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Influence of carrier based and liquid biofertilizers on yield attributing characters and yield of guava cv. Taiwan White

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Abstract
An experiment was carried out to know the influence of carrier and liquid biofertilizers on yield attributing characters and yield of guava cv. Taiwan White at College of Horticulture, Dr. YSRHU, V.R. Gudem, Andhra Pradesh during 2019-20 and 2020-21 on three 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 yield parameters than inorganic fertilizer alone. Guava plants applied with 100% RDF +NFB, PSB and KSB liquid biofertilizers (T_2) showed significant differences with respect to number of fruits plant^{-1} (62.67), fruit weight (375.09 g), fruit diameter (9.61cm), fruit length (9.65 cm), fruit volume (368.38 cm^3), fruit yield plant^{-1} (23.51 kg) and fruit yield acre^{-1} (11.96 t/acre) which was on par with 80% RDF + NFB, PSB and KSB liquid biofertilizers (T_5) for number of fruits plant^{-1} (61.50), fruit weight (371.03 g), fruit diameter (9.49 cm), fruit yield plant^{-1} (22.82 kg) and for fruit yield acre^{-1} (11.58 t/ha).

Keywords: Guava, inorganic fertilizer, carrier based biofertilizer, liquid biofertilizer, yield

Introduction
Guava (*Psidium guajava* L.) is one of the most important fruit crops of India originated from tropical America. It covers around 3.3% of the total area under fruit crops and contributes 3.3% of the total fruit production in India. It is one of the most popular fruit grown in tropical and sub-tropical regions of India, which 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 (Anon, 2020).Guava is considered as "apple of tropics" because of its richness in vitamins and minerals. Singh *et al*. (2003) [16] reported that guava is a good source vitamin C (75-260 mg 100 g^{-1} pulp), pectin (0.5-1.8%), thiamine (0.03-0.07 mg 100 g^{-1} pulp) and riboflavin (0.02-0.04 mg 100 g^{-1} pulp) and. Besides this, guava fruits are also a rich source of minerals like phosphorous (22.5-40 mg 100 g^{-1}), calcium (10-30 mg 100 g^{-1}) and iron (0.60-1.39 mg 100 g^{-1}).

Decline in soil health due to excessive dependence on chemical inputs left us with no other option but to utilising biological inputs like biofertilizers which is sought to be one of the answers to restore the soil health apart from solving nutrition problem of plants. Biofertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilize plant nutrients in soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. It is mainly used for field crops but now-a-days it is used for fruit crops also.

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 There are several advantages of liquid biofertilisers over conventional carrier based biofertilisers. The shelf life of common solid carrier based biofertilisers is around six months whereas it could be as high as two years for a liquid formulation. Further, solid carrier based biofertilisers are less thermo sensitive however liquid formulations can tolerate the temperature of 55 ^{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 (Verma *et al.*, 2011) [17].

Now-a-days farmers are opting fertigation which allows precise timing and uniform distribution of fertilizer nutrients and is an efficient and agronomically sound method of providing soluble plant nutrients directly to the active plant root zone. Biofertigation with liquid biofertilisers is the efficient and precise use of beneficial microorganisms through a microirrigation system over carrier based biofertilizers. Considering the above facts in view, the integrated approach of inorganic fertilizers and biofertilizers were used to know the effect on yield attributing characters and yield of guava cv. Taiwan White.

Material and Methods

The present research was carried out at the Instructional orchard, Department of Fruit Science, College of Horticulture, V.R.Gudem, Dr.YSRHU, Andhra Pradesh during the years 2019-20 and 2020-21 and the research was conducted on three year old guava trees planted at 2.8 x2.8 m spacing. The experiment was carried out in a factorial RBD with three replications. The first factor consists of three levels of chemical fertilizers and the second factor consists of three different combinations of biofertilizers totaling to nine treatment combinations of varying levels of chemical fertilizers and different combination of biofertilizers. The treatment combinations are T_1: F_1B_1- 100% RDF + NFB + PSB + KSB (carrier based biofertilizer);T_2: F_1B_2- 100% RDF + NFB+ PSB + KSB (liquid biofertilizer); T_3: F_1B_3- 100% RDF + without biofertilizer; T_4: F_2B_1- 80% RDF + NFB + PSB + KSB (carrier based biofertilizer); T_5: F_2B_2- 80% RDF + NFB + PSB + KSB (liquid biofertilizer); T_6: F_2B_3- 80% RDF + without biofertilizers; T_7: F_3B_1- 60% RDF + NFB + PSB + KSB (carrier based biofertilizer); T_8: F_3B_2- 60% RDF + NFB + PSB + KSB (liquid biofertilizer) and T_9: F_3B_3- 60% RDF + without biofertilizer. Recommended dose of fertilizer was 400:160:400 g NPK/tree. Biofertilizers *viz.*, NFB (*Azotobacter chroococcum*) + PSB (*Bacillus megaterium*) + KSB (*Bacillus mucilaginosus*) were thoroughly mixed with FYM and allowed to multiply for one week under shade, prior to application in tree basins. Biofertilizers were applied in the tree basins 60 cm away from the tree trunk after two weeks of inorganic fertilizers application. Dosage of carrier based biofertilizer was 100 g per plant and liquid biofertilizer was 5 ml per plant. Observations on yield attributing and yield parameters such as number of fruits per plant, fruit weight, fruit diameter, fruit length, fruit volume, fruit yield per plant and yield per acre were recorded.

Results and Discussion

Number of fruits plant^{-1}

The data recorded in table 1 reveals the number of fruits per plant of guava cv. Taiwan White under different treatment combinations. The maximum number of fruits per plant (62.67) was recorded in (T_2) and was on par with number of fruits per plant (61.50) recorded in (T_5) followed by (T_1) with 56.17 and the lowest number of fruits per plant (36.17) was recorded in T_9. Maximum fruit retention per tree might be due to supply of all the nutrients in adequate quantities right from inception of the experiment to the harvesting of the crop, which induced more flowering and retention of fruits by supply of photosynthates at critical stage (Mahendra and Singh, 2009b) [11]. Chandra (2014) [5] reported that biofertilizers application could be a result of the improvement in soil physical, biological and chemical properties which in turn, provided required nutrition for the conversion of flowers to fruits resulting in higher fruit set and ultimately increased the number of fruits per tree. The results were also in accordance with the findings of Yadav *et al.* (2011) [18] and Nehete and Jadav (2019) [12] in mango, Yadav *et al.* (2009) [19] in aonla, Mahendra and Singh (2009b) [11] in ber, Barne *et al.* (2011) [2] and Godage (2012) [10] in guava.

Table 1: Influence of different levels of NPK and biofertilizers on number of fruits per plant, fruit weight (g), fruit diameter (cm) and fruit length (cm) in guava cv. Taiwan White (Pooled data of 2019-20 and 2020-21)

Recommended dose of fertilizers (400:160: 400 g NPK/tree)	Biofertilizers															
	Number of fruits tree^{-1}				Fruit weight (g)				Fruit diameter (cm)				Fruit length (cm)			
	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	56.17	62.67	51.83	56.89	355.66	375.09	331.11	353.95	9.22	9.61	8.83	9.22	9.31	9.65	8.98	9.31
F_2	52.17	61.50	40.17	51.28	337.30	371.03	254.93	321.09	9.06	9.49	7.99	8.85	9.13	9.47	8.32	8.97
F_3	42.33	42.67	36.17	40.39	278.43	294.03	211.65	261.37	8.34	8.48	7.26	8.03	8.55	8.59	6.63	7.93
Mean	50.22	55.61	42.72	49.52	323.79	346.72	265.90	312.14	8.87	9.19	8.03	8.70	9.00	9.24	7.98	8.74
Factor	F	B	F x B		F	B	F x B		F	B	F x B		F	B	F x B	
SE (m) +	0.32	0.32	0.55		0.79	0.79	1.36		0.03	0.03	0.04		0.03	0.03	0.05	
CD at 5%	0.96	0.96	1.66		2.36	2.36	4.09		0.08	0.08	0.13		0.08	0.08	0.14	

F_1- 100% RDF; F_2- 80% RDF; F_3- 60% RDF

B_1- NFB, PSB and KSB carrier based biofertilizers; B_2- NFB, PSB and KSB liquid biofertilizers; B_3- Without biofertilizer

Fruit weight (g), fruit diameter (cm), fruit length (cm) and fruit volume (cm^3).

Data exhibited in table 1 revealed that the maximum fruit weight (375.09 g) was recorded in (T_2) and was on par with fruit weight of 371.03 g recorded in (T_5). This was followed by (T_1) with 355.66 g and the minimum fruit weight (211.65 g) was recorded in T_9. The data on fruit diameter in guava cv. Taiwan White under different biofertilizers treatments combinations were exhibited in table 1. The higher diameter of fruit (9.61 cm) was recorded with (T_2) which was on par with fruit diameter (9.49 cm) observed in (T_5) followed by (T_1) (9.22 cm) and the least fruit diameter (7.26 cm) was recorded in (T_9).The data presented in table 1 reveals that the treatment combination (T_2) recorded maximum fruit length (9.65 cm) followed by (T_5) with fruit length (9.47 cm) and the minimum fruit length (6.63 cm) was recorded in (T_9). The data presented in table 2 reveals that the treatment combination (T_2) was found superior and recorded maximum fruit volume (368.38 cm^3) followed by (T_5) with 363.33 cm^3 and lowest fruit volume (205.67 cm^3) was recorded with (T_9).

The fruit characters *viz.*, fruit weight, fruit length, fruit diameter and fruit volume were improved by the application of NPK along with biofertilizers. The application of N, P and K fertilizers might have resulted in high rate of

photosynthesis which leads to higher carbohydrate accumulation in fruit and thereby increasing the fruit size and weight. They also enhanced the plant growth through their beneficial effects, which in turn resulted in higher fruit size (Singh *et al*. 2003) [16]. Biofertilizers improve microbial distribution and moisture retention capacity in soil that results in greater enzymatic activities. This increase in enzymatic activities improves the growth parameters which ultimately reflect in increased fruit length and fruit diameter (Binepal *et al*., 2013) [4]. The increase in fruit volume was attributed to the corresponding increase in fruit length and fruit diameter and also due to balanced availability of macro and micro nutrients and growth promoting substances produced by biofertilizers. This may have led to better metabolic activities in the tree which ultimately lead to high protein and carbohydrate synthesis (Sharma *et al*., 2009) [15]. These observations are in agreement with findings of Patil *et al*. (2005) [13], Yadav *et al*. (2011) [18] and Nehete and Jadav (2019) [12] in mango, Mahendra and Singh (2009a) [11] in ber, Pilania *et al*. (2010) [14], Barne *et al*. (2011) [2] and Godage (2012) [10] in guava, Baviskar *et al*. (2011) [3] in sapota and Dheware and Waghmare (2009) [7] in sweet orange.

Table 2: Influence of different levels of NPK and biofertilizers on fruit volume (m^3), fruit yield $plant^{-1}$ (kg) and fruit yield $acre^{-1}$(t) in guava cv. Taiwan White (Pooled data of 2019-20 and 2020-21)

Recommended dose of fertilizers (400:160: 400 g NPK/tree)	Biofertilizers											
	Fruit volume (cm^3)				Fruit yield $plant^{-1}$ (kg)				Fruit yield $acre^{-1}$(t)			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
F_1	346.71	368.38	321.53	345.54	19.98	23.51	17.16	20.22	10.19	11.99	8.75	10.31
F_2	330.14	363.33	248.46	313.98	17.61	22.82	10.25	16.89	8.98	11.64	5.23	8.62
F_3	267.58	283.69	205.67	252.32	11.79	12.55	7.65	10.66	6.01	6.40	3.90	5.44
Mean	314.81	338.47	258.56	303.95	16.46	19.63	11.69	15.93	8.40	10.01	5.96	8.12
Factor	F	B	F x B		F	B	F x B		F	B	F x B	
SE (m) +	0.63	0.63	1.09		0.15	0.15	0.27		0.08	0.08	0.13	
CD at 5%	1.88	1.88	3.26		0.46	0.46	0.80		0.23	0.23	0.40	

F_1- 100% RDF; F_2- 80% RDF; F_3- 60% RDF

B_1- NFB, PSB and KSB carrier based biofertilizers; B_2- NFB, PSB and KSB liquid biofertilizers; B_3- Without biofertilizer

Fruit yield $plant^{-1}$ (kg) and fruit yield $acre^{-1}$(t)

The data presented in table 2 reveals that the treatment combination (T_2) registered maximum fruit yield (23.51 kg/plant) and was on par with (22.82 kg/plant) obtained in (T_5) followed by (T_1) with 19.98 kg/plant while, the lowest fruit yield (7.65 kg/plant) was recorded in (T_9). The treatment combination (T_2) recorded maximum fruit yield $acre^{-1}$ (11.99 t/acre) which was at par with (11.64 t/acre) recorded in (T_5). It was followed by (T_1) with (10.19 t/acre) and the lowest was recorded in (T_9) with 3.90 t/acre.

The increased fruit yield (kg/plant and t/acre) might be attributed due to increasing levels of nutrients near the assimilating area of plant enhanced the rate of dry matter production and its rational partitioning to economic part improved the yield (Dalal *et al.,* 2004) [6]. Positive response of yield as a result of biofertilizers treatments maybe due to the high ability of these microbes in nitrogen fixation and the secretion of several compounds that increase soil fertility, and organic matter increase bacteria activity, number of this bacteria, thus it can fix atmospheric nitrogen, increase phosphorus and potassium availability in soil and enhanced absorption of elements by Eureka lemon tree, that reflected to tree's ability to grow and increase productivity (Ennab, 2016) [9]. The above results are in conformity with the findings of Athani *et al*. (2007) [1], Pilania *et al*. (2010) [14], Barne *et al*. (2011) [2] and Godage *et al*. (2012) [10] in guava, Patil *et al*. (2005) [13], Yadav *et al*. (2011) [18] and Nehete and Jadav (2009) [12] in mango, Baviskar *et al*. (2011) [3] in sapota, Mahendra and Singh (2009a) [11] in ber, Dheware and Waghmare (2009) [7] and Dheware *et al*. (2020) [8] in sweet orange.

Conclusion

The yield attributing and yield parameters study of guava cv. Taiwan White under application of different treatment combinations on Mrig bahar guava trees revealed that application of T_2 treatment (100% RDF +NFB, PSB and KSB liquid biofertilizers) manifested better results in terms of number of fruits per plant, fruit weight, fruit diameter, fruit length, fruit volume, fruit yield per plant and yield per acre which was on par with T_5 treatment (80% RDF +NFB, PSB and KSB liquid biofertilizers) for number of fruits $plant^{-1}$, fruit weight, fruit diameter, fruit yield $plant^{-1}$ and for fruit yield $acre^{-1}$ as compared to other treatments.

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