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The morphological response of the soybean growth (*Glycine max* (l)) until vegetative stage 3 on various intensities of light

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Abstract. This study aims to determine the effect on various intensity of light on the response of vegetative growth of local soybean to vegetative three stadia. Greenhouse experiments with 15 experimental units were prepared in a completely randomized design with treatments consisting of: without shade, 50, 60, 70, and 80% shade. The observed variables are plant height, number of leaves, number of branches, and stem diameter, root length, wet weight, and dry weight of stove. All data were analyzed by variance followed by All data were analyzed by variance followed by LSD test at 5%. The results showed that shading percentage had an effect on plant response on all growth variables until the end of vegetative-3 stage. The higher the shade percentage, the more increase the growth of plant height and root length, but on the contrary decrease the growth of the number of leaves, in effect on the decrease of leaf number, branch number, stem diameter, and wet weight and dry weight of plant.

1. Introduction

At least 60% of soybean needs in Indonesia are fulfilled from imports [1]. To create independence in the procurement of soybeans, despite improving the production technology of soybean plants, it also need to develop the extension of soybean cultivation. In dry land utilization there are often significant obstacles, such as: soil acidity, low caption exchange capacity, availability of phosphate, water stress [2], and low light intensity, especially in intercropping cropping patterns utilizing land in plantation and agro forestry systems. Low light intensity will be a limiting factor in crop production [3], as it will affect the balance between water retrieval and water loss which is borne by the mechanism of opening and closing of stoma holes [4], [5]. The stoma hole will close in response to dehydration to prevent water loss and low intensity of light that falls onto the leaf surface which will ultimately lead to photosynthesis [6], [7], [8]. So far, local soybean varieties have been developed with shade up to 50% [9], but the information on how the original soybean growth response at higher shade intensity or up to 80% is unknown. For testing on high shade intensity as in plantation and agro forestry conditions needs to be done.

This study aims to determine the effect of light intensity on the response of local soybean vegetative growth until the three vegetative stadia.

2. Experimental Method

The seed surface of Gepak Kuning's soybean varieties is sterilized by dipping them into 50% alcohol solution for 5 seconds. After rinsing the compost with sterile water 3 times, the seeds are sieved. Meanwhile, 20 x 10 cm polybags were prepared containing a mixture of soil and planting medium (8: 1 v.v). The sterile soybean seeds are planted into polybags that have been placed under the aegis of para-net within the greenhouse with shade percentage according to treatment i.e. 0% (without shade), 50%, 60%, 70%, and 80%, Each treatment is repeated three times to obtain 15 units of experiments.

Every day, from one day after planting (DAP) to 18 DAP at 15.00 WIB, an observation of the morphological response of plant vegetative growth to stage 3. Plant height (cm) is measured from the root neck to the growing point. The number of branches is determined by counting the number of branches on the main stem of the sample plant. The number of leaves is determined by counting the number of perfect leaves on the sample plant. The diameter of the stem is measured by using the sliding term when the plant has entered the vegetative phase 3 (V3). Root length (cm) is determined by measuring the root length from the root neck to the root. The wet weight of the plant (gram) is determined by weighing the wet weight of the sample plant per treatment. The dry weight of the plant (gram) was determined by weighing the dry oven dry weight of each sample plant. All data of observation variable were analyzed by using variance and 5% LSD test to know the effect difference between the treatments on vegetative plant response.

To obtain supporting data, it was observed plant growing environment conducted every day (1-18 DAP) at 07.00, 12.00, and 15.00 WIB. The supporting data and their measurement tools are: (i) light intensity by using light meter; (ii) the temperature of the leaf using infrared thermometer, and (iv) the pH temperature planting medium with pH meter.

3. Results and Discussion

The mean of plant height in response to shade intensity differences in the initial phase to the end of vegetative-1 (7 and 11 DAP), the vegetative-2 end phase (15 DAP), and the vegetative-3 final phase are presented in table 1. It shows that at all time observed, the height of shaded plants higher than without shade.

The mean of number of leaves (12-18 DAP), number of branches (12-18 DAP), and stem diameter (18 DAP) can be seen in table 2. The mean of number of leaves is not different between without shade and with 70% of shade. The same thing happen on the number of branches (14 and 18 DAP) and stem diameter (18 DAP).

Table 1. The mean of plant height in response to shade intensity differences in the initial and the end of vegetative-1 phases, the vegetative-2 end phase, and the vegetative end-3 phase (cm)

Treatment	Initial-end vegetative -1phase		End phase of vegetative-2	End phase pf vegetative-3
	7 DAP	11 DAP	15 DAP	18 DAP
Without shade	5.86 a	10.33 a	14.00 a	16.03 a
50% shade	7.13 ab	11.70 ab	15.50 ab	17.93 ab
60% shade	8.03 ab	12.66 ab	16.23 ab	18.67 b
70% shade	8.80 ab	13.40 bc	17.13 bc	19.83 bc
80% shade	10.13 b	15.16 c	19.03 c	21.56 c
LSD 5%	3.24	2.44	2.63	2.34

Means followed by the same letter in the same row are not significantly different at $p<0.05$.

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Table 2. The mean of number of leaves and branches (12-18 DAP) and stem diameter (18 DAP) in response to shade intensity differences

Treatment	Average number of leaves			Average number of branches			stem diameter(cm)
	12 DAP	14 DAP	18 DAP	12 DAP	14 DAP	18 DAP	18 DAP
Without shade	5.0 b	5.0 b	8.0 b	3.00 b	3.13b	8.12 b	0.25 b
50% shade	3.0 a	5.0 b	8.0 b	2.33 a	2.66 b	8. 27 b	0.24 b
60% shade	3.0 a	4.0 b	7.0 b	2.33 a	3.13 b	8. 17 b	0.23 b
70% shade	2.0 a	4.0 b	7.0 b	2.13 a	2.66 b	8.12 b	0.21 ab
80% shade	2.0 a	2.0 a	5.0 a	2.13 a	2.27 a	6.27 a	0.17 a
LSD 5%	1.99	1.99	1.99	0.66	0.66	1.99	0.04

Means followed by the same letter in the same row are not significantly different at $p<0.05$.

The same result was indicated by the average root length. but different on the average wet weight and dry weight of plants at 18 DAP (table 3). Up to 70% shade. the root length is equal to no shade and will increase in the shade of 80%.

Table 3. The mean of root length. wet weight. and dry weight of plants at 18 DAP in response to shade intensity differences

Treatment	root length (cm)	wet weight ofplants (gr)	dry weight of plants (gr)
Without shade	20.36 a	8.51 d	0.95 c
50% shade	22.76 ab	6.57 c	0.62 b
60% shade	23.90 ab	5.00 bc	0.55 b
70% shade	28.50 bc	3.22 ab	0.46 ab
80% shade	32.70 c	2.70 a	0.23 a
LSD 5%	6.16	1.90	0.24

Means followed by the same letter in the same row are not significantly different at $p<0.05$.

The results oflight intensity measurement (lux) and air temperature under paranet shade and leaf temperature are presented in table 4.

Table 4. Average light intensity. temperature under para-net shade. and leaf temperature

Environment Variables	Shade Level				
	P0	P1	P2	P3	P4
Light intensity (Lux)	26,366	18,360	17,056	16,039	14,999
Temperature inside shade (°C)	-	29.9	29.2	28.5	27.7
Leaf temperature (°C)	31.0	29.2	28.6	28.1	27.4

Note: we measure every morning. day and evening; the average temperature outside shade is 34 ^{0}C; pH of planting media is 7.0; P0: without shade. P1: 50% shade. P2: 60% shade. P3: 70% shade. P4: 80% shade.

On the shade treatment the crown and plant parts at the above ground level have the higher average height and longer root length than those without shade treatment. The intensity and duration of irradiation and water saturation affects the formation of root cuttings [10], [11]. Dark conditions will increase the formation of root meristems [12]. There is an interaction between light and auxin in which light affects either synergistically or antagonistically to the growth regulator of auxin and cytokines related to root growth [13],[14]. Auxin greatly affects the growth of the stem [15], while the light will affect the level of the induction auxin both regarding transport and its metabolism involving photo-oxidation [16], [17], [18]. Etiolation is strongly influenced by the level of sucrose [19]. In this case the transition phase growth from young plants to mature plants is stimulated by high indigenous sucrose [20]. Sucrose plays an important role in the growth of the juvenile phase tissue [21]. Conditions with low light intensity in this experiment (14,999-18,360 lux) inhibited the rate of photosynthesis and attributed to total sugar useful for plant growth. Despite high root growth and canopy length, however, the wet weight and dry weight of plant stalks in the treatment under the shade is relatively small compared with no shade (table 3). Elevation of crown and root tissue indicates an increase in CO_2 storage in vascular bundle cells. High CO_2 levels combined with low light intensity levels can improve light photosynthetic reactions [22], [23] and improve the efficiency of light use in photosynthesis [24], [25]. High CO_2 levels can increase carbon uptake by increasing the efficiency of photosynthesis under dynamic light conditions [26], [24].

4. Conclusion

The percentage of shade affected the plant response on all growth variables until the end of the vegetative-3 stage. Higher the shade percentage, better on the growth of plant height and root length. On the contrary, lesser the shade percentage will decreasing the growing leave number, that will affecting leaf number, branch number, stem diameter, and wet weight and dry weight of plant. Soya plants with shade up to 70% are able to provide high growth response, stem diameter, and same number of leaves with no shade.

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