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ENHANCING THE YIELD AND QUALITY TRAITS OF RED FLESH DRAGON FRUIT (*HYLOCEREUS COSTARICENSIS*) GROWN UNDER COCONUT PLANTATION USING PLANT GROWTH REGULATORS

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ABSTRACT

The Dragon fruit (*Hylocereus costaricensis*), otherwise called 'Pitaya or Kamalam' has recently drawn much attention of the growers worldwide, not only because of their red purple colour and economic value as food products but also for their enormous health benefits. Being native of Southern Mexico, Guatemala and Costa Rica, dragon fruit was introduced in India during the late 90s and still the area under its cultivation is gradually increasing. Coconut being widely spaced owing to its morphological features provides ample opportunities for cropping in the interspaces. Active root zone of coconut is confined to 25 per cent of the available land area and the remaining area could be profitably exploited for raising subsidiary crops. Although the initial investment is relatively high, profit is substantial within 4-5 years. The red flesh species are additionally rich in betalains, meeting the increasing trade interest for antioxidant products and natural food colorant. Fruits are easy to keep fresh under room condition. The crop is hardy and survive in any type of climatic condition favourable for flowering and fruiting and soil condition provided with good drainage. The fruit setting percentage in dragon fruit under coconut plantation was found very less. The yield and quality of the fruits can be affected by the application of plant growth regulators. The present study aimed to evaluate the influence of GA_3 and NAA on yield and quality of five year old red flesh dragon fruit grown under coconut plantations. A field experiment was carried out at ICAR-CPCRI, Kasaragod with five treatments replicated six times in Randomized Block Design. The treatments included GA_3 @ 20 ppm, GA_3 @ 40 ppm, combination of GA_3 @ 20 ppm + NAA @ 20 ppm, GA_3 @ 40 ppm + NAA @ 20 ppm and control. The treatments were applied at 7, 14, 21 days after fruit set. The results showed that application of GA_3 @ 40 ppm + NAA @ 20 ppm increased the fruit length (13.04 cm), fruit weight (620.03 g $fruit^{-1}$) and fruit yield (28.54 kg $tree^{-1}$) significantly. The study concluded that the combination of GA_3 and NAA at appropriate concentrations could improve yield and fruit quality of red fleshed dragon fruit under coconut plantations.

Keywords **:** NAA, GA_3, *Hylocereus costaricensis*, red flesh dragon fruit

Introduction

Dragon fruit is native to the tropical forest regions of Mexico and Central and South America (Mizrahi *et al*., 1997) belonging to the Cactaceae family. It is also referred as "Queen of the Night" or "Noble Woman" because of its beautiful night blooming flower. Coconut is being a widely spaced, provides ample opportunities for intercropping. Active root zone of coconut could be profitably exploited for raising subsidiary crops like dragon fruit. Dragon fruit is one of the rich sources of Vitamin C, which is one of the most important water soluble vitamins, naturally present in fruits and vegetables and also widely used as a food additive and antioxidants. Fruits with pink flesh have higher phenolics and flavonoids content compared to white fleshed fruits. Phenolic compounds

have been associated with colour, sensory qualities and nutritional and antioxidant properties of foods. Phenolics act as antioxidants, due to the free radical scavenging activity of the phenol moiety (hydroxyl substituent on the aromatic ring.

Presence of numerous health promoting phenolic acids and flavonoids in both fresh sap and its value added products make them functional food. Considering the climatic condition in Indian states of Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Orissa, West Bangal, Andhra Pradesh and Andaman and Nicobar islands can be ideal for dragon fruit production. Level of risk in producing the crop is lesser and to some extent more tolerant to adverse weather conditions as compared to the production of other high value commercial crops like Rambutan, Mangosteen and Durian. Gibberelic acid and Naphthalene Acetic Acid have ability to increase fruit set percentage, yield and quality of fruit crops. The size and quality of the fruits can be affected by the application of plant growth hormones. NAA increased fruit number, fruit weight and yield of Sapota (Agarwal *et al.*, 2008). The gibberellin is involved in cell elongation, which results in larger and heavier fruits. Another effect is an increase in fruit set, so all of these effects combined provided more yield and higher fruit quality. The percent fruit setting in dragon fruit under coconut plantation was found very less. Hence the present study was undertaken with an objective to evaluate the effect of GA_3 and NAA on yield and quality of red flesh dragon fruit grown under coconut plantations.

Materials and Methods

A field experiment was carried out at ICAR-CPCRI, Kasaragod, Kerala. The present study aimed to evaluate the influence of GA_3 and NAA on yield and quality of five-year-old red flesh dragon fruit grown under coconut plantations. The treatments included GA_3 @ 20 ppm, GA_3 @ 40 ppm, combination of GA_3 @ 20 ppm + NAA @ 20 ppm, GA_3 @ 40 ppm + NAA @ 20 ppm and control. The experiments consisting of five treatments and replicated six times in Randomized Block Design. Each treatments consisting of 12 trees and randomly selected and tagged for data collection. Fruits on trees were sprayed three stages at 7, 14, 21 days after fruit set. The data was statistically analyzed by using online software WASP-Web Agri Stat Package.

Observation recorded

Number of fruits (fruit/tree) and yield (kg/tree): Fruits were harvested and recorded in total number of fruits on tree from treatments. All fruits per tree were weighted on actual yield. At harvest, the fruits at each sampling point were tags and harvested for quality analysis.

Fruit physical characteristics:

Samples of ten fruits were devoted to determining the following fruit characteristics as fruit lengh (cm). fruit diameter(cm), fruit weight (g).

Fruit total soluble sugars (%)

Fruit total soluble sugars (%) was followed method from AOAC. TSS was measured by hand refractometer.

Total Sugars (%)

Total sugars were estimated by taking above 50 ml sample in volumetric flask. To this sample, five ml of HCl was added, mixed well and allowed to stand for overnight. On next day, acid was then neutralized with NaOH using a drop of phenolphthalein as an indicator till the pink colour persisted for at least few seconds. After this the final volume of the sample was made 100 ml by adding distilled water and total sugars were estimated then by titrating sample against the Fehling solution (5 ml A+ 5 ml B) using methylene blue as an indicator and the titration was done till the appearance of brick red colour as in reducing sugars. The results were expressed in percentage.

$$\text{Total sugars}(\%) = \frac{\text{Factor} \times \text{volume made up}}{\text{Titre value} \times \text{weight of sample}} \times 100$$

Shelf Life (days)

Shelf life of the fruits was determined by recording the number of days the fruits remained in good condition in storage. The stage where in more than 50 per cent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days (Padmaja and Bosco, 2014).

Total Soluble Solids (^{o}Brix)

Total Soluble solids were determined (AOAC, 1965) by using refractometer expressed as ˚B. A drop of the homogenized dragon fruit pulp was squinted on the prism of refractometer and observing the coincidence of shadow of the sample with the reading on the scale and mean values in ˚B were expressed as total soluble solids. The percentage of TSS was obtained from direct reading on the instrument.

Titratable acidity (TA)

Titratable acidity was determined by adding 2 drops of 0.1% phenolphthalein solution to 5 mL of fruit juice and titration against 0.1 N NaOH until the

pH reached 8.1. The fruit juice was obtained by homogenizing 10 g of fruit pulp from a mixture of 4 fruit in a kitchen blender with 10 mL of purified water. The mixture was centrifuged at 5000 × g for 5 min and then filtered through a cheese cloth. The results were expressed as percentage of citric and l-lacticacids (mg/100 g of fresh weight) (Ali *et al*., 2013).

$$\text{Acidity (\%)} = \frac{\text{Weight of sample} \times \text{Vol. of aliquot} \times 1000}{\text{Titre} \times \text{Normality of alkali} \times \text{vol made} \times \text{eq. wt of acid} \times 100}$$

Ascorbic acid content (mg 100 g^{-1})

The indophenol-xylene extraction method for ascorbic acid and modifications for interfering substances by (Robinson and Stotz, 1945)

$$(\%) = \frac{\text{Ascorbic acid content from the standard curve} \times 100 \times 100}{2 \times \text{weight of sample taken for extraction}} \times 100$$

Results

Table 1 showed and recorded that the number of days taken for fruit set to fruit maturity was significantly different among treatments when GA_3 and NAA were used individually or in combination. There were significantly difference in number of fruits and fruit weight among the treatments. The combination GA_3 @ 40 ppm + NAA @ 20 ppm performed higher yield (28.54 kg $tree^{-1}$) than individually GA_3 @ 20 ppm and control (19.22 kg $tree^{-1}$).

Table 2 showed that using GA_3 and NAA increased fruit length, fruit diameter, pulp weight in comparison to the control. In terms of fruit length, GA_3 and NAA, either individually or in combination, were significantly different from control. The treatment T_4 (GA_3 @ 40 ppm + NAA @ 20 ppm and T_3 (GA_3 @ 20 ppm + NAA @ 20 ppm) were recorded 13.04 cm and 12.40 cm, respectively.

Table 3 showed that the quality parameters among the treatments,The highest TSS content (18.33 ^{o} Brix) was recorded in treatment T_4 (combination of GA_3 and NAA). There were significantly difference in titrable acidity (0.22 g/100 ml), total sugars (7.88 g/100g), reducing sugars (4.15 g/100g) and ascorbic acid (9.72 mg/100g) content between the treatments.

Table 1 : Effect of GA_3 and NAA on yield parameters of red flesh dragon fruit grown under coconut

Treatments	No of days taken for fruit set to fruit maturity (days)	No of fruits	Fruit weight (g)	Yield (kg/tree)
T_1 (GA_3 @ 20 ppm)	33.50	31.66	466.80	23.81
T_2 (GA_3 @ 40 ppm)	33.83	39.50	469.56	24.48
T_3 (GA_3 @ 20 ppm + NAA @ 20 ppm)	32.83	41.00	513.59	26.62
T_4 (GA_3 @ 40 ppm + NAA @ 20 ppm)	30.66	46.50	620.03	28.54
T_5 (Control)	36.83	17.50	329.22	19.22
CD	2.44	5.45	37.18	2.55

Table 2 : Effect of GA_3 and NAA on fruit character of red flesh dragon fruit grown under coconut

Treatments	Fruit length (cm)	Fruit diameter (cm)	Pulp weight (g)	Peel weight (g)
T_1 (GA_3 @ 20 ppm)	12.05	8.22	274.13	85.57
T_2 (GA_3 @ 40 ppm)	11.68	8.38	295.07	89.35
T_3 (GA_3 @ 20 ppm + NAA @ 20 ppm)	12.40	8.41	312.03	91.81
T_4 (GA_3 @ 40 ppm + NAA @ 20 ppm)	13.04	9.23	440.58	124.04
T_5 (Control)	11.07	7.71	201.89	75.75
CD	0.74	0.55	22.50	8.68

Table 3 : Effect of GA_3 and NAA on quality parameters of red flesh dragon fruit grown under coconut

Treatments	TSS (^{0} Brix)	Titratable acidity (g/100 ml)	Total sugars (g/100g)	Reducing sugars (g/100g)	Ascorbic acid content (mg/100 g)
T_1 (GA_3 @ 20 ppm)	17.54	0.31	6.73	3.40	9.29
T_2 (GA_3 @ 40 ppm)	17.38	0.30	6.81	3.72	9.56
T_3 (GA_3 @ 20 ppm + NAA @ 20 ppm)	17.75	0.27	7.15	3.81	9.45
T_4 (GA_3 @ 40 ppm + NAA @ 20 ppm)	18.33	0.22	7.88	4.15	9.72
T_5 (Control)	16.86	0.35	6.57	3.23	9.16
CD	0.58	0.03	0.55	0.37	0.27

Discussion

The number of days taken for fruit set to fruit maturity was significantly different among treatments when GA_3 and NAA were used individually or in combination. There were significantly difference in number of fruits and fruit weight among the treatments. The combination GA_3 @ 40 ppm + NAA @ 20 ppm performed higher yield (28.54 kg tree^{-1}) than individually GA_3 @ 20 ppm and control (19.22 kg tree^{-1}) (Fig 1) . This result conforms to that of the results obtained by Hilay H.A *et al.*2017 i.e., The foliar spraying Washington navel orange trees with 20 ppm GA_3 and 25 ppm of NAA gave the highest of fruit physical parameters such as fruit weight and fruit diameter [4] and also conforms the results obtained by Nkansah *et al.* 2012 by the Using GA_3 @ 25 ppm and NAA @ 25 ppm increasesd number of fruits per bunch, fruit weight and improved fruit quality of keitt mangos.

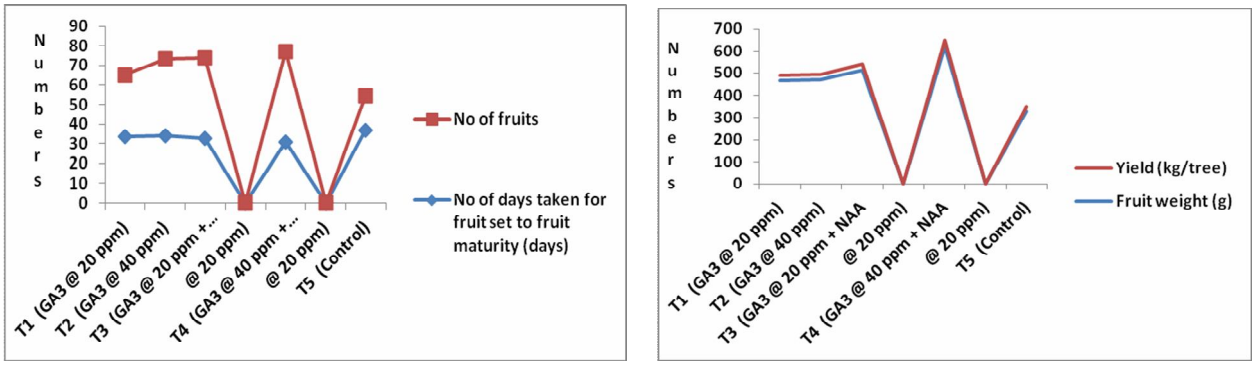

Fig. 1 : Effect of GA_3 and NAA on yield parameters of red flesh dragon fruit grown under coconut

Combination of GA_3 and NAA has increased fruit length, fruit diameter, pulp weight in comparison to the control. In terms of fruit length, GA_3 and NAA, either individually or in combination, were significantly different from control. The treatment T_4 (GA_3 @ 40 ppm + NAA @ 20 ppm and T_3 (GA_3 @ 20 ppm + NAA @ 20 ppm) were recorded 13.04 cm and 12.40 cm, respectively. However, their combination were significantly different when compared to the treatment individually GA_3 and control (Fig. 2). This result conforms to that of the results obtained by Moneruzzamam and his co workers, wax apple var. Jambu air madu applied GA_3 @ 50 mg /l increased fruit length, fruit diameter and fruit weight.

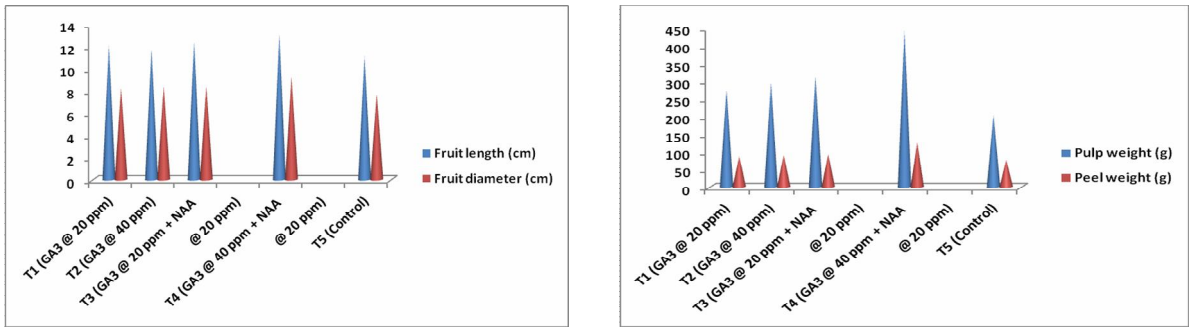

Fig. 2 : Effect of GA_3 and NAA on fruit character of red flesh dragon fruit grown under coconut

The quality parameters were significantly differ among the treatments, The highest TSS content (18.33 ^{o} Brix) was recorded in treatment T_4 (combination of GA_3 and NAA). There were significantly difference in titrable acidity (0.22 g/100 ml), total sugars (7.88 g/100g), reducing sugars (4.15 g/100g) and ascorbic acid (9.72 mg/100g) content between the treatments (Fig 3). Described a similar trend in Java Rambutan spraying 30 ppm GA_3, 20 ppm NAA + 30 ppm GA_3 increased total soluble solid (TSS).

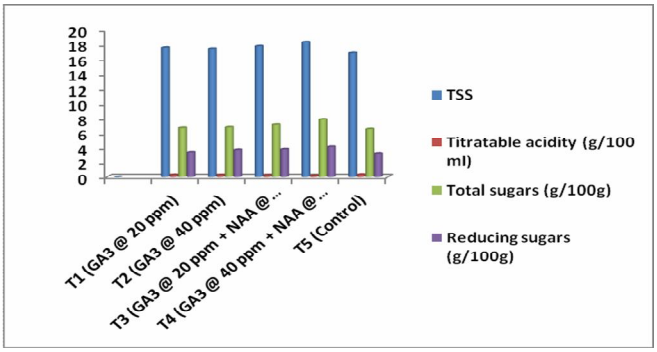

Fig. 3 : Effect of GA_3 and NAA on quality parameters of red flesh dragon fruit grown under coconut

Conclusion

From this study, it is inferred that, the combined application of GA_3 @ 40 ppm and NAA @ 20 ppm (T_4) at 7, 14, 21 days after fruit set could improved the fruit set, yield and fruit quality of red flesh dragon fruit grown under coconut plantation.

Plate 1: Field view of experiment plot at ICAR-CPCRI

Plate 2 : Best treatment

Data Availability

The data used to support the fndings of this study are provided in this article. However, any additional information can be provided by the corresponding author upon request.

Disclosure

All the reagents used in this study were prepared, used, and disposed of according to the set laboratory standard operating procedures and the material safety data sheet (MSDS).

Conflicts of Interest

The authors declare that they have no conficts of interest.

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