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Prolific and Uniformity Test of Two Cobs Corn in F4 Generation

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Abstract

One of the efforts that can be done is to increase the national corn productivity by developing prolific composite corn varieties. This is done because prolific corn is a type of corn with a tendency to produce two or more cobs, so that it can increase the value of corn production. The purpose of this study was to obtain prolific corn candidates (two cobs) with high yield and uniformity. This research was conducted using the mass selection method. Mass selection is done by selecting plants that have the desired character, namely prolific corn (cob two). The observed variables were the diversity in the F4 population, the percentage of prolific corn, and the comparison of the yield components of prolific corn with non-prolific corn. This study succeeded in obtaining 50% prolific corn on the cob and has wide diversity criteria. Of the 561 prolific corn plants, there are 91 corn plants that are classified as productive prolific. Prolific corn has a higher yield component than non-Prolific corn. Seed weight with cobs on productive prolific corn reached 318 g and seed weight reached 268 g.

Keywords: diversity, genotype, maize, population, prolific

1. Introduction

Corn (*Zea mays*L.) is the main food crop in Indonesia after rice. Corn is a multipurpose plant which can be used as an ingredient to meet the needs of food, feed, and bioenergy. In Indonesia, corn is widely used as raw material for animal feed, according to Pelu*et al.,* (2008 or 2016?) corn used as the main component of feed rations reaches 45%. The increase in demand for corn is in line with the increasing demand for feed. According to the Directorate General of PKH of the Ministry of Agriculture (2019), the need for corn in 2019 of 8.59 million tons was used to meet the needs of the feed industry and 2.92 million tons were used to meet the needs of independent farmers.

The increasing demand for corn that continues to occur must be accompanied by an increase in national corn production. According to the Ministry of Agriculture (2020), corn production in 2016 has increased compared to corn production in 2015, from 19.61 million tons to 23.19 million tons. Corn production in 2018 decreased compared to corn production in 2017, from 28.92 million tons to 21.66 million tons. The decline in corn production in 2018 was due to a decrease in harvested area by 26.52% or equivalent to 1.47 million hectares. Indonesian corn production is still relatively low when compared to corn production in corn central countries, such as the United States and China. According to data from the Food and Agriculture Organization (2020), the average corn production in the United States and China reached 381.78 million tons and 252.10 million tons, while the average corn production in Indonesia was 24.27 million tons. This low corn production causes Indonesia to still import corn to meet domestic corn needs.

According to the Ministry of Agriculture (2020), in 2017 Indonesia imported 714 thousand tons of corn or decreased by 46.34% when compared to import activities in 2016. In 2018 corn import activities increased by 60.98% or 1.15 million tons and again increased by 25.49% or 1.44 million tons in 2019. The increase in import activities can be suppressed by increasing the national corn production. The increase in national corn production will meet domestic corn needs so that corn import activities can be minimized. Efforts that can be made to increase corn production so that corn import activities can be reduced are extensification and intensification. Extensification can be done by expanding the land planted with corn and intensification can be done by increasing the use of superior and quality seeds.

Superior and quality corn seeds consist of hybrid seeds and composite seeds. Increasing corn production by using hybrid seeds is quite constrained because it can increase production costs. The increase in production costs was due to the relatively more expensive price of hybrid seeds and the corn yields obtained could not be used as a source of corn seeds for subsequent planting (Ministry of Trade, 2016). Hybrid corn must be cultivated on fertile land and intensive maintenance is carried out to obtain high yields. Composite seeds or free pollinated corn seeds can be used as an alternative in an effort to increase domestic corn production because they have advantages, such as corn cropping results can be used as a source of seeds for subsequent planting, so that the use of composite corn seeds can reduce production costs. Composite corn also has a wider adaptability, so it can be cultivated in various land conditions. The disadvantage of composite corn is that its yield productivity is relatively lower when compared to hybrid corn.

This deficiency can be corrected by producing prolific composite corn varieties. Prolific corn is a type of corn with a tendency to produce two or more cobs. According to Yudiwanti et al., (2006) prolific characters are influenced by genetic and environmental factors. The genetic factor that affects the corn prolific is a recessive gene. Prolific caused by a recessive gene means that by self-crossing for up to 5-6 generations, a pure line (inbred) will be obtained which shows a prolific character. Increased corn production will increase if prolific corn is developed, because the number of cobs produced from each plant will be more than corn in general. This is because corn comes from the domestication of the teosinte plant (Zea mays subsp. Parviglumis) which has many cobs per plant. The prolific genetic potential is generally found in local corn species, but the yield potential is still low, which is still around 3-4 tons per hectare. This is due to the lack of uniformity in the size and weight of the first and second cobs, so it is necessary to select prolific corn characters in order to achieve yield stability (Efendi*et al.,* 2021). One of the selection activities that can be carried out is mass selection (Wati et al., 2020). The mass selection activity aims to visually select individuals with the desired character, namely the two cob character. Mass selection activity is one of the efforts in purifying the corn lines so that corn with two cobs can be produced which is more optimal.

Suliansyah et al., (2018) are breeding prolific composite maize. This prolific composite corn is the result of a cross between the elders BSM0729S3A and BSM0729S3B originating from the highlands of North Sumatra resulting from the 4th self-crossing with BAP277991 originating from the Thai landrace of the 3rd self-crossing. In the first and second generations, the corn produced was still characterized by high seed yield and biomass, then in the third generation some corn with prolific characters of two cobs began to be found. In the fourth generation of corn with two cob prolific characters more than in the third generation. This is the basis for developing corn with a prolific character of two cobs in the fifth generation. The development of prolific corn is considered to be able to reduce corn imports because national corn production can be increased by using prolific corn. The aim of this study was to obtain prolific corn candidates (two cobs) with high yields and a high degree of uniformity.

2. Materials and Methods

This experiment was carried out from July to December 2021 in KenagarianCingkariang, Agam Regency, West Sumatra. The research was conducted at an altitude of 925 masl, at coordinates 0°21'06.1"LS 100°23'046"BT. The tools used in this experiment are hoe, sickle, sprayer, meter, caliper, digital scale, seed moisture tester, knife. The materials used in the experiment were prolific corn strain (two cobs), chicken manure, urea fertilizer, TSP fertilizer, KCl fertilizer, labels, plastic, harvest sacks and fungicide with the active ingredient Dimetomorph 500 g/L+Pyraclostrobin 10 g/L with a dose of 5 ml.

This research was conducted using the mass selection method. Mass selection is done by selecting plants that have the desired character, namely prolific corn (cob two). The samples observed in this study were all corn plants, then at the end of the mass selection was carried out on prolific corn plants (two cobs). Observational data for each observational variable were analyzed for its mean, variance and standard deviation. The average can be calculated using the following formula:

$$\mu = \frac{\sum Xi}{n} = \frac{X1+X2+X3+\ldots+Xn}{n}$$

Description: μ: Average Xi : Sum of all data points and n : Number of data

The variance and standard deviation can be calculated using the formula:

$$\sigma^2 = \frac{\sum(xi - \mu)^2}{n-1}$$

$$\sigma = \sqrt{\frac{\sum(xi - \mu)^2}{n-1}}$$

Information:

σ^2 : Variety, σ : Standard deviation, μ : Average, xi : Data 1st, 2nd, etc, n : The amount of dataGenetic diversity is said to be wide if $\sigma^2 g \geq 2$ standard deviations (sd) and is said to be narrow if $\sigma^2 g \leq 2$ sd (Wardani et al., 2009). Then the comparison of the yield components of prolific corn with non-prolific corn analyses with T-test 0,05 level.

The land is cleaned of weeds and remnants of the previous plants that are still left on the land using a hoe. According to Manrapi (2018), the land used must be isolated at least 300 m from other corn crops or isolated for at least 3 weeks from other corn crops. The processed land was then mapped with a size of 3 m x 12.4 m and made up of 5 plots.The seeds used are F4 generation seeds resulting from a cross between two parents from the A X B cross. The seeds were obtained from the collection of Prof. Dr. Ir. IrfanSuliansyah, M.S. which has a prolific character (cob two). The seeds used were 1500 seeds, with a total of 300 seeds per plot. Before planting, the seeds were treated with a fungicide with the active ingredient Dimetomorph 500g/L+Pyraclostrobin 10g/L at a dose of 2.5 ml to prevent downy mildew (*Peronosclerosporamaydis*). Planting is carried out 7 days after land processing is done manually by ditugal. Seeds are planted 1 seed per planting hole with a spacing of 60 cm x 20 cm (Wangiyana et al., 2018).

Chicken manure is given once at a dose of 15 tons/ha or as much as 55.8 kg per plot by being spread and leveled in each plot (Hutasoit et al., 2020). Fertilization is done twice. The first application of fertilizer was carried out at the age of 10 days after plant (DAP) and the second fertilization was carried out at 30 DAP by giving 300 kg/ha of urea, 200 kg/ha of TSP fertilizer and 100 kg/ha of KCl fertilizer. Fertilizer is given in a row and placed between rows of plants, then covered with soil. Harvesting is done when the corn plants meet the harvest criteria such as corn husks that have dried or are brown, the seeds have hardened and a black layer of at least 50% has formed on each row of corn seeds (Abdullah et al., 2015).

3. Results and Discussion

Population Diversity F4

In population diversity, observations were made on plant height, stem diameter, male flowering age, female flowering age, anthesis silking interval and observations on harvest age. Based on the results of the analysis that was carried out on the F4 population, it was found that the observation of plant height and stem diameter had wide diversity criteria. In the observation of anthesis age, silking age, anthesis silking interval and harvest age, the criteria for diversity were narrow. The data analysis results can be seen in Table 1.

Table 1. Results of analysis of mean, variance, standard deviation, 2sd and criteria for diversity in the F4 population.

Observation Variable	Average	Variance (σ^2)	sd	2sd	Diversity criteria
Plant Height (cm)	318,33	1392,72	37,32	74,64	wide
Stem diameter(mm)	25,17	15,91	3,99	7,98	wide
DaystoAnthesis (DAP)	63	0	0	0	narrow
Days to silking(DAP)	65	0	0	0	narrow
AnthesisSilking Interval	2	0	0	0	narrow

Harvest Age (DAP)	134	0	0	0	narrow

In the observation variable of plant height, it was found that the diversity in the planted population had a wide variety. The wide level of diversity is caused by differences in the genetic makeup of each individual plant. The wide level of diversity has a good influence on the sustainability of the selection process, this is because there are more choices so that it can be adjusted to the desired character. According to Herlinda et al. (2018), the high level of diversity in a population can make the selection process more effective. It can be seen in Table 1 that the average plant height in the population is 318,33 cm and is considered to be higher than the height of corn in general, which ranges from 120 to 300 cm. Plants that grow too tall have the disadvantage that they are prone to fractures in the stems. To reduce the risk of fracture in the plant stem, a large stem diameter is needed so that it can support the plant body. In Table 1, the planted population had an average stem diameter of 25,17 mm.

Based on the observation of the stem diameter of the corn population, it was found that the average diameter of the corn stalk was 25,17 mm. Corn stalks function as a means of supplying nutrients. Size of stem diameter It can be seen in Table 1 that the observation of stem diameter in the corn population has a wide level of diversity. The wide diversity in a population is caused by genetic variations in each individual plant (Sain, 2016). The breadth of diversity in the corn population still requires continuous mass selection to obtain corn with a more uniform character. In this study, there were corn stalks that were broken due to environmental factors, namely wind. Strong winds that occurred at the research site caused the plant stems to fall down and break due to the disproportionate height of the plant to the diameter of the stem.

In the observation of female flowering age, male flowering age, anthesissilking interval and harvest age, the results of narrow diversity criteria were obtained. The narrow diversity was caused by the selection activity carried out on the previous population, where the plant population had reached a uniform level in the characteristics of female flowering age, male flowering age, anthesissilking interval and harvest age. This shows that the selection in the previous population was good.

Based on the results of observations on the age of male flowering carried out when the population has issued more than 50% male flowers, it can be seen in Table 1 that the diversity criteria in the population show narrow diversity results. The age of male flowering in the population occurred when the corn plant was 63 DAP. The male flowers of corn come out first because corn is classified as a protandry plant. According to Suwardi(2009), male flower pollination tends to be 2-5 days faster than female flower pollination.

Based on the results of observations on the age of female flowering carried out when the population has issued more than 50% female flowers, it can be seen in Table 1 that the diversity criteria in the population show narrow diversity results. The age of female flowering in the population occurred when the corn plants were 65 DAP.

Based on the results of observations of the anthesissilking interval in the corn population, the results were 2. It can be seen in Table 1 that the anthesissilking interval shows a narrow diversity. The smaller the time interval between the appearance of male flowers and female flowers indicates the higher the chances of corn to be perfectly pollinated. Breast milk has a close relationship with flowering, so a small value of breast milk can increase the chances of perfect pollination in corn (Sihotang, 2018).

Harvest age data can be seen in Table 1. Based on Table 1 it can be seen that harvesting is carried out when the corn plant is 134 DAP. With a narrow diversity criteria. Harvesting is carried out when the corn plants have shown the harvest criteria, namely the husks have dried, the plant seeds have hardened so that they do not leave a trace when pressed and there is a black coating on the seeds. Harvest age in the corn population in this study indicates that corn has a deep age. This is due to environmental conditions, where corn plants are planted at an altitude of ±925 masl which belongs to the highlands. Plants grown in the highlands generally have a longer harvest life than those grown in the lowlands. This relates to the degree of heat received by the plant.

The degree of heat received by plants is also known as growing degree days or units of heat. Each plant requires a different heat unit to complete its growth cycle. In the highlands the air temperature in the environment will decrease every time the altitude increases, the rate of decrease in environmental temperature occurs for every 100 meter increase with a decrease of 0.98 ° C, the increase in altitude of 100 meters causes the longer harvest age of a plant(Balitklimat, 2021).

Prolific Corn Percentage

Based on the results of observations on 1111 plants, the second cob prolific corn was obtained as many as 561 plants or equivalent to 49%. Observing the location of the cobs, length of the ear, diameter of the ear, number of rows per ear, number of seeds per ear, number of seeds per row, weight of seeds with cobs on 14% water content, and weight of seeds without ear on 14%, the results of the analysis of variance were obtained. Contained in Table 2 with the criteria for diversity in all observations showed that the prolific corn cob planted had wide diversity criteria. The wide variety of prolific corn on the second cob produced will have a better chance in the selection process, because of the large number of character choices that are obtained to produce the desired variety. According to Sain (2016), wide diversity will increase the chances of producing new superior cultivars.

Table 2. The results of the analysis of prolific corn cob two in F4 generation

Observation Variable	Average	Variance	Sd	2sd	Diversity Criteria
LT1	179,55	975,79	31,24	62,48	wide
LT2	158,30	1026,73	32,04	64,09	wide
PT1	18,54	14,18	3,77	7,53	wide
PT2	9,11	12,85	3,58	7,17	wide
DT1	53,75	77,19	8,79	17,57	wide
DT2	15,09	154,92	12,45	24,89	wide
BaT1	14,38	10,77	3,28	6,56	wide
BaT2	2,05	21,88	4,68	9,35	wide
BB1	34,12	104,15	10,21	20,41	wide
BB2	3,19	64,24	8,01	16,03	wide
BiT1	508,81	26519,55	162,85	325,70	wide
BiT2	40,63	12672,48	112,57	225,14	wide
BT1 14%	149,35	2729,88	52,25	104,50	wide
BT2 14%	10,59	752,04	27,42	54,85	wide
BBi1 14%	123,12	2120,05	46,04	92,09	wide
BBi2 14%	6,85	474,63	21,79	43,57	wide

Note: LT = Cob Location (cm); PT = Cob Length (cm); DT = Cob Diameter (mm); BaT = Row per Cob (Row); BB= Seeds per Row (seeds);BiT = Seeds per Cob (seeds); BT = Weight Seed with Cob 14% (g); BBi = Weight Seed 14% (g).

Based on Table 2, the average position of the first cob is 179,55 cm and the average position of the second cob is 158,30 cm. The condition of the location of the corncobs in prolific corn has broad criteria, so that selection activities are still needed to get the right location of the cobs to facilitate the harvesting process. According to Wardani (2009), the location of the corn cobs is proportional to the height of the plant, the higher the plant, the higher the location of the cobs.

The average length of the cob on the first cob is 18,54 cm while the second cob is smaller with an average cob length of 9,11 cm. This shows that the first cob with the second cob is still not uniform in size. The first cob is larger, while the second cob is smaller. Selection still needs to be done to get the desired character, the first cob and the second cob are expected to be uniform.

Based on Table 2, the average diameter of the first ear is 53,75 mm and the average diameter of the second ear is 15.09 mm. The criterion of diversity for the diameter of the cob, both the first and second cobs, is broad. Based on Table 2, the average number of rows on the first ear is 14,38 rows per ear, while the average number of rows on the second ear is 2,05 rows per ear. The second cob produced generally does not produce seed.

Table 3. esult of productive prolific corn analysis in F4 generation

Observation Variable	Average	Variance	Sd	2sd	Diversity Criteria
LT1	190,76	1090,12	33,02	66,03	wide
LT2	171,62	1162,31	34,09	68,19	wide
PT1	20,01	8,74	2,96	5,91	wide
PT2	13,04	16,24	4,03	8,06	wide
DT1	53,87	50,56	7,11	14,22	wide
DT2	36,49	214,91	14,66	29,32	wide
BaT1	14,60	2,83	1,68	3,36	narrow
BaT2	11,33	17,59	4,19	8,39	wide
BB1	37,01	61,33	7,83	15,66	wide
BB2	17,80	105,78	10,29	20,57	wide
BiT1	541,23	16032,39	126,62	253,24	wide
BiT2	230,69	28912,03	170,04	340,07	wide
BT1 14%	156,72	2240,30	47,33	94,66	wide
BT2 14%	57,72	2068,05	45,48	90,95	wide
BBi1 14%	128,73	1945,43	44,11	88,21	wide
BBi2 14%	43,04	1502,05	38,76	77,51	wide

Note: LT = Cob Location (cm); PT = Cob Length (cm); DT = Cob Diameter (mm); BaT = Row per Cob (Row); BB= Seeds per Row (seeds);BiT = Seeds per Cob (seeds); BT = Weight Seed with Cob 14% (g); BBi = Weight Seed 14% (g).

Based on the results, there were 561 prolific plants and 91 plants which were classified as productive prolific. Productive prolific corn is corn that produces more than one cob and both cobs produced have seeds. It can be seen in Table 3, the location of the first cob for productive prolific corn is on average at 190,76cm and the second cob is at 171,62 cm with wide variation.

Based on Table 3, the average length of the first cob and the length of the second cob in productive prolific corn were 20,01 cm and 13,04 cm, respectively. The two cobs produced still show non-uniformity, so it is necessary to make a selection to get the results with the desired character.

Table 4 shows that plant height, stem diameter, cob length, cob diameter, row per cob, seeds per cob, weight with cob and weight without cob, seed per row, non-prolific corn has a lower size than prolific maize. This result is linear with the yield component obtained in table 5 where the yield component of non-prolific corn is lower than the yield component of prolific maize.

In table 5 it can be seen that the yield components of Prolific corn are higher than that of non-prolific corn. Seed weight with cobs on productive prolific corn reached 318g and seed weight reached 268 g. Meanwhile, for non-profile corn, it was only 155 g for Seed Weight with Cobs and 131 g for Seed Weight. 1000 grain weight on productive prolific cornis 317 g meanwhile, 1000 grain weight of non prolific is 285 g. This result is in accordance with the statement of Vagas et al 2004 that prolific corn will usually give higher yields than non-prolific corn because it is supported by the weight of the second cob which has a large number of seeds and weight per plant.The yield component is the result of the interaction between the potential genes of a plant and environmental factors. When plants are able to adapt to the environment, the yields obtained will be high (Syafruddin et al., 2012).

Table 4. Result of non-prolific corn analysis in F4 generation

Observation Variable	Average	Variance	Sd	2sd	Diversity Criteria
TT	311,79	1407,86	37,52	75,04	wide
DB	24,17	15,21	3,90	7,80	wide
LT	164,06	1024,59	32,01	64,02	wide
PT	16,90	10,02	3,17	6,33	wide
DT	51,06	39,69	6,30	12,60	wide
BaT	15,17	4,19	2,05	4,33	narrow
BB	30,14	61,98	7,87	15,75	wide
BiT	457,40	17625,67	132,76	265,52	wide
BT 14%	118,56	2092,39	45,74	91,49	wide
BBi 14%	98,43	1570,75	39,63	79,27	wide

Note: TT = Plant Height (cm); DB= Rod Diameter (mm); LT = Cob Location (cm); PT = Cob Length (cm); DT = Cob Diameter (mm); BaT = Row per Cob (Row); BB= Seeds per Row (seeds);BiT = Seeds per Cob (seeds); BT = Weight Seed with Cob 14% (g); BBi = Weight Seed 14% (g).

Table 5.Comparison of yield components between productive prolific with non-prolific corn

Observation Variable	Average		
	Weight Cob	Weight Seed	1000 Grain Weight
Non-Prolific	155 b	131 b	285 b
Productive Prolific	318 a	268 a	317 a

Note: Average in same category followed by different letter are significantly different at T-test two sample assuming unequal variance on 0,05 level.

4. Conclusions

Of the 561 prolific corn plant candidates, there are 91 corn plants that are classified as productive prolific with wide diversity criteria. With a wide level of diversity, the chances of success in assembling prolific corn varieties according to the desired character will be higher.

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