Growth production and color segregation on the plants and seeds of F2-F3 generations selected from population derived from crossing yellow and purple corn

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Abstract. Purple-corn becomes more popular as a functional food. This research was to develop superior purple-corn varieties. Series of research were carried out in 2021-2023 at Research Station and with cooperation with farmer near Campus Universitas Sriwijaya. In crossing, purple-corn was used as male parent to produce F1-seeds and resulted in F2-seed consisted of 4 purple-coloration of dark-purple, purple, yellowish-purple, and purpleish-yellow. Later on, research only utilized those F2-seeds having dark-purple. Dual-planting system was used to produce fresh-boiled corncob and dry-corn kernel. The F2-plants showed normal growth with plant heights of 244.63-258.87 cm; ear position at 104.97-113.23 cm; and anthesis at 54-56 days. Fresh-weight of fresh corncob harvested at 84 days reached 155.19-160.79 g, and dry-corn-kernel weight, harvested at 109 days reached 128.60-147.78 g/plant. The accessions, in general showed good potential to be candidate for open-pollinated varieties of purple-corn, which included purple-kernel corn, purple-baby corn and purple-boiled corncob varieties. Most F2-plants produced dark-purple and purple kernel and cob that corresponded to purple coloration of the plant, especially purple-line coloration on the leaf. Plants segregation that produced yellow and white-kernel of F3-seeds were about 2.63-23.07%. Further selection program, to minimize purple-kernel segregation was still needed especially for UJ1U accession.

1 Introduction

Corn or maize (*Zea mays* L.) is an important crop plant in Indonesia and in the world. The use was widely increase not only as corn kernel in food and feed industry but also as a fresh product for daily household consumption such as a baby-corn, pop-corn, sweet and boiled corn [1]. Corn, indeed, could be harvested at different stages that was depending on the

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purpose and utilization. As a functional foods, however, depend on varieties [2], maturity stages and processing methods [3].

Recent intent investigation in medical field reported by many scientist (bioactive; ferron; khampasan; kim review; kim PCE; simla; saika [4–10] that revealed several beneficial of consuming corn especially, purple corn has been promoted corn product to be more popular. Research [11,12] reported that purple corn contained rich antioxidant derived from anthocianine that provide health benefits to reducing risk of chronic diseases. [12] reported anthocianine of purple corn showed important role on prevention of cardiovascular disease, obesity, and diabetes alleviation. Furthermore [13] stated that anthocianine on purple corn can be used to replacing synthetic colorants in food and beverages industries. Thus, purple corn was considered as an alternative plant with high potential for further research and development of functional food product, and beverages industries.

Farmers in Indonesia grow corn for various purposes and utilization to produce dry-corn-kernel for food and feed industries, boiled-corncob, and baby corn. Most of them are yellow corn and the seeds available in the market are hybrid varieties developed by seed company [14,15]. Several Indonesian researcher have put their attention to do research on purple corn. [16] reported their work on selection of F-3 generation to develop open-pollinated variety of purple corn. [17] reported their research on selection of F2 generation to develop corn with higher anthocianine content. [18,19] reported their research on effect of salinity, and fermented corn-waste to growth and yield of several purple corn cultivars. [7] reported colour changed on the kernel colour of the plants derived from the cross of purple corn and yellow sweet corn. The objective this research was to identify growth production and purple-colour segregation on several initial populations to be developed as superior purple corn varieties in Indonesia.

2 Materials and Methods

Series of research were done in 2020-2023 in university-research station and in the cooperation with local farmer to use land around campus Universitas Sriwijaya, Indralaya, Ogan Ilir South Sumatera. Parental material of a local purple corn as male parent and 3 accessions of yellow corn or Unsri J1, J2, and J3) as female parent was naturally crossed in 2021 and resulted seeds (F1) was planted in 2022 (Figure 1a,b,c,d) to produce F2-seeds (Figure 1e), in which, only seeds having dark-colour were selected form each accession, were used for this research (Table 1).

Tabel 1. The F2 -seeds of purple corn accessions derived from crossing yellow and purple corn to be used in the research.

No	Accessions	Number of cob	Number of bulked seeds available for research
1	UJ1U	10	3506
2	UJ2U	10	3763
3	UJ3U	10	4162

Research utilized a Randomized Blok Design (RBD) consisted of 3 blocks, in which, each accession of J1U; J2U, and J3U was planted in a plot by using 80 x25cm planting distance. The research applied dual planting system to produce fresh boiled–corncob and dry-corn-kernel, and therefore 2-4 seed were initially planted in each planting hole, and then left

2-best plants for the research. Standard practices of weeding, fertilizing, and controlling pest and diseases were done to promote growth and development of the plants. At designated time, several agronomic variables were observed and measured by using 10 random sample of plants per plot. Statistical data analysis was performed by using Analysis of Variance (Anova) and Least Significant Different (LSD) methods at α= 0.05. Calculations were done by using application of Statistical Analysis System (SAS).

3 Results and Discussions

3.1 Plant Growth

Anova analysis (Table 2.) indicated that plant growth variables of plant height were significant, while, ear position at 104.97-113.23 cm (Figure 2) were not statistically different. At 60 days, the plant height reached 244-260 cm in which, accession of UJ2U and UJ3U with plant height of 260 cm and 258 cm, respectively, were significantly higher than plant height of UJ1U with plant height of 244 cm. [15] reported that the parental plants of UJ2 and UJ3 had higher plant height than UJ1, and therefore, higher plant height of UJ2xU and UJ3xU could be derived from genetically-factor differentiation.

3.2 Plant Production

Two-types product were observed in this research, dry-corn kernel and boiled-fresh corncob (Table 3 and Figure 2k) as an additional products. Anova analysis (Table 2.) indicated that dry-weight of corn kernel was not significant. Dry-weight of corn kernel resulted by UJ1U, UJ2U and UJ3U accessions were 138.40, 128.60, and 147.78 g per cob, respectively (Figure 2.h.). Observation on other production variables, such as length and diameter of cob, weight of 100 seeds (Table 3 and Figure 3.), were comparable to their productivity reported by [15]. Corn accession of UJ1U, UJ2U and UJ3U, apparently had about similar productivity.

Table 2. Result of analysis variance on growth and production variables of F2-plants.

No.	Variables	F-value	CV (%)
1	Plant height (18 days)	4.58*	12.29
2	Plant height (32 days)	5.61*	9.72
3	Plant height (46 days)	1.45^{ns}	9.57
4	Plant height (60 days)	4.59*	8.82
5	Ear position	1.29^{ns}	18.43
6	Dry kernel weigh per cob	1.30ns	10.23

CV: Coefficient of variation, ns = Non-significant; *= Significant at at α= 0.05.

Furthermore, observation on fresh-weight, length and diameter of boiled corn were 155.19-160.79 g; 15.89-16.96 cm; and 4.46-4.72 cm, respectively. Preference test conducted by student respondents for flavor, aroma, indicated that > 80% of the respondents liked to

consume these corn accession as fresh-boiled corn. Confirm with research by [7], respondent of this research said that purple-corn of UJ1U, UJ2U, and UJ3U, had more sticky and softer texture as compared to yellow corn.

Table 3. Average value and standard deviation of production variables of F2-plants.

No.	Variables	Aceessions		
		UJ1U	UJ2U	UJ3U
1.	Fresh cob weight (g)	155.19(17.94)	145.39(1.99)	160.79(24.68)
2.	Length of boiled corn-cob (cm)	15.89(1.42)	16.45(1.69)	16.96(1.24)
3.	Diameter of boiled corn-cob (cm)	4.69(0.34)	4.46(0.39)	4.72(0.46)
4.	Length of kernel corn-cob (cm)	18.40(1.36)	18.03(1.39)	18.60(1.20)
5.	Diameter of kernel corn-cob (cm)	5.19(0.24)	4.99(0.45)	5.09(0.30)
6.	Number of kernel per cob	470.7(54.12)	460.10(57.22)	495.90(96.72)
7.	Dry kernel weight per cob (g)	138.40(27.17)	128.60)14.91)	147.78(18.55)
8.	Weight of 100 dry kernel (g)	24.00(3.25)	24.20(3.76)	24.30(3.00)

Note: Number inside the bracket are standard deviation value of each variables.

3.3 Purple Colour Segregation

This research observed colour segregations were observed on several plant parts, since researchers have reported that purple colour of the corn containing anthocyanins might be found in several parts of the corn plant. [6,13] reported and beside in the kernel, purple colour containing anthocyanins also found in husk, cob, corn-silk that potential to be used in the industry, and eventually the young cob was popular to be consumed as baby corn.

Visual observation on the purple-coloration (Figure 4.) indicated the whole body of the F2-plant was green and purple colorations were seen inform of line, blotch, and little dots on the stalk, leaf and husk. Furthermore, investigation (Table 4), showed that F2-plants having purple coloration on the stalk, leaf, and husk, in general, also produced purple-kernel and purple-cob. Plant breeder, therefore, may utilized purple coloration on the plants, especially purple-line coloration on the leaf, as a tool in selection program to develop purple-corn variety. Most of the F2-plants resulted in dark purple and purple kernels. Segregation data (Table 4.) of the plants that produce non-purple color (yellow and white) kernel, however, showed that accession of UJ3U had lowest segregation value of 2.63 % followed by UJ2U and UJ1U accessions with segregation value of 15.54% and 23.07%, respectively. Further selection program, especially for UJ2U and UJ1U accessions was still needed to have accessions with minimum segregation. As showed on Table 4, accessions of UJ1U, UJ2U and UJ3U with purple-kernel also had purple-cob, and therefore, these three accessions were potential, to be parental population to develop, not only, new purple-kernel corn variety, new purple-boiled corncob varieties, but also new purple baby corn variety.

Table 4. Number of F2-plants indicated purple-colour segregation observed on their stalk, leaf, husk, cob and kernel.

No.	Variables	Accessions		
		UJ1U	UJ2U	UJU
1	Total plant observed	40	40	40
2	Plants with good growth (n)	39	39	38
3	Plants with bad growth	1	1	2
4	Off-type plants produce yellow-white kernel (a)	9 (23.07%)	6 (15.54%)	1 (2.63%)
5	Plants with purple stalk*	31	33	37
6	Plants with purple leaf*	30	34	37
7	Plants with purple husk*	30	34	37
8	Plants with purple cob*	30	34	37
9	Plants with purple kernel*	30	34	37

* Plants having purple-coloration inform of line, blotch, little dot on the husk, stalk, and leaf. Value inside the bracket indicates percent segregation value calculated as (a/n)x100%.

4 Conclussion

This research concluded that accession of UJ1U, UJ2U and UJ3U, in general showed good potential to be used as initial population to developed as open-pollinated varieties of purple-corn varieties including purple-kernel corn variety, purple-baby corn and purple-boiled corncob varieties. Most F-3 plants produced dark-purple and purple kernel and cob which were corresponded to purple coloration of the plant, especially purple-line coloration on their leaf. Further selection program, to minimize purple-kernel desegregation is still needed especially for UJ1U accession.

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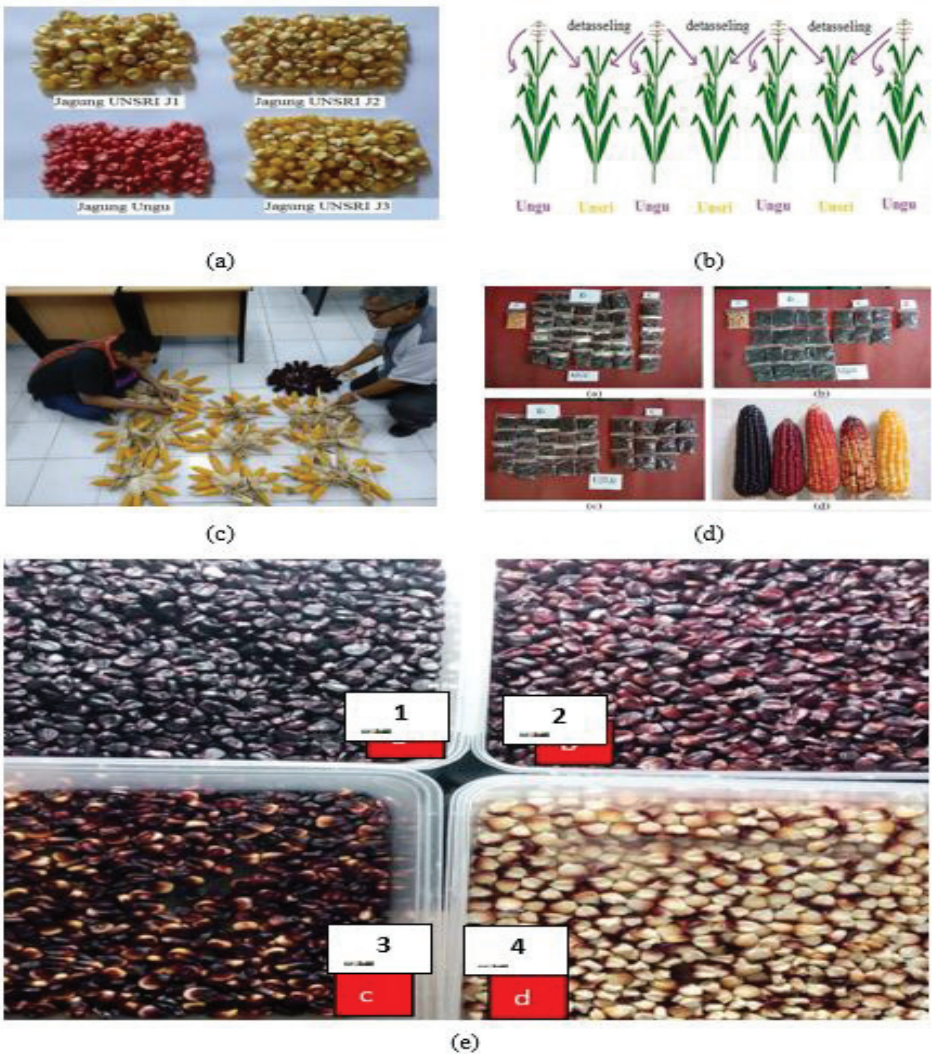

Fig 1. Parental seeds of purple and yellow corn (a), natural crossing scheme (b), F1-seeds resulted from the cross (c), Seeds of F2-generation (d), and 4-type of purple-seed coloration of F2-seed (e).

Fig 2. Field condition and some research activities (a,b,c,d,e,f,g,h,i), boiled-fresh corncob (k), corncob (l), and purple-cob resulted from the research.

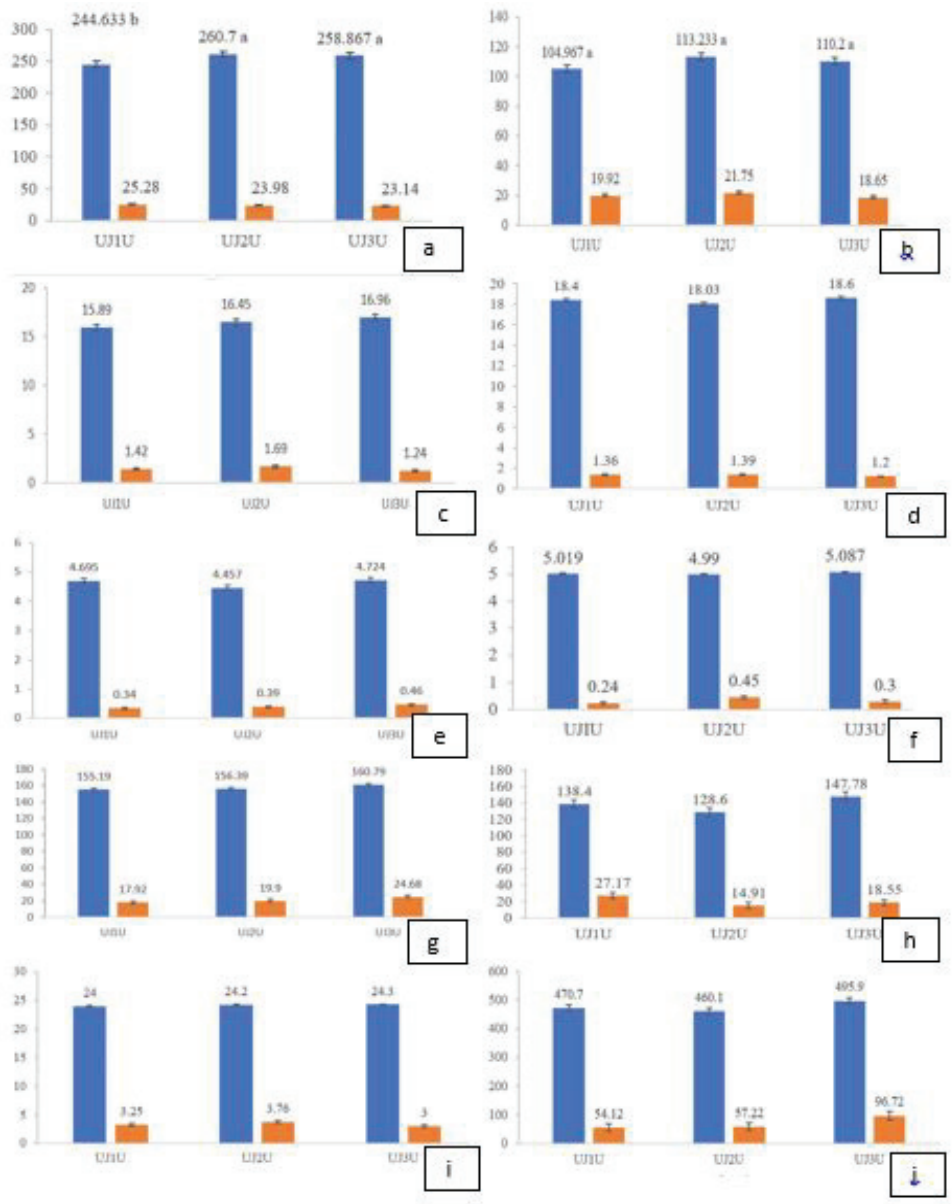

Fig 3. Growth and production of F2-plants (a) Plant height at 4 and (b) ear position in cm; (c) Length of fresh cob to produce boiled-corn and (d) Length of cob to produce dry kernel-cob; (e) Diameter of fresh cob to produce boiled-corn (f) Diameter of cob to produce dry kernel in cm (g) Fresh-weight of cob to produce boiled-corn and (h) Dry weight of kernel per cob; (i) Weight of 100 dry seed in g and (j) Dumber of seed per cob.

Fig 4. Purple coloration on the stalk, leaf, and husk of F2-plants that produced purple kernels of UJ1U, UJ2U, and UJ3U accessions.