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Inheritance of Agronomic Characteristics in F3 Soybeans (Agromulyo X Tanggamus) Using the Pedigree Method

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Abstract

The research was conducted at the end of October 2020 - February 2021 in Raya Usang Village, Dolog Massagal District, Simalungun Regency, at an altitude of 1090 m above sea level. The purpose of this research was to determine the agronomic characteristics, heritability estimation value and the variety of genotypes of F3 (Agromulyo X Tanggamus). This research uses planting with the Pedigree method. The research design used an Augmented design, namely a strain design that was not repeated but with the elder plant being planted, to prove that the strain tends to be the parent of Agromulyo or Tanggamus. Observations made include: flowering age (days), harvesting age (days), plant height (cm), number of branches (units), number of pods (units), the seed weight per plant (g) and the weight of 100 seeds (g). From the results of research and analysis of statistical data taken from the mean character value, it is known that in the agronomic characteristics of F3 (Agromulyo X Tanggamus), there were several characters that have improved (load, harvest age, and weight of 100 seeds), there were also characteristics whose mean were between the Agromulyo and Tanggamus elder plant (plant height and number of branches, number of pods per plant, seeds weight per plant and the weight of 100 seeds). The criterion of the GCV is, low: GCV <7%, medium: GCV <14%, and high: GCV> 14%. All characters have a high GCV value except for the harvest age and the flowering age, which have a low GCV value. For heritability values in the broad sense of the criteria, it is h2 <0.2 for low heritability, 0.2 <h2 <0.5 for medium heritability, and h2> 0.5 for high heritability. The results showed that all characters in this study had high broad heritability values. The higher the heritability value, the greater the selection progress that is achieved and the faster the superior varieties are released. The results of this study were obtained in 20 genotypes through direct selection based on the character of the seed weight of which had the highest seed weight. The genotype numbers of the promising strains obtained were 181, 123, 196,113, 116, 162, 104, 39, 69, 200, 227, 70, 221, 63, 128, 15, 99, 66, 52 and 184. The genotype with the highest seed weight was found in genotype 181 (44.02 g), while the genotype with the lowest seed weight was found in genotype number 88 (28.69 g).

Keywords: Soybean, Pedigree Method, Agromulyo, Tanggamus.

1. Introduction

Soybean is a plant with a source of vegetable protein used as raw material for the manufacture of tofu and tempeh and as a material for other food processing. The demand for soybean

products is increasing every year, the biggest demand is for raw materials in the production of tofu and tempeh. On one side, production of soybean every year is experiencing fluctuation in production as well as the current production rate that have been unable to meet national consumption needs. This is because every year the data on soybean harvested area shows a decrease due to the competition between soybean planting and other commodities such as rice and corn. According to projections, it is predicted that the production and consumption of soybeans in 2016-2020 will experience an increase in deficit by 36,95% per year, while according to Aldillah (2015) in Wijaya&Maksudin, (2018), in 2020 it is predicted that the production of soybeans will experience an average increase of 6,80% per year and average increase of 2,10% per year in consumption. One of the ways to increase the national soybean production is by increasing the area size per soybean plant. However until now the increase of soybean area size is constrained by programs of other commodities that also need high production capacity (self-sufficiency), namely rice and corn.

One of the ways to meet the national soybean need is to use a superior variety of soybean. The assembly of these superior varieties can be done through plant breeding programs. One of the ways in the assembly process of the superior variety is through hybridization and followed by plant selection. Plant selection is a process to increase gene frequency for traits that need improvement in the plant-breeding program. Before the selection of methods to be used and when to begin the selection, the results diversity, heritability and selection process relationship must be known so that the process can be effective and more accurate.Selection is an important part in plant breeding program to increase the chance of obtaining superior genotypes. This is also applies to soybean plant breeding. Testing needs to be conducted as much as possible on strains of selected soybean plants, therefore being able to obtain strains of soybean plants that are high-performing (Smitha et al., 2003 in Dewiet al., 2018).

With the selection in plant breeding, it is hoped that there is a potential to obtain superior soybean strains, the inheritance of characters that support high performance results and heritability illustrates the contribution of genetics and the environment towards plant characteristics in the field (Ajjapplavara et al., 2009 inDewiet al., 2018). Characters with high heritability value shows that genetics has a larger influence than environment (Suprapto et al., 2007 inDewiet al., 2018). In this research, F3 selection is done with the female elder plant of the Tanggamus variety, crossed with the Anjasmoro variety, Argopuro variety, and the Brawijaya strain.

Genetic and heritability variety are an absolute requirement in the success of a plant breeding program (Acquaah, 2012 dalam Effendy et al., 2018). Genetic variety can increase the chance of obtaining better genotypes through selection. Character variety and genotype variety are useful to determine patterns in genotype grouping in certain population based on observed characteristics and can be used as a basis for Jurnal Agro 5(1), 2018 32 seleksi (Agustina&Waluyo, 2017 in Effendy et al., 2018). Variety analysis can be conducted with various types of markers, one of them being morphology on the plant (Nadhifah et al., 2016 inEffendyet al., 2018).Indicator that said character is controlled genetically based on heritability value. Heritability is a genetic parameter used to measure genotype performance in a plant population in passing down its own characteristics (Meenaet al., 2016 inEffendyet al.,

2018). The expected heritability value functions to determine the success in selection, as it indicates whether a characteristic is influenced more by genetic or environmental factors (Rosmainaet al., 2016 inEffendyet al., 2018).

2. Research Method

1. Research Period and Site

This Research is conducted on 24 October – 14 April 2021 in Raya Usang farming field, DologMasagal District, Simalungun Regency.

2. Tools and Materials

Tools that the researcher has used in this experiment are the following: spade, camera, hoe, tape measure, cleaver, hand sprayer, bucket, and analytic scales. Materials that the researcher has used are 240 seeds from the crossing of the AgromulyodanTanggamus variety, 180 seeds of the Argomulyo elder, and 180 seeds of the Tanggamus elder dan water. And then Urea, NPK, KClfertilisers and have also been prepared to support the growth of the plants.

3. Research Methodology

This research design uses the augmented design, namely a strain design that was not repeated but with the elder plant being planted, to prove which characteristics the strains inherits from the elder plant. This research design is used due to the limited amount of seeds available and the uncertainty of the seeds' characteristics. As a result, data processing used in this research:

1. Environmental variety with formula

$$\sigma^2 e = \frac{\sigma^2{}_{P_1} + \sigma^2{}_{P_2}}{2}$$

Note: σ 2e : environmental variety
σ 2p: phenotype variety

2. Genetic variety is calculated from the difference of the phenotype variety selected population and the expected environmental variety result (Stansfield, 1991).

Note: σ2 genetic variety

3. Genotypic Coefficient of Variability (GCV)

$$\text{GCV} = \frac{\sqrt{\sigma 2g}}{\bar{x}} \text{ x } 100\%$$

4. Heritability

Heritability in a broad sense (h2) is calculated according to the formula: h2 = (σ2g)/ (σ2p) (Stansfield (1991)) dividing the estimated heritability value into three categories: Low: < 0,20, Medium: 0,20 - 0,50 and High: 0,50.

Research Application

a. Land Preparation

Land preparation is done 2 weeks before planting. Land is ploughed and then mixed with manure in equal measure to increase soil fertility.

b. Soybean Planting

Soybean planting consisting of 240 planting holes of the crossed types, 180 Argomulyo elders and 180 Tanggamus elders. First, seeds are soaked in water for 20 minutes. Then seed is planted with a planting distance of 20cm x 30 cm. During planting, Furadan is first sown into the planting hole before the seed.

c. Fertilisation

Fertilisation is done twice; the first fertilisation is done 14 days after planting using NPK fertiliser with a dose of 100 kg/ha. The second fertilising is done after plant reaches 35 days after planting with a dose of 100 kg/ha of NPK fertiliser.

d. Treatment and Maintenance

Maintenance is done starting from removal of dead plants up to two weeks after planting, watering of plants with watering cans or sprinkler, weeding through mechanical means, spraying of fungicide and insecticide according to the recommended dose on the label. Watering is continued on according to the plant condition and is conducted once a week during seed filling phase.

e. Harvesting

Harvesting is conducted when all pods have reached maturity that is when the colour turns brownish-yellow. Harvesting is also conducted when the soybean leaves turn brownish-yellow. Harvesting is done by plucking all plants and collected in a container.

5. Observation

a. Flowering age (days)

Flowering age of F3is counted from planting and flowering age on the elder plants is counted from the day of planting until 75% of the population have flowered.

b. Harvest age (days)

Soybean harvest age is counted since the day of planting until 75% of soybean plants on each row are ready to be harvested.

c. Plant height (cm)

Plant height is measured from the stem to the growing point of the plant. Measuring is done by using a measuring tape after the plant has been harvested.

d. Number of productive branches (branches)

Number of productive branches that are counted are the number of branches that produces pods.

e. Number of seeds per plant (pods)

Number of seeds is counted from all seeds that have empty pods as well as filled pods.

f. Seed weight per plant (g)

Dry seed weight is measured by weighing all seeds using an electronic scale in grams.

g. Weight of 100 seeds (g)

The weight of 100 seeds is measured after harvesting by weighing 100 seeds after having being dried out.

4. Results and Discussion

Based on the results of the research conducted using the pedigree selection, in Raya Usang Village. Seeds that were planted were F2 from the crossing of Argomulyo and Tanggamus totalling 240 plants. While the number of Argomulyo elder plants were 180 plants and Tanggamus elder plants were 180 plants. The replanting of F2 results in F3 of which its characters are shown in Table 1.

Table 1. Mean character value of the F3 Population (Argomulyo x Tanggamus)

Character	Argomulyo	Tanggamus	F3	Seed planted (F2)
Plant height	34,04 ± 7,49	57,63 ± 6,58	40,58 ± 8,04	65
Branches	3,48 ± 1,23	6,16 ± 1,11	4,01 ± 0,99	6
Pods	40,57 ± 13,23	111,28 ± 32,35	41,12 ± 13,34	87
Plant age	37 ± 0,00	47 ± 0,00	35,45 ± 0,69	31
Harvesting age	99 ± 0,00	113 ± 0,00	90,99 ± 1,54	88
Seed weight	19,21 ± 6,79	36,35 ± 11,14	19,002 ± 6,82	29,2
Weight of 100 seeds	21,16 ± 2,79	14,92 ± 2,08	18,16 ± 5,56	17,11

From Table 1, it can be seen that in the F3 population, the plant height, number of branches, number of pods, plant age and harvesting age tends to follow the Argomulyo elder while the weight of 100 seeds follows the Tanggamus elder. In the F2 population it can be seen that in some characters, improvements can be seen in plant age, harvesting age, seed weight and weight of 100 seeds. From the table above it can be seen that there is an improvement in the mean values from the results of the crossing. The fact that the mean values of the F3 were in between the elder plants shows that their characteristics come from the combination of the elders' characteristics.

Table 2. Genetic Variety (σ^2G) dan Genotypic Coefficient of Variability (GCV) on the F3 Population. GCV variety value grouping, Low: GCV < 7% , Medium: 7% ≤ GCV ≤ 14% dan High: GCV > 14%.

CHARACTER	(σ^2g)	GCV (%)	CRITERIA
Plant Height	64,1448	19,7389	High
Number of Branches	0,98455	24,7288	High
Number of Pods	171,2904	31,8244	High
Plant Age	0,475	0,475	Low
Harvesting Age	2,36	2,36	Low
Seed Weight	45,7364	35,5903	High
Weight of 100 Seeds	24,8275	27,4757	High

Genotypic Coefficient of Variability (GCV) in Table 2 shows that characters with a high value are found in the plant height, number of branches, number of pods, seed weight and weight of 100 seeds whereas low GCV values can be found in the plant age and harvesting age. According to Bahar dan Zen (1993) inSetyoet al., (2016) characters with a broad variability value can be used to improve genotype and can also improve the potential of the genetic characters on the next generation in which selection on those characters can be more effective. Characters with a low to medium Genotypic Coefficient of Variability value shows that the difference in genetics in that character have a much smaller variety or in other words the variety is almost uniform.

Genotypic Coefficient of Variability (GCV) describes how broad the genetic variety a character possesses. According to Bahar dan Zen (1993) inSetyoet al., (2016), they state thatGenotypic Coefficient of Variability is used to measure a specific character's genetic variety and to compare the genetic varietyof a plant's trait. A high Genotypic Coefficient of Variability value shows the possibilities of effective efforts to improvements through selection. Coefficient variability is a benchmark of character variability that is observed in a population that is being studied upon. The criteria of whether a population has a high or low variability is based on the Genotypic Coefficient of Variability.

Table 3. Heritability value for all characters in the F3 population

CHARACTER	H2	CRITERIA
Plant Height	1	High
Number of Branches	0,98	High
Number of pods	0,96	High
Plant age	1	High
Harvesting age	1	High
Seed weight	0,98	High
Weight of 100 Seeds	0,8	High

The heritability value in table 3 shows that all characters possess high values. The high heritability values shows that genetic factors highly influence the appearance of the characters. By obtaining heritability values, one can also predict the selection progress rate to improve yield in the next selection. The higher the heritability value and accompanied by higher genetic improvement values, the more effective the selection process shall be.

The inheritance of a plant's character is known from its heritability value. The heritability value decides the success in selection because it can be used as a guide to a certain character whether it is influenced by environmental or genetic factors. According to Hermanto et al., (2017) in Hidayat & Adiredjo, (2020) the heritability value must be known as it is useful to predict the progress of a certain selection and to determine whether a plant's character is influenced by genetic or environmental factors.

The pattern of distribution of plant height and the number of branches and number of pods is shown in figures 2 and 3 respectively. The flowering age and harvesting age, seed weight and weight of 100 seeds is shown in figures 4 and 5 respectively.

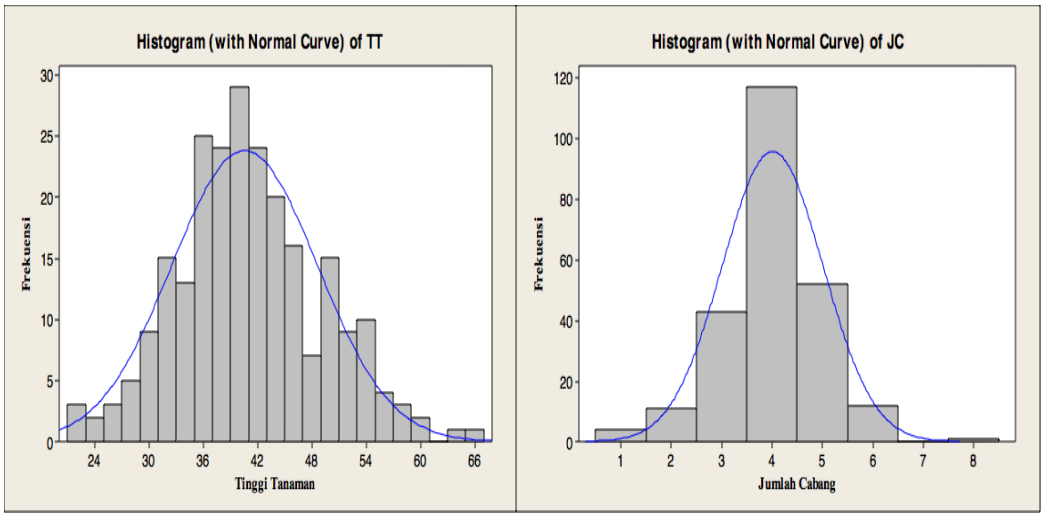

Figure 2. The pattern of distribution of plant height and number of branches

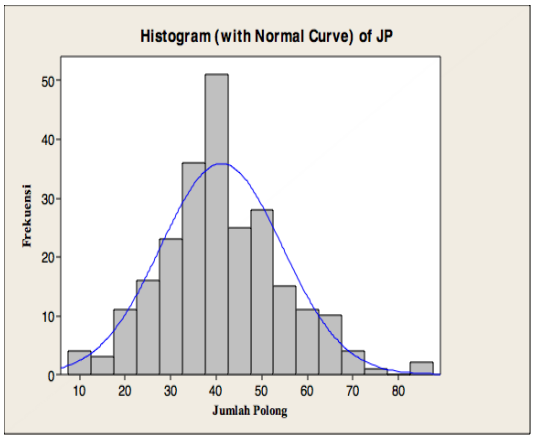

Figure 3. The pattern of distribution of the number of pods

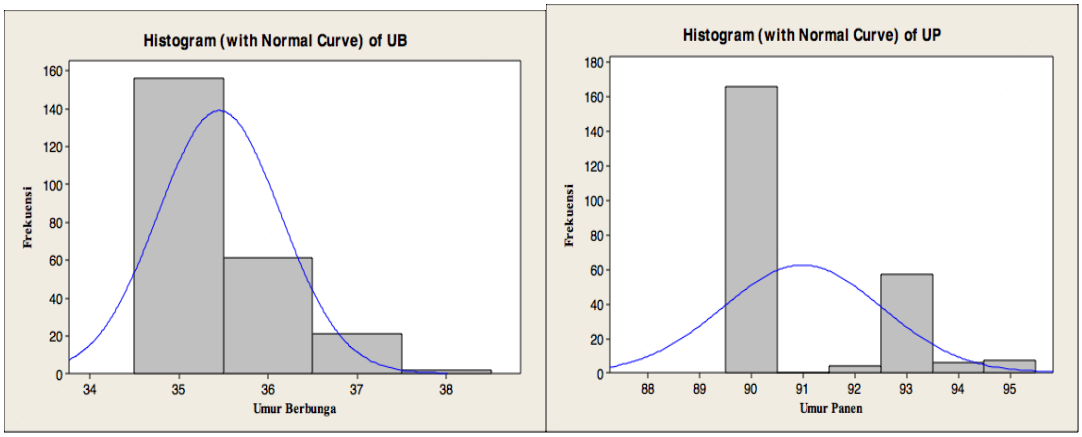

Figure 4. The distribution pattern of plant and harvesting ages

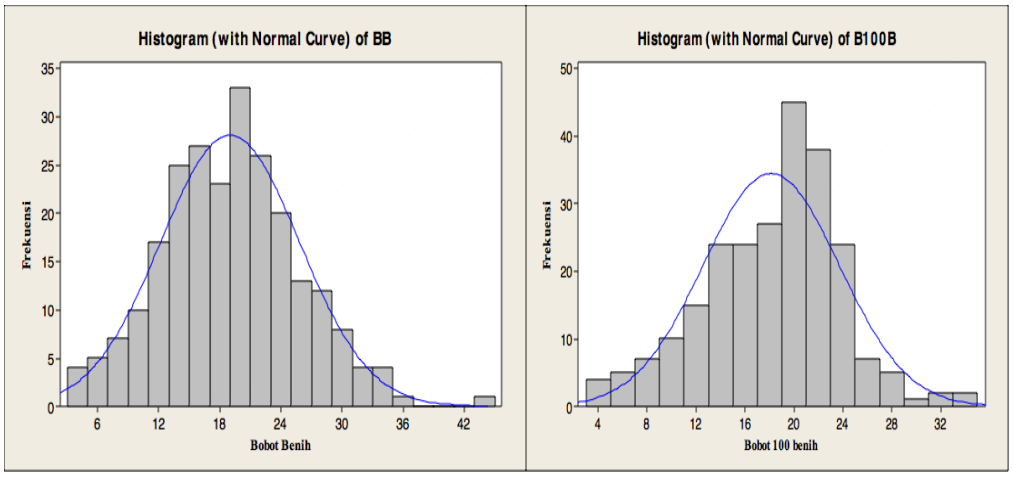

Figure 5. Distribution pattern of seed weight of plants and weight of 100 seeds

Graphs showing a normal distribution is found in the plant height, number of branches, flowering age and harvesting age whereas an uneven distribution is found in the number of pods, seed weight and weight of 100 seeds. Characters with the uneven distribution are highly influenced by environmental factors.

Based on the selection which was done by pedigree in the F3 population, to determine the promising lines that are to be developed as the superior variety, the characters with highest values are selected. Th results from the highest yield are shown in Table 4.

Table 4. Genotype numbers of promising lines

NO	Genotype	Seed weight/plant (g)
1	181	44,02
2	123	35,28
3	196	34,89
4	113	34,21

5	116	33,89
6	162	33,87
7	104	32,97
8	39	32,53
9	69	32,44
10	200	31,53
11	227	30,93
12	70	30,3
13	221	30,25
14	63	30,15
15	128	30,13
16	15	29,96
17	99	29,64
18	66	29,56
19	52	28,99
20	184	28,69

The research method used is the pedigree selection, based on observed characters that support the production which is in the seed weight, there were 20 genotypes selected that yielded the highest seed weight. The results using the seed weight shown in Table 4 shows that the genotype with the highest seed weight (44,02 g) was found in genotype number 181, while the genotype with the lowest seed weight (28,69 g) was found in genotype number 184.

5. Conclusion & Recommendation

1. Conclusion

a) Based on the results of this research it can be concluded that agronomic characteristics on F3 have not formed any superior variety.
b) Agronomic characters on F3 based on the GCV value shows that plant height, number of branches, number of pods per plant and seed weight were categorised as high. The flowering age and harvesting age were categorised as low.
c) Heritability value on F3 was obtained in which plant height, number of branches, number of pods per plant and harvesting age were categorised as high whereas the flowering age was categorised as low.
d) Expected strain genotypes based on seed weight through selection method with genotype numbers 181, 123, 196, 113, 116, 162, 104, 39, 69, 200, 227, 70, 221, 63, 128, 15, 99, 66, 52 and 184.

2. Recommendation

Researchers recommend further research through multi-location testing to ensure the creation of new superior variety with high productivity in various locations.

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