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Agronomic Characteristics of Various Soybean Varieties (Glycine Max, Merril) Under Drought Stress Conditions

Yonny Koentjoro*, Sukendah, F. Deru Dewanti

Agrotechnology, Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia

*Corresponding author:
E-mail:
yonny_k@upnjatim.ac.id

ABSTRACT

Drought conditions are a problem that is often found in soybean cultivation because in general soybeans are planted in the dry season where production is largely determined by the amount of water given. This study aims to evaluate the physiological and production characteristics of several soybean varieties under drought-stress conditions. 10 soybean varieties were tested at three levels of watering. This study was designed using a Completely Randomized Design with Factorial. The research was carried out in the experimental garden of the Faculty of Agriculture at Universitas Pembangunan Nasional Veteran Jawa Timur. The results showed that increasing the concentration of PEG given in the germination phase decreased germination, primary root length, and number of seminal roots. A significant interaction between varieties and water application occurs in the variable pod weight per plant. The genetic diversity of each variety tested showed differences in all of the observed variables. The decreasing availability of water affects all metabolism in plants, giving 50% of the normal requirement of water shows the lowest results in all observed variables. While giving 75% water is generally not significantly different from giving 100% water for normal needs.

Keywords: Drought, PEG, production, variety

Introduction

The ability of plants to live in water shortage conditions is an indicator of the success of a plant in adapting to extreme environmental conditions, especially in drought conditions. Water deficit is associated with several physiological processes related to growth which can cause decreased production and even death. The effect of drought stress on soybean plants varies depending on the variety, the magnitude and duration of the stress, and the growth period of the plant. The ability of a plant to survive in conditions of water shortage is one indicator of the success of a plant in adapting to extreme environmental conditions, especially in drought conditions. Water deficit is associated with several physiological processes related to growth which can cause decreased production and even death. The effect of drought stress on soybean plants varies depending on the variety, the magnitude and duration of the stress, and the growth period of the plant.

Prolonged drought stress conditions in plants can be a serious cause of the decline in the plant's ability to carry out the photosynthesis process, this is due to dehydration of the protoplasm. Water loss that occurs in plant cells due to drought stress will greatly affect metabolic processes in plant cells. Levitt (1980) suggested that protein synthesis decreases, in line with reduced water content. Abe et al. (1997); Epstein (1972); Macrobbie (1997) and Ober and Sharp (2003) explain that in conditions of water shortage which causes a dehydration process in plants, it will stimulate the formation of Abcisic Acid (ABA). Finkelstein and Rock (2002); Seo and Koshiba (2002), and Xiong and Zhu (2003) the formation

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Plants have mechanisms to adapt, one of which is through closing the stomata. An increase in the level of drought stress will trigger maximum stomata opening. The effect of increasing water stress on plants on stomata behavior shows that plants under water stress conditions have the smallest opening of stomata openings in daily variations at 10.00 – 14.00. The process of closing the stomata can have a positive impact because it can reduce water loss from the plant body, but from a growth aspect, it has a negative impact, because the process of CO2 diffusion into the leaf tissue is hampered as a result of which the photosynthesis process is disrupted. Stomata closure occurs due to redistribution of ABA stored in the chloroplast into the apoplast. This redistribution process is very dependent and influenced by differences in pH in the leaves, the weak acid content contained in the ABA molecule, and membrane permeability conditions (Taiz & Zieger, 1991).

Guntoro and Koentjoro (2004) explained that the role of abscisic acid is very influential in reducing the dry weight of seeds and soybean plants in drought conditions of 75% field capacity in all phases of plant growth and continues to increase its role in drought conditions below 75% field capacity, it is also explained that abscisic acid as a hormone inhibiting plant growth and is very decisive in the process of stomatal closure, this role can be inhibited by the application of external treatments such as the provision of sugar alcohol compounds that can act as moisturizers and in the plant body can function as stability of cell moisture. As a controller of cell moisture, sugar alcohol plays a role in increasing turgor pressure in guard cells, so that stomata will open and photosynthesis will take place normally.

This study aims to evaluate the morphological response of several soybean varieties under water shortage conditions.

Material and Methods

Germination Test: Test of the Response of Soybean Varieties to Stress Drought in the Germination Phase

The aim of the germination test is to evaluate the response of tolerant and sensitive soybean varieties to drought stress as a reference for determining the character of the tolerant selection of soybean varieties in the germination phase. The research implementation at this stage used a Completely Randomized Factorial Design with three replications. The first factor is 10 Soybean Varieties while the second factor is the administration of PEG 6000 with concentrations of 10%, 15% and 20% which are equivalent to -0.19, -0.41, and -0.67 MPa respectively, as a comparison without PEG administration. The experiment was carried out in three sets of experiments. The varieties tested include Dering 1 (V1), Sinabung (V2), Panderman (V3), Argomulyo (V4), Gema (V5), Kaba (V6), Anjasmoro (V7), Grobogan (V8), Gepak Kuning (V9)) and Wilis (V10) Seeds of each variety were germinated using the paper roll in plastic test method. The 30 soybean seeds were arranged on three sheets of 30 x 20 cm straw paper and covered with three sheets of straw paper that had been moistened with PEG solution according to the treatment. The merang paper containing the seeds was rolled up and incubated in a germinator. Observations included several variables, namely germination, primary root length, and number of seminal roots.

Field trials: Testing soybean varieties under drought conditions

Research in this phase aims to determine the response of planted soybean varieties to drought stress conditions and to classify soybean varieties that are sensitive and resistant to drought stress. Planting soybean seeds is carried out in plastic pots with a capacity of 20 kg of soil media. Field testing was designed following the rules of factorial experiments using a Completely Randomized Design consisting of two factors and three replications. As factor I are varieties: Varieties Ring 1 (V1), Sinabung (V2), Panderman (V3), Argomulyo (V4), Gema (V5), Kaba (V6), Anjasmoro (V7), Grobogan (V8), Gepak Kuning (V9) and Wilis (V10) The second factor provides water requirements: 100% (W1), 75% (W2) and 50% (W3) of plant water requirements.

The amount of water indicated is based on the water requirements of the soybean plants for each period. According to Fagi and Tangkuman (1993), the average water requirement of Wilis soybean plants during the growing season is 325 mm. The distribution and amount of water given to each treatment combination are shown in Table 1.

Table 1. Distribution and amount of water given to each plant growth period in polybags

Water giving	Distribution and Amount of Water Given to Each (ml/day/polybag)				Amount of water (ml/season)
	Early growth (0 – 15 day)	Vegetative (16 – 30 day)	Flowering-pot filling (31 – 65 day)	Seed maturity (66 – 85 day)	
50% Normal needs	94 ml	94 ml	94 ml	94 ml	7990 ml

Source: Data processed

The variables evaluated included: plant height, number of leaves, number of flowers, number of pods per plant, pod weight per plant, and potential seed yield per hectare. The overall observational data were analyzed using a Completely Randomised Analysis of Variance and, where there were differences between sources of variation, a multiple comparison test, 5% honestly significant difference test.

Results and Discussion

The results of the statistical analysis showed that the variables germination, primary root length, and number of seminal roots did not have a significant interaction effect between variety treatment and PEG 6000 on the three observed germination phase variables. Each variety tested showed significantly different germination growth in the observed germination phase variables (germination power, primary root length, and number of seminal roots). The variety Gepak Kuning (V9) showed the highest percentage of germination, primary root length, and number of seminal roots compared to other varieties, followed by the variety Dering 1 (V1). Meanwhile, Panderman and Argomulyo varieties produced the lowest germination growth.

The addition of polyethylene glycol (PEG 6000) at the germination stage appeared to have an inhibitory effect on each of the germination variables observed. As the concentration of PEG added to the germination media increased, the germination ability of the soybean varieties tested decreased. In the 10% PEG treatment (P1), the germination results were the highest compared to the other water requirement treatments. The 20% PEG treatment (P3) gave the lowest germination results (Table 2). The addition of polyethylene glycol (PEG 6000) at the germination stage appeared to have an inhibitory effect on each of the germination variables observed. As the concentration of PEG added to the germination media increased, the germination ability of the soybean varieties tested decreased. In the 10% PEG treatment (P1), the germination results were the highest compared to the other water requirement treatments. The 20% PEG treatment (P3) gave the lowest germination results (Table 2).

Table 2. Germination growth, length of primary roots, number of seminal roots in the treatment of soybean varieties and polyethylene glycol

Treatment	Germination growth (%)	Length of primary roots (cm)	Number of seminal roots
V1 (Dering 1)	92.22 abc	7.55 ab	7.27 ab
V2 (Sinabung)	94.44 bc	6.57 a	6.04 a
V3 (Panderman)	80.00 a	5.79 a	5.09 a
V4 (Argomulyo)	85.93 abc	6.21 a	5.66 a
V5 (Gema)	85.93 abc	7.72 ab	7.16 ab
V6 (Kaba)	88.52 abc	7.48 ab	6.58 ab
V7 (Anjasmoro)	82.59 ab	6.48 a	5.45 a
V8 (Grobogan)	82.96 ab	6.22 a	5.51 a
V9 (Gepak Kuning)	98.89 c	9.66 b	10.93 b
V10 (Wilis)	91.85 abc	7.17 a	6.60 ab
HSD 5 %	14,13	2,37	5,12
P1 (PEG 10 %)	87.11 b	8,45 c	10.91 b
P2 (PEG 15 %)	80.44 a	7,17 b	4.91 a
P3 (PEG 20 %)	76.44 a	5,64 a	4.07 a
HSD 5 %	6,24	1,05	2,26

Notes: Numbers followed by the same letters in the same column showed no significant difference at HSD 5%

The vegetative growth phase of soybean begins with the germination phase, which is characterized by the emergence phase of the cotyledons (VE). Germination is the process of growth and development of the embryo or emergence of the plantula (small plants from inside the seed).

Changes in the embryo during germination generally include the radicle growing and developing into roots, and then the plumule growing and developing into stems and leaves. The reduction in germination capacity that occurs is not due to poor seed quality but is thought to be caused by the inhibition of cell division and elongation processes due to the desiccation conditions simulated by PEG 6000.

The growth in plant height of each variety tested showed significant differences, although it did not show any real interaction effect with the water treatment. Based on the results of the statistical analysis of the variety of treatments, it showed real differences from the beginning of the observation 14 days after to the end of the vegetative phase (49 days after planting). house, but when the plants are 1 month old, all the plants are moved to a large area. The Grobogan variety (V8) showed the highest plant height. Meanwhile, the Gepak Kuning variety (V9) produces the lowest plant height (Figure 1).

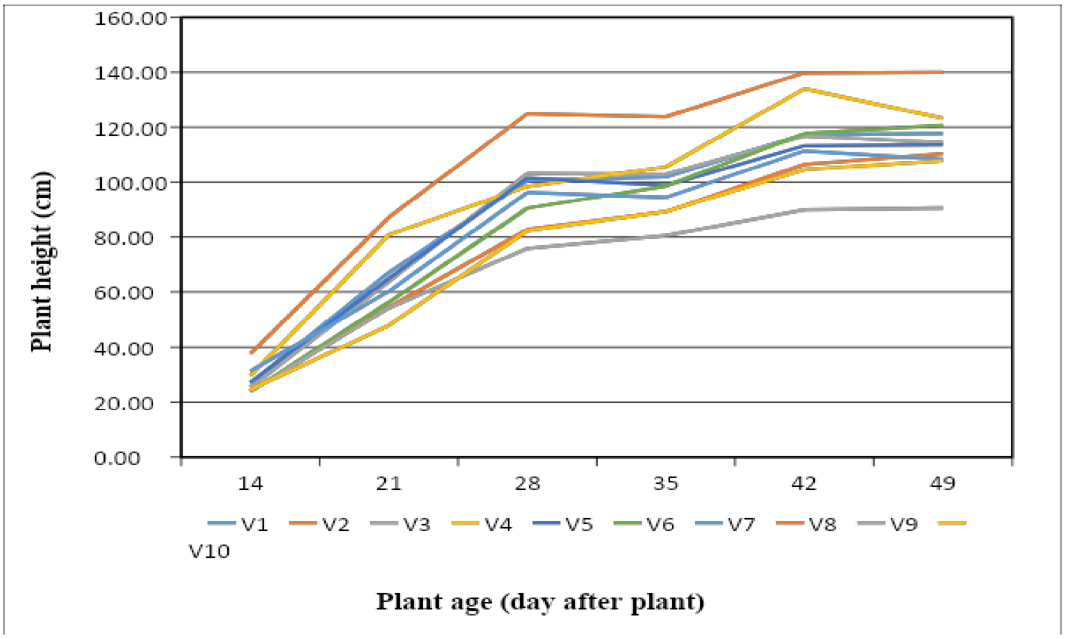

Figure 1. Plant Height Growth of 10 Soybean Varieties

The results of the statistical analysis showed that water supply had a significant effect on plant height only at the beginning of the observation (14 days after planting) and then no real effect, but there was a tendency for decreasing water availability to soybean plants to inhibit growth in plant height when water was supplied at 50% of normal requirements. The lowest yield of plant height when compared to giving 75 and 100% water. (Figure 2).

The character of each variety showed different results on the number of leaves, the results of statistical analysis of the number of leaves showed that the combination of treatment between varieties and water application did not show a significantly different interaction effect. Variety treatment showed varying effects at each age, at the age of 14, 35, 42, and 49 days after planting showed significantly different numbers of leaves while at 21 and 28 were not significantly different. The Kaba variety produced the highest number of leaves followed by Sinabung and Dering 1. The treatment of water requirement showed a significantly different effect at the age of 21, 28, 42, and 49 days after planting where the provision of 50% water from normal needs gave the lowest number of leaves and was significantly different from the treatment of 75% and 100% water provision.

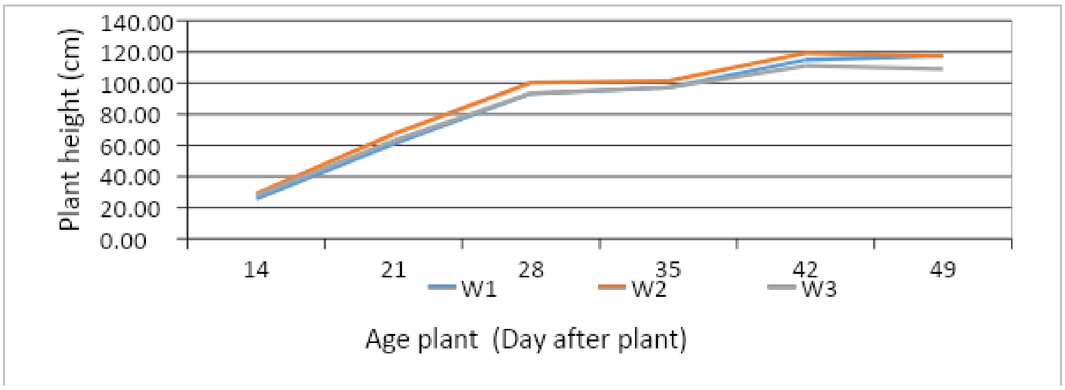

Figure 2. Plant height of soybean by treatment Providing 100% (W1), 75% (W2), and 50% (W3) water

Table 3. Number of leaves in the treatment of Soybean Varieties and Application of Water

Treatment	Plant age (Day after plant)					
	14	21	28	35	42	49
V1 (Dering 1)	4.00 a	6.67	10.00	9.89 a	20.00 a	29.56 cde
V2 (Sinabung)	4.11 ab	6.33	9.89	9.33 a	21.89 ab	30.56 de
V3 (Panderman)	4.33 ab	6.44	9.22	9.11 a	19.78 a	24.78 abc
V4 (Argomulyo)	4.44 ab	6.67	9.22	9.33 a	18.78 a	22.56 ab
V5 (Gema)	4.33 ab	7.22	10.33	12.22 ab	20.89 ab	26.11 bcd
V6 (Kaba)	4.11 ab	6.67	8.67	10.00 a	20.56 a	31.56 e
V7 (Anjasmoro)	4.56 ab	6.78	9.22	9.44 a	19.56 a	28.89 cde
V8 (Grobogan)	4.78 b	7.11	9.89	11.89 ab	18.22 a	20.33 a
V9 (Gepak Kuning)	4.78 b	6.78	11.22	13.44 b	25.78 b	32.78 e
V10 (Wilis)	4.22 ab	6.78	9.22	9.78 a	21.56 ab	31.33 de
HSD 5 %	0,70	tn	tn	3,23	4.94	5,39
W1 (100 % water)	4.27	7,00 b	10.43 b	12.67	23.30 c	32.10 c
W2 (75 % water)	4.37	6.73 ab	9.53 ab	10.97	20.90 b	27.70 b
W3 (50 % water)	4.47	6.00 a	9.10 a	10.10	17.90 a	23.73 a
HSD 5 %	tn	0,42	1,34	tn	2,18	2,38

Notes: Numbers followed by the same letters in the same column showed no significant difference at HSD 5%

Based on the results of statistical analysis of the number of flowers in response to the genotype of each plant variety showed significant differences, but at each level of treatment of water needs of soybean plants showed significantly different results from the age of 42 to 56 days after planting (Table 4). At the observation age of 28 days after planting, Sinabung, Kaba, Anjasmoro, Gepak Kuning and Wilis varieties have not produced flowers, while Dering 1, Panderman, Argomulyo, Echo and Grobogan varieties have appeared to produce flowers which means they have entered the generative phase.

The effect of water application began to show significant differences since the plants were 42 to 56 days after planting, the decreasing water availability greatly affected the formation of flowers on soybean plants. Giving 50% water produces the lowest number of flowers compared to other treatments, while the 75% water requirement treatment is not significantly different from the 100% water requirement treatment.

Pods formed on soybean plants are the result of the fertilization process between male and female flowers. The factor of genetic diversity in soybean varieties is very decisive in the process of pod formation. The results of statistical analysis showed that the number of pods formed in each variety tested varied. Some varieties showed similar responses such as Gepak Kuning, Kaba, Dering 1, Sinabung, Echo, Anjasmoro and Wilis. While Argomulyo and Grobogan varieties produced a lower number of pods (Table 5).

Table 4. Number of flowers in soybean varieties and treatments giving water

Treatment	Plant age (Day after plant)				
	28	35	42	49	56
V1 (Dering 1)	1.78 ab	6.00 ab	12.44 ab	32.22 abc	10.00 a
V2 (Sinabung)	0.00 a	4.89 ab	9.44 a	31.78 abc	7.44 a
V3 (Panderman)	5.89 c	6.22 ab	12.11 ab	19.22 a	5.33 a
V4 (Argomulyo)	0.67 a	0.89 a	11.11 ab	20.22 a	5.56 a
V5 (Gema)	4.33 bc	5.00 ab	13.22 ab	29.11 abc	8.00 a
V6 (Kaba)	0.00 a	7.11 ab	11.33 ab	34.00 bc	8.78 a
V7 (Anjasmoro)	0.00 a	8.89 b	13.89 ab	37.56 c	10.00 a
V8 (Grobogan)	9.78 d	9.00 b	13.22 ab	20.89 ab	4.89 a
V9 (Gepak Kuning)	0.00 a	7.44 b	15.78 b	39.56 c	15.78 b
V10 (Wilis)	0.00 a	6.56 ab	10.11 a	30.00 ab	9.67 a
HSD 5 %	3,41	6,26	5,38	13,60	5,44
W1 (100 % water)	2.37	6,87	14.50 c	34.60 b	9.53 b
W2 (75 % water)	1.77	5,93	12.00 b	30.27 b	9.43 b
W3 (50 % water)	2.60	5,80	10.30 a	23.50 a	6.67 a
HSD 5 %	tn	tn	2,38	6,01	2,40

Notes: Numbers followed by the same letters in the same column showed no significant difference at HSD 5%

Table 5. Number of pods in the treatment of soybean variety and water application

Treatment	Plant age (Day after plant)			
	42	49	56	63
V1 (Dering 1)	15.67 abc	28.89 abcd	31.67 abc	36.67 abc
V2 (Sinabung)	12.11 abc	31.56 d	36.67 abc	36.78 abc
V3 (Panderman)	12.11 abc	21.89 abc	27.00 ab	24.22 ab
V4 (Argomulyo)	16.56 abc	19.89 a	24.67 a	25.22 a
V5 (Gema)	18.44 bc	29.00 abcd	31.11 abc	34.11 abc
V6 (Kaba)	9.33 a	30.89 cd	37.44 abc	39.00 abc
V7 (Anjasmoro)	11.78 abc	29.22 bcd	40.00 bc	42.56 bc
V8 (Grobogan)	19.11 c	21.11 ab	26.11 ab	25.89 ab
V9 (Gepak Kuning)	13.89 abc	41.11 e	44.89 c	44.56 c
V10 (Wilis)	11.56 ab	29.44 bcd	36.11 abc	35.00 abc
HSD 5 %	7,44	9,24	15.58	13.59
W1 (100 % water)	16.00 b	32.27 b	40.30 b	39.43 b
W2 (75 % water)	15.20 b	30.13 b	29.13 a	35.27 b
W3 (50 % water)	10.97 a	22.50 a	31.27 a	28.50 a
HSD 5 %	3,29	4.08	6.88	6.00

Notes: Numbers followed by the same letters in the same column showed no significant difference at HSD 5%.

The effect of water availability on the process of pod formation gives a real influence, at the level of water provision of 50% of normal needs produces the lowest number of pods and is significantly different from the provision of water 100 and 75% of normal needs. Estrada et al (2008) suggested that drought stress that occurs in the pre and post anthesis phase will reduce the process of pod and seed formation in legume plants.

The tested varieties gave different responses to the given water conditions in general under normal water availability conditions (100% water requirement) still produced the highest pod weight, but under reduced water availability conditions (75% treatment) showed results that were not different from the treatment of 100% water requirement this occurred in all tested varieties. The 50% water requirement treatment gave the lowest pod weight and was significantly different from the 75 and 100% water supply treatments.

Table 6. Pod weight per plant result of interaction between soybean variety treatment and water giving

Treatment	W1 (100 % water)	W2 (75 % water)	W3 (50 % water)
V1 (Dering 1)	21.00 j	17.33 efghij	12.33 abcd
V2 (Sinabung)	16.67 defghij	15.33 bcdefgh	14.67 bcdefg
V3 (Panderman)	16.00 defghi	13.00 abcde	10.67 ab
V4 (Argomulyo)	15.33 bcdefgh	12.00 abcd	13.33 abcde
V5 (Gema)	20.33 ij	12.00 abcd	10.67 ab
V6 (Kaba)	13.67 abcdef	13.00 abcde	13.50 abcdef
V7 (Anjasmoro)	21.33 j	18.33 fghij	12.67 abcde
V8 (Grobogan)	18.67 ghij	13.00 abcde	9.67 a
V9 (Gepak Kuning)	20.00 hij	13.33 abcde	11.00 abc
V10 (Wilis)	19.33 ghij	15.67 cdefghi	10.67 ab
HSD 5 %		4.96	

Notes: Numbers followed by the same letters in the same column showed no significant difference at HSD 5%.

Drought stress occurring at any stage of plant growth and development can reduce yield, although the extent depends on the growth phase at which the stress occurs and the duration of the stress. Drought stress is a limiting factor, as it can inhibit photosynthesis and photosynthate translocation.

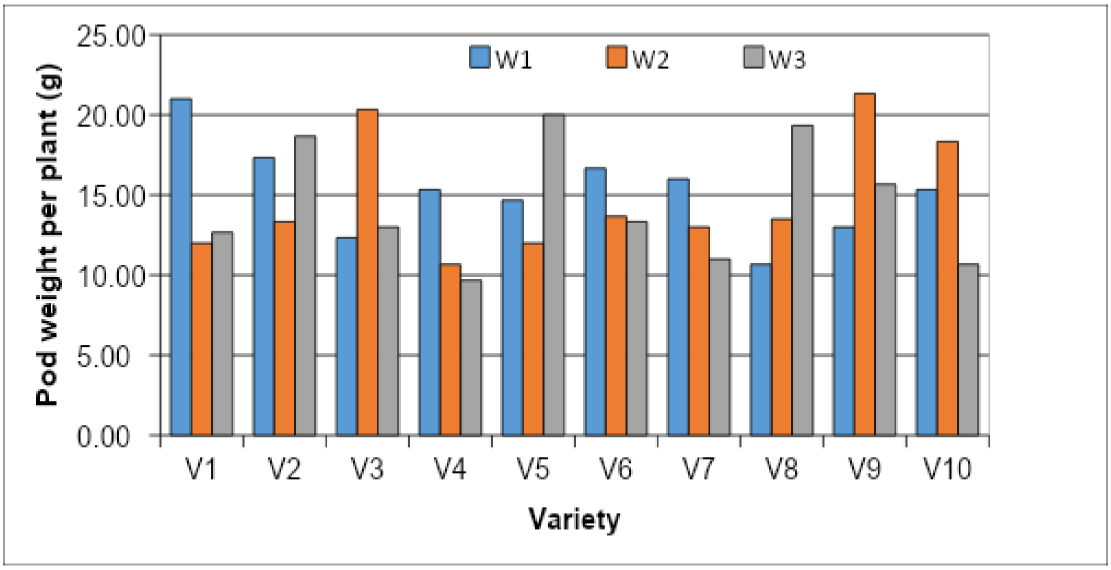

Figure 3. Weight of Pods per Plant of Several Soybean Varieties in the Water Treatment of 100% water requirement (W1), 75% water requirement (W2) and 50% water requirement (W3).

Based on the results of statistical analyses, each variety and water application treatment showed the potential seed yield per hectare (Table 6). The ability of plants to show their yield potential varies greatly depending on several genetic factors and environmental conditions, among others. Genetic variation is an important asset for improving the genetic quality of a plant species, soybean is classified as a plant that has high genetic diversity.

The potential seed yield per hectare of each variety shows different variations, the ability of plants to produce optimally becomes the criterion for measuring yield potential. Gepak Kuning variety showed better yield potential followed by Anjasmoro, Argomulyo, Echo, Kaba, and Dering 1. Panderman variety showed the lowest yield potential (Table 7). The ability of plants to show their yield potential varies greatly depending on several factors including genetic factors and environmental conditions. Genetic variation is an important asset for improving the genetic quality of a plant species, soybean is classified as a plant that has high genetic diversity.

Conclusion

Based on the results of observations and data analysis, it can be decided that:

1. The significant interaction effect between variety and water provision occurs in the variable Pod Weight per Plant, the lower the water given to each variety, the lower the pod weight per plant.
2. Each variety tested gave a different response to each observed variable.
3. The increasing drought stress applied to soybean plants will reduce growth and production.

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