Effect of GA3 plus Yogen foliar fertilization on yield and fruit quality of red dragon fruit at Lap Thanh district in Vietnam

Abstract

The present study aimed to evaluate the effect of GA3 plus Yogen foliar fertilization application on fruit yield and quality of TL4 red dragon fruit from March to Agust 2015 at Lap Thach district, northen Vietnam. For this reason the experiment was conducted based on random complete block design with three replications. Fruit yield parameters anddifferent fruit quality parameters, as well as grade of fruit were determined. The results indicated that application of GA3 30ppm plus Yogen4 foliar fertilization significantly increase fruit set, fruit weight, fruit yield as well as fruit quality and reduce percentage grade S for red dragon fruit. Therefore, we could be concluded that application of 30ppm plus Yogen4 foliar fertilization markedly enhancing fruit set, improving fruit quality for TL4 red dragon fruit cultivar to meet commercial demands.

Keywords: Red dragon fruit, GA3, Yogen foliar fertilization, fruit yield and quality

1. Introduction

The red dragon fruit *(Hylocereus spp.)* or well known as pitaya or pitahaya (Latin America), strawberry pear, thang loy (Vietnamese), pitaya roja (Spanish), and la pitahaya rouge (French) and night blooming cereus (English) (Mizrahi et al., 1997; Paull, 2004). Dragon fruit is the fruit of several cactus species that have been classified as white (Hylocereus undatus), red (H. polyrhizus), and yellow (Selenicereus megalanthus) [Nerd et al., 2002; Hoa et al., 2006], and are native to Americas (Barthlott and Hunt, 1993), with a wide distribution in the tropics and sub-tropics (Merten, 2003). However, only the red and white flesh varieties are popular in VietNam. The dragon fruit is a large, oblong fruit with a red peel and large green scales. The flesh is sweet, delicate, red–purple, and contains numerous tiny black seeds. The fruit is nonclimacteric and has the best flavor when harvested at full red color (Nerd et al., 1999). Dragon fruit is rich in vitamins, minerals and fibers that helps the digestive process, prevent colon cancer and diabetes, neutralize toxic substances such as heavy metals, and helps to reduce cholesterol levels and high blood pressure [Zainoldin et al., 2009]. Dragon fruit is enjoyed as a fresh fruit or juice, but also is valued as a natural food colorant (Wybraniec and Mizrahi, 2002). Currently, dragon fruit is being grown commercially in Australia, Brazil, Colombia, Costa Rica, Egypt, Israel, Japan, Mauritius, Mexico, Nicaragua, Taiwan, the USA and Vietnam (Merten, 2003). This probably due to its exceptional tolerance to extreme drought, its micronutrient content and the vibrant color of the fruit itself has attracted consumer is high in the national and international markets. Its production could potentially create jobs and promote income for the nation that produces it (Stintzing et al., 2002; , Cos et al., 2004; Yolanda et al., 2012). These factor, as well as the prospect of a good economic return, attracted big investors.

Plant growth regulators (PGRs) have become an important component of agrotechnical procedures for most of the cultivated plants and especially for fruit plants (Monselise, 1979). According to (Morgan,1980) growth regulators may provide the means of bringing about required growth responses as there is abundant data indicating that their use can increase the yield of product perunit of time and land. The use of plant growth regulators compounds (auxins, cytokinins and gibberellins) is becoming popular to ensure efficient production (Guardiola, A. Garcia-Luis,2000). Moreover, many previous studies have shown that the application of PGRs can enhance the rapid changes in physiological and biochemical characters thus increasing crop productivity. Sprayed GA3 had been shown a positive effect on fruit development, reduced fruit drop, fruit crack and improved fruit quality of wax apple under field conditions (Nguyen and Yen, 2013). Reference [Chao and C.J. Lovatt, 2010] indicated that among agricultural practices which may increase the fruit production and improve the quality of several other fruit crops are the applications of plant growth regulators, especially gibberellic acid. Gibberellic acid has been reported to influence vegetative growth, flowering, fruiting and various disorders in many fruit crops (Paroussi et al., 2002). Sprays of GA3 have been widely adopted in commercial orchards because they have consistently been shown to increase fruit size and firmness of cherry (Clayton et al., 2006). Moreover, GA3 increased the yield of fruit in Balady mandarin (El-Sese,2005), and increases soluble solids as well as fruit weight in sweet cherry (Basak et al., 1998). Therefore, in order to increase the fruit production, plant growth regulators are one of the production tools that can enhance product quality and marketability. They must be used with proper attention to other cultural practices, especially proper fertility and irrigation management.

Moreover, the plant nutrition is one of the most important factors responsible for the proper growth and development of the plants. The methods of nutrient application play an important role in supplying the nutrients to the plants because the efficacy of fertilizers applied in soil being low due to various losses and fixations. Foliar nutrition is designed to eliminate the above problems particularly with respect to macro nutrients. Nowadays application of N, P and K application in different ratios through foliar sprays is modern method of fertilization in vegetable crops due to the nature of heavy feeder of nutrients (Chaurasia et al., 2005). Foliar nutrition is more effective on young leaves, and shortage of macro and micro nutrients can be removed by this factor (Kashi, 1994).Rapid uptake of nutrients and no influence of pH and soil texture as well as providingcations such as Zn and Fe in the soil for plants that stabilize these elements and finally being cheaper than other methods are the advantages of foliar nutrition method (Lanauskas and Kvikliene, 2006). Karuppaiah et al. (2001) studied the effects of folia application using nitrate and the results revealed that the yield of cucumber raised up to 14.5 tons per ha and there were an increase of NPK in plants applying foliar application.

Red dragon fruit cultivation has been recently introduced and fruit comsumption has gained popularity in south VietNam. Although these references are available in the literature and efforts have been made to improve fruit set as well as fruit quality by applying of chemical compounds but there is no available literature on the effect of plant growth regulator and foliar fertilizer on physiological and biochemical parameters of red dragon fruit in the North Vietnam. Therefore, this study was carried to investigate the effects of GA3 plus Yogen foliar application on growth, yield and quality of red dragon fruit under field conditions.

2. Material and methods

Plant Materials and Experiment Treatments

The experiment was conducted at red dragon fruit orchard in Lap Thach district, Vinh Phuc province, Northern VietNam from March to Agust 2015. The TL4 pitaya cultivar with the red peel-red pulp were chosen for the experiment. The experiment was design in Randomized Complete Block Design (RCBD) with three replicated and three uniform trees were taken as an experiment unit. The experiment consited of five treatments were applied for forliar application: Treatment 1 (GA3ppm + Yogen1 NPK: 30:10:10); Treatment 2

(GA3ppm +Yogen2 NPK: 10:30:10); Treatment 3 (GA3ppm + Yogen3 NPK: 10:10:30); Treatment 4 (GA3ppm + Yogen4 NPK componds of Yogen1+Yogen2+Yogen 3); Treatment 5 (Control treatment (water spray). GA3 and Yogen were applied after fruit set stage on windless mornings with a truck-mounted monitorized sprayed until dripoof and subsequently in 7 day intervals as 3 times.

Data Collection

The observations with regards to the growth, yield and quality was recorded from the randomly selected and tagged plants.The percentage of fruit setting was calculated using the following formula:

Fruit set (%) = Number of fruit / Number of flowers x 100.

At harvesting, final fruit length, fruit diameter, peel thickness was determined with the help of Vernier caliper. The fruit diameter measurement recorded was the average of two readings taken at two axes of the midsection of the fruit. Fruit length was measured from the part attached to the petiole to the base of the fruit. Peel thickness was determined at the equatorial point of fruit. Yield per treatment was recorded by weighing and counting the total number of fruits. Fruit fresh weights (FWs) were measured using anelectronic balance (GF-6100; A&D Co. Ltd., Tokyo,Japan), and the edible portion of each fruit was calculated as:

Edible percentage = (Pulp weight / Fruit weight) x 100.

TSS content was measured using a hand refractometer (model PAL-1, Atago, Tokyo,Japan). Fruit flesh was squeezed from a sample of the middle of freshly cut fruit and theresult is expressed as ^{0}Brix. The fruits were peeled prior to determining the nutritional properties

Statistical Analysis

The data obtained from the study were analyzed using SAS 9.1 statistical software for each cultivar separately. Differences betweentreatments were measured using Duncan's multiplerange test at a significance level of $P \leq 0.05$.

3. Results and discusions

Effect of GA3 and Yogen foliar fertilization on fruit set and fruit yield

The percentage fruit set was found to be statistically significant between the different ($P \leq 0.05$) treatments and control treatment, except GA30ppm + Yogen1 application. From the results, it was observed that the highest (72.56%) fruit set was recorded in spraying with GA30ppm + Yogen4, followed by GA30ppm + Yogen3, GA30ppm +Yogen2, GA30ppm + Yogen1, with value of 65.91 %; 64.95%; 62.20% fruit set, respectively while, the lowest percentage fruit set (60.13%) was recorded in untreated control (Table 1). It seems be that external application of gibberellin induces fruit set in several species. In the case study, best result for increasing fruit set was achieved with spraying GA30ppm + Yogen4 foliar fertilization combination. These results are in agreement with the findings of Taylor and Knight (1986) who indicated that gibberellic acid is used widely in horticultural crops for improving fruit set. Moreover, enhance fruit set of dragon fruit in the study might be a reason of supplying more nutrients at the critical fruit set stage, which is in accordance with the finding reported by Vibhute (1988) and Naik et al. (2002)

Table 1. Effect of GA3 and Yogen foliar fetilization on fruit set and yield of red dragon fruit

Treatment	Fruit set (%)	Yield (kg/tree)
GA30ppm + Yogen1[y]	62.20c[x]	10.67c
GA30ppm +Yogen2	64.95b	9.30d
GA30ppm + Yogen3	65.91b	12.47b
GA30ppm + Yogen4	72.56a	15.00a
Control treatment (water spray)	60.13c	8.13e

[y]mean forliar ratio with Yogen 1 NPK (30:10:10); Yogen 2 NPK (10:30:10); Yogen 3 NPK (10:10:30); Yogen 4 (Yogen 1 + Yogen 2 + Yogen 3 compounds)

[x] mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

Fruit yield

As shown in **Table 1**, there was significantly increased fruit yield in all treatment as compared to untreated control. In the case of this study, the highest fruit yield was found in GA30ppm + Yogen4 treatment with 15.00 kg/tree, followed by GA30ppm + Yogen3, GA30ppm + Yogen1 application, whereas the control treatment showed the lowest value of 8,13 kg/tree. This implies that chemical compounds might be effective in improving fruit yield. In the current study, fruit yield was markedly enhanced by application GA30ppm + Yogen4 in comparison with control. Our results were found to be in agreement with that of Saraswathi et al. (2003) who observed that, GA3 significantly influenced the fruit weight as well as yield in mandarin. Ferthermore, the increase in the yield might be due to greater availability of nutrients, increased uptake of nutrients and water, resulting in more photosynthesis and enhanced food accumulation in edible part of the dragon fruits in the study (Table 1). The Guievence and Budence (2000) and Singh and Singh (1992**)** also reported similararly. However, application of GA30ppm + Yogen2 showed slightly increased fruit set as compared to untreated control, with the significantly difference at (p≤0.05) (Table 1).

Effect of GA3 and Yogen foliar fertilization on fruit parameter

Table 2. Effect of GA3 and Yogen foliar fetilization on fruit parameter of red dragon fruit

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Peel thickness (cm)	Edible percentage (%)
GA30ppm + Yogen1[y]	488.2ab[x]	11.37bc	8.61b	0.45a	82.52bc
GA30ppm +Yogen2	443.7bc	11.19bc	8.58b	0.46a	82.56bc
GA30ppm + Yogen3	516.4a	12.55b	8.73b	0.46a	83.61ab
GA30ppm + Yogen4	534.6a	14.22a	9.85a	0.45a	84.09a
Control treatment (water spray)	406.3c	10.45c	8.04 b	0.43 a	81.72 c

[y]mean forliar ratio with Yogen 1 NPK (30:10:10); Yogen 2 NPK (10:30:10); Yogen 3 NPK (10:10:30); Yogen 4 (Yogen 1 + Yogen 2 + Yogen 3 compounds)

[x] mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

Fruit weight

Data in Table 2 indicated that, there was significantly affected by application of GA3 + Yogen foliar fertilization on fruit weight among treatments as compared with control treatment, in term the control treatment had the lowest of fruit weight (406.3g), whereas the highest fruit weight (534.6g) were recorded with GA30ppm + Yogen4 treatment, followed by GA30ppm + Yogen3 application, GA30ppm + Yogen1 treatment in this study with value of 516.4g and 488.2 g, respectively (Table 2). It seems that the role of GA3 was to multiply and to lengthen the meristem cells, which resulted in the increase of fruit weight.In addition, spraying with GA30ppm + Yogen4 foliar fertilization combination resulted in significantly fruit weight enhancement as compared to untreated control (Table 2). This is in agreement with (Nguyen and Yen,2013) who found that spraying wax apple trees with GA3 significantly increased fruit weight. However, aplication of GA30ppm +Yogen2 slightly increase fruit weight as compared untreated control allthough there was not significantly different at ($p\leq0.05$) (Table 2). This results are in agreement with the report of (Eman et al., 2007), who indicated that the role of GA in improving fruit quantity namely, fruit weight and fruit size may be due to its role in increasing cell elongation

Fruit length and fruit diameter

The results summarized in Table 2 showed that, the application of different chemical compounds had significant effects on fruit length, in which the highest fruit length of 14.22 cm was recorded in GA30ppm + Yogen4 treatment, followed by spraying GA30ppm + Yogen3 with value of 1255 cm. It consider that the increase in fruit size might be attributed to increase in cell division and cell elongation caused by auxins and GA3which is in accordance with the finding reported by (Ranjan et al., 2003) who demonstrated that the increase in fruit size may be attributed to the increase in cell division and cell elongation caused by GA3. However, there was no effect of spraying with GA30ppm +Yogen2, GA30ppm + Yogen1 on fruit length than the untreated control (Table 2).

Ferthermore, (Horvitz et al., 2003) indicated that the fruit size is one of the most important quality parameter in sweet cherry. For this reason, as the big fruits are much more flesher, they are preferred more by the consumers. In the case of the study, there was significant differences fruit diameter between treatments (Table 2). In term, the treatment with GA30ppm + Yogen4 application produced the highest fruit diameter (9.85 cm), whereas the lowest fruit diameter (8.04cm) was recorded for untreated control. It seems that spray GA30ppm + Yogen4 markedly increased fruit diameter compared with the control. It consider that fruit size were significantly different due to the interaction effect of drgon fruit with GA3, indicating differential response in increasing size of red dragon fruit to GA3 application (Table 2). These results are in agreement with Usenik et al., 2005 who found that GA3 application increased cell division and elongation and had a positive effect on fruit size. However, application of GA30ppm + Yogen3, GA30ppm +Yogen2, GA30ppm + Yogen1 slightly improve fruit diameter than the control treatment although there was not significantly different at ($p\leq0.05$) (Table 2).

Peel thickness of fruit

The peel thickness for all treatment in this study is presented in Table 2. In term, spraying with GA30ppm + Yogen3 gave the highest Peel thickness with values of 0,46cm, while the control treatment produced the lowest Peel thickness (0,43cm). The same was also observed concerning the peel thickness of remained treatment. In which, spraying with GA30ppm +Yogen2, GA30ppm + Yogen4, and GA30ppm + Yogen1 had higher peel thickness (0,46cm, 0,45cmand 0,45cm, respectively) in comparison with control, although the difference was not statistically significant (p≤0.05) (Table 2).

Edible percentage of fruit

The results summarize in Table 2 showed that there was greatly effect of chemical compounds application on percentage of edible among treatment. Spraying with GA30ppm + Yogen4 had the maximum edible percentage (84.09%), followed by GA30ppm + Yogen3 applications with value of 83.61% edible percentage. However, application of GA30ppm +Yogen2 and GA30ppm + Yogen1 showed slightly increased edible percentage as compared to untreated control, although there were not significantly different.

Effect of GA3 and Yogen foliar fertilization on fruit quality

Table 3. Effect of GA3 and Yogen foliar fetilization on fruit quality of red dragon fruit

Treatment	**TSS ^{0}Brix**	**Vitamin C (mg/100g)**	**Sugar content (%)**
GA30ppm + Yogen1[y]	13.26a[x]	7.94ab	10.88a
GA30ppm +Yogen2	13.60a	7.93ab	10.76a
GA30ppm + Yogen3	13.39a	7.95ab	10.89a
GA30ppm + Yogen4	14.19a	8.79a	11.08a
Control treatment (water spray)	13.01a	6.90 b	10.91a

[y]mean forliar ratio with Yogen 1 NPK (30:10:10); Yogen 2 NPK (10:30:10); Yogen 3 NPK (10:10:30); Yogen 4 (Yogen 1 + Yogen 2 + Yogen 3 compounds)

[x] mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

TSS are considered an important quality parameter of any fruit. It has been reported that, chemical compounds can change the TSS content of fruits. As shown in Table 3, there was no significant difference TSS among treatment (p≤0.05), in terms of the GA3ppm + Yogen4 application produced the highest TSS (14.19^{0}Brix), followed by GA3ppm + Yogen3 sprayed and the other treatments. In the same table data showed that application of chemical compounds also significantly increase vitamin C as compared to untreated control, which was recorded in GA30ppm + Yogen4 application with value of 8.79mg/100g. It seem be that the increase in quality character might be due to the growth promoting substances which could have accelerated synthesis of carbohydrate, vitamins and other quality characters. These results are in conformity with those of Fagaria et.al. (1992) and Singh and Singh (1992). However, spraying with GA30ppm + Yogen3, GA30ppm +Yogen2, GA30ppm + Yogen1 showed slightly enhance vitamin C than the control treatment with values of 7.95mg/100g, 7.93mg/100g, and 7.94mg/100g although there were not significantly different. It is well known now that plant growth regulators can play a role in increase in the sugar content in fruits. Data presented in Table 3 indicated that there were various responses among treatments with GA3 +Yogen compounds at different concentration, although the difference was not statistically significant (p≤0.05).

Table 4. Effect of GA3 + Yogen on percentage of grading standard for dragon fruit

Treatment	**XL[z] (%)**	**L (%)**	**M (%)**	**S (%)**
GA30ppm + Yogen1[y]	5.21 ab[z]	48.40 ab	33.6 a	12.79 c
GA30ppm +Yogen2	4.93 b	48.33 ab	32.40 a	14.34 c
GA30ppm + Yogen3	5.88 a	44.41 b	33.24 a	16.47 b
GA30ppm + Yogen4	5.95 a	52.38 a	33.57 a	8.10 d
Control treatment (water spray)	3.35 c	37.48 c	35.68 a	23.49 a

[y]mean forliar ratio with Yogen 1 NPK (30:10:10); Yogen 2 NPK (10:30:10); Yogen 3 NPK (10:10:30); Yogen 4 (Yogen 1 + Yogen 2 + Yogen 3 compounds)
[x] mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test
[z] grade 1 (XL – Extra Large fruit): above 700 g; gradge 2 (L-large fruit): 500 to 700g; grade 3 (M-regular fruit 330 to 500g); grade 4 (S-small fruit: 200 to 330g) modify size grades suggested for Vietnam of (Le et al., 2000)

Fruit are generally graded by size and color. The result of the study shows that there were significantly diffirent graded of dragon fruit among treatment at different chemical compounds (Table 4). In term, the highest value of 5.95% and 52.38% was recorded with GA30ppm + Yogen4 application compared to lowest value of 3.35 % and 37.48 % was found in untreated control in the case of grade XL and L, respectively. However, the lowest value of 8.10% was obtained in GA30ppm + Yogen4, but highest value of (23.49%) was recorded in control treatment, which was achieved in the case of grade S (Table 4). It seem be that gibberellic acid (GA3) plays a very important role in enlarging fruit size of red dragon fruit. This results are in agreement with (Nor Shariah et al., 2014), who indicated that strengthen the role of gibberellic acid (GA3) in the agricultural sector where previously it had been well known to be used to increase fruit set and fruit size of many plants and fruits: grapes (Vitis vinifera), lemon (Citrus spp .), banana (Musa spp.), currant (Ribes aureum), pineapple (Ananas comosus) and sweet cherry (Prunus avium). In the current study grade L gave the highest value of (52,38 %) as compared to other grades (Table 4)

4. Conclusions

From the above mentioned results it can be concluded that the GA3 30ppm + Yogen4 foliar fertilization componds application greatly increased the percentage of fruit set. Moreover, application of GA330ppm +Yogen4 foliar fertilization gave the best results in the physiological and biochemical parameters of red dragon fruit with improved fruit size, fruit weight, enhanced total soluble solids, total sugar, and vitamin C as well as increased fruit yield. Hence, application of GA3 30ppm +Yogen 4 foliar fertilization could be a valuable tool in improving quality of red dragon fruit, based on both physical and biochemical quality characteristics.

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