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EVALUATION OF QUALITATIVE AND QUANTITATIVE CHARACTERS OF PINEAPPLE HYBRIDS RESULTED FROM CROSSING BETWEEN CAYENNE AND QUEEN

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ABSTRACT

The aim of the research was to evaluate the qualitative and quantitative characters of pineapple hybrids from crossing between Cayenne x Queen and their reciprocal**.** This research was conducted at the Indonesian Tropical Fruits Research Institute from June 2004 to December 2006. Genetic materials used were 75 hybrid plants from Cayenne x Queen crossing and 40 hybrid plants from Queen x Cayenne crossing. The qualitative and quantitative characters were observed on each of sampled plants. The results showed that the distribution of spines on the leaves and the shape of eyes were affected by female parents. The percentage of hybrid plants possessing spiny leaves was 14.3% lower on the Cayenne x Queen crossing than on the Queen x Cayenne crossing. Similarly, the percentage of plants bearing fruit ≥1019.5-g was 14.2% lower on the Cayenne x Queen crossing. In contrast, plants bearing fruit with broad eyes and sugar content ≥ 16° Brix were 23.8% and 6.7%, respectively, higher on the Cayenne x Queen Hybrids than on the Queen x Cayenne hybrids. The hybrid plants possessing the combined characters of spineless or spiny at the leaf tip, fruit ≥ 1000 g, sugar content (TSS ≥ 16°Brix), and broad eyes are CQ-4, CQ-20, CQ-22, CQ-26, CQ-41 and QC-26. Except for the projected eyes, these characters are also possessed by the hybrids CQ-16, CQ-46, and QC-8. These results can potentially provide valuable information on the choice of female and male parents for the programs of pineapple variety improvement.

Keywords: pineapple hybrids, *Ananas comosus*, Queen x Cayenne crossing, characters, evaluation.

INTRODUCTION

Pineapple (*Ananas comosus* (L.) Merr.) is an important tropical fruit crop in terms of economic value, usefulness, and nutrition content. As one of the main export commodities, Indonesian export of pineapple has being risen from 148.053.124 kg with value of US $ 87.286.570 in 2003 to 269.663.512 kg with value of US $204.552.168 in 2008 (Direktorat Jenderal Hortikultura 2009).

Based on the plant habit, especially the shape of leaf and fruit, pineapple crop is grouped into four types, namely: Cayenne, Queen, Spanish, and Abacaxi (Pracaya 1982). The first two are varieties of pineapple most widely grown in Indonesia. Cayenne is the famous variety in the world and is very good for canning. It has the characteristics such as spineless leaves except at the tips, broad and flat eyes; when ripe its flesh is pale yellow, translucent, non-fibrous, sweet and sour in taste, while the core is medium in size. In general, the flesh of Cayenne contains higher sugar (Total Soluble Solid) and total acid compared with flesh of Queen. Queen type possesses character of spiny leaves with reddish spines; its eyes are projected and smaller than Cayenne eyes. When ripe its flesh is golden, opaque, crisp, and less acid, while its core is smaller than Cayenne's core. Queen type is mostly used for fresh fruit (Collins 1968; Py *et al*., 1987; Hadiati *et al*., 2003; Prakash *et al*., 2009).

Ideotypes of pineapple plant are rapid growth, short and spineless leaf, short and strong fruit peduncle, high productivity, good root system, cylindrical-shape fruit, deep yellow flesh, low oxalic calcium and bromelin content, fulfilling the standard of fresh and canned consumption, and tolerant to pest and disease as well. One of the methods to obtain the pineapple plant appropriate to such ideotypes is through crossing or hybridization.

Pineapple plant is self-incompatible, that is no seed will be formed if self-pollination (selfing) takes place (Py *et al*., 1987; Coppens *et al*., 1993). Therefore, hybridization among pineapple varieties should be conducted in order to find the seeds. The characteristic of *self-incompatible* in pineapple plant will result in highly heterogeneous progeny. This is due to the heterozygotic parents, so that their progeny undergo the segregation.

In general, plant breeder's use Cayenne type as a parent for crossing because it has the best quality amongst the other cultivars (Py *et al*., 1987; Leal and Coppens 1996). Nevertheless, the weakness of Cayenne type is susceptible to wilt disease. Hybridization between Queen and Cayenne is expected to be able to generate the new superior varieties having higher quality than both Queen and Cayenne types.

This study is intended to evaluate the qualitative and quantitative characters of pineapple hybrids generated from crossing between Cayenne x Queen and their reciprocal.

MATERIALS AND METHOD

The study was carried out at the Indonesian Tropical Fruit Research Institute in Solok, West Sumatera located on 143 m above sea level from June 2004 up to December 2006. Genetic materials used were 75 Cayenne x Queen Hybrids and 40 Queen x Cayenne hybrids. Crossing was conducted in the morning when stigma is in mucus condition. Males' pollens were rubbed over the

females' stigma and then the flower was covered with plastic bag to avoid the interference of other pollens. The number of flowers crossed varied from one plant to another depending on the availability of opening flowers at that time.

Seeds produced were then germinated in petri dish lined with moist filter paper. These seeds will germinate after 25-40 days (Indriyani and Hadiati 2007). The sprouts were then transplanted to small pots filled with sand medium and covered for 1 month. Seedlings were subsequently transplanted to the 15 cm x 20 cm polybags filled with medium mixture of soil, manure, and sand (1:1:1) for six months. After that, the seedlings were moved again to the bigger polybags (40 cm x 50 cm) containing the same medium mixture until plants producing fruit. The plants were cultivated as optimum as possible. To induce flowering, the central cup of plants were sprayed with 2 cc/l Ethrel 40 GR in the afternoon (Siswondono 1978; van de Poel *et al*. 2009).

Observation was done on the qualitative and quantitative characters of each plant sampled.

Qualitative characters

Qualitative characters covering spine distribution, eye shape and fruit shape were observed following the method of *Descriptor list for Pineapple* (IBPGRI 1991).

Quantitative characters

Parameters observed in this aspect were as follows:

- Fruit weight (g), weighed without crown and peduncle.
- Fruit length (cm), measured from fruit base to top of fruit, excluding crown.
- Fruit diameter (cm), measured at maximum breadth of fruit.
- Flesh thickness (cm); the fruit was longitudinally sliced and then measured at maximum breadth of flesh.
- Core diameter (cm); the fruit was horizontally sliced and then measured at maximum breadth of heart.
- TSS value (°Brix), some juice from the base, middle and top part of fruit with yellow skin were assessed its TSS using *Hand Refractometer*.

RESULTS AND DISCUSSIONS

The number of plants observed on each crossing was unequal due to the different number of seeds produced. The average number of seeds per fuitlet produced by Cayenne x Queen Hybrids and Queen x Cayenne hybrids was 12 seeds and 6 seeds, respectively (Indriyani and Hadiati 2007). In general, qualitative and quantitative characters of pineapple hybrid plants from both Cayenne x Queen and Queen X Cayenne are shown in Table-1.

Qualitative characters

Qualitative characters in pineapple were more affected by simple gene rather than by environmental factors (Borojevic 1990). One of the pineapple ideotypes is the spineless leaf. It is profitable for the farmers in cultivating and managing, as well as harvesting their crops, resulting in more efficient in terms of production cost. Various distribution of spines on leaves was observed on hybrids from Cayenne x Queen crossing. Some hybrids have spineless leaves while some others have spiny leaves. These spines are located at the tip, base, or along margin of leaves. The percentage of plants with spineless, some spines either at the tip or base, and spines along margin of leaves on the Cayenne x Queen hybrids was 40.0%, 29.3% and 30.7%, respectively. In the same case, that on Queen x Cayenne hybrids was 37.5%, 17.5% and 45.0%, respectively (Table-2). It appeared that the female parent influenced the domination of presence and absence of spines on their hybrid leaves. Regarding the occurrence of spines, the ratio between spiny and spineless leaves on hybrids from Queen x Cayenne crossing was 1: 1.22, opposite to that reported by Sripaoraya (2009) that the ratio of spiny vs. smooth leaf type for Queen x Cayenne crossing was 1.21: 1. Nonetheless, these results revealed that Queen x Cayenne crossing could reduce the characteristic of spine on Queen where from the current study the spines were reduced by 55.0% turning into spineless or spiny only at the tips of leaves. As we know those Queen types have spiny leaves whilst Cayenne has spineless leaves or some spines only at the tip or base of leaf.

Fruits with broad eyes are also an ideotype of pineapple plant. Table-2 shows that Hybrids from Cayenne x Queen crossing that have fruits with the broad-eye shape and projected-eye shape were 61.3% and 38.7%, respectively. Whereas hybrids from Queen x Cayenne crossing that have fruits with the broad-eye shape and projected-eye shape were 37.5% and 62.5%, respectively. This phenomenon seemed that female parent also influenced the dominant character of eye shape on the hybrids.

Combining the characters of spine and eye shape can be expected to generate hybrids having fruits with broad eyes and spineless leaves or spiny leaves at the tips. Hence, the existing Queen clones can be improved through combination of the two characters. In this study, 40.0% of hybrids from Cayenne x Queen and 17.8.0% of hybrids from Queen x Cayenne crossing were observed to have fruits with broad eyes and spineless leaves or spiny leaves at the tips.

Table-1. Quantitative and qualitative characters of pineapple hybrids.

No.	Crossing	Spine Distribution*	Fruit weight (g)	Fruit shape**	Flesh thickness (cm)	Core thickness (cm)	Eye shape	Crown weight (g)	TSS (º Brix)
	Cayenne x queen								
1	CQ-1	0	840	6	4.3	2.6	Projected	85	13.6
2	CQ-2	3	770	4	3.8	2.7	Broad	70	17.5
3	CQ-3	1	840	6	4.3	2.6	Projected	85	13.6
4	CQ-4	0	1250	3	4.7	2.3	Broad	340	16.1
5	CQ-5	1	825	10	4.4	2.6	Broad	80	16.0
6	CQ-6	1	860	3	4.5	3.5	Broad	340	18.5
7	CQ-7	0	720	9	3.5	1.9	Projected	80	18.2
8	CQ-8	3	750	7	4.4	1.7	Broad	180	14.5
9	CQ-9	0	940	3	4.3	4.4	Broad	80	18.0
10	CQ-10	3	600	4	3.3	2.7	Projected	90	18.5
11	CQ-11	3	620	7	3.7	1.8	Projected	110	19.1
12	CQ-12	0	980	7	4.1	3.2	Broad	80	14.3
13	CQ-13	0	600	3	4.3	2.5	Broad	100	18.3
14	CQ-14	0	420	3	3.5	3.0	Broad	30	22.4
15	CQ-15	1	730	3	4.1	2.9	Broad	100	16.9
16	CQ-16	1	1450	2	5.0	3.4	Projected	100	20.0
17	CQ-17	1	540	3	3.8	3.1	Broad	120	13.7
18	CQ-18	0	920	1	5.0	2.0	Broad	500	18.9
19	CQ–19	1	760	3	4.1	2.5	Broad	190	15.3
20	CQ-20	0	1050	1	4.2	3.2	Broad	90	20.3
21	CQ-21	1	570	3	4.0	2.7	Broad	90	13.9
22	CQ-22	0	1170	7	4.6	1.9	Broad	450	17.8
23	CQ-23	3	590	3	4.3	2.2	Broad	175	17.4
24	CQ-24	0	900	4	4.4	3.0	Broad	35	18.6
25	CQ-25	0	500	7	3.0	1.5	Broad	150	17.1
26	CQ-26	0	1200	9	4.5	2.3	Broad	130	16.3
27	CQ-27	0	780	1	3.6	3.1	Projected	90	10.9
28	CQ-28	1	360	4	3.5	1.9	Projected	110	19.5
29	CQ-29	0	820	3	4.4	2.8	Projected	150	17.1
30	CQ-30	0	755	2	2.8	2.9	Projected	50	17.5
31	CQ-31	3	950	4	4.3	2.2	Broad	100	19.8
32	CQ-32	1	785	3	4.0	3.5	Projected	70	15.8
33	CQ-33	0	680	7	4.2	1.5	Projected	270	16.4
34	CQ-34	3	450	3	3.6	2.7	Broad	130	17.4
35	CQ-35	0	800	7	4.2	2.7	Broad	150	16.8
36	CQ-36	1	790	4	3.7	2.3	Broad	135	16.0
37	CQ-37	1	720	3	4.6	1.9	Projected	80	11.9

38	CQ-38	1	1020	7	5.0	2.3	Projected	90	15.9
39	CQ-39	1	580	4	3.5	2.7	Broad	150	12.3
40	CQ-40	0	890	10	4.7	1.9	Broad	300	16.2
41	CQ-41	0	1000	9	4.1	2.4	Broad	135	16.0
42	CQ-42	1	1250	1	4.4	2.9	Projected	80	11.9
43	CQ-43	1	500	3	4.0	2.6	Projected	90	15.9
44	CQ-44	0	930	4	4.4	2.9	Broad	150	12.3
45	CQ-45	3	525	3	3.5	2.3	Broad	300	16.2
46	CQ-46	0	1170	10	4.8	2.5	Projected	100	16.4
47	CQ-47	0	800	4	4.1	2.3	Projected	175	20.5
48	CQ-48	1	420	4	3.5	1.6	Broad	125	18.0
49	CQ-49	3	600	3	3.4	3.3	Broad	260	17.2
50	CQ-50	3	880	3	3.9	4.3	Broad	40	16.7
51	CQ-51	3	560	4	3.4	2.2	Projected	80	18.4
52	CQ-52	3	690	4	4.1	1.9	Projected	155	15.7
53	CQ-53	0	1120	4	4.5	2.9	Board	60	12.6
54	CQ-54	3	950	7	4.4	2.3	Projected	170	17.5
55	CQ-55	3	410	4	3.8	1.9	Projected	190	22.0
56	CQ-56	3	420	3	3.5	2.2	Board	120	18.2
57	CQ-57	1	840	9	4.5	1.6	Board	80	15.7
58	CQ-58	3	730	7	3.2	2.5	Projected	160	17.0
59	CQ-59	3	740	7	4.2	2.3	Broad	130	18.1
60	CQ-60	3	660	4	4.3	2.1	Projected	170	19.7
61	CQ-61	3	845	4	3.2	3.2	Broad	100	21.9
62	CQ-62	0	620	4	4.4	1.3	Projected	100	17.1
63	CQ-63	1	850	1	4.2	3.8	Broad	440	15.1
64	CQ-64	3	650	10	3.3	2.3	Broad	40	14.8
65	CQ-65	3	850	4	4.8	1.7	Broad	90	12.6
66	CQ-66	3	1100	7	4.3	3.0	Broad	120	17.5
67	CQ-67	1	600	7	3.4	1.1	Projected	40	13.7
68	CQ-68	0	500	3	4.2	2.9	Projected	175	22.3
69	CQ-69	0	600	9	4.4	1.5	Projected	100	21.1
70	CQ-70	1	870	7	3.8	1.5	Projected	60	20.1
71	CQ-71	0	790	4	4.0	2.7	Projected	185	22.3
72	CQ-72	1	700	8	3.9	1.6	Broad	50	13.5
73	CQ-73	0	610	3	4.0	2.4	Broad	230	18.5
74	CQ-74	3	600	3	4.5	2.7	Projected	320	19.6
75	CQ-74	0	650	7	4.1	1.8	Broad	230	15.7
	Queen x Cayenne								
1	QC-1	1	790	8	3.5	1.6	Projected	40	13.5
2	QC-2	1	470	2	3.5	2.6	Broad	130	13.7

3	QC-3	3	850	4	4.5	1.9	Projected	480	14.3
4	QC-4	0	530	4	4.1	1.4	Broad	200	18.6
5	QC-5	3	650	8	3.9	2.7	Projected	100	17.7
6	QC-6	0	320	3	3.7	2.1	Broad	450	21.0
7	QC-7	1	700	4	3.6	3.1	Projected	180	12.7
8	QC-8	0	1085	10	4.9	2.2	Projected	240	20.2
9	QC-9	0	800	7	3.0	1.6	Projected	100	16.2
10	QC-10	1	600	7	3.9	1.9	Projected	150	17.5
11	QC-11	3	840	10	3.4	2.4	Projected	120	15.0
12	QC-12	0	840	9	4.1	2.4	Projected	140	19.2
13	QC-13	3	520	7	3.8	1.6	Projected	90	20.0
14	QC-14	1	870	10	3.7	1.9	Projected	40	15.0
15	QC-15	0	940	3	4.4	1.7	Broad	50	16.2
16	QC-16	0	980	7	4.1	3.1	Projected	125	15.3
17	QC-17	1	650	4	4.3	1.8	Broad	250	18.3
18	QC-18	3	1000	10	4.2	3.1	Projected	40	19.5
19	QC-19	3	530	4	3.9	1.7	Broad	655	19.2
20	QC-20	3	820	4	4.0	2.4	Broad	190	10.5
21	QC-21	3	340	3	3.1	2.0	Projected	200	16.9
22	QC-22	3	490	3	3.2	2.3	Broad	230	16.9
23	QC-23	3	1130	3	4.4	4.0	Projected	110	11.1
24	QC-24	0	1170	10	4.5	2.7	Projected	50	14.4
25	QC-25	0	1670	6	4.8	2.7	Projected	100	12.2
26	QC-26	1	1330	6	3.7	4.1	Broad	80	16.5
27	QC-27	0	870	4	3.9	3.3	Broad	290	12.3
28	QC-28	0	330	3	3.1	2.1	Projected	150	19.5
29	QC-29	3	950	4	3.4	4.0	Projected	70	15.9
30	QC-30	0	1110	1	3.9	3.4	Projected	930	21.7
31	QC-31	3	1490	6	5.1	1.9	Projected	60	12.1
32	QC-32	0	900	10	4.2	2.4	Projected	75	13.4
33	QC-33	3	1450	1	4.3	2.9	Projected	120	17.1
34	QC-34	3	750	6	4.4	1.1	Projected	120	12.0
35	QC-35	3	1330	3	5.0	1.4	Broad	100	15.7
36	QC-36	3	1060	7	3.9	1.9	Broad	220	19.0
37	QC-37	0	650	3	3.4	2.6	Projected	140	16.7
38	QC-38	3	900	4	3.5	1.3	Broad	140	15.7
39	QC-39	3	1240	1	4.2	2.8	Broad	140	19.7
40	QC-40	0	900	7	4.3	1.3	Broad	80	15.1

Note: * 0: spineless, 1: spines at the base or tip of leaf, 3: spines along leaf margin; **1: square-like, 2: oval, 3: round, 4: conical, 5: long-conical, 6: pyramid, 7: cylindrical-slight taper, 8: cylindrical-sharp taper, 9: pyroform, 10: reniform

Table-2. The percentage of plants based on the distribution of spines on leaves and the eye shape in each of pineapple crossing.

Plant	Distribution of spine on leaves (%)			Eye shape (%)	
	Spineless	At base/tip	Along margin	Broad	Projected
Cayenne x queen	40.0	29.3	30.7	61.3	38.7
Queen x cayenne	37.5	17.5	45.0	37.5	62.5

The shape of fruit produced from the population of hybrid plants varied from square-like to reniform. Cayenne x Queen crossing tended to generate hybrids with shape of fruit between square-like and conical as many as 64%. On the contrary, hybrids from Queen x Cayenne crossing produced fruit in comparable proportion between square-like - conical and pyramid - reniform.

Quantitative characters

The weight of fruits produced by all hybrid plants in this study varied from 320 g to 1670 g (Table-1). As much as 13.3% of hybrid plants from Cayenne x Queen crossing produced heavier fruits than their female parent (Cayenne = 1019.5 g) while 46.7% of them heavier than their male parent (Queen = 712.45 g). In Queen x Cayenne hybrid plants, 40.0% of them produced fruits heavier than their female parent (Queen) and 27.5% of them produced fruits heavier than their male parent (Table-3). These results suggested that crossing between Cayenne x Queen and their reciprocal resulted in higher fruit weight on more than 50% of the hybrids compared to fruit weight of Queen.

Table-3. The percentage of hybrid plants producing fruit 712.45 - ≤ 1019.5 g and >1019.5 g.

Plant	Percentage of hybrid plants producing fruit	
	712.45 g - ≤ 1019.5 g	>1019.5 g
Cayenne x queen	46.7	13.3
Queen x cayenne	40.0	27.5

According to Smith (1988) that TSS is one of the parameters generally used to predict the eating quality of pineapple. Based on the TSS, Table-4 shows that the percentage of plants producing fruit with TSS ≥ 16 °Brix was higher in Cayenne x Queen crossing (68.0%) than in Queen x Cayenne crossing (52.5%). This is probably influenced by Queen either as a male or a female parent since Queen has sweeter fruit flesh than Cayenne**.** In addition, Queen contains less acid than Cayenne (Hadiati *et al*. 2003; Py *et al*. 1987). Some hybrids, in fact, have the value of TSS ≥ 20 °Brix, i.e. CQ-14, CQ-16, CQ-20, CQ-21, CQ-47, CQ-68, CQ-69, CQ-70, and CQ-71 for Cayenne x Queen crossing and QC-6, QC-8, and QC-30 for Queen x Cayenne crossing.

Table-4. Percentage of hybrid plants with TSS ≥ 16 °Brix and crown ≤ 100 g.

Plant	Percentage of hybrid plants with	
	TSS ≥ 16 °Brix	Crown ≤ 100 g
Cayenne x queen	68.0	48.0
Queen x cayenne	52.5	37.5

Crown size that is measured in weight unit will affect the package and transportation in which the lighter the crown weight the easier the fruits are packaged and transported. In current study, the hybrid plants producing small crown were as much as 48.0% and 37.5%, respectively in Cayenne x Queen Hybrid plants and in Queen x Cayenne hybrid plants (Table-4).

Concerning the most commonly sought characters, there are four characters determined in this study, i.e. spineless leaves or spiny at the leaf tip, fruit weight, sweet taste (TSS), and eyes shape. Hybrid plants having spineless leaves or spiny at the leaf tip, fruit weight ≥ 1000 g, TSS ≥ 16º Brix, and broad eyes were CQ-4, CQ-20, CQ-22, CQ-26, CQ-41 and QC-26. The same characters except for projected eyes were also owned by the hybrid plants of CQ-16, CQ-46, and QC-8. All these hybrids appeared to have similarity to the Cayenne type but their superiority in sugar content (TSS). Nevertheless, further evaluation on these hybrids should be carried out to ensure their stability before releasing to be new superior varieties.

CONCLUSSIONS

a) Qualitative characters in terms of distribution of spines and eye shape were influenced by female parent. The number of hybrid plants from Cayenne x Queen crossing possessing spiny leaves was fewer than that from Queen x Cayenne crossing, i.e., 30.7% vs. 45.0%. On the contrary, the number of hybrid plants with broad eyes was more on Cayenne x Queen crossing (61.3%) compared with on Queen x Cayenne crossing (37.5%).
b) Fruits with ≥ 1019.5 g weight produced by hybrid plants from Cayenne x Queen crossing were fewer than from Queen x Cayenne crossing (i.e. 13.3% vs. 27.5%). Whereas fruits with sugar content (TSS ≥16°Brix) were more given by hybrid plants from Cayenne x Queen crossing (68.0%) compared with

hybrid plants from Queen x Cayenne crossing (52.5%).

c) The combined characters of spineless or spiny at the leaf tip, fruit ≥ 1000 g, sweet fruit (TSS ≥ 16°Brix), and broad eyes took place on CQ-4, CQ-20, CQ-22, CQ-26, CQ-41 and QC-26 hybrids. Except for the projected eyes, these characters also took place on CQ-16, CQ-46, and QC-8 hybrids.

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