (175.30 g). The maximum number of seeds per fruit (216.04) was found in the treatment combinations of 80% RDF (216.82) in the cultivar Lalit followed by L-49 (215.23) with the same treatment combinations. The minimum number of seeds per fruit (213.34) was observed in the cultivar Allahabad Safeda with the treatment combination of 60% RDF (212.94). The maximum seed weight (6.64 g) was found in the treatment combinations, 80% RDF (6.17 g) in the cultivar Lalit with followed by Allahabad Safeda (5.57 g) with the same treatment combinations. The minimum seed weight (4.08 g) was noticed in the cultivar L-49 with the treatment combination of 60% RDF (4.52 g). The maximum TSS (14.99 ^{0}Brix) was found in the treatment combinations of 80% RDF (15.00 ^{0}Brix) in the cultivar Lalit followed by Allahabad Safeda (13.84 ^{0}Brix) with the same treatment combinations. The minimum TSS (12.53 ^{0}Brix) was observed in the cultivar L-49 with the treatment combinations of 60% RDF (12.89 ^{0}Brix). Ram and Rajput (2000) concluded that the highest total soluble solids was observed in the cvs. L-49 and Allahabad Safeda, respectively. The maximum pH of fruit juice (4.94) was found in the treatment combinations of 80% RDF (4.57) in the cultivar Lalit with followed by Allahabad Safeda (4.15) with the same treatment combinations. The minimum pH of fruit juice (3.94) was noticed in the cultivar L-49 with the treatment combination of 60% RDF (4.09). The maximum acidity (0.64 %)) was found in the treatment combinations of 80% RDF (0.60%) in the cultivar Lalit followed by Allahabad Safeda (0.56 %) with the same treatment combinations. The minimum acidity (0.55 %) was noticed in the cultivar L-49 with the treatment combinations of 60% RDF (0.56%). Acidity with the treatment I_2F_2 (75 % irrigation of IW/CPE ratio 45, 20, 20 g NPK/plant/year) recorded better quality fruits indicated in (Table 2).

Total cost of cultivation indicated in (Table 3), gross income and net return (Rs. 221000), (Rs. 836483.69),

(Rs. 615283.69) respectively, was found in the treatment combinations of 80% RDF (Rs. 221200) (Rs. 796377.78), (Rs. 575177.78) in the cultivar Lalit followed by L-49 (Rs. 221000), (Rs. 776711.11), (Rs. 555511.11) with the same treatment combinations. The minimum total cost of cultivation, gross income and net return (Rs.221000), (Rs. 668577.78), (Rs. 447377.78) was observed in the cultivar Allahabad Safeda with the treatment combinations of 60% RDF (Rs. 221000), (Rs. 716140.74), (Rs. 495140.74). The maximum Benefit cost ratio (2.78)) was found in the treatment combinations of 80% RDF (2.60) in the cultivar Lalit followed by L-49 (2.51) with the same treatment combinations. The minimum Benefit cost ratio (2.02) was observed in the cultivar Allahabad Safeda with the treatment combinations of 60% RDF (2.24). Drip irrigation is being widely adopted for the orchards for improving fertilizer and water use efficiency through drip in the orchards. The economic analysis revealed that the drip fertigation technology for guava was feasible with benefit cost ratio 2.48:1. (Singh *et al.*, 2012).

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