Mem. Fac. Agr. Kagoshima Univ., 15, 55-62, 1979

Studies on Fruit Characteristics and Seedless Fruit Formation of Semarang Rose Apple, *Syzygium javanicum* Merr. & Perry, in South Vietnum

Mitsuo IKEDA
(*Laboratory of Tropical Crops*)
Received for Publication August 31, 1978

Introduction

Semarang rose apple is one of the most popular fruits in South Vietnum. It is not only produced commercially in the orchards, but is also planted in many home gardens for fresh fruits, or as an ornamental tree. The main orchards, in the low land of Mekon Delta of South Vietnum, consist of flat, long rectangular dikes of 6 - 8 m wide, surrounded with the water channels of about 1.5 m in depth and 2 m in width, the former being constructed with soils dug up from the site of the latter. The prevalent propagation is made by the method of 'air-layering' practiced during the early rainy season, May to July. The rooting medium around the wound of the shoot is a mud ball mixed with the cut fibrous roots of water hyacynth, *Eichornia crassipes* Solms, a plant growing abundantly near water in this country. One to 2 years old seedlings planted 6 - 7 m apart, in two rows, near the both edges of dikes come into bearing in 2 - 3 years. Compound fertilizer (Ammophosco: 16-16-8) is usually dressed, in shallow circles properly set away from the base of the trunk, two times a year, at the rate of 1.5 kg per a tree. In addition, the laborious works of returning back rich mud on to the dike from the bottom of the channels eroded down by intense and heavy showers occurred during the previous wet season are performed every year in dry season to ensure the good yields. The most serious damage is caused by borer attack, which is not to be controlled by the pesticide at present. Average annual yields of a single tree reach about 100 kg, at the full bearing age. Harvesting continues from January to July accompanied with two peaks.

Fruit characteristics of the semarang rose apple were considerably variable and were examined in 1972, especially for the purpose of evaluating the relationship between the seed number and the fruit shape. One of the most interesting facts obtained was that the mixed production of the seeded and seedless fruits was prevalent in this species. Then another experiment was conduced in 1973, to obtain some informations on the formation of seedless fruits.

Materials and Methods

Experiment 1.

The fruits of semarang rose apple were inspected in their external appearance throughout the open-air markets in Cantho city, located at the central part of Mekon Delta, and were classified into a few groups on the basis of the combinations of three fruit character-

istics; skin-color, size and shape. After this, the bearings of the fruits of each group were observed on the respective trees in view of the varietal classification, because of the fact that no variety name is fixed in this region. Forty fruits belonging to the respective groups were randomly taken both at the markets (groups 1 – 9) and in the orchards (groups 10 – 14). They were individually marked, weighed, and cut longitudinally into half parts, before measuring height, maximum width, width at one-third-height from the base, inside-pore-diameter, and seed number. Shape index computed in order to express variable shape, numerically using the formula; Shape index = (Maximum width/width at 1/3 height from base) × 100, as illustrated at the upper right diagram in Fig. 2. Besides, coefficients of variation of the respective characteristics among the groups were also computed.

Experiment 2.

The respective 2 semarang rose apple trees of Green variety (seedless type) and Large Red variety (seeded type) were selected in the orchard near the Faculty of Agriculture, Cantho University, in Cantho city. They were about 10 years old, bearing promptly every year in the past. The treatments described below were applied on the flowers of the randomly selected clusters, during the period, November 1 – 8, 1973, at the onset of dry season.

I-i: Natural self-pollination. Flowers in a cluster were thinned to 2 – 3, and were bagged individually before the flower opening.

I-c: Natural self-pollination. Each cluster was bagged before the flower opening. In this case, the stigmata could accept pollen from their own and neighbouring flowers in the same cluster.

II-s: Non-pollination. Flowers were bagged individually after the removal of the stigma before the opening of flower.

II-a: Non-pollination. Flowers were bagged individually after the removal of anther before the opening of flower.

III-i: Hand self-pollination. Flowers were thinned in a cluster to 2 – 3 and were bagged after hand-pollination carried out with the pollen of their own flower before opening.

III-c: Hand self-pollination. Each cluster was bagged after flowers were pollinated with the pollen of its own and the neighbouring flowers.

IV-i: Open pollination. Flowers in a cluster were thinned to 2 - 3 and were bagged 1 day after flower opening.

IV-c: Open pollination. Clusters were bagged 1 day after the flower opening.

Ripe fruits were harvested about 3 months after the treatment and were assessed on presence or in absence of seeds.

Results and Discussion

Experiment 1.

Six kinds of skin-color were distinguished, namely bright red, ivory white, light green, white-pink, light green-red, and light green-pink. The skin-color of the white-pink fruit is white around the base, pink around the apex and mixed of these at the intermediate portion, green-red and green-pink being similar to this. Fruit size or volume was roughly graded into small, medium and large. Fruit-shape was most noticeable and basically divided into oval and bell-shaped, including a few depressedly or longishly transformed ones as shown in Figs. 1, 2. From the standpoint of the combinations of the characteristics mentioned above, fruits were to be classified into 14 groups. Additionally, after the field observation it was

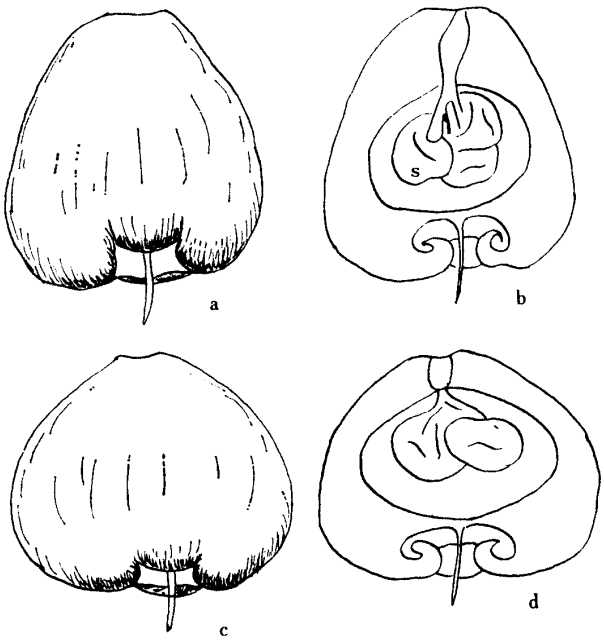

Fig. 1. Oval and depressed-oval fruits
a: oval fruit, group 3
b: half section of a
c: depressed oval fruit, group 9
d: half section of c
s: seed

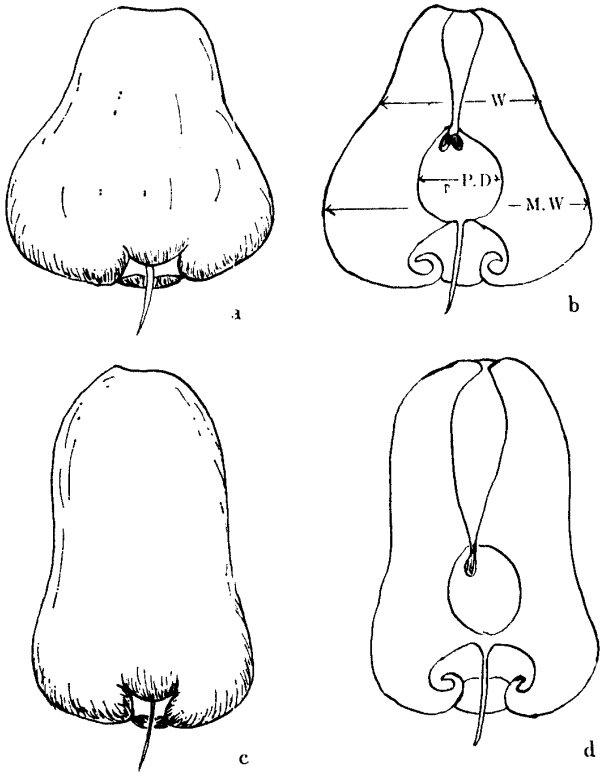

Fig. 2. Bell-shaped and long bell-shaped fruits, seedless types
a: bell-shaped fruit, group 13
b: half section of a
c: long bell-shaped fruit, group 11
d: half section of c
P.D.: inside pore diameter
M.W.: maximum width
W: width at one-third-height from base

recognized that fruits belonging to 2 different groups; groups 1–2, 3–4, 6–7, 9–10, respectively; were beared on the same tree, as shown in Fig.3. Under these considerations, 10 varieties were determined, and the following names were allotted to these, temporarily;

Table 1. Fruit characteristics of varieties and groups

Variety	Group No.	Color	Size	Shape
Large Red	1	Bright red	Large	Oval
	2	Bright red	Large	Bell-shaped
Medium Red	3	Bright red	Medium	Oval
	4	Bright red	Medium	Bell-shaped
Small Red	5	Bright red	Small	Bell-shaped
White	6	Ivory white	Medium	Oval
	7	Ivory white	Small	Bell-shaped
Green	8	Light green	Medium	Depressed-bell-shaped
White-pink	9	White and pink mixed	Medium	Depressed-oval
	10	White and pink mixed	Medium	Oval
Bell-white-pink	11	White and pink mixed	Medium	Long bell-shaped
Green-red	12	Light green and red mixed	Medium	Depressed-oval
Bell-green-red	13	Light green and red mixed	Medium	Bell-shaped
Green-pink	14	Light green and pink mixed	Small	Bell-shaped

Large Red, Medium Red, Small Red, White, Green, White-pink, Bell-white-pink, Green-red, Bell-green-red, and Green-pink (Table 1). Since the varietal classification was tried under the restricted time and region, this could not help being tentative but might be reliable.

Every skin-color had a tendency to be deep, both at the apex and base, and to be light at the intermediate portion. It was found in general that in the same varieties, bell-shaped fruits were smaller in shape, but denser in color, than the large oval ones suggesting the existence of nearly equal quantity of color-pigments in the skin of one fruit, regardless of the difference in skin area. Probably, red, white and green colored types are basic, and their mutual crosses have derived other types. In Taiwan[4], red, white, pink, and green colored varieties were described before the world War II, and in Indonesia, Ochse et al.[2] describes only white and pink colored fruits. In this respect, South Vietnum should reasonably be esteemed as one of the centers of semarang rose apple production. Medium Red ones were sold most abundantly, and mixedly colored varieties, except white-pink, were sold relatively in small quantity.

Table 2 summarizes the average values of 40 fruits of each group, on the following items: weight, height, maximum width, width at one-third-height from the base, pore diameter, number of seeds per fruit and shape index as well as coefficient of variation of the characteristics among the groups on the bottom row. Among the groups, both the height and the maximum width were less variable than the other characteristics, and both showed almost equal figures within groups, except the groups 8, 9, 11, 12, having either depressed or longish shape. It was of great interest that the number of seeds was most variable among groups, as shown by its high coefficient of variation, ranging from 0 to 4.6. The greatest number of seeds contained in one fruit was 8, and the frequency distributions in each variety differed markedly (Table 3).

Reference to Tables 2, 3 shows that the varieties were to be separated into two types, one seedless and another seeded, with the same numbers. The former included Small Red, Green, Bell-white-pink, Bell-green-red and Green-pink, and the latter included Large Red, Medium Red, White, White-pink and Green-red. Among the seedless types, Small Red

Table 2. Fruit characteristics of groups and their coefficient of variation among groups

Group No.	Weight	Height	Max. width	Width at 1/3 from base	Shape index	Pore diameter	Seed number
	(g)	(cm)	(cm)	(cm)		(cm)	
1	60.6	5.4	5.4	4.1	132	3.5	2.8
2	60.4	6.0	5.3	3.4	156	2.5	1.2
3	42.7	4.9	4.7	3.4	138	2.9	3.4
4	40.5	4.8	4.8	2.8	170	1.4	0.2
5	27.9	4.4	4.3	2.5	172	1.0	0.2
6	47.2	4.5	4.6	3.7	133	3.1	3.0
7	27.0	4.0	4.0	2.7	148	1.9	1.5
8	44.9	4.0	5.0	3.4	150	1.6	9.0
9	43.8	4.4	4.8	4.1	118	3.1	4.5
10	43.4	4.6	4.7	3.4	137	2.2	1.3
11	38.4	5.6	4.3	2.7	155	0.8	0.0
12	45.5	4.3	5.1	4.5	113	3.7	4.6
13	33.5	4.6	4.5	2.8	162	0.8	0.0
14	24.0	3.9	4.0	2.5	157	1.0	0.1
C.V.%	15.3	7.8	5.4	11.2	22.5	28.8	50.0

Table 3. Frequency distributions of seed number among the varieties

Variety	Fruit number	Seed number								
		0	1	2	3	4	5	6	7	8
Large Red	80	11	23	19	16	9	2			
Medium Red	80	33	10	9	14	6	2	5	1	
Small Red	40	33	7							
White	80	5	24	21	14	12	2	2		
Green	40	40								
White-pink	80	12	13	9	23	8	3	4	4	4
Bell-white-pink	40	40								
Green-red	40			3	10	8	8	4	5	2
Bell-green-red	40	40								
Green-pink	40	38	2							

and Green-pink contained a few fruits of one seed,but the other varieties did not.On the other hand, only Green-red did not produce seedless fruit among seeded varieties. Such diversity might be due to the shortage of sample obtained, because Green variety, as an example, produced apparently seeded fruits, though small in rates, in the experiment 2 conducted in the following year. In the same way, Green-red was expected to show, at least, a small rate of production of seedless fruits, provided the number of them increased. It was assumed

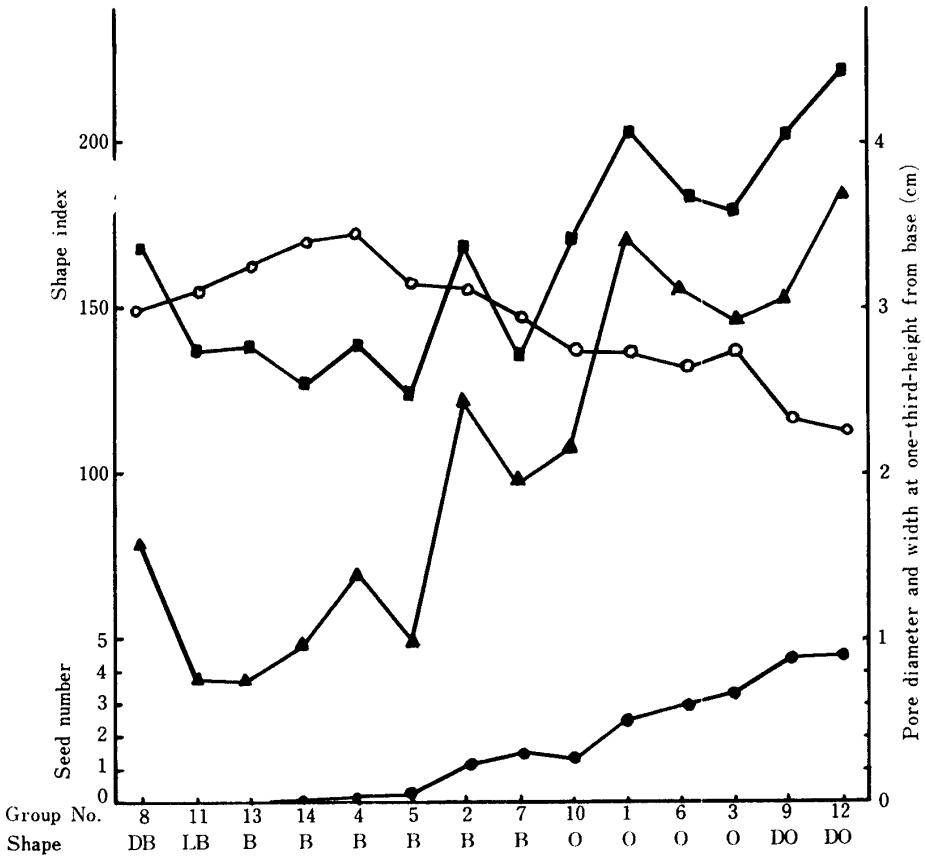

Fig. 4. Relationships between fruit shape and 4 characteristics; number of seeds (●), pore diameter (▲), shape index (○), and width at one-third-height from base (■) of fruits of 14 groups.
B: Bell-shaped, DB: Depressed Bell-shaped, LB: Long Bell-shaped,
O: Oval, DO: Depressed Oval.

that Small Red (seedless type) probably might be bred from the bud mutation of Medium Red (seeded type) producing seedless fruits at relatively a high rate.

Pore diameter, shape index and width at one-third-height from the base, were the main factors contributing to the determination of the fruit shape, together with the number of seeds, as seen in Table 2, more clearly in Fig. 4. It is indicated that fruits of 0–2 seeds were resulted in bell-shaped fruits supplied with beyond 148 shape index, and those of beyond 3 seeds were resulted in oval fruits supplied with below 132 shape index, with the exception of group 10, of which seed number was below 2, regardless of oval shape. Although the similar trend was, of course, occurred within each variety, its aspect differed somewhat among the varieties. In Fig. 5, for instance, the declining of the shape index of Medium Red happening in accordance with the seed number is sharp within the range of 0–2 seeds, but, once beyond the range, it comes to be flat, while that of White-pink is continuously gentle. Seed size tended to become smaller according to the increase of seed number in the range of beyond 3. Thus semarang rose apple is assumed to give the most typical and conspicuous case in the fact that fruit shape is to be affected by the seed number contained, though such cases were reported in some fruit trees, such as pear and Japanease persimmon[1]. Moreover, it seems very rare that 2 kinds of fruits of different forms are born on a tree. Fruit weight appeared to be depending not on the seed number contained but rather on varieties, though exceptionally, fruits of two seedless varieties were smallest.

The fruits sometimes, especially, when they contained one seed, grew a little more at one side than another, probably, due to the irregular shape of seed aggregates as well as

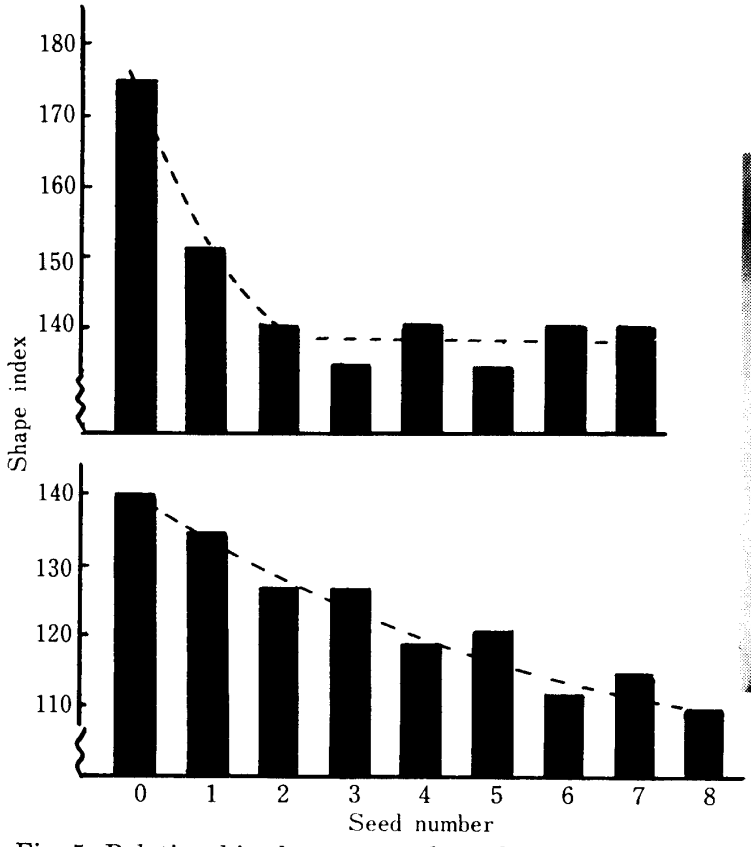

Fig. 5. Relationships between seed number and shape index.
Upper: Medium Red, Lower: White-pink

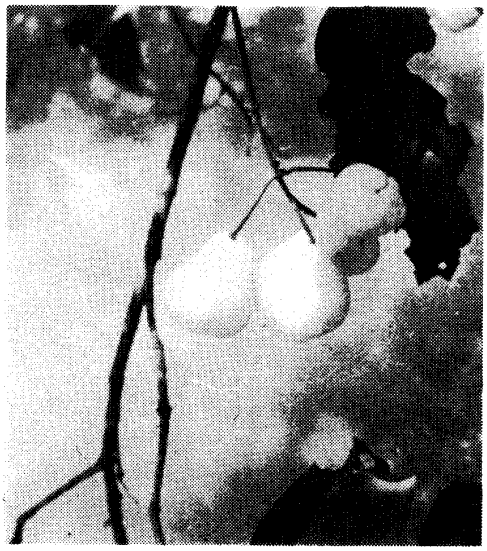

Fig. 3. Bell-shaped and Oval fruits on a cluster, White variety.

individual seed. In general, seeded fruits tasted better than seedless fruits in a variety; however, Green (seedless type) was esteemed by people as the one having the best quality.

Experiment 2.

Table 4 presents average values of the respective 2 trees of Large Red and Green varieties in each plot, determined on the numbers of treated flowers, ripe fruits, seeded fruits and seedless fruits, and on the ratios of ripe fruits to 100 treated flowers and of seedless fruits to 100 ripe fruits.

Table 4. Relationship between seedless fruit production and pollination in semarang rose apple

Plot, Treatment	Variety	Treated fruit number (T)	Ripe fruit		Seeded fruit number	Seedless fruit	
			number(R)	rate % S/T × 100		number(S)	rate % S/R × 100
I-i Natural self-pollination	Green	30	10.5 ± 2.12	35.0	1.0 ± 0.00	9.5 ± 2.12	90.5
	Large Red	30	17.0 ± 1.40	56.7	16.5 ± 0.71	0.5 ± 0.71	2.9
I-c Natural self- and neighbour pollination	Green	50	12.5 ± 2.12	25.0	1.5 ± 0.70	11.0 ± 4.12	88.0
	Large Red	50	32.5 ± 0.71	65.0	29.0 ± 1.40	3.5 ± 0.71	10.8
II-s Non-pollination	Green	30	11.0 ± 1.41	36.5	0	11.0 ± 1.41	100.0
	Large Red	30	0 0	0	0	0	0
II-a Non-pollination	Green	30	5.0 ± 1.41	16.5	0	5.0 ± 1.41	100.0
	Large Red	30	0 0	0	0	0	0
III-i Hand self-pollination	Green	30	21.0 ± 2.80	70.0	1.5 ± 0.71	19.5 ± 3.53	92.9
	Large Red	30	26.0 ± 0.00	86.0	24.5 ± 0.70	1.5 ± 0.71	5.8
III-c Hand self-pollination	Green	50	29.0 ± 1.41	58.0	3.0 ± 1.40	27.0 ± 1.41	93.1
	Large Red	50	37.5 ± 3.53	75.0	34.5 ± 2.23	3.0 ± 1.40	8.0
IV-i Open-pollination	Green	30	13.5 ± 1.80	44.5	0.5 ± 0.71	13.0 ± 0.00	96.5
	Large Red	30	19.5 ± 1.50	65.0	19.0 ± 2.00	0.5 ± 0.50	2.6
IV-c Open-pollination	Green	50	19.0 ± 1.41	38.0	2.0 ± 1.40	17.0 ± 0.00	89.5
	Large Red	50	34.0 ± 1.40	68.0	31.5 ± 2.12	2.5 ± 0.71	7.3

Note: Treatments are detailed in method paragraph.
Green is seedless type variety and Large Red is seeded type variety.
Figures are averaged values of two trees.

Since both varieties did not produce seeded fruits when no pollination took place (II-s, II-a plots), they should not be looked upon as parthenogenesis. In these plots, on the other hand, Large Red variety did not produce seedless fruits, while Green variety produced some seedless fruits. Consequently, Green variety is considered to be parthenocarpic but Large Red variety is not. Nevertheless, Large Red could produce some seedless fruits when pollination took place (I, III, IV plots), indicating its capability of non-parthenocarpic production of seedless fruits. The production of seedless fruits in Green variety was more fastidious through all the pollination plots than in non-pollination plots, indicating that this variety produced seedless fruits by means of non-parthenocarpicity as well as by parthenocarpicity, and the former seemed generally to play a role greater than the latter in the production of this.

Non-parthenocarpic production of seedless fruits of both varieties may be casued by embryo abortion in the developing seeds, and it was evidently to be favored by more perfect pollination, as larger number of seedless fruits were obtained in hand-pollination plots (III plots) than that in natural self-pollination plots (I plots).

The ratio of ripe fruits to 100 treated flowers was higher in Large Red variety than

that in Green in all pollination plots, suggesting that the seed formation was favorable for the fruits developing, as recognized generally in other fruit tree species[3], and it was lower in bagged cluster plots as compared with the bagged-individual-flower plots; possibly owing to the more fastidious nutritive competition between fruits in the former.

Summary

The fruit characteristics were examined in Cantho city in 1972. Six kinds of skin-color; bright red, ivory white, light green, white-pink, light green-red, light green-pink, 5 kinds of shape; oval, depressed oval, bell-shaped, depressed bell-shaped, long-shaped, and 3 kinds of size; large, medium and small were distinguished. Then, the fruits were classified into 14 groups on the basis of the difference of the combinations of these three characters. After field observations, 10 varieties were conveniently determined. Forty fruits of each group were randomly selected and inspected on weight, height, maxiumm width, width at one-third-height from the base, pore diameter and seed number; and both the shape index and coefficient of variation of the characteristics among groups were computed. Seed number contained in the fruits was most variable and had very strong effects on width at one-third-height from fruit base, pore diameter, shape index, and the determination of shape, oval or bell-shaped. The fruits of the seedless and the below 2 seeds were bell-shaped, and those of beyond 3 seeds were oval.

The preliminary experiment on the formation of seedless fruits of semarang rose apple was conducted by using the seedless and seeded type varieties. Both varieties were not of parthenogenesis. The seedless type was partialy parthenocarpic but the seeded type variety was not. Seeded type produced non-parthenocarpically a small rate of seedless fruits at the time when pollination took place. The formation of seedless fruit in seedless type variety was parthenocarpic as well as non-parthenocarpic, but the latter played a role greater than the former. The production of non-parthenocarpic seedless fruits might be caused by the embryo abortion in the developing seed, and it was apparently made to be increased by the perfect pollination (hand-pollination plots).

Acknowledgments

This work was done while the author had the status of the dispatched proffesor to Faculty of Agriculture, Cantho University, Cantho city, South Vietnum from 1971 to 1973, and Tran Van Chinn and Le Trum Tinh were zealous collaborators in Exp. 1 and Exp. 2, respectively. The author gratefully acknowledge the generous help given to him by Dr. Ngayer Viet Trung, Mr. Le Din Qui, Mr. Trink Minh Long and The Japan oversea Co-operation Agency.

References

1) Gardener, V. R., Bradford, F. C. and Hooker, H. D.: The fundamentals of fruit production. p. 696, McGraw-Hill B. C. Inc. (1952)
2) Ochse, J. J., Soule, Jr., Dijkman, M. J. and Wehlburg, C.: Tropical and subtropical agriculture. p. 677–679, Macmillan. New York (1961)
3) Olmo, H. P.: Pollination and the setting of fruit in the black corinth grape. *Proc. Amer. Soc. Hort. Sci.*, **34**, 402 (1937)
4) Taiwan Farmer's Handbook: *Taiwan Agr. Exp. Sta.*, p. 478–479 (1944)