Growth and Yield of Various Soy Varieties (Glycine max L. Merr.) on Drought Stress

Rusmana¹, Eltis Panca Ningsih¹, Amelia Justika¹

¹ Agroekoteknologi, Faculty of Agriculture, Sultan Ageng Tirtayasa University.

email: rusmana@untirta.ac.id

ABSTRAK

Soybeans become a source of plant protein and an essential food ingredient in Indonesia. Extreme climate change causes weather changes; the impact is a long dry season which results in drought. Efforts to deal with drought stress are carried out using drought-tolerant soybean varieties that drop of production can be suppressed. The purpose of the study is to study growth responses for several different soybean varieties with drought-stricken conditions. The research was conducted from October 2019 to January 2020 at the Green House Agroecotechnology Laboratory of the Faculty of Agriculture, University of Sultan Ageng Tirtayasa, Banten. Factorial randomized block design method was then used which consists of two factors and three repetition. The first factor were that the Varieties consists of V1: Argo mulyo variety; V2: Deja 2 and V3 varieties: Dena varieties. The second factor was drought percentage comprising k1: 100% ATT (Groundwater Available); k2: 80% ATT, k3: 60% ATT and k4: 40% ATT. The results showed that differences in varieties and drought stress did not significantly affect the growth and yield of soybean crops. Argo Mulyo varieties are superior to drought stress compared to Deja 2 and Dena varieties from the weight of 100 seeds. No interaction of different soybeans varieties treatment and drought stress on all observation parameters.

doi https://doi.org/10.21776/ub.jkptb.2020.008.03.04

1. Introduction

Soybean is a food source of plant protein for Indonesians which stand for third rank after rice and corn. The soybean needs increased along with an increase in the population in Indonesia. Currently, in order to fulfill domestic demand, importing the crop is done to satisfy national consumption such as, tempeh (6.99 kg/year) and tofu (7.51 kg¹/year) [1]. Moreover, as a raw material for making soy sauce and tauco which popular ingredient in Indonesia, soybean becomes more important commodity in food industry. However, the average soybean production between 2011-2015 was 885 000 tons, while the national demand reached up to 2 946 000 tons; in the near future, while domestic production of soybean still grows slowly, imported supply is inevitable [2].
Increased productivity in soybean crops can be done by using high quality of cultivar. in addition it can be done with proper cultivation techniques, choosing superior varieties that have been released by the government, adjusting the environmental growth and setting high selling price. One of the superior varieties of soybean crops such as Agro mulyo has purple flower color, yellow seed color and rust tolerant leaves. In 2016 the government has released 83 superior varieties and characteristics of both morphology and agronomy, one of which such as dena 1 and Devon 2 varieties support results, mature time, seed size and resistance to biotic and abiotic stress [3].

Low soybean production is influenced by the low quality of soybean, lack of cultivation techniques, drought stress, excessive rainwater during harvest, flooding, pest invasion and competition with grasses or weeds. Soybean crops are sensitive to drought, temperature and length of the day. One of the obstacles in soybean cultivation is drought stress. The growth of stadia and plant species in drought conditions can decrease crop production. Water shortages in plants bring an effect on their metabolic activity, growth morphology and productivity as well as cell development that is sensitive to water limitations. Water deficiency affects cell turgor it will affect cell development, protein wall synthesis and cell synthesis. The response of plants lacking water in the vegetative phase is that the leaves develop to a smaller size thus lowering chlorophyll synthesis and the intensity of incoming light as well as increasing the activity of hydrolysis enzymes such as amylase. The use of superior drought-tolerant varieties with high yields is a way to increase soybean production. The superior variety characters are high production, pest and disease resistance and adaptation of various environments [4]. The results of Saputra et al. [5] study that agromulyo varieties are still tolerant of drought 2/3 KL shown by higher crop height of 24.48%, the weight of fill pods and the number of seeds more by 40.71% and 40.19% respectively compared to Kaba varieties and Grobogan varieties.

The germination process depends on the availability of water. The need for water increases with the increasing growth phase of plants. At the time of flowering phase and filling pods the need for water is very high. Some methods are proposed to overcome the drought in soybeans in the flowering phase and the formation of pods i.e. with the right planting time by maintaining soil moisture during germination [6]. Sumampow [7] stated that on 30% of soil moisture gives a very high of germinated seeds percentage.

The plant's total water potential, osmotic pressure as well as cell turgor pressure are related to the plant's response to drought. Turgor cells function in the division and development of cells, osmotic pressure works on the process of enzyme activity and cell metabolism. Water shortages result in decreased floem and xylem activity and translocation of assimilat will decrease so that the growth response and crop yield will be reduced. The influence of plants adapting to different environments depends on the type and cultivar of the plant. The response of plants to changes in the growing environment can be positive and negative. Such a response will lead to interactions between the environment and plant genotypes that affect the physical changes of soybean crops. The response of plants can also be seen from physiological processes such as the speed of photosynthesis and the translocation of photosynthetics. The environment with soil is quite humid, the temperature is moderate and the intensity of light is quite in accordance with the growth of soybeans [8]. The purpose of this study was to look at the responses of various varieties of soybeans to growth and yields on drought stress.

doi https://doi.org/10.21776/ub.jkptb.2020.008.03.04
2. Research Methods

2.1 Research Location and Time

The research at Greenhouse Agroecotechnology Laboratory of The Faculty of Agriculture Sultan Ageng Tirtayasa Serang University, Banten, began in October 2019 until January 2020.

2.2 Tools and Materials

The tools used in the study were polybags, analytic scales, and oven. Materials used in the implementation of research are water, soybean crops Argo mulyo variety, Deja 2, Dena, rice field and fertilizer Urea, TSP and KCL. Argo mulyo variety was used because this plant is tolerant to leaf rust. the use of dena and Deja varieties can survive both biotic and abiotic stress.

2.3 Research Design

The design of this study using the Randomized Group Design method consists of two factors with three replays. The first factor is the Variety consisting of V1: Argo mulyo variety; V2: Deja 2 and V3 varieties: Dena varieties. The second factor is drought stress consists of k1: 100% ATT (Groundwater Available); k2: 80% ATT, k3: 60% ATT and k4: 40% ATT. There are 12 combinations of treatments. Each combination of treatments is repeated 3 times so that 36 units of experiments are obtained. Each test unit has 2 polybags where each polybag is filled with 1 plant so that the total required plants as many as 72 plants.

The observation variables for growth and results in this study are plant height, number of leaves, root length, number of fill pods, number of hollow pods, weight of 100 seeds, the value of dried seeds per plant.

The measurement data of each parameter is then analyzed using a variety of fingerprints. If the fingerprint results of the F-test have a real effect, the DMRT (Duncan Multiple Range Test) tests will continue at a 5% confidence level.

2.4 Research Methods

This research was conducted at several stages, comprising: (1) Preparation of Planting media; Prepare the planting media used such as soil, polybags, and water. The soil is taken from the outer surface with a depth of 20 cm and the soil is cleaned and spared from the remains of other impurities. Then, put in polybag as much as 5 kg of soil. Moisture content of 19.4%. (2) Seed Preparation; Seed preparation by choosing seeds that are quality, whole, clean, and the seeds are uniform in size. (3) Planting; The seed is inserted into a planting hole as deep as 3 cm and each polybag is planted 2 seeds per polybag. (4) Fertilization; The use of fertilizer in the form of Urea with a dose of 100 grams/polybag, TSP 100 gram/polybag and KCl 75 gram/polybag when 1-time vegetative phase at 2 MST and 1 time the beginning of the generative phase at 5 MST. Fertilizer is administered by immersed in the soil by digging a little soil in the polybag forming a side circle of the plant then the fertilizer is sprinkled and then closed back to the soil. (5) Plant Nursery; Weeding is carried out according to the condition of the plant or plant should be clean from weeds in the plant-growing organism. Looting is carried out on 1 MST through the shedding of other plants that grow so as not to interfere with other plants. Soybean crops that do not grow are done in the morning. (6) Irrigation; At the beginning of planting until the plant is 2 weeks old after planting (MST), watering the plant is watered daily based on Available Groundwater (ATT) up to 100% ATT on all plants. Drought treatment is carried out at the age of 2 MST to 5 MST plants only in the vegetative phase where each water supply is carried out daily according to the needs and calculation provisions that have been presented in Appendix 8.
soybean plant has appeared flowers and entered the period of filling pods, then the stress is stopped. Water administration in the generative phase returns to normal with daily watering up to 100% ATT. (6) Harvesting; this stage is done after the soybean plant reaches full ripening with the characteristics of the leaves have begun to yellow and fall, the stems of the plant are yellow rather brown, and the pods begin to change color from green to brownish yellow. Harvesting is done by cutting the soy stem about 5 cm above ground level. The crops are separated from the brangkasan, then dried. Harvesting is carried out at the time of 12 weeks after planting.

3. Results and Discussions
3.1 Plant Height

The treatment of varieties with drought stress has no significant effect on high variable soybean crops. No interaction between varieties and drought stress against high parameters of plants (Table 1). Deja 2 varieties have higher plant height than Argo Mulyo and Dena varieties in drought-stricken conditions. The treatment of varieties has no effect; it is thought that each plant has a different genetic character so the response in the face of the environment is different anyway. Water needs in each type of plant are not the same, resulting in lowering plant growth. According to Arabi [9] that good genetic potential in plant types or varieties will provide good results supported modification and good function of environmental factors in plants.

| Table 1. The effect of drought stress on crop height on different soybean varieties |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Age of Plants (WAP) | Varieties (V) | Drought (K) ATT |                |                |                |                |
|                |                  |                | 100%           | 80%            | 60%            | 40%            | Average        |
|                |                  |                | ATT            | ATT            | ATT            | ATT            |                |
| Crop Height (cm) | Argo Mulyo |              | 36.00          | 40.17          | 37.83          | 37.83          | 37.96          |
|                | Deja 2       |              | 40.00          | 49.00          | 41.17          | 45.50          | 43.92          |
|                | Denia        |              | 37.17          | 34.83          | 36.00          | 39.00          | 36.75          |
|                | Average      |              | 37.72          | 41.33          | 38.33          | 40.78          |                |
|                | Argo Mulyo   |              | 77.83          | 69.67          | 72.67          | 72.50          | 73.17          |
|                | Deja 2       |              | 71.17          | 77.67          | 60.50          | 74.00          | 70.83          |
|                | Denia        |              | 66.33          | 54.17          | 63.83          | 75.83          | 65.04          |
|                | Average      |              | 71.78          | 67.17          | 65.67          | 74.11          |                |
|                | Argo Mulyo   |              | 126.83         | 111.00         | 102.17         | 102.33         | 110.58         |
|                | Deja 2       |              | 97.83          | 109.50         | 78.67          | 107.17         | 98.29          |
|                | Denia        |              | 118.00         | 77.50          | 105.33         | 124.83         | 106.42         |
|                | Average      |              | 114.22         | 99.33          | 95.39          | 111.44         |                |
|                | Argo Mulyo   |              | 153.67         | 131.17         | 123.50         | 126.17         | 133.63         |
|                | Deja 2       |              | 129.67         | 145.17         | 107.00         | 137.50         | 129.83         |
|                | Denia        |              | 150.17         | 92.50          | 131.17         | 131.00         | 126.21         |
|                | Average      |              | 144.50         | 122.94         | 120.56         | 131.56         |                |

*WAP: week after planting
Drought stress has no effect on soybean crops but lowers the height of soy crops. Water deficiency is able to inhibit the development and division of cells during the vegetative phase. Based on Purwanto and Agustono's statement [10] that the high growth of plants decreased due to drought in the vegetative phase. Gardner et al. [11] describes the high growth of plants and the formation of leaves when vegetative stages decrease due to drought-stricken conditions. Sopandie [12] added that the process of growth and photosynthesis decreased due to drought. The closure of stomata and decreased metabolism in drought-stricken conditions can lower the rate of photosynthesis. Water limitations resulted in stomata shutting down, lowering CO$_2$ concentrations, and causing damage to photosynthetic organs due to dehydration of mesophile cells. Plants that are tolerant at times of low water potential are able to adapt by maintaining their biological function even with limited growth.

3.2 Number of leaves

The treatment of varieties affects at the time of 3 WAP and drought stress has no effect on the parameters of the number of leaves. On the parameters of the number of leaves is not obtained interaction between varieties and drought stress (Table 2). Argo Mulyo varieties have decreased more than deja 2 and Dena varieties in the same dexterous conditions. The number of leaves decreases as drought levels increase. At times of drought stress occurs the growth process is hampered and the mechanism of adaptation of plants with the abortion of leaves in an effort to suppress water loss thus causing the number of leaves to become small. According to Gardner et al. [11] that water shortages in plants up to the point of withering will generally be refreshed after being given water, but old leaves will fall out and new leaves will grow smaller.

| Age of Plants (WAP) | Varieties | 100% ATT | 80% ATT | 60% ATT | 40% ATT | Average ATT |
|---------------------|-----------|----------|---------|---------|---------|-------------|
|                     |           |          |         |         |         |             |
| 2                   | Argomulyo | 4.67     | 5.00    | 4.67    | 5.00    | 4.83        |
|                     | Deja 2    | 5.00     | 5.00    | 4.33    | 4.67    | 4.75        |
|                     | Dena      | 4.33     | 4.67    | 4.67    | 4.67    | 4.58        |
|                     | Average   | 4.67     | 4.89    | 4.56    | 4.78    |             |
| 3                   | Argomulyo | 6.00     | 5.67    | 6.00    | 6.00    | 5.92 $^{ab}$|
|                     | Deja 2    | 6.33     | 7.00    | 6.00    | 6.67    | 6.50 $^a$   |
|                     | Dena      | 6.00     | 5.33    | 5.33    | 5.67    | 5.58 $^b$   |
|                     | Average   | 6.11     | 6.00    | 5.78    | 6.11    |             |
| 4                   | Argomulyo | 9.67     | 8.00    | 6.67    | 7.67    | 8.00        |
|                     | Deja 2    | 8.33     | 7.67    | 7.00    | 8.33    | 7.83        |
|                     | Dena      | 10.00    | 6.67    | 8.00    | 8.67    | 8.33        |
|                     | Average   | 9.33     | 7.44    | 7.22    | 8.22    |             |
| 5                   | Argomulyo | 12.33    | 10.33   | 8.00    | 9.00    | 9.92        |
|                     | Deja 2    | 11.00    | 10.33   | 9.67    | 9.33    | 10.08       |
|                     | Dena      | 13.33    | 7.33    | 10.00   | 12.67   | 10.83       |
|                     | Average   | 12.22    | 9.33    | 9.22    | 10.33   |             |

*The numbers followed by letters in the same column show no different according to the DMRT test at a rate of 5%
3.3 Root length

On the long parameters of the treatment of varieties and drought stress has no effect. There is no interaction between the treatment of varieties and drought stress in root length mods (Table 3). The mechanism of adaptation of drought-tolerant soybean crops with root lengthening thus expanding the field of water absorption. The length of the root is getting longer as the drought worsens. According to Sunaryo [13] that when soybean crops are in drought-stricken conditions it will have an impact on the length of the roots.

| Varieties (V) | 100% ATT | 80% ATT | 60% ATT | 40% ATT | Average |
|--------------|---------|---------|---------|---------|---------|
| Argo Mulyo   | 12.33   | 12.33   | 15.00   | 17.67   | 14.33   |
| Deja 2       | 17.33   | 15.33   | 13.67   | 14.33   | 15.17   |
| Dena         | 14.33   | 12.33   | 14.33   | 15.67   | 14.17   |
| Average      | 14.67   | 13.33   | 14.33   | 15.89   |         |

Table 3. Effect of drought stress on root length on different soy varieties

3.4 Number of pods per plant

On variable amounts of pods of contents per plant the treatment of varieties and drought stress have no effect. There is no interaction between the treatment of varieties and drought stress in the parameters of the number of pods of contents per plant (Table 4). In the varieties of soybeans used and the declining availability of water makes dry conditions during flowering or vegetative phases resulting in flowering periods until forming young pods easily fall out thus lowering the number of filled pods per plant. According to Nurhayati [14], water deficiency at the most sensitive level is the final phase of pod development and seed filling. Water deflection results in a decrease in the rate of photosynthesis so that at the time of filling the pods will decrease the seed yield. Bahri’s research [4] explains that giving a small amount of water will have an impact on the number of filled pods formed, due to the decrease in the amount of carbohydrates and protein synthesis. Because when the enlargement process is stopped caused by the decline of protein constituents that will affect the speed of plant growth and decrease crop yields and affect the quality of crop yields.

| Varieties (V) | 100% ATT | 80% ATT | 60% ATT | 40% ATT | Average |
|--------------|---------|---------|---------|---------|---------|
| Argo Mulyo   | 16.67   | 23.67   | 8.67    | 12.33   | 15.33   |
| Deja 2       | 23.67   | 23.00   | 19.33   | 14.33   | 20.08   |
| Dena         | 29.00   | 24.00   | 24.33   | 17.67   | 23.75   |
| Average      | 23.11   | 23.56   | 17.44   | 14.78   |         |

Table 4. Effect of drought stress on number of pods per plant on different soybean varieties

doi https://doi.org/10.21776/ub.jkptb.2020.008.03.04
3.5 Number of seeds per plant

On the parameters of the number of seeds per plant the treatment of varieties and drought stress have no effect. There is no interaction between varieties and drought stress in the parameters of the number of seeds per plant (Table 5). The reduction in the number of seeds increased as the drought level increased. Argomulyo varieties have seen a decrease in the number of seeds due to the drought of Deja 2 Varieties and Dena Varieties in the same dexterous conditions. The decrease in the number of seeds is thought to be due to a decrease in the rate of photosynthesis due to drought stress as the process of adaptation of crops so that soybean seed yields are reduced. Candogan et al. [15] explained that soybean seed production decreases along with increased water stress.

| Varieties (V) | Drought (K) | 100% | 80% | 60% | 40% | Average |
|--------------|-------------|------|-----|-----|-----|---------|
|              | ATT         | ATT  | ATT | ATT |     |         |
| Argo Mulyo   | 38.67       | 61.00| 21.00| 31.67| 38.08|
| Deja 2       | 47.00       | 46.33| 32.33| 27.67| 38.33|
| Dena         | 52.33       | 43.33| 42.67| 28.00| 41.58|
| Average      | 46.00       | 50.22| 32.00| 29.11|     |

Table 5. The effect of drought stress on the number of seeds per plant on different soybean varieties

3.6 Weight of 100 seeds

On a variable weight of 100 seeds the treatment of varieties affects and drought stress has no effect. There is no interaction between varieties and drought stress in the weight parameters of 100 seeds (Table 6). Argomulyo varieties have a weight of 100 seeds greater than Deja 2 varieties and Dena varieties. The response of each type of plant during drought stress to the weight loss of seeds of its size is not the same. Harnowo [16] explained that drought in plants during the reproductive phase can prevent the distribution of assimilat to reproductive organs so that the formation of the number of pods, seeds and seed weight per plant decreases. According to Arabi [9], drought stress can decrease seed yields at the growth stage, but drought stress in the formation phase and filling of pods becomes a critical phase in crops. Saputra et al. [5] added that increasing drought in crops, the availability of water for crops is reduced, thus reducing the growth and yield of soybean crops.

| Varieties (V) | Drought (K) | 100% | 80% | 60% | 40% | Average |
|--------------|-------------|------|-----|-----|-----|---------|
|              | ATT         | ATT  | ATT | ATT |     |         |
| Argo Mulyo   | 15.09       | 13.14| 10.78| 12.54| 12.89\a|
| Deja 2       | 11.46       | 10.60| 9.60 | 9.82 | 10.37\b|
| Dena         | 13.06       | 10.74| 13.84| 11.28| 12.23\a|
| Average      | 13.20       | 11.50| 11.40| 11.22|     |

*the numbers followed by letters in the same column indicate no different according to the DMRT test at a rate of 5%
4. Conclusion

Argo mulyo varieties are tolerant to drought stress compared to Deja 2 varieties and Dena varieties. Argo Mulyo varieties are better than Deja 2 varieties and Dena varieties are visible from the weight of 100 seeds. There is no interaction between treatment of varieties and drought stress in all observation variables.

References

[1] Central Bureau of Statistics. Consumption of Calories and Protein of the Population of Indonesia and the Province of the Central Statistics Agency. Jakarta, 2015.

[2] S. R. Yunita, Sutarno, and E. Fuskhah. The response of several varieties of soybeans (Glycine max L. Merr) to the salinity level of watering water. *J. Agro Complex, ED-2*, pp. :43-51, Feb. 2018. [In Indonesian]

[3] G. W. Anggoro and N. Nugrahaeni. Introduction and Characteristics of Superior Varieties of Soybean. Malang: Balitkabi, 2017. [In Indonesian]

[4] S. Bahri. Growth and yield response of three soybean varieties (Glycine max L. merr) to drought stress. Jurnal Penelitian, vol. ED-4, pp. 8-14, 2017. [In Indonesian]

[5] D. Saputra, P. B. Timotiwu and Ermawati. Effect of drought stress on growth and seed production of five soybean varieties. *J. Agrotek Tropika*. ED-3, pp. 7 – 13, Jan. 2015. [In Indonesian]

[6] Y. S. Nugraha, T. Sumarni dan R. Sulistyono. Effect of time intervals and water levels on growth and yield of soybean (Glycine max L. Merr). *J. Produksi Tanaman*, ED-2, pp. 552-559, 2014. [In Indonesian]

[7] D.M.F. Sumampow,. Effect of Soil Moisture on germination of soybean (Glycine max L. Merr) Seeds. Jurnal Agronomi Tanaman Tropis, vol. ED-1, pp. 15-20, 1999.

[8] A. Taufiq and T. Sundari. Response of Soybean Plants to the Tumbu Environment. Buletin Palawija. ED-1, pp. 14-22, Feb. 2012. [In Indonesian]

[9] M. Arabi. Drought resistance test of several soybean varieties at various concentrations of polyethile gligol (PEG). http://elib.pdii.lipi.go.id/, 2004. [In Indonesian]

[10] Purwanto, T. Agustono. Study of soybean plant physiology under drought stress conditions and various densities of nut weeds. *Agrosains*, ED-12, pp. 24-28, 2010. [In Indonesian]

[11] F.P. Gardner, R.B. Pearce, R.L. Mitchell. Cultivated Plant Physiology. Jakarta: UI Press, 1991. [In Indonesian]

[12] D. Sopandie. Physiology of plant adaptation to abiotic stress in tropical agroecosystems. Bogor: IPB Press, 2014. [In Indonesian]

[13] W. Sunaryo. Regeneration and evaluation of the somaclonal variation of soybean (Glycine max (L) Merrl.) From tissue culture and selection for drought stress using a polyethylene glycol (PEG) simulation. Tesis, Faperta, Institut Pertanian Bogor, Bogor, 2002. [In Indonesian]

[14] Nurchayati. Effect of Water stress on Two Types of Soil on Growth and Yield of Soybean (Glycine Max (L.) Merrill). *Jurnal Floratek* ED-4, pp. 55 – 64, 2009. [In Indonesian]

[15] B.N. Candogan, M. Sincik, H. Buyukcangaz, C. Demirtas, A.T. Goksoy, S. Yazgan. Yield, quality and crop water stress index relationships for deficit-irrigated soybean (Glycine max L. Merr.) in sub-humid climatic conditions. Agricultural Water Management, pp.113– 121, 2013.

[16] D. Harnowo. The response of soybean plants to potassium fertilization and drought stress in the reproductive phase. Faperta, Institut Pertanian Bogor, Bogor, 1992. [In Indonesian]

doi https://doi.org/10.21776/ub.jkptb.2020.008.03.04