Study the Effect of Shade Stress on Indonesian Soybeans to Anticipate the Need for Breeding Superior Variety

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Abstract. The need for superior soybeans which resistant against low light is a challenge for Indonesia that has large of soybean germplasms which potential for achieving national soybean self-sufficiency and sustainability. Unfortunately, research on this field still very lack. This study aims to investigate the responses of 28 soybean accessions to shade stress, and looking for potential candidates or basic material for the development of high-yielding varieties. The research was conducted in the Cikeumeuh-Bogor field using a randomized block factorial design with two treatments (genotype and percentage of shade), with three replications. Based on the results, all of the morph-agronomic characters significantly influenced by the treatments, except for the number of filled pods (p-value <0.001). There was interaction between genotypes and shade stress which influenced the plant height, number of branches, number of trifoliate leaves and flowering time. Based on this study, Kedelai Hijau (G-19) and Lokal Brebes (G-21) were potential to be candidate for breeding on shade-resistant varieties. G-19 had the best response to the number of branches and number of trifoliate leaves, while G-21 best on height and root length. This information becomes a novelty that contributes to breeding soybeans resistant to shade stress for food sustainability.

1 Introduction

The drastic change in global climate and implications for the increasingly limited carrying capacity of land that can be used for plant production media has implied the urgency of the need for more resilient plants, especially those that can adapt to conditions of higher cropping density while maintaining the productivity of individual plants [1]. Agriculture is one of the sectors most vulnerable to climate change [2], [3]. Climate change is expected to have a negative influence to crop production for food in areas of lower latitudes [4]which are currently experiencing food insecurity. It was also reported that yields are widely projected to fall the greatest.. Production of wheat, maize and sorghum and other cereals will experience an average yield loss of 8% in Africa and South Asia by 2050; even wheat in

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Africa, is predicted to undergo a -17% yield decrease [5]. Climate change disruption to the recorded rainy season from 1966 to 2002 is estimated to have decreased rice yields by 4% in India [6]. For other developing countries, this implication is very bad for rural and poor communities who depend on their agriculture income [7], including Indonesia.

Over the years Indonesia has become a net importer of soybeans as a result of the decline in soybean production caused by reduced soybean harvested areas [8], [9], whereas on the other hand the demand for soybeans continues to increase because soybeans are one of the strategic food commodities [10]. Indonesia's soybean production is estimated to continue to decline from 2021 to 2024, where in 2021 it is projected that domestically produced soybeans will reach 613.3 thousand tons, which is down 3.01% from 2020 which reached 632.3 thousand tons [11]. In 2022, it is estimated that it will decrease by 3.05% to 594.6 thousand tons; then fell again 3.09% to 576.3 thousand tons in 2023; and in 2024 the decrease will be 3.12% to 558.3 thousand tons [11]. According to Agricluture Ministry, this downward trend in national soybean production is due to the intense competition for land use with other strategic commodities, such as corn and chilies, which resulted in a decrease in harvested area of around 5% per year [11]. This is also further exacerbated by global climate change, which is detrimental to agriculture in general, including national soybean production.

The development of soybeans as intercrops under plantation stands, agroforestry environments, or intercropping with other food crops is a mainstay alternative to increase national soybean production which is still very low [8]. This is also strategies to answer the challenges of the food system where there is an interest to reduce and adapt to climate change, prevent the desertification and land degradation, and achieve food security [12]. Unfortunately, the realization of these efforts is constrained by the limited information on soybean varieties that are resistant to shade.

Currently in Indonesia, there are more than 114 soybean varieties existed but those with tolerance to shade are still limited. The previously released shade-tolerant soybean varieties were Dena-1 and Dena-2 created by researcher from Indonesian Agency for Agriculture Research and Development (IAARD) [13]. Several other newly released varieties from universities mostly are not subject to tolerance against shade stress, for example, Devatra 1 and Devatra (released by Bengkulu University). We considered that now is the time to give large portion of efforts to increase our local soybean production through the expansion of planting shade-tolerant soybeans. Through optimization of agricultural land which more limited in size, production is expected to be increased significantly. In this regards, we therefore conducted research aimed to study the effect of shade stress against 28 varieties of soybean in Indonesia as a basic step for engineering an adaptive and high-yielding soybeans with tolerance against low-light.

2 Method

Research activities were carried out at the Cikeumeuh Experimental Station (Lat S -6’34”’ Long E 106º 47”’) from March 2020 to September 2020. The average temperature in the field was 25 º Celsius with the lowest temperature reached 21º Celsius, and highest temperature reached up to 31º Celsius in the daytime, with the daily air humidity fall under the range of 60% to 20% (data not shown). Total of 28 accessions of soybeans mainly from local varieties of soybeans as tested materials (Table 1).

The study used a randomized block factorial design with two treatments i.e. shade-intensity and soybean genotype; with three replications each. The shade intensity consisted of 3 levels: no shade (0% shade), 50% shade, and 70% shade; while genotype of soybean was consisting of 28 levels from 28 accessions of soybean.

Table 1. List of soybean accessions in this study

No	Accession number	Accession Name	Genotype code	Collection Site/Province
1	050003-00902 b	LOK. BALI B	KD-1	East Java
2	050003-00933	LOK. ACEH (KUNING)	KD-2	NAD
3	050003-00961	KACANG DUDUK	KD-3	East Kalimantan
4	050003-01549	ICA-SILI	KD-4	Columbia
5	050003-01593-b	KEDELE BALI	KD-5	East Java
6	050003-01633	LOK. PURING	KD-6	Central Java
7	050003-01638	NTU.KS NO.5	KD-7	Taiwan
8	050003-01658	LOK. SOPENG 2	KD-8	South Sulawesi
9	050003-01667	GALUNGGUNG	KD-9	West Java
10	050003-01670	LOK. SUMBAR	KD-10	West Sumatera
11	050003-01671	LOK. ACEH	KD-11	NAD-Nanggroe Aceh Darusalam
12	050003-03083	LOK.HITAM A	KD-12	West Java
13	050003-03184	HITAM LOKAL	KD-13	West Java
14	050003-03185	KEROK LOKAL	KD-14	West Java
15	050003-03186	KEPET HITAM	KD-15	West Java
16	050003-03187	KEPET	KD-16	West Java
17	050003-03189	KEPET GODEK	KD-17	West Java
18	050003-03194	KEPET MINYAK	KD-18	West Java
19	050003-03218	KEDELAI HIJAU	KD-19	West Java
20	050003-03233	KED.KECIPIR PUTIH	KD-20	West Java
21	050003-03246	LOK. BREBES	KD-21	West Java
22	050003-04672	Dena-1	KD-22	East Java
23	050003-03293	GENJAH HITAM	KD-23	East Java
24	050003-03391	LOK. KEBUMEN	KD-24	Central Java
25	050003-03453	LOK. HIJAU	KD-25	Central Java
26	050003-03456	MERBABU	KD-26	Central Java
27	050003-03458	TIDAR	KD-27	Central Java
28	050003-03459	GUNTUR	KD-28	West Java

Observations on the morpho-agronomic characters were conducted at the vegetative stage, the generative stage, and at harvest time, depend on the characters. Plant height, number of branches, number of trifoliate leaves, and the diameter of the plant crown were observed during the vegetative stage of each accession when reached maximum. Flowering time were observed when plants entering the generative staged. Number of empty pods, number of filled pods, root length, and the weight of 100 seeds were observed after harvested.

The acquired data were examined using Analysis of variance (ANOVA) and if significant differences were found (pvalue < 0.05), the Duncan Multiple Range Test (DMRT) was used for further analyzed. We conduct data tabulation using Microsoft Excel, while data analysis was performed using Minitab version 19.

3 Results and Discussion

Based on visual observations, almost all soybean plant accessions in control plots (without shade) showed better growth and development than those with shading. Leaf development under conditions of 70% shading showed clear inhibition, where the leaf surface area was generally narrower and the stem diameter was also smaller when compared to the genotype of soybeans grown in 0% and 50% shading.

Table 2. ANOVA on the influence of genotype, shading and their interactions towards traits

	P value**						
Source	plant height	number of branch	number of clumps	number of filled pods	number trifoliate leaves	root length	flowering time
Model	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Accession	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Shade	0.000	0.000	0.000	0.033	0.000	0.000	0.000
Accession * Shade	**0.001**	**0.001**	0.026	0.357	**0.000**	0.003	**0.000**
Reps	0.241	0.001	0.001	0.000	0.009	0.111	0.674
							F value
Source	plant height	number of branch	number of clumps	number of filled pods	number trifoliate leaves	root length	flowering time
Model	174.872	33.409	229.623	37.724	318.484	103.733	2044.026
Accession	6.467	4.862	13.885	3.854	7.515	3.327	6.086
Shade	702.756	314.341	24.900	500.866	1643.886	1053.213	23.992
Accession * Shade	1.903	1.908	1.506	1.472	2.737	1.787	2.216
Reps	1.437	7.767	7.052	1.036	4.866	2.225	0.395

** Significant at value < 0.001

According to Table 2, almost all variables (traits) are significantly influenced by genotype and shade treatment, except for the number of filled pods (at p value <0.001). Another point is, there is interaction between genotype and shading which influencing the plant height, number of branches, number of trifoliate leaves and flowering time. But there is no significant effect of the interaction to the number of clumps, number of filled pods and root length.

Table 3. Effect of genotype and shading to plant height

Shading	**Genotype of soybean**									
	G-1	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	36.408 A	40.767 B	39.533 C	40.233 B	46.567 B	39.967 B	35.967 B	43.000 B	37.100 B	
	bc	abc	abc	abc	ab	abc	bc	ab	bc	
0%	48.400 A	53.833 B	50.900 B	48.700 B	65.200 B	42.800 B	38.833 B	54.300 B	45.267 B	
	cdefgh	bcdef	bcdefgh	cdefgh	b	efgh	gh	bcdef	defgh	
50%	68.933 A	105.700 A	95.067 A	77.467 A	106.867 A	88.733 A	84.300 A	88.733 A	80.467 A	
	h	ab	abcdefg	fgh	ab	bcdefgh	defgh	bcdefgh	defgh	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	44.400 B	44.900 B	46.000 B	43.333 B	26.767 C	37.900 B	53.867 B	43.133 B	47.467 B	
	ab	ab	ab	ab	c	ab	a	ab	ab	
0%	45.233 B	46.00 B	61.667 B	46.033 B	48.167 B	43.867 B	59.300 B	52.333 B	51.733 B	
	defgh	defgh	bc	efgh	cdefgh	gh	bcd	bcdefgh	bcdefgh	
50%	91.600 A	79.700 A	92.600 A	72.000 A	85.467 A	82.400 A	90.833 A	77.900 A	104.467 A	
	abcdefg	defgh	abcdefg	gh	cdefgh	defgh	abcdefg	efgh	abc	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	**G-28**
70%	50.500 B	47.233 B	53.700 B	39.700 B	36.667 B	46.867 B	41.667 C	39.567 B	46.533 B	44.333 B
	ab	ab	a	abc	bc	ab	ab	abc	ab	ab
0%	86.400 A	57.433 B	61.700 B	42.027 B	38.667 B	50.067 B	54.467 B	58.367 AB	54.000 B	52.433 B
	a	bcde	bc	fgh	h	cdefgh	bcdef	bcd	bcdef	bcdefgh
50%	99.200 A	98.000 A	109.133 A	91.933 A	84.667 A	93.267 A	93.533 A	85.800 A	78.567 A	79.767 A
	abcd	abcde	a	abcdefg	cdefgh	abcdefg	abcdefg	cdefgh	efgh	defgh

Note : Value followed by capital letters indicates the effect of shading treatment to plant height. Values followed by lowercase letters indicate genotype influence on plant height.

The results of the analysis showed that the genotype had a significant effect on plant height, especially in plots without stress-shade treatment. The stress-shade treatment that has a significant effect on plant height is the 50% shade treatment (Table 3).

Table 4. Effect of genotype and shading to the number of branches

	Genotype of soybean									
Shading	**G-1**	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	0.200 C	0.133 B	0.200 B	0.200B	0.667 B	0.133 B	0.200 B	0.667 B	0.067 B	
	bcde	cde	bcde	bcde	ab	cde	bcde	ab	de	
0%	1.867 B	0.600 B	1.467 A	1.333B	1.200 AB	1.933 A	1.133 AB	1.933 A	0.800 AB	
	cdefghi	i	bcdefgh	defghi	efghi	cdefghi	efghi	cdefghi	hi	
50%	3.200 A	2.200 A	2.133 A	2.800 A	2.733 A	2.067 A	1.933 A	2.533 A	1.867 A	
	abcde	bcdef	f	abcdef	abcdef	cdef	def	abcdef	def	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	0.267 C	0.467 A	0.667 B	0.267 B	0.000 B	0.400 C	0.733 B	0.533 B	0.533 A	
	abcde	abcde	ab	abcde	e	abcde	a	abcd	abcd	
0%	1.667 B	1.867 A	2.400 A	2.267 A	1.800 A	1.933 B	1.667 B	2.800 A	1.600 A	
	cdefghi	cdefghi	bcdefg	bcdefgh	abcde	cdefghi	cdefghi	abcde	cdefghi	
50%	2.333 A	1.933 A	2.600 A	2.517A	2.60A	3.400 A	3.267 A	3.133 A	1.867 A	
	abcdef	def	abcdef	abcdef	ef	abc	abcd	abcde	def	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	**G-28**
70%	0.667 B	0.733 B	0.533 C	0.067B	0.200 B	0.667 B	0.467 B	0.533 B	0.467 B	0.600 C
	ab	a	abcd	de	bcde	ab	abcde	abcd	abcde	abc
0%	3.067 A	2.867 A	1.533 B	1.117B	2.200 A	0.933 B	2.400 A	3.467 A	2.467 A	2.200 B
	abcde	abc	cdefghi	fghi	bcdefgh	ghi	bcdefg	ab	cdefg	bcdefgh
50%	3.867 A	3.533 A	2.333 A	2.667 A	2.933 A	2.467 A	2.600 A	3.600 A	3.667 A	3.267 A
	abcde	ab	abcdef	abcdef	abcde	abcdef	abcdef	ab	a	abcd

Note : Value followed by capital letters indicates the effect of shading treatment on the number of branch. Values followed by lowercase letters indicate genotype influence on the number of branch.

The result showed that stress-shade treatment that has a significant effect on the number of branch is the 70% shade treatment, while the genotype which had significant effect are especially G1- G9 when combined with shading 70% and 0% (Table 4).

Table 5. Effect of genotype and shading to the number of clumps

	Genotype of soybean									
Shading	**G-1**	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	11.67 B	24.67 A	22.00 B	26.67 A	27.33 A	19.33 A	21.00 A	26.67 A	9.00 A	
	abc	bcde	abc	abc	abc	abcd	abc	f	bcde	
0%	19.00 AB	26.67 A	27.00 A	29.00 A	28.33 A	24.00 A	23.33 A	27.67 A	13.00 A	
	bcde	abcd	ab	a	a	ef	de	Ab	g	
50%	22.67 A	28.67 A	28.67 A	29.33 A	29.33 A	26.67 A	24.00 A	29.67 A	21.67 A	
	e	ab	ab	a	a	abc	bcd	a	de	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	21.67 B	25.67 A	26.33 A	27.67 A	26.67 A	15.33 B	26.33 A	26.33 A	21.33 B	
	abc	abc	abc	abc	e	abc	abc	cde	abc	
0%	26.67 AB	26.00 A	28.00 A	28.00 A	27.67 A	17.33 B	29.00 A	28.67 A	27.67 A	
	abc	abcd	a	a	ab	fg	a	a	ab	
50%	29.00 A	28.67 A	30.00 A	29.67 A	29.00 A	22.67 A	29.67 A	29.33 A	28.67 A	
	a	ab	a	a	a	cde	a	a	ab	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	**G-28**
70%	27.00 A	25.67 A	26.33 A	25.00 A	28.33 A	26.67 A	26.67 A	18.00 A	24.67 A	25.00 A
	abc	ab	abc	a	abc	abc	de	abc	abc	
0%	27.67 A	27.00 A	28.00 A	27.67 A	29.0 A	28.67 A	28.00 A	22.00 A	27.33 A	27.67 A
	a	abcd	a	abcd	a	a	a	cde	a	ab
50%	28.67 A	27.33 A	28.67 A	27.67 A	29.33 A	29.00 A	28.33 A	22.33 A	28.00 A	29.00 A
	ab	ab	abc	ab	ab	a	ab	cde	ab	a

Note : Value followed by capital letters indicates the effect of shading treatment on the number of clumps. Values followed by lowercase letters indicate genotype influence on the number of clumps.

Shading treatment had no significant effect on the number of clumps, as well as the effect of the soybean genotype (Table 5).

Table 6. Effect of genotype and shading to the number of pods

	Genotype of soybean									
Shading	**G-1**	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	0.133 B	0.800 B	0.333 C	0.200 B	0.133 B	0.200 C	0.067 B	0.133 B	0.000 B	
	ab	a	ab	ab	ab	ab	b	ab	b	
0%	23.867 A	16.400 A	24.867 B	23.600 A	26.000 A	27.933 B	18.600 A	24.667 A	14.667 AB	
	fgh	gh	cdefgh	fgh	bcdefg	bcdef	gh	fgh	fgh	
50%	24.800 A	18.667 A	28.733 A	25.400 A	30.733 A	33.533 A	19.467 A	25.333 A	22.667 A	
	abcde	de	abcde	abcde	abcde	abcde	cde	abcde	e	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	0.467 B	0.033 B	0.200 B	0.000 B	0.000 C	0.133 B	0.400 B	0.067 B	0.333 B	
	ab	ab	ab	b	b	ab	ab	b	ab	
0%	25.333 A	25.667 A	26.733 A	25.550 A	14.733 B	25.467 A	27.000 A	38.133 A	23.733 A	
	fgh	cdefgh	efgh	cdefgh	fgh	fgh	defgh	ab	fgh	
50%	27.200 A	28.200 A	27.133 A	27.600 A	21.600 A	37.200 A	37.933 A	41.867 A	26.400 A	
	abcde	abcde	abcde	abcde	e	a	a	a	abcde	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	**G-28**
70%	0.200 B	0.467 B	0.267 B	0.000 B	0.467 B	0.067 B	0.267 B	0.133 B	0.600 B	0.533 B
	ab	ab	ab	b	ab	b	ab	ab	ab	ab
0%	32.333 A	37.467 A	26.467 A	16.867 A	24.733 A	30.733 A	28.067 A	33.600 AB	26.333 A	36.133 A
	abcd	abcde	efgh	h	fgh	bcdefg	cdefgh	a	efgh	abc
50%	38.600 A	38.000 A	30.800 A	20.800 A	25.067 A	32.200 A	29.000 A	46.867 A	34.267 A	38.867 A
	abc	a	abcd	bcde	abcde	abc	abcde	abc	abc	bc

Note : Value followed by capital letters indicates the effect of shading treatment on the number of pods. Values followed by lowercase letters indicate genotype influence on the number of pods.

There was a significant genotype effect on the number of pods in treatment plot N00 (without shade), especially genotypes G-1 to G-18, but almost all of the genotypes in the shaded plots did not show a significant effect on the number of pods (Table 6).

Table 7. Effect of genotype and shading to the number of trifoliate leaves

	Genotype of soybean									
Shading	**G-1**	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	3.933 B	4.400 C	4.333 B	4.067 B	4.867 B	4.200 B	4.200 B	5.000 B	3.933 B	
	c	c	c	c	bc	abc	abc	abc	abc	
0%	12.267 A	10.067 B	11.600 A	11.133 A	12.733 A	11.467 A	10.067 A	12.067 A	10.533 A	
	abcdefghi	cdefg	defghji	defghji	bcde	efghij	j	cdefg	efghij	
50%	12.733 A	13.133 A	12.333 A	12.267 A	13.733 A	11.467 A	10.533 A	13.067 A	11.600 A	
	bcd	ef	bcdef	bcdef	abc	bcdef	def	bcd	def	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	4.400 B	4.533 B	4.400 B	4.667 B	3.933 B	4.467 B	5.267 B	4.200 B	4.866 B	
	abc	abc	abc	abc	abc	abc	abc	abc	abc	
0%	10.600 A	11.133 A	11.000 A	11.050 A	10.000 A	10.333 A	12.333 A	12.800 A	12.333 A	
	hij	ghij	efghij	fghij	hij	ij	cdfg	cdefg	cdefgh	
50%	11.800 A	11.200 A	11.667 A	1.200 A	10.533 A	11.200 A	12.933 A	13.000 A	12.733 A	
	bcdef	bcdef	cdef	bcdef	f	bcdef	bc	abc	bc	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	**G-28**
70%	5.333 C	4.933 B	5,133 B	4.000 B	4.467 B	4.667 B	4.400 B	4.267 B	5.133 B	4.733 B
	abc	abc	abc	abc	abc	abc	abc	abc	ab	a
0%	11.467 B	14.133 A	11.933 A	10.533 A	11.067 A	12.000 A	10.067 A	12.667 A	12.333 A	12.467 A
	a	bcd	defghij	hij	ghij	defghi	ghij	bc	b	abcdef
50%	17.933 A	14.200 A	12.000 A	10.5833 A	11.400 A	12.400 A	10.867 A	14.667 A	15.400 A	13.467 A
	bcdef	abc	bcd	def	bcdef	bcd	ef	abc	bc	bc

Note : Value followed by capital letters indicates the effect of shading treatment on the number of trifoliates leaves. Values followed by lowercase letters indicate genotype influence on the number of trifoliates leaves.

The 70% shade treatment had a significant effect on the number of trifoliate leaves, as well as the genotype. However, the combination of genotype treatment with 70% shading had no significant effect on the number of trifoliate leaves (Table 7).

Table 8. Effect of genotype and shading to the root length

	Genotype of soybean									
Shading	**G-1**	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	0.922 C	1.100 C	1.153 B	1.000 C	0.973 C	1.420 C	1.087 B	1.820 B	1.107 C	
	a	a	a	a	a	a	a	a	a	
0%	5.833 B	7.000 B	6.333 A	5.433 B	4.967 B	5.667 B	7.133 A	7.200 A	5.100 B	
	bcde	bcd	bcde	bcde	bcde	cde	de	de	cde	
50%	9.100 A	9.400 A	8.267 A	8.767 A	7.733 A	7.367 A	8.100 A	9.367 A	7.300 A	
	cde	abcde	cde	e	e	cde	abc	abcde	e	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	0.867 B	1.407 B	1.387 B	1.260 B	0.960 C	1.140 B	1.473 B	1.187 B	1.467 C	
	a	a	a	a	a	a	a	a	a	
0%	7.233 A	6.533 A	7.133 A	7.483 A	5.067 B	7.433 A	8.867 A	7.233 A	6.033 B	
	cde	bcde	bcd	bcde	cde	bcde	bcd	cde	bcde	
50%	7.400 A	7.733 A	9.367 A	7.867 A	7.667 A	8.000 A	9.500 A	7.367 A	8.200 A	
	abcde	bcde	abcde	abcde	e	abcde	ab	abcde	cde	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	
70%	1.613 B	1.087 B	1.513 C	0.967 B	0.927 B	1.747 C	1.113 C	1.113 C	1.400 B	
	a	a	a	a	a	a	a	a	a	
0%	8.100 A	8.367 A	7.267 B	6.400 A	5.567 A	5.400 B	7.367 B	7.200 B	8.033 A	
	ab	bcde	a	bcde	e	bcde	bc	bcde	bcde	
50%	10.067 A	9.367 A	11.833 A	7.817 A	6.967 A	9.100 A	9.567 A	8.967 A	8.133 A	
	abc	a	abcde	bcde	de	e	abcde	abcde	abcd	

Note : Value followed by capital letters indicates the effect of shading treatment on the root lengths. Values followed by lowercase letters indicate genotype influence on the

Almost all genotype had no significant effect on the root lengths, except at G-1 - G9 when combined with 0% shading (N00). Meanwhile, the effect of 70% shade treatment was significant on the root length to all genotypes tested (Table 8).

Table 9. Effect of genotype and shading to the flowering time

	Genotype of soybean									
Shading	**G-1**	**G-2**	**G-3**	**G-4**	**G-5**	**G-6**	**G-7**	**G-8**	**G-9**	
70%	39.333 A	37.333 A	38.670 B	38.670 A	37.670 A	41.333 A	38.670 A	39.670 A	38.333 A	
	cdef	cdef	a	bcdef	ef	abcdef	abcde	ef	abcdef	
0%	40.000 A	40.333 A	43.333 A	40.670 A	39.670 A	42.333 A	40.000 A	42.000 A	39.333 A	
	defg	ghi	efgh	efgh	fghi	abc	efgh	abc	efgh	
50%	40.333 A	40.333 A	44.333 A	41.330 A	40.000 A	42.333 A	42.000 A	42.333 A	41.670 A	
	fgh	efgh	a	cdefgh	fgh	abcde	fgh	bcdef	h	
Shading	**G-10**	**G-11**	**G-12**	**G-13**	**G-14**	**G-15**	**G-16**	**G-17**	**G-18**	
70%	39.333 A	39.000 A	40.333 B	39.333 A	35.670 B	38.670 B	41.670 A	39.333 A	41.670 A	
	def	abcdef	cdef	cdef	abc	abcd	abcdef	def	abc	
0%	40.000 A	40.333 A	40.670 B	40.000 A	40.000 A	42.330A	41.670 A	40.000 A	42.330A	
	defg	efgh	ab	defg	i	efgh	abcd	cdef	abcd	
50%	41.333 A	41.000 A	43.333 A	40.333 A	42.670 A	42.670 A	42.330 A	40.333 A	42.670 A	
	cdefgh	efgh	defgh	fgh	fgh	abcd	abcde	h	abcde	
Shading	**G-19**	**G-20**	**G-21**	**G-22**	**G-23**	**G-24**	**G-25**	**G-26**	**G-27**	**G-28**
70%	42.670 A	42.330 A	41.000 A	36.330 B	36.330 B	40.670 A	38.330 B	41.670 A	39.000 A	38.670 A
	ab	abcd		f	abcdef	bcdef	abc	abcdef	bcdef	
0%	43.000 A	43.330 A	42.000 A	39.330 AB	40.670 A	41.670 A	42.330 A	42.330 A	40.330 A	39.330 A
	a	ab	bcde	hi	hi	abc	efgh	abc	efgh	
50%	43.670 A	43.670 A	42.000 A	39.670 A	41.000 A	42.330 A	42.670 A	43.000 A	40.670 A	40.330 A
	abcd	ab	bcdef	gh	defgh	bcdefg	abcde	abc	efgh	

Note : Value followed by capital letters indicates the effect of shading treatment on the flowering times. Values followed by lowercase letters indicate genotype influence on the flowering times.

The significant effect of genotype on flowering time was shown by G1 - G18 and G21 - G28. In general, the effect of shade on flowering time was not significant, except for the combination of 70% shade treatment with genotypes G3, G14, G15, G22, G23 and G25 (Table 9).

It is known that in addition to provide the primary energy source for photosynthesis [14], light provides plants with important temporal and spatial information about their surrounding environment [15]. An individual's ability to effectively tolerate or avoid shade will significantly increase competitiveness, and ultimately also increase the likelihood of reproductive success, in a rapidly growing population [1]. The development of soybean as an inter-crop is faced with the main challenge in the form of tolerance of soybean varieties to low light intensity (shade) – in this case, the shade of the main vegetation stand.

In shaded vegetation, plants generally experience a significant reduction in the quantity of light, particularly the red and blue bands, which are used by the canopy to support photosynthesis. Variation of plants to vegetative shade is thought to confer a selective advantage in different ecological habitats. Previous studies have shown that soybean morphological properties change significantly under shading conditions, resulting in increased plant height, decreased yield, and reduced root length [15, 16, 17]. Leaf expansion was also suppressed when soybeans responded to shade stress[18, 19].

Based on the results of the above research, to select potential accessions as breeding base material for assembling superior shade-tolerant varieties are available on genotypes that received 50% shade-stress treatment where almost all the tested soybean genotypes responded positively by showing good plant growth and development. In this case, information was also obtained that the 70% shade stress treatment was not recommended for soybean cultivation, because in general it causes plant death (low plant survival).

The genotype with the best plant height response was G21 (Lokal Brebes), the highest number of branches was G19 (Kedelai Hijau), the highest number of clumps was G12 (Lokal Hitam A), the highest number of filled pods was G26 (Merbabu), the highest number of trifoliate leaves was G19 (Kedelai Hijau) and the best root length is G21 (Lokal Brebes) Using these considerations, the potential genotype candidates as breeding material for assembling high yielding varieties of shade tolerant soybeans are G-19 (Kedelai Hijau) and G-21 (Lokal Brebes).

4 Conclusion

Almost of the morph-agronomic characters were significantly influenced by the genotype and shade-stress, except for the number of filled pods, root length and flowering time (p-value <0.001). Interaction between genotypes and shade stress showed significant effect to plant height, number of branches, and number of trifoliate leaves.

Variety of G-19 (Kedelai Hijau) and G-21 (Lokal Brebes) were potential as candidate for breeding on shade-resistant varieties. The implication is that there needs to be further research to develop new superior varieties that are shade tolerant by utilizing this material.

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