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Effect of INM on biochemical and postharvest parameters of guava (*Psidium guajava*) cv. Hisar Surkha

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ABSTRACT

An experiment was conducted during rainy (*kharif*) and winter (*rabi*) season of 2018–19 and 2019–20 at the research farm of CCS Haryana Agricultural University, Hisar, Haryana to study the effects of organic amendments and biofertilizers on biochemical and post-harvest parameters of guava fruits (*Psidium guajava* L. cv. Hisar Surkha). The experiment consisted of 19 treatments in different combinations and levels of RDF with vermicompost, farmyard manure, and biofertlizers were applied. The results revealed that almost all treatments with combined application of organic and inorganic sources of nutrients significantly influenced the biochemical and post-harvest parameters of guava fruits over control of which treatments T_{16} (RDF 100% + Farmyard manure + *Azotobacter* + PSB) and T_{17} (RDF 100 % + Vermicompost + *Azotobacter* + Phosphate solubilizing bacteria) proved most effective. All treatments had a significant impact on the total soluble solids, acidity, vitamin C, pectin and sugar content of fruit over the course of two years of experimentation. Shelf-life of fruits also increased with integrated use of 100% RDF with vermicompost and biofertilizers. Physiological loss in weight was minimum (9.73 and 18.34%; 9.61 and 18.46% after 4 and 8 days of harvesting) and shelf-life increased (4.74 and 6.85 days) in harvested fruit in T_{17} during rainy and winter season, respectively. The overall quality of the fruit was higher throughout the winter than during the rainy season. Hence, a portion of chemical fertilizers can be reduced in fertilization of guava plants through the integrated application of different organic amendments with improvement in different quality parameters.

Keywords: Biofertilizers, Biochemical parameters, Fruits, Guava, Organic treatments, Shelf-life

Guava (*Psidium guajava* L.), a tropical American fruit that is frequently referred to as a superfruit, is a member of the Myrtaceae family. With 4.1% of the total area under horticultural crops under guava cultivation, it is the fifth-most significant fruit crop in India (Singh 2009, Anonymous 2021). In Haryana, guava crop occupies 1.4543 thousand ha area with yield of 260851.25 MT and productivity of 17.9 MT/ha (Anonymous 2021). The fruit holds significant commercial importance in India, China, Florida, Hawaii, Egypt, Yemen, Brazil, Mexico, Colombia, West Indies, Cuba, Venezuela, Indonesia, New-Zealand, Philippines, Vietnam, South Africa and Thailand (Tate 2000).

Physiological growth and fruit yield of guava tree is largely influenced by nutrient availability. Nitrogen, phosphorus, potassium, zinc, iron, copper, manganese, and boron are macro-and micronutrients that are vital for increasing growth, vigour, and productivity (Zagade *et al.* 2017). However, the unrestricted utilization of chemical fertilizers in conventional farming, which aims to maximise productivity, has resulted in several issues. Non-judicious use of fertilizers has caused large scale multi-nutrient deficiency and loss of soil's ability to produce (Chhonkar 2008). Addition of organic fertilizers/manure and inoculation of crop with beneficial microorganisms (biofertilizers) enhances atmospheric nitrogen fixation, decomposes organic wastes and residues, improves soil properties and speeds up nutrient cycling resulting in increased plant growth. As an effect of the application of organic manures and biofertilizers, there are reports of an improvement in fruit and vegetable yield and quality (Sourabh *et al.* 2018). Thus, the present study was carried out to determine the amount of inorganic fertilizers to be replaced with organic manures and/or biofertilizers in guava, with prime focus on the biochemical and post-harvest parameters of fruits.

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MATERIALS AND METHODS

The field study was carried out at the experimental orchard, and biochemical analysis was performed at the Department of Horticulture and Soil Science's laboratory, CCS Haryana Agricultural University, Hisar (29º 10´ N and 75º 46´ E with 215.2 m amsl), Haryana during rainy (*kharif*) and winter (*rabi*) season of 2018–19 and 2019–20, respectively. Hisar has a typical semi-arid climate with hot and dry summer and extremely cold winter. The mean monthly maximum and minimum temperature show a wide range of fluctuations both in summer and winter months. The pattern of precipitation is highly unpredictable, with seasonal variance accounting for 30–50% and annual variation for 20–30%.

Experimental layout and treatment details: The study was carried out on 57 trees of Hisar Surkha (4-years-old) with a spacing of 6 m × 6 m in the experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar. For experimentation, 3 replications of each treatment and one fruit tree per replication were arranged in a randomised block design. Dosage of fertilizer recommended for 4-year-old guava plants (100% RDF) was 40 kg FYM + 0.8 kg Urea + 0.8 kg Super phosphate + 0.4 kg Potassium sulphate. The other two doses were 75% RDF and 50% RDF. The following 19 treatments were given: T_1, RDF 50%; T_2, RDF 50% + FYM 30 kg/plant; T_3, RDF 50% + Vermicompost 10 kg/plant; T_4, RDF 50% + FYM + *Azotobacter* + PSB; T_5, RDF 50% + Vermicompost + *Azotobacter* + PSB; T_6, RDF 50% + *Azotobacter* + PSB; T_7, RDF 75%; T_8, RDF 75% + FYM 30 kg/plant; T_9, RDF 75% + Vermicompost 10 kg/plant; T_{10}, RDF 75% + FYM + *Azotobacter* + PSB; T_{11}, RDF 75% + Vermicompost + *Azotobacter* + PSB; T_{12}, RDF 75% + *Azotobacter* + PSB; T_{13}, RDF 100%; T_{14}, RDF 100% + FYM 30 kg/plant; T_{15}, RDF 100% + Vermicompost 10 kg/plant; T_{16}, RDF 100% + FYM + *Azotobacter* + PSB; T_{17}, RDF 100% + Vermicompost + *Azotobacter* + PSB; T_{18}, RDF 100% + *Azotobacter* + PSB; T_{19}, Control (absolute).

Biochemical analysis of fruit samples: Total soluble solids of guava fruits from different treatments were determined by hand refractometer and the values were expressed in °Brix (Ranganna 1986). The method suggested by A.O.A.C. (2000) was followed for estimation of titratable acidity. The ascorbic content (Vitamin C) of the guava fruit flesh was determined using the 2,6-dichlorophenol indophenol dye (DCPIP) visual titration method in accordance with A.O.A.C. (2000). According to Ranganna's method (1979), the pectin content of guava pulp was determined as calcium pectate.

Post-harvest parameters: The physiological loss in weight (PLW) of the guava fruit was recorded as (Srivastava and Tandon 1968):

$$\text{PLW (\%)} = \frac{\text{Initial weight (g)} - \text{final weight (g)}}{\text{Initial weight (g)}} \times 100$$

Observations of the fruit's shelf life were based on ripeness, appearance and physiological weight loss. Ten randomly selected, uniformly ripe fruits were collected from each treatment and stored at room temperature. The number of days from the date of harvest that fruit remains in acceptable condition were recorded as the shelf-life of fruit.

Statistical analysis was carried out using OPSTAT (Sheoran 1998), a windows-based computer programme, at 5% level of the significance

RESULTS AND DISCUSSION

Biochemical parameters: Observations pertaining to bio-chemical parameters of guava fruits (TSS, acidity, vitamin C and pectin content) are presented in Table 1. The data reveals that TSS was higher during the winter than during the rainy season. During both seasons, T_{17} resulted in the higher TSS (11.73 and 12.54°Brix), which is comparable to 100% RDF treatments with biofertilizers, such as T_{16} and T_{18}. The control treatment (T_{19}) resulted in the lowest TSS levels (9.38 and 9.75°Brix, respectively) throughout the rainy and winter seasons. Over the two-year study period, fruits from the winter season were less acidic than fruits from the rainy season, regardless of the integrated nutrient treatments. During the rainy and winter seasons, T_{16} had the lowest acidity (0.43 and 0.37%), while the control had the highest acidity (0.71 and 0.60%, respectively). It is obvious from a review of the data that the various organic amendments and biofertilizers influenced the vitamin C content of guava fruit. The treatment T_{16} resulted in fruits with highest vitamin C content (200.5 and 208.8 mg/100 g) compared to control (169.5 and 183.6 mg/100 g). Throughout the rainy and winter seasons, fruits harvested from trees fertilized with T_{17} had the highest pectin content (0.83 and 0.87%), whereas plants without any fertilization produced fruits with the lowest pectin content (0.60 and 0.62%). In addition, regardless of treatment, winter-harvested fruits contained a high proportion of vitamin C (ascorbic acid) and pectin than rainy season fruits.

The optimal amount of NPK permits phosphorus to efficiently build phospholipids and nucleic acids, which interact with proteins to form nucleo proteins, hence enhancing chemical properties. The chain reactions of these factors might have been the reason for the improvement in guava fruit quality in our study (Kundu *et al.* 2007, Kumar *et al.* 2008 and Kumar *et al.* 2009). Biofertilizers are reported to accelerate mineralization and conversion of plant nutrients in soil (Chandra *et al.* 2016). Bio inoculants such as PSB generate organic acids that transform insoluble phosphates into readily absorbable forms such as hypophosphite (Parveen *et al.* 2008). In addition, FYM enhances growth of soil microorganisms and excrete plant promoting substances such as hormones, vitamins and amino acids. In agreement with our conclusions, previous workers have reported enhanced fruit quality in acid lime (Khan and Begum 2007); strawberry (Kirad *et al.* 2009); guava [Shukla *et al.* (2009), Sahu *et al.* (2015), Gupta *et al.* (2021), Kumar *et al.* (2022)], and mango, and papaya (Yadav *et al.* 2011). According to Shukla *et al.* (2009), the application of 50% of the prescribed dose of NPK + 50 kg FYM + 250 g *Azotobacter* considerably raised the TSS (14%), ascorbic acid (198.30 mg/100 g pulp), reducing sugar (4.77%), and total sugars (8.10%) in high density Sardar guava plantations. Nitrogen fixed in phyllosphere might

Table 1 Effect of different treatments on biochemical parameters of guava fruits during the study period

Treatment	TSS (°Brix)		Acidity (%)		Vitamin C (mg/100 g)		Pectin (%)	
	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season	Rainy season	Winter season
T_1	9.75	10.72	0.60	0.51	174.9	188.5	0.64	0.66
T_2	9.84	10.92	0.59	0.50	175.9	190.0	0.65	0.68
T_3	9.93	10.99	0.61	0.52	177.3	191.6	0.66	0.69
T_4	10.11	11.48	0.59	0.50	180.1	194.2	0.65	0.68
T_5	10.22	11.55	0.60	0.51	182.8	194.8	0.66	0.69
T_6	10.17	11.47	0.58	0.49	179.9	193.6	0.68	0.71
T_7	10.48	11.58	0.56	0.49	184.3	196.0	0.68	0.70
T_8	10.54	11.68	0.53	0.46	186.1	197.3	0.69	0.71
T_9	10.61	11.73	0.53	0.47	187.1	198.0	0.70	0.73
T_{10}	10.74	11.87	0.52	0.45	188.8	198.4	0.73	0.75
T_{11}	10.85	11.89	0.54	0.47	190.6	200.3	0.74	0.77
T_{12}	10.73	11.75	0.53	0.49	188.4	198.9	0.74	0.76
T_{13}	11.07	12.02	0.49	0.42	194.1	202.3	0.76	0.79
T_{14}	11.27	12.15	0.47	0.44	195.4	203.5	0.77	0.80
T_{15}	11.33	12.25	0.46	0.40	196.6	205.6	0.80	0.83
T_{16}	11.62	12.46	0.43	0.37	200.5	208.8	0.81	0.85
T_{17}	11.73	12.54	0.45	0.39	199.1	208.4	0.83	0.87
T_{18}	11.48	12.34	0.48	0.41	197.6	206.7	0.82	0.84
T_{19}	9.38	9.75	0.71	0.60	169.5	183.6	0.60	0.62
CD (P=0.05)	0.32	0.35	0.06	0.05	5.5	5.9	0.02	0.02

Treatment details are given under Materials and Methods.

have enhanced photosynthesis thereby increasing available photosynthates and their translocation from leaves to fruit, thus enhancing nutrient utilization efficiency. Vitamin C as well as pectin content is suggested to increase due to fixation of atmospheric nitrogen, increased availability of phosphorus along with secretion of growth promoting substances by accelerating the physiological process like carbohydrate synthesis by microbial inoculants (Tripathi *et al.* 2014).

Post-harvest parameters: During rainy season, 2018–19 and 2019–20, minimum physiological loss in weight (9.73 and 18.34%; 9.61 and 18.46%) was perceived in T_{17} after 4 and 8 days of storage, respectively in contrast to control that exhibited maximum physiological loss in weight (Table 2). Successive winter seasons in both years produced identical results. The findings revealed winter season fruits exhibited longer shelf-life as compared to rainy season fruits, irrespective of treatments. Treatments comprising 75% RDF (T_7 to T_{12}) and 100% RDF (T_{13} to T_{18}) were found superior to the control as well as 50% RDF treatments (T_1 to T_6). Maximum shelf-life (4.74 and 6.85 days) was documented in T_{17} while minimum (2.17 and 3.13 days) in control during rainy and winter season, respectively.

Though, literature perusal shows scarce reports are available on the subject. In line with our findings, Sharma *et al.* (2013) and Krishna and Krishnappa (2002) reported longer shelf-life in fruits harvested from plants supplemented with organic manures and *Azotobacter* in addition to inorganic fertilizers. This has been attributed to the fruit's altered physiology and biochemistry as a result of the influence of both organic and inorganic fertilizers, which reduced respiration and transpiration, resulting in minimal cumulative physiological weight loss and an increase in shelf-life. Better growth resulting into firm fruits with more pericarp thickness, on account of proper and adequate availability of all macro and micro nutrients, leads to improved shelf-life (Gosavi *et al.* 2010).

According to the findings of the study, all treatments consisting of various organic amendments and biofertilizers significantly affected and improved the biochemical and post-harvest parameters of guava fruits. T_{17} had the highest TSS, whereas T_{16} had the lowest acidity and the highest TSS: Acidity ratio. T_{16} was found to have the highest level of vitamin C, while T_{17} had the highest level of pectin. During the winter season, fruit contained more vitamin C and pectin compared to the rainy season. All treatments had a significant effect on the fruit's total sugars, reducing sugars, and non-reducing sugars. T_{17} had the highest levels of total sugars during the rainy season, while T_{16} had the highest levels during the winter season. Integration of organic manures and biofertilizers with RDF had a substantial impact on post-harvest fruit quality. In T_{17}, physiological weight loss was minimal and the shelf-life of harvested fruit

Table 2 Effect of different treatments on post-harvest parameters of guava fruits during the study period

Treatment	Physiological loss in weight (%)								Shelf-life (days)					
	2018–2019				2019–2020				2018–2019		2019–2020		Pooled rainy	Pooled winter
	Rainy season		Winter season		Rainy season		Winter season		Rainy season	Winter season	Rainy season	Winter season		
	After 4 days	After 8 days	After 4 days	After 8 days	After 4 days	After 8 days	After 4 days	After 8 days						
T_1	13.87	25.70	8.14	23.37	13.82	25.08	8.42	23.41	2.42	3.51	2.44	3.53	2.43	3.52
T_2	13.83	25.63	8.09	23.03	13.72	25.37	8.49	23.06	2.48	3.60	2.51	3.61	2.50	3.60
T_3	13.77	25.52	8.02	23.23	13.78	25.26	8.20	23.24	2.63	3.81	2.61	3.82	2.62	3.82
T_4	12.97	24.04	7.00	21.15	13.09	24.40	7.12	21.16	2.78	4.03	2.74	4.06	2.76	4.05
T_5	13.03	24.15	6.92	20.27	12.94	24.51	6.39	20.25	3.12	4.52	3.21	4.56	3.17	4.54
T_6	13.27	24.59	7.06	21.40	13.02	24.94	7.60	21.42	2.65	3.84	2.36	3.81	2.51	3.83
T_7	12.63	23.01	6.80	22.25	12.98	23.41	6.24	22.26	3.27	4.74	3.23	4.76	3.25	4.75
T_8	12.57	22.90	6.76	20.18	12.11	12.10	6.67	20.16	3.56	5.16	3.45	5.18	3.51	5.17
T_9	12.69	23.12	6.69	20.20	12.98	23.43	6.96	20.23	3.65	5.29	3.64	5.26	3.65	5.28
T_{10}	12.48	23.94	6.04	19.90	12.32	23.50	6.41	19.80	3.93	5.70	3.93	5.72	3.93	5.71
T_{11}	12.50	23.98	5.97	19.86	12.58	23.87	5.78	19.86	3.97	5.76	3.97	5.74	3.97	5.75
T_{12}	12.53	24.04	6.28	20.10	12.47	24.42	6.39	20.12	3.88	5.63	3.86	5.67	3.87	5.65
T_{13}	10.92	20.58	5.32	20.08	11.19	20.87	5.34	20.07	4.06	5.89	4.08	5.91	4.07	5.90
T_{14}	10.57	19.75	5.13	19.85	11.04	19.58	5.24	19.87	4.27	6.19	4.29	6.22	4.28	6.21
T_{15}	10.43	19.14	4.95	19.49	10.24	19.52	4.66	19.45	4.48	6.50	4.51	6.53	4.50	6.51
T_{16}	9.87	18.64	4.72	18.59	9.62	18.47	4.46	18.57	4.63	6.71	4.63	6.75	4.63	6.73
T_{17}	9.73	18.34	4.65	18.31	9.61	18.46	4.34	18.33	4.72	6.84	4.75	6.86	4.74	6.85
T_{18}	9.95	18.56	4.84	19.06	9.98	18.61	4.67	19.08	4.58	6.64	4.61	6.66	4.60	6.65
T_{19}	13.94	26.06	8.25	23.68	13.92	25.59	8.51	23.69	2.15	3.12	2.18	3.14	2.17	3.13
CD (P=0.05)	0.39	0.73	0.21	0.66	0.36	0.66	0.19	0.61	0.11	0.16	0.11	0.16	0.12	0.15

Treatment details are given under Materials and Methods.

was increased. Fruit quality parameters specifically TSS, acidity, TSS:Acid ratio, vitamin C content, pectin content, total sugars, reducing sugars and non-reducing sugars were improved with 100% RDF + vermicompost + *Azotobacter* + PSB. Shelf-life of fruits increased with integrated use of 100% RDF with vermicompost and biofertilizers. In addition, the total fruit quality was higher throughout the winter than during the rainy season.

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