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Research paper

The Crossing Effect of Dragon Fruit Plant Caltivars [*Hylocereus Sp.*] on Yield

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Abstract

Type of dragon fruit that is cultivated commercially is the red dragon fruit. There is no optimal production, because the flower of plant is incompatible. One way of improving production [fruiting] of dragon fruit is through manual crossing. This research aim was to study the crossing suitabilityof the red dragon fruit on fruiting. The research was conducted in dragon fruit plantation, West Java. Experimental design used was Randomized Block Design with four treatments and six replications. Treatments were: Natural Pollination [control];Crossing in one flower;Crossing between flowers; Crossing between varieties. Dimension of fruit measured were:diameter, length, fresh weight, and sugar content of fruit. Analysis of variance was applied with Duncan test at 5% significance level. Preparation of flower pollination was done by selecting the probable flower to bloom at night to come. The blooming flower can be predicted in the afternoon and the crossing was done at midnight.The result showed that the crossing between varieties was the best [improved fruiting]production. This report was suplemented with literature study on betalain showing that betalain is great beneficial for human health, and may be the next subject to study once the bulk production of fruit is done.

Keywords: *Betalain; cross; dragon fruit; sugar content.*

1. Introduction

Dragon fruit plant is trending among farmers in tropical and subtropical. The Genus *Hylocereus*is plant is *long-day* plant andtolerantto the arid environment and being resistant to pests and diseases[1]. So this variety of plant will be adaptive invarious marginal soil conditions[neglected mine areas where other commercial crops are not suitable to cultivate] in the South East Asia region.

Dragonfruit plant has the potential to survive in a dry area. Results of research indicated on the genotype "pitaya" [*Hylocereus spp.*]. The nature of the genes that is responsive to the dry conditions and tolerant to environmental stress conditions and indicates the mechanism toward genes that are resistant to strong tolerance to the drought conditions[2]. Study in the environmental areas of mild climate, the higher the temperature and the lower the humidity, and it was revealed that dragon fruit plants more responsive to the dry conditions [3]

One of the obstaclesin increasing production of dragon fruit is the plant ability to form fruit [fruit setting]. Natural fruit settingrate of dragon fruit is very low due to the nature of the self-incompatible. Self-incompatibility causes failed in pollination and fertilization of the flower.

Figure 1 shows the morphological limitation make the self pollination may fail. The Stigma of flower is extrude to outside, while the anther [male organ] position intrude and lower than the female organ [stigma].

Genetically, genus *Salinicereus* and *Hylocereus*are self-incompatible and not many insects are attracted to come to assist the natural pollination[4].

Revealed that *Hylocereus*spp genotypes was only 10% self-compatible and more works need to be done as the manual crossing. Manual pollination conducted by farmer will be very helpful and give significant effect. that pollen derived from the types and varieties of different plants will produce fruit such different weights,and the crossing affected on quality of fruit. [5]. So farmers must plant at least two clones that bloom in one season [the same time]and compatible.

Efforts to get a hybrid clone that are self-compatible [SC] will be very beneficial to farmers so that farmers do not need to plant a variety of clones for the crossing[6]

Cytoplasmic analysis gave the proof that hybrids are self-compatible, and the hybrids are tetraploid. Thus polyploidy technique becomes important and gives prospective hope of solving their self-incompatibility in *Hylocereus*spp[7].

The quality and quantity of dragon fruit include sugar content, betalain pigment content and the overall condition of the fruit including weight and appearance thatareaffected by agronomic practices. But there is factor that more effective on the yield [quantity and quality] of dragon fruit plants is the genotype. Genotype is the determining factor in the success of fruiting process [fruitset]. The disadvantage properties of plants [self-incompatibility] can be solved through technical challenges and out-crossing. However, before the research on hybridization of this plantcompleted andis fruitful, traditional farmersmust do the manual crossing if they want to get their plantation a better yield. And that study on the crossing of dragon fruit flower is required to be done, either crossing in a single floweror crossing between flowers, and the crossing between varieties [interspecies crossing]. The red dragon fruit is more and morepopular in thecommunity of this region for at least two considerations, they havethe character-

istics as nutrition and contain strong antioxidant and *anti-inflammatory* beneficial in avoiding cancer. This characteristics exist in the fruit due to the betalain pigment content in the fruit having apositive contribution to medicine efficacy[8].

Betalain having deep purple in colour is attractive to cosmetic and food industrial.The whole world is turning towards the use of traditional products and adopting more natural way of life through increased use of herbal products in their daily life[9].

The red-violet betacyanins and the yellow betaxanthins belong to the betalain pigments, which are characteristics for plants of the order Caryophyllales. Betalains occur only in the plants from 10 families in the order Caryophyllales [10]

Betalain functionsas a balancing agent of blood sugar in humans has proven its merits[11]. The prebiotic properties of dragon fruit performed because of carbohydrate in dragon fruit is white and red are glucose, fructose and some classes of oligosaccharides with a total concentration of between 86.2 g/kg and 89.6 g/kg which has a function as a prebiotic. Oligosaccharide mixture showed persistence against hydrolysis by human intestinal fluids. Oligosaccharide mixture was found to be able to stimulate the growth of lacto bacilli and bifidobacteria[12].

People are more interested in natural food, herbal medicines and traditional practices for healthy life. Recently, herbal cosmetics are pushing through the cosmetics industry. Dragon fruit is generally consumed in the fresh form as relieving thirst. This is due to extremely high water content, approximately 90.20% of the weight of the fruit. It was pretty sweet because it is supported by the sugar content reaches 13-18 brix [13].

2 Methodology and Materials

This study was conducted in the dragon fruit plantation of farmers group, West Java Province. The materials used in this study were dragon fruit plants of white type *[Hylocereusundatus*] and dragon fruit plants of red type [*Hylocereuspolyrhizus*]thatwere ready to bloom. Experimental design used was Random Block Design [RBD] with four treatments and six replications. As for the treatments were:

A : Natural Pollination [control]
B : Crossing in one flower
C : Crossing between flowers
D : Crossing between varieties.

Analysis of variance applied for the measured dimension of fruit as fruit diameter, fruit length, weight of fresh fruit and sugar content of fruits and further analysis by Duncan test at 5% significance level. The analysis of variance using statistical soft ware program of Departemento di Science Agrarie ed Ambiental [DSAA] on data obtained from the measurement of parameters.

Preparation ofthe application of flower pollination was done by selecting the most probable flower to bloom at the night to come [Figure 1]. The blooming flower can be predicted in the afternoon and the crossing was done at around midnight. Extracting and preparing pollen were done at the same night [Figures at the appendix]. Meteorological elements as temperature and humidity were observed to support the discussion and conclusion.

This studywas included a short review of batalain pigment with secondary data basis as it was said by [14] that betalain pigment is becoming the public concerned especially for nutrition and medicinal experts. And the fruit has a medicine efficacy among others are as balancing agent of blood sugar, lowering blood triglyceride levels and total cholesterol, cancer prevention, preventing bleeding, and as a remedy complaints whitish.

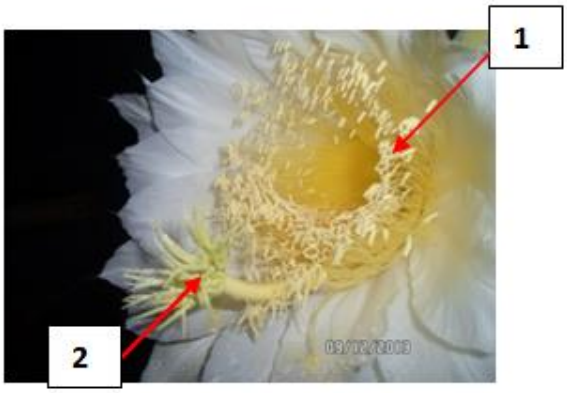

Fig. 1: Flower anatomy when bloom
[1:anther; 2: stigma]

Application of crossing dragon fruit flower is conducted when flowers bloom, that is at night. [Figure 2]. Manual pollination comes into effective when the anatomical development of flower is complete.

Fig. 2: Manual Cross Pollination at Night

3. Results and Findings

The average daily temperature recorded was 28,45°C. The highest daily temperature was 32,00°C and the lowest daily temperature was 27.00°C. As for the average humidity was 91.75%. The highest daily humidity was 95.66% and the lowest daily humidity was 87.33%.

Fruit diameter [cm]

Results of analysis offruit diameter at the age of 10 days, 20 days, 30 days and 40 days after crossing [DAC] showed some responses diversity, then further test showed that the difference in each parameter observed. The analysis result is presented in Table 1.

Table 1: Effect of Treatments of Crossing on Diameter of Fruit at the Age 10 days, 20 days, 30 days, and 40 days after crossing [DAC]

Treatments	Fruit diameter [cm]			
	10DAC	20DAC	30DAC	40DAC
A	1.65a	3.08a	4.43a	5.40a
B	2.41b	4.33b	5.45b	6.26b
C	2.63b	5.08c	6.78c	7.50c
D	3.35c	6.18d	9.71d	10.38d

Note: Mean figures at the same column marked with the same italic are not significantly different at5% Duncan test.

Treatment D had shown the greatest diameter of the fruit, it was the result of the cross between the varieties of dragon fruit [red and white dragon fruit]. Each fruit has larger size. The improved fruit size yielded from the crossing is larger than the results of other crosses.

Fruit length [cm]

The result of variance analysis of fruit length at the age of 10 days, 20 days, 30 days, and 40 days[DAC] is significantly different. Likewise, after further testing, there was significant difference. The result of analysis is presented in Table 2.

Table 2: Effect of Crossing Treatment on Length of Fruits at the Age 10 days, 20 days,30 days, and 40 days after crossing [DAC]

Treatments	Means length of plant [cm]			
	10DAC	20DAC	30DAC	40DAC
A	1.26 a	2.80 a	4.13 a	5.10 a
B	2.48 b	4.03 b	5.16 b	5.96 b
C	2.33 b	4.78 c	6.48 c	7.20 c
D	3.06 c	5.90 d	9.41 d	9.81 d

Note: Means figures at the same column marked with the same italic are not significantly different at5% Duncan test.

Measurement of length of fruit revealed that the longest fruit length was at the age of 40 days after cross[treatment D was 9.81 cm]. The length of fruit was influenced by the source of pollen.The white flesh dragon fruit has a slightly rounded shape and longer, so the fruit of crossbred has a shape longer than the fruit yielded from other treatments.

Weight of Fresh Fruits

The resultofvariance analysis showed that the treatments affected the quality of flower fertilization. Manual pollination has made better fertilization process that showed in different results with the measurement of the weight of fresh fruit. Significant differences occur independently. Treatment D has shown the highest value of fresh weight of yielded fruit in measured weight as presented in the Table 3.

Table 3: Effect of Crossing Treatment on Fresh Weight of Dragon Fruit

Treatments	Mean of Fresh weight of fruit[g]
A	106.66 a
B	123.33 b
C	208.33 c
D	463.33 d

Note: Mean figures at the same column marked with the same italic are not significantly different at5% Duncan test.

Analysis of fruit fresh weight showed that D treatment was significantly different from other treatments [treatments A, B and C].Treatment C significantly different from treatment B and treatment B significantly different from treatment A. The result of variance analysis is presented in Table 6. The heaviest weight of fresh fruit gained by D treatment is 463.33 g , and the lightest fresh weight was in the A treatment that is 106.66 g.

This was due to the effect of the pollen which was supplied by white flesh dragon fruit, so this process of fertilization will not happen in nature because of incompatible flower. Based on the result of treatment D.dragon fruit of red flesh, and of white fleshyielded the highestweight. While the lightest weight of fruit was the result of A treatment. This result shows that crossover effect on the fresh weight of the fruit.This is consistent with research result reported by[4, 15], that the origin of pollen [xenia] will affect the weight of the fruit.

Crosses inter-varieties will produce fruit fresh weight that is greater than the cross intra-varieties. The weight of fresh fruit produced at the smallest natural pollination [control]. This is because the red flesh dragon fruit species is self-incompatible. To obtain fruits with high productivity, farmer has to applied the crossbreeding with other species.

Sugar Content of Fruit

Results of analysis of variance showed sugar/glucose content were significantly different. Similarly, theresult of further test, significantly different treatment independently. A treatment showed an average sugar content of the low brix value of 6.45 and the value of the highest sugar content was treatment D with brix value of 8.40 . The result of analysis is presented in Table 4.

Table 4: Effect of Crossing Treatment on Sugar Content

Treatments	**Meanof Sugar Content [Brix]**
A	6.45 a
B	6.55 a
C	6.51 a
D	8.40 b

Note: Mean figures at the same column marked with the same italic are not significantlydifferent at5% Duncan test.

Analysis of sugar content of fruit of the treatment D showed significant effect on treatment C, Band A. It can be seen in Table 4. The observations of fruit sugar content arehighest in treatment D is 8.40 brix, and observations lowest levels of sugar contained in a treatment that is 6.45 brix. This means that cross-pollination to produce fruit with a higher sugar content. The results of analysis of this study was in line with the results of research[4] are presented in Table 1 and Table 2 which show cross inter-types that yielded high levels of dissolved sugar. Crosses *H polyrhizus* with S. *megalanthus*can increase sugar levels and vice versa crosses with *S.grandiflorus* sugar levels decreased.

Betalains

Colors play an important role in enhancing the aesthetic appeal of food products. Red pulp and peel [skin] produce the betalains that contains high level of antioxidant activity. a result, natural pigment from biological sources came into consideration especially plant pigments which include betalain, anthocyanins, and other flavonoids, carotenoids and chlorophylls. Betalain is commercially used as food colorant in the food industry. Unlike synthetic coloring agents, betalain is also easily degraded, heat-labile and low in stability due to their natural structure. Besides, betalains possess antioxidation properties which are prone to oxidation. Thus, prevention of oxidation which occurs during extraction and storage is crucial[16]

Pitaya fruit [dragon fruit] is a fast growing and developing fruit. Under Malaysia condition, the flesh of fruit turn from creamy white to full red-violet within 26-28 daysafter flower anthesis[10].

Betalains pigment becomes important for bioactivity as antioxidant capacities, and itschemical and medicinal affects as cancer-preventing properties[17]. Betalain biosynthesis expression on the dragon fruit flesh and the color formation phase 132-4 [*H. undatus*] and 7-1 [*H. polyrhizus*] using RT-qPCR. The expression pattern of increases in the initial phase and decreased in the final phase[8].

Hylocereusundatus and *Hylocereuspolyrhizus* both these varieties yielding two kinds of isomers of oleic acid which is an essential fatty acid and becomes a substrate required for human metabolism and cannot be synthesized in vivo. Both varieties of the dragon fruit contain approximately 50% of essential fatty acids [C18: 2 [48%] and C18: 3 [1.5%].[18].In addition to the medicinal efficacy, dragon fruit is also consumed to augment energy as mentioned. The total betalain content was 856.07–2968 μg per gram of pulp dry weight. Three confidence intervals for total betalain content [μg g^{-1}] were calculated: low [<1208], medium [2935–3288], and high [4488–9248]. Thus, the cactus fruits can be categorized as a poor, good, and excellent source of betalain pigments[19].

Total phenolic contents [TPC], total flavonoid contents [TFC], and total betacyanin contents [TBC] showed the following: Red Pulp ≥ White Pulp> Red Flesh> White Flesh. TPC, TFC, TBC, and betalain-related metabolites were higher in the peel than in the flesh and suggested to be the main contributors to antioxidant activity in pitayas. Therefore, peels as well as pulp of pitaya could beneficially help in the food industry [20].

4. Conclusion

Based on the results and discussion of this study conclude that crosses between the red flesh dragon fruit with the white flesh dragon fruit could increase the yield of red dragon fruit types. This improvement in pollination process has resulted in better process of fertilization resulted in the increase of size, diameter, length, and weight of fruit, and the sugar content of fruit.Manual pollination or crossing between red flesh with white flesh dragon fruit is needed to get better yield.

The study on increasing production of bulk fruit has been followed up by the detailed study on betalain. Researchers found the red pigment on the dragon fruit is of great beneficialfor human health. Betalain contained both in peels and in pulp, even there is more betalain contained in peel.

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Appendix

Pollen extraction

Prepared Pollen