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Response of guava to integrated nutrient and water management

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ABSTRACT

Micro irrigation and fertigation supplemented with plastic mulch has proven to be the best to mitigate water scarcity. Calibrated systems and calculative irrigation and fertigation doses were tested for studying the efficiency of provided water and nutrients under different mulching treatments in guava cv VNR Bihi. The experiment was executed at Horticulture Research Center of G.B.P.U.A&T Pantnagar, during the years 2017 and 2018. The experimental plants of four years old were irrigated as well as fertigated with a drip system having four emitters per plant of eight litre/hour (LPH) capacity. Three levels each of drip irrigation (100%, 80% and 60% CPE) and fertigation (100%, 80% and 60% RDF) and two levels of mulching (with and without use of silver-black plastic mulching 100 *μ*) were set for the experiment. Among the different levels of irrigation and fertigation, 100 per cent recommended dose of fertilizers (RDF) with drip irrigation at 80% (CPE) along with Silver-black plastic mulch improved the yield (52.55 kg/tree), no of fruits per plant (89.77), fruit weight (585.36 g), TSS (10.57 ºB), ascorbic acid (267.13 mg/100g), total sugars (7.78 %) and leaf N (1.49 %), P (0.46%), K (0.80%) and Zn (65.37 ppm) contents. WUE and FUE were 72.71 kg.ha^{-1}.mm^{-1} and 84.87 kg/ha, respectively. Treatment combinations of mulching with drip irrigation at 60% CPE along with 100 RDF revealed the highest WUE of 81.83 kg.ha^{-1} mm^{-1}. Similarly. treatment combination of mulching with drip irrigation at 80% CPE and 60% RDF recorded FUE to the tune of 107.11 kg.ha^{-1}.

Key words: *Psidium guajava* Linn, fertigation, mulching, WUE, FUE, VNR Bihi

INTRODUCTION

The demand of guava is increasing tremendously due to its nutritional quality even during this period of Covid-19 pandemic, it is highly recommended by the medical fraternity to consume guava due to its richness in vitamin C. It covers an area of 265 thousand ha with an output of 4.05 million tonnes fruit production which contributes nearly about 4 per cent of total fruit production in India (Anonymous, 1). Earlier, it was observed that the farmers of *Tarai* region usually preferred L-49, Allahabad Safeda and Pant Prabhat among the different guava cultivars of guava, due to their popularity and adaptability in this region. But nowadays people have started adopting cv. VNR Bihi because it performs extremely well under drip fertigation and mulching (Preet *et al.,* 10). It is highly demanded as a raw material for making processed products viz. jam and jelly. It is also highly suitable for it's use in fruit salad. However, irrigation and fertigation scheduling for guava in *Tarai* region of Uttarakhand are practiced arbitrarily due to lack of systematic and scientifically sound technologies on judicious water management through micro-irrigation, fertigation and water conservation practices.

Availability of water near the root zone is the prime prerequisite for the uptake of nutrients during the growing phase (Crisostomo and Naumoy, 3). Water scarcity as a limiting factor due to shrinkage in water bodies (Raina*,* 11) and excessive water application via conventional method leads to water logging conditions, soil salinity, poor soil aeration, contamination of water bodies and weed infestation (Veeraputhiram *et al.,* 17), whereas micro irrigation promises higher water savings (12-84%) and fertilizer use efficiency (10-55%), depending on type of soils and climate (Pramanik and Patra, 9). Hence, a study on the response of guava to integrated nutrient and water management was undertaken with the objectives of improving the water and fertilizer use efficiency in the *Tarai* region of Uttarakhand.

MATERIALS AND METHODS

Field trials on guava cv. VNR Bihi were executed at Horticulture Research Centre, Patharchatta, G.B.P.U.A. &T, Pantnagar, Uttarakhand, India, during the year 2017 and 2018 for winter season guava. The physical and chemical characteristics of soil before the execution of experiment are presented in Table 1. The plants were grafted on the seedling rootstock of L-49 cultivar of guava planted at the spacing of 5 m × 3 m. The age of orchard was 3 years at the time of experiment and was maintained under uniform cultural operations. The experiment was laid under

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Table 1. Physical and chemical attributes of soil before the execution of experiment.

S. No.	Soil particulars	Values
1	Soil texture	Silty loam
2	pH	6.17
3	EC (dSm^{-1})	0.19
4	Organic carbon (%)	0.74
5	Available nitrogen (kg/ha)	203.25
6	Available phosphorus (kg/ha)	54.35
7	Available potassium (kg/ha)	232.64

factorial Randomized Block Design (2×3×3) including plastic mulching (with and without use of silver-black plastic mulching 100 μ), three fertigation levels (100 %, 80 % and 60% RDF) and three irrigation levels (100 %, 80 % and 60% CPE).There were 19 treatments (Table 2) repeated four times having one plant per replication according to which recommended dose of fertilizers (RDF) (225: 195: 150g/plant) nitrogen (N), phosphorus (P) and potassium (K) and sufficient needed irrigation water as per cumulative pan evaporation method were given to the plant zone via drip system. Estimated irrigation water requirement (V) based on crop evapotranspiration in liters/plant was calculated according to Vermeiren and Jobling (18) using the following formula:

$V = Ep \times Kp \times Kc \times Kr \times$ Ground cover area

Where, E_p is pan evaporation (mm/day), K_p is pan coefficient (0.85), K_c is crop coefficient (0.8), K_r is reduction coefficient (1). The water received through rain was accommodated in irrigation schedule in successive days in all the treatments except to those plants kept as control.

The amount of fertilizers were provided through different grades of water soluble fertilizers *i.e.* N: P: K (18:18:18), Urea (46% N), Mono potassium phosphate (N:P:K 00:52:34), Sulphate of Potash (50% K), via drip irrigation but when the conventional method of irrigation was adopted, fertilizer requirement was fulfilled through Urea (46% N), DAP (18% N, 46% P_2O_5) and MOP(60% K). These fertilizers were applied through drip fertigation in 15 split doses. Foliar application of 0.5% $ZnSO_4$ was applied in the ist week of September. The irrigation was applied at alternate days during April to June and afterwards twice in a week based on 100%, 80%, and 60% of CPE.

The observations on fruit yield, weight and chemical attributes were recorded at the time of commercial harvesting. The leaf nutrient status (N, P, K and Zn) was studied in June (before treatment) and November (fruit harvesting). For the fruit weight, the average weight of ten fruits per replication was measured with the help of an electronic balance. TSS of fruit was measured with hand refractometer, ascorbic acid was determined using 2, 6-Dichlorophenol-indophenol visual titration method and sugars were determined by Lane and Eynon (8) method. For leaf N, P, K and Zn contents, recently matured third pair of 30 leaves from the middle of shoots were collected in June (before treatment) and November. Nitrogen was estimated by using modified Micro-Kjeldahl Method (Jackson *et al.,* 4), Phosphorus by Vanado-Molybdo phosphoric acid yellow colour method and Potassium by Flame Emission Photometer method (Jackson, 5). The total zinc contents in digested guava leaves were analyzed using method as described by Jackson (5) with the help of atomic absorption spectrophotometer. The water use efficiency (kg ha^{-1} mm^{-1}) for different treatments was computed by dividing yield (kg ha^{-1}) to total amount of water used (mm). The fertilizer use

Table 2. Treatment details

S. No.	Treatments	Treatments details	S. No.	Treatments	Treatments details
1	MDI_1F_1	Mulch + 100%CPE+100% RDF	11	$M_0DI_1F_2$	No Mulch +100%CPE +80% RDF
2	MDI_1F_2	Mulch +100%CPE +80% RDF	12	$M_0DI_1F_3$	No Mulch +100%CPE +60% RDF
3	MDI_1F_3	Mulch +100%CPE +60% RDF	13	$M_0DI_2F_1$	No Mulch +80%CPE +100% RDF
4	MDI_2F_1	Mulch +80%CPE +100% RDF	14	$M_0DI_2F_2$	No Mulch +80%CPE +80% RDF
5	MDI_2F_2	Mulch +80%CPE +80% RDF	15	$M_0DI_2F_3$	No Mulch +80%CPE +60% RDF
6	MDI_2F_3	Mulch +80%CPE +60% RDF	16	$M_0DI_3F_1$	No Mulch +60%CPE +100% RDF
7	MDI_3F_1	Mulch +60%CPE +100% RDF	17	$M_0DI_3F_2$	No Mulch +60%CPE +80% RDF
8	MDI_3F_2	Mulch +60%CPE +80% RDF	18	$M_0DI_3F_3$	No Mulch +60%CPE +60% RDF
9	MDI_3F_3	Mulch +60%CPE +60% RDF	19	Control	Conventional system (CS) +100% RDF
10	$M_0DI_1F_1$	No Mulch +100%CPE +100% RDF			

DI: Drip Irrigation; RDF: Recommended Dose of Fertilizers; M: Mulch; M0: Without mulch M

efficiency (kg ha^{-1}) was computed by dividing Yield (kg ha^{-1}) to total quantity of nutrient applied (kg ha^{-1}) as described by Veeranna (16).

The Pooled data for both the years 2017 and 2018 were analyzed by using software like MS Excel and STPR 15.0 version. Fisher's least significant difference at $p< 0.05$ level was used to determine the significant difference between the means of individual treatments.

RESULTS AND DISCUSSION

The effect of mulch with drip irrigation and fertigation on fruit yield of guava, pooled for the year 2017 and 2018 have been presented in Table 3. It was found that the treatment MDI_2F_1 (mulch + 80% CPE + 100% RDF) resulted the maximum yield (52.55 kg/tree) as compared to the control (Conventional system (CS) +100 % RDF) *i.e.* 36.85 kg/tree. Among three levels of drip irrigation, maximum fruit yield was attained under 80 per cent CPE, followed by 100 per cent CPE likewise in three level of fertigation, 100 per cent RDF resulted in higher fruit yield (45.20 kg/tree). Interaction wise 80 per cent CPE with 100 per cent RDF augmented the higher yields (48.20 kg/tree) likewise plastic mulch with 100 percent RDF resulted superior in enhancing the fruit yield of guava (47.01 kg/tree). Due to better nutrient and soil moisture distribution, yield was relatively higher under the interaction of mulch and drip fertigation over control. Nitrogen application might increase the supply of auxins to the fruits, which reduces abscission thereby the yield/tree (Kumawat *et al*., 6). Singh *et al*. (15) also reported that 80 per cent irrigation level with plastic mulching resulted in maximum yield in guava *cv.* Allahabad Safeda.

The data pertaining to fruit weight of guava were presented in Table 4. Maximum fruit weight (585.36 g) was found under treatment MDI_2F_2 (mulch +80% CPE and 80% RDF) which was statistically at par with MDI_2F_2 (581.46 g), whereas minimum fruit size 520.96 g was found under control. The interaction of 80 per cent drip irrigation level with 100 per cent RDF

Table 3. Effect of drip based NPK fertigation and plastic mulch on fruit yield of guava cv. VNR Bihi

Mulch	Irrigation levels	Fruit yield (kg/tree)			
		Fertilizer levels			Mean (M × DI)
		F_1	F_2	F_3	
M	DI_1	42.54	46.20	41.19	43.31
	DI_2	52.55	46.90	42.71	47.39
	DI_3	45.95	41.46	39.72	42.38
	Mean (M × F)	47.01	44.85	41.21	44.36
M_0	DI_1	44.48	41.04	38.51	41.34
	DI_2	43.85	39.54	37.84	40.41
	DI_3	41.86	39.14	37.53	39.51
	Mean (M_0 × F)	43.39	39.91	37.96	40.42
I × F	DI_1	43.51	43.62	39.85	42.33
	DI_2	48.20	43.22	40.28	43.90
	DI_3	43.90	40.30	38.62	40.94
Mean	F	45.20	42.38	39.58	
	Mean			C.D. at 5%	
Control	36.85			0.99	
Factor	M	DI	M × DI		F
$C.D._{(5\%)}$	0.34	0.42	0.59		0.41
SE(m)	0.12	0.15	0.21		0.14
Factor	M × F		DI× F		M × DI× F
$C.D._{(5\%)}$	0.59		0.72		1.02
SE(m)	0.20		0.25		0.36

*DI_1 (100 % CPE), DI_2 (80 % CPE), DI_3 (60 % CPE), F_1 (100 % RDF), F_2 (80 % RDF), F_3 (60 % RDF), M (mulch), M_0 (non-mulch) NS (Non-significant)

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

Mulch	Irrigation levels	Fruit weight (g)			
		Fertilizer levels			Mean (M × DI)
		F_1	F_2	F_3	
M	DI_1	561.75	576.64	550.62	563.00
	DI_2	585.36	581.46	561.69	576.17
	DI_3	573.38	554.11	544.37	557.29
	Mean (M × F)	573.50	570.73	552.23	565.49
M_0	DI_1	569.44	548.14	537.98	551.85
	DI_2	568.15	542.85	533.20	548.07
	DI_3	555.13	539.04	536.09	543.42
	Mean (M_0 × F)	564.24	543.34	535.76	547.78
I × F	DI_1	565.60	562.39	544.30	557.43
	DI_2	576.75	562.15	547.45	562.12
	DI_3	564.26	546.57	540.23	550.35
Mean	F	568.87	557.04	543.99	
	Mean			C.D. at 5%	
Control	520.96			9.53	
Factor	M	DI	M × DI	F	
$C.D._{(5\%)}$	3.20	3.92	5.54	3.92	
SE(m)	1.13	1.38	1.95	1.38	
Factor	M × F	DI× F		M × DI× F	
C.D. at 5%	5.54	6.79		9.60	
SE(m)	1.95	2.37		3.38	

also gave highest fruit weight (576.75 g) as compared to other interactions. Superior results regarding fruit weight (568.87 g) were obtained in those plants which received fertigation level at 100 per cent (RDF) as compared to other levels of water and nutrients. The findings are in accordance to Raina *et al.* (11) who found maximum fruit weight with the application of 100 per cent RDF in apricot under fertigation. Singh *et al.* (15) also revealed higher fruit weight in guava cv. Allahabad Safeda with polyethylene mulching and drip irrigation at 80 per cent cumulative pan evaporation.

The different drip irrigation and fertigation levels significantly affected the nitrogen, phosphorus and potassium content of the guava leaves (Table 5). Maximum total leaf nitrogen (1.36 %), phosphorus (0.38 %) and potassium (0.72 %) content were observed in the plants which received irrigation at the rate of 80 per cent CPE, and in case of phosphorus, it was statistically at par with 100 percent drip irrigation level. However, in case of fertigation levels, maximum total nitrogen (1.40 %), phosphorus (0.39 %), and potassium (0.72 %), was recorded in plant which received 100 per cent (RDF) but in case of potassium, it was statistically at par with 80 per cent RDF. Further among the interaction between mulch and fertigation levels, maximum amount of total nitrogen (1.43 %) and phosphorus (0.41 %) content was recorded in plants under silver black plastic mulch with 100 per cent RDF. However, maximum total potassium (0.75 %) was observed under plastic mulch with 80 % RDF, while it was minimum (1.32 % N, 0.35 % P and 0.69 % K) under plastic mulch with 60 % RDF. The interaction of drip irrigation with plastic mulch further reduces the volatilization losses and provided favourable micro-environment for active nitrogen absorption. Ramana *et al.* (13) also recorded maximum leaf nitrogen and potassium content in sweet orange cv. Sathgudi subjected to drip irrigation over control.

Maximum leaf zinc content (57.32 ppm) was observed under the 80 per cent CPE and minimum (52.53 ppm) in 60 % CPE (Fig. 1). Under different fertigation levels, the maximum zinc content (59.07 ppm) in guava leaves was found in plant which received fertilizers at 100 per cent RDF, while minimum (51.37 ppm) was under 60 per cent RDF.

Table 5. Effect of drip based NPK fertigation and plastic mulch on leaf nutrient status of guava cv. VNR Bihi

Mulch		Leaf nitrogen (%)				Leaf phosphorus (%)				Leaf potassium (%)			
	Irrigation levels	Fertilizer levels			Mean M × DI	Fertilizer levels			Mean M×DI	Fertilizer levels			Mean M ×DI
		F_1	F_2	F_3		F_1	F_2	F_3		F_1	F_2	F_3	
M	DI_1	1.37	1.43	1.31	1.37	0.38	0.41	0.36	0.38	0.68	0.75	0.68	0.70
	DI_2	1.49	1.46	1.36	1.44	0.46	0.43	0.37	0.42	0.80	0.78	0.71	0.76
	DI_3	1.42	1.31	1.28	1.34	0.39	0.36	0.33	0.36	0.74	0.71	0.67	0.70
	Mean (M × F)	1.43	1.40	1.32	1.38	0.41	0.40	0.35	0.38	0.74	0.75	0.69	0.72
M_0	DI_1	1.40	1.30	1.25	1.32	0.40	0.34	0.35	0.36	0.71	0.68	0.64	0.68
	DI_2	1.38	1.27	1.23	1.29	0.37	0.34	0.32	0.35	0.72	0.67	0.63	0.67
	DI_3	1.32	1.25	1.22	1.26	0.36	0.33	0.32	0.34	0.68	0.67	0.62	0.66
	Mean (M_0 × F)	1.37	1.27	1.23	1.29	0.38	0.34	0.33	0.35	0.70	0.67	0.63	0.67
I × F	DI_1	1.39	1.37	1.28	1.34	0.39	0.37	0.35	0.37	0.69	0.71	0.66	0.69
	DI_2	1.43	1.36	1.30	1.36	0.41	0.39	0.35	0.38	0.76	0.72	0.67	0.72
	DI_3	1.37	1.28	1.25	1.30	0.37	0.34	0.33	0.35	0.71	0.69	0.65	0.68
Mean	F	1.40	1.34	1.27		0.39	0.37	0.34		0.72	0.71	0.66	

	Mean	C.D. at 5%			Mean		C.D. at 5%		Mean		C.D. at 5%	
Control	1.15	0.02			0.33		0.03		0.64		0.024	
Factor	M	DI	M × DI	F	M	DI	M × DI	F	M	DI	M × DI	F
$C.D._{(5\%)}$	0.008	0.010	0.015	0.010	0.009	0.011	0.015	0.011	0.008	0.010	0.014	0.010
SE(m)	0.003	0.004	0.005	0.004	0.003	0.004	0.005	0.004	0.003	0.003	0.005	0.003
Factor	M × F	DI × F	M×DI× F		M × F	DI× F	M × DI× F		M × F	DI× F	M × DI× F	
$C.D._{(5\%)}$	0.015	0.018	0.025		0.015	NS	NS		0.014	0.018	0.025	
SE(m)	0.005	0.006	0.009		0.005	0.007	0.009		0.005	0.006	0.009	

The combination of irrigation and fertigation levels i.e. DI_2F_1 tended to improve the leaf zinc content (61.23 ppm) and lowest leaf zinc content (48.24 ppm) was recorded in DI_1F_3. On the combination of all the three factors i.e. mulch, drip irrigation and fertigation, the treatment MDI_2F_1 (mulch + 80 % CPE + 100 % RDF) resulted in maximum amount of zinc in guava leaves (65.37 ppm) which was statistically at par with MDI_2F_2 (64.00 ppm). The role of nitrogen in enhancing leaf zinc content was initially reported by Kwomg (7). Similarly these findings are in the conformity with the results of Singh *et al.* (15) in which 100 per cent recommended dose of nitrogen gave higher leaf zinc content in nectarines.

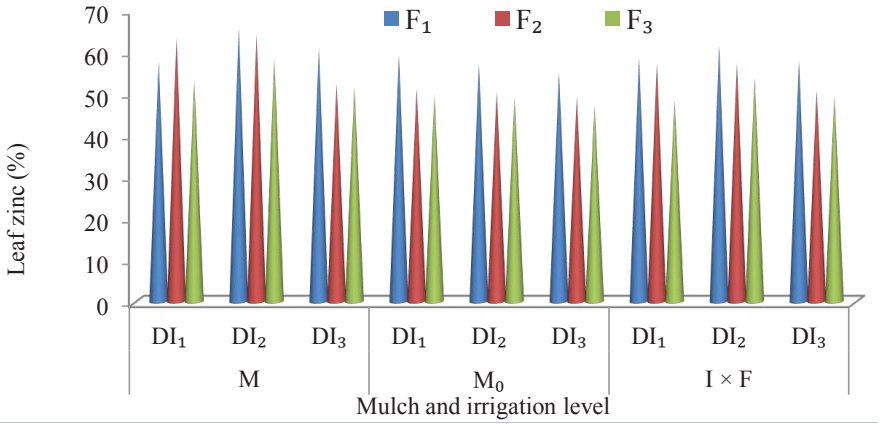

Fig. 1. Effect of drip based NPK fertigation and plastic mulch on leaf zinc of guava cv. VNR Bihi

The response of drip irrigation and fertigation levels on quality characteristics of guava are given in table 6. Maximum TSS (9.79 ºB), ascorbic acid (236.57 mg/100g) and total sugars (7.21 %) were found under 80 per cent CPE level and in case of TSS it was statistically at par with 100 percent DI level. However, in case of fertigation levels, maximum TSS (9.87 ºB), ascorbic acid (243.68 mg/100g) and total sugars (7.25 %), was recorded under 100 per cent (RDF). Further among the interaction between mulch and fertigation levels, maximum ascorbic acid (250.60 mg/100g) and total sugars (7.40 %) ware recorded under silver black plastic mulch with 100 per cent RDF. However, TSS showed non-significant results in the interactions of mulch and fertigation levels. On the interaction of three sole parameters, mulch + 80 percent CPE and 100 per cent RDF resulted into maximum ascorbic acid (267.13 mg/100g) and total sugars (7.78 %) of the fruits, while these were minimum under control. Bhanukar *et al.* (2) revealed that mulching contributes to higher T.S.S. content in Kinnow fruits. Singh *et al.* (1) also confirmed that application of polyethylene mulch in combination with drip irrigation at 80 per cent cumulative pan evaporation resulted in higher TSS, ascorbic acid and total sugars in guava cv. Allahabad Safeda.

Increament in the levels of irrigation decreased the water use efficiency. The highest water use efficiency (72.71 kg ha^{-1} mm^{-1}) was noted in DI3 (60% irrigation of CPE level) and minimum (45.02 kg ha^{-1} mm^{-1}) in DI1 (100% irrigation of CPE level) (Table 7). It was observed that DI3 level resulted in maximum water use efficiency because of less water use for irrigation and comparatively higher fruit yield (but, lower than DI2 and DI3). The results are in line with the findings of Kumawat *et al*. (6) who reported lowest water use efficiency with highest water application through drip in guava. Among the different fertigation level, F1 treatment (100% recommended dose of NPK) registered to the highest WUE (62.85 kg ha^{-1} mm^{-1}) followed by 58.44 kg ha^{-1} mm^{-1}in treatment F2 (80% recommended dose of NPK). Where, the lowest WUE (54.81kg kg ha^{-1} mm^{-1}) was observed in treatment F3. The possible explanation

Table 6. Effect of drip based NPK fertigation and plastic mulch on TSS, ascorbic acid and total sugars of guava cv. VNR Bihi

Mulch	TSS (°Brix)					Ascorbic acid (mg/100g)				Total sugars (%)			
	Irrigation levels	Fertilizer levels			Mean M×DI	Fertilizer levels			Mean M×DI	Fertilizer levels			Mean M×DI
		F_1	F_2	F_3		F_1	F_2	F_3		F_1	F_2	F_3	
M	DI_1	9.75	10.27	9.55	9.86	231.44	249.86	223.59	234.96	7.09	7.38	6.97	7.15
	DI_2	10.57	10.37	9.82	10.25	267.13	259.45	234.76	253.78	7.78	7.72	7.09	7.53
	DI_3	10.02	9.52	9.38	9.64	253.23	225.24	216.43	231.63	7.33	6.96	6.89	7.06
	Mean (M × F)	10.11	10.05	9.58	9.91	250.60	244.85	224.92	240.12	7.40	7.35	6.98	7.25
M_0	DI_1	9.80	9.60	9.26	9.55	243.44	219.36	211.72	224.12	7.14	6.91	6.84	6.96
	DI_2	9.66	9.29	9.06	9.34	238.26	212.74	207.12	219.37	7.09	6.84	6.72	6.88
	DI_3	9.44	9.17	9.07	9.22	228.62	208.66	204.02	213.76	7.05	6.86	6.63	6.84
	Mean (M_0 × F)	9.63	9.35	9.13	9.37	267.77	213.58	207.62	219.32	7.09	6.87	6.73	6.90
I × F	DI_1	9.77	9.93	9.40	9.70	237.44	234.61	217.65	229.90	7.12	7.15	6.90	7.05
	DI_2	10.11	9.83	9.44	9.79	252.69	236.09	220.94	236.57	7.44	7.28	6.90	7.21
	DI_3	9.73	9.34	9.23	9.43	240.92	216.95	210.23	222.70	7.19	6.91	6.76	6.95
Mean	F	9.87	9.70	9.36		243.68	229.21	216.27		7.25	7.11	6.85	
		Mean		C.D. at 5%		Mean		C.D. at 5%		Mean		C.D. at 5%	
Control		8.97		0.52		197.24		7.05		6.60		0.17	
Factor		M	DI	M× DI	F	M	DI	M × DI	F	M	M	DI	M×DI
C.D.$_{(5\%)}$		0.17	0.21	0.31	0.22	2.37	2.90	4.10	2.90	0.05	0.07	0.09	0.06
Factor		0.07	0.09	0.13	0.09	0.83	1.02	1.44	1.02	0.03	0.04	0.05	0.03
C.D.$_{(5\%)}$		M × F	DI× F	M × DI× F		M × F	DI× F	M × DI× F		M × F	DI× F	M × DI× F	
SE(m)		NS	NS	NS		4.10	5.02	7.10		0.09	0.10	0.13	
		0.11	0.13	0.18		1.44	1.77	2.50		0.05	0.07	0.08	

Table 7. Effect of drip based NPK fertigation and plastic mulch on water use efficiency of guava cv. VNR Bihi

Mulch	Irrigation levels	WUE (kg/ha-mm)			
		Fertilizer levels			Mean (M×DI)
		F1	F2	F3	
M	DI1	45.23	49.13	43.51	46.02
	DI2	69.95	62.43	56.85	63.08
	DI3	81.83	73.58	70.48	75.29
	Mean (M × F)	65.73	61.71	56.95	61.46
M0	DI1	47.34	43.70	41.01	44.02
	DI2	58.31	52.31	50.37	53.67
	DI3	74.29	69.47	66.61	70.14
	Mean (M0 × F)	59.98	55.16	52.68	55.94
I × F	DI1	46.38	46.41	42.26	45.02
	DI2	64.13	57.37	53.61	58.37
	DI3	78.05	71.52	68.57	72.71
Mean	F	62.85	58.44	54.81	
Control		Mean		C.D. at 5%	
Factor		36.87		4.86	
C.D.(5%)		M	DI	M×DI	F
SE(m)		1.53	1.97	2.75	1.92
		0.55	0.68	0.96	0.67
Factor		M × F	DI× F	M × DI× F	
C.D.(5%)		NS	3.34	3.48	
SE(m)		0.96	1.17	1.66	

for the increased water use efficiency with F1and F2 treatments might be due to high yield obtained by these treatments. The same was revealed by Pramanik et al. (9) in guava. Among the different treatment combination of plastic mulch, irrigation and fertigation, maximum WUE (81.83 kg ha^{-1} mm^{-1}) was obtained in MDI_3F_1 (Mulch+60 % CPE+100 % RDF) whereas the overall lowest was observed in the control treatment which received irrigation as well as fertilizers through conventional method.

The maximum FUE (84.87 kg/ha) was obtained with treatment DI2 (80% irrigation of CPE level). However, it was statistically at par with treatment DI1 and minimum FUE (79.51 kg/ha obtained under treatment DI1 (100% irrigation of CPE level) (Table 8). This might be attributed to the reason of higher yield obtained from treatment DI2 (80% irrigation of PE level). It is also true that drip irrigation at continues interval basis provides a consistent moisture regime in the soil and thereby keeps the roots active for a longer period. Continues moisture regime also enhances the availability of nutrients and translocation of mineral nutrients and moreover reduction in leaching loses of nutrients is also minimized. Fertilizer use efficiency showed increasing trend with decreasing fertilizer doses. Highest (FUE 99.27 kg/ha) was observed in F3 (60% RDF) as compared to minimum (67.91 kg/ha) in F1 (100 % RDF). The combination of plastic mulch, irrigation and fertigation levels obtained maximum FUE (107.11 kg/ha) in the treatment MDI_2F_3 (Mulch + 80 % CPE + 60% RDF) as compared to lowest FUE (55.35 kg/ha) was recorded in control treatment in which plants received irrigation and fertilizer through conventional method. The lower FUE in conventional method of irrigation might be attributed to uneven distribution of nutrients and moisture in the root zone of a crop which resulted in poor uptake of nutrients. The increase in fertilizer use efficiency in F3 might be due to the reduction in quantity of fertilizers received by these treatments. The lowest FUE was recorded from the conventional method application of fertilization which might be due to low efficient use of fertilizers by the plant which further declined the

Table 8. Effect of drip based NPK fertigation and plastic mulch on fertilizer use efficiency of guava cv. VNR Bihi

Mulch	Irrigation levels	FUE (kg/ha)			
		Fertilizer levels			Mean (M× DI)
		F_1	F_2	F_3	
M	DI_1	63.91	86.81	103.29	84.67
	DI_2	78.94	88.12	107.11	91.39
	DI_3	69.03	77.90	99.60	82.18
	Mean (M × F)	70.63	84.28	103.33	86.08
M_0	DI_1	66.82	77.11	96.59	80.17
	DI_2	65.87	74.30	94.90	78.36
	DI_3	62.88	73.54	94.11	76.84
	Mean (M_0 × F)	65.19	74.98	95.20	78.46
I × F	DI_1	65.35	81.96	99.94	82.42
	DI_2	72.41	81.21	101.00	84.87
	DI_3	65.96	75.72	96.86	79.51
Mean	F	67.91	79.63	99.27	
	Mean		C.D. at 5%		
Control	55.35		2.07		
Factor	M	DI	M × DI	F	
$C.D._{(5\%)}$	1.70	2.86	1.92	1.82	
SE(m)	0.54	0.86	0.62	0.59	
Factor	M × F		DI× F	M × DI× F	
$C.D._{(5\%)}$	1.76		1.66	2.34	
SE(m)	0.57		0.49	0.74	

Table 9. Correlation table of yield attributing characteristics leaf nutrient status and biochemical attributes of guava

	No of fruits/ plant	Fruit weight	Fruit yield	Leaf N	Leaf P	Leaf K	Leaf Zn	TSS	Fruit ascorbic acid	Total Sugars
No of fruits/plant	1									
Fruit weight	0.854**	1								
Fruit yield	0.985**	0.929**	1							
Leaf N	0.887**	0.925**	0.926**	1						
Leaf P	0.862**	0.765**	0.861**	0.835**	1					
Leaf K	0.890**	0.829**	0.901**	0.886**	0.804**	1				
Leaf Zn	0.861**	0.885**	0.899**	0.924**	0.827**	0.859**	1			
TSS	0.762**	0.762**	0.787**	0.772**	0.658**	0.809**	0.755**	1		
Fruit ascorbic acid	0.905**	0.911**	0.936**	0.951**	0.828**	0.902**	0.909**	0.805**	1	
Total Sugar	0.890**	0.845**	0.905**	0.909**	0.843**	0.889**	0.883**	0.772**	0.918**	1

**Correlation is significant at the 0.01 level (2-tailed).

yield guava. These results are in line to the results reported by Kumawat *et al.* (6) Ramniwas *et al.* (14) in guava.

The correlation matrix between fruit yield, quality and leaf nutrient attributes are shown in the Table 9. Significant correlations were found between the fruit yield with leaf nitrogen (r = + 0.926). Similarly, leaf zinc content is found to be significantly correlated with TSS, ascorbic acid and total sugars. All these effects indicated that zinc played an important role in maintaining a high efficiency of various enzymes and other elements in improving the general health and vigour of guava trees. Fruit weight has been found t have positive correlation with the content of leaf phosphorus. This may be attributed to the fact that nitrogen, phosphorus are the essential constituent of cell and its component. Nitrogen actively performs in cell division and cell elongation while phosphorus is important in energy transfer.

Hence, 80 per cent irrigation of pan evaporation replenishment level along with incorporation of 100 per cent recommended dose of fertilizer, especially water soluble fertilizers supplemented with silver black plastic mulch proved to be best in terms of yield and leaf nutrient status of guava cv. VNR Bihi in *Tarai* region of Uttarakhand.

AUTHORS' CONTRIBUTION

Conceptualization of designing of the research experiments (Manpreet Singh Preet and Rajesh Kumar); Execution of field/lab experiments (Manpreet Singh Preet and Ankit Dongariyal), Provided facility for research (Neha and Ranjan Srivastava); Preparation of the manuscript (Manpreet Singh Preet, Rajesh Kumar and V.P. Singh.).

DECLARATION

The authors declare no conflict of interest.

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