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Influence of combination and doses of boron and gibberellic acid on fruit yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Surkha

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Abstract

The present field experiment was carried out at the horticulture research farm of Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj during the year 2024-25 to study the performance of different treatments combination. The experiment comprised of 16 (15+1) treatments with 3 replications in randomized block design. The present study was conducted to evaluate the influence of exogenous applications of plant growth regulators and boron on the physiological, reproductive, yield, biochemical, and economic traits of guava (*Psidium guajava* L.) cv. Allahabad Surkha. Among the treatments, T_{14} consistently recorded the highest values across key parameters including chlorophyll content (44.33 SPAD), number of flowers (150.67), fruit set (79.87%), fruit dimensions (5.76 cm polar and 6.91 cm radial diameter), fruit weight (142.63 g), number of fruits per plant (116.67), fruit yield per tree (16.65 kg), yield per hectare (554.93 q/ha), pulp weight (128.58 g), seed number (494), seed weight (14.05 g), and 100 seed weight (1.13 g). Biochemical quality was also superior in T_{14}, with maximum TSS (10.23 °Brix), lowest acidity (1.03%), highest pH (4.20), and ascorbic acid content (240 mg/100 g). Economically, T_{14} achieved the highest net return (Rs. 11,64,540) and benefit-cost ratio (2.50), confirming its superiority. T_{13} and T_{15} closely followed T_{14} in most parameters, indicating their substantial effectiveness. In contrast, the untreated control (T_0) consistently recorded the lowest values across all traits, reaffirming the positive impact of treatment applications. Overall, treatments T_{14}, T_{13}, and T_{15} emerged as the most efficient combinations for enhancing the growth, yield, fruit quality, and profitability of guava cultivation under the given agro-climatic conditions.

Keywords: Guava, gibberellic acid, boron, yield, fruit quality, growth regulators

Introduction

Guava, (*Psidium guajava* L.), small tropical tree of the family Myrtaceae, cultivated for its edible fruits also the chromosome number 2n= 22. Guava trees are native to tropical America and are grown in tropical and subtropical areas worldwide. Guava is grown on heavy clay soils to very light sandy soils as well as on those which are commonly considered suitable for fruit production. Guava trees are very hardy and can thrive on all types of soil. Guava is grown in areas with pH ranging from 4.5 to 7.5. The ideal soil must be deep, friable and well drained.

Allahabad Surkha is the most famous and demanded cultivar of all the available guava varieties. It is used for both table and processing purposes. The tree for this variety grows tall and has an upright growing tendency.

Also, this variety tree bears a lot of fruits in its long shoots covered in dense foliage. The crown of the tree is expansive and compact, mostly dome shaped. Guava is very responsive to the application of inorganic fertilizers, along with organic manures. However, the amount of the manures and fertilizers that is to be applied depends upon the age of the plant, fertility status of soil, climate conditions and management practices.

Guava sometimes suffers from deficiency of zinc and boron. Spraying the trees twice with 450 g zinc sulphate mixed with 300 g slaked lime dissolved in 73 litres of water cure zinc deficiency. First spray should be done in June July and second in August-September. Two sprays of boron (5 g per litre of water) first in June-July and second in August-September were effective in curing boron deficiency.

Allahabad Surkha cultivar fruit is round in shape and is not very large. The skin of the fruit is very mild and the flesh is red with not many seeds inside it. The smoothness of the skin and less seed offers top notch quality.

Justification

Gibberellic acid plays a major role in inducing parthenocarpy fruit as well as in fruit retention. The maximum fruit weight (181.71 g) was recorded with foliar spray of 60 ppm. About 80-90 percent flowers of guava set fruits initially of which 35-60 percent reaches to maturity while seedless cultivar fruit retention is low. Sharma *et al*. (1993) reported that GA_3 50, 100 and 200 ppm significantly increased fruit set. Boron plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, and pollination and seed set. It also plays important role in flowering per plant.

Material and Methods

The experiment will be carried out during 2024-25 on Horticulture research farm of Department of Horticulture, Naini Agriculture Institute Allahabad, India-211007, (U.P.) India, the experimental site is located at 24.26 N latitude 81.51 E longitude and 98 m above the mean sea level. During the period from July 2024 to January 2025, Prayagraj (formerly Allahabad) experienced a typical monsoon-to-autumn transition in its climate. July marked the height of the monsoon season, with average maximum temperatures ranging from 35 °C to 39.6 °C and minimums around 22 °C to 29 °C. Significant rainfall was recorded on certain days, notably 68.2 mm on July 25th, contributing to relatively high humidity levels, often exceeding 60% in the mornings and 50% in the afternoons. In August, temperatures slightly dipped due to consistent rainfall and thick cloud cover, with some days receiving over 70 mm of rain, and sunshine hours were reduced to as low as 0 to 2.2 hours. September saw a gradual retreat of the monsoon, with decreasing rainfall and increasing sunshine. Temperatures remained high, often above 35 °C, but humidity levels began to decline. By October and November, rainfall became negligible, skies cleared up, and evaporation rates increased again, signalling the start of the dry season. Daily sunshine exceeded 8 hours, and maximum temperatures stabilized between 30 °C and 36 °C. This climatic progression reflects the subtropical nature of Prayagraj, with hot, wet summers transitioning into cooler, drier autumn months. The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). The significance of comparison was tested. The significant difference values were computed for 5% probability of error. Wherever the variance ratio (F value) was found significant, critical difference (CD) values were computed for the comparison among the treatment means.

Plate 1: Experimental field in Horticulture Research Farm, Department of Horticulture, NAI, SHUATS

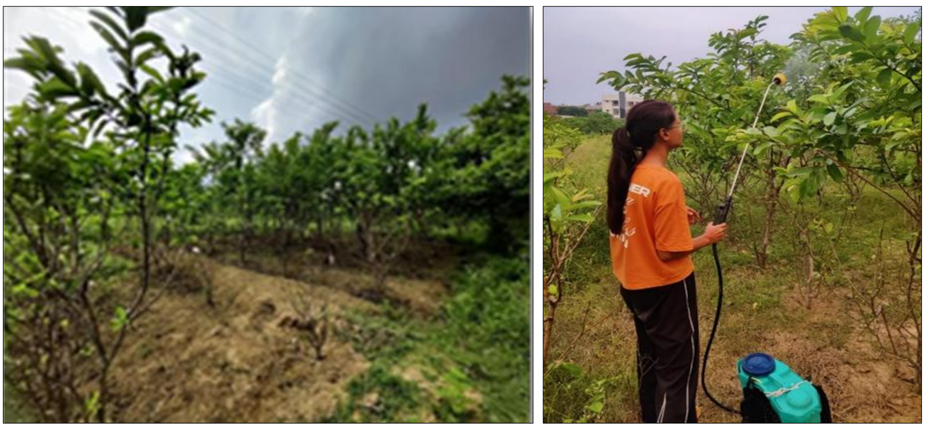

Plate 2: Spraying of Gibberellic Acid and Boron on different concentration in Allahabad Surkha Guava in Departmental Research Field, Department of Horticulture, Nai, Shuats

Treatment Details

The experiment comprised sixteen treatments including a control (T_0). Treatments T_1, T_2, and T_3 involved the application of boron at concentrations of 0.1%, 0.2%, and 0.3%, respectively. Treatments T_4, T_8, and T_{12} consisted of GA_3 applied alone at 50 ppm, 100 ppm, and 150 ppm, respectively. The combined applications of GA_3 and boron were also evaluated: T_5 (GA_3 @ 50 ppm + Boron @ 0.1%),

T_6 (GA_3 @ 50 ppm + Boron @ 0.2%), and T_7 (GA_3 @ 50 ppm + Boron @ 0.3%); T_9 (GA_3 @ 100 ppm + Boron @ 0.1%), T_{10} (GA_3 @ 100 ppm + Boron @ 0.2%), and T_{11} (GA_3 @ 100 ppm + Boron @ 0.3%); and finally, T_{13} (GA_3 @ 150 ppm + Boron @ 0.1%), T_{14} (GA_3 @ 150 ppm + Boron @ 0.2%), and T_{15} (GA_3 @ 150 ppm + Boron @ 0.3%).

Results and Discussion

The observations recorded and results obtained during the period of investigation have been presented below:

As Affected by Different Treatments

A. Chlorophyll Content (SPAD) value

The maximum chlorophyll content was recorded in Treatment T_{14} (44.33), indicating the highest efficiency in photosynthetic pigment accumulation among all treatments. This was followed by T_3 (42.60), T_{13} (42.33), and T_{12} (41.70), which also exhibited comparatively higher values, suggesting these treatments effectively promoted chlorophyll synthesis and potentially contributed to enhanced photosynthetic activity.

Moderately high values were observed in T_6 (40.47), T_1 (39.77), and T_{15} (39.33), indicating a good response in terms of chlorophyll content, although slightly lower than the top-performing treatments. Treatments like T_8 (38.77), T_4 (38.13), T_{11} (37.77), T_9 (37.33), and T_5 (37.57) maintained mid-range chlorophyll levels, suggesting average effectiveness in improving chlorophyll content.

On the other hand, the minimum chlorophyll content was recorded in T_0 (34.00), the control treatment, highlighting the lack of treatment influence on pigment development. Other treatments showing relatively lower chlorophyll content included T_{10} (35.83), T_2 (36.67), and T_7 (36.97), implying limited efficiency in enhancing chlorophyll synthesis when compared to the top-performing treatments. These finding have got the support from Katiyar *et al*. (2009) and Jayachandran *et al*. (2005) who also observe the same ppm of GA3 application chlorophyll content level in the plant.

Flowering, Fruiting Parameters

A. Number of Flower/Plant and Fruit Set (%)

Treatment T_{14} emerged as the most effective, recording the highest number of flowers (150.67) and fruit set percentage (79.87%), indicating its strong influence on both floral development and reproductive success. It was closely followed by T_{13} (136.00 flowers; 76.88%) and T_{15} (128.67 flowers; 75.18%), which also demonstrated excellent performance. Treatments T_{12}, T_{11}, T_{10}, T_9, T_8, and T_6 showed moderately high values in both parameters, confirming their effectiveness in enhancing flowering and fruit retention. In contrast, the control (T_0) recorded the lowest values for both flower number (68.00) and fruit set percentage (56.86%), while T_1 and T_3 also showed limited effectiveness, highlighting the significant role of GA_3 and boron combinations in improving reproductive outcomes in guava. These results were further supported by Katiyar *et al*. (2009) who observed the increase in emergence of flowers and Fruit Set (%) in the plants with the same treatment.

B. Polar Diameter (cm) and Radial Diameter (cm)

A significant variation in fruit dimensions was observed across the treatments. Treatment T_{14} exhibited the best overall fruit development, recording the highest polar diameter (5.76 cm) and radial diameter (6.91 cm), signifying its strong effectiveness in enhancing both fruit length and girth. It was closely followed by T_{13} (5.62 cm; 6.73 cm) and T_5 (5.42 cm; 6.50 cm), which also showed excellent results in improving fruit size. Treatment T_{11} (5.40 cm; 6.46 cm) also performed well, confirming its potential in promoting balanced fruit enlargement. Moderately high dimensions were observed in T_{15}, T_6, T_4, and T_9, reflecting a positive but slightly lesser impact. Treatments such as T_{12}, T_2, and T_{10} showed mid-range values for both parameters, indicating average influence on fruit development. In contrast, the control T_0 recorded the lowest polar (3.48 cm) and radial (3.84 cm) diameters, while treatments like T_1, T_3, T_7, and T_8 showed only marginal improvement, highlighting their limited effectiveness in enhancing fruit morphology. These finding have got the support from Katiyar *et al*. (2009), Rajput *et al*. (2015) [45] & Shukla *et al*. (2011) [53] who also observe that application of GA3 and Boron increases the Polar Diameter (cm) and Radial Diameter (cm) of the fruits.

C. Fruit Weight (g)

Treatment T_{14} recorded the highest fruit weight (142.63 g), reflecting its outstanding efficacy in enhancing fruit biomass and yield potential. It was closely followed by T_{13} (139.53 g) and T_{15} (126.87 g), both of which significantly improved fruit development. T_5 (126.67 g) and T_{10} (118.47 g) also demonstrated strong positive effects on fruit size and density. Moderately high fruit weights were observed in T_8, T_9, T_6, and T_7, indicating good but slightly lesser effectiveness. Average performance was seen in T_{11} (89.04 g) and T_4 (75.10 g). In contrast, the lowest fruit weight was recorded in the control T_0 (41.67 g), while T2, T_1, T_3, and T_{12} also exhibited relatively low values, suggesting limited impact of these treatments on enhancing fruit weight compared to the more effective combinations. These finding have got the support from Katiyar *et al*. (2009), Rajput *et al*. (2015) [45] & Shukla *et al*. (2011) [53] who also observe that application of GA3 and Boron increase the Weight of fruit (g) of the fruits.

D. Number of Fruit/Tree

The maximum number of fruits per plant was observed in Treatment T_{14} (116.67), indicating the highest fruit-bearing capacity and overall productivity. This was followed by T_{13} (102.67) and T_{15} (102.00), which also showed remarkable fruit production, suggesting these treatments significantly enhanced flowering, fruit set, and retention. Treatment T_{12} (90.67) and T_{11} (86.00) also demonstrated strong performance, contributing to higher yields per plant.

Moderately high fruit numbers were recorded in T_{10} (85.00), T_9 (81.00), T_8 (79.33), and T_6 (72.33), reflecting effective but slightly lower productivity than the top-tier treatments. T_7 (66.33) and T_5 (60.33) were also above average, showing good potential for fruit production.

On the lower end, the minimum number of fruits per plant was recorded in T_0 (38.67), the untreated control, indicating limited fruit-bearing capacity. Other treatments with relatively lower fruit counts included T_3 (44.67), T_1 (45.33), T_4 (51.33), and T_2 (52.67), suggesting moderate improvement in fruit number, but notably less than the best-performing treatment combinations. These finding have got the support from Katiyar *et al*. (2009) Rajput *et al*. (2015) [45] & Shukla *et al*. (2011) [53] who also observe that application of GA3 and Boron increase the of the fruits yield per tree.

E. Fruit Yield/Tree (Kg) and Fruit Yield/Hac. (Q)

Treatment T_{14} recorded the highest fruit yield per tree (16.65 kg) and per hectare (554.93 q/ha), highlighting its outstanding effectiveness in maximizing productivity through enhanced fruit number, size, and weight. It was closely followed by T_{13} (14.33 kg; 477.54 q/ha) and T_{15} (12.92 kg; 430.62 q/ha), both demonstrating excellent performance in yield enhancement. Treatments T_{10} (10.07 kg; 335.74 q/ha) and T_8 (9.24 kg; 307.85 q/ha) also showed strong positive effects on overall yield. Moderately high yields were observed in T_9, T_{11}, T_5, T_6, and T_7, reflecting substantial but comparatively lower productivity. Treatments T_{12} (5.97 kg; 199.08 q/ha) and T_4 (3.85 kg; 128.31 q/ha) showed average improvement. In contrast, the minimum yield per tree (1.60 kg) and per hectare (53.43 q/ha) was recorded in the control (T_0), while T_1, T_2, and T_3 also showed relatively low yields, indicating limited effectiveness of these treatments in enhancing guava productivity at both individual tree and orchard scale. These finding have got the support from Katiyar *et al*. (2009), Rajput *et al*. (2015) [45], Shukla *et al*. (2011) [53] & Ashour *et al*. (2018) [2] who also observe that application of GA3 and Boron increase the fruit yield/tree and fruit yield per hac.

F. Number of Seed/Fruit and Pulp Weight (g)

Treatment T_{14} recorded the highest number of seeds per fruit (494.67) and maximum pulp weight (128.58 g), indicating its superior performance in enhancing both reproductive potential and fruit quality. It was closely followed by T_{15} (483 seeds; 114.40 g) and T_{13} (471 seeds; 125.81 g), which also demonstrated excellent results. T_{10} (471.67 seeds; 106.82 g) and T_5 (114.03 g pulp) showed strong positive effects on seed development and edible portion. Moderately high values for pulp weight were observed in T_8, T_9, T_6, T_7, and T_{11}, reflecting effective but slightly lesser performance. The control treatment T0 recorded the minimum seed number (171.67) and pulp weight (35.33 g), highlighting poor reproductive and fruit quality outcomes in the absence of treatment. Treatments T_1, T_2, and T_3 showed relatively lower values, indicating limited improvements compared to the more effective combinations. These findings confirm that exogenous application of GA_3 and boron significantly improves both seed formation and pulp development in guava. These finding have got the support from Katiyar *et al*. (2009), Rajput *et al*. (2015) [45] & Shukla *et al*. (2011) [53] who also observe that application of GA3 and Boron increase the of the fruits pulp weight (g).

G. Seed Weight (g) and 100 Seed Weight (g)

Treatment T_{14} recorded the highest seed weight (14.05 g) and 100 seed weight (1.13 g), highlighting its superior effectiveness in enhancing seed development and maturity in guava. It was closely followed by T_{13} (13.72 g; 0.83 g) and T_{15} (12.47 g; 0.73 g), both of which also showed strong performance, suggesting that the synergistic application of GA_3 and boron significantly improved seed mass and quality. In contrast, the lowest seed weight (4.00 g) and 100 seed weight (0.37 g) were recorded in the untreated control (T_0), with similarly low values in T_1 and T_2, indicating limited influence on seed attributes. These findings confirm that higher-performing treatment combinations, particularly T_{13} to T_{15}, substantially contribute to better seed weight accumulation and quality, likely through enhanced nutrient uptake, hormonal balance, and improved physiological processes.

Biochemical Characteristics of Fruits

A. Acidity (%)

Acidity content in guava fruits showed notable variation across treatments, reflecting the influence of plant growth regulators and micronutrient combinations on organic acid metabolism. The highest acidity was recorded in the untreated control T_0 (2.23%), followed by T_1 (2.00%) and T_2 (1.90%), indicating limited effectiveness in reducing sourness. In contrast, the lowest acidity was observed in T_{14} (1.03%), followed closely by T_{13} (1.06%) and T_{15} (1.23%), signifying their superior role in enhancing fruit sweetness and palatability. These findings suggest that treatments T_{13}, T_{14}, and T_{15} effectively reduced acidity, likely by improving sugar-acid balance and metabolic regulation, thereby enhancing overall fruit quality and consumer acceptability. These finding have got the support from Kaur (2017) [27] who also observe that application of GA3 and Boron decrease the fruit acidity (%).

B. TSS (°Brix)

Total Soluble Solids (TSS), a key determinant of sweetness and fruit quality, varied significantly among treatments. The highest TSS was recorded in Treatment T_{14} (10.23 °Brix), followed by T_{13} (9.97 °Brix) and T_{15} (9.80 °Brix), indicating superior enhancement in sugar accumulation due to the synergistic effects of GA_3 and boron. These treatments likely promoted improved carbohydrate metabolism, resulting in better fruit palatability. In contrast, the lowest TSS was observed in T_6 (8.57 °Brix), followed by T_1 and T_{11} (both 8.67 °Brix), reflecting limited effectiveness in enhancing sweetness. Overall, T_{13}, T_{14}, and T_{15} emerged as the most effective treatments for improving TSS content and fruit marketability, while T_6, T_1, and T_{11} were comparatively less beneficial. These finding have got the support from Jayachandra *et al*. (2005), Rajput *et al*. (2015) [45] & Shukla *et al*. (2011) [53] who also observe that application of GA3 and Boron increase the of the fruits yield per tree.

C. pH

The pH of guava fruits varied significantly among treatments, reflecting differences in their ability to modulate fruit acidity. The highest pH was recorded in Treatment T_{14} (4.20), followed by T_{13} (4.10) and T_{15} (4.00), indicating a substantial reduction in acidity and improvement in fruit sweetness and overall palatability. In contrast, the lowest pH was observed in the control T_0 (3.00), followed by T_6 (3.03) and T_9 (3.07), suggesting limited effectiveness of these treatments in moderating acidity. These findings confirm that treatments T_{13}, T_{14}, and T_{15} were most effective in enhancing fruit pH, contributing positively to taste and consumer acceptability, while untreated and suboptimal treatments maintained more acidic profiles.

D. Ascorbic Acid (mg/100 g)

Ascorbic acid content, an important indicator of nutritional quality and antioxidant potential, varied notably among the treatments. The highest content was recorded in Treatment T_{14} (240.00 mg/100 g), followed by T_{13} (213.33 mg/100 g) and T_{15} (210.00 mg/100 g), indicating the effectiveness of these combinations in enhancing vitamin C levels through improved physiological and metabolic responses. In contrast, the lowest ascorbic acid concentration was observed in the control T_0 (110.00 mg/100 g), with relatively low values also noted in T_2 (123.33 mg/100 g) and T_1 (136.67 mg/100 g), reflecting minimal improvement without effective external inputs. These results underscore the significant role of treatments T_{13}, T_{14}, and T_{15} in boosting the nutritional profile of guava, while highlighting the limited impact of untreated or minimally treated plants. These finding have got the support from Katiyar *et al*. (2009), Rajput *et al*. (2015) [45], Jayachandran *et al*. (2005) & Shukla *et al*. (2011) [53] who also observe that application of GA3 and Boron increase the of the fruits yield per tree.

E. Economics of the Treatments

Table 3.1: Influence of Exogenous Applications of Plant Growth Regulators & Boron on Gross Profit/Plant of Guava (*Psidium guajava* L.) cv. Allahabad Surkha

Treatment	No. of Fruit	Fruit Weight (g)	Fruit Yield /Tree (kg)	Fruit Yield/hac. (q)	Selling Rate (Rs/q)	Gross Return (Rs)	Cost Of Cultivation	Net Return (Rs)	B/C Ratio
T_0	38.67	41.67	1.6	53.43	3000	160290	70320	99970	1.4216
T_1	45.33	52.53	2.38	79.21	3000	237630	90063	147567	1.6385
T_2	52.67	48.7	2.56	85.32	3000	255960	95060	160900	1.6926
T_3	44.67	55.43	2.47	82.43	3000	247290	105690	141600	1.3398
T_4	57.33	75.1	3.05	128.31	3000	384930	125125	274280	2.192
T_5	60.33	126.67	7.46	240.53	3000	745590	238560	507030	2.1254
T_6	72.33	94.67	6.83	227.75	3000	683250	232500	450750	1.9387
T_7	66.33	94.40	6.25	208.08	3000	624240	260960	363280	1.3921
T_8	79.33	116.47	9.24	307.85	3000	923550	365700	557850	1.5254
T_9	81	95.93	71.79	259.52	3000	778560	260780	538554	2.0652
T_{10}	85	118.47	10.07	335.74	3000	1007220	400560	606660	1.5145
T_{11}	86	89.04	7.66	255.08	3000	765240	242530	522710	2.1552
T_{12}	90.67	65.97	5.97	199.08	3000	597240	210960	386280	1.8311
T_{13}	102.67	139.53	14.33	477.54	3000	1432620	430750	961770	2.2328
T_{14}	116.67	142.63	16.65	554.93	3000	1664490	465950	1164540	2.4993
T_{15}	102	126.87	12.92	430.62	3000	1291860	404560	878300	2.171

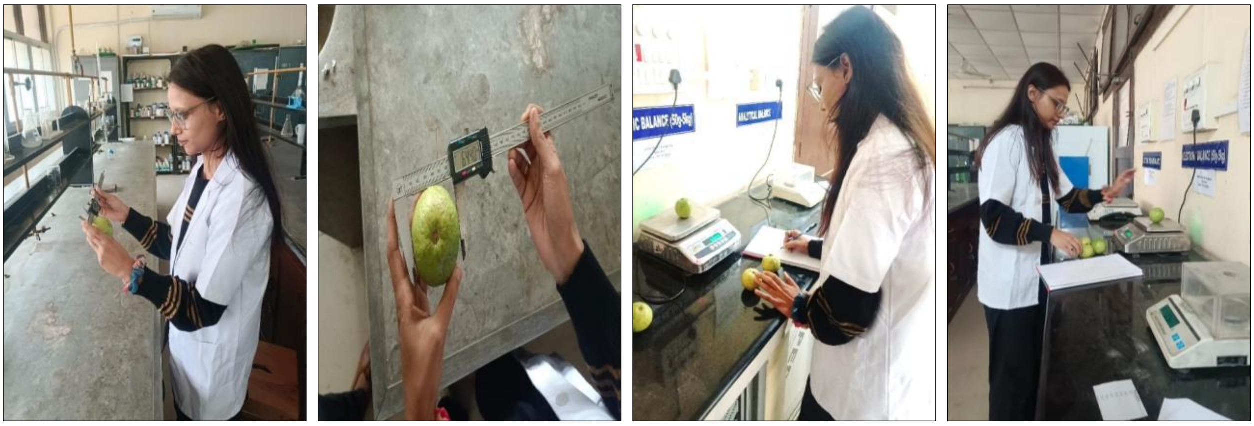

Plate 2: Measure a Polar and Radial Diameter of fruit & Fruit weight of Allahabad Surkha Guava in Departmental Lab, Department of Horticulture, NAI, SHUATS

Conclusion

A comprehensive study on guava (*Psidium guajava* L.) cv. Allahabad Surkha revealed that exogenous applications of plant growth regulators and boron significantly improved growth, yield, quality, and economic returns. Treatment T_{14} was the most effective, showing the highest chlorophyll content (44.33 SPAD), flower number (150.67), fruit set (79.87%), fruit weight (142.63 g), yield per tree (16.65 kg), and per hectare (554.93 q/ha). It also enhanced biochemical traits like TSS (10.23 °Brix), ascorbic acid (240 mg/100 g), and pulp weight (128.58 g), while reducing acidity (1.03%). Economically, T_{14} recorded the highest net return (Rs. 11,64,540) and B:C ratio (2.50). Treatments T_{13} and T_{15} also performed well, whereas the control (T_0) showed the lowest values. The results confirm that T_{14}-type treatments are ideal for maximizing guava yield, quality, and profitability.

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