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Influence of liquid and carrier based biofertilizers on growth characters of guava (*Psidium guajava* L.) cv. Taiwan White

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Abstract
An experiment was carried out to know the influence of liquid and carrier based biofertilizers on growth characters of guava cv. Taiwan White at College of Horticulture, Dr. YSRHU, V.R. Gudem, Andhra Pradesh during 2019-20 and 2020-21 on four year old guava trees planted at 2.8 x 2.8 spacing. The experiment was carried out in a factorial RBD with three replications. Among the treatments, all the inorganic and biofertilizer combinations exhibited profound effect on growth parameters than inorganic fertilizer alone. Guava trees applied with 100% RDF along with liquid biofertilizers (T_2) was found superior in respect of increment in tree height (0.65 m), trunk girth (3.35 cm), E-W canopy spread (0.68m), N-S canopy spread (0.63 m), canopy volume (7.05 m^3), leaf area (64.81 cm^2) and leaf chlorophyll content (56.66 SPAD units) during both the years of study. It was on par with trees applied with 80% RDF in combination with liquid biofertilizers (T_5) in respect of increment in N-S canopy spread (0.60 m), leaf area (63.57 cm^2) and leaf chlorophyll content (54.94 SPAD units).

Keywords: Influence, liquid, carrier, biofertilizers, characters, *Psidium guajava* L.

Introduction
Guava (*Psidium guajava* L.) is one of the most popular fruit grown in tropical and sub-tropical regions of India and belongs to the family Myrtaceae. It stands as the fifth most important fruit crop in both area and production after mango, banana, citrus and papaya. At present in India, it occupies nearly 2.65 lakh ha area with a production of 40.54 lakh tonnes and productivity of 15.3 MT ha^{-1}. In Andhra Pradesh it is cultivated in an area of 9,530 ha producing 2, 29, 780 MT (NHB, 2020) [8].

Guava is highly responsive to application of fertilizers. Though chemical fertilizers fulfil the major requirement of the crop, their excessive and unbalanced use may lead to ecological hazards, depletion of physico- chemical properties of the soil and degradation of soil health which ultimately affect crop yield. Under such circumstances there is a need to consider other sources of nutrients in lieu of chemical fertilizers to raise crop productivity without degradation of the soil properties and the environmental quality.

Biofertilizers are known to play a number of vital roles in soil fertility, crop production and productivity in horticulture. They are low cost, renewable sources of plant nutrients and have the ability to use freely available solar energy, atmospheric nitrogen and water. Biofertilizers are gaining momentum recently due to the emphasis on maintenance of soil health, minimize environmental pollution and cut down the use of chemicals in agriculture (Choudhury and Kennedy, 2005) [5]. Liquid biofertilizers are liquid formulations containing the dormant form of desired microorganisms and their nutrients along with the substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to adverse conditions (Verma *et al.*, 2011) [12]. The advantages of liquid biofertilizers over conventional carrier based biofertilizers include longer shelf life (12- 24 months), no effect of high temperature and no contamination, no loss of properties due to storage at high temperature up to 45 ^{0}C and high populations can be maintained at more than 10^9 cells/ ml up to 12 to 24 months. It is farmer's friendly for use, recommended dosage is four times less than carrier based biofertilizer and recorded high export potential (Viswakarma *et al.*, 2017) [13].

In the present scenario, farmers are opting fertigation which ensures precise timing and uniform distribution of nutrients and is an efficient and agronomically sound method of providing soluble plant nutrients directly to the active plant root zone.

Biofertigation with liquid biofertilizers is the efficient and precise use of beneficial microorganisms through a microirrigation system over carrier based biofertilizers. However, limited attempts have been made to study the influence of liquid formulations on the growth, yield and quality of fruits in India and there is need to validate the relative advantage of liquid formulations over carrier based biofertilizers. Keeping these points in view, an investigation entitled "Influence of liquid and carrier based biofertilizers on growth characteristics of guava (*Psidium guajava* L.) cv. Taiwan White".

Material and Methods

The present investigation "Influence of liquid and carrier based biofertilizers on growth characteristics of guava (*Psidium guajava* L.) cv. Taiwan White" was carried out for two fruiting years (Mrig Bahar) *viz.*, 2019-2020 and 2020-2021 in an existing four year old guava orchard with uniform size trees planted in square system with spacing of 2.8 m x 2.8 m at Instructional Farm, Department of Fruit Science, College of Horticulture, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari district of Andhra Pradesh. The experiment was laid out in Factorial RBD with two factors and three replications. The first factor consisted of three levels of RDF (100%, 80% and 60% of RDF) and the second factor with three levels of different combinations of biofertilizers (NFB + PSB + KSB liquid biofertilizers, NFB + PSB + KSB carrier based biofertilizers and without biofertilizers) comprising nine treatment combinations *viz.*, T_1 (100% RDF + NFB + PSB + KSB carrier based biofertilizers), T_2 (100% RDF + NFB + PSB + KSB liquid biofertilizers), T_3 (100% RDF + NFB + PSB + KSB without biofertilizers), T_4 (80% RDF + NFB + PSB + KSB carrier based biofertilizers), T_5 (80% RDF + NFB + PSB + KSB liquid biofertilizers), T_6 (80% RDF + without biofertilizers), T_7 (60% RDF + NFB + PSB + KSB carrier based biofertilizers), T_8 (60% RDF + NFB + PSB + KSB liquid biofertilizers), T_9 (60% RDF + without biofertilizers). The salient findings with respect to growth parameters are summarized below.

Results and Discussion

It has been observed that the growth characteristics of guava *viz.*, tree height, trunk girth, canopy (N-S and E-W), leaf area and leaf chlorophyll content significantly increased with the combined application of bio fertilizers and inorganic fertilizers (Table 1 & 2).

Guava trees applied with 100% RDF along with liquid biofertilizers (NFB, PSB and KSB) (T_2) was found superior in respect of increment in tree height (0.65 m), trunk girth (3.35 cm), E-W canopy spread (0.68m), N-S canopy spread (0.63 m), canopy volume (7.05 m^3), leaf area (64.81 cm^2) and leaf chlorophyll content (56.66 SPAD units) during both the years of study. It was on par with trees applied with 80% RDF in combination with liquid biofertilizers (NFB, PSB and KSB) (T_5) in respect of increment in N-S canopy spread (0.60 m), leaf area (63.57 cm^2) and leaf chlorophyll content (54.94 SPAD units). The minimum increment in tree height (0.33 m), trunk girth (1.68 cm), E-W canopy spread (0.30 m), N-S canopy spread (0.39 m), canopy volume (3.27 m^3), leaf area (41.98 cm^2) and leaf chlorophyll content (37.08 SPAD units) was recorded in trees applied with 60% RDF alone.

The increase in the growth parameters *viz.*, tree height, trunk girth, Canopy spread (East-West and North-South) and canopy volume with the application of RDF along with biofertilizer might be due to better uptake and translocation of nitrogen to the growing trees as a result of more nutrient availability. The fact behind increment in growth is that, application of nitrogen encourages vegetative growth through the formation of new cells, cell division, cell elongation and cell development. Moreover, biofertilizers produce the growth promoting substances *viz.*, auxins, gibberellins and cytokinins, which contributes toward vigorous growth of the plant (Azcon and Barea, 1975) [2]. The biofertilizers also help in fixing atmospheric nitrogen and also solubilization of phosphorous and potassium by producing organic acids through their metabolic process (Verma *et al*., 2011) [12]. This resulted in vigorous growth of root system, which ultimately helped in better absorption and utilization of nutrients from soil and from applied nitrogen and biofertilizers as reflected in terms of better tree growth. The increment in growth parameters might be due to due to continuous supply of nutrients by the quick release of inorganic fertilizers in the initial stages and the slow release of organic fertilizers at later stages.

Leaf area is having direct correlation with photosynthetic efficiency in trees. Leaf area was significantly increased by nitrogen application possibly because nitrogen helps in greater assimilation of food material by the tree which resulted in greater meristematic activities of cells and consequently the number of leaves, leaf length and width of leaf. The amount of chlorophyll in tree depends on soil nitrogen availability and the ability of nitrogen absorption by the tree. The increase in leaf chlorophyll might be ascribed to the fact that the trees enjoyed better nutrition especially N from inorganic as well as biofertilizers and hence enhanced chlorophyll content. Bacterial inoculation in soil through applied biofertilizers could have improved phosphorus and potassium availability in the soils by producing organic acids and other chemicals leading to stimulate growth and mineral uptake of trees which might resulted in improved chlorophyll content (Park, 2005). The results of this investigation are also supported by the findings of Bhobia *et al*. (2005) [4], Ram *et al*. (2007), Baksh *et al*. (2008) [3], Atom (2013) [1], Godage *et al*. (2013) [7], Kumar *et al*. (2017) and Dwivedi and Agnihotri (2018) [6] in guava and Singh and Singh (2009) [11] in ber.

Table 1: Influence of different levels of RDF and biofertilizers on increment in tree height (m), trunk girth (cm) and canopy spread (E-W and N-S) in guava cv. Taiwan White Pooled data of 2019-20 & 2020-21)

Fertilizers (F)	Biofertilizers (B)															
	Tree height (m)				Trunk girth (cm)				Canopy spread (E-W) (m)				Canopy spread (N-S) (m)			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
F_1(100% RDF)	0.54	0.65	0.51	0.57	3.05	3.35	2.79	3.06	0.57	0.68	0.50	0.58	0.54	0.63	0.49	0.55
F_2 (80% RDF)	0.52	0.60	0.44	0.52	2.89	3.17	2.35	2.80	0.51	0.62	0.44	0.52	0.51	0.59	0.45	0.52
F_3 (60% RDF)	0.46	0.49	0.33	0.43	2.39	2.42	1.68	2.16	0.45	0.47	0.30	0.40	0.47	0.48	0.39	0.45
Mean	0.51	0.58	0.43	0.50	2.78	2.98	2.27	2.68	0.51	0.59	0.41	0.50	0.50	0.57	0.45	0.51
Factor	S Em +		CD at 5%		S Em +		CD at 5%		S Em +		CD at 5%		S Em +		CD at 5%	

Fertilizers (F)	0.01	0.02	0.02	0.05	0.01	0.02	0.01	0.02
Biofertilizers (B)	0.01	0.02	0.02	0.05	0.01	0.02	0.01	0.02
F x B	0.01	0.04	0.03	0.08	0.01	0.04	0.01	0.04
Average initial observations	3.22		31.60		2.43		2.83	

F_1- 100% RDF (400:160:400 g NPK per tree)
F_2- 80% RDF (320:128:320 g NPK per tree)
F_3- 60% RDF (240:96:240 g NPK per tree)
B_1- Carrier based biofertilizers (NFB + PSB + KSB) @ 100 g per tree
B_2- Liquid biofertilizers (NFB + PSB + KSB) @ 5 ml per tree
B_3- Without biofertilizers

Table 2: Influence of different levels of RDF and biofertilizers on increment in canopy volume (m^3), leaf area (cm^2) and leaf Chlorophyll content (SPAD Units) in guava cv. Taiwan White (Pooled data of 2019-20 & 2020-21)

Fertilizers (F)	**Biofertilizers (B)**											
	Canopy volume (m^3)				**Leaf area (cm^2)**				**Leaf chlorophyll content (SPAD UNITS)**			
	B_1	**B_2**	**B_3**	**Mean**	**B_1**	**B_2**	**B_3**	**Mean**	**B_1**	**B_2**	**B_3**	**Mean**
F_1(100% RDF)	5.67	7.05	5.10	5.94	58.26	64.81	53.69	58.92	52.99	56.66	49.48	53.04
F_2 (80% RDF)	5.25	6.36	4.44	5.35	56.84	63.57	48.64	56.35	50.76	54.94	44.00	49.90
F_3 (60% RDF)	4.56	4.84	3.27	4.23	49.33	50.50	41.98	47.27	45.33	46.67	37.08	43.03
Mean	5.16	6.08	4.27	5.17	54.81	59.63	48.10	54.18	49.70	52.76	43.52	48.66
Factor	S Em +		CD at 5%		S Em +		CD at 5%		S Em +		CD at 5%	
Fertilizers (F)	0.05		0.16		0.32		0.95		0.35		1.05	
Biofertilizers (B)	0.05		0.16		0.32		0.95		0.35		1.05	
F x B	0.09		0.28		0.55		1.64		0.60		1.81	

Average initial canopy volume - 8.02 m^3

F_1- 100% RDF (400:160:400 g NPK per tree)
F_2- 80% RDF (320:128:320 g NPK per tree)
F_3- 60% RDF (240:96:240 g NPK per tree)
B_1- Carrier based biofertilizers (NFB + PSB + KSB) @ 100 g per tree
B_2- Liquid biofertilizers (NFB + PSB + KSB) @ 5 ml per tree
B_3- Without biofertilizers

Conclusion

Conjoint application of 100% RDF along with liquid biofertilizers has produced significantly superior effects on most of the growth parameters of guava. The performance of 80% RDF along with liquid biofertilizers in respect of growth was found at par with the superior treatment besides maintaining the soil fertility. The results also indicated that the dosage of inorganic fertilizers can be reduced by 20 per cent when applied with liquid biofertilizers.

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