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A Study on the Effect of Cloprop on Crown Size and Quality of Pineapple cv. Giant Kew

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present study was carried out to determine the effect of 2-(3- chlorophenoxy) propionic acid (3- CPA) on crown size, yield and quality of pineapple cv. Giant Kew.

Study Design: Completely Randomised Design

Place and Duration of Study: Department of Horticulture, School of Agriculture Sciences and Rural Development, Nagaland University, Medziphema campus.

Methodology: Five treatments consisted of different concentrations of the growth regulator viz., C_1 (Control), C_2 (50 ppm), C_3 (100 ppm), C_4 (150 ppm) and C_5 (200 ppm) were evaluated with four replications each. Treatment was applied as foliar spray on pineapple crowns when apical flowers were in final stage of dehiscence. Growth and yield attributes viz., length and circumference of crown, crown to fruit length ratio, length of fruit with and without crown, pulp weight, peel weight, pulp to peel ratio, core weight, days taken to mature and dry matter content were recorded. Furthermore, biochemical parameters viz., TSS, titratable acidity, TSS: acid ratio, ascorbic acid, total sugar, reducing sugar and non- reducing sugar were analyzed, along with shelf life and Physiological loss in weight (PLW).

Results: The experiment revealed C_3 (100 ppm) as optimum concentration for reduction of crown size with minimum crown length (14.28 cm), circumference (49.72 cm) and crown to fruit ratio (0.83) and showed 48% reduction in crown length over control. Also, maximum values for length of fruit (17.22 cm), pulp weight (1080 g), peel weight (403 g), core weight (200 g), shelf life (19.33 days) and minimum PLW were observed in C_3 (100 ppm). It was found that higher concentration of 3- CPA reduced TSS and increased titratable acidity. Incidence of burns on lower leaves of crown was observed in 150 and 200 ppm treatments.

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Conclusion: 2-(3- chlorophenoxy) propionic acid is effective in altering the plant physiological processes and from the present experiment, treatment with 100 ppm showed effective result in terms of crown attributes, quality and shelf life.

Keywords: Pineapple crown; 2-3(chlorophenoxy) propionic acid; fruitone CPA; 3-CPA.

1. INTRODUCTION

Pineapple (*Ananas comosus* L.) is a unique fruit of the tropics with a beautiful crown. It is ranked third in production of tropical fruit after banana and citrus. It is widely grown in the tropical and subtropical regions of the world and the top six pineapple producing countries are Philippines, Costa Rica, Brazil, Indonesia, China, and India [1]. In India, pineapple production covers an area of 107000 ha with annual production of 1800000 MT [2]. Pineapple is one of the most important commercially grown fruit crops in Nagaland and covers an area of 8697 ha with annual production of 115086 MT (2019-20) [3]. The pineapples grown from this region are considered to be of world class due to its high juice content, almost fibreless pulp and high TSS [4] and is one of the export potential crops of Nagaland.

Pineapple primarily contains carbohydrates and water which are vital sources of dietary fibre, organic acids, vitamins (ascorbic acid, niacin, and thiamin) and minerals such as magnesium, manganese, and copper [5]. The crown is used as a source of natural fibres that has high flexural rigidity and tensile strength, which are also cheap, biodegradable, renewable, and available in abundance [6]. However, the pineapple crown becomes a burden to farmers and traders due to its big size and heavy weight which increases logistical expenses during storage and transport. Also, during the period of growth, the crown becomes so large and heavy that the fruit and peduncle are lodged and bends or falls over, leading to spoilage of fruits due to contact with soil. The complete removal of crown does not result in any increase in fruit size or yield, rather leads to injury of the central core and fruit becomes prone to pathogenic infection and sun burning [7] and impacts the occurrence of the fruit translucency disorder with a significant seasonal response [8]. Furthermore, according to [9], postharvest detachment of pineapple crown significantly aggravated internal browning and increased yellowing or ripening of pineapple fruit, suggesting that the crown is necessary for extending shelf-life of pineapple.

Manual removal of crown becomes difficult and expensive when cultivated in large scale. Spraying of growth hormones to inhibit vegetative growth tends to be a practical approach in achieving small crown pineapples with enhancement in fruit quality and yield. The auxin 2 – (3- chlorophenoxy) propionic acid is an important biologically active compound belonging to the phenoxypropionic class of compounds [10] and has been used in thinning peach and nectarines and inhibitory effect on vegetative growth has been reported along with fruit thinning effect [11]. This growth hormone consists of synonyms such as Cloprop, 3- CPA, 3- CP, Propanoic acid, Fruitone CPA, α- (3-Chlorophenoxy) propionic acid etc. [12]. Findings have been reported on the effect of this chemical on pineapple crown size, fruit size [13], flowering time [14] and delay in harvest [15]. In plants, the chemical mimic the action of auxins, hormones chemically related to Indoleacetic acid that stimulates growth.

Taking into account the commercial importance of pineapple, a need was perceived to study the effect of the growth regulator 2- (3-chlorophenoxy propionic acid) on pineapple crown size, yield and quality of the fruits.

2. MATERIALS AND METHODS

The present study was conducted in the experimental field of the Department of Horticulture, SASRD, Nagaland University, Medziphema campus during 2017-18. The experimental site was located in the foothill of Nagaland at an altitude of 305 meters above mean sea level (MSL) with geographical location of 25º45'43" N latitude and 93º53'04" E. The experimental plot was situated at Nagaland in the subtropical and sub-humid climatic condition in the foothills. Fruit quality parameters were analysed in the laboratory of the Department of Horticulture, SASRD, Nagaland University.

The experiment was carried out in winter season pineapples. For enhancing growth of the ratoon pineapple plants, intercultural operations as fertilization, weeding and earthing up were done at regular intervals. NPK dose of 12:4:12g per plant was applied in the month of July after harvest. Three times manual weeding was done during the period of investigation followed by earthing up of the plants.

The experiment was laid out in Completely Randomised Design with four replications comprising of five pineapple plants per replication. The treatments consisted of control and four concentrations: C_1 (Control), C_2 (50 ppm), C_3 (100 ppm), C_4 (150 ppm) and C_5 (200 ppm). The acid was dissolved in methanol and then added to water. The solution was applied as foliar spray on the crowns when the apical flowers were in the final stage of dehiscence or when the last flowers were about to dry out since at this juncture the crown is 6-8 cm in height. Fruits were harvested when there was visible colour change at the base of developing fruit.

Growth and yield attributes *viz.,* length and circumference of crown, crown to fruit length ratio, length of fruit with and without crown, width of fruit, size of fruit, crown weight, weight of fruit with and without crown, pulp weight, peel weight, pulp to peel ratio, core weight, days taken to mature and dry matter content were recorded. Different bio-chemical parameters *viz.,* Total Soluble Solids, titratable acidity, TSS: acid ratio, ascorbic acid, total sugars, reducing sugars and non-reducing sugars were analysed according to the procedure reported by [16]. The TSS of fruit was determined with the help of EMRA hand refractometer (0-32º Brix) calibrated at 20ºC and the results were expressed in Brix (ºB). Total sugar content of the fruit was estimated by titrating the fruit juice against Fehling 'A' and Fehling 'B' reagents using methylene blue as indicator and presented in percent (%). Titratable acidity was estimated by titrating the diluted fruit juice against 0.1N NaOH solution using phenolphthalein as an indicator and expressed in term of percentage fresh weight of fruit . Ascorbic acid (Vitamin-C) content was estimated by visual titration method of 2, 6 Dichlorophenol Indophenols dye. Shelf life and Physiological Loss in Weight (PLW) during storage at ambient temperature were also recorded. The data obtained were statistically analyzed by the method of analysis of variance [17].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Crown size showed significant decrease in terms of length, circumference, crown to fruit length ratio and weight of treated pineapple crowns in comparison to control pineapple crowns. The lowest crown length (14.28 cm), circumference (49.72 cm) and crown to fruit length ratio (0.83) were reported in C_3 (100 ppm) followed by C_4 (150 ppm). The highest values were observed in control (C_1). The highest crown weight (712 g) was observed in control and the lowest crown weight (163 g) was observed in C_5 (200 ppm) followed by C_4 (150 ppm) with 175 g. Incidence of burns on the lower leaves of crown at 150 and 200 ppm was observed which was also reported by [18].

Similar findings have been reported by [18] who reported the least crown length obtained from 112.5 ppm application. [19], [20], [13], [18], [15],[21], [22], [23], [24] and [25] confirms reduction in crown size using the growth regulator 2- (3- Chlorophenoxy) propionic acid at various concentrations. The reduction in crown size may be due to the ability of 2- (3-chlorophenoxy) propionic acid to influence physiological processes [21] and alter growth cycle of pineapple, which can reduce crown development [28].

Maximum fruit length (17.22 cm) was recorded in C_3 (100 ppm) followed by C_4 (150 ppm) with 16.94 cm and maximum fruit width (13.42 cm) was observed in C_4 (150 ppm) followed by C_3 (100 ppm). Subsequently, maximum fruit size was observed in C_4 (150 ppm) with 221 cm^2 followed by C_3 (100 ppm). The least values were observed in control. It may be noted that a slight increase in fruit length is very significant in terms of processing as a 1 cm increase in fruit length could increase cannery slice recovery by as much as 10% in pineapple [29]. In the present finding, delay in maturity of treated fruits was also observed with maximum days taken to mature (125 days) recorded in C_4 (150 ppm) followed by C_5 (200 ppm) with 120 days.

These findings are in partial conformity with [21] who reported maximum fruit length and fruit size in 200 ppm and maximum fruit width in 150 ppm concentration. [26] has also reported increase in fruit circumference in pumpkin at 250 ppm and muskmelon at 500 ppm concentration. Increase in fruit diameter in peach was also reported by [31]. [30] [32] reported four weeks delay in harvest with 197 ppm concentration. [18] also reported delay in maturation of fruits where 82% of control plant pineapples have already matured when the maturation of treated fruits begun. [24] reported 19 days delay in harvest over control when 1500 ml per ha of 3- CPA was applied in two equal applications. [20] also reported delay in shell colouring or ripening process by the use of the growth regulator.

3- CPA can modify the growth cycle of pineapple plant, which may delay maturation, and this allows for an extended assimilation of plant nutrients by the fruit, producing larger and heavier fruits and reducing the air space in the cavities, giving a more cylindrical shaped fruit, and delaying maturity [28]. Increase in weight of fruit was observed in the treated fruits. Maximum weight (1.83 kg) was recorded in C_5 (200 ppm) followed by 100 ppm (C_3) with 1.79 kg and the lowest weight of fruit was observed in C_1 (1.09 kg).

3.2 Biochemical Attributes

The treatment significantly reduced TSS and increased titratable acidity in pineapples whereby highest TSS (15.29°B) and lowest acidity (1.02%) was recorded in control (C_1) and the minimum TSS (13.28°B) and maximum titratable acidity (1.39%) was observed in C_4 (150 ppm).

This finding is in conformity with the findings of [25],[17], [20], [27] who reported decrease in TSS and increase in titratable acidity over control pineapples. However, in contrary, [22] reported no reduction in TSS content with application of 100 ppm at different stages of growth. [25] also reported Fruitone CPA did not lower the brix degrees at any concentrations, for which he concludes, reduction in TSS occurred in November and December application or in winter harvest.

Highest ascorbic acid value (8.58 mg/100g) was observed in C_5 (200 ppm) followed by C_3 (100 ppm) with 8.46 mg/ 100g and the lowest value was observed in C_2 (50 ppm) with 7.92 mg/100 g. Similar increase in ascorbic acid content due to application of Fruitone CPA was reported by [28] and [31].

Table 1. Effect of 2- (3- chlorophenoxy) propionic acid on growth attributes of pineapple at harvest

Treatments	Crown length (cm)	Crown circumference (cm)	Crown to fruit length ratio	Length of fruit with crown (cm)	Length of fruit without crown (cm)	Width of fruit (cm)
C_1 (Control)	27.50	101.00	1.73	44.20	15.89	11.90
C_2 (50 ppm)	25.10	80.59	1.55	42.30	16.23	12.93
C_3 (100 ppm)	14.28	49.72	0.83	31.50	17.22	13.29
C_4 (150 ppm)	16.72	58.09	0.99	33.67	16.94	13.42
C_5 (200 ppm)	17.84	66.99	1.08	34.43	16.59	13.26
SEm±	0.79	1.63	0.05	0.63	0.24	0.17
CD (P=0.05)	2.39	4.91	0.16	1.90	0.72	0.52

Table 2. Effect of 2-(3-chlorophenoxy) propionic acid on yield attributes of pineapple at harvest

Treatments	Size of fruit (cm^2)	Weight of fruit with crown (kg)	Weight of fruit without crown (kg)	Crown weight (g)	Pulp weight (g)	Peel weight (g)	Pulp to peel weight	Core weight (g)
C_1 (Control)	169	1.81	1.09	712	731	322	2.27	158
C_2 (50 ppm)	203	1.56	1.25	308	945	339	2.78	191
C_3 (100 ppm)	210	2.01	1.79	215	1080	403	2.71	200
C_4 (150 ppm)	221	1.99	1.83	163	1017	393	2.58	194
C_5 (200 ppm)	213	1.88	1.75	134	1058	398	2.62	197
SEm±	3.67	0.05	0.04	24.87	26.62	6.53	0.06	6.46
CD (P=0.05)	11.06	0.15	0.13	74.98	80.23	19.69	0.19	19.48

Table 3. Effect of 2-(3-chlorophenoxy) propionic acid on quality attributes of pineapple at harvest

Treatments	TSS (°B)	Titratable acidity	TSS:Acid ratio	Ascorbic acid (mg/100g pulp)	Total sugar	Reducing sugar	Non reducing sugar	Dry mater content	Shelf-life days
C_1 (Control)	15.29	1.02	15.13	8.20	9.16	3.95	4.95	3.89	14.67
C_2 (50 ppm)	14.94	1.19	12.53	7.92	8.84	3.40	5.17	3.83	16.00
C_3 (100 ppm)	14.80	1.22	12.15	8.46	8.98	4.40	4.46	3.61	19.33
C_4 (150 ppm)	13.33	1.39	9.62	8.24	8.56	3.55	4.76	2.70	19.00
C_5 (200 ppm)	13.28	1.23	10.78	8.58	8.46	3.35	4.85	2.92	18.33
SEm±	0.18	0.04	0.34	0.10	0.09	0.10	0.28	0.22	0.28
CD (*P*=0.05)	0.55	0.11	1.02	0.32	0.26	0.32	0.85	0.67	0.84

Table 4. Effect of 2-(3-chlorophenoxy) propionic acid on Physiological Loss of Weight (PLW) of pineapple during storage

Treatments	PLW (%)							
	Initial weight of fruit (kg)	2 DAS	4 DAS	6 DAS	8 DAS	10 DAS	12 DAS	14 DAS
C_1 (Control)	1.68	1.44	2.39	2.84	5.88	7.84	9.48	14.04
C_2 (50 ppm)	1.80	1.30	2.22	3.04	4.19	5.40	6.03	6.85
C_3 (100 ppm)	1.94	1.51	1.76	2.97	3.53	4.32	4.54	4.85
C_4 (150 ppm)	1.87	1.58	1.17	2.07	2.87	3.44	4.05	4.97
C_5 (200 ppm)	1.64	1.75	1.38	2.31	3.37	4.04	5.24	6.28
SEm±	0.01	0.21	0.33	0.34	0.28	0.23	0.32	0.64
CD (P=0.05)	0.02	0.65	1.00	NS	0.85	0.69	0.96	1.92

Decrease in total sugar content was recorded where the highest value (9.16%) was observed in control followed by C_3 (100 ppm) with 8.98% and the lowest content was reported in C_5 (8.46%). Minimum sugar content at harvest may be due to delay in ripening, thus delaying the conversion of polysaccharides to free sugars. [20] reported that with increase in Fruitone concentration, there was reduction in sugar content. [28] also reported higher total sugar content in control pineapples over the treated ones at harvest.

Highest value for reducing sugar (4.40%) was observed in C_3 (100 ppm) followed by C_1 (3.95%) and the lowest value was observed in C_5 (3.35%). Highest non reducing sugar (5.17%) was observed in 50 ppm (C_2) followed by C_1 (4.95%) and the lowest ratio was reported in C_3 (4.35%).

Significant difference in dry matter content was observed. Highest value (3.89%) was observed in control followed by 50 ppm (3.83%) and the lowest (2.70%) was reported in C_5 (200 ppm). [27] reported high dry matter genotypes in Kiwi fruit had higher TSS and were perceived as sweeter than low dry matter genotypes. The same trend between TSS and dry matter content has been observed in the findings.

Prolonged shelf life and minimal PLW of treated pineapples at ambient temperature was observed. Longest shelf life (19.33 days) and lowest PLW was observed in C_3 (100 ppm) followed by C_4 and the lowest shelf life and highest PLW was observed in C_1. The reduced weight loss may be due to increased fruit size resulting in reduced surface area to volume ratio, better filling of fruitlets, narrower locules and reduced air spaces which modified water deficit stress and the effect of the growth regulator on crown size reduction may also reduce weight loss because most of the fruit’s initial water loss is through their stomata found substantially in the crown. The reduction in weight loss during storage, subsequently reduced the texture loss, maintained the freshness, and delayed the ripening, hence, increased shelf life of treated pineapples. Delay in ripening in treated pineapples may be related to alterations in fruitlets air space which may have altered the internal atmosphere, retention of chlorophyll, photosynthesis, and respiratory rates [25], [28].

4. CONCLUSION

From the present study, it was observed that treatment of pineapple with 100 ppm 2- (3-Chlorophenoxy) propionic acid (C_3) gave the most effective result in terms of crown attributes (minimum length, circumference and crown to fruit ratio), quality (maximum length of fruit, pulp weight, peel weight, core weight, reducing sugar), minimum PLW, longest shelf life and resulted in 48% reduction in crown length of treated pineapples over control pineapples. Growth regulators and their uses in crop production is considered to be the most beneficial yet very complex. The same growth regulator in different concentrations, cultivar, age, vigor, time/ season, method of application etc. brings about different results. Same diverse result is observed by workers on the effect of 3-CPA where application in warm and cool season had opposite effects on the qualitative characters of pineapple. Also, work on this growth regulator has been confined mostly to the pineapple growing regions of South America, thereby, requires work to be taken up to validate the present findings and also, obtain the optimum concentration, time/ season, method of application etc. suitable for the pineapple grown in India for commercial exploitation, if required, in the near future to augment export efficiency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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