Conference Paper

Polianthes tuberose Breeding in Indonesia

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Abstract

Tuberose (Polianthus tuberosa) is an important ornamental plant in Indonesia that has been cultivated by farmers for a long time mainly in Java and North Sumatra provinces. However, the availability of new superior varieties is only a few so that the consumers only have a limited choice. Until now, there are three types of tuberose in Indonesia, which is distinguished by the type of flower namely single, semi-double and double flower. Some breeding efforts to obtain new varieties have been done through crossbreeding, mutation induction and selection to local cultivars. But the success on the crossbreeding of tuberose was only about 0.05%, as it can only be done in the direction of the single flower with double flowers. Because in the double flowers pistils are not found, the variability is very low. Nevertheless from these crossbreeding obtained 29 genotypes that showed differences in several characters, especially in the arrangements of flowers; and flower stalks straightness and rigidness. The other study indicates that each genotype has a different resistance levels against leaf spot disease (*Xanthomonas* sP.). Meanwhile, breeding of tuberose through mutation induction technique has not been widely studied. Application of gamma ray irradiation on tubers caused morphological damaged on *Polyanthes*, reduced bulb growth less than 30% and reduced the plant height more 400% than no treated plants (control). Polyploidy induced mutations by using colchicine led to changes in the length and diameter of the flowers and harvesting time. Until now, there is no result of the crossbreeding and mutation techniques that released as a new variety. Despite this, based on the positive selection breeding on local cultivars, there have been two superior genotypes released as new varieties namely Dian Arum (double flower type; origin of Cianjur, West Java) and Roro (semi double flower type; origin of Pasuruan, East Java).

Keywords: Polianthes tuberosa; breeding; local cultivars, new varieties,Dian Arum, Roro Anteng.

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1. Introduction

Tuberose (*Polianthes tuberosa*) or sedap malam (Indonesian language) is an important and popular ornamental plant in Indonesia [1] and has been cultivated by farmers for

a long time mainly in Java and North Sumatra provinces [2]. National production of tuberose in 2014 was up to 104,625,690 stalk in 2014 [3].

Although the production and demand of tuberouse are high but the consumers have a limited choice. There are several variations of tuberose flower petal shapes in various regions in Indonesia i.e. a single layer (single flower), two layers (semi-double flowers) and more than two layer (double flowers). A single and semi-double flower was found in Bangil Pasuruan (East Java). Semi-double flowers are also found in production centers in Central Java such as Ambarawa area, Magelang and Bandungan. Double flowers are found in production centers in West Java such as Cianjur, Sukabumi and Tasikmalaya [1].

Sihombing *et al*. [4] also reported that the diversity of colors and shapes of tuberose flower in Indonesia is very limited. Flowers color is white only and a little difference with a tinge of pink at the end of the flower petals. The type tuberose flower can only be distinguished by the amount of the petal layers i.e. single flower with has a layer of petal with five petals piece, semi-double has 2-3 layers with 10-12 petals piece and double flowers that have more than three layers of petals with 18-25 petals piece.

Meanwhile, breeding programs to create new varieties of tuberose plants are still rare [2]. The chances to creating of new varieties through crossbreeding is very small, because the success of crosses are very small, only 0.05% [5]. It is influenced by limitation of crossbreeding in tuberose mother plant and it can only be made between double flowers with single flower. Because the double flowers do not have pollen, so that crossbreeding can only be done in one direction. This paper was aimed to review all advance activities in tuberose breeding in Indonesia, so a new strategy and different approach can be develop in breeding programs to make a new superior varieties.

2. Research of tuberose breeding in Indonesia

To obtain new superior varieties of tuberose that has a new and unique the appearance of flower, various breeding programs have been carried out either through crossbreeding, induced mutation and selection of local cultivars.

Haryanto *et al.* [5] has done a crossbreeding of tuberose between a single flower with double flowers. After the selection in the line was obtained 39 best genotypes (Figure 1). Further testing shows that all genotype generally has a narrow-sense genetic variability and a low heritability estimates value (Table 1 and 2) [6, 7].

The subsequent observations on several important characters of flower morphology showed that all characters had a narrow-sense variability, except the stalk length and the petal numbers (Table 1). Based on these criteria, the result indicated that almost all of the flower characters observed had a narrow-sense genetic variability coefficient

Table 1: Genetic variability of some flower morphological characters of *Polianthes tubrose* hybrid [7].

Characters	GVC (%)	Criteria	PVC (%)	Criteria
1. Stalk length	22.89	broad	25.17	broad
2. Stalk diameter	2.22	narrow	6.38	narrow
3. Rachis diameter	9.68	rather narrow	15.26	rather narrow
4. Flower number	5.32	narrow	12.14	narrow
5. Petal number	31.30	very broad	32.29	very broad
6. Flower bud diameter	4.34	narrow	8.30	narrow
7. Flower bloom diameter	3.72	narrow	11.71	rather narrow
8. Vas life	3.98	narrow	6.99	narrow

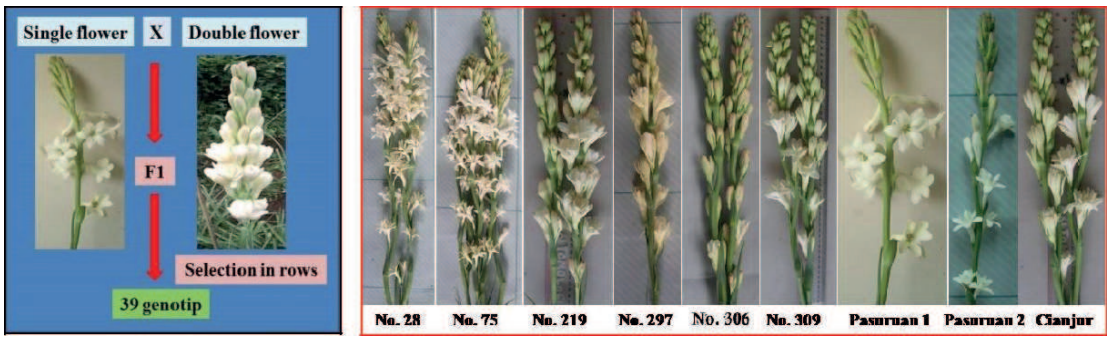

Figure 1: Scheme of tuberose cross breeding (left) and performance of some selected clones of tuberose hybrid and reference cultivars [8] (right).

(GVC) and phenotypic variability coefficient (PVC), except in the character of the stalk length and petal numbers.

In estimating the heritability and genetic gain, the entire flower genotypes observed generally had a low value. Only the character of the flower stalk length and petal number has a high value of heritability and genetic gain. Stalk length of the flower had a heritability 82.70% and the expected genetic gain 42.46%, while the character of the petal has a heritability 93.97% and the expected genetic gain 62.50% (Table 2). Based on the above results, the selection would be done both on the stalk length and petal number of flower.

Based on the evaluation of phenotypic appearance in several characters, the regularity of the floral formation, cohesiveness of flowers and stalks straightness and toughness of flower, it was found six best genotypes i.e. genotype no. 28, no. 75, no. 219, no. 297, no. 306 and no. 309 (Table 3; Table 4 and Figure 1b) [7, 8].

An other study was done to find out resistance of these selected clones to mealybug, a serious pest of tuberose in Indonesia [9]. The result showed that the increase of the intensity of mealybug infestation that showed a significantly differences between genotypes were tested. In early observations it appears that the highest damage intensity was shown by clone no. 297, 219, 75 and cultivar Cianjur i.e 70.00%, 67,5.00%

Table 2: Heritability and genetic gain of some morphological flower traits of *Polianthes* genotypes [7].

Character	H (%)	Criterion	Genetic advance (%)	Criterion
1. Stalk length	82.70	Height	42.46	Rather height
2. Stalk diameter	12.06	low	1.59	low
3. Rachis diameter	40.22	moderate	12.64	low
4. Flower number	19.19	low	4.80	low
5. Petal number	93.97	height	62.50	height
6. Flower bud diameter	27.40	moderate	4.69	low
7. Flower bloom diameter	10.07	low	2.43	low
8. Vas life	17.88	low	3.58	low

and 62,5%. While the lowest damage intensity shown by cv. Pasuruan Single that it has only 15% in average intensity. In further investigation it was appeared that all genotypes have a low level of resistance against mealybug, except for a single cv. Pasuruan that had a higher resistance level. Presumably, the level of resistance was influenced by the physical condition of plants. Pasuruan Single genotype that categorized as rather resistant varieties have the glossy leaf surface more than the other varieties (Table 5).

Handayati [10] also tested resistance level of these selected clones to leaf spot disease (*Xanthomonas* sp.) The result showed that there were no cultivars that resistant to leaf spot disease, but each genotype had different levels of resistance to soft rot disease. Genotypes no. 28, cultivars Cianjur and Pasuruan Single were categorized as rather susceptible; genotypes no. 75 as susceptible; whereas no. 219, no. 297, no. 301, no. 309 and cultivars semi double Pasuruan were classified as highly susceptible.

Unfortunately, breeding research of tuberose through mutation induction technique has not been widely studied. Mubarok *et al.* [11] reported that the use of gamma ray irradiation greater than 25 Gy caused more than 50% of tuberose bulbs did not grow or the growth percentage was less than 50%. The use of gamma ray irradiation more than 25 Gy was ineffective and had a negative effect on the growth or germination of tuberose tubers (Figure 2). Percentage growth tuberose bulbs obtained from the highest dose (100 Gy), which is about 16.67% and significantly different with the control, 25 Gy and 50 Gy dosage levels. The use of gamma-rays irradiation at high dose might provide a direct negative effect on the plant, due to the high dose of mutagen may cause plant to die. Treatment of gamma rays at a dose between 25 to100 Gy significantly lowers the height of plants or make plants becoming stunted compared with the control. A decrease in plant height reaches 400% compared with the plant control. In addition to causing stunted plants, application of gamma-ray also causes change in other plant morphological i.e. leaf color. Irradiation of plants with gamma

Table 3: The flower type, flower fragrant and flower performance of *Polianthes tuberose* hybrid [7].

Clones no.	Flower Type	Flower fragrant	Flower performance
28	Semi double	Rather fragrant	Regular floral formation and has straight and tight flower stalk
61	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
62	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
63	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
64	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
67	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
74	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
75	Semi double	Rather fragrant	Regular floral formation and has straight and tight flower stalk
83	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
84	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
85	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
102	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
104	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
107	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
120	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
126	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
127	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
151	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
152	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
162	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
219	Double	Fragrant	Regular floral formation and has straight and tight flower stalk
228	Semi double	Rather fragrant	Irregular floral formation and has slightly curved flower stalk
240	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk
247	Double	Fragrant	Regular floral formation and has slightly curved flower stalk
297	Double	Fragrant	Regular floral formation and has straight and tight flower stalk
301	Semi double	Rather fragrant	Regular floral formation and has straight and slightly curved flower stalk
306	Double	Fragrant	Regular floral formation and has tight flower stalk
309	Double	Fragrant	Regular floral formation and has straight and tight flower stalk
311	Semi double	Rather fragrant	Regular floral formation and has slightly curved flower stalk

Table 4: Flowers color, fragrance and performance of promising clones and reference cultivars [8].

Clones No./ Reference Cultivar	Flower color	Flower fragrance	Flower performance
28	white 155c	Rather fragrance	Straight and quite weak flower stalk; irregular floral formation
75	white 155c	Rather fragrance	Straight and quite weak flower stalk; irregular floral formation
219	white 155c	Fragrance	Straight and rigid flower stalk; compact floral formation
297	white 155c	Fragrance	Straight and rigid flower stalk; compact floral formation
306	white 155c	Fragrance	Straight and rigid flower stalk; compact floral formation
309	white 155c	Fragrance	Straight and slightly rigid flower stalk; compact floral formation
Pasuruan 1	white 155c	Moderately fragrance	Straight and quite weak flower stalk; irregular floral formation
Pasuruan 2	white 155c	Rather fragrance	Bend and weak flower stalk; irregular floral formation

Table 5: Damage intensity of some *Polianthus genotypes*by mealybug [9].

Clone no./ Cultivars	Damage intensity (%)	Resintance levels to mealybug
28	62.50	Very susceptible
75	55.00	Very susceptible
219	80.00	Very susceptible
297	75.00	Very susceptible
306	57.00	Very susceptible
309	82.50	Very susceptible
Conjure	95.00	Very susceptible
Pasuruan Single	15.00	Moderately resistant
Pasuruan Semi Double	47.50	Susceptible

rays doses higher than 50 Gy cause the color of the leaves become pale, due to the reduced content of chlorophyll in the leaves.

Another study was done using gamma irradiation at 0, 5, 10, 15, 20, 25 and 30 Gy dosage leves [12]. The effects of these first-generation mutations (M1V1) cause physiological damage and lethality. The damage appears in the form of a reduction in plant height at increasing dose irradiation, dwarf plant, the death of all the bulbs at a dose of 30 Gy, the tip of the bud like a burn, the deviation of growth floret at a dose of 15 Gy i.e florets formed early at the end of the shaft which should be at the bottom, floral fragrance strength was decrease on any increase in irradiation dose, 50% lethal dose (LD 50) at a dose of 15.53 Gy, while genetic effects were not visually visible. Even if there are mutants, it could not be ascertained because it could have the effect of

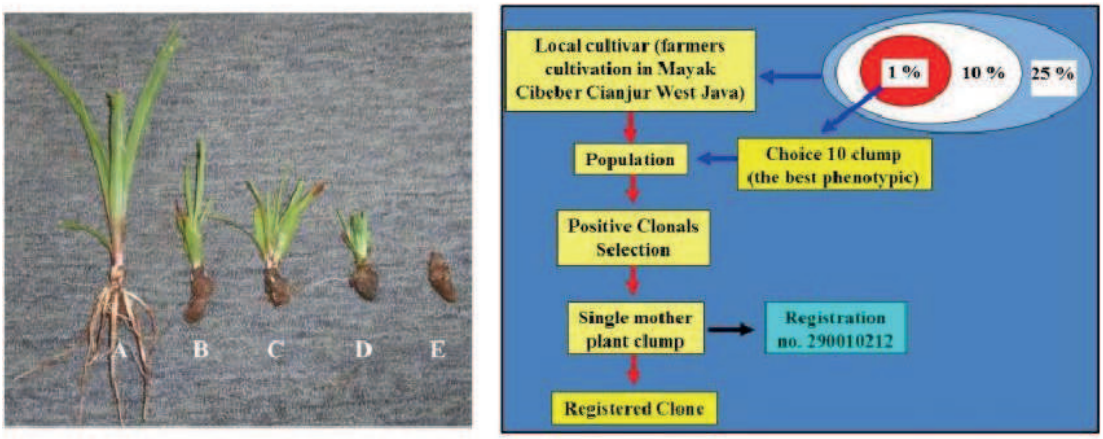

Figure 2: Performance of tuberose plant after irradited with gamma rays (A = 0 Gy, B = 25 Gy, C = 50 Gy, D = 75 Gy, E = 100 Gy (left) [11]; Selection method of Dian Arum variety from Cianjur local cultivar (right) [6].

chimera. Therefore, it is necessary to do research on the M1V2 generation to find out the extent of the influence of mutations to change the genetic of tuberose.

Meanwhile, increasing diversity of tuberose with mutation induction through poliploidy with colchicine was reported by Zuhrah *et al*. [13]. Their treatment consisted of 4 levels of colchicine concentration (0, 100, 200 and 300 ppm) and 3 levels of immersion time (3, 6 and 9 hours). The result showed that there was an interaction between concentration and time of immersion on the length of flower stalk, size of flower and time of harvesting. Application of 1000 ppm for 3 hour immersion made longer stalk of flower but become shorter when continues immersion up to 9 hours. Size of flower increased with the increased of concentration and imersion time, but colchicine did not affected number flower. The higher the concentration of colchicine, the length the flowers, diameter of flowers, harvesting time the flowers, but the lower the shelf live and time of the first leaves appear. And the longer the imersion time, it can increase the diameter of the flower stalk, shelf lifed and number of leaves, but decreased length of flowers, flower diameter, flower harvesting age, length and flower arrangements.

The same research with the different concentration levels of colchicine was reported by Rahayu *et al*. [14]. The result showed that interaction between the concentration levels of colchicine and imersion time did not affect significantly on the average plant height, but colchicine at 100 ppm to 500 ppm concentration level resulted in higher average plant height than without colchicine treatment. The treatment also affects the number of leaves and leaf area significantly. At 300 ppm of colchicine with 6 hours immersion time; and 100 ppm of colchicine with 9 hours immersion time resulted in the higher average leaf number and leaf area. Observation on the number of tillers per clump showed that at 100 ppm with 9 hours immersion time; and at 300 ppm with 6 and 9 hours immersion time resulted in the higher average number of tillers. Aplication of colchicine up to 500 ppm caused the real change in the plant growth and

yield components include plant heigh, number of leaves and leaf area compared to control.

One of the alternatives breeding to obtain new superior varieties is the selection of local cultivars or varieties that have been introduced for a long time or have been regarded as local varieties. Based on the positive selection on local cultivars, until now there are two superior genotypes that released as a national varieties namely Roro Anteng (origin of Pasuruan, East Java) and Dian Arum (origin of Cianjur, West Java). Roro Anteng variety was the result of positive mass selection of the local population semi double flower cultivars that were cultivated in Lumpang Bolong, Dermo, Bangil, Pasuruan, East Java. This variety was released by East Java Assesment Institute for Agriculture Technology in cooperation with the Government of Pasuruan Regency – East Java, with the Letter of the Agriculture Minister of the Republic Indonesia No. 535/Kpts/PD.210/10/2003 [15]. Meanwhile, Dian Arum variety was resulted from the positive clonal selection of double flower local cultivars tuberose that cultivated in Mayak Cianjur West Java. The selection pathway can see in the (Figure 2). This variety was released by Indonesian Ornamental Crops Research Institute together with the Government of Cianjur Regency, West Java, with the Letter of the Agriculture Minister of No. 613/Kpts/SR.120/5/2008 [16, 17].

2.1. Performance of tuberose superior varieties

2.1.1. Dian Arum

Dian Arum varieties have flower stalk length more than 75 cm and have met the criteria desired by the market tuberose flower. Likewise, the diameter of the flower stalk is not so great but stocky, so it is suitable for use in flower arrangements in vases large and small. Diameter flower buds are not so great, but after bloom diameter greater than 5 cm. In addition, flowers color greenish and the end of the flower that still close slightly reddish.

Dian Arum has a number of petals quite a lot and quite thick. Petal number that will make the flowers become more compact appearance. Petal thicker typically will have a period of flower freshness longer. The number of petals is one of the main characters that distinguish varieties with varieties Roro Dian Arum Anteng origin Pasuruan, East Java. Number of flowers is quite high so that the flower panicles stalks tightly closed. With shorter panicle length and number of florets increase there will be more meetings between florets. It further enhances the overall appearance of flowers. The yield up to 3 stalks per clump per year.The vase life more than five days. Overall, flower appearance was pretty good with a regular and compact arrangement of petals, so that the flower panicles stalks covered. The flower stalks are straight and muscular,

Dian Arum Roro Anteng

Figure 3: The different flower performance of Dian Arum and Roro Anteng varieties [17].

Table 6: The observation on qualitative characters of Dian Arum and Roro Anteng variety [17].

Character	Varieties	
	Dian Arum	**Roro Anteng**
Upper leaf color	Green 143 C	Green 139 C
Down leaf color	Green 139 C	Green 138 B
Sepal color	Yellow green 149 D	White 157 D
Petal color	White 155 C	White
Flower fragrance	Very smell	Smell
Flower type	Double	Semi double
Comperehensive appearence	Regular and compact flowers arragement;	Regular flower arrangement; straight and
	straight and sturdy flower stalks	less stocky flower stalks

making it easily plugged in when the flowers were arranged in a large and small vase or bouquet (Figure 3 and Table 6) [16, 17].

2.1.2. Roro Anteng

This variety has a special characteristic such as the tip of reddish flowers, fragrant aroma, pure white color, stocky stem, not easily be broken and resistant to wilt. The flowers look more attractive than the varieties from other regions, namely: the flower stalk is longer, more flower panicle length, more number of buds/stems and more dense structure. In addition, flower was more muscular, more width and double-layered, floral crowns more muscular, wider and plated two, diameters blooming bud wider, stem diameter larger, meet the export standard size, more powerful scent of flowers, blooming flower panicles longer and more robust flower stalk. Plants start flowering at 9 months old after planting and flowering highway at 18 months after planting with a production of 48,000 stalks/month with 2 harvests/week. No smell of the flowers in the morning and during the day, but it will appear from late afternoon (16.00 pm) until late morning (04:30 am). The flower can be used as cut flowers, flower sow and essential oil [15, 18].

3. Conclusions

1. The tuberose breeding research in Indonesia is limited.
2. Breeding activity was done by crossbreeding and induced mutation with gamma ray irradiation and poliploidy with colchicine, but a variety has not been released yet.
3. Clonal or mass positive selection to local cultivars resulted in two superior genotypes that were released as new national varieties namely Roro Anteng (semi double flower) and Dian Arum (double flower).

4. Future outlooks

Research activities in tuberose plant breeding through various techniques are expected to be done comprehensively and continuously involving various government research institutes, universities and the private sector, so that promising genotypes can be attained and ready to be released as new varieties. To increase the genetic diversity of tuberose, the types or varieties with different flowers colors need to be introduced from abroad such as Taiwan, so possibility to obtain a new variation of the tuberose flower easier.

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