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Effect of plastic mulch, drip irrigation and fertigation on vegetative growth and chemical attributes of guava in *Tarai* region

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Abstract
The present study was carried out in an experimental field at horticulture research centre Patharchatta, department of horticulture, G. B. P. U. A & T Pantnagar Uttarakhand during the year 2017 and 2018, respectively. The experiment was conducted under randomized block design with 19 treatments and 4 replications in which irrigation and fertilizers were provided through drip system. There were different levels of drip irrigation (100, 80 and 60 per cent based on estimated irrigation water requirement) and fertigation (100, 80 and 60 percent of recommended dose fertilizer NPK) along with silver-black plastic mulch to standardize an appropriate level of irrigation as well as fertigation for proper growth and development of guava cv VNR Bihi in *Tarai* region. The results depicted that the treatment combination MDI_2F_1 *i.e.* mulch application with drip irrigation at 80 per cent level and fertigation at 100 per cent recommended dose of fertilizer (225: 165: 150g NPK) was most superior with maximum plant height, plant girth, T.S.S. and acidity during the year 2017 as well as 2018, respectively.

Keywords: Plastic mulch, fertigation on vegetative, guava

Introduction

Guava (*Psidium guajava* L.) being tropical and subtropical fruit crop in nature is considered the fifth most important fruit in area and production. It is also known as “apple of tropics”. Guava is hardy, prolific bearer and remunerative fruit. It is fairly cold-hardy and can survive as low as 5 °C (41 °F) for short periods of time at night (Wei 2008) [20]. Guava seems doing equally well on heavy clay, marl, light sand, gravel bars near streams, or on limestone and tolerating a pH range from 4.5 to 9.4. It is also known somewhat as a salt-resistant a crop (Singh *et al.*, 2017). Nowadays water table in *Tarai* region of Uttarakhand has also shown a declining trend there by decreasing the availability of water for irrigation purposes. The 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 growth, yield and quality of fruits (Singh and Singh, 2007) [14].

Drip irrigation provides an effective and cost efficient way to supply water and nutrients to crops (Bar-Yosef, 1999) [3]. Drip irrigation with fertigation offers the possibility of precisely placing water and nutrients in the plant root zone at the timing and frequency needed to enhance the agricultural production and water use efficiency. It is established that drip irrigation and plastic mulching improves the fruit quality in many other crops (Singh *et al.*, 2009) [15]. Many workers have reported that there is 50 to 70 percent saving in irrigation water and 10 to 70 percent increase in yield of fruit and vegetable crops through drip irrigation (Cetin *et al.*, 2004; Ramniwas *et al.*, 2012; Singh *et al.*, 2006) [4, 8, 13]. As the global water consumption is doubling every 20 years (Vorosmarty *et al.*, 2000) [19] and projected increase in food demand will have to be met by irrigation. Appropriate scheduling of irrigation increases the water use efficiency along with water saving for other purposes. The surface irrigation system is most common method of irrigation. Fertigation (application of fertilizer solution with drip irrigation) has the potential to ensure that the right combination of water and nutrient is available at the root zone. Fertigation saves fertilizer as it permits applying fertilizer in small quantities at a time matching with the plants nutrient need. Mulching has been found beneficial in improving physical and biological health of soil (Garg *et al.*, 2007) [5]. The response of guava to the combined effect of drip with different levels of irrigation in conjunction with polyethylene mulch and their economic feasibility are not well known. The water requirement through drip irrigation has not been studied for guava in *Tarai* region, therefore an experiment was conducted to evaluate optimum irrigation level with fertigation dose and plastic mulching to improve the vegetative characteristics of plant as well as physical and biochemical attributes of guava fruit.

Material and Methods

The experiment was executed at Horticulture Research Center, Patharchatta, GBPUA & T, Pantnagar, located in foothills of Himalayas at an altitude of 243.84 m above mean sea level and lies between 29˚N latitude and 79.3˚E longitude during the year 2017 and 2018. The experimental site had typically humid sub-tropical type of climate. The soil of the research field was silty loam in texture with a pH of 6.17 and an electrical conductivity of 0.19 $dSm^{-1.}$ The spacing between the plants in the experimental field was 5m × 3m. The experiment included eighteen treatment combinations with one control (conventional system of irrigation with soil application of recommended dose of fertilizers) and was laid out in randomized block design. There were twelve treatment combinations with one control (surface irrigation with soil application of recommended dose of fertilizers). The different treatment combinations comprised of three levels of drip irrigation (100%, 80% and 60% of estimated irrigation water requirement) as well as fertigation with three different levels of recommended doses of fertilizers (100%, 80% and 60% RDF) in combination with and without silver-black plastic mulch. The recommended dose of fertilizers for three year old guava tree was 225g/plant N: 195g/plant P: 150 g/plant K. there were 4 replication foe each treatment therefore 76 plants were selected for the experiment. Also, every plant row was provided with one lateral drip line having 4 emitters (of 4 l/hr discharge rate) per plant. The operating pressure of the drip irrigation system was maintained at 1.2 kg/cm^2.

During the present study, the vegetative character of guava plant, physical and bio-chemical quality attributes of fruits *viz.*, plant height, plant girth, fruit firmness, T.S.S. and acidity were investigated. The height of tree was measured from the bottom to the top of a tree with the help of a measuring pole and expressed in metres, once before the start of experiment and again after the termination of the experiment during the years 2017 and 2018. The increase in tree height was expressed in per cent (%) as calculated by dividing the difference in plant height with the initial plant height. Before the commencement of the experiment, the stem of the each tree was marked at a point 15 cm above the ground level. The stem girth was measured with a measuring tape before the commencement of experiment and after the termination of experiment during the years 2017 and 2018. The values of increase in trunk girth were expressed in per cent (%). Total soluble solid content was determined from the juice of four randomly selected fruits per plant. The extracted juice was stirred properly. A drop of this juice was placed on the prism of Erma Hand refractometer and degree brix of total soluble solids was obtained from direct reading (AOAC, 1990) [1]. The titratable acidity (per cent) was determined through the titration method as mentioned by (Ranganna, 1986).

Results

Data related to plant height (Table 1) revealed significant differences among percent increase in the plant height under different treatment combinations in both the years. During both the years 2017 and 2018, the increase in plant height 39.39 and 38.75 per cent was found significantly maximum under MDI_2F_1 (mulch +80% DI +100% RDF) and minimum increase in height 21.58 and 23.75 per cent was under control (conventional irrigation with recommended fertilizer dose). The observations on plant height under different treatments excluding control were also statistically analyzed using three factorial randomized block design. The results revealed that there was a significant difference in the main effect of mulch and fertigation during both the years of experiment (2017 and 2018) but in case of drip irrigation there was a non-significant difference. Plants which were mulched showed maximum increase in height (36.45 and 34.31 per cent) as compared to those which were kept without mulch. Likewise among the different levels of recommended dose of fertilizers (RDF), 100 per cent RDF shower maximum (36.65 and 35.00 per cent) increase in plant height during the both years of study. On the other hand the impact of drip irrigation solely had a non-significant effect on the per cent increase in plant height during the entire course of study. Increase in plant height might be attributed to the fact that constant and continuous supply of nutrients to the active root zone might have caused minimum time lag between application and uptake of nutrients resulting in better cell turgidity which had led to cell enlargement and better cell wall development thus resulting in better plant vigour (Viers, 1972) [18]. The availability of N and K in the root zone through fertigation might have induced more plant vigour (Raskar, 2000). Similarly, Ramniwas *et al.* (2012) [8] found that in guava plants the maximum plant height was under 100 per cent application of recommended dose of fertilizers also, the interaction effect of irrigation and fertigation levels on plant height was non-significant. Also Khan *et al.* (2013) [6] revealed that interaction effect of mulch, fertigation and drip irrigation was found non-significant on plant height of guava cv. Allahabad Safeda. Among the different treatment combinations, the higher plant girth (50.29 per cent) was found under MI_1F_2 during the year 2017. In the following year (2018), the treatment combination MI_1F_1 exhibited highest plant girth (32.64 per cent). On the other hand, the lowest (22.01 per cent and 25.05 per cent) plant girth were obtained under control, in 2017 and 2018 respectively (Table 2). Further, the integrated effect of mulch × drip irrigation, drip irrigation × fertigation and fertigation × mulch was almost non-significant during both the years of study. Also the sole effect of drip irrigation gave non-significant results in the entire course of study. The individual effect of mulch and fertigation also revealed significant variations as mulched plans showed maximum increase in plant girth as compared to the UN mulched plants during the both years of study also the higher dose of recommended dose of fertilizer was able to augment maximum plant girth during the year 2017 and 2018, respectively. According to Shirgure *et al.* (2001) [12], total nitrogen and potassium uptake was appreciable higher with increasing nitrogen and potassium rate with more frequent than with less frequent fertigation. No significant difference was revealed for the stem girth of pomegranate cv. Ganesh subjected to varied levels of drip irrigation (Sulochanamma *et al.*, 2005) [17]. Similarly Khan *et* *al.* (2013) [6] revealed that interaction effects of mulch, fertigation and drip irrigation were found non-significant on plant girth of guava cv. Allahabad Safeda.

During the study, the highest (10.51˚B and 10.63˚B) amount of total soluble solids (T.S.S.) were seen under treatment MDI_2F_1 *i.e.* (mulch +80% DI +100% RDF), while the lowest amounts (8.90˚B and 8.97˚B) were observed under control in which plants received irrigation through conventional system and 100% recommended dose of fertilizers during 2017 and 2018, respectively (Table 3). Maximum T.S.S. was observed under mulched treatments *i.e.* 9.81˚B and 10.02˚B, respectively as compared to un-mulched. Further, the application of drip irrigation at 100 per cent level significantly augmented the T.S.S. (9.72 ˚B and 9.86 ˚B) in the respective years. T.S.S. also changed significantly with the advancement in fertigation levels, wherein maximum T.S.S. (9.78 ˚B and 9.96 ˚B) was observed under 100 per cent recommended dose of fertilizers. The interactive effects of drip irrigation × fertigation and mulch × fertigation were also found statistically non-significant in both the years. This could be as a result of availability of optimum soil temperature, moisture and nutrient supply under mulch in association with drip irrigation, while under control due to absence of mulch, soil temperature fluctuations and moisture evaporation losses were quite common resulting into poor uptake and assimilation and subsequently low T.S.S. content. Further, fertigation at higher potassium doses also improved the total soluble solids which might be due to its affect on photosynthesis and translocation of photosynthates to developing fruits. In accordance with these findings, higher T.S.S. under mulched conditions over non-mulched conditions was also reported by Khan *et al.* (2013) [6] in guava. Singh *et al.* (2015) [7] also confirmed that application of polyethylene mulch resulted in higher T.S.S. in guava cv. Allahabad Safeda but in combination with drip irrigation at 80 per cent pan evaporation. Rao *et al.* (2017) [11] revealed that interaction effect of drip irrigation and fertigation was found to be non-significant in guava cv. L 49.

The highest titratable acidity (0.50 per cent and 0.56 per cent) was found under control while lowest (0.38 per cent and 0.35 per cent) under MDI_2F_1, during the years 2017 and 2018 respectively (Table 4). The results revealed that the sole effect of silver polyethylene mulch was significant on titratable acidity during both the years of study. Drip irrigation at 60 per cent level produced significantly higher titratable acidity (0.46 per cent and 0.50 per cent) while the lowest (0.43 per cent and 0.46 per cent) was observed under irrigation at 80 per cent level during the years 2017 and 2018, respectively. Overall effect of fertigation was found to be non-significant throughout the study. Fertigation on the other hand, exhibited no significant effect on titratable acidity. The combined effect of all the main factors *i.e.* mulch, drip irrigation and fertigation gave non-significant results during both the years. This could be attributed to the favourable moisture and nutrient supply throughout the entire fruit development stage due to the combined influence of all the three factors which promoted the enzymatic activity and further favoured the hydrolysis of metabolites (such as organic acids) resulting into reduced acidity level, under drip irrigation and fertigation in association with mulch. The prevalence of high acidity under no mulch and low acidity under mulched conditions was also reported by Khan *et al.* (2013) [6] in guava cv. Allahabad Safeda. In line with these results, decline in titratable acidity was also found in guava cv. Shweta when irrigated at 100 per cent level under drip irrigation (Ramnivas *et al.*, 2013) [6]. Bhanukar *et al.* (2015) [2] also reported similar findings with comparatively low titratable acidity in Kinnow under mulch condition as compared to control *i.e.* without mulch. Kumar *et al.* (2015) [7] also reported decline in titratable acidity under black polyethylene mulch in Eureka lemon.

Table 1: Effect of drip based NPK fertigation and plastic mulch on per cent increase in plant height of guava cv. VNR Bihi

% increase in height									
Mulch	**Irrigation levels**	**2017**				**2018**			
		Fertilizer levels			**Mean (M × DI)**	**Fertilizer levels**			**Mean (M ×DI)**
		F_1	**F_2**	**F_3**		**F_1**	**F_2**	**F_3**	
M	DI_1	34.80	39.03	34.15	35.99	33.81	35.84	32.22	33.96
	DI_2	39.39	39.14	35.84	38.12	38.75	36.40	33.79	36.31
	DI_3	37.96	34.39	33.32	35.22	35.54	32.34	30.07	32.65
	Mean (M × F)	37.38	37.52	34.44	36.45	36.03	34.86	32.03	34.31
M_0	DI_1	37.24	33.61	28.76	33.20	35.30	32.03	28.90	32.08
	DI_2	35.94	32.07	28.29	32.10	34.11	29.85	26.49	30.15
	DI_3	34.59	31.72	27.24	31.18	32.49	29.46	26.04	29.33
	Mean (M_0 × F)	35.92	32.46	28.10	32.16	33.96	30.45	27.14	30.52
I × F	DI_1	36.02	36.32	31.46	34.60	34.55	33.93	30.56	33.02
	DI_2	37.67	35.60	32.07	35.11	36.43	33.13	30.14	33.23
	DI_3	36.27	33.05	30.28	33.20	34.01	30.90	28.05	30.99
Mean	F	36.65	34.99	31.27		35.00	32.65	29.59	
	Mean		**C.D. at 5%**			**Mean**		**C.D. at 5%**	
Control	21.58		7.32			23.75		6.97	
Factor	M	DI	M × DI		F	M	DI	M × DI	F
C.D. at 5%	2.46	NS	NS		3.01	2.35	NS	NS	2.83
SE(m)	0.86	1.06	1.50		1.06	0.82	1.01	1.43	1.01
Factor	M × F	DI × F		M × DI× F		M × F	DI× F	M × DI× F	
C.D. at 5%	NS	NS		NS		NS	NS	NS	
SE(m)	1.50	1.83		2.60		1.43	1.75	2.48	

Table 2: Effect of drip based NPK fertigation and plastic mulch on per cent increase in plant girth of guava cv. VNR Bihi

% increase in girth									
Mulch	Irrigation levels	2017				2018			
		Fertilizer levels			Mean (M × DI)	Fertilizer levels			Mean (M ×DI)
		F_1	F_2	F_3		F_1	F_2	F_3	
M	DI_1	38.43	43.90	36.09	39.47	29.84	31.22	27.73	29.60
	DI_2	46.82	50.29	38.45	45.19	32.64	31.83	30.22	31.56
	DI_3	41.31	36.94	32.12	36.79	31.22	28.74	27.26	29.07
	Mean (M × F)	42.19	43.71	35.55	40.48	31.23	30.60	28.40	30.08
M_0	DI_1	38.77	34.41	25.61	32.93	30.96	27.54	26.18	28.22
	DI_2	38.61	32.09	22.12	30.94	30.50	26.77	25.96	27.74
	DI_3	38.29	27.25	23.28	29.61	28.76	26.67	25.08	26.81
	Mean (M_0 × F)	38.56	31.25	23.67	31.16	30.07	26.99	25.71	27.59
I × F	DI_1	38.60	39.16	30.85	36.20	30.40	29.38	26.95	28.91
	DI_2	42.71	41.19	30.28	38.06	31.57	29.30	28.09	29.65
	DI_3	39.80	32.10	27.70	33.20	29.99	27.70	26.13	27.94
Mean		40.37	37.48	29.61		30.65	28.80	27.05	
	Mean		**C.D. at 5%**			**Mean**		**C.D. at 5%**	
Control	22.01		10.10			25.05		NS	
Factor	M	DI	M × DI		F	M	DI	M × DI	F
C.D. at 5%	3.28	NS	NS		4.01	1.62	NS	NS	1.99
SE(m)	1.15	1.41	2.0		1.41	0.53	0.70	1.40	0.70
Factor	M × F	DI × F			M × DI× F	M × F	DI× F	M × DI× F	
C.D. at 5%	NS	NS			NS	NS	NS	NS	
SE(m)	2.0	2.45			3.46	0.99	1.21	1.72	

Table 3: Effect of drip based NPK fertigation and plastic mulch on T.S.S. of guava cv. VNR Bihi

Mulch	T.S.S. (ºB)								
	Irrigation levels	2017				2018			
		Fertilizer levels			Mean (M × DI)	Fertilizer levels			Mean (M ×DI)
		F_1	F_2	F_3		F_1	F_2	F_3	
M	DI_1	9.52	10.28	9.32	9.70	9.98	10.26	9.78	10.00
	DI_2	10.51	10.30	9.72	10.18	10.63	10.44	9.92	10.33
	DI_3	9.92	9.42	9.30	9.54	10.12	9.62	9.46	9.73
	Mean (M × F)	9.98	10.00	9.44	9.81	10.24	10.10	9.72	10.02
M_0	DI_1	9.72	9.52	9.22	9.48	9.88	9.68	9.30	9.62
	DI_2	9.62	9.25	8.94	9.27	9.70	9.33	9.18	9.40
	DI_3	9.42	9.12	9.03	9.19	9.45	9.22	9.12	9.26
	Mean (M_0 × F)	9.58	9.29	9.06	9.31	9.67	9.41	9.20	9.43
I × F	DI_1	9.62	9.90	9.27	9.59	9.92	9.97	9.54	9.81
	DI_2	10.06	9.78	9.33	9.72	10.16	9.88	9.55	9.86
	DI_3	9.67	9.27	9.16	9.36	9.78	9.42	9.29	9.49
Mean		9.78	9.65	9.25		9.96	9.76	9.46	
	Mean		**C.D. at 5%**			**Mean**		**C.D. at 5%**	
Control	8.90		0.53			9.03		0.52	
Factor	M	DI	M × DI		F	M	DI	M × DI	F
C.D. at 5%	0.18	0.22	0.31		0.23	0.17	0.21	0.30	0.21
SE(m)	0.07	0.08	0.11		0.08	0.06	0.07	0.11	0.07
Factor	M × F	DI × F			M × DI× F	M × F	DI× F	M × DI× F	
C.D. at 5%	NS	NS			NS	NS	NS	NS	
SE(m)	0.11	0.14			0.19	0.11	0.13	0.18	

Table 4: Effect of drip based NPK fertigation and plastic mulch on acidity of guava cv. VNR Bihi

Mulch	Acidity (%)								
	Irrigation levels	2017				2018			
		Fertilizer levels			Mean (M × DI)	Fertilizer levels			Mean (M ×DI)
		F_1	F_2	F_3		F_1	F_2	F_3	
M	DI_1	0.46	0.43	0.46	0.45	0.43	0.40	0.43	0.42
	DI_2	0.38	0.41	0.44	0.41	0.35	0.38	0.47	0.40
	DI_3	0.43	0.46	0.45	0.45	0.46	0.49	0.48	0.48
	Mean (M × F)	0.42	0.43	0.45	0.43	0.41	0.42	0.46	0.43
M_0	DI_1	0.43	0.45	0.46	0.45	0.46	0.48	0.50	0.48
	DI_2	0.46	0.45	0.46	0.46	0.50	0.49	0.51	0.49
	DI_3	0.47	0.47	0.48	0.48	0.51	0.52	0.53	0.51
	Mean (M_0 × F)	0.45	0.46	0.47	0.46	0.49	0.50	0.51	0.50
I × F	DI_1	0.44	0.45	0.47	0.45	0.44	0.43	0.47	0.45
	DI_2	0.42	0.43	0.45	0.43	0.42	0.44	0.48	0.46

	DI_3	0.45	0.47	0.48	0.46	0.48	0.50	0.51	0.50
Mean		0.44	0.45	0.46		0.46	0.45	0.48	
	Mean		**C.D. at 5%**			**Mean**		**C.D. at 5%**	
Control	0.50		0.04			0.56		0.05	
Factor	M	DI	M × DI		F	M	DI	M × DI	F
C.D. at 5%	0.01	0.02	NS		NS	0.02	0.02	0.03	0.02
SE(m)	0.005	0.007	0.009		0.007	0.005	0.007	0.009	0.007
Factor	M × F	DI × F			M × DI× F	M × F	DI× F	M × DI× F	
C.D. at 5%	NS	NS			NS	NS	NS	0.05	
SE(m)	0.009	0.012			0.016	0.009	0.012	0.016	

Conclusion

It can be consoled that mulch along with 80% DI and 100% RDF can improve vegetative growth and chemical attributes of guava in *Tarai* region.

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