

Selection of Bangka Local Groundnut (*Arachis hypogaea* L.) Germplasm Tolerant to Drought Stress

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Abstract—Bangka Belitung is dominated by marginal lands, such as dry land, which can affect the productivity of groundnut by reducing groundnut yield. Increased groundnut yield in Bangka Belitung could be done by using drought tolerance genotypes. The objective of this study is to obtain 24 groundnut genotypes tolerant to drought stress. This research was conducted at Experimental and Research Garden, University of Bangka Belitung, from January to March 2018. This research used experimental method with Split Plot Complete Randomized Design. It consisted of 2 main plot and 8 subplot levels. The main plot consists of 100% and 40% of field capacity used in drought stress assessment. Subplot consist of eight groundnut genotypes. These genotypes were Bangka local groundnuts (Belimbing, Arung Dalam, Air Ketimbai 1, Bedeng Akeh, and Lubuk Kelik accession), and national varieties (Tuban, Hypoma and Kancil varieties). Research result showed Bangka local groundnut genotypes tolerant to drought stress was Belimbing accession for 100 seeds weight character. National varieties tolerant to drought stress were Tuban and Hypoma varieties. Tuban variety showed drought tolerance through the following characters: root length, number of seeds per pod, root dry weight, and seed weight per plant. Hypoma variety showed drought tolerance on root length and number of seeds per pod characters. Tuban, Hypoma and Belimbing could be recommended for groundnut cultivation on dry land.

Keywords—germplasm, groundnut, drought stress, field capacity, Bangka.

I. INTRODUCTION

1 Groundnut (*Arachis hypogaea* L.) is a food crop commodity and main staple food. It also plays a role in increasing income and farmers welfare. Groundnut have considerable benefits such as source of protein, raw materials for processed food industries, and animal feeds. The average demand of groundnut reached up to ± 816 thousand tons of dry beans/year. On the other hand, the production of domestic groundnut is 570,477 tons in 2016 [1].

Currently, Indonesian demand for groundnut is fulfilled through imports. The average of groundnut imports in Indonesia in 2010-2014 amounted to 242,804 tons [2]. Groundnut production needs to be improved by utilizing the

marginal land, such as available lands in Bangka Belitung. Groundnut production in Bangka Belitung in 2015 only amounted to 151 tons of dry beans in 55 ha area cultivation [3]. This exhibited groundnut productivity in Bangka Belitung is low and needs to be improved.

Bangka Belitung is dominated by marginal lands, such as dry land. Dryland can affect the productivity of groundnut by reducing groundnut yield. Increased groundnut yield in Bangka Belitung could be done by using drought-tolerant varieties or accessions. Drought tolerant groundnut is very beneficial when grown on dry land because it can reduce the decrease in groundnut yields. Some varieties of drought tolerance groundnut varieties are Panter, Singa, Jerapah, Sima, Turangga, Tuban and Hypoma 2 [4].

Bangka Belitung had found 9 accessions of local groundnut as exploration results. The accessions are Air Ketimbai 1, Air Ketimbai 2, Belimbing, Bedeng Akeh, Lubuk Kelik, Sungailiat, Arung Dalam, Matras and Jongkong [5]. Nevertheless, these accessions have not gone through drought stress assessment, hence its adaptation level was unknown. Groundnut varieties tolerant to drought stress could be developed through plant breeding activities. Selection is one of the plant breeding methods to obtain an expected genotype. Therefore, it is necessary to select Bangka local groundnut germplasm to obtain a source of germplasm tolerant to drought stress.

II. MATERIAL AND METHOD

A. Material

This research was conducted in Experimental and Research Garden, Faculty of Agriculture, Fisheries and Biology, University of Bangka Belitung. The materials used in this research were 5 Bangka local groundnuts (Belimbing, Arung Dalam, Air Ketimbai 1, Bedeng Akeh, and Lubuk Kelik) and 3 national varieties groundnut (Hypoma, Kancil, and Tuban). Other materials used were topsoil, polybag, label, compost (chicken manure), urea fertilizer, SP-36, KCl, fungicides, and pesticides.

B. Method

This research used experimental method Split Plot Complete Randomized Design. The main plot is concentration of field capacity (F) consisting of two levels which are described as follows:

- F1 = 100% field capacity
- F2 = 40% field capacity

Subplot contains groundnut genotypes (G) consisting of 8 levels (5 local Bangka groundnut germplasm and 3 national varieties as check) which are described as follows:

- G1 = Belimbing
- G2 = Arung Dalam
- G3 = Air Ketimbai 1
- G4 = Bedeng Akeh
- G5 = Lubuk Kelik
- G6 = Tuban
- G7 = Hypoma
- G8 = Kancil

There were 16 treatment combinations and each treatment combination consisted of 2 replications to obtain 32 experimental units.

1) Field Capacity Determination

Filtered and dried soil media were put into polybags. Each polybag contained 8 kg of the material. Polybag containing weighted soil is placed on a bench with water container under the bench. The soil was watered with a specified volume as initial volume, then set aside for 2 x 24 hours. The collected water volume was measured as final volume. The difference between the initial volume and the final volume is the amount 100% field capacity. The determination of 100% and 40% field capacity calculated using formula suggested by [6]:

$$100\% \text{ FC (L)} = (V_0 - V_1)$$

$$\text{Medium } 100\% \text{ (Kg)} = \text{Soil Weight (Kg)} + 100\% \text{ FC} \dots\dots(1)$$

$$40\% \text{ SML (L)} = (V_0 - V_1) \times 40\%$$

$$\text{Medium } 40\% \text{ (Kg)} = \text{Soil Weight (Kg)} + 40\% \text{ FC} \dots\dots\dots(2)$$

where, FC= field capacity; V0 = initial volume; V1 = final volume

Each polybag containing the soil was maintained at 100% and 40% field capacity by watering the polybag until the media weight is appropriate.

2) Drought Stress Treatment

Groundnut were grown at 100% field capacity up to 30 days after planting (DAP). Drought stress treatment was started after 30 DAP until the groundnut crops were harvested. The plants were not watered to achieve the desired weight (40% field capacity). The media weight was maintained by weighing the media for each treatment, then watered until it reaches the desired weight.

The observed parameters were plant height, number of leaves, stem diameter, flowering age, harvest age, root length, root volume, root dry weight, plant dry weight, pod

number per plant, seed number per pod, 100 seed weight, and drought tolerance index.

The Drought Tolerance Index was calculated using the formulas proposed by [7].

$$S = (1 - Y_p/Y) (1 - X_p/X)^{-1} \dots\dots\dots(3)$$

where, S = Stress tolerance index; Yp= Average of a stressed genotype; Y = Average of a non-stressed genotype; Xp = Average of all stressed genotypes; X= Average of all non-stressed genotypes.

The criteria of drought tolerance index are:

$S \leq 0.5$, tolerant; $0.5 < S \leq 1$, moderate; and $S > 1$, sensitive.

The observed data on the parameters were analyzed using t-test with α 0.05 level. Any significant effect was analyzed using Duncan's Multiple Range Test (DMRT) with α 0.05 level

III. RESULT AND DISCUSSION

A. Result

Five accessions of Bangka local groundnuts and three national varieties were planted to determine the growth ability. Out of 8 genotypes, only 5 genotypes of groundnut are able to grow. These were Belimbing, Arung Dalam, Tuban, Hypoma and Kancil. Three accessions of Bangka local groundnuts Air Ketimbai 1, Bedeng Akeh and Lubuk Kelik were not able to grow or possess very low growth ability. This is presumably because the groundnut seeds have exceeded the shelf life. The results of F-test for 5 groundnut genotypes are showed in Table 1.

Table 1 showed that field capacity treatment had a very significant effect on plant height, number of leaves, stem diameter, pod number per plant, root volume, 100 seeds weight, plant dry weight, and seed weight per plant. Field capacity has no significant effect on flowering age, root length, number of seeds per pod, and root dry weights. Groundnut genotypes had a very significant difference on number of leaves, stem diameter, flowering age, pod number per plant, seed number per pod, 100 seeds weight, plant dry weight, and seed weight per plant. Genotypes had a significant difference on plant height, root volume, and root dry weight. Genotypes showed not significant different on root length characters. The interaction between field capacity and genotypes only showed on seed number per pod and seed weight per plant.

DMRT result on significant character for field capacity treatment is showed in Table 2. All parameters of groundnuts treated with drought stress showed the better results in the 100% field capacity, except the 100 seeds weight character that showed better results at 40% field capacity. The plant height, number of leaves, stem diameter, pod number per plant, root volume, and plant dry weight has the best value in the 100% field capacity and significantly different with the 40% field capacity.

DMRT result for genotypes showed Tuban variety is the best variety compared to other genotypes (Table 3). Tuban and Hypoma varieties exhibits the best values on almost every observed parameters. The genotype possessing the lowest adaptability is Arung Dalam accession. Based on the observed parameters, Arung Dalam accession possesses the smallest value on all characters.

Data from Table 4 and Table 5 showed the DMRT result for interaction between field capacity and genotypes on seed number per pod (Table 4) and seed weight per plant (Table 5). The most number of seeds per pod in 100% field capacity was found in Belimbing and Arung Dalam accession, while the smallest are exhibited by Tuban, Hypoma and Kancil varieties. The highest number of seeds in 40% field capacity showed by Arung Dalam accession and the smallest are exhibited in Tuban, Hypoma and Kancil varieties. The most weight of seeds per plant in 100% field capacity exhibited in Hypoma varieties, while the lowest weight was exhibited by the Arung Dalam accession. The heaviest seeds per plant in 40% field capacity was exhibited by Tuban varieties and the lightest seeds were exhibited by the Arung Dalam accession.

TABLE I. F-TEST RESULTS FOR GROUNDNUT GENOTYPES BY DROUGHT STRESS TREATMENT

Parameters	Field Capacity	Genotype	Interaction
	Pr>f ^a	Pr>f	Pr>f
Plant height	0.0009**	0.0235*	0.26 ns
Number of leaves	0.0025**	0.0013**	0.25 ns
Stem diameter	0.0035**	0.0001**	0.51 ns
Flowering age	0.6104 ns	<.0001**	0.31 ns
Root length	0.5287 ns	0.7741 ns	0.06 ns
Pod number per plant	0.0030**	<.0001**	0.21 ns
Seed number per pod	0.0954 ns	0.0003**	0.05*
Root volume	0.0086**	0.0272*	0.66 ns
100 seeds weight	0.0080**	<.0001**	0.09 ns
Root dry weight	0.1432 ns	0.0124*	0.59 ns
Plant dry weight	0.0008**	0.0004**	0.14 ns
Seed weight per plant	0.0001**	0.0001**	0.013*

^a. Pr>f = probability level; * = very significant different at α 0.05; ** = significant different at α 0.01; ns = not significant different.

TABLE II. RESULT OF DMRT FOR FIELD CAPACITY TREATMENT.

Parameters	Field Capacity (%) ^b	
	100	40
Plant height (cm)	47.91a	33.26b
Number of leaves	410.63a	274.20b
Stem diameter (mm)	5.61a	4.77b
Pod number per plant	39.63a	18.83b
Root volume (ml)	52.00a	28.83b
100 seeds weight (g)	54.02b	61.36a
Plant dry weight (g)	45.05a	19.01b

^b. Number followed by same letter in row mean not difference by DMRT at α 0.05.

TABLE III. RESULT OF DMRT FOR FIVE GROUNDNUT GENOTYPES.

Parameters	Genotypes ^a				
	Belimbing	Arung Dalam	Tuban	Hypoma	Kancil
Plant height (cm)	38.47bc	32.26c	42.44ab	46.88a	42.88ab
Number of leaves	261.25b	261.25b	401.75a	429.08a	374.08a
Stem diameter (mm)	4.83b	4.18c	5.50a	5.80a	5.65a
Flowering age (days)	30.67b	36.83a	25.67c	27.00c	26.58c
Pod number per plant	20.67c	20.67c	40.83a	29.83b	34.17b
Root volume (ml)	26.67bc	20.00c	56.67a	50.00ab	48.75ab
100 seeds weight (g)	64.51b	35.60d	49.64c	77.86a	64.51b

Root dry weight (g)	3.6bc	2.99c	13.60a	6.77c	9.42ab
Plant dry weight (g)	19.09b	19.35b	38.53a	39.92a	43.26a

^c. Number followed by same letter in row mean not difference by DMRT at α 0.05.

TABLE IV. TWO-WAY TABLE FOR INTERACTION BETWEEN FIELD CAPACITY AND GENOTYPES ON SEED NUMBER PER POD PARAMETER.

Field Capacity (%)	Genotypes ^d				
	Belimbing	Arung Dalam	Tuban	Hypoma	Kancil
100	2.83 Aa	2.83Aa	12 Ab	2.00Ab	2.00Ab
40	2.17 Bab	2.50Aa	2.00Ab	2.00Ab	2.00Ab

^d. Number followed by same uppercase letters in column, and same lowercase letters in row, showed not different by DMRT at α 0.05.

TABLE V. TWO-WAY TABLE FOR INTERACTION BETWEEN FIELD CAPACITY AND GENOTYPES ON SEED WEIGHT PER PLANT PARAMETER.

Field Capacity (%)	Genotypes ^e				
	Belimbing	Arung Dalam	Tuban	Hypoma	Kancil
100	41.10Aab	16.42Ac	38.43Ab	48.28Aa	44.77Aab
40	13.10Bbc	11.30Ac	29.85Aa	27.03Ba	21.60Bab

^e. Number followed by same uppercase letters in column, and same lowercase letters in row, showed not different by DMRT at α 0.05.

TABLE VI. DROUGHT TOLERANCE INDEX (S) FIVE GROUNDNUT GENOTYPES.

Parameters	Belimbing	Arung Dalam	Tuban	Hypoma	Kancil
	S	S	S	S	S
Plant height	0.74M	0.61M	1.12SV	1.19SV	1.06SV
Number of leaves	1.33SV	2.33SV	0.60M	0.97M	1.24SV
Stem diameter	1.53SV	1.13SV	0.80M	0.87M	0.73M
Root length	14.5SV	1.00M	-8.50T	-4.5T	1.00M
Pod number per plant	1.26SV	0.90M	0.83M	0.96M	0.98M
Seed number per plant	2.67SV	1.30SV	0.00T	0.00T	0.00T
Root volume	1.22SV	1.31SV	0.57M	1.36SV	0.73M
100 seed weight	0.21T	3.57SV	1.28SV	1.00SV	0.07T
Root dry weight	1.20SV	0.76M	0.26T	1.20SV	1.60SV
Plant dry weight	1.18SV	1.02SV	0.82M	1.06SV	0.97M
Seed weight per plant	1.47SV	0.67M	0.47T	0.96M	1.13SV

^f. T = Tolerant; M = Moderate; SV = Sensitive.

The result of drought tolerance index analysis is described in Table 6. Belimbing accession has tolerant index value on 100 seed weight character, moderate value on plant height, and sensitive value on other characters. Arung Dalam accession showed moderate tolerance index on plant height, root length, number of pods per plant, root dry weight and seed weight per plant. Tuban variety showed tolerant index value on root length, seed number per pod, root dry weight, and seed weight per plant. Hypoma variety has tolerant index value on root length and seed number per pod. Kancil variety has a tolerant index value on the seed number per pod and 100 seed weight.

B. Discussion

Germplasm and groundnut varieties possess different tolerance properties against drought stress. The plant response to drought stress varies depending on the duration, intensity of stress, plant species and plant growth stage [8]. [9] stated that genotypes difference is one of the factors causing diverse plant phenotypic because different genetic

factors can be expressed in various plant traits such as shape and function. It would then affect growth in diversity.

Flowering age exhibited the difference in each groundnut genotype. Tuban genotype tends to mature faster than other groundnut genotypes. Belimbing and Arung Dalam accession take a longer time to mature, while Tuban, Hypoma and Kancil varieties grow faster compared to plant description in non-stressed environment. The influence of drought stress accelerates flowering age. Lacking water on plant growth will produce high levels of absorbent acid (ABA) [10]. High concentrations of ABA hormone will inhibit the activity of auxin and cytokinin. Therefore vegetative growth will be inhibited, its use is directed toward the development of reproductive organs such as flower formation.

The pod number per plant and the 100 seeds weight showed the difference in 15th groundnut genotype. Tuban varieties possess the most number of pods per plant. Hypoma possesses the heaviest weight of 100 seeds. Root volume and root dry weights exhibited differences in each groundnut genotype. These results indicate that each plant has its own growth diversity, as expressed on various traits of the plant. According to [11], an existing difference in plant populations grown under the same environmental conditions indicates a difference derived from the genotype of the planted population.

Drought stress is one of the problems that become obstacles in groundnut cultivation because it reduces plant quality. Drought stress with the treatment 9th soil moisture reduction can decrease crop quality both in the vegetative phase and in the generative phase. [12] revealed that drought stress that occurs during groundnut growth will affect the plant growth. It may decrease groundnut yield during harvest. The growth of groundnut genotypes at 100% field capacity is better than groundnut genotype at 40% field capacity. At 100% field capacity, groundnut plant water requirement is fulfilled. [13] stated that the best plant growth is generally found in groundwater field capacity, as it possesses high soil moisture. Therefore plant water requirement is fulfilled which promotes better plant growth. Conversely, [14] states plants growing in areas with water stressed generally have a smaller size.

The average plant character value has decreased in drought stress. Due to drought stress, plant height, the number of leaves, and stem diameter experienced growth inhibition. [15] state that drought-degraded plants stomata holes would shrink to reduce water loss through transpiration. Shrinking stomata hole can reduce CO₂ intake and decrease the production of photosynthate thus slowing plant growth. In contrast, [10] states that sufficient water during plant growth encourages a smooth process of nutrient uptake and photosynthesis rate. Roots play an important role in responding to water shortages by reducing transpiration rates to conserve water. [16] states that increased root volume is an important morphological response in the process of plant adaptation to water shortages. Groundnut with a large volume of roots will be able to absorb more water to survive drought stress.

The pod number per plant under drought stress 11% field capacity) is less than the pod number per plant under

normal conditions (100% field capacity). Drought occurring during the flowering phase increased withering flower [17]. If the drought continues into the pod formation and filling phase, it would cause a large number of pods to wither as well. The drought stress also had a significant effect on the 100 seeds weight character. The weight of 100 seeds is heavier during drought stress than in normal condition. The average weight of 100 seeds during drought stress is > 55 g / 100 seeds, hence it was classified into large groundnut seeds. [18] stated that based on seed size, groundnuts can be distinguished into three: small groundnut seeds (<40 g / 100 seeds), medium groundnut seed (40-55 g / 100 seeds), and large groundnut seeds (> 55 g / 100 seeds). Under normal condition, groundnut plants are more focused on pod propagation to encourage more pods production. Under conditions that causes less pod formation, the plant focuses on seed enlargement. Groundnut genetic factors also cause 100 seeds weight is heavier during drought stress compared to normal condition.

The interaction between groundnut genotypes and drought stress had a significant effect on the seed number per pod and seed weight per plant. [19] stated that the diversity of a plant population can be caused by two factors, genetic and environmental factors. Plant quantitative characters are influenced by many genes and are heavily influenced by the environment. [20] state that genetic and environmental influences are factors that cause differences in the appearance of each plant (phenotype).

Groundnut plant tolerance against drought stress is also exhibited through the calculation of the drought tolerance index to observed characters. Belimbing groundnut genotype exhibits its tolerance through 100 seed weight character. Tuban varieties exhibit its tolerance through root length, the number of seeds per pod, root dry weight and seed weight per plant. Hypoma varieties exhibit its tolerance through root length and number of seeds per pod. Kancil varieties exhibit its tolerance through the number of seeds per pod and weight of 100 seeds. There are three mechanisms of plant tolerance to water drought stress: avoidance, tolerant, and escape [21]. Groundnut plant behavior against drought stress is a tolerant mechanism. Despite the groundnut plant itself damaged, such as withered due to drought stress, it remains alive and capable to yield produce. [22] stated that the drought tolerance mechanism is the relative ability of plants to maintain decreasing water/turgor, keeping minimal damage to the body in order to maintain biological function. Plant tolerance to drought stress is influenced by genetic factors. [23] states that the P5CS gene (Pyrroline-5-carboxylate synthetase) is a key encoding gene in the proline biosynthesis, which expression increases with drought stress (dehydration) and decreases in non-drought stress (rehydration). Over-expression of P5CS results in accumulation of proline in transgenic plants and they increase crop tolerance to drought stress. [24] suggest that along with a decrease in osmotic potential, accumulation of proline and betaine increases in roots and buds occur as well. The decrease in osmotic in cells can cause the plant to maintain turgor, hence physiological and biochemical processes remain normal during drought stress.

Tuban and Hypoma varieties are more tolerant than other groundnut genotypes, as both varieties of groundnut have more tolerant characters. Tuban and Hypoma varieties are known as drought stress tolerant varieties based on national plants varieties description. However, based on the 100 seeds weight characters, the varieties does not exhibit tolerant value. Instead, it was exhibited by local Belimbing accession. Thus, Belimbing accession is used as a source of genes in 100 seeds weight characters to improve Tuban and Hypoma national varieties.

IV. CONCLUSION

Tuban and Hypoma varieties are more tolerant to drought stress than other groundnut genotypes. Belimbing accession is Bangka local groundnut tolerant to drought stress on 100 seeds weight character.

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