Phenotypic Variability of The S2 Families Derived from Crosses Between Local and Introduced Okra Cultivars

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ABSTRACT

Okra (*Abelmoschus esculenthus* L.) is a functional food crop consumed when the pod is immature and tender. Crosses the local okra, i.e. green and red okra, with introduced varieties B291 and Ve022 aimed to improve the local cultivar traits. This study aimed to assess the agronomic variability of S2 from a cross between green okra and red okra with introduced varieties and select superior families that can be used to produce new cultivars. The study used an experimental method with individual observation. There were 12 S2 families evaluated in this study. There were 12 S2 families evaluated in this study, derived from selfed-pollinated plants of the S1 families. Results showed that all S2 okra plants had tender fruit at 8 DAA, 56.3% and 7.8% of the entire population had tender fruit at 9 and 10 DAA, respectively. The increase in the fruit picking time was in line with the increase in size and weight of okra fruit. Variations in quantitative traits were observed, including flowering time, plant height, and the number of flowers and fruits in the S2 families. The performance of qualitative traits of the S2 families was uniform. There was a decrease in the quantitative trait of S2 families compared to the S1, which the inbreeding depression might cause. FOHVE022-17.4.8, FOHB291-15.7.20, SOMB291-24.18.1 and SOMVE022-10.1.8 families can be continued for further evaluation because they have a good quantitative trait performance.

Keywords: *Traits, Fruit Picking, Fruit Texture, Inbreeding Depression*

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L). Moench) is an annual vegetable crop from Africa and is currently grown in tropical and subtropical areas. It is consumed when the pod is immature and tender. As a functional food crop, okra fruit has many benefits for human health because it contains many nutritional substances and medicinal value [1]. Fresh okra pods contain 175.2 mg of minerals, 2.1 g of protein, 0.2 g of lipid, 1.7 g of fibre, 8 g of carbohydrates, 36 calories and 88 ml of water per 100 g of okra [2]. Pods also contain numerous minerals and various vitamins such as folic acid, vitamin C and E, carotenoids, xanthin, lutein, polyphenols and flavonoids [3][4][5]. The levels of flavonoids in red okra are higher than those in green okra due to anthocyanin content with red characteristics [6].

This vegetable, known as okro in Java, is relatively new in Indonesia; therefore, it is usually found in supermarkets. Local okra cultivars are unimproved open-pollinated cultivars, namely okra Hijau and okra Merah. Both cultivars produce small fruit and low fruit weight due to a short picking period of harvest, *i.e.* 6-7 days after anthesis (DAA). The improvement of harvest time traits was conducted with the cross between local with an introduced cultivar with a more extended fruit picking period, *i.e.* Ve-022 and B291 that have tender fruit up to nine DAA [7]. The F1 population revealed an increase in the picking period of up to eight DAA [1]. The F2 population showed improved picking time traits, revealing that 67.0% and 14.4% of the population have tender fruit textures up to eight and nine DAA, respectively [8].

Okra fruit has different sizes and weights depending on the type or cultivar [4]. The increase in the okra picking period is in line with the increase in fruit size, including fruit length, diameter and weight [7]. This study aimed to assess the variability of the agronomic

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traits and determine the prolonged picking period of S2 families.

2. MATERIALS AND METHOD

This research has been carried out in the Field Research Station, Faculty of Agriculture, Andalas University, Padang, in West Sumatra province, Indonesia, located at 175 m above sea level. Rainfall during research ranges from 20 - 272 mm/month, while daily temperatures range from 29.4 – 30.8^{o}C.

The study used an experimental method with individual observation. The genotypes evaluated in this research consisted of twelve S2 families and two control varieties, i.e. okra Merah and okra Hijau cultivars. Okra seeds were obtained from self-pollinated selected plants of the F2 generation with the covering of the un-bloom flower of each F2 plant using parchment paper. The number of plants evaluated within families varied depending on their survival throughout the evaluation. The plants were planted in plots of 10 m in length, 1.2 m in width and 0.3 m in height. The plots consisted of two rows with 60 cm x 40 cm spacing for inter-and intra-row. Fertiliser dose and application are similar to those reported by [7]. All agronomic practised followed as per standard recommendation.

Data collection was conducted based on individual observation. The description of each plant was carried out by observing the plant's morphological traits based on the International Board Plant for Plant Genetic Resources for okra description guide [9] and the International Union for the Protection of New Varieties of Plants [10]. Analysis for quantitative observations was carried out using descriptive statistics by calculating the mean, variance and standard deviation, and unpaired t-test at the 5% level to compare the S2 population and the control. Phenotypic variability is narrow if the phenotypic variance is less than two times its standard deviation [11]. The observed variables were first flowering time, the number of flowers, the number of fruits, plant height, the optimum picking time, weight, diameter and length of pods. The picking time is the maximum of the day when the pod texture is still tender and not fibrous. The manually fragmented pods into two parts were conducted to determine the pod firmness. If the pod can be fragmented easily, the fruit texture is tender.

3. RESULTS AND DISCUSSION

Each family has different growth characteristics due to differences in genetic composition that provide different growth responses. Plants within families tended to have similar performance in the first flowering trait, number of flowers and number of fruits (Table 1), while varied in plant height. Similar performance indicates that the genotypic composition of families tends to homozygote for such traits due to the inbreeding process and selection program. Five families showed earlier flowering than control okra Hijau or okra Merah cultivars, indicating improved flowering traits. Almost all families showed less number of flowers and fruits compared to the control okra Hijau. In comparison, the

Table 1. First flowering day, the number of flowers, the number of fruits, and the plant height of the S2 family

Family	First flowering day	Number of flowers	Number of fruits	Plant height (cm)
FOHVE022-8.2	53,00 ± 3,41*	9,36 ± 4,00*	7,27 ± 3,93*	86,50 ± 20,84^{ns}
FOHVE022-17.3	54,11 ± 4,43^{ns}	9,44 ± 2,31*	6,00 ± 1,76*	40,61 ± 10,61*
FOHVE022-17.4	56,50 ± 4,66^{ns}	12,12 ± 5,92^{ns}	10,00 ± 6,34^{ns}	52,43 ± 20,90*
FOHB291-15.7	49,00 ± 4,74*	10,95 ± 4,44*	9,20 ± 4,21*	63,06 ± 15,78*
FOHB291-41.1$^{\#}$	55,00 ± 0	11,00 ± 0	10,00 ± 0	58,50 ± 0
FOHB291-41.3	53,33 ± 3,09^{ns}	9,66 ± 2,49*	6,66 ± 3,09*	38,00 ± 13,49*
Okra Hijau	58,80 ± 5,60	18,20 ± 4,12	16,40 ± 3,61	83,62 ± 13,12
SOMB291-23.6	53,40 ± 2,15*	14,80 ± 5,03^{ns}	12,40 ± 5,20^{ns}	98,80 ± 18,99^{ns}
SOMB291-16.1	45,50 ± 1,50*	22,00 ± 4,00*	19,00 ± 4,00*	100,50 ± 2,50^{tn}
SOMB291-16.3	49,00 ± 5,65*	12,28 ± 4,33^{ns}	8,14 ± 3,60^{ns}	90,85 ± 12,58*
SOMVE022-10.1	54,75 ± 7,19^{ns}	8,68 ± 1,72*	5,93 ± 2,10^{ns}	68,71 ± 13,59*
SOMVE022-20.1	57,66 ± 6,46^{ns}	7,33 ± 3,39*	5,55 ± 3,33^{ns}	44,22 ± 13,44*
SOMB291-24.18	55,12 ± 4,53^{ns}	16,50 ± 4,94^{ns}	14,50 ± 4,30*	116,94 ± 14,88^{ns}
Okra Merah	58,80 ± 3,76	12,60±2,58	7,00 ± 2,10	109,72 ± 12,78

Means ± 1 x SD, ns and *= not significant and significant based on the t-test at 5% level, # one single plant

two families showed fewer flowers and fruits than the control okra Merah, indicating that inbreeding affects the traits more for okra Hijau than okra Merah. All families tend to decrease in height compared to the control due to inbreeding effects.

Compared to the flowering trait in the S1 generation, some S2 families tend to be slower, with a decrease of 0.4-13.5%, while some showed faster than the S1 families, ranging from 4.8%-17.9%. Most of the S2 okra plant height decreased compared to the S1 generation by 6.7%-60.7%. The decrease in plant height in the S2 compared to the S1 was in line with a decrease in the number of flowers and fruits in the related family and vice versa. Plant height affects the number of fruit harvested [12][7] because flowers that will develop into fruit appear in the leaf axillar, which is found on each stem segment of the okra plant [13]. The number of flowers and fruits in several families was less than that in the S1 generation, with a decrease of 8.3%-83.2% and 1.7%-87.6% for the number of flowers and fruit, respectively. The increase in the number of S2 okra flowers compared to the S1 generation was 19.4%-45.2%, while the number of fruits increased by 17.4%-53.8%.

Most S2 okra families have wide variability in the first flowering day, the number of flowers, the number of fruits and plant height (Table 2). Wide variability in these characters has also been reported previously in the S1 family [8]. Differences between okra families that show variations in each observed genotype indicate an opportunity to choose a genotype that performs better for each trait [12]. Wide variability criteria are one of the conditions for the selected program to run effectively, and selection will be more effective if the trait inherits easily [14]. Selection is an inseparable component of developing plant varieties [15].

The observation of the qualitative traits, including stem color, leaf color, leaf shape, fruit color and fruit shape, showed uniform results in all families (Table 3), except FOHVE022-8-2. This family showed 91.9% red stem, green leaves and red vein, type 7 leaf shape, red fruit and type 8 fruit shape, and 8.9% showed green with red spot stem, green leaf, type 4 leaf shape, and green fruit and type 3 fruit shape. The variation found in this family may be due to allele segregation. The consistent performance of the qualitative trait of the most of S2 families indicates that the gene composition for the traits is homozygous. Figure 1 shows the variation of the leaves, stems and fruit of the S2 families.

The fruit texture was observed twice for each picking period at different times. The increased picking period from 8 to 10 increases fruit weight, diameter and length (Figure 2). All S2 okra families (103 plants) had a tender texture at 8 DAA, 56.3% (44 plants) still had a tender texture at 9 DAA, and only 7.8% (8 plants) had a tender texture at 10 DAA. The increase in the fruit picking period indicates an improvement in the quality of okra fruit compared to the previous generation, as [8] reported. Ref [16] stated that the longer the okra fruit is harvested, the cells in the okra fruit will continue to undergo cell division and enlargement, causing differences in fruit size between harvest periods of 8 DAA, 9 DAA and 10 DAA.

Table 2. Variance value and phenotypic variability criteria for first flowering time, the number of flowers, the number of fruits and plant height of the S2 family.

Family	First flowering day	Number of flower	Number of fruit	Plant height
FOHVE022-8.2	11.64 W	16.05 W	15.47 W	434.64 W
FOHVE022-17.3	19.65 W	5.36 W	3.11 N	112.71 W
FOHVE022-17.4	21.75 W	35.11 W	40.25 W	437.15 W
FOHB291-15.7	22.50 W	19.79 W	17.75 W	249.03 W
FOHB291-41.3	9.56 W	6.22 W	9.56 W	182.17 W
SOMB291-23.6	4.64 W	25.36 W	27.04 W	360.66 W
SOMB291-16.1	2.25 N	16.00 W	16.00 W	6.25 W
SOMB291-16.3	32.00 W	18.78 W	12.98 W	158.41 W
SOMVE022-10.1	51.81 W	2.96 N	4.43 W	184.75 W
SOMVE022-20.1	41.78 W	11.56 W	11.14 W	180.67 W
SOMB291-24.18	20.61 W	24.50 W	18.50 W	221.53 W

W and N are wide and narrow criteria variability, respectively. Phenotypic variability is wide if the variance is higher than two times its standard deviation

Table 3. Qualitative trait performance of each S2 family

Family	Stem Color	Leaf and Venation Color	Leaf Shape	Fruit Color
FOHVE022-8.2	-Red/purple -Green with red spots	- Green with red veins - Green	-Type 7 -Type 4	- Red/purple - Green
FOHVE022-17.3	Green	Green	Type 4	Green
FOHVE022-17.4	Green	Green	Type 4	Green
FOHB291-15.7	Green with red spots	Green	Type 4	Green
FOHB291-41.1	Green	Green	Type 4	Green
FOHB291-41.3	Green with red spots	Green	Type 4	Green with red spots
SOMB291-23.6	Red/Purple	Green with red veins	Type 7	Green with red spots
SOMB291-16.1	Red/Purple	Green with red veins	Type 7	Green with red spots
SOMB291-16.3	Red/Purple	Green with red veins	Type 4	Greenish red
SOMVE022-10.1	Red/Purple	Green with red veins	Type 4	Red/Purple
SOMVE022-20.1	Green	Green with red veins	Type 4	Green

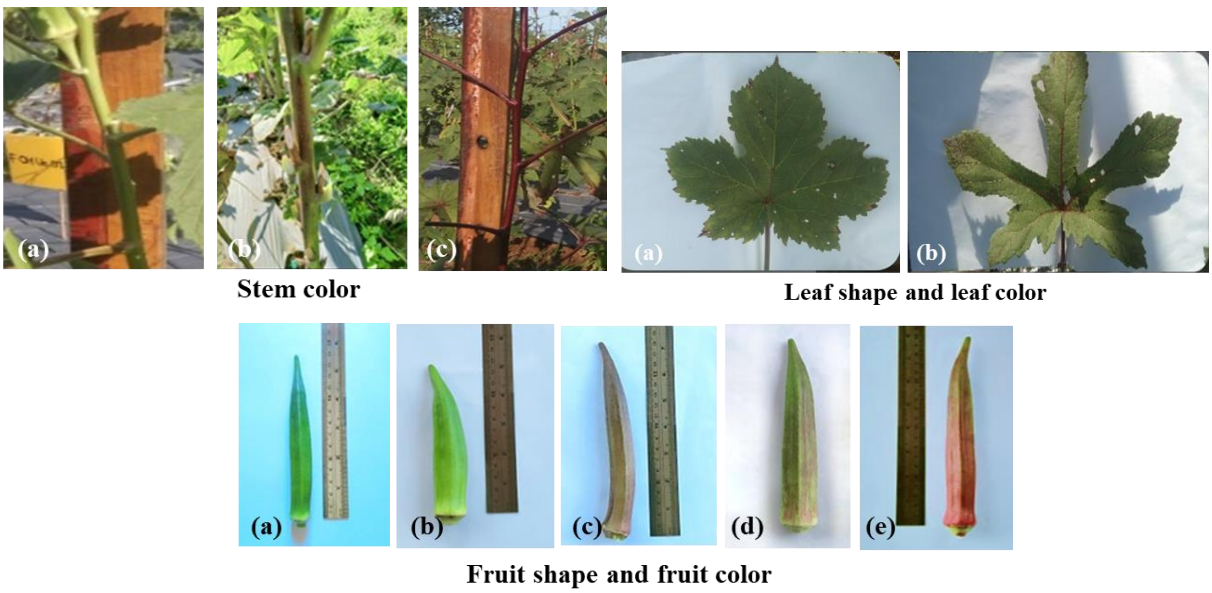

Figure 1. Performance of stem, leaf and fruit. Stem color (a) green, (b) green with red spots, (c) red/purple), Leaf shape (a) type 4, green, (b) type 7, green with red veins. Fruit shape and fruit color (a) type 3, green, (b) type 8, green, (c) type 3, green with red spots, (d) type 8, green with red spots, (e) type 8, red

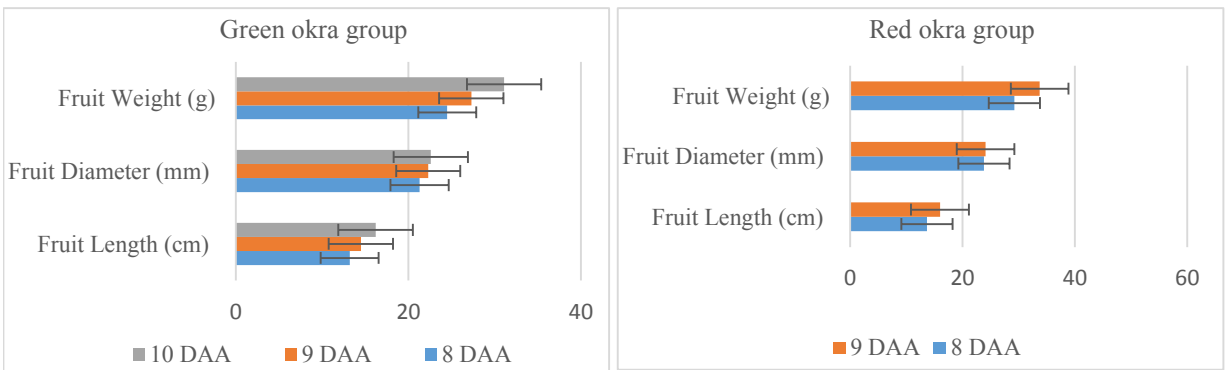

Figure 2. Length, diameter, and weight of fruit of the S2 families at different picking time. The bar shows the standard deviation

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4. CONCLUSION

The evaluation observed variations in quantitative traits, including flowering time, plant height, and the number of flowers and fruits in the S2 families. The performance of qualitative characters of the S2 genotypes was uniform, except for the FOHVE022-8.2 family. All S2 okra plants had tender fruit at 8 DAA, while 56.3% and 7.8% of the entire population had tender fruit at 9 and 10 DAA, respectively. The increase in the fruit picking time was in line with the increase in size and weight of okra fruit. Plants from FOHVE022-17.4.8, FOHB291-15.7.20, SOMB291-24.18.1 and SOMVE022-10.1.8 families can be continued for further evaluation because they have a good quantitative trait performance.

AUTHORS' CONTRIBUTIONS

The first and the third authors conceived and planned the experiments. The first and the second authors conducted the experiments and analysed the data. The first and the second authors wrote the manuscript with support from the third and fourth authors.

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