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Correlation of net photosynthesis to the sum of productive branches and seed weight on shaded soybean

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Abstract. The morpho-physiological of plants will be changed in shaded condition. This paper examined the correlation of net photosynthesis to the sum of productive branches and seed weight on four shaded soybeans at various shading levels. A split-plot factorial design was used in this study with three replications. The treatments consisted of shading level as the main plot with four treatment levels, namely 0% (no shade), 30%, 50%, and 70% shade; soybean varieties as the subplot consisted of four soybean varieties, namely Anjasmoro, Pangrango, Tanggamus, and Nanti. The net photosynthetic data and seven agronomic characteristics data were analyzed by ANOVA (F test) followed by the DMRT and Pearson correlation analysis at test level 5%. The result showed that the number of productive branches and seed weights per plant positively correlated with net photosynthesis which was significant at 0.47% and 0.41%, respectively.

1. Introduction
Cropland narrowing process was one of the problems on soybean production. One of the existing solutions is by using the lands under the plantation crops, such as oil palm and rubber. However, this condition will cover the light and resulting a low light intensity which affect the growth and yield of soybeans [1]. Shade plants will receive limited sunlight, even though the light has an important role for the plant growth and the development process. The photosynthesis process was the primary key to this phenomena. Net photosynthesis can be accumulated in vegetative and generative growth until the yield production [2,3,4]. Handayani [5] was found that morphology character in soybean shaded tolerance was sum of branches meanwhile the anatomy character was chlorophyll-a content. Wu *et al* [6] found that soybean newly developed leaves exhibited lower net photosynthetic rate in the shaded mature leaf and whole plants grown in shade treatment. The net photosynthesis is possible mechanism to measured at various phenomenon. High midday temperatures can depress net photosynthesis in leaves of *Eperua grandiflora* (Aubl.) Benth, the tropical tree [7]. Used the net photosynthesis could alert to more immediate raised drought risk [8] even as growth control-mostly [9]. The aim in this paper was to analysis the agronomic characteristics on shaded soybean to the net photosynthesis and finding the corellation between them.

2. Method

We simulated this shading microclimate by using polybags in the shading house at the Experimental Farm, Faculty of Agriculture, Agriculture Universiti Malaysia (UPM) located at latitude 2.986649 longitude 101.708301 in April to October 2009. A split-plot factorial design was used in this study with three replications. The treatments consisted of   I. shading level (S) as the main plot with 4 treatment levels, namely: no shade (S0), 30% shade (S1), 50% shade (S2) and 70% shade (S3); II. Soybean varieties (V) as the subplot consisted of four varieties, namely: Anjasmoro (V1), Pangrango (V2), Tanggamus (V3), and Nanti (V4).

The materials used were soybean seeds including variety of Anjasmoro, Pangrango, Tanggamus and Nanti (Table 1). According to the classification of [10], the size of soybeans could be classified into three groups, namely small seed (<10 g/100 seeds), medium seed (10-12 g/100 seeds), and large seed (13-18 g/100 seeds). The Anjasmoro variety was in large seed group, the Pangrango and Tanggamus varieties were in medium seed groups and the Nanti variety was in small seed group. In this research, all varieties became the determinant of development type.

Table 1. Description of soybean varieties [10]

Variety	Source	Potential Production (ton/ha)	Development type	Weight of 100 seeds (g)
Anjasmoro	Mass selection from pure strain Mansuria	2.03-2.25	Determinite	14.8-15.3
Pangrango	Crossing local variety of Lampung x Davros in 1983	1.4 - 2.0	Determinite	± 10
Tanggamus	Derivate selection of Kerinci x No. 3911	1.22	Determinite	11
Nanti	Single cross of Dempo variety and No. 3623	1.24	Determinite	10

These varieties were screened from the earlier research, which showed that the Anjasmoro and Pangrango varieties were the consistently tolerant to shade condition, on the other hand the Tanggamus and Nanti varieties were not. Based on seed yield per plant, it was found that Nanti variety had a small tolerance index while the Pangrango variety was able to tolerate 70% of shade condition and the Anjasmoro variety was able to tolerate 30% and 50% of shade condition [11]. Fertilizer was given at the planting time with a dose of 50 kg/ha Urea, 100 kg/ha SP36 and 100 kg/ha KCl. Pest control was done intensively by spraying an insecticide in accordance with the attacking pest.

Net photosynthesis as physiology characteristics measured by the toll LI-6400XT. Another parameters were agronomic characteristics, namely, leaf area, plant hieght, flowering age, number of productive branches, number of pods filled, the seed weight per plant and weight of 100 seeds. Leaf area meter was used for measured the leaf area on destructive samples. Seed weight was used the dried seed (water content 16%) and measured by digital scale. Then, all data were analyzed by ANOVA (F test), followed by the DMRT test and continued by Pearson correlation analysis at test level 5% [12]. The datas were processed by SAS and Microsoft Excel program.

3. Results and Discussions

The results will be discussed in four subsections, they are net photosynthesis, the sum of productive branches, the seed weight per plant and the correlation between them. The sum of productive branches and the seed weight per plant were choiced because they have significant correlation to net photosynthesis which is describe at fourth subsection.

3.1. Net photosynthesis

The highest net photosynthesis was obtained by Anjasmoro variety followed by Pangrango. The lowest net photosynthesis was obtained by the Tanggamus which was not significantly different from

Pangrango and Nanti. In our experiment [11] Pangrango variety was good tolerant in the 70% shade but it becamed not tolerant on 30 and 50% shade level. Shade level of 70% gave the lowest net photosynthesis meanwhile, the highest net photosynthesis in no shading condition, of course.

Table 2. Net photosynthesis at various levels of shade and variety

| Varieties | Shade levels | | | | |
	0%	30%	50%	70%	Average
	----------		μmol m^{-2}s^{1}		-----------------
Anjasmoro	16.08	21.01	19.54	15.16	17.95　a
Pangrango	18.18	14.90	9.30	7.32	12.42　ab
Tanggamus	10.26	12.48	9.20	6.19	9.53　b
Nanti	22.44	8.28	8.23	8.73	10.67　b
Average	16.74　a	14.17 ab	11.57 b	9.35 b	

Note : the numbers followed by an unequal notation on the same row and same column indicate significantly different at 5% level based on DMRT test

3.2. Sum of productive branches

The treatment of shade and varieties and the interaction of the two factors had no significant effect on the sum of productive branches. The sum of productive branches was about 34 to 37 branches, it is not big different.

Table 3. The sum of productive branches at various levels of shade and variety

| Varieties | Shade   levels | | | | |
	0%	30%	50%	70%	Average
	----------	------------	branches	------------	---------------
Anjasmoro	36.83	37.33	37.67	35.83	36.92
Pangrango	32.53	37.70	36.17	35.57	35.49
Tanggamus	34.57	34.33	36.07	36.43	35.35
Nanti	35.03	31.90	35.90	35.13	34.49
Average	34.74	35.32	36.45	35.74	

3.3. Seed weight per plant

The highest seed weight per plant was obtained by Anjasmoro variety which was not significantly different from Pangrango. The lowest seed weight was found in the Nanti variety which was not significantly different from Tanggamus.

Table 4. Seed weight per plant at various levels of shade and variety

| Varieties | Shade   Levels | | | | |
	0%	30%	50%	70%	Average
	----------	------------	g	------------	--------
Anjasmoro	30.24	26.51	27.87	21.91	26.63　a
Pangrango	29.02	17.58	23.76	21.44	22.95　ab
Tanggamus	19.85	17.20	12.05	11.33	15.11　c
Nanti	13.74	12.73	18.25	15.64	15.09　c
Average	23.21	18.51	20.48	17.58	

Note : the numbers followed by an unequal notation on the same row and same column indicate significantly different at 5% level based on DMRT test

3.4. Correlation analysis

Table 5 shows the results of correlation analysis among seven agronomic characteristic on shaded soybean were testing by Pearson Analysis [12]. Based on the results of the correlation analysis, it is seen that only two characteristics are positively correlated with net photosynthesis, while the others are negatively correlated with net photosynthesis. The two characteristics are number of productive branches and seed characteristic weights per plant. The correlation of net photosynthesis to the sum of productive branches and seed weight per plant were significant at 0.47% and 0.41%, respectively.

Table 5. Correlation coefficient among net photosynthesis and seven agronomics characteristics in shaded soybean

	Corelation to the net photosynthesis
Leaf area	0.39^{ns}
Plant height	0.05^{ns}
Flowering age	-0.20^{ns}
Number of productive branches	$0,47^{*}$
Number of pods filled	-0.21^{ns}
Seed weights per plant	$0,41^{*}$
The weight of 100 seeds	0.25^{ns}

ns= not significant , *= significant at P<0.05, **=significant at P<0.01

Morphological and physiological characteristics have proven to correlate with agronomic characteristics. The leaf area was not correlated with net photosynthesis it maybe crop leaves are subject to continually changing light levels in the field. Photosynthetic efficiency of a crop canopy and productivity will depend significantly on how quickly a leaf can acclimate to a change [13]. Seed weight per plant is positively correlated with net photosynthesis but not in weight of 100 seeds. It became because the seed weight per plant came from net photosynthetic in the same plant. Meanwhile, measured to the weight of 100 seeds maybe came from more than one plant.   Futhermore, the net photosynthesis was correlated to sum of productive branches in same plant. The increased sum of productive branches making increasing seed weight per plant [14]

4. Conclusions

The result showed that the number of productive branches and seed weights per plant positively correlated with net photosynthesis which was significant at 0.47% and 0.41%, respectively.

References

[1] Trikoesoemaningtyas *et al*. 2008. Maximizing genetic improvement in the selection of soybean for adaptation to low light intensity. *Proc.*Toward harmonization between development and environmental conservation in biological production. p.74-83.

[2] Fehr WR, CE Caviness, DT Burmood, and JS Pennington. 1971. Stage of Development Descriptions for Soybeans, Glycine max (L) http://dl.sciencesocieties.org

[3] Wheeler RM, CL Mackowiak and JC Sager. 1990. Proximate composition of seed and biomass from soybean plants grown at different carbon dioxide concentrations (CO_2). *The Bionetics Corp*. Kennedy Space Center, Florida - p.4.

[4] Benkeblia N. 2014. Variation of reducing and total sugars during growth of onion tissues. Acta Horticulturae

[5] Handayani T. 2003. Inheritance Patterns of Tolerant Characteristics Against Low Light Intensity in Soybeans with Specific Characteristics of Anatomical, Morphological and Molecular Characteristics. *Dissertation*. Agricultural Institute Bogor [Indonesian]

[6] Wu Y *et al*. 2018. Leaf area and photosynthesis of newly emerged trifoliate leaves are regulated by mature leaves in soybean. *J Plant Res*. **4** 671-680

[7] TL Pons and Welschen RA. 2003. Midday depression of net photosynthesis in the tropical

rainforest tree Eperua grandiflora: contributions of stomatal and internal conductances, respiration and Rubisco functioning. *Tree Physiol*. **14** 937-947.

[8]   Huntingford C *et al*. 2015. Combining the [ABA] and net photosynthesis-based model equations of stomatal conductance. *Eco. Mod.* **300** 81-88

[9]   Korner C. 2013. Growth Controls Photosynthesis– Mostly. *Nova Acta Leo*. **114** 273-283

[10] [Balitkabi]. 2016. Description of Soybean Superior Varieties 1918 – 2016 [Indonesian]

[11] Mawarni L. 2011. Preliminary Study of Varieties of Shade-Resistant Soybeans for Crops in Oil Palm Plantations, respitory@usu.ac.id

[12] Gomez, A.K and Arturo A. Gomez. 1984. Statistical Procedures for Agricultural Research. (London: Wiley) 680 pp.

[13] A Soleh M *et al*. 2015. Factors underlying genotypic differences in the induction of photosynthesis in soybean [Glycine max (L.) Merr.]. *Plant, cell & env.* **10** 12674.

[14] Sulistyo A, Purwantoro and KP Sari. 2017. Correlation, path analysis and heritability estimation for agronomic characteristics contribute to yield on soybean. IOP Conf. Series: *Earth and Env. Sci.* **102** 012034