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Diversity of Watermelon Crop Morphology from Crossing Several Watermelon Cultivars

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Abstract:
Background*: Watermelon crops are widely cultivated by the community, especially in the lowlands, thus providing many benefits to watermelon farmers and entrepreneurs, and can improve Indonesia's economic system.This research was conducted in the rice fields of PalohJeureula Village, Sakti District, Pidie Regency, from March to September 2019. This research was conducted using a Randomized Block Design (RBD). Overall, there were 19 treatments, namely V_1, V_2, V_3, V_4, V_1V_1, V_1V_2, V_1V_3, V_1V_4, V_2V_1, V_2V_2, V_2V_3, V_2V_4, V_3V_1, V_3V_2, V_3V_4, V_4V_1, V_4V_2, and V_4V_3. Crosses between watermelon cultivars V_1, V_2, V_3 and V_4 obtained a very high level of diversity. Plant length at 15 DAP was best at V_3 (138 cm), V_4 (133cm), V_4V_2 (134.33cm), and V_4V_3 (134.33 cm) and at 30 DAP the best plant length was at V_4V_2 (372 cm) and V_4V_3 (372 cm). Plant lengths at 45 DAP were V_3 (504.33 cm) and V_4 (505.67 cm). Concurrently, when watermelon crops were 60 DAP, the best plant length was at V_3 (637.33 cm) and V_4 (645.67 cm). Parameters of the 5th longest petiole are V_3V_4 (11.50 cm), on the 8thleaf the longest stalk is found in V_4 (11.17 cm), the 12th longest leaf stalk of watermelon plants is found in V_3V_4 (13.60 cm). Meanwhile, in the generative phase, it also had a very significant effect on the some parameters. The longest harvesting time of watermelon was found in V_4 (31.33) and V_3V_4 (31.33). Meantime, the fastest harvesting time was found in V_1 (28.33). The heaviest fruit weight was found in V_3 (4.97 kg) which was not significantly different from V_4 (4.70 kg). The highest number of female flowers was found in V_1V_3 (13.67 flowers).*

Key Word*:Crosses, Cultivars, Fruit weights, Vegetative, Generative, and Diversity*

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I. Introduction

Watermelon (*Citrullus lanatus*) is an annual plant from the pumpkin family (*Cucurbitaceae*). Watermelon crops are widely cultivated by the community, especially in the lowlands, thus providing many benefits to watermelon farmers and entrepreneurs, and can improve Indonesia's economic system[1]. Watermelon is favored by the people of Indonesia because of its sweet taste, the flesh of the fruit which has high water content and the color of the flesh is yellow or red. There are many types of watermelon plants, namely seedless watermelon and seeded watermelon.

In Southeast Asia, Indonesia is the second largest watermelon producer, after Vietnam, with a total production in 2017 of 499,475 tons (planted area of 32,558 ha), in 2018 of 481,727 tons (planted area of 31,699 ha), and 2019 of 523,355 tons (planted area of 34,505). ha)[2]. This amount of production can fulfill national needs, even though Indonesia exported 165.01 tons of watermelon in 2018[3]. In 2019, the Ministry of Agriculture stated that watermelon had an average production yield of 13.86 tons/ha, while in 2014 it was 18.27 tons/ha. This increase in market demand is an obstacle for farmers due to the absence of stable and superior local seeds to meet demand. Meanwhile, one of the efforts to produce superior and stable seeds is the use of plant breeding techniques through quality development in hybrid varieties of watermelon seeds[4 56].

The first step in assembling of high-yielding watermelon varieties is to explore local varieties in watermelon planting centers.Plant exploration aims to collect germplasm as a source of genes in the assembly of plant varieties in plant breeding programs[7]. The use of local varieties in the assembly of high-yielding varieties is often recommended to enrich the genetics of the high-yielding varieties[8]. The use of local varieties containing genes controlling resistanceto various environmental stresses can increase the superiority of superior varieties to be produced through plant breeding programs[9 10 11].

There are about 118 general *Citrullus* and 825 species and each species has a different size, taste, and shape[12]. Based on the color of the flesh, there are two types of watermelon, namely watermelon with yellow flesh and watermelon with red flesh. In this study, 4 cultivars of watermelon will be used as the parents, namely the DendeInges, Farmers Giant, New Dragon, and Baginda watermelon cultivars. The DendeInges watermelon

cultivar is a type of watermelon with yellow flesh color that is very popular in public. In addition, the selling price of yellow watermelon is higher than red watermelon, also this yellow watermelon has a very sweet taste that makes consumers interested in consuming it.

The disadvantages of the DendeInges variety are that the fruit size is smaller than other watermelons, the number of seeds is very large, the skin is thin so it is easy to break during transportation and is susceptible to leaf blight[13]. New Dragon variety has red flesh color, very large fruit size (9-11 kg.fruit^{-1}), low the number of seeds and adapts well in low to medium altitudes with an altitude of 50-500 m asl[14]. Meanwhile, the Baginda variety has red flesh color, the fruit sizes is ranging from 5.5-7.5 kg.fruit^{-1}, resistant to Gummy Stem Blight (*Didymellabryoniae*) and has a shorter harvest time than the other parents, namely 55-60 DAT[15].

In this study, crosses between the four parents were carried out in the hope of obtaining superior watermelon strains with a combination of traits according to consumer desires. From the description above, this study aims to analyze the diversity of watermelons from crosses between DendeInges, Esteem, New Dragon and Baginda varieties.

II. Material and Methods

Location, duration and design of the research

This research was conducted in the rice fields of PalohJeureula Village, Sakti District, Pidie Regency, from March to September 2019. This research was conducted using a Randomized Block Design (RBD). The number of treatments in this study were 4 treatments as parents and 15 treatments from crosses, in total there were 19 treatments, namely V_1 (DendeInges cultivar), V_2 (Esteem cultivar), V_3(New Dragon cultivar), V_4 (Baginda cultivar), V_1V_1(a cross between the DendeInges and DendeInges), V_1V_2 (a cross between DendeInges and Esteem), V1V3 (a cross between DendeInges and New Dragon), V_1V_4 (a cross between DendeInges and Baginda), V_2V_1 (a cross between Esteem and DendeInges), V_2V_2 (a cross between Esteem and Esteem), V_2V_3 (a cross between Esteem and New Dragon), V_2V_4 (a cross between Esteem and Baginda), V3V1 (a cross between New Dragon andDendeInges), V_3V_2 (a cross between New Dragon and Esteem), V_3V_3 (a cross between New Dragon and New Dragon), V_3V_4 (a cross between New Dragon and Baginda), V_4V_1 (a cross between Baginda and DendeInges), V_4V_2 (a cross between Baginda and Esteem), V_4V_3 (a cross between Baginda and New Dragon). The research data were analyzed by using analysisof variance (ANOVA) and continued with a further test using the Least Significant Difference (LSD) at a significance level of 5% if the F test showed a significant influence.

Research Implementation

This study used 19 genotypes as treatment with 3 replications, in total it obtained 57 experimental units. For beds with dimensions of 4.2 m x 4 m x 0.5 m (length x width x height). Basic fertilization is applied 7 days before installing mulch. NPK fertilizer was applied 2 days before installing mulchat a dose of 160 g/plant. The mulch was installed during the day to make it easier to withdraw. Planting holes were made with a distance of 0.6 m. Planting was done when the seedlings are 10 days olds or with characteristics that already have 2-3 leaves.

Plant maintenance includes watering, replanting, weed control and pest and disease control. Watering was done every day, namely in the morning and evening or adjusted to weather conditions. Embroidery was done on the plants that die or their growth is not good. Weed control can be done by physical or mechanical means. Pest and disease control was more effective by chemical means. Harvesting was carried out at the age of 60 DAP with the characteristics of the lines on the skin of the fruit were slightly faded, the tendrils found in the axils of the leaves where the dried fruit stalks were attached and the fruit stalks had shrunk.

Observation Parameter

The samples observed were 10 plants/plot, apart from the plants at each end of the bed. Parameters observed were quantitative parameters. Quantitative parameters are variables that can be expressed in numbers. The variables observed in this study were as follows:

I. Vegetative phase

a. Plant length(cm)

Observation of plant length was carried out by measuring the length of the plant from the base of the stem to the farthest growing point. The tool used is a 5 meter cloth meter. Observations were made at the 15, 30, 45 and 60 DAP.

b. Petiole length (cm)

The length of the petiole was measured from the petiole attached to the stem to the base of the leaf blade. Observations were made on the 5th, 8th and 12th leaves.

II. Generative phase

a. Harvest times (Days After Pollination)

Observation of the times of flowering plants was calculated from the time the plants were planted until the plants produced flowers.

b. Fruit weight (kg)

Fruit weight per plant was calculated when the fruit has been harvested.

c. Number of female flowers (fruit)

The number of female flowers was counted until the plant was 45 DAP.

III. Result

Vegetatif phase

a. Plant Length

The parameter of plant length had a very significant effect due to cross-breeding of several parents of watermelon plants at the 15, 30, 45, and 60 DAP.

Table 1. Length of plants at the 15, 30, 45, and 60 DAP.

Treatments	Plant Length (cm)			
	15 DAP	30 DAP	45 DAP	60 DAP
DendeInges	113,67 b	333,33 b	469,67 j	603,33 j
Esteem	118,67 bcd	338,33 bc	474,00 j	609,00 j
New Dragon	138,00 g	364,33 f	504,33 k	637,33 k
Baginda	133,00 g	363,33 f	505,67 k	645,67 k
DendeInges × DendeInges	121,00 cde	342,00 cd	413,67 i	535,33 bc
DendeInges × Esteem	123,00 def	346,33 de	357,00 efg	523,33 a
DendeInges × New Dragon	125,00 ef	346,00 de	339,33 b	553,33 de
DendeInges× Baginda	99,00 a	304,33 a	347,67 cd	556,00 de
Esteem× DendeInges	103,33 a	309,67 a	306,33 a	528,33 ab
Esteem × Esteem	103,67 a	306,00 a	343,00 bc	554,67 de
Esteem × New Dragon	103,00 a	306,67 a	353,67 de	564,67 efg
Esteem × Baginda	123,67 def	342,33 cd	338,33 b	545,00 cd
New Dragon × DendeInges	123,00 def	343,00 cd	370,67 h	585,33 i
New Dragon × Esteem	127,67 fg	351,33 e	359,00 efg	576,00 ghi
New Dragon × New Dragon	126,67 ef	347,00 de	355,00 def	556,00 de
New Dragon × Baginda	124,67 def	345,67 cde	362,00 fg	563,67 ef
Baginda × DendeInges	116,33 bc	340,00 bcd	365,00 gh	571,33 fgh
Baginda × Esteem	134,33 g	372,00 g	359,67 efg	580,33 hi
Baginda × New Dragon	134,33 g	372,00 g	347,67 cd	561,33 ef

Note: Number followed by the sama letter on the same column is not significantly different according to 0,05 test level of Least Significant Difference (LSD)

Based on table 1, when watermelon crops were 15 DAP the best plant lengths were found in New Dragon (138 cm), Baginda (133 cm), Baginda×Esteem (134.33 cm) and Baginda× New Dragon (134.33 cm) but not significantly different with New Dragon ×Esteem (127.67 cm). Meanwhile, the shortest plants at the age of 15 DAP were found in DendeInges×Baginda (99 cm), Esteem×DendeInges (103.33 cm), Esteem×Esteem (103.67 cm) and Esteem× New Dragon (103 cm). At the age of 30 DAP, the best watermelon plant length was found in Baginda×Esteem (372 cm) and Baginda× New Dragon (372 cm). Also, watermelon plants with the shortest growth at the age of 30 DAP were DendeInges×Baginda (304.33 cm), Esteem×DendeInges (309.67 cm), Esteem×Esteem (306 cm) and Esteem× New Dragon (306.67 cm). Equally important that watermelon plants with the longest growth at 45 DAP were New Dragon (504.33 cm) and Baginda (505.67 cm). While the plants with the shortest growth were found in Esteem×DendeInges (335.33 cm). When watermelon plants were 60 DAP, the longest plant growth was found in New Dragon (637.33 cm) and Baginda (645.67 cm) and the shortest watermelon plant at the 60 DAP was DendeInges×Esteem (523.33 cm).

b. Petiole length

The length of the petiole was measured from the petiole attached to the stem to the base of the leaf blade. Observations were made on the 5th, 8th and 12th leaves.

Table 2. Length of leaf stalk of watermelon crops

Treatments	Petiole length (cm)		
	Leaf 5th	Leaf 8th	Leaf 12th
DendeInges	7,83 ab	9,47 abcd	9,73 b
Esteem	7,83 ab	9,50 bcd	9,90 bc

New Dragon	10,57	gh	10,83	hij	11,17	gh
Baginda	10,83	hi	11,17	j	11,50	hi
DendeInges×DendeInges	7,67	ab	9,50	bcd	10,60	def
DendeInges×Esteem	7,83	ab	9,33	abc	10,87	efg
DendeInges× New Dragon	8,17	abc	9,67	cde	10,87	efg
DendeInges×Baginda	7,33	a	9,67	cde	11,07	fgh
Esteem×DendeInges	8,17	abc	8,83	a	9,87	bc
Esteem×Esteem	7,67	ab	9,33	abc	9,73	b
Esteem× New Dragon	9,33	def	9,67	cde	11,93	ij
Esteem×Baginda	9,83	efg	10,33	fghi	11,87	ij
New Dragon ×DendeInges	8,50	bcd	10,00	def	10,27	cd
New Dragon ×Esteem	9,00	cde	10,17	efg	10,47	de
New Dragon × New Dragon	7,83	ab	10,90	ij	13,10	k
New Dragon ×Baginda	11,50	i	10,23	efgh	13,60	l
Baginda×DendeInges	9,83	efg	9,00	ab	11,00	fg
Baginda×Esteem	9,33	def	10,07	def	12,17	j
Baginda× New Dragon	10,17	fgh	10,73	ghij	9,00	a

Note: Number followed by the sama letter on the same column is not significantly different according to 0,05 test level of Least Significant Difference (LSD)

From the table above, it can be seen that the 5th longest petiole wasNew Dragon ×Baginda (11.50 cm) but was not significantly different from Baginda (10.83 cm). Meanwhile, the shortest petiole was found in DendeInges×Baginda (7.33 cm). In watermelon leaves, the 8th longest stalk was found in Baginda (11.17 cm) which was not significantly different from New Dragon (10.83 cm), New Dragon × New Dragon (10.90 cm) and Baginda× New Dragon (10.73 cm). While the shortest stalk was found in Esteem ×DendeInges (8.83 cm). The longest leaf stalks of the 12 watermelon plants were found at New Dragon ×Baginda (13.60 cm), on the other hand, the shortest petiole was found in Baginda× New Dragon (9 cm).

Generative phase

Table 3. Observation of the generative phase

Treatments	Harvest age (DAP)		Fruit weight (kg)		Number of female flowers (fruit)	
DendeInges	28,33	A	2,47	d	9,67	abc
Esteem	28,67	ab	2,47	d	10,00	bc
New Dragon	30,67	gh	4,97	k	12,67	fg
Baginda	31,33	i	4,70	jk	12,33	ef
DendeInges×DendeInges	28,33	a	2,57	de	9,33	ab
DendeInges×Esteem	28,67	ab	2,50	d	10,00	bc
DendeInges× New Dragon	29,67	de	1,87	c	13,67	g
DendeInges×Baginda	30,33	fg	3,03	ef	12,33	ef
Esteem×DendeInges	29,33	cd	2,50	d	11,33	de
Esteem×Esteem	29,00	bc	0,97	a	10,67	cd
Esteem× New Dragon	30,00	ef	3,73	gh	13,33	fg
Esteem×Baginda	31,00	hi	3,67	gh	10,67	cd
New Dragon ×DendeInges	29,67	de	2,60	de	11,33	de
New Dragon ×Esteem	30,00	ef	2,67	de	12,67	fg
New Dragon × New Dragon	31,00	hi	4,00	hi	12,33	ef
New Dragon ×Baginda	31,33	i	3,33	fg	13,00	fg
Baginda×DendeInges	29,33	cd	4,13	hi	8,67	a
Baginda×Esteem	29,67	de	4,33	ij	11,33	de
Baginda× New Dragon	30,33	fg	1,30	ab	9,00	ab

Note: Number followed by the sama letter on the same column is not significantly different according to 0,05 test level of Least Significant Difference (LSD)
DAP : Day After Polination

Table 3 shows harvesting ages of watermelons were different, where the longest harvesting age was found in Baginda (31.33) and New Dragon ×Baginda (31.33) but not significantly different from Esteem ×Baginda (31). Meanwhile, the fastest harvesting age was found in DendeInges (28.33). Fruit weight also had a very significant effect, where the best fruit weight was found in New Dragon (4.97) which was not significantly different from Baginda (4.70). While the smallest fruit weight was found in Esteem × Esteem (0.97). The

highest number of female flowers was found in DendeInges× New Dragon (13.67) but not significantly different from New Dragon (12.67), Esteem × New Dragon (13.33), New Dragon × Esteem (12.67) and New Dragon ×Baginda (13). Nevertherless, the lowest number of female flowers was found in Baginda×DendeInges (8.67).

IV. Discussion

Table 4 above shows the growth of watermelon crops has a level of diversity at each age of observation. This is because the characteristics of cultivars DendeInges, Esteem, New Dragon and Baginda are very different. Watermelon DendeInges and Esteem at the 0-30 DAP experienced faster lateral shoot growth than New Dragon and Baginda, thus inhibiting the growth of the main stem. The results of the crosses of the parentsDendeInges×DendeInges, DendeInges× Esteem, DendeInges× New Dragon, DendeInges×Baginda, Esteem ×DendeInges, Esteem × Esteem, Esteem × New Dragon and Esteem ×Baginda resulted in shorter plants at observations 15 and 30 DAP. Futhermore, at the age of 30-60 DAP there was a significant change where the longest plant growth was found in DendeInges, Esteem, New Dragon and Baginda. This was because the characteristics of the watermelons from crosses at the time of the age of the plant approaching harvest still experience the growth of tertiary shoots, in that case it suppresses the growth of the main stem. Genetic selection caused by environmental differences results in greater genetic diversity. Moreover, watermelon crops with the same genotype when planted in different places affects genetic diversity, especially on quantitative characters.[16 17]. Genotypes originating from the same area are not always in one group[18].

General, the phenotypic characters of F_2 watermelons from the cross of 'Putri Delima' with 'Maduri' with F_1 watermelons showed different results. Previous research stated that differences in location, time, and weather conditions affect the fruit produced[19]. Furthermore, [20]stated that the difference in phenotypic characters produced between the two studies was caused by the interaction between the genotype and the environment. Meanwhile, polygenes interact with various environmental factors that affect plant growth. Environmental factors that influence are water, nutrients, temperature, light intensity, soil moisture, and others[21 22 23].

The various leaf stalk lengths are thought to be the result of genetic traits, namely the ability to absorb nutrients from each cultivar used. Based on Table 2, overall cultivar New Dragon has longer petioles, thus watermelon plants New Dragon ×DendeInges, New Dragon × Esteem, New Dragon × New Dragon, New Dragon ×Baginda, DendeInges× New Dragon, Esteem × New Dragon and Baginda× New Dragon produce plants that have relatively longer petioles. The initial growth of plants will require a large number of nutrients, with the availability of nutrients in sufficient and balanced quantities for the plant growth process. if these nutrients are not sufficient to be utilized by plants, the process of cell division, the process of photosynthesis, and the process of cell elongation will not occur quickly. Hence, it can cause some plant organs to be hampered, especially in the vegetative phase[24]. The availability of nutrients in a balanced amount for plant growth causes the process of cell division, enlargement and elongation to take place rapidly which results in several plant organs growing rapidly, hence they are able to form growth organs including growing points and are used in stem development[25].

Watermelon cultivars DendeInges, Esteem, DendeInges×DendeInges, DendeInges× Esteem, DendeInges× New Dragon, DendeInges×Baginda, Esteem ×DendeInges, Esteem × Esteem, Esteem × New Dragon and Esteem ×Baginda tend to have shorter harvest life. This is thought to be due to the genetic characteristics of plants in accumulating the results of photosynthesis. The ability of plants to distribute photosynthetic yields greatly affects the rate of plant growth, fruit, and seed maturity[26 27 28]. The intensity of light also greatly affects the age of watermelon harvest. The higher radiation causes the fruit to ripen quickly due to the higher accumulation of photosynthate. In addition to sufficient light, watermelon grows optimally when planted in a temperature range of 22°C-30°C, humidity less than 80%, rainfall on average 40 to 50 mm/month, and is influenced by soil structure and microbial composition[29 23].

Watermelon cultivars New Dragon, Baginda and crosses involving both parents produced heavier fruit weights. This is because the characteristics of the watermelon cultivar have a greater weight. Selection of these characters has a high chance of genetic progress because genetic factors control the observed characters while they can be passed on to their offspring[30,] Selection of characters with high heritability values can be done in the early generations[31]. In accordance with the research results[32], the quality of the yield is significantly affected by fruit pruning combined with the pruning process. Research[33], showed that pruning fruit at 51 days after planting reduced sugar solubility in watermelon fruit. The results of the research[34], showed that fruit pruning accompanied by spacing between fruits could increase the weight of watermelons.

The highest number of female flowers was produced by watermelon cultivar Baginda namely watermelon plants New Dragon ×DendeInges, New Dragon × Esteem, New Dragon × New Dragon, New Dragon ×Baginda, DendeInges× New Dragon, Esteem × New Dragon and Baginda× New Dragon had a large number of female flowers. This proves the decline in the characteristics of parents to their offspring. Genotypes

that have many similarities in morphological characters have a closer relationship, while genotypes with few similarities in morphological characters have a more distant relationship[35].

V. Conclusion

Crosses between watermelon cultivars DendeInges, Esteem, New Dragon and Baginda obtained a very high level of diversity, as a result very significant effect on the growth and yield of watermelon crops. In the vegetative phase which includes plant length and leaf stalk length, the diversity level was very unstable. Where the best plant length at 15 DAP was New Dragon (138 cm), Baginda (133cm), Baginda× Esteem (134.33cm) and Baginda× New Dragon (134.33 cm) and at 30 DAP the best plant length was Baginda× Esteem (372 cm) and Baginda× New Dragon (372cm). Watermelon crops with the best growth at 45 DAP were New Dragon (504.33 cm) and Baginda (505.67 cm). Meanwhile, when watermelon crops were 60 DAP, the best plant growth was in New Dragon (637.33 cm) and Baginda (645.67 cm). Parameters of the 5th longest petiole are New Dragon ×Baginda (11.50 cm), on the 8th leaf the longest stalk is found in Baginda (11.17 cm), the 12th longest leaf stalk of watermelon crops was found in New Dragon ×Baginda (13.60 cm). Instead, in the generative phase, it also had a very significant effect on the measured parameters. The longest harvesting age of watermelon was found in Baginda (31.33) and New Dragon ×Baginda (31.33). Although, the fastest harvesting age was found in DendeInges (28.33), the heaviest fruit weight was found in New Dragon (4.97 kg) which was not significantly different from baginda (4.70 kg). Henceforth, the highest number of female flowers was found in DendeInges× New Dragon (13.67 flowers).

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