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Effect of foliar feeding of plant growth regulators and nutrients on morphological and yield attributing characteristics of guava (*Psidium guajava* L.) cv. Gwalior-27

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Abstract
The investigation entitled "Effect of foliar feeding of plant growth regulators and nutrients on morphological and yield attributing characteristics of Guava (*Psidium guajava* L.) cv. Gwalior-27" was carried out in the Fruit orchard, Department of Horticulture, R.V.S.K.V.V, CoA, Gwalior district of Madhya Pradesh during mrig-bahar of 2021-22 and 2022-2023. The field experiment was laid under FRBD (Factorial randomized block design) which comprised of 20 treatments combinations of various PGR's and nutrients and were replicated thrice. The results implied that among all the morphological characteristics i.e., polar diameter (8.13 cm), equatorial diameter (8.11 cm), average fruit weight (212.08 g) and fruit volume (209.47 cm^3) and among all the yield attributing characteristics i.e., number of fruits per plant (225.50), yield / plant (45.40 kg) and yield / hectare (126.10 q), the highest value were found in the treatment combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) as compared to P_0M_0 (control).

Keywords: Foliar feeding, morphological characteristics, yield, PGRs, nutrients, FRBD

Introduction
Guava (*Psidium guajava* L.) being the member of the family Myrtaceae. It is often regarded as a "magical" fruit because of its wide range of nutritional benefits and medicinal applications. Its exceptional productivity sets it apart from many other fruits, making it highly lucrative across various soil and climate conditions. Its economic feasibility, practicality, and potential for substantial profit, coupled with its nutritive value, have made it increasingly popular among the fruit growers. (Das *et al*., 1995) [5].

Fruit contains 88.5% water, 4.45% reducing sugar, 5.23% non-reducing sugar, 9.75% TSS, 0.48% ash, acidity (0.22-0.39%), thiamine (0.03-0.007) and crude protein (0.82-1.45 g/100g pulp). Compared to other fruits, guava serves as reasonably good source of minerals like; calcium (10-30 mg/100 g), iron (0.60-1.39 mg/100 g pulp), phosphorus (22.5-40 mg/100 g) and dietary fibres (2-7.2 g/100 g), amino acid, proline and lipid which alters with the cultivar, stage of fruit maturity and growing season of crop.

Among numerous factors, probably nutrition is a pivotal factor determining the growth and development of fruit trees. These elements play very important contribution in several enzymatic activities and synthesis. Their intense inadequacy sometime poses serious problems. Nutrients and growth regulators to the plant can be accessible by the basal as well as by the foliar feeding. The foliar feeding of fruit tree has gained much emphasis in recent timespan as it is quite efficient and obviously a flawless approach of evading the problems of nutrients reachability and complementing the fertilizers to the soil because some amounts are draining out and some become inaccessible to the plant due to complex soil reactions.

Micronutrients help in the uptake of major nutrients and play an active role in the plant metabolism begins with cell wall development to respiration, photosynthesis, chlorophyll accumulation, enzyme activity hormone synthesis, nitrogen fixation and reduction (Das 2003) [6]. The positive effect of zinc application has been well validated (Chhonkar and Singh 1981) [4] in guava. It is a necessary micronutrient involved in enzymatic systems essential for protein synthesis, seed production and maturity rate in plants (Swietlik, 1999 and 2002) [35, 36]. It also plays an important role in starch metabolism in plants (Alloway, 2008) [2]. It is well known that Zn acts as a co-factor of many enzymes and influences many biological processes such as photosynthesis, nucleic acids metabolism, and biosynthesis of proteins and carbohydrates (Marschner, 1995) [21]. It is also, induces pollen tube growth resulted from its role on tryptophan synthesis as an auxin precursor biosynthesis (Hassan *et al*., 2010) [11]. Singh *et al*., (1983) [32] obtained that boric acid has good effect on physico-chemical constitution of guava. The scarcity of boron, second to zinc deficiency, has imparted a major significance to boron amendment. An adequate boron amendment ensures not only ample fruit set, but optimum fruit yield with superior quality in terms of ratio between total soluble solids and acidity (Srivastava and Singh 2005) [34].

Gibberellic acid is culpable for cell elongation, in lieu of cell division (Francis and Sorrell 2001) [7]. Gibberellins are instinctive growth hormones occupying a principal function in captivating the auxin reaction, which facilitates in regulating the growth, as well as its straight influence on internode elongation, blooming, fruiting, quality and yield. GA_3 urges the cell division and elongation; expansion of the stalk length, boosted flower and fruit volume. GA_3 had the highest fruit sustenance and yield during both winter and rainy seasons.

Recent advances in the field of nutrition of various fruit crops have confirmed that the urge for quality produces is turning into a concern of high solicitude, driving the growers' focus on superior fruit quality. The prudent use of plant growth promoting substances not only upsurge the productivity, but also ameliorate the quality of the produce. Foliar feeding of chemicals gives hasty results via fast assimilation and utilization, averting losses due to fixation and leaching and at the same time their amount used is quite economical. Therefore, foliar application of different plant growth promoting substances and macro as well as micronutrients can constitute an important breakthrough for getting maximum response.

Materials and Methods

The experiment was carried out in the Fruit orchard, Department of Horticulture, R.V.S.K.V.V, CoA, Gwalior district of Madhya Pradesh during mrig-bahar of 2021-22 and 2022-2023 on twenty-seven years old guava trees cv. Gwalior-27 planted at 6 x 6 m distance and trees were maintained under uniform cultural schedule. The experimental was laid out in FRBD (Factorial randomized block design) comprising 20 treatment combinations and were replicated thrice. There were two factors, first is plant growth regulators contains 5 level and second is nutrient which contains 4 levels. The plants were sprayed with different concentrations of plant growth regulators (propyl gallate 200 & 300 ppm and gibberellic acid 50 & 100 ppm) and nutrients (Borax 0.4%, $ZnSO_4$ 0.5% and $Ca(NO_3)_2$ 2%) and control. Treatments were given thrice i.e., first, before bud initiation, second, at fruit setting stage and third after pre harvest stage. The following treatment combinations have been used presented in Table1, The details of the treatments are as follows:

Table 1: Various treatment combinations

Notation	Treatment combination
P_0M_0	Control (with RDF)
P_0M_1	Borax 0.4%
P_0M_2	$ZnSO_4$ 0.5%
P_0M_3	$Ca(NO_3)_2$ 2%
P_1M_0	Propyl gallate 200ppm
P_1M_1	Propyl gallate 200 ppm + Borax 0.4%
P_1M_2	Propyl gallate 200 ppm + $ZnSO_4$ 0.5%
P_1M_3	Propyl gallate 200 ppm + Ca $(NO_3)_2$ 2%
P_2M_0	Propyl gallate 300 ppm
P_2M_1	Propyl gallate 300 ppm + Borax 0.4%
P_2M_2	Propyl gallate 300 ppm + $ZnSO_4$ 0.5%
P_2M_3	Propyl gallate 300 ppm + Ca $(NO_3)_2$ 2%
P_3M_0	Gibberellic acid 50 ppm
P_3M_1	Gibberellic acid 50 ppm + Borax 0.4%
P_3M_2	Gibberellic acid 50 ppm + $ZnSO_4$ 0.5%
P_3M_3	Gibberellic acid 50 ppm + Ca $(NO_3)_2$ 2%
P_4M_0	Gibberellic acid 100 ppm
P_4M_1	Gibberellic acid 100 ppm + Borax 0.4%
P_4M_2	Gibberellic acid100 ppm + $ZnSO_4$ 0.5%
P_4M_3	Gibberellic acid 100 ppm + Ca $(NO_3)_2$ 2%

Results and Discussion

The interaction effect of both the factors i.e., PGR's and nutrients which is computed in Table.2 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on polar diameter (cm) of guava. The maximum polar diameter (cm) (7.80, 8.40 & 8.13) was reported in combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by (7.50, 7.49 & 7.49) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, minimum polar diameter (cm) (5.59, 5.68 & 5.64) was recorded in P_0M_0 (control), respectively, in the first, second year and in pooled data.

The interaction effect of both the factors i.e., PGR's and nutrients which is computed and Table.3 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on equatorial diameter (cm) of guava. The maximum equatorial diameter (cm) (7.99, 8.21 & 8.11) was reported in combination P_4M_1 (Gibberellic acid100 ppm + Borax 0.4%) followed by (7.98, 7.95 & 7.97) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, minimum equatorial diameter (cm) (5.64, 5.28 & 5.46) was recorded in P_0M_0 (control), respectively, in the first, second year and in pooled data.

The interaction effect of both the factors i.e., PGR's and nutrients which is computed Table.4 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on average fruit weight (g) of guava. The maximum average fruit weight (g) (210.37, 213.78 & 212.08) was reported in combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by (200.52, 204.66 & 202.59) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, minimum average fruit weight (g) (127.66, 129.50 & 128.58) was recorded in P_0M_0 (control), respectively, in the first, second year and in pooled data.

The interaction effect of both the factors i.e., PGR's and nutrients which is computed in Table.5 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on fruit volume (cm^3) of guava. The maximum fruit volume (cm^3) (201.23, 228.12 & 209.47) was reported in combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by (193.69, 194.49 & 194.72) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, minimum fruit volume (cm^3) (126.49, 111.61 & 119.05) was recorded in P_0M_0 (control), respectively, in the first, second year and in pooled data.

The interaction effect of both the factors i.e., PGR's and nutrients which is computed in Table.6 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on number of fruits per tree of guava. The highest number of fruits per tree (227.00, 224.00 & 225.50) was reported in combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by (217.00, 211.00 & 214.50) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, least number of fruits per tree (109.00, 112.00 & 110.50) was recorded in P_0M_0 (control), respectively, in the first, second years and in pooled data.

The interaction effect of both the factors i.e., PGR's and nutrients which is computed in Table.7 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on yield / tree (kg) of guava. The highest yield / tree (kg) (46.27, 44.52 & 45.40) was reported in combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by (45.54, 44.11 & 44.61) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, least yield / tree (kg) (23.81, 22.04 & 22.92) was recorded in P_0M_0 (control), in the first, and second years and in pooled data.

The interaction effect of both the factors i.e., PGR's and nutrients which is computed in Table.8 revealed that there were significantly more effective interaction effect of different PGR's and nutrients on yield / hectare (q) of guava. The highest yield / hectare (q) (128.53, 123.67 & 126.10) was reported in combination P_4M_1 (Gibberellic acid 100 ppm + Borax 0.4%) followed by (126.50, 122.53 & 124.51) in P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) while, least yield / hectare (q) (66.14, 61.22 & 63.68) was recorded in P_0M_0 (control), in the first year, second year and in pooled data.

The reason behind the increment of both morphological as well as yield attributing characteristics might be the role of gibberellins exerts control over fruit development through influence at different stages of growth and development. Developing fruits serve as strong sinks for nutrients with hormones actively modulating the progression of the process. (Brenner and Cheikh, 1995) [3]. Gibberellins are recognized for their role in influencing both cell division and cell enlargement due to the reason of increase the cell wall plasticity, hydrolyse starch into sugars, therefore, reduce cell wall potential, allowing water to enter cell and hence promotes elongation during the process (Adams *et al.* 1975) [1].

According to Kozłowska *et al.* (2007) [14] GA_3 strengthened the sink which might be attributed to the fact that it increases the extracellular invertase and sucrose gradient through the conversion of sucrose to glucose, which helps in phloem unloading of carbohydrate in sink organ, subsequently increasing plant yield. Moreover, increased number of fruits per plant might be due to fact that nitrogen being a component of chlorophyll which increases by gibberellic as it promotes the biosynthesis of chlorophyll that regulate the establishment of proper C: N ratio, which regulates the flowers to be produced together with a quick elongation of the peduncle. These results are in close conformed to finding of Purohit *et al.* (2019) [26], Vani *et al.* (2020) [39], Goyal *et al.* (2019) [10], Kumar *et al.* (2018) [18], M. Thiruppathi (2020) [38], Kumar *et al.* (2013) [17] in guava, Sharma and Tiwari, (2015) [30], Garner *et al.* (2011) [8] and Moneruzzaman *et al.* (2011) [22], Kaseem *et al.* (2011) [13] and Singh *et al.* (2017) [33].

Among all the nutrient treatments, the increment of both morphological as well as yield attributing characteristics may be linked to the role of boron in the present study helped to optimizing the plant growth attributes by expediting the transportation of photosynthates from leaves to maturing fruits. The swift expansion in the fruit size (polar and equatorial diameter) observed with the application of boron could be attributed to factors such as increased cell division, cell elongation and elevated fruit moisture content (Rajput and Chand, 1976) [27]. Boron has been observed to have a positive association with the initial phases of fruit development (Heinicke, 1942) [12]. Increase in the number of fruits per tree might be related to boron ensuring a higher number of fruits reach maturity due to the fact that boron is crucial for the synthesis of cell wall component which acts as a key role for the structural integrity of plant cell, this can lead to better fruit development and increased the harvest, (Shreekant *et al.* 2017) [31].

Movchan and Soboroikova (1972) [23] reported that boron boosts nitrogen absorption, therefore aiding photosynthesis process, which, in turn, leading to a greater carbohydrate accumulation, thus contributing to increased fruit size and weight. The aforementioned findings have been repeatedly confirmed by the findings of Kumar *et al.* (2018) [18], Gaund *et al.* (2022) [9], Tiwari *et al.* (2014) [37], M. Thiruppathi (2020) [38], Vani *et al.* (2020) [39], Shreekant (2017) [31], Poojan *et al.* (2020) [25], Kumar *et al.* (2022) [19], Pratap *et al.* (2022) [28], Lenka *et al.* (2019) [20], Goyal *et al.* (2019) [10], Pippal *et al.* (2019) [24], Kumar *et al.* (2015) [15], and Saini *et al.* (2021) [29].

Table 2: Interaction effect of foliar feeding PGR's and nutrients on polar diameter (cm) of guava (*Psidium guajava L.*) cv. Gwalior-27 during 1st yr, 2nd yr and pooled data

Micronutrients	**Polar diameter (cm)**				
	PGR's				
	1st year				
	P_0	**P_1**	**P_2**	**P_3**	**P_4**
M_0	5.59	6.27	6.26	7.45	7.42
M_1	7.26	6.96	6.98	7.47	7.80
M_2	7.10	6.70	6.91	7.45	7.50
M_3	6.54	7.22	6.38	6.95	7.45
2nd year					
M_0	5.68	6.13	6.18	7.17	7.40
M_1	7.33	7.00	7.02	7.45	8.40
M_2	7.11	6.89	6.98	7.36	7.49
M_3	6.60	6.31	6.33	7.22	7.33
Pooled data					
M_0	5.64	6.20	6.22	7.31	7.41
M_1	7.27	6.93	6.84	7.46	8.13
M_2	7.10	6.80	6.98	7.41	7.49
M_3	6.57	6.77	6.35	7.09	6.82
	1st year		**2nd year**		**Pooled**
S.E(M) ±	0.271		0.260		0.255
CD (5%)	0.777		0.744		0.731

Table 3: Interaction effect of foliar feeding of PGR's and nutrients on equatorial diameter (cm) of guava (*Psidium guajava* L.) cv. Gwalior-27, during 1st yr, 2nd yr and pooled data

Micronutrients	Equatorial diameter (cm)				
	PGR's				
	1st year				
	P_0	P_1	P_2	P_3	P_4
M_0	5.64	5.68	5.77	7.50	7.78
M_1	6.95	7.16	6.98	7.87	7.99
M_2	6.81	6.96	6.91	7.72	7.98
M_3	6.51	5.87	6.12	7.34	7.57
2nd year					
M_0	5.28	5.66	5.74	7.69	7.74
M_1	7.00	7.05	6.90	7.88	8.21
M_2	6.86	6.78	6.98	7.74	7.95
M_3	6.46	5.97	5.95	7.06	7.67
Pooled data					
M_0	5.46	5.67	5.75	7.59	7.76
M_1	6.97	7.10	6.93	7.87	8.11
M_2	6.85	6.85	6.95	7.73	7.97
M_3	6.49	5.92	6.04	7.20	7.62
	1st year		2nd year		Pooled
S.E(M) ±	0.235		0.301		0.158
CD (5%)	0.669		0.858		0.449

Table 4: Interaction effect of PGR's and nutrients on average fruit weight (g) of guava of guava (*Psidium guajava* L.) cv. Gwalior-27 during 1st yr, 2nd yr and pooled data

Micronutrients	Average fruit weight (g)				
	PGR's				
	1st year				
	P_0	P_1	P_2	P_3	P_4
M_0	127.66	137.45	137.99	175.64	191.76
M_1	162.30	173.33	167.93	198.45	210.37
M_2	150.20	168.00	156.59	187.80	200.52
M_3	149.28	141.72	141.99	176.96	186.23
	2nd year				
M_0	129.50	136.98	138.83	178.50	195.08
M_1	166.50	175.12	161.35	196.30	213.78
M_2	152.81	169.17	155.36	186.45	204.66
M_3	147.35	140.50	144.11	182.59	185.00
	Pooled data				
M_0	128.58	137.22	138.41	177.07	193.42
M_1	164.40	174.23	164.64	197.37	212.08
M_2	151.51	168.59	155.97	187.13	202.59
M_3	148.31	141.11	143.05	179.78	185.61
	1st year		2nd year		Pooled
S.E(M) ±	4.314		6.963		4.007
CD (5%)	12.350		19.934		11.471

Table 5: Interaction effect of PGR's and nutrients on fruit volume (cm^3) of guava of guava (*Psidium guajava* L.) cv. Gwalior-27 during 1st yr, 2nd yr and pooled data

Micronutrients	Fruit volume (cm^3)				
	PGR's				
	1st year				
	P_0	P_1	P_2	P_3	P_4
M_0	126.49	132.46	134.20	173.64	190.82
M_1	170.63	161.24	154.29	181.80	201.23
M_2	168.48	166.48	156.90	174.43	193.69
M_3	139.92	134.43	140.83	177.73	171.70
	2nd year				
M_0	111.61	116.85	143.06	175.84	188.22
M_1	179.16	152.05	156.56	190.05	228.12
M_2	169.74	181.66	168.59	161.55	194.49
M_3	132.25	133.07	157.11	175.58	158.54
	Pooled data				
M_0	119.05	124.65	138.63	174.74	181.72
M_1	174.89	156.64	152.42	185.92	209.47
M_2	168.78	174.07	156.74	167.99	194.72
M_3	136.08	133.75	148.97	176.66	165.12
	1st year		2nd year		Pooled
S.E(M) ±	6.189		6.897		5.890
CD (5%)	17.567		19.652		16.793

Table 6: Interaction effect (AXB) of PGR's and nutrients on number of fruits per tree of guava (*Psidium guajava* L.) cv. Gwalior-27 during 1st yr, 2nd yr and pooled data

Micronutrients	No. of fruits per tree of guava				
	PGR's				
	1st year				
	P_0	P_1	P_2	P_3	P_4
M_0	109.00	117.00	115.00	145.00	165.00
M_1	192.00	183.00	188.00	205.00	227.00
M_2	189.00	175.00	175.00	196.00	217.00
M_3	148.00	138.00	134.00	167.00	177.00
	2nd year				
M_0	112.00	113.00	116.00	149.00	168.00
M_1	199.00	188.00	189.00	208.00	224.00
M_2	184.00	171.00	170.00	190.00	211.00
M_3	143.00	134.00	137.00	162.00	181.00
	Pooled data				
M_0	110.50	115.00	115.50	147.00	166.50
M_1	195.50	185.50	188.50	206.00	225.50
M_2	186.50	173.00	172.50	193.00	214.50
M_3	145.50	136.00	135.50	164.50	179.00
	1st year		2nd year		Pooled
S.E(M) ±	7.082		6.626		6.803
CD (5%)	17.812		19.970		18.045

Table 7: Interaction effect of PGR's and nutrients on yield / tree (kg) of guava (*Psidium guajava* L.) cv. Gwalior-27 during 1st yr, 2nd yr and pooled data

Micronutrients	Yield/tree (kg)				
	PGR's				
	1st year				
	P_0	P_1	P_2	P_3	P_4
M_0	23.81	26.66	26.72	31.90	36.59
M_1	39.12	36.91	33.59	44.46	46.27
M_2	37.26	33.70	31.46	41.46	45.54
M_3	30.31	30.36	30.11	36.55	38.46
	2nd year				
M_0	22.04	25.61	24.81	33.39	32.46
M_1	38.79	37.28	35.16	42.52	44.52
M_2	36.85	30.69	29.96	39.76	44.11
M_3	28.95	29.81	29.46	33.88	35.85
	Pooled data				
M_0	22.92	26.14	25.77	32.65	34.53
M_1	38.96	37.10	34.38	43.49	45.40
M_2	37.06	32.20	30.71	40.61	44.61
M_3	29.63	30.09	29.79	35.22	37.16
	1st year		2nd year		Pooled
S.E(M) ±	1.622		1.598		1.520
CD (5%)	4.643		4.574		4.352

Table 8: Interaction effect of PGR's and nutrients on yield / hectare (q) of guava (*Psidium guajava* L.) cv. Gwalior-27 during 1st yr, 2nd yr and pooled data

Micronutrients	Yield/hectare (q)				
	PGR's				
	1st year				
	P_0	P_1	P_2	P_3	P_4
M_0	66.14	74.06	74.22	88.61	101.64
M_1	115.00	98.64	97.31	123.50	128.53
M_2	109.83	93.61	87.39	115.17	126.50
M_3	84.20	84.33	83.64	101.53	106.83
	2nd year				
M_0	61.22	71.14	68.92	92.75	90.17
M_1	114.08	99.67	101.67	118.11	123.67
M_2	103.14	95.25	83.22	110.45	122.53
M_3	80.42	82.81	81.83	94.11	99.58
	Pooled data				
M_0	63.68	72.60	71.57	90.68	95.90
M_1	114.54	99.15	99.49	120.81	126.10
M_2	106.49	94.43	85.31	112.81	124.51
M_3	82.31	83.57	82.74	97.82	103.21
	1st year		2nd year		Pooled
S.E(M) ±	4.505		4.546		4.209
CD (5%)	12.897		13.015		12.051

Conclusion

Foliar feeding of PGR's and nutrients given thrice, first, before bud initiation, second, at fruit setting stage and third after pre harvest stage was an effective way for improvement of morphological as well as yield attributing characteristics of guava. The treatment combination P_4M_1 (Gibberellic acid 100ppm + Borax 0.4%) followed by P_4M_2 (Gibberellic acid 100 ppm + $ZnSO_4$ 0.5%) was found to be effective in maximising the above parameters significantly.

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