PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 11(2): 79–84
https://doi.org/10.14719/pst.2733

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RESEARCH ARTICLE

Influence of plant growth regulators on fruit drop, fruit retention and fruit yield of mango (*Mangifera indica* l.) cv. Amrapali under west central table land zone of Odisha

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OPEN ACCESS

ARTICLE HISTORY

Received: 18 July 2023
Accepted: 06 February 2024

Available online
Version 1.0 : 05 March 2024
Version 2.0 : 01 April 2024

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
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Kundu A K, Tarai R K, Nayak A, Senapati B. Influence of plant growth regulators on fruit drop, fruit retention and fruit yield of mango (Mangifera indica l.) cv. Amrapali under west central table land zone of Odisha. Plant Science Today. 2024; 11(2): 79–84. https://doi.org/10.14719/pst.2733

Abstract

Farmers in the western region of Odisha are grappling with issues related to low fruit set, fruit drop, and erratic yield in mango cultivation. Plant growth regulators (PGRs) play a pivotal role in addressing fruit drop at different developmental stages by modulating the nutritional and hormonal status of the plant. This study aims to investigate the impact of specific PGRs on fruit drop, fruit retention, and overall yield of Mango (*Mangifera indica* L.) cv. Amrapali in the West Central Table Land zone of Odisha. The experimental setup was implemented at the research plot of the College of Horticulture, Chiplima, Sambalpur, following a randomized block design with ten treatments, each replicated three times. The treatments involved various concentrations of three PGRs: NAA, GA_3, and 2,4-D, applied during the pea and marble stages of fruit growth. The outcomes indicated that the application of 30 ppm GA_3 significantly mitigated fruit drop, with comparable efficacy observed for 30 ppm 2,4-D. GA_3 positively influenced fruit retention, particularly Treatment T7 (30 ppm GA_3), exhibiting the highest retention percentages at 30, 60, and 90 days post-spraying. Furthermore, GA_3 at 30 ppm resulted in the maximum average fruit weight and volume. The highest number of harvested fruits per plant and maximum yield per plant were recorded in Treatment T7. These findings underscore the potential of GA_3 in alleviating fruit drop, enhancing fruit retention, and improving overall yield in mango cultivation, specifically for the Amrapali variety in the West Central Table Land Zone of Odisha.

Keywords

Mango; Amrapali; fruit drop; fruit retention; fruit yield

Introduction

Mangifera indica L., commonly known as mango, is a prominent member of the Anacardiaceae family, renowned for its widespread cultivation and global popularity due to its significant nutritional and economic contributions. Despite robust blooming and initial fruit set, mango growers face substantial economic losses attributed to pronounced fruit drop, a phenomenon that diminishes overall fruit yield. The distinct phases of fruit growth associated with abscission include preharvest drop (occurring shortly before fruit maturity), mid-season drop (at approximately 65-75 days post-fruit initiation), and post-setting drop (within the first two months after fruit set). Contributing factors to this phenomenon encompass nutrient deficiencies, intra-fruitlet competition, drought conditions, adverse weather events, and the onset of pathogenic diseases such as powdery mildew and anthracnose. Additionally, pests like hoppers and mealy bugs play a role in exacerbating fruit drop (1). Notably, beyond the natural fruit fall, young fruit primordia undergo premature abscission, underscoring the distinction between senescence and abscission processes driven by hormonal imbalances. Rapid developmental stages correlate with heightened auxin levels, while an elevated inhibitor level is associated with increased fruit drop rates. Researchers have explored the application of plant growth regulators, including 1-Naphthaleneacetic acid (NAA), gibberellic acid (GA_3), 2,4-Dichlorophenoxyacetic acid (2,4-D), among others, to mango trees in varying concentrations. These efforts aim to enhance fruit set and retention percentages (2). It is imperative to acknowledge that the effectiveness and optimal concentrations of plant growth regulators for influencing flowering, fruit drop, and retention are subject to modification under diverse agro-climatic conditions (3).

The augmentation of fruit yield is a confluence of heightened fruit production stemming from diminished fruit attrition and amplified fruit mass consequent to the foliar application of plant growth regulators. Notably, the dimensions and weight of mango fruits, pivotal indicators of yield, experienced positive modulation through the intervention of these regulators. The application of a 30 ppm concentration of GA_3 during the crucial developmental stages, namely the pea and marble stages of fruit formation, exerted a discernible influence. This intervention led to a reduction in both fruit shedding and overall fruit loss, attributable to the yield-enhancing attributes induced by the foliar spray. Consequently, this approach resulted in the maximal production of fruits and overall yield (4). The application of plant growth regulators and their specific impact on the yield of the Amrapali variety of mango cultivated in the West Central Table Land Zone of Odisha remains an underexplored domain, with scant information available. In light of the aforementioned facets, the current investigation endeavors to address this knowledge gap and contribute to the scientific understanding of the subject matter.

Materials and Methods

A research study was conducted at a mango orchard located in the instructional farm of the College of Horticulture, Odisha University of Agriculture and Technology, Chiplima, Sambalpur. The primary objective was to investigate the impact of various plant growth regulators on fruit drop, fruit retention, and overall fruit yield in Mango (*Mangifera indica* L.) cultivar Amrapali. The experimental site, situated approximately 20 km from the renowned Hirakud Dam, is positioned at 20° 21' N latitude and 80° 55' longitude, with an altitude of 155m above sea level. The soil composition at the experimental site is characterized as sandy loam, with a pH of 5.22, electrical conductivity of 0.11 dS/m, and organic carbon content of 0.65% (Table 1). The regional climate is typified by hot and dry summers and mild winters. The experiment involved the Amrapali mango variety, with ten distinct treatments replicated three times in a randomized block design. Each block consisted of three plants, spaced at 5m x 5m. Detailed information regarding the treatments is provided in Table 2.

On March 2nd and April 1st, 2021, a controlled experiment was conducted to investigate the effects of plant growth regulators, specifically NAA, GA_3, and 2,4-D, when applied twice during the hours of 9:15 a.m. to 2:15 p.m. The application targeted mango fruit at both the pea and marble stages of growth, involving the spraying of solutions on both the fruit and foliage. In preparation for the experiment, intercultural operations were performed during field preparation. Manual removal of weeds through hand weeding and shallow hoeing was carried out to eliminate any interference around the plants. Irrigation using the ring method was employed on the experimental mango plants. Subsequent to these procedures, the harvest of mature, uniformly sized, and fresh Amrapali mango fruits per tree was initiated from the last week of May through the second week of June. Following the completion of harvesting, a comprehensive assessment was conducted, calculating the total number of fruits on each plant. Additionally, the fruit weight of each plant was documented separately for each harvest. Statistical analyses, adhering to the established protocols outlined in the Randomized Block Design by Panse and Sukhatme (5), were applied to the recorded data. Parameters such as fruit drop percentage, fruit retention percentage, and overall fruit yield were subjected to rigorous statistical scrutiny and subsequently presented through tabular and graphical representations.

Table 1. Physico-chemical properties of Soil

PHYSICAL PROPERTIES	VALUES
Sand (%)	80.37
Silt (%)	3.12
Clay (%)	16.51
TEXTURE	Sandy loam
CHEMICAL PROPERTIES	
pH	5.22
Electrical conductivity	0.11 dS/m
Organic carbon %	0.65 %
NPK CONTENT DURING THE TIME OF CULTIVATION	
N	102.0 Kg/ha
$P_{-2}O_5$	14.5 kg/ha
K_2O	337.3 kg/ha

Table 2. Treatment details

Treatments		Treatment Details	Time and dose of application
T_1	Control	(Water spray)	For each treatment, the plants were sprayed with 10, 20 and 30 ppm each of NAA, GA_3 and 2,4-D respectively, twice once, during 2nd March (pea stage) and another during 1st April (marble stage) of the crops .The control plants were only sprayed with water.
T_2	NAA (10 ppm)	Naphthalene acetic acid (10 ppm)	
T_3	NAA (20 ppm)	Naphthalene acetic acid (20 ppm)	
T_4	NAA (30 ppm)	Naphthalene acetic acid (30 ppm)	
T_5	GA_3 (10 ppm)	Gibberellic acid (10 ppm)	
T_6	GA_3 (20 ppm)	Gibberellic acid (20 ppm)	
T_7	GA_3 (30 ppm)	Gibberellic acid (30 ppm)	
T_8	2,4-D (10 ppm)	2,4-Dichlorophenoxy acetic acid (10 ppm)	
T_9	2,4-D (20 ppm)	2,4-Dichlorophenoxy acetic acid (20 ppm)	
T_{10}	2,4-D (30 ppm)	2,4-Dichlorophenoxy acetic acid (30 ppm)	

Results

Following the application of diverse concentrations of plant growth regulators during distinct developmental stages, specifically the pea and marble stages of fruit growth, the ensuing data is presented in Table 3, Table 5, and Figure 1, elucidating fruit drop percentages and fruit retention at 30, 60, and 90 days post-spraying. Treatment T7, involving 30 ppm GA_3, demonstrated the most favorable outcome with the lowest fruit drop percentages: 63.54%, 71.44%, and 83.68% at 30, 60, and 90 days post-spraying, respectively. Conversely, treatment T1 (Control) exhibited the highest fruit drop percentages, recording values of 86.81%, 92.74%, and 96.57% at corresponding time intervals. Treatment T7, statistically comparable to T10 (30 ppm 2,4-D), displayed fruit drop percentages of 67.72%, 75.00%, and 88.48% at 30, 60, and 90 days post-spraying, respectively. Figure 1 visually represents the noteworthy impact of T7 (30 ppm GA_3) on fruit retention percentages, yielding values of 36.46%, 28.56%, and 16.32% at 30, 60, and 90 days, respectively. Following a similar statistical trend, T10 (30 ppm 2,4-D) demonstrated fruit retention percentages of 32.28%, 25.00%, and 11.52% at the corresponding time intervals (Table 5).

The statistical analysis of data pertaining to average fruit weight is presented in Table 4. Notably, the maximum average fruit weight of 263.21 g was observed in T7 (application of GA_3 at 30 ppm), whereas the minimum of 202.77 g was recorded in T1 (Control). Treatments T6 (258.45 g), T2 (241.78 g), and T4 (236.84 g) exhibited statistical parity with T7 in terms of this trait. Additionally, T7 (GA_3 at 30 ppm) demonstrated the maximum fruit volume of 256.32 ml, while the minimum of 194.66 ml was observed in T1 (Control). The data concerning the number of harvested fruits per plant, as detailed in Table 4, revealed significant variations among different plant growth regulator treatments. T7 (GA_3 at 30 ppm) displayed the highest number of harvested fruits per plant (69.67), statistically comparable to T10 (69.00), T6 (67.00), and T4 (64.67). In contrast, T1 (Control) exhibited the lowest number of harvested fruits per plant, recording 21.67. The observed differences extended to the yield per plant, with T7 (GA3 at 30 ppm) registering the maximum yield at 18.34 kg/plant, and T1 (Control) recording the minimum at 4.41 kg/plant. Nevertheless, treatments T6 (17.31 kg/plant), T10 (16.07 kg/plant), T4 (15.31 kg/plant), T3 (14.57 kg/plant), T9 (15.64 kg/plant), and T8 (12.22 kg/plant) exhibited statistical equivalence with T7 in terms of this trait.

Table-3: Effect of plant growth regulators on fruit drop percentage in Mango cv.Amrapali

Treatment	**Fruit Drop (%)**		
	30 DAS	**60 DAS**	**90 DAS**
T_1- Control	86.81	92.74	96.57
T_2 – NAA (10 ppm)	78.54	85.60	92.26
T_3- NAA (20 ppm)	80.16	84.62	91.02
T_4-NAA (30 ppm)	76.46	83.65	90.04
T_5-GA_3 (10 ppm)	86.02	90.06	95.86
T_6-GA_3 (20 ppm)	76.50	83.21	90.66
T_7-GA_3 (30 ppm)	63.54	71.44	83.68
T_8-2,4-D (10 ppm)	73.59	89.32	92.69
T_9-2,4-D (20 ppm)	72.77	81.35	90.17
T_{10}-2,4-D (30 ppm)	67.72	75.00	88.48
SE(m) ±	**2.57**	**3.48**	**1.78**
C.D. at 5 %	**7.49**	**10.06**	**5.16**

DAS- Days after spraying, C.D. at 5 %- Critical Difference at 5% level of significance, SE(m) – Standard Error of Means

Table-4: Effect of plant growth regulators on fruit weight, fruit volume, number of fruits per plant and yield in Mango cv. Amrapali sampled during May,2021.

Treatment	Fruit weight (g)	Fruit volume (ml)	Number of harvested fruits per plant	Yield (Kg/Plant)
T_1- Control	202.77	194.66	21.67	4.41
T_2 – NAA (10 ppm)	241.78	233.00	39.67	9.60
T_3- NAA (20 ppm)	213.22	205.00	68.33	14.57
T_4-NAA (30 ppm)	236.84	228.48	64.67	15.31
T_5-GA_3 (10 ppm)	204.37	197.40	31.67	6.47
T_6-GA_3 (20 ppm)	258.45	249.66	67.00	17.31
T_7-GA_3 (30 ppm)	263.21	256.32	69.67	18.34
T_8-2,4-D (10 ppm)	206.08	199.62	59.33	12.22
T_9-2,4-D (20 ppm)	225.67	219.33	63.33	15.64
T_{10}-2,4-D (30 ppm)	232.98	227.67	69.00	16.07
SE(m) ±	**9.52**	**9.16**	**9.90**	**2.59**
C.D. at 5 %	**27.55**	**26.50**	**28.64**	**7.49**

DAS- Days after spraying C.D. at 5 %- Critical Difference at 5% level of significance SE(m) – Standard Error of Means

Table-5: Effect of plant growth regulators on fruit retention percentage in Mango cv. Amrapali

Treatment	30 DAS	60 DAS	90 DAS
T_1- Control	13.19	7.26	3.43
T_2 – NAA (10 ppm)	21.46	14.40	7.74
T_3- NAA (20 ppm)	19.84	15.38	8.98
T_4-NAA (30 ppm)	23.54	16.35	9.96
T_5-GA_3 (10 ppm)	13.98	9.94	4.14
T_6-GA_3 (20 ppm)	23.50	16.79	9.34
T_7-GA_3 (30 ppm)	36.46	28.56	16.32
T_8-2,4-D (10 ppm)	26.41	10.68	7.31
T_9-2,4-D (20 ppm)	27.23	18.65	9.83
T_{10}-2,4-D (30 ppm)	32.28	25.00	11.52
SE(m) ±	**2.57**	**3.48**	**1.78**
C.D. at 5 %	**7.49**	**10.06**	**5.16**

DAS- Days after spraying C.D. at 5 %- Critical Difference at 5% level of significance SE(m) – Standard Error of Means

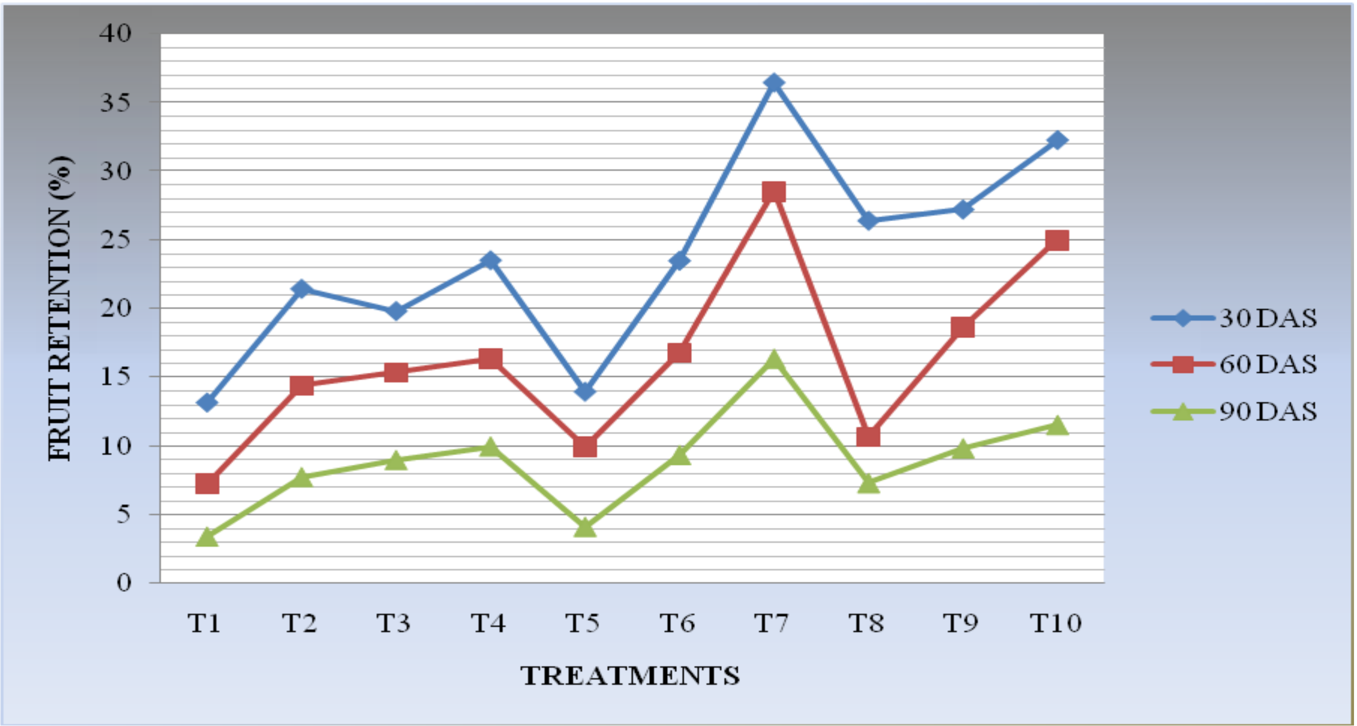

Figure 1. Fruit retention (%) as influenced by foliar spray of plant growth regulators in mango cv. Amrapali

Discussion

The utilization of multiple plant growth regulators significantly mitigated the percentage of fruit drop in mango. Notably, the lowest fruit drop percentage was observed with the application of 30 ppm of GA_3 followed by 30 ppm of 2,4-D. This reduction in fruit drop can be attributed to the accelerated ovarian growth during the early stages facilitated by GA_3 and 2,4-D administration. Consequently, a decrease in the magnitude of peak abscission occurred. The effectiveness of GA_3 and 2,4-D lies in their capacity to enhance the efficient utilization of nutrients for sexual development, flower and fruit production. Moreover, these regulators contribute to increased photosynthetic efficiency, improved source-sink relationships between the plant and its environment, heightened nutrient and water uptake, enhanced translocation, accumulation of sugars, and other metabolites, while concurrently decreasing transpiration. This outcome aligns with previous findings, such as those reported by (6), where misting GA_3 at varying concentrations resulted in the least fruit drop across various mango varieties. Furthermore, the application of GA_3 acts in opposition to endogenous hormones, specifically ethylene and abscisic acid, thereby augmenting fruit retention. The augmented fruit weight and volume can be attributed to the exogenous application of growth-promoting chemicals, promoting the accumulation of sugars and water. GA_3-induced elongation and multiplication of meristem cells contribute to the observed increase in fruit volume, a phenomenon also substantiated by the findings of Parauha and Pandey (7), Wahdan et al., (8), and Rhman et al., (9).

The foliar administration of GA_3 has demonstrated a pronounced enhancement in fruit yield attributable to increased fruit weight and retention. Noteworthy effects on fruit set and retention in mango trees have been documented by researchers (3), (10), and (11). The physiological processes of mango trees appear to be positively influenced by the application of GA_3, resulting in heightened fruit production. Correspondingly, similar observations have been made by researchers (11) and (12) in the context of mango cultivation. The mechanism behind this improvement is attributed to the ability of Gibberellic Acid to stimulate both cell division and elongation. Conversely, a deficiency in gibberellins has been linked to fruit drop. The application of GA_3 is postulated to enhance reproductive processes, leading to increased fruit set and retention, ultimately minimizing fruit drop (13). Furthermore, the positive impact of GA_3 on fruit set has been observed at critical stages such as the pea and marble stage. This effect is achieved through a reduction in abscisic acid content, promoting fruit set and retention compared to untreated controls. The application of GA_3 has been associated with the induction of enzymes linked to improved fruit sets, playing a pivotal role in post-fertilization events (14). Specifically, GA_3 is thought to facilitate the breakdown of the cellulase enzyme, influencing cell wall dynamics. This action prevents the dissolution of middle lamella cells and the cell wall, thereby impeding the formation of separation layers. Consequently, this process contributes to a reduction in fruit drop and an augmentation of fruit retention in mango trees.

Conclusion

In conclusion, this research investigates the influence of plant growth regulators on fruit drop dynamics, fruit retention, and overall yield in mango (*Mangifera indica*) cv. Amrapali under the unique agro-climatic conditions of the West Central Table Land Zone of Odisha. The experiment, conducted at the student research plot of the College of Horticulture, Chiplima, employed a randomized block design with ten treatments, each meticulously replicated thrice. The primary focus was on varying concentrations of three plant growth regulators, namely, NAA, GA_3, and 2,4-D, administered at critical pea and marble stages of fruit growth. The results reveal that 30 ppm of GA_3 significantly mitigates fruit drop, surpassing the efficacy of even 30 ppm of 2,4-D. Furthermore, GA_3 demonstrates a positive influence on fruit retention, particularly in treatment T7 (30 ppm GA_3), which exhibits superior retention percentages at 30, 60, and 90 days post-spraying. This positive impact extends to other essential metrics, as 30 ppm GA_3 yields the maximum average fruit weight, number of harvested fruits per plant, and overall yield. These findings underscore the potential of GA_3, not only in minimizing losses attributable to fruit drop but also in enhancing fruit quality and overall yield in the cultivation of the Amrapali variety of mango.

Acknowledgements

The authors thankfully acknowledge the support rendered by the Odisha University of Agriculture and Technology in financial support through Research Operating Costs in carrying out the work.

Authors' contributions

All the authors contributed to the above works, starting from lay out, designing of the experiment, taking observation on different growth, flowering, and fruiting parameters, statistical analysis, and interpretation of the result to preparation of the manuscript.

Compliance with ethical standards

Declaration: The authors declare that they do not have any conflict of interest.

Ethical issues: None

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