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Effect of plant growth regulators on induction of flowering and yield of pineapple (*Ananas comosus* L.) cv. queen under Konkan agro-climatic condition

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Abstract
Field experiment entitled 'Effect of plant growth regulators on induction of flowering and yield of pineapple cv. Queen' was carried out at College of Horticulture, Dr. Balashaeb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri during the year 2023-2024 to find out the different levels of plant growth regulators on early flowering and yield of pineapple. The experiment was laid out in randomized block design with nine treatments *viz*., T_1: application of NAA 100 ppm, T_2: NAA 200 ppm, T_3: ethrel 50 ppm, T_4: ethrel 100 ppm, T_5: GA_3 50 ppm, T_6: $GA_3$100 ppm, T_7: PBZ 500 ppm, T_8: PBZ 1000 ppm, T_9: Control (without application of PGRs) which were replicated three times. Results revealed that the application of PBZ 500 ppm (T_7) was significantly effective for early flowering (26.0 days), minimum days for flowering completion (32.67 days), fruit yield (56.53 kg/plot), fruit yield (35.88 t/ha), maximum crown weight (82.28 g) and fruit weight with crown (807.60 g) over the other treatments. Application of NAA 100 ppm) (T_1) and ethrel 50 ppm (T_3) were at par with PBZ 500 ppm (T_7). Similarly, the ethrel 50 ppm (T_3) recorded the highest flowering percentage (95%) and was at par with the PBZ 500 ppm (T_7). Thus PBZ 500 ppm, NAA 100 ppm and ethrel 50 ppm were the promising treatments for induction of flowering, fruit weight and fruit yield. Considering the cost of production, the ethrel 50 ppm (T_3) was maximum B:C ratio of 1.88 owing to the lower cost of ethrel in the market as compared to NAA and PBZ. Thus, it can be concluded that for synchronized and early flowering and more yield with high B:C ratio, the pineapple plants should be treated with ethrel 50 ppm at 27-30 leaves stage.

Keywords: Pineapple, plant growth regulators, ethrel, flowering and yield

Introduction

Pineapple (*Ananas comosus* L.), the only edible fruit in Bromeliaceae family, is a significant global fruit crop, making up 51% of the world's tropical fruit trade (FAO, 2008). Indonesia, Philippines, and Costa Rica are the top producers of this fruit, with a total world production of over 29 million MT. In India, pineapple is grown on approximately 108,000 hectares, with West Bengal, Assam, and Tripura being the leading states in production (Anon. 2024) [1]. The 'Giant Kew' is most popular commercial cultivar grown in India. Pineapples are rich in nutrients, including vitamins, minerals, and enzyme bromelain, which aids in digestion (Krishan *et al*., 2017) [5]. The plant, a monocotyledonous herb, grows to a height of 1-2 meters, has adventitious roots, and its leaves form a spiral rosette. Its cultivation thrives in humid tropical climates with temperatures between 22ºC -32 °C and rainfall ranges from 100-150 cm. The major challenge in pineapple cultivation is late and uneven flowering, which leads to unscheduled fruiting and prolonged land use. To address this, synthetic plant growth regulators (PGRs) like NAA, ethrel, gibberellic acid, and paclobutrazol are used to induce early and uniform flowering, which in turn leads to uniform fruiting and harvesting. This study aims to find out the different levels of PGRs on early flowering and yield of pineapple cv. Queen, hypothesizing those different PGRs and their concentrations will significantly influence reproductive physiology and fruit quality, while acknowledging the limitations of focusing on a single cultivar and specific concentrations.

Materials and Methods

Experiment was carried out at the Hi-tech unit, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S) India. The experiment was laid out in randomized block design with nine treatments *viz*., T_1: application of NAA 100 ppm, T_2: NAA 200 ppm, T_3: ethrel 50 ppm, T_4: ethrel 100 ppm, T_5: GA_3 50 ppm, T_6: $GA_3$100 ppm, T_7: PBZ 500 ppm, T_8: PBZ 1000 ppm, T_9: Control (without application of PGRs) which were replicated three times to find out the suitable PGRs with appropriate concentration for early flowering and yield of pineapple cv. Queen. The suckers of pineapple Queen cultivar were collected from the Central Experiment Station, Tetavli block, District- Ratnagiri. Every planting material was good quality and weighed between 300 and 400g. The suckers were planted on 10th July 2023. Fertilizers were applied to the pineapple plants including urea and 18:18:10 during the early leaf stage and subsequently humic acid and 19:19:19 were applied in weekly interval from the month of December up to first forth night of March 2024 at the 30-leaf stage before application of PGRs. The solutions of different PGRs were prepared and 50 ml of the required solutions were poured into the heart of pineapple plant. The PGRs were applied during the month of March and April 2024. To guarantee that there was moisture available at the active root zone, the plants in the experimental plot were watered with sprinkler on alternate days so that sufficient moisture will be available for plants. There was no water provided especially during rainy season. Fruits were harvested at horticulture maturity. The observations including plant height (cm), plant spread NS and EW (cm), stem girth at collar (mm), D-leaf length (cm), D-leaf width (cm), D-leaf weight (g), D-leaf thickness (mm) which were recorded before application of PGRs while, the number of days to flower initiation, number of days to completion of flowering, flowering percentage, days for flower initiation to fruit maturity, fruit weight with crown, crown weight, fruit weight without crown, number of suckers and slips per plant, fruit yield kg per plot, fruit yield (t/ha) were recorded after application of PGRs. The data generated from the studies were subjected to statistical analysis by using standard method suggested by Panse and Sukhatme (1995) [9].

Results and discussion

Plant height (cm)

Data on pineapple plant height before application of PGRs was registered non-significant variation among the treatments and was in the range of 60.9 cm to 64.4 cm (Table 1). Highest plant height (64.4 cm) was recorded in the T_3 (ethrel 50 ppm) which was followed by T_4 (ethrel 100 ppm) (63.4 cm) while, lowest plant height (60.85 cm) was recorded in T_9 (control-without application of PGRs).

Stem girth (cm)

The stem girth of pineapple before application of PGRs was recorded non-significant variation among the treatments with the range of 59.10 cm to 71.11 cm (Table 1). Highest stem girth (71.11 mm) was in T_8 (PBZ 1000 ppm) followed by T_2 (NAA 200 ppm) (70.32 mm), whereas lowest stem girth (63.04 mm) was in T_7 (PBZ 500 ppm).

Plant spread N-S (cm)

Data on canopy spread (N-S) of pineapple before application of PGRs showed the significant variation among the treatments (Table 1). Highest North-South plant spread (91.3 cm) was recorded in T_8 (PBZ 1000 ppm) which was followed by T_6 (GA_3 100 ppm) (87.6 cm), whereas lowest NS plant spread (77.6 cm) was in T_4 (ethrel 100 ppm).

Plant spread E-W (cm)

The East-West plant spread of pineapple before application of PGRs showed the significant variation among the treatments (Table 1). Highest East-West plant spread (94.8 cm) was recorded in T_8 (PBZ 1000 ppm) which was at par with T_6 (93.4 cm), T_7 (92.7 cm) and T_3 (92.0 cm) whereas, lowest (85.5cm) was in T_2 (NAA 200 ppm).

Table 1: Initial growth parameters recorded in pineapple cv. Queen before application of plant growth regulators

Treatments	Plant height (cm)	Stem girth (mm)	Plant spread N-S (cm)	Plant spread E-W (cm)
T_1: Application of NAA 100 ppm	62.17	64.84	82.27	91.03
T_2: Application of NAA 200 ppm	62.29	70.32	80.20	85.47
T_3: Application of ethrel 50 ppm	64.44	68.80	82.90	92.00
T_4: Application of ethrel 100 ppm	63.44	65.40	77.60	87.80
T_5: Application of GA_3 50 ppm	61.66	64.67	86.40	89.45
T_6: Application of GA_3 100 ppm	62.39	64.30	87.57	93.37
T_7: Application of PBZ 500 ppm	62.06	63.04	86.20	92.73
T_8: Application of PBZ 1000 ppm	62.42	71.11	91.27	94.83
T_9: Control (Without application)	60.85	59.10	83.18	91.77
SE m. ±	0.84	2.68	2.16	1.61
CD (P=0.05)	2.52	8.02	6.48	4.82
CV (%)	2.34	7.05	4.45	3.06

D – Leaf length (cm)

D-leaf length of pineapple before application of PGRs recorded significant variation (Table 2). Highest D-leaf length (52.8 cm) was recorded in T_8 (PBZ 1000 ppm) which was at par with T_5 (GA_3 50 ppm) (52.2 cm) and T_7 (50.3 cm), whereas as lowest (44.7 cm) was in T_2 (NAA 200 ppm).

D – Leaf width (cm)

D-leaf width of pineapple before application of PGRs recorded significant variation (Table 2) and highest D-leaf width (5.1 cm) was recorded in T_8 (PBZ 1000 ppm) which was at par with T_2 (NAA 200 ppm) (4.95 cm), whereas as the lowest (4.3 cm) was in T_4 (ethrel 100 ppm).

D – Leaf weight (g)

The pineapple D-leaf weight before application of PGRs recorded significant variation (Table 2) and highest D-leaf weight (70.5 g) was recorded in T_6 (GA_3 100 ppm), followed by T_5 (69.86 g), T_8 (69.85 g) and T_7 (68.64 g), whereas as the lowest (58.05 g) was in T_3 (ethrel 50 ppm).

D – Leaf thickness (mm): Data regards to pineapple D-leaf thickness before application of PGRs recorded significant variation among treatments. Highest D-leaf thickness (1.66 mm) was recorded in T_3 (ethrel 50 ppm) which was at par with T_1 (1.61 mm) and the lowest (1.39 mm) was in T_2 (NAA 200 ppm). The non-significant variation was found in plant height and girth which is due to same age and management of the suckers used for planting (Rosmania *et al.,* 2019 and Neri *et al.,* 2021) [11, 7]. The significant differences in D-leaf length, breath and thickness might be due to the difference in the weight of suckers at the time of planting. However, suckers might have produced healthier leaves having higher length, width thickness and weight (Rosmania *et al*., 2019 and Bhowmick *et al*., 2022) [11, 3].

Table 2: Leaf parameters recorded in pineapple cv. Queen before application of plant growth regulators

Treatments	D-Leaf length (cm)	D-Leaf width (cm)	D-Leaf weight (g)	D-Leaf thickness (mm)
T_1: Application of NAA 100 ppm	47.94	4.55	64.15	1.61
T_2: Application of NAA 200 ppm	44.68	4.95	60.06	1.39
T_3: Application of ethrel 50 ppm	48.96	4.67	58.05	1.66
T_4: Application of ethrel 100 ppm	48.88	4.33	58.97	1.52
T_5: Application of GA_3 50 ppm	52.24	4.48	69.86	1.46
T_6: Application of GA_3 100 ppm	48.00	4.41	70.51	1.45
T_7: Application of PBZ 500 ppm	50.32	4.76	68.64	1.43
T_8: Application of PBZ 1000 ppm	52.77	5.06	69.85	1.45
T_9: Control (Without application)	49.31	4.49	58.11	1.40
SE m. ±	1.03	0.09	2.12	0.05
CD (P=0.05)	3.08	0.26	6.35	0.15
CV (%)	3.61	3.25	5.71	5.80

Days required for initiation of flowering: The significant differences were observed on number of days for flowering initiation in pineapple cv. Queen among the treatments (Table 3). The earliest flowering (26.0 days) was recorded in T_7 (PBZ 500 ppm) which was at par with T_1 (NAA 100 ppm) (26.67 days), T_2 (NAA 200 ppm) (27.67 days), T_3 (ethrel 50 ppm) (29.0 days) and T_8 (PBZ 1000 ppm) (29.0 days) than the other treatments, whereas the maximum days (40.33 days) were observed in T_9 (control). The PBZ 500 ppm, NAA 100 ppm and NAA 200 ppm affected the early flower initiation, might be due to the suppression of gibberellin by PBZ promoting early flowering by suppressing vegetative growth. Similarly, NAA, a synthetic auxin, is known to influence floral induction by altering hormonal balance and enhancing sink strength at the shoot apex. The similar findings were also observed by Pal *et al*., 2010 [8] and Pasi *et al*., 2023 [10] in pineapple.

Days required for completion of flowering: The significantly minimum days for completion of flowering (32.67 days) was recorded in T_7 (PBZ 500 ppm) which was at par with T_1 (NAA 100 ppm) (33.0 days), T_2 (NAA 200 ppm) (35.33 days) and T_8 (PBZ 1000 ppm) (34.00 days) than the other treatments, whereas the maximum days (47.0 days) were in T_9 (control) (Table 3). The PBZ 500 ppm, NAA 100 ppm and NAA 200 ppm treated plants noticed the minimum days required for completion of flowering. This was because of PBZ, which is a known gibberellin biosynthesis inhibitor, which promotes early flowering by suppressing vegetative growth and encouraging reproductive development in pineapple. Similarly, NAA, a synthetic auxin, is known to influence floral induction by altering hormonal balance and enhancing sink strength at the shoot apex. The delay of flowering was due to GA_3, which promotes vegetative growth, appears to delay the transition from vegetative to reproductive phase. The similar findings were also observed by Pal *et al*., 2010 [8] and Pasi *et al*., 2023 [10] in pineapple.

Table 3: Effect of plant growth regulators on days required for flower initiation, flowering percentage and fruit maturity in pineapple cv. Queen

Treatments	Days for initiation of flowering	Days for completion of flowering	Flowering percentage	Days for flower initiation to fruit maturity
T_1: Application of NAA 100 ppm	26.67	33.00	83.00	128.00
T_2: Application of NAA 200 ppm	27.67	35.33	85.67	137.67
T_3: Application of ethrel 50 ppm	29.00	38.33	95.00	134.67
T_4: Application of ethrel 100 ppm	29.33	40.67	82.67	142.33
T_5: Application of GA_3 50 ppm	39.00	42.33	72.33	148.67
T_6: Application of GA_3 100 ppm	39.67	43.00	73.00	146.67
T_7: Application of PBZ 500 ppm	26.00	32.67	89.67	112.33
T_8: Application of PBZ 1000 ppm	29.00	34.00	88.00	98.33
T_9: Control (Without application)	40.33	47.00	65.00	151.67
SE m. ±	1.00	1.67	2.82	1.71
CD (P=0.05)	3.01	5.02	8.44	5.12
CV (%)	5.46	7.53	5.98	2.22

Percentage of flowering

The significantly highest flowering percentage (95.0%) was recorded in T_3 (ethrel 50 ppm) which was at par with T_7 (PBZ 500 ppm) (89.67%) and T_8 (PBZ 1000 ppm) (88.0%), whereas the lowest flowering percentage (65.0%) was in T_9 (control) (Table 3). The ethrel may alter the endogenous auxin level to a threshold concentration which cause flowering. Ethrel is highly potential in inducing flower formation in pineapple plants and it can induce a plant to flower in any season if it attains the minimum age required for initiation of flowering. The PBZ which is a known gibberellin biosynthesis inhibitor, which promotes flowering by suppressing vegetative growth and encouraging reproductive development in pineapple. The highest flowering percentage of pineapple with ethrel and PBZ application was also reported by Pal *et al*., 2010 [8], Kumari *et al*., 2020 [6] and Pasi *et al*., 2023 [10] in pineapple.

Days for flower initiation to fruit maturity

The minimum days for flower initiation to fruit maturity (98.33 days) was significantly recorded in T_8 (PBZ 1000 ppm) than other treatments (Table 3). The PBZ 500 ppm (T_7) recorded (112.33 days) for the fruit maturity and next superior treatment, whereas the maximum days (151.67 days) to fruit maturity were in T_9 (control). The observed reduction in maturity duration under PBZ treatments may be attributed to its role as a gibberellin biosynthesis inhibitor, which suppresses vegetative growth and enhances reproductive development and fruit filling. The application of PBZ 1000 ppm, significantly reduced the time from flower initiation to fruit maturity, making it the most effective treatment for early fruit development in pineapple cv. Queen. The present findings are accordance with results obtained by Pal *et al*., 2010 [8] in pineapple.

Number of suckers per plant: The significantly maximum suckers (1.80) were recorded in T_5 (GA_3 50 ppm) which was at par with T_6 (GA_3 100 ppm) (1.77) and T_4 (ethrel 100 ppm) (1.73), whereas minimum suckers per plant (1.33) were in T_7 (PBZ 500 ppm) (Fig. 1). The plants treated with GA_3 50 ppm recorded maximum suckers might be due to the increase in sucker production with GA_3 owing to its role in promoting vegetative growth by stimulating cell elongation and division, leading to more vigorous offshoot development, whereas lowest suckers in PBZ treated plants may be due to its anti-gibberellin action. The similar findings were also observed by Suwandi *et al*., 2016 [13] and Senapati *et al*., 2020 [12] in pineapple.

Number of slips per plant

The maximum slips were (1.0) recorded in T_2 (NAA 200 ppm) which was at par with T_1 (NAA 100 ppm) (0.87), T_4 (ethrel 100 ppm) (0.77), T_5 (GA_3 50 ppm) (0.77), T_8 (PBZ 1000 ppm) (0.8) and T_9 (control) (0.77) whereas the minimum slips in pineapple (0.57) were in T_3 (ethrel 50 ppm) (Fig. 2). NAA 200 ppm showed higher slips production, this suggested that, under the given conditions, PGRs had limited influence on slip development, and other factors such as cultivar, environmental conditions, or cultural practices may play a more dominant role. The results are identical with findings obtained by Suwandi *et al*., 2016 [13] and Senapati *et al*., 2020 [12] in pineapple.

Fruit length (cm)

The significantly maximum fruit length (20.0 cm) was recorded in T_7 (PBZ 500 ppm) followed by T_2 (NAA 200 ppm) (18.0 cm), whereas the minimum length (12.0 cm) was in T_9 (control) (Table 4). The superior performance of PBZ 500 ppm might be due to enhancing assimilate partitioning towards the fruit, and improving sink strength, ultimately leading to increased fruit size. Similar results reported by Pal *et al*., 2010 [8] in pineapple.

Fruit girth (cm)

The maximum fruit girth (16.0 cm) was significantly recorded in T_7 (PBZ 500 ppm) which was at par with T_1 (NAA 100 ppm) (15.0 cm), T_2 (NAA 200 ppm) (14.00 cm) and T_5 (GA_3 50 ppm) (14.00 cm) over the other treatments, whereas the minimum fruit girth (9.33cm) was in T_9 (control) (Table 4). The increase in fruit girth under PBZ 500 ppm might be due to its role in modifying hormonal balance, improving sink strength, and reducing vegetative growth, thereby channelling more assimilates toward fruit development. Similar results were reported by Pal *et al*., 2010 [8] in pineapple.

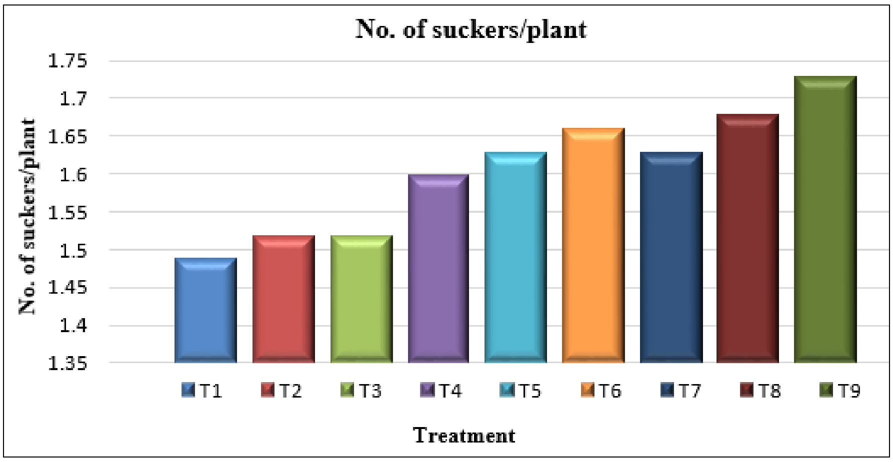

Fig 1: Effect of plant growth regulators on number of suckers per plant in pineapple cv. Queen

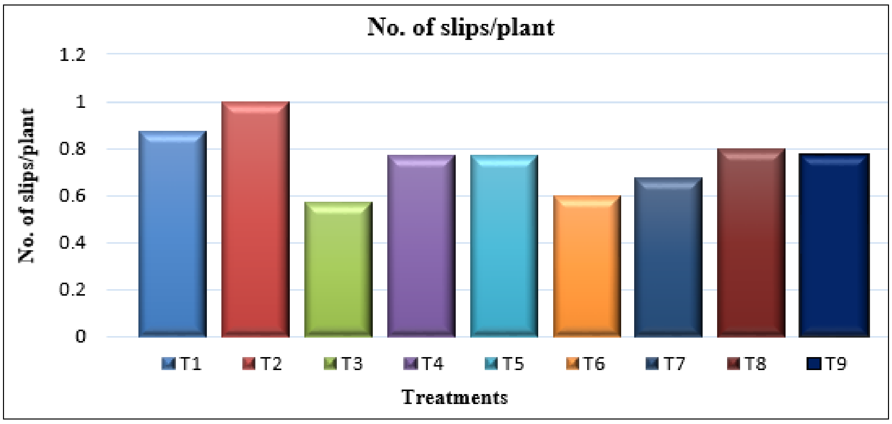

Fig 2: Effect of plant growth regulators on number of slips per plant in pineapple cv. Queen

Weight of fruit with crown (g)

The significantly maximum fruit weight with crown (807.6 g) was recorded in T_7 (PBZ 500 ppm) which was at par with T_1 (NAA 100 ppm) (804.87 g), T_3 (ethrel 50 ppm) (795.53 g), T_8 (PBZ 1000 ppm) (736.17 g) and T_2 (NAA 200 ppm) (735.90 g) while minimum (626.57 g) was in T_9 (control) (Table 4). The performance of PBZ 500 ppm can be attributed to its growth-retardant effect, which reduces vegetative growth and diverts assimilates toward fruit development, thereby improving fruit weight with crown. The effectiveness of NAA 100 ppm, may be due to its role in enhancing cell expansion and fruit sink strength. The findings are accordance with results obtained by Pal *et al.,* 2015 and Senapati *et al*., 2020 [12] in pineapple.

Weight of crown (g): The significantly maximum crown weight (82.28 g) was recorded in T_7 (PBZ 500 ppm) which was followed by T_6 (GA_3 100 ppm) and T_2 (NAA 200 ppm) (79.52 g) than other treatments, whereas minimum crown weight (42.22 g) was recorded in T_9 (control) (Table 4). The increase in crown weight under PBZ 500 ppm may be due to its ability to regulate vegetative growth and promote compact, thicker crown development by modifying gibberellin biosynthesis. NAA and GA_3 at optimal concentrations might have enhanced cell expansion and meristematic activity in the crown region, leading to increased biomass accumulation. Similar results also reported by Pal *et al*., 2015, Suwandi *et al*., 2016 [13] and Senapati *et al*., 2020 [12] in pineapple.

Table 4: Effect of plant growth regulators on yield and yield attributing parameters in pineapple cv. Queen

Treatments	Fruit length (cm)	Fruit girth (cm)	Weight of fruit with crown (g)	Weight of crown (g)	Fruit yield (Kg/plot)	Fruit yield (t/ha)
T_1: Application of NAA 100 ppm	17.00	15.00	804.87	71.49	56.33	35.76
T_2: Application of NAA 200 ppm	18.00	14.00	735.90	79.52	51.51	32.70
T_3: Application of ethrel 50 ppm	17.33	12.00	795.53	71.61	55.68	35.35
T_4: Application of ethrel 100 ppm	13.00	10.00	631.95	69.57	44.23	28.17
T_5: Application of GA_3 50 ppm	16.00	14.00	669.93	55.88	46.89	29.77
T_6: Application of GA_3 100 ppm	15.00	11.00	673.43	79.68	47.14	29.92
T_7: Application of PBZ 500 ppm	20.00	16.00	807.60	82.28	56.53	35.88
T_8: Application of PBZ 1000 ppm	16.33	13.00	736.17	64.40	51.53	32.17
T_9: Control (Without application)	12.00	9.33	626.57	42.22	43.86	27.84
SE m. ±	0.61	1.01	24.12	2.73	1.69	1.07
CD (P=0.05)	1.83	3.04	72.31	8.18	5.06	3.21
CV (%)	6.58	13.81	5.80	6.90	5.80	5.80

Fruit yield (kg/plot)

The significantly highest fruits yield (56.53 kg/plot) was recorded in T_7 (PBZ 500 ppm) which was at par with T_1 (NAA 100 ppm) (56.33 kg/plot), T_2 (NAA 200 ppm) (51.51 kg/plot), T_3 (ethrel 50 ppm) (55.68 kg/plot) and T_8 (PBZ 1000 ppm) (51.53 kg/plot), whereas the lowest fruits yield (43.86 kg/plot) was recorded in T_9 (control) (Table 4). The performance of PBZ 500 ppm can be attributed to its growth-retardant effect, which reduces vegetative growth and diverts assimilates toward fruit development, thereby improving fruit weight and ultimately increased the yield level. NAA and ethrel improved yield when applied at lower concentrations, likely due to their roles in fruit set and yield of fruit. However, the higher concentrations of ethrel 100 ppm, the effectiveness diminished, possibly due to phytotoxic effects or hormonal imbalance. The findings are accordance with results obtained by Pal *et al.,* 2015, Kumari *et al.,* 2020 [6] and Senapati *et al*., 2020 [12] in pineapple.

Fruit yield (t/ha)

The significantly highest fruit yield (35.88 t/ha) was recorded in T_7 (PBZ 500 ppm) which was at par with T_1 (NAA 100 ppm) (35.76 t/ha), T_3 (ethrel 50 ppm) (35.35 t/ha) and T_2 (NAA 200 ppm) (32.70 t/ha), respectively over the other treatments, whereas the lowest fruit yield (27.84 t/ha) was in T_9 (control) (Table 4). The performance of PBZ 500 ppm can be attributed to its growth-retardant effect, which reduces vegetative growth and diverts assimilates toward fruit development, thereby improving fruit weight and ultimately increased the yield level. NAA and ethrel improved yield when applied at lower concentrations, likely due to their roles in fruit set and yield of fruit. However, the higher concentrations (ethrel 100 ppm), the effectiveness diminished, possibly due to phytotoxic effects or hormonal imbalance. The findings are accordance with results obtained by Pal *et al.,* 2015, Kumari *et al.,* 2020 [6] and Senapati *et al*., 2020 [12] in pineapple.

Benefit: cost of pineapple cultivation

The maximum gross returns of Rs. 1977200/-, net returns of Rs. 925933/- and B:C ratio (1.88) was obtained from T_3 (ethrel 50 ppm) which was followed by T_2 (NAA 200 ppm) (1.83) and T_1 (NAA 100 ppm) (1.79), whereas the T_9 (control) obtained minimum value of gross returns and net returns as well as B:C ratio (1.61) over the other treatment under studied. The superiority of ethrel 50 ppm which consistently shows the highest gross return, net return, and B:C ratio, suggested that this treatment is most economically beneficial. While PBZ 500 ppm might lead to slightly higher fruit yields, but its treatment cost is considerably higher. The ethrel 50 ppm achieves a very high flowering percentage and good yield, critically, it does so at a much lower cost, leading to a superior net return and B:C ratio. This demonstrated that economic viability is a function of both increased output and input costs. Similar results expressed by Baidya *et al*., 2023 [2] in pineapple.

Table 5: Effect of plant growth regulators on cost of production of pineapple cv. Queen

Treatments	General cost (Rs.)	Additional treatment cost (Rs.)	Total cost (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C ratio
T_1: Application of NAA 100 ppm	1045315	3238	1048553	1884160	835607	1.79
T_2: Application of NAA 200 ppm	1045315	6476	1051791	1929720	877929	1.83
T_3: Application of ethrel 50 ppm	1045315	5952	1051267	1977200	925933	1.88
T_4: Application of ethrel 100 ppm	1045315	10952	1056267	1677760	621493	1.58
T_5: Application of GA_3 50 ppm	1045315	13809	1059124	1824400	765276	1.72
T_6: Application of GA_3 100 ppm	1045315	27619	1072934	1819840	746906	1.69
T_7: Application of PBZ 500 ppm	1045315	42857	1088172	1903360	815188	1.74
T_8: Application of PBZ 1000 ppm	1045315	85714	1131029	1790160	659131	1.58
T_9: Control (Without application)	1045315	-	1045315	1683840	638525	1.61

Note: Selling prize of pineapple fruit Rs. 40/kg, pineapple sucker Rs. 8/sucker, market prize of PBZRs. 4500/lit., market prize of ethrel Rs. 250/100 ml, market prize of NAA Rs. 170/100g and market prize of GA_3Rs. 14500/kg.

Conclusion

From the study, it can be concluded that the application of ethrel 50 ppm was most effective treatment. It achieved synchronized and early flowering, along with a high yield, and was the most economically viable option due to its low cost, resulting in the highest benefit-to-cost ratio of 1.88. While other treatments like PBZ 500 ppm and NAA 100 ppm were also effective in inducing flowering and increasing yield, but higher cost of cultivation. Thus, the pineapple plants should be treated with ethrel 50 ppm at 27-30 leaves stage.

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