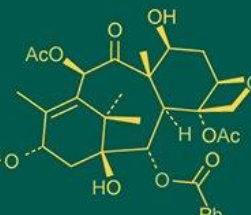
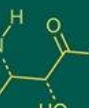
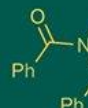


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Efficacy of new generation plant growth regulators on fruit set, fruit drop and nubbins of mango (*Mangifera indica* L.) cv. Kesar under HDP

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Abstract

The present research entitled “Efficacy of new generation plant growth regulators on fruit set, fruit drop and nubbins of mango (*Mangifera indica* L.) cv. Kesar under HDP” was conducted at Fruit Research Station, Sakkarbaug, College of Horticulture, Junagadh Agricultural University, Junagadh during the year 2023-24 and 2024-25. The experiment was carried out in Randomized Block Design with three replications and 10 treatments comprised T₁ (Control), T₂ (Tricontanol 500 ppm), T₃ (Tricontanol 750 ppm), T₄ (Tricontanol 1000 ppm), T₅ (Brassinosteroid 1ppm), T₆ (Brassinosteroid 2 ppm), T₇ (Brassinosteroid 3 ppm), T₈ (Salicylic acid 1500 ppm), T₉ (Salicylic acid 2000 ppm) and T₁₀ (Salicylic acid 2500 ppm). The results revealed that the maximum number of fruits at the grain stage per panicle (74.98, 72.18 and 73.58), number of fruits at pea stage per panicle (21.58, 20.30 and 20.94), number of fruits at marble stage per panicle (5.37, 4.96 and 5.16), fruit set at grain stage per panicle (79.58, 78.50 and 79.04%), fruit set at pea stage per panicle (28.79, 28.25 and 28.52%), fruit set at the marble stage per panicle (24.94, 24.45 and 24.70%), minimum fruit drop at pea stage per panicle (71.21, 71.75 and 71.48%), fruit drop at marble stage per panicle (75.06, 75.55 and 75.30%) and lowest number of nubbins per 50 fruits at pea stage (0.52, 0.57 and 0.55) were noted with the foliar spray of brassinosteroid 1 ppm (T₅) during both experimental years and in the pooled data.

Keywords: Mango, Kesar, Tricontanol, brassinosteroid, Salicylic acid and HDP

1. Introduction

The mango (*Mangifera indica* L.) a botanical cornerstone of the anacardiaceae family stands as the prominent horticultural icon of India and the global tropics. While the genus *Mangifera* encompasses 69 recognized species and an expansive global diversity of 11,595 cultivars. India remains the unparalleled custodian of its genetic heritage harboring a germplasm repository of approximately 1,000 distinct cultivars (Bose, 1999) [4].

In Gujarat, mango is cultivated on estimated area of 1.84 lakh hectare with 12.72 lakh metric tonne production and productivity of 6.92 t/ha (Anon., 2025) [2]. Mango serves as the backbone of Gujarat's commercial horticulture. Gujarat state maintains a diverse germplasm including traditional and regional cultivars such as Alphonso, Kesar, Rajapuri, Totapuri, Sonpari, Jamadar, khodi, Vanraj, Karanjio, Dadamio, Pachhatio, Sardar, Sinduriyo many of these exhibit limitations in specific economic traits. Consequently Kesar, Alphonso and Rajapuri have emerged as the three primary commercial cultivars. Among these Kesar is highly esteemed for its distinctive saffron colored pulp and green overtone orange yellow exocarp which facilitates easy varietal identification.

Nowadays mango growers faced a problem of low fruit setting, high fruit drop and more number of nubbins due to climate change. In mango fruit drop occurs at pea, marble and maturity stage that leads to low fruit yield. Number of factors are involved in pre mature fruit drop; such as irregular pattern of rain and high wind at the time of flowering and fruit setting due to climate change, nutrient deficiencies at embryo developmental stage, lack of pollination, serious pest and diseases. Post fertilization fruit drop occurs due the longer period of stress i.e., in the form of high temperature, low soil moisture content, low atmospheric humidity during flowering and fruiting that cause hormonal imbalance like low auxin and high ABA content. These leads to more fruit drop. In mango, flowering and fruit setting is crucial event.

Modulation of flowering and fruit setting by spraying of new generation plant growth regulators at flowering, pea and marble stage is the best alternative to mitigate climate change effect on mango.

Triconanol (TRIA) acts as a metabolic catalyst that enhances photosynthetic rate and nutrient acquisition. It is primarily used to minimize premature fruit drop (Neem and Khan, 2011) [9]. Brassinosteroids (BRs) function at low concentrations to promote pollen germination and tube growth ensuring higher reproductive success. By modulating hormonal level and stabilizing chloroplast membranes they enhance sink strength and fruit retention especially under abiotic stress and fluctuating temperatures (Seif *et al.*, 2014; Yue *et al.*, 2019) [13, 15]. Salicylic Acid (SA) is natural signaling molecule that inhibits ethylene biosynthesis to prevent fruit abscission. It improves the hermaphrodite flower ratio and strengthens the plant's defense architecture against environmental stressors, boosting overall yield (Hayat *et al.*, 2010 and Ding *et al.*, 2001) [6, 5].

2. Materials and Methods

The study entitled "Efficacy of new generation plant growth regulators on fruit set, fruit drop and nubbins of mango (*Mangifera indica* L.) cv. Kesar under HDP" was conducted on 7 years old trees at Fruit Research Station, Sakkarbaug, College of Horticulture, Junagadh Agricultural University, Junagadh which is located in the South Saurashtra Agro-

climatic Zone. The study was carried out during 2023-24 and 2024-25. The experiment was carried out in Randomized Block Design with three replications and 10 treatments comprised T₁ (Control), T₂ (Triconanol 500 ppm), T₃ (Triconanol 750 ppm), T₄ (Triconanol 1000 ppm), T₅ (Brassinosteroid 1ppm), T₆ (Brassinosteroid 2 ppm), T₇ (Brassinosteroid 3 ppm), T₈ (Salicylic acid 1500 ppm), T₉ (Salicylic acid 2000 ppm) and T₁₀ (Salicylic acid 2500 ppm).

This study aimed to increase fruit set and reduce fruit drop and nubbins, thereby addressing the major challenges faced by farmers due to climate change. The parameters recorded during the study included number of hermaphrodite flowers, number of fruits at grain stage, pea stage and marble stage, fruit set at grain stage, pea stage and marble stage, fruit drop at pea stage and marble stage and number of nubbins per 50 fruits at pea stage. The data collected from the experiment underwent statistical analysis using the method proposed by Panse and Sukhatme (1985) [10]. The significance of each character was assessed using the "F" test. Additionally, the Standard Error of Mean (S. Em.±) and Critical Difference (CD) were calculated at a 5% level of significance to evaluate the variation and significance among the different treatments. The formulas adopted for the observations are detailed below.

1. Fruit set at grain stage/panicle (%)

$$\text{Fruit set (\%)} \text{ at grain stage} = \frac{\text{Number of fruits at grain stage}}{\text{Total number of hermaphrodite flowers}} \times 100$$

2. Fruit set at pea stage/panicle (%)

$$\text{Fruit set (\%)} \text{ at pea stage} = \frac{\text{Number of fruits at pea stage}}{\text{Number of fruits at grain stage}} \times 100$$

3. Fruit set at marble stage/panicle (%)

$$\text{Fruit set (\%)} \text{ at marble stage} = \frac{\text{Number of fruits at marble stage}}{\text{Number of fruits at pea stage}} \times 100$$

4. Fruit drop at pea stage/panicle (%)

$$\text{Fruit drop (\%)} \text{ at pea stage} = \frac{\text{No. of fruits at grain stage} - \text{No. of fruits at pea stage}}{\text{No. of fruits at grain stage}} \times 100$$

5. Fruit drop at marble stage/panicle (%)

$$\text{Fruit drop (\%)} \text{ at marble stage} = \left| \frac{\text{No. of fruits at pea stage} - \text{No. of fruits at marble stage}}{\text{No. of fruits at pea stage}} \right| \times 100$$

3. Results and Discussion

The experimental results summarized in Tables 1 to 5 demonstrate a statistically significant enhancement in mango fruit set parameters following treatments with modern plant growth regulators.

The fruit set parameters significantly influenced by new generation plant growth regulators whereas hermaphrodite flowers were not significantly influenced.

The maximum number of fruits at the grain stage per panicle (74.98, 72.18, and 73.58), number of fruits at pea stage per panicle (21.58, 20.30 and 20.94) and number of fruits at marble stage per panicle (5.37, 4.96 and 5.16) were recorded with the foliar spray of brassinosteroid 1 ppm (T₅) during

both experimental years as well as in the pooled analysis.

The highest fruit set at grain stage per panicle (79.58, 78.50 and 79.04%), fruit set at pea stage per panicle (28.79, 28.25 and 28.52%) and fruit set at the marble stage per panicle (24.94, 24.45 and 24.70%) were noted with the foliar spray of brassinosteroid 1 ppm (T₅) during individual years and in the pooled data.

The minimum fruit drop at pea stage per panicle (71.21, 71.75 and 71.48%) and fruit drop at marble stage per panicle (75.06, 75.55 and 75.30%) were recorded with the foliar spray of brassinosteroid 1 ppm (T₅) during both experimental years as well as in the pooled results. The significantly lowest number of nubbins per 50 fruits at pea

stage (0.52) was recorded with the foliar application of brassinosteroid 1 ppm (T₅) during first year.

The minimum number of nubbins per 50 fruits at pea stage (0.57 and 0.55) was recorded in brassinosteroid 1 ppm (T₅) during both experimental years and in the pooled analysis. However, poor performance was registered in treatment control (T₁) in above all the fruit set attributing characters during the year 2023-24, 2024-25 and in pooled data.

Brassinosteroids increase the number of fruits at the grain stage and increase fruit set at grain stage might be due to it promote vascular differentiation within the panicle rachis which strengthens the physical connection between the hermaphrodite flower and the panicle rachis. In high

temperature environments it provides a critical rescue effect by protecting pollen grain membranes from thermal damage and accelerating pollen tube growth to ensure successful fertilization before ovule senescence. Furthermore, at the grain stage the young ovaries are highly susceptible to oxidative stress. Brassinosteroids enhance the activity of antioxidant enzymes like Superoxide Dismutase (SOD) and Catalase (CAT) which protect these developing fruitlets from premature abortion. The present findings are in close conformity with the results of Ramani *et al.* (2016) ^[12], Tepkaew *et al.* (2022) ^[14], Almutairi *et al.* (2023) ^[1] and Attia and Shehata (2023) ^[3] in mango.

Table 1: Efficacy of new generation plant growth regulators on number of hermaphrodite flowers of mango (*Mangifera indica* L.) cv. Kesar under HDP

Treatments	Number of hermaphrodite flowers/panicle		
	2023-24	2024-25	Pooled
T ₁ : Control	100.31	99.36	99.84
T ₂ : TRIA 500 ppm	93.99	100.91	97.45
T ₃ : TRIA 750 ppm	95.28	99.57	97.43
T ₄ : TRIA 100 ppm	103.60	103.34	103.47
T ₅ : BRs 1 ppm	94.25	91.97	93.11
T ₆ : BRs 2 ppm	93.30	94.45	93.88
T ₇ : BRs 3 ppm	94.62	97.97	96.29
T ₈ : SA 1500 ppm	96.55	98.81	97.68
T ₉ : SA 2000 ppm	97.37	99.01	98.19
T ₁₀ : SA2500 ppm	101.15	102.01	101.58
S.Em.±	2.477	4.128	2.407
C.D. at 5%	NS	NS	NS
C.V.%	4.42	7.24	6.02
Year			
S.Em.±	-	-	1.076
C.D. at 5%	-	-	NS
Y × T			
S.Em.±	-	-	3.404
C.D. at 5%	-	-	NS

Table 2: Efficacy of new generation plant growth regulators on number of fruits at grain, pea and marble stage of mango (*Mangifera indica* L.) cv. Kesar under HDP

Treatments	Number of fruits at grain stage/panicle			Number of fruits at pea stage/panicle			Number of fruits at marble stage/panicle		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Control	51.38	48.73	50.06	8.40	7.03	7.72	1.31	1.24	1.28
T ₂ : TRIA 500 ppm	61.60	59.22	60.41	11.89	10.50	11.20	1.96	1.87	1.92
T ₃ : TRIA 750 ppm	63.35	62.21	62.78	12.72	11.72	12.22	2.16	2.12	2.14
T ₄ : TRIA 100 ppm	58.69	56.21	57.45	10.74	10.24	10.49	1.77	1.83	1.80
T ₅ : BRs 1 ppm	74.98	72.18	73.58	21.58	20.30	20.94	5.37	4.96	5.16
T ₆ : BRs 2 ppm	73.46	71.22	72.34	21.18	19.71	20.44	5.06	4.53	4.80
T ₇ : BRs 3 ppm	73.57	70.96	72.26	20.37	19.08	19.72	4.81	4.41	4.61
T ₈ : SA 1500 ppm	68.38	67.68	68.03	17.78	16.42	17.10	3.99	3.61	3.80
T ₉ : SA 2000 ppm	70.37	70.64	70.51	18.56	17.07	17.81	4.36	3.90	4.13
T ₁₀ : SA2500 ppm	68.36	66.52	67.44	16.95	16.12	16.53	3.58	3.36	3.47
S.Em.±	2.304	2.655	1.758	0.904	0.654	0.558	0.193	0.161	0.126
C.D. at 5%	6.85	7.89	5.04	2.69	1.94	1.60	0.57	0.48	0.36
C.V.%	6.01	7.12	6.58	9.77	7.64	8.86	9.74	8.74	9.30
Year									
S.Em.±	-	-	0.786	-	-	0.249	-	-	0.056
C.D. at 5%	-	-	NS	-	-	NS	-	-	NS
Y × T									
S.Em.±	-	-	2.486	-	-	0.789	-	-	0.178
C.D. at 5%	-	-	NS	-	-	NS	-	-	NS

Table 3: Efficacy of new generation plant growth regulators on fruit set at grain, pea and marble stage of mango (*Mangifera indica* L.) cv. Kesar under HDP

Treatments	Fruit set at grain stage/panicle (%)			Fruit set at pea stage/panicle (%)			Fruit set at marble stage/panicle (%)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Control	51.33	49.06	50.19	16.32	14.43	15.37	15.82	17.68	16.75
T ₂ : TRIA 500 ppm	65.40	58.69	62.05	19.38	17.72	18.55	16.43	18.19	17.31
T ₃ : TRIA 750 ppm	66.56	62.48	64.52	20.03	18.83	19.43	17.35	18.08	17.71
T ₄ : TRIA 100 ppm	56.71	54.54	55.62	18.32	18.23	18.28	16.46	17.94	17.20
T ₅ : BRs 1 ppm	79.58	78.50	79.04	28.79	28.25	28.52	24.94	24.45	24.70
T ₆ : BRs 2 ppm	78.88	75.62	77.25	28.79	27.74	28.27	24.02	23.05	23.54
T ₇ : BRs 3 ppm	77.77	72.45	75.11	27.69	26.89	27.29	23.61	23.15	23.38
T ₈ : SA 1500 ppm	70.82	68.51	69.67	26.11	24.28	25.20	22.53	22.05	22.29
T ₉ : SA 2000 ppm	72.39	71.37	71.88	26.37	24.17	25.27	23.52	22.93	23.22
T ₁₀ : SA2500 ppm	67.56	67.27	67.41	24.86	24.30	24.58	21.19	20.84	21.01
S.Em.±	2.402	3.530	2.135	1.345	1.058	0.856	1.380	1.289	0.944
C.D. at 5%	7.14	10.49	6.12	4.00	3.14	2.45	4.10	3.83	2.71
C.V.%	6.06	9.29	7.77	9.84	8.15	9.08	11.61	10.72	11.17
Year									
S.Em.±	-	-	0.955	-	-	0.383	-	-	0.422
C.D. at 5%	-	-	2.74	-	-	1.10	-	-	NS
Y × T									
S.Em.±	-	-	3.019	-	-	1.210	-	-	1.335
C.D. at 5%	-	-	NS	-	-	NS	-	-	NS

Table 4: Efficacy of new generation plant growth regulators on fruit drop at pea and marble stage of mango (*Mangifera indica* L.) cv. Kesar under HDP

Treatments	Fruit drop at pea stage/panicle (%)			Fruit drop at marble stage/panicle (%)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Control	83.68	85.57	84.63	84.18	82.32	83.25
T ₂ : TRIA 500 ppm	80.62	82.28	81.45	83.57	81.81	82.69
T ₃ : TRIA 750 ppm	79.97	81.17	80.57	82.65	81.92	82.29
T ₄ : TRIA 100 ppm	81.68	81.10	81.39	83.54	82.06	82.80
T ₅ : BRs 1 ppm	71.21	71.75	71.48	75.06	75.55	75.30
T ₆ : BRs 2 ppm	71.21	72.26	71.73	75.98	76.95	76.46
T ₇ : BRs 3 ppm	72.31	73.11	72.71	76.72	76.85	76.79
T ₈ : SA 1500 ppm	73.88	75.72	74.80	77.47	77.95	77.71
T ₉ : SA 2000 ppm	73.63	75.83	74.73	76.48	77.07	76.78
T ₁₀ : SA2500 ppm	75.14	75.70	75.42	78.81	79.16	78.99
S.Em.±	2.223	2.629	1.721	2.129	1.511	1.305
C.D. at 5%	6.60	7.81	4.94	6.32	4.49	3.74
C.V.%	5.04	5.88	5.48	4.64	3.31	4.03
Year						
S.Em.±	-	-	0.770	-	-	0.584
C.D. at 5%	-	-	NS	-	-	NS
Y × T						
S.Em.±	-	-	2.434	-	-	1.846
C.D. at 5%	-	-	NS	-	-	NS

Table 5: Efficacy of new generation plant growth regulators on number of nubbins of mango (*Mangifera indica* L.) cv. Kesar under HDP

Treatments	Number of nubbins per 50 fruits at pea stage		
	2023-24	2024-25	Pooled
T ₁ : Control	3.07	3.11	3.09
T ₂ : TRIA 500 ppm	2.30	2.74	2.52
T ₃ : TRIA 750 ppm	2.15	2.59	2.37
T ₄ : TRIA 100 ppm	2.20	2.82	2.51
T ₅ : BRs 1 ppm	0.52	0.57	0.55
T ₆ : BRs 2 ppm	0.80	0.76	0.78
T ₇ : BRs 3 ppm	0.89	0.90	0.90
T ₈ : SA 1500 ppm	1.70	1.68	1.69
T ₉ : SA 2000 ppm	1.65	1.30	1.48
T ₁₀ : SA2500 ppm	1.71	1.92	1.81
S.Em.±	0.063	0.064	0.144
C.D. at 5%	0.19	0.19	0.46
C.V.%	6.39	6.02	6.20
Year			
S.Em.±	-	-	0.020
C.D. at 5%	-	-	0.06
Y × T			
S.Em.±	-	-	0.063
C.D. at 5%	-	-	0.18

Brassinosteroid increase the number of fruits at the pea stage, which ultimately leads to an improved final fruit set and reduce fruit drop per panicle at pea stage. Highest fruit set at the pea stage per panicle under brassinosteroid might be due to the stabilization of the developing embryo and the maintenance of a favorable endogenous hormonal balance. Brassinosteroid effectively suppress the activity of ACC synthase, thereby inhibiting ethylene biosynthesis and delaying the formation of the abscission layer at the fruit pedicel junction. By enhancing the plants antioxidant defense system through increased Superoxide Dismutase (SOD) and Peroxidase (POX) activity and improving water use efficiency through stomatal modulation brassinosteroids protect young fruitlets from oxidative stress and desiccation leading to an increased fruit set at the pea stage per panicle. The notable improvement in fruit set at pea stage recorded in the present investigation is Supported by the findings of Patel *et al.* (2021) ^[11], Ramani *et al.* (2016) ^[12], Tepkaew *et al.* (2022) ^[14], Almutairi *et al.* (2023) ^[1] and Attia and Shehata (2023) ^[3] in mango, Mostafa and Kotb (2018) ^[8] in sugar apple and Isci and Gokbayrak (2015) in grapes.

The application of brassinosteroid significantly increases the number of fruits at the marble stage by enhancing the photosynthetic rate and ensuring a steady supply of nutrients which ultimately results in a higher final fruit set and reduction in fruit drop per panicle at marble stage. Besides this, brassinosteroid enhances metabolic sink strength prioritizing the flow of photo assimilates to the fruits and promotes vascular differentiation in the pedicel to provide mechanical support for the increasing fruit weight. Simultaneously, by upregulating the antioxidant defense

system and modulating ethylene biosynthesis, brassinosteroid mitigate late season heat stress and prevent the formation of the abscission layer. The results recorded for the highest fruit set at marble stage in this study are validated by the research of Ramani *et al.* (2016) ^[12], Tepkaew *et al.* (2022) ^[14], Almutairi *et al.* (2023) ^[1] and Attia and Shehata (2023) ^[3] in mango.

Brassinosteroid play vital role in reduction of number of nubbins (underdeveloped or seedless fruitlets) per 50 fruits at pea stage. Nubbins typically develop due to failure in fertilization or premature embryo abortion often triggered by physiological stress or hormonal deficiencies during the early post anthesis phase. When the embryo fails to develop the fruitlet loses its primary source of auxin signaling leading to a cessation of growth and subsequent abscission. Minimizing nubbins is primarily due to its role in ensuring successful embryo development. Brassinosteroid promote pollen tube elongation and stimulate active cell division within the newly formed embryo which prevents its premature abortion. Since a healthy developing seed serves as the physiological engine that provides the necessary hormonal signals to keep the fruit attached. The stabilization of the embryo by brassinosteroid ensures that the fruitlets do not revert to a nubbin state. Furthermore, it enhances the metabolic sink strength and the flow of metabolites toward the developing seed ensuring it has sufficient energy to complete its initial growth phase thereby significantly lowering the percentage of underdeveloped fruitlets. The reduction in number of nubbins at pea stage in the current study perfectly aligns with the findings of Tepkaew *et al.* (2022) ^[14].

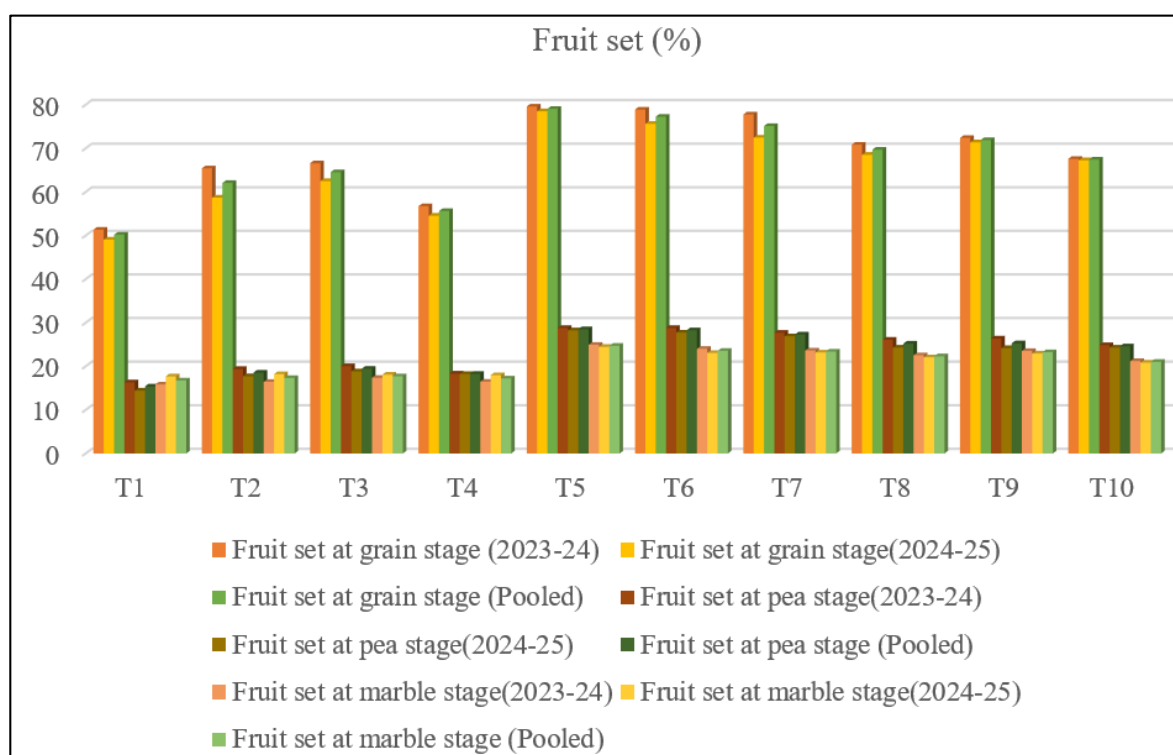


Fig 1: Efficacy of new generation plant growth regulators on fruit set percent at grain, pea and marble stage of mango (*Mangifera indica* L.) cv. Kesar under HDP



Plate 1: Efficacy of new generation plant growth regulators on number of fruits at grain, pea and marble stage of mango (*Mangifera indica* L.) cv. Kesar under HDP

4. Conclusion

The findings of investigation lead to the conclusion that the foliar spray of brassinosteroid 1 ppm at full bloom, pea and marble stage improves the number of fruits as well as the fruit set percent at grain at grain, pea and marble stage, while reduce the fruit drop at pea and marble stage as well as the number of nubbins in mango cv. Kesar under HDP.

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