International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 8, Issue 5
May, 2021
Pages: 1-11

Estimation of Heritability of Several Genotype of Soil (Arachis Hypogaea L.) and Tolerance Test of Shade and Drought Stress

Marsinah; A. Farid Hemon; Lestari Ujianto

Master Program of Dry Land Agriculture, Mataram University, Indonesia

http://dx.doi.org/10.18415/ijmmu.v8i5.2517

Abstract

This study aims to determine the heritability estimation of several peanut genotypes and to test tolerance to shade and drought stress. The research was carried out in 3 stages, the first stage from May to July 2019 in Sigerongan village, Lingsar District, West Lombok Regency, the second phase from August to October 2019 in Sigerongan village, Lingsar District, West Lombok Regency, and the third stage from July to September 2020 in Nyiurlembang village, Narmada District, West Lombok Regency, West Nusa Tenggara. The experimental design used in estimating heritability was a randomized block design (RAK) consisting of 20 peanut genotypes, namely G2T5, G3D6, G2D2, G5-UII, G300-II, G2T3, G11-UI, G3T4, G200-I, and G12. -UI, G2T1, G2D7, G3T10, G3D8, G7-UII, G7-UIII, G3T7, G16-UI, G7-UI and G2D3. Tolerance test of peanut genotypes to shade and drought stress used a Randomized Block Design (RBD) with a Split Plot Design. The results showed that the genetic diversity value of peanut genotypes against the tested parameters showed that all peanut genotypes were ineffective for further tests on the parameters of plant height, number of leaves and number of branches, while the parameters of the number of filled pods and dry weight of pods all genotypes showed moderate criteria which means that it is effective for further selection. Shade treatment was more influential than treatment without shade. The parameters of pod dry weight and number of filled pods showed a significant difference between the two. Genotypes sensitive to shade stress are G2T5, G3D6, G2T3, G200-I, G2T1, G2D7, G3D8, G7-UII, TAKAR, G3T7, mildly tolerant genotypes, namely G2D2, G5-UII, G300-II, G11-UI, G3T4, G12-UI, G3T10, G7-UI, and G2D3 and the shade tolerant is G16-UI. Plant genotypes that were sensitive (P) to drought stress were G2T5, G3D6, G2D2, G5-UII, G2T3, G11-UI, and G3T4. And the genotypes that are somewhat tolerant are G200-I and G12-UI. Meanwhile, the drought tolerant genotype was G300-II.

Keywords: *Peanut; Heritability Estimation; Shade Stress; Drought Stress*

Introduction

Peanuts (Arachis hypogaea L.) is a leguminosa plant that is quite important in Indonesia, where about 20% of the protein consumed by Indonesian households comes from legume crops, especially soybeans and peanuts, therefore the demand for peanuts continues to increase both for consumption and the food industry. National peanuts in 2013-2015 tend to continue to decline by 701,680 tons in 2013, 638,896 in 2014 and 605,449 tons in 2015 with average productivity still around 1.3 t/ha, where productivity is fairly lower when compared to potential yields reaching 4.3 t/ha (BPS, 2018; Deptan, 2013). The decrease in peanut production in 2013-2015 occurred due to a decrease in harvest area. The high demand for peanuts in the country that is not affected by increased productivity and production causes the government to continue to import 125,636 tons (Deptan, 2016).

Peanut plants are also widely developed under the establishment as intermittent plants (intercropping) in addition to being developed on dry land. Suparman and Abdurrahman (2003) reported peanuts are plants that are responsive to shade. The response of plants in the shaded environment is determined by the tolerance of plants to the reduction of light intensity. One of the influences of shade on the morphology of plants is that the stems of plants become higher because the stems of plants are ethiolasi (Uchimiya, 2001). In addition, shade can also affect the initial growth of plants. Plants that experience shade at the beginning of growth have characteristics such as long hypocotyl, closed cotiledon, low chlorophyll content, and low levels of photosynthetic gene expression (Baharsyah, 1985). Lack of light received by plants will cause physiological disorders, especially the decrease in the rate of photosynthesis which further results in low productivity of plants.

Dry land conditions often cause problems in peanut farming, which is very influential on peanut productivity. In the state of water deficit, the area of peanut plant leaves will be reduced when compared to optimum conditions. Collino et al. (2000) and Chapman et al. (1993) reported water insecurity led to a reduction in the biomass of dried leaves and peas as well as a decrease in the weight of dried pods thought to be due to the inhibition of the process of initiation and lengthening of ginophores, thus lowering crop yields but the magnitude of the decrease in yield depends heavily on cultivated peanut cultivars (Jogloy et al. 1996; Boote and Ketring, 1990). Other studies have also shown that groundwater deficiency reduces the growth of peas and peanut seeds by 30% and seed weight reduction by approximately 428-563 mg (Sexton et al., 1997).

Efforts to overcome drought and shade are to use drought-tolerant genotypes and shade through hybridization. Previous research has obtained several drought-tolerant mutant genotypes namely G300-II and G200-I (Hemon et al., 2012-2016). This genotype wants to be improved in a shade-tolerant nature. Crosses of G300-II with Bison cultivars (shade tolerant) and G200-I with Bison cultivars (shade tolerant) have been performed. This research has produced a derivative of the genotype F1. Then hemon research, et al (2018) conducted a cross of drought-tolerant genotypes namely G300-II and G200-I with cultivars Bison, Sheep and Takar produce derivatives F2. These generations need to know their genetic diversity and heritability.

Wide genetic diversity and high heritability are among the requirements for effective selection (Hakim, 2010). High heritability values indicate genetic factors play more role in controlling a trait compared to environmental factors (Barmawi et al. 2013). Heritability determines the progress of selection, the greater the value of heritability the greater the progress of selection, and vice versa. Character selection must have high diversity and heritability, in order to obtain the target of selection progress (Lubis et al., 2014).

Based on the description above, the purpose of this study is to find out the coefficient of genetic diversity and heritability of some peanut genotypes, as well as its tolerance to shade and drought.

Method

The design used in the heritability estimation study is a RandomIzed Group Plan (RAK) consisting of 20 genotypes namely G2T5, G3D6, G2D2, G5-UII, G300-II, G2T3, G11-UI, G3T4, G200-I, and G12-UI, G2T1, G2D7, G3T10, G3D8, G7-UII, G7-UIII, G3T7, G16-UI, G7-UI and G2D3. Each treatment is repeated 3 times. Analysis of the value of broad meaning heritability using formulas according to Singh and Chaudhary (1985): Variety of genotypes (σ_g^2)= $\frac{KTg-KTe}{r}$, Variety of phenotypes (σ_p^2)= $\sigma_g^2 + KTe$, The expected value of heritability (H^2)= $\frac{\sigma_g^2}{\sigma_p^2}$. Falconer (1989) in Sutjahjo (2007), a measure of genetic variability can be expressed in kkg, the following formula:

KKG = $\frac{\sqrt{\sigma^2_{Gx}}}{\bar{x}}$ x 100 %. The implementation of research includes seed preparation, planting media preparation, fertilization, watering, weeding, harvesting, sampling and observation. There are 5 observation parameters namely the height of the plant (cm), the number of leaves (strands), the number of branches (strands), the dry weight of the pods (g) and the number of fill pods (g). Planting is done with a length of approximately 3 m, and a width of 50 cm.

The design used in the study of tolerance test to shade safety is RAK Split Tile with two factors, namely: Shade (T, as the main tile) consisting of 2 levels (T0= without shade; T1= with shade), and peanut genotype (G, as a plot child) consisting of 20 levels: G2T5, G3D6, G2D2, G5-UII, G300-II, G2T3, G11-UI, G3T4, G200-I, G12-UI, G2T1, G2D7, G3T10, G3D8, G7-UII, G7-UIII, G3T7, G16-UI, G7-UI and G2D3, respectively repeated 3 times. The implementation of research includes seed preparation, planting media preparation, fertilization, watering, weeding, harvesting, sampling and observation. There are 5 observation parameters namely the height of the plant (cm), the number of leaves (strands), the number of branches (strands), the dry weight of the pods (g) and the number of fill pods (g). Planting is done with a length of approximately 3 m, and a width of 50 cm. The shade is made with a height of 3 m, a width of 8.5 m and facing east west. coated with 65% black paranet.

Calculation of Sensivity (S) values based on fischer and maurer formula (1978), i.e.:

S=((1-Y/Yp))/((1-X/Xp))

Description:

Y = The average value of certain changes (eg: number of branches, height of plants, etc.) in one genotype that experiences shade insecurity.

Yp = The average value of the change in one genotype of the optimum environment.

X = The mean value of the modifier on all genotypes that experience shading.

Xp = The average value of the change in all genotypes of the optimum environment.

Score or Score:

A = Tolerant genotype of shade if it has a value of $S < 0.5$.

B = Somewhat tolerant if $0.5 \geq S \leq 1$.

C = Sensitive if $S > 1$.

The design used in the research tests tolerance to drought insecurity is RAK Split Tile with two factors, namely drought safety (N) as the main tile that is attached to two levels, namely (N0= without drought treatment; N1= with drought treatment), peanut genotype (G) as a plot consisting of 10 levels, namely: G2T5, G3D6, G2D2, G5-UII, G300-II, G2T3, G11-UI, G3T4, G200-I, and G12-U. Each treatment is repeated 3 times. Planting is done in polybags, and irrigation by means, all plants are watered to a roomy capacity from the beginning of planting until the age of 14 days. Airy capacity is determined by watering the planting medium until saturated. Water saturation is indicated by dripping water on the polybag base aeration hole. Drought-stricken treatment is given starting from plants aged 15 days after planting until 85 Days After Planting (HST). When the plant enters the age of 15 HST, some plants do not experience drought insecurity (plants in the condition of land lengas field capacity) and some are maintained in drought-stricken conditions partly due to reduced water delivery. Drought-stricken plants are watered to an airy capacity once every 4-7 days (a day after 70% of the symptoms of withering on the leaves). Drought-stricken treatment is given until the plant is 85 days old. The next plant is given optimum conditions until the harvest plant (Hemon, 2006). The implementation of research and calculation of sensivity value (S) in tolerance test to drought insecurity is the same as tolerance test to shade safety.

Results and Discussion

1. Heritability Estimation

In Table 1 it appears that the suspected value of the genotype heritability of peanuts to the height of the plant indicates a "low" criterion which means that the criteria provide little chance of improvement through selection. The dry weight of the pods and the number of fill pods indicate "moderate" criteria which means that it can provide opportunities for improvement. In Table 2 it is seen that the coefficient value of genetic diversity of peanuts against the height of plants and the dry weight of pods shows a "rather low" criterion. The number of fill pods indicates the "high" criteria. This indicates that in selection activities with a rather low variability of traits resulting in selection activities can increase genetic progress, so that the opportunity for improvement efforts through selection in the selection of the desired genotypes is effective.

Table 1. The Expected Value of Broad Meaning Heritability (H2) for Five Genotype Parameters of Peanuts

No	Parameter $\sigma^2_{G=((KTG-KTE)/r)}$	σ^2_G	σ^2_P	H^2	Criteria
1	Plant Height (cm)	2,966	18,801	0,157	Low
2	Number of Leaves (strands)	-19,869	157,003	-0,126	***
3	Number of Branches (strands)	-0,037	1,310	-0,028	***
4	Dry Weight Pods (g)	10,763	46,656	0,230	Medium
	Number of Fill Pods (g)	6,162	13,927	0,442	Medium

Description : σ_g^2 = genetic variety; σ_p^2 = phenotype variety; H2 = heritability; Dayability criteria (H2): low = < 0.2; Medium = > 0.2 - > 0.4; height = > 0.5. = Data is not worth analyzing because the KTG value (treatment middle square) is smaller than the KTE (Middle square of error) value (Whirter, 1979)

Sutaryo and Sudaryono (2010) in their research stated that the expected value of moderate to high heritability plays a role in improving the effectiveness of selection. In characters that have high heritability selection will run effectively because the influence of the environment is so small that genetic factors are more dominant in the appearance of plant genotypes. In characters with low heritability, selection will be relatively less effective, because the appearance of plant phenotypes is more influenced by environmental factors compared to genetic factors.

Purba et al. (2013) states that high heritability values indicate that genetic factors have a greater influence than environmental factors. The value of moderately crimined heritability indicates that the influence of environmental factors is as great as the influence of genetic factors, while the value of low-critical heritability indicates that the variability caused by environmental factors is greater than that of genetic variability. It is supported by Hanafiah et al. (2016) that high heritability values are caused by relatively homogeneous environments, while low heritability values are caused by non-homogeneous environments. This suggests the appearance of a character with high heritability is more influenced by genetic factors than environmental factors.

Based on the value of heritability in Table 1 obtained negative values on the number of leaves and the number of branches. This is in accordance with Allard's explanation (1960). The genetic variety value is negative, because the middle square value of the genotype is smaller than the middle squared value of the error. Or it could be said that the parameters of the number of leaves and the number of branches tend to be uniform.

Table 2. Genetic Diversity Coefficient Value (KKG)

No	**Parameter**	**KKG**	**Criteria**
1	Plant Height (cm)	9,161	Somewhat Low
2	Number of Leaves (strands)	0	***
3	Number of Branches (strands)	0	***
4	Dry Weight Pods (g)	7,031	Somewhat Low
	Number of Fill Pods (g)	17,829	High

Description: KKG = coefficient of genetic diversity; Kreteria KKg (%) low: 0 %-6.8%; low: 6.9 %- 13.6 %; somewhat high: 13.7 %- 22%; height: > 22%. = Data is not worth analyzing because the KTG value (Middle square of treatment) is smaller than the KTE value (Middle square of error) (Sofi, 2008)

According to Suwardi (2002) in his research stated that the high low value will describe the reality of diversity of a character. The low diversity value indicates that individuals in the population tested tend to be uniform. While the value of moderate or somewhat low to high diversity indicates that individuals in the population need to make improvements through subsequent selection.

Hapsari (2016) states that the more diverse individual traits in a population, the higher the frequency of desired genes, while the high genetic diversity indicates that individuals in the population need to make further improvements through selection.

The coefficient of genetic diversity is a measure to determine whether the observed material has a large genetic variety or not. This is related to the selection activities that will be conducted in the population to be observed so that the breeder is very interested in this value. A large coefficient of genetic diversity indicates that genetic manipulation performed on a trait that has such a coefficient will have a great chance of being achieved, while traits that have a small coefficient of genetic diversity will give a very small chance of success if the traits are improved (Samsudin and Saleh, 2009).

2. Tolerance Test for Shade Safety

Based on fischer and maurer formula (1978) obtained several genotypes of peanuts that are tolerant of shade. In Table 3, it is seen that the genotype of plants that are sensitive (P) to the sunken shade is G2T5, G3D6, G2D2. Somewhat Tolerant Genotypes (AT) are G2T3, G11-UI,G3T4,G3T10,G7-UII,G7-UIII, G3T7. Plant genotypes that are tolerant of shade check are G7-UI, G16-UI, G2D7, G2T1, G12-UI, G200-I, G300-II, and G5-UII.

Peanuts are plants that are resistant to shade and the roots are able to bind nitrogen (N2) from the air through symbiosis with rhizobium bacteria (Adisarwanto, 2003). Based on the research of Suparman and Abdurrahman (2003), peanuts are plants that are responsive to shade. The response of plants as a result of environmental factors is seen in the appearance of plants (performance). Plants try to meet their life needs in the form of morphological, physiological or anatomical responses. The same genotype, in different environments the appearance can be different.

Table 3. Sensibility Index Value of twenty Peanut Genotypes tested on Shade Safety and no Shade

No	**Genotypes**	**Sensivity Value (S)**		**Average**	**Phenotype**
		BKP	**JPI**		
1	G2T5	1,95	2,19	2,07	P
2	G3D6	2,38	2,15	2,26	P
3	G2D2	1,04	1,39	1,21	P
4	G5-UII	0,83	0,04	0,43	T
5	G300-II	0,30	0,28	0,29	T
6	G2T3	1,43	0,12	0,78	AT
7	G11-UI	1,36	0,12	0,74	AT
8	G3T4	1,57	0,42	1,00	AT
9	G200-I	0,41	0,56	0,49	T
10	G12-UI	0,24	0,02	0,13	T
11	G2T1	0,12	0,6	0,14	T
12	G2D7	0,44	0,5	0,40	T
13	G3T10	1,18	0,1	0,59	AT
14	G3D8	1,52	3,8	2,70	P
15	G7-UII	0,83	0,2	0,58	AT
16	G7-UIII	1,52	0,5	0,98	AT
17	G3T7	0,83	0,4	0,58	AT
18	G16-UI	0,50	0,8	0,29	T
19	G7-UI	0,35	0,0	0,37	T
20	G2D3	2,43	0,38	1,41	P

Description: S=Sensitivity Index Value; T= Tolerant (< 0.5); AT= Somewhat Tolerant (> 0.5 S < 1); P= Peka (S > 1); BKP= Dry Weight Pods; JPI= Number of Fill Pods

Hanafi et al. (2005) stated that the treatment of shade level has no noticeable effect on the production of fresh ingredients and the production of dry green ingredients. Sundari et al. (2005) mentions the yield of green beans in the shade 75% decreased the yield of green beans reached 65.21% when compared to without shade, but when compared to the shade 50% green bean yield only down 34.01%. The results of hemon et al. (2020) showed that the sunken shade given from the beginning of the plant to the harvest resulted in a longer segment of peanut plant stems. Sundari et al. research (2015) reported that shade intensity up to 75% increases plant height and reduces the number of leaves in soybean crops.

Shade has less effect on both growth and crop yields, where the higher the shade rate of plant growth and yields such as the number of leaves per plant, the number of branches per plant, the percentage of the number of fill pods per plant, the number of pods per plant, the weight of dried seeds per plant, the weight of 100 seeds, except the height of the plant is decreasing, except in the parameters of height of plants where the shade is getting tighter makes the plant higher. The density of shade results in poor plant growth (Herdiana et al., 2008). Shade that is too tight for plants that require light will cause ethiolasi, disruption to growth and even death for tolerant plants. In addition, photosynthesis factors can affect the growth and yield of plants as revealed by Arissworo (2006) that photosynthesis is the process of converting certain organic matter into organic food, where sunlight is a source of energy to be used as plant foodstuffs. Sunlight is an energy source in the process of photosynthesis, so it can affect vegetative and generative growth (Cahyono, 2002).

Photosynthesis is the process of forming carbohydrates from CO2 and H2O in green leaves with the help of solar energy. Carbohydrate production will increase with increased nitrogen nutrients, as well as nitrogen will be utilized by plants to synthesize proteins. Carbohydrates and proteins that are components of dry ingredients of plants so that the increasing formation of proteins and carbohydrates will increase the production of dry forage ingredients (Humphreys, 1978). According to Salysbury and Roos (1995) there are several factors that affect plant photosynthesis, namely: water (H2O), carbon dioxide (CO2), light, nutrients and temperature.

Plants classified as C3 and C4 exhibit the same morphological response to shade, but photosynthesis responses differ from shade. In the shade-resistant grass group has a higher content of N leaves than those sensitive to shade (Kephard and Buxton, 1993). According to Haris (1999), the increase in leaf area is one of the mechanisms of tolerance to shade to obtain higher light or optimization of light reception by plants. Shade can increase the proportion of leaves and cause the leaf area to spread more throughout the canopy.

3. Tolerance Test for Drought

Based on fischer and maurer formula (1978) obtained several genotypes of peanuts that are tolerant of shade. In table 4, it appears that the genotype of plants that are sensitive (P) to the sunken shade are G2T5, G3D6, G2D2, and G5-UII. Somewhat Tolerant Genotypes (AT) are G200-I and G12-UI. Genotype of plants that are tolerant of drought is G300-II.

Drought in the field affects the yield of peanut pods with yield losses ranging from 3-95% (Kasno et al. 1995). A real drought check lowers the yield of peanut pods when they occur in the entire generative phase. Peanut plants that experience drought in the vegetative phase can then be overcome in the development phase of the pods will give the same pod yield (Kumaga et al., 2003). Drought in the cooking phase of pods does not decrease the yield of peanut pods (Rahmianna et al., 2009).

Table 4. Ten Genotypes of Peanut Sensivity Index Values tested on Drought And No Drought

No	Genotypes	Sensivity Value (S)				Average	Phenotype
		BKP	JPI	BA	PA		
1	G2T5	0,11	2,45	1,04	0,65	1,06	P
2	G3D6	0,42	3,96	1,04	1,63	1,76	P
3	G2D2	2,37	1,72	0,31	0,13	1,13	P
4	G5-UII	2,09	1,89	1,40	0,64	1,51	P
5	G300-II	0,36	0,23	0,00	0,41	0,25	T
6	G2T3	2,33	1,28	1,79	1,35	1,69	P
7	G11-UI	1,10	2,71	1,13	1,76	1,68	P
8	G3T4	2,13	5,94	0,28	0,58	2,23	P
9	G200-I	1,25	0,19	0,42	1,25	0,78	AT
10	G12-UI	0,85	0,22	1,19	0,81	0,77	AT

Keterangan: S=Nilai Indeks Sensitivitas; T= Toleran (< 0,5); AT= Agak Toleran (> 0,5 S < 1); P=Peka (S > 1);; BP= Berat Kering Polong; JPI= Jumlah Polong Isi; BA= Berat Akar; PA= Panjang Akar; R= Rerata; G= Genotipe

Water safety is associated with dryness, photosynthesis, mineral nutrients, metabolism, growth and peanut yield (Devaiah et al., 2007). The availability of water in green bean plants has a real effect on physiological and metabolic processes in plants. The plant's response to water dryness is generally indicated by a decrease in the concentration of leaf chlorophyll. Decreased chlorophyll content at a time when plants lack water is related to the acuity of photosynthetic devices and decreases the rate of photosynthesis of plants. Lack of water will affect the content and organization of chlorophyll in chloroplasts in tissues (Song et al., 2011).

The content of prolina leaves is one of the mechanisms of plants to prevent the negative influence of drought. prolina content increases in line with increasing drought insecurity (Yang and Kao 1999). According to Clanssen (2005) in his research stated that proline is an indicator of plants experiencing water stress. In moderate to severe water deprivation conditions, the concentration of proline amino acids increases compared to other amino acids (Gardner et al., 1991). Furthermore, Fitranty et al. (2003), stated that in drought conditions, proline oxidation will be inhibited, so that proline production will increase and in the presence of pscs genes proline production is increasing because pscs enzyme triggers glutamate catalysis to proline.

Water limitation is one of the factors in the process of photosynthesis in plant tissues that will reduce the rate of growth speed that basically by administering drought insecurity can decrease dry weight. Barus and Yusuf (2004) reported in his research that the influence of the length of time of watering showed a noticeable reduction in the dry weight of plants. The longer the watering time the more tingi reduction of dry weight of plants, the length of watering time significantly decreases dry weight and total absorption N. This is due to water limitation as one of the factors in the process of photosynthesis and metabolism in plant tissues will reduce the rate of growth speed.

The first response of plants in response to severe water deficit conditions is by closing the stomata. The decrease in turgor pressure that coincides with the increase of free abscess acid on the leaves leads to narrowing of the stomata. The closure and/or narrowing of the stomata inhibits the process of photosynthesis, this concerns the transportation of water in the body of plants and the decrease in the flow of carbon dioxide on the leaves. The decrease in the concentration of carbon dioxide in the leaves affects the mobilization of starch and potentially increases respiration. Plants will reduce the use of carbohydrate reserves to maintain their metabolic processes, and this triggers a lack of carbon so that plants will experience a decrease in growth and the longer the plant will experience death (Anggraini et al., 2015).

Conclusion

The suspected heritability of peanut genotypes indicates a low criterion of plant height, which indicates the medium criteria of dry weight of pods and the number of filled pods. The expected value of negative heritability is indicated by the number of leaves and the number of branches. The value of the coefficient of genetic diversity (KKG) which indicates a rather low criterion is the height of the plant and the dry weight of the pods, which indicates the high criteria that is the number of fill pods. The coefficient of genetic negative diversity is indicated by the number of leaves and the number of branches. Sensitive peanut genotypes (P) to shade insecurity are G2T5, G3D6 and G2D2. Rather tolerant genotypes (AT) are G2T3, G11-UI, G3T4, G3T10, G7-UII, G7-UIII, G3T7. Tolerant genotypes (T) include G7-UI, G16-UI, G2D7, G2T1, G12-UI, G200-I, G300-II, and G5-UII. Peanut genotypes that are sensitive (P) to drought insecurity are G2T5, G3D6, G2D2, G5-UII, G2T3, G11-UI, and G3T4. Rather tolerant genotypes (AT) are G200-I and G12-UI. The genotype that is tolerant (T) to drought is G300-II. Peanut genotype that is also tolerant of shade and drought, namely G300-II.

References

Adisarwanto T. 2003. *Meningkatkan Produksi Kacang Tanah di Lahan Sawah dan Lahan Kering.* Penebar Swadaya, Jakarta.

Allard, R.W. 1960. *Principles of plant breeding*. John Wiley & Sons Inc., New York. 485p.

Anggraini, Novita., Faridah, Eny., Dan Indrioko, Sapto. 2015. *Pengaruh Cekaman Kekeringan Terhadap Perilaku Fisiologi Dan Pertumbuhan Bibit Black Locust (Robinia Pseudoacacia).* Jurnal Ilmu Kehutanan. Vol. 9 No. 1 Hal : 41-46.

Arrisworo, D.2006. *Ilmu Pengetahuan Alam*. Grafindo. Jakarta.

Baharsyah, J. S, Suwardi, D dan Irsal Las. 1985. *Hubungan Iklim dengan Pertumbuhan Kedelai*.Badan penelitian dan pengembangan tanaman pangan.Pusat penelitian dan pengembangan tanaman pangan. Bogor.

Barmawi, M., A. Yushardi, dan N. Sa'diyah. 2013. *Daya waris dan harapan kemajuan seleksi karakter agronomi kedelai Generasi F2 hasil persilangan antara Yellow bean dan Taichung*. J. Agrotek Tropika 1(1):20-24.

Barus J, Yusuf K. 2004. *Seed yield determination of peanut crops under water deficit: Soil strengtheffects on pod set, the source–sink ratio and radiation use efficiency*. Field Crops Research 109: 24–33

Badan Pusat Statistik. 2018. *Badan Pusat Satistik Indonesia*. http://www.bps.go.id. [28 November 2018].

Cahyono, B. 2002. *Wortel Teknik Budidaya dan Analisis Usaha Tani*. Kanisius. Yogyakarta.

Chapman SC, Ludlow MM, Blamey FPC, Fisher KS. 1993. *Effect ofdrought at pod filling on utilization of water and growth of cultivarsof groundnut*. Field Crop Res 32: 243-255.

Collino DJ, Dardanelli JL, Sereno R, Racca RW. 2000. *Physiologicalresponses of argentine peanut varieties to water stress*. Water uptakeand water use efficiency. Field Crop Res 68: 133-142.

Deptan. 2013. *Budidaya Aneka Kacang dan Umbi Irektorat Jenderal Tanaman Pangan.*

Deptan. 2016. *Produksi, Luas Panen, dan Produktifitas Padi Palawija*. Departemen Pertanian. Jakarta. httpwww.pertanian.go.id. Indikator tabel-1-prod-lspnprodvitas-padi-palawija. Diunduh: 22 Oktober 2016.

Devaiah, K.M.; G. Bali, T.N. Athmaram, and S.M. Basha. 2007. *Identification of Two New Genes from Drought Tolerant Peanut Up-Regulated in Responsse to Drought*. Plant Growth Regulation. 52:249–258.

Falconer, D.S. 1989. *Introduction to Quantitative Genetics*. Longman. London.

Fitranty, N., F. Nurilmala, D. Santoso, H. Minarsih. 2003. Agobacterium neutransfer gen PSCS ke dalam kalus tebu klon PS851. Menara Perkebunan 71: 16-27.

Fischer R.A dan Maurer R. 1978. *Drought Resistence in Spring Wheat Cultivars. I.Grain Yield Responses.* Aust J Agr Res 29:897-912.

Gardner, F.P.R.1991. *Fisiologi Tanamanan Budidaya*. Universitas Indonesia Press: Jakarta.

Hakim, L. 2010. *Keragaman genetik, heritabilitas dan korelasi beberapa karakter agronomi pada galur F2 hasil persilangan kacang hijau (Vigna radiate (*L.*) Wilezek).*Pusat Penelitian dan Pengembangan Tanaman Pangan Bogor. Berita Biologi 10(1)-April 2012.

Haris A. 1999. *Karakteristik Iklim Mikro dan Respon Tanaman Padi Gogo pada Pola Tanam Sela dengan Tanaman Karet* (Tesis). Bogor: Progam Pascasarjana, Institut Pertanian Bogor.

Hanafi, D.N., S. Umar dan I. Bachri. 2005. Pengaruh tingkat naungan pada berbagai pastura campuran terhadap produksi hijauan. *Jurnal agibisnis Peternakan*, 1(3): 101-105.

Hanafiah et al. 2016. *Induced mutations by gamma ray irradiation to Argomulyo soybean (Glycine max) variety*. *Nusantara Bioscience*, 2(3), 121–125.

Hapsari, R. T. 2016. *Pendugaan keragaman genetik dan korelasi antara komponen hasil kacang hijau berumur genjah*. *Buletin Plasma Nutfah*, 20 (2), 51.

Hemon, A.F., 2006. *Efektifitas Seleksi in Vitro Berulang untuk Mendapatkan Plasma Nutfah KacangTanah Toleran Terhadap Cekaman Kekeringan dan Resisten Terhadap Penyakit Busuk Batang Sclerotiumrolfsi*. Disertasi. Sekolah Pasca Sarjana IPB. Bogor. 200h.

Hemon, A.F. 2009. Pertumbuhan tanaman kacang tanah hasil seleksi in vitro Pada media polietilena glikol terhadap cekaman Larutan polietilena glikol.*Crop Ago, Vol. 2. No.1*

Hemon AF, Hanafi AB, Sumarjan. 2012-2016. *Seleksi dan uji adaptasigalur hasil induksi mutasi dengan iradiasi sinar gamma padapenanaman di lahan sawah dan tegalan untuk mendapatkan kultivarkacang tanah toleran cekaman kekeringan dan berdaya hasil tinggi.*Penelitian Hibah Bersaing, 2012-2016. Universitas Mataram, Mataram.

Hemon AF, Ida Wahyuni, Kisman, Sumarjan, Hanafi Abdurrachman. 2018. *Penampilan Genotipe mutan kacang tanah yang ditanam pada cekaman kekeringan dan naungan*. Submit. Prosiding seminar nasional masyarakat biodiversitas Indonesia. Bandung.

Hemon *et al*. 2020. *Pengaruh intensitas cahaya rendah pada berbagai fase pertumbuhan terhadap karakter morfologi dan daya hasil kacang tanah*. Seminar Nasional Peragi 2020.

Herdiana N, Siahaan H, Rahman TS. 2008. Pengaruh Arang Kompos dan Intensitas Cahaya terhadap Pertumbuhan Bibit Kayu Bawang. penelitian Hutan Tanaman 5(3): 1-7.

Humpreys, L.R. 1979. *Tropical Pasture Seed Production FAO*, Rome Italy.

Jogloy S, Patanothai A, Toomsan S, Isleib TG. 1996. *Breeding peanut tofit into Thai cropping systems. Proc. of the Peanut Collaborative Research Support Program-International.* Research Symposium andWorkshop, Two Jima Quality Inn, Arlington, Virginia, USA, 25-31 March, 1996: 353-362.

Kasno, A. A. Bahri, A. Mattjik, Subandi dan S. Somaatmaja. 1995. *Pendugaan parameter genetik sifatsifat kuantitatif kacang tanah dalam beberapa lingkungan tumbuh dan penggunaannya dalam seleksi*. Pen. Pert. Bogor 3(1): 44-48.

Kephard KD, Buxton DR., 1993. *Forage Quality Response of C3 and C4 Perennial Gasses to Shade*. Crop Sci.

Kumaga F.K., S.G.K. Adiku, and K. Ofori. 2003. *Effect of post-flowering water stress on dry matter and yield of three tropical grain legumes*. Internat. J. of Agric. & Biol. 5(4):405–407.

Lestari. A. D. W. Dewi. W.A Qosim. M. Rahardja. N. Rostini dan R. Setiamihardja. 2006. *Variabilitas Genetik Dan Heritabilitas Karakter Komponen Hasil Dan Hasil Lima Belas Genotip Cabai Merah*. Zuriat 17 (1):97-98.

Lubis A., 2014. *Respon Pertumbuhan dan Produksi Tanaman Kacang Tanah Yang Diinokulasi Fungi Mikoriza Arbuskular*. USU Medan.

MC. Whirter, K. S. 1979. *Breeding of crass polination crop. In. R. Knight (ed).* Plant breeding, Brisbance Australian Vicc-chancellors Committee pp. 79-111.

Myers DA, Jordan DN, Vogerman TC., 1997. *Inclination of Sun and Shade Leaves Influenced Choloroplast Light Harvesting and Utilization*. Plant Physiol

Purba, K. R., Bayu, E. S., & Nuriadi, I. 2013. *Induksi mutasi radiasi sinar gamma pada beberapa varietas kedelai hitam (Glycine max (L.) Merril). Jurnal Online Agroekoteknologi*, 1(2), 67–75.

Rahmianna A.A., A. Taufiq, and E. Yusnawan. 2009. *Pod yield and kernel quality of peanut grown under two different irrigations and two harvest times. Indonesian J*. of Agric. 2(2):103–109.

Samsudin dan Saleh. 2009. *Penentuan Indikator Seleksi Untuk Perbaikan Hasil dan Mutu.*J. Agroland 12(4): 339-445.

Sexton PJ, Benett JM, Boote KJ. 1997. *The effect of dry use efficiencyand carbon I sotope discrimination in peanut under pegging zone soilon pod formation.* Peanut Sci 24: 19-24.

Sundari, T., Soemartono., Tahari dan W. Mangoendidjojo. 2005. *keragaan hasil dan toleransi genotipe kacang hijau terhadap penanungan*. Jurnal ilmu pertanian, 12 (1) : 12-19.

Sofi, L., Masnenah, E., Murdaningsih H.K., R. Setiamihardja, W. Astika, dan A. Baihaki. 2008. Parameter genetik karakter- karakter ketahanan terhadap penyakit karat kedelai dan beberapa karakter lainnya. Zuriat 8 (2), 57-63.

Song, Nio Dan Banyo, Yunia. 2011. *Konsentrasi Klorofil Daun Sebagai Indikator Kekurangan Air Pada Tanaman.* Jurnal Ilmiah Sains Vol. 11 No. 2. Hal 169-170.

Suparman dan Abdurrahman. 2003. *Teknik Pengujian Galur Kacang Tanah Toleran naungan dibawah Pohon Kelapa*. Buletin Teknik Pertanian vol.8.no.2:76-79.

Sutaryo dan Sudaryono. 2010. *Keragaan Fenotip Dan Beberapa Parameter Genetik Hasil Dan Karakter Agronomi Enam Padi Hibrida Di Lahan Kering Masam*. Balai Pengkajian Teknologi Pertanian, Yogyakarta.

Sutjahjo, S.H., dkk. 2007. *Kajian Genetik Dan Seleksi Genotipe S5 Kacang Hijau (Vigna Radiata) Menuju Kultivar Berdaya Hasil Tinggi Dan Serempak Panen*. Departemen Agronomi dan Hortikultura, Faperta IPB. Bogor.
Suwardi. 2002. *Teknologi Produksi dan Pascapanen Benih Unggul Jagung Hibrida.*Prosiding Seminar Nasional Seralia. Vol 7 (2): 307-312.
Uchimiya, H. 2001. *Genetic engineering for abiotic stress tolerance in plants*.SCOPAS. http://www. sciencecouncil.cgiar.org. [11 Februari 2010].
Whirter K.S. 1979. *Breeding of cross-pollinatedcrops.In a. course manual in plant breeding*.Knight. R. (Ed). Australian videchancellor’s Committee. P77-121.
Yang CW, Kao CH. 1999. *Importance of ornithine-δ-transferase to proline accumulation caused by water stress in detached rice leaves.* Plant Growth Reg 27:189-192.