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Research Article
Effect of Paranet Shade on the Four Green Bean in Jatikerto Dry Land Indonesia

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Abstract
Background and Objective: The increased frequency of drought causes low yield of green beans in dry land. Therefore, the selection of tolerant varieties and the use of paranet as a shade can provide the best solution related to the problems. The aim of this study was to investigate the effect of paranet shade on the yield of four Green Beans in dry land of Indonesia. **Materials and Methods:** The study was conducted at Techno Park Universities Brawijaya Malang Indonesia and planting was carried out in September to November, 2016. The treatments of variety and paranet shade were arranged in a split-plot design with 3 replications. Variety was placed as the main plot and percentage of paranet shade as sub-plot. F-test at 5% is used to determine the effect of treatments, while differences between treatments were referred to least significant different (LSD) value at 5%. **Results:** The highest yield was obtained in the treatment without shade for all varieties, including total dry weight of plants, number of pods/plant, weight of seeds/plant, yield of seeds/hectare and reception of radiation energy. Provision of shade causes a decrease in seed yield/hectare by an average of 46.37, 24.16, 46.85 and 37.14%, respectively for the varieties of Murai, Sriti, Kenari and Perkutut compared to the treatment without shade. However, the provision of shade led to an increase in leaf size by 10.50, 18.21 and 19.38%, respectively for the treatment of 20, 40 and 60% shade than without shade. **Conclusion:** In the treatment without shade, total dry weight of plants, number of pods/plant, weight of seeds/plant and yield of seeds/hectare produced is higher than shade treatment.

Key words: Paranet shade levels, dry land, green beans varieties, light intensity

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Climate change poses challenges for agricultural production and their impact varies depending on regional focus and on the type of production system[1]. To avoids loss of production, adaptation in agricultural management will definitely be needed, especially on dry land. Climatologically, dry land is an area with a limited level of water availability, water requirements for plants are completely dependent on rainfall and the land is never permanently inundated for most of the time or all the time[2]. The wet period (rainy season) only lasts around 3-4 months and the rest is in the form a dry period (dry season)[3]. The air temperature is quite high due to the high intensity of radiation received by the region. Moreover, this condition has also been spurred by the increasingly frequent El-Nino, causing the earth's surface to be hotter and drier than normal[4]. Therefore, to anticipate these events and in an effort to avoid risks due to climate change, several approaches are needed. Pelling *et al.*[5] state that there are two approaches that can be used as a guideline to prevent the negative impacts of climate change, namely: (1) through adaptation and (2) through appropriate mitigation. Selection of varieties is one step that can be used to determine the level of adaptation of plants in dealing with environmental changes. Tolerant plants will be able to grow and produce well in changing environmental conditions. This is important, especially for dry land farmers who generally still use varieties derived from their ancestral heritage as planting material. Local varieties are generally of low yield potential (6.59 quintal ha^{-1}), besides the level of adaptation also decreases in the current environmental changes. Meanwhile, superior varieties have developed and circulated in the market with high yield potential[6] up to 15-20 quintal ha^{-1}. This gap causes the low availability of green beans nationally. Haraito[7] states that the production of green beans in Indonesia has only reached 47.82% (172,090 t), from the target of 360,000 t. As a result, imports must be done to meet the needs of national green beans. The high demand for green beans in Indonesia is not only for culinary purposes but more importantly is for the fulfillment of community nutrition. This is quite relevant because besides its cheap price, green beans are also a source of nutrients (protein, fat, fiber, sugar and calories), minerals (Mg, Mn, Zn, Ca) and vitamins (B_1, B_5 and B_6) needed by human body[8].

The second approach is in the form of mitigation, which is a series of efforts that need to be done to reduce the risks and impacts of disasters[9]. In this research, the form of mitigation carried out is through the provision of paranet shade, which aims to provide an optimal growing environment for green bean plants in the dry land. This is related to the high intensity of radiation received by the plant surface when planted monoculture. Shao *et al.*[10] states that At high light intensity (above the optimum limit) for a loving-shade group can have an impact on the destruction of the photosynthetic system (photo inhibition), because the capture of light energy cannot be fully utilized in the photosynthesis process. On the other hand, the leaves also do not have the capacity to dispose of excess energy through a cycle of xanthophylls[11]. Conversely, if the green bean plants intercropped with corn plant simultaneously, the corn plant will become a potential shade for the green bean plant, because the growth rate of the corn plant is faster than green bean plant. As a result, the rate of assimilation is reduced due to the low light intensity received by the green bean plant. In connection with these problems, the research which aims to get the right level of shade on various varieties of green beans in dryland needs to be done. This is considering that each variety has a different response at each level of shade and environment. For tolerant varieties, they will be able to grow and produce well in changing environmental conditions. However, for sensitive varieties, environmental change is a major obstacle to completing its life cycle[12]. The aim of this study is to investigate the effect of paranet shade on the yield of four Green Beans varieties in Jatikerto dry land of East Java, Indonesia.

MATERIALS AND METHODS

Description of the study area: The study was conducted in the Brawijaya University Techno Park in Jatikerto Village, Kromengan District, Malang Regency, East Java Province, Indonesia, from September to November, 2016. The location is at an altitude of 330 above sea level, in the form of dry land with Alfisol type. Climatologically, the average annual rainfall is around 1200 mm with average daily temperatures ranging from 24-31°C[13].

Research material: The planting material in the form of green bean seed varieties Murai, Sriti, Kenari and Perkutut obtained from Cereal Crops Research Institute MAROS with about 90% germination rate. Paranet with a shade percentage of 0% (control), 20, 40 and 60% as well as bamboo used as a paranet shade framework with a height of 1.75 m, a width of 3 m and a length of 7.5 m. Fertilizers applied in the form of N fertilizer (in the form of urea: 46% N), phosphate fertilizer (such as SP_{36}: 36% P_2O_5) and potassium fertilizer (such as KCl: 60% K_2O) respectively of 50 kg urea ha^{-1}, Sp-36 75 kg ha^{-1} and 50 kg KCl ha^{-1}. P fertilizer is applied to all doses at the beginning of planting, while N and K fertilizers are given in stages. Phase I is applied when the plant is 7 days after planting, half the dose and the rest is applied when the plant is 21 days after planting. Fertilizer was applied on the left/right side of the plant with a distance of 5 cm and with a depth of 7 cm.

Research implementation: Green bean seeds are planted with a spacing of 30 cm×20 cm by placing 3 seeds/planting holes, which are then left with 1 plant that has the healthiest growth. The area of each treatment plot is 4.2 m^2 containing 70 plants.

Experimental design: The experiment used a split-plot design (SPD) and was repeated 3 times. Percentages of shade (0% (control), 20, 40 and 60%) as the main plot and various varieties (Murai, Sriti, Kenari and Perkutut) as a subplot. A level F-test of 5% is used to determine the interaction or the significant effect of the treatment, while the LSD test level of 5% is used to determine the difference between treatments. Regression analysis is used to explore the relationship between two or more variables observed.

Data collection

Micro environment: Observation of the microenvironment only focused on the intensity of solar radiation under the shade, carried out when the plants were 18 days after planting, 28, 38, 48 and 58 dap. The intensity of solar radiation was measured using a digital instrument Lux meter AMTAST LX1332B which was carried out in the shade with a height of 1.15 m above the ground at every 11 o'clock with the assumption that the sun could be recorded at around 06.00 (morning). The incident angle of sunlight is desired 75° consideration the atmosphere fairly high level of transparency[14].

Agronomic: Data collection was carried out destructively by taking 3 sample plants for each treatment, carried out when the plants were 20 days after planting (dap), 30, 40, 50 and 60 daps and at harvest (63 daps). Agronomic data collected includes growth parameters, namely leaf area and total dry weight of the plant. Whereas the yield component includes measurements of the number of pods/plant, weight of seeds/plant and yield of seeds ha^{-1} at harvest. The harvest plot is 1 m^2 and contains 15 plants.

Leaf area: Leaf area was measured using a leaf area meter type LI-3100 C for leaves that had been fully opened, excluding young or senescence leaves. Leaf samples are placed above the glass lens in a non-folded or non-overlapping position. Records were taken for all sample leaves from three sample plants per treatment, then averaged. The leaf area value is determined by multiplying the average value of the recording by the correction factor. Correction factors can be sought by dividing the measurement value of the actual paper area (for example 100 cm^2) with the value of the paper area that has been measured by leaf area meters, for example 99 cm^2. So the value of the correction factor[15] is 99/100 cm^2 = 0.99.

Total dry weight of plants: The total dry weight of plants obtained, in an oven-type OVL 12 with a temperature of 81°C. Before roasting, the separation of plant parts such as stems, leaves, roots and economic yield must be done, because each part requires different time to achieve a constant dry weight. Parts of the plant that have been separated then inserted into a cement bag and then put in the oven. Weighing is done when a constant weight is obtained and then added up[16].

Yield component: Number of pods formed/plant was count using a counter. Weight of seeds/plant, weighed all seeds formed using a scout pro analytic scales. Weight of 100 seeds, Weighing 100-seed weight were randomized to each treatment with an analytical scale type Scout-pro. Seed yield ha^{-1}, obtained by converting from crop yield per plot (1 m^2) to the unit hectare using the equation[16]:

$$\text{Yield ha}^{-1} = \frac{\text{Land area of 1 ha}}{\text{Harvest plot area (1 m}^2\text{)}} \times \frac{\text{Weight of seed/}}{\text{harvest plot}\times 0.90}$$

RESULTS

Intensity of solar radiation: There is no significant interaction between shade and variety on the intensity of solar radiation. Varieties also do not have a significant effect on this variable, only shade treatment has an effect on this variable (Table 1).

Table 1 shows that the highest radiation intensities were generated in the control treatments at all age of observation 18, 28, 38, 48 and 58 dap, respectively 1503.17, 1563.08, 1449.75, 1224.00 and 1251.75 $cal.cm^{-2}$/day. The provision of shade causes the intensity of radiation under the shade to decrease and the magnitude of the reduction is proportional to the percentage of shade. Provision of 20% shade caused a lower intensity of radiation received in the shade for all age observations (i.e., 18, 28, 38, 48 and 58 daps), each amounting to 1202.33, 1226.50, 1122.17, 865.25 and 935.58 $cal.cm^{-2}$/day when compared to controls. However, these results are higher

Table 1: Average intensity of solar radiation at various shading percentages and varieties at various age of observation

	Average intensity of solar radiation (cal.cm^{-2}/days) at various ages of observation (dap)				
Treatments	18	28	38	48	58
Paranet shade (%)					
0 (control)	1503.17^{d}	1563.08^{d}	1449.75^{d}	1224.00^{d}	1251.75^{d}
20	1202.33^{c}	1226.50^{c}	1122.17^{c}	865.25^{c}	935.58^{c}
40	905.42^{b}	925.58^{b}	862.08^{b}	712.75^{b}	772.50^{b}
60	602.00^{a}	633.58^{a}	593.75^{a}	520.83^{a}	548.33^{a}
LSD 5%	74.94	63.78	69.73	125.65	75.59
Varieties					
Murai	1040.00	1088.58	1014.42	852.33	911.17
Sriti	1041.58	1097.67	1020.92	827.08	868.50
Kenari	1065.92	1088.25	1000.50	791.75	882.33
Perkutut	1065.42	1074.25	991.92	851.67	846.17
LSD 5%	ns	ns	ns	ns	ns

Numbers are accompanied by the same letters in the same treatment and column are not significantly different by LSD 5%, ns: Not significant effect, dap: Days after planting

Table 2: Average leaf area/plant at various shading percentages at various observational ages

	Average leaf area (cm^2/plant) at observation (dap)	
Treatments	40	50
Shade (%)		
0 (control)	510.39^{a}	603.14^{a}
20	594.86^{b}	635.58^{b}
40	648.37^{b}	667.90^{c}
60	645.67^{b}	683.08^{c}
LSD 5%	63.85	21.85

Numbers are accompanied by the same letters in the same column are not significantly different by LSD 5%, ns: Not significant effect, dap: Days after planting

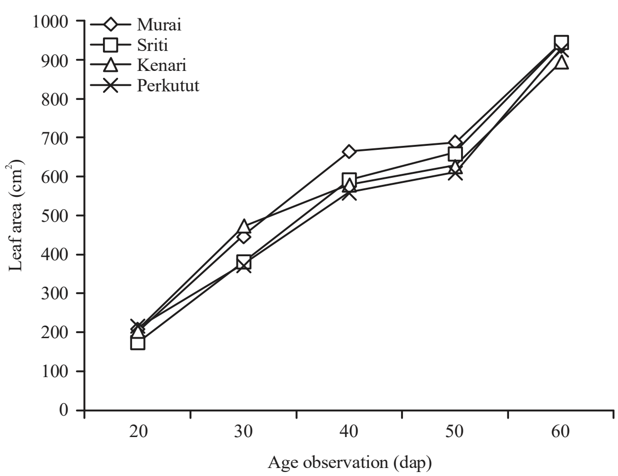

Fig. 1: Pattern of leaf area development of four green bean varieties at various ages of observation of four green bean varieties at various ages of observation

(p>5%) when compared to the provision of 40 and 60% shade for all age observations, each of which only reaches 905.42, 925.58, 862.08, 712.75 and 772.50 cal.cm^{-2}/day for shade 20% and amounted to 602.00, 633.58, 593.75, 520.83 and 548.33 cal.cm^{-2}/day to shade 60%. Whereas in the use of 40% shade, the intensity of radiation received under the shade is higher (p>5%) when compared to 60% shade, respectively 905.42, 925.58, 862.08, 712.75 and 772.50 cal.cm^{-2}/day, for the observation age of 18, 28, 38, 48 and 58 dap. The use of 40 and 60% shade, the intensity of radiation received under the shade is lower when compared to control and the lowest was obtained at the use of 60% shade, compared to other treatments.

As for the variety, it did not have a significant effect on the reception of solar radiation at various ages of observation. At each age of observation, the intensity value received under the shade of each variety showed almost the same value.

Leaf area: The leaf area is only affected by the percentage of shade (Table 2). While the patterns of leaf area development in various varieties at various ages of observation are presented in Fig. 1.

At the age of 40 dap observations, the narrowest leaf was found in the control, which is 510.39 cm^2/plant. Provision of 20, 40 and 60% shade produced wider leaf sizes of 594.86, 648.37 and 645.67 cm^2/plant, respectively compared to controls. However, the leaf area showed no significant difference in the shade of the three treatments (20, 40 and 60%) at p = 5%. Whereas at the age of 50 dap observations, wider leaves were obtained at the provision of 40 and 60% shade, compared to the control and use of 20% shade. At the provision of 40% shade, the leaf area produced was 667.90 and 683.08 cm^2/plant for 60% shade and both showed no significant difference at p = 5%. Whereas at the age of 50 dap observations, wider leaves were obtained at the provision of 40 and 60% shade, compared to the control and use of 20%

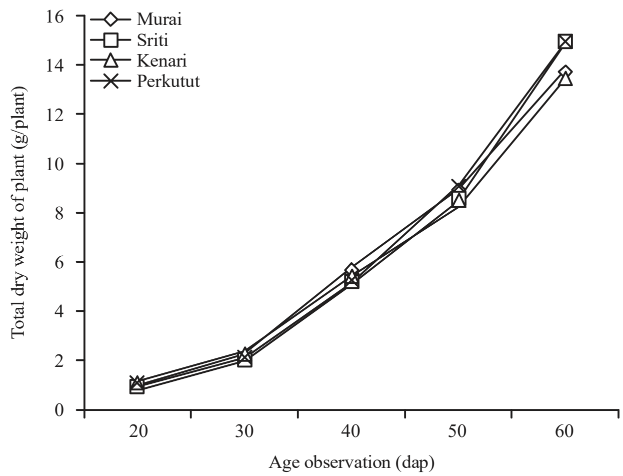

Fig. 2: Pattern of total dry weight of plant of four varieties at various ages observations

Table 3: Averages of total dry weight of plant at various shading percentage on 50 dap

Shading (%)	Total dry weight of plant (g/plant)
0	9.73[c]
20	8.91[b]
40	8.43[ab]
60	7.79[a]
LSD 5%	0.78

Numbers are accompanied by the same letters in the same column are not significantly different by LSD 5%, dap: Days after planting

Table 4: Average number of pods/plant at various levels of shade in the 4 varieties at harvest

	Shade (%)			
Treatments	0 (control)	20	40	60
Varieties				
Murai	10.73[dB]	8.37[cAB]	6.82[bA]	4.82[aA]
Sriti	9.49[dA]	8.24[cA]	6.49[bA]	5.26[aA]
Kenari	10.21[dAB]	9.16[cB]	6.58[bA]	5.30[aA]
Perkutut	9.84[dA]	8.26[cA]	6.47[bA]	4.68[aA]

LSD test 5% 0.80, numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column, are not significantly different based on the LSD test at 5% level

shade. At the provision of 40% shade, the leaf area produced was 667.90 and 683.08 cm^2/plant for 60% shade and both showed no significant difference at p = 5%. While the use of 20% shade, leaf area produced more extensive than the control. Narrowest leaf produced in the control treatment, namely 603.14 cm^2/plant. The patterns of leaf area development of various varieties at different ages of observation are presented in Fig. 1.

Figure 1 shows the increase in leaf area in line with the age of observation and plant growth phase in all varieties. However, the increase in value is relatively the same at each age of observation in each variety. The highest increase in leaf area when entering the age of 20-40 dap.

Total dry weight of plant: Total dry weight of plant only affected by shading percentage at 50 daps. The average of total dry weight of plant on various shading percentages showed in Table 3.

Table 3 shows that the highest total dry weight of plants was obtained in the control than other treatments, which was 9.73 g/plant. While the provision of 20% shade, the total dry weight of plants produced was not significantly different from the provision of 40% shade, each of 8.91 and 8.43 g/plant. However, with the use of 20% shade, the total dry weight of plants produced is higher than that of 60% shade, reaching only 7.79 g/plant. However, with the use of 60% shade, the total dry weight of plants produced was not significantly different at p = 5% with the use of 40% shade. The lowest total dry weight was obtained in 60% of the shade (7.79 g/plant). While, the development pattern of total dry weight of plants from four varieties of green beans at various ages is presented in Fig. 2.

Figure 2 shows the formation of a linear pattern between the total dry weights of plants with plant age. The total dry weight of plants shows increased with increasing age of the plant, which is from 20-60 dap. However, the increase resulted in relatively the same value for each variety at each age of observation.

Number of pods/plant: The discussion only focused on the main plot for all variables that occurred interaction.

There was a significant interaction between the percentage of shade and variety on the number of pods/plant (Table 4).

Table 4 shows the same yield patterns of the number of pods/plant in 4 varieties at various shade percentages. The highest number of pods/plant was generally produced in the treatment without shade for all varieties, respectively 10.73 pods/plant for Murai variety, 9.49 pods/plant for Sriti variety, 10.21 pods/plant for Kenari variety and 9.84 pods/plant for Perkutut variety, compared with shade treatment. The use of 20% shade, the number of pods/plant produced higher (p>5%) when compared with the use of 40 and 60% shade. On the use of 20% shade, the number of pods/plant produced as much as 8.37, 8.24, 9.16 and 8.26 pods/plant each for varieties Murai, Sriti, Kenari and Perkutut. Whereas with the use of 40% shade, the number of pods/plant is around 6.82, 6.49, 6.58 and 6.47 pods,

Table 5: Average seed weight/plant (g) in various shade percentages in 4 varieties at harvest

	Shade (%)			
Treatments	0 (control)	20	40	60
Varieties				
Murai	7.97dB	5.53cA	4.29bA	3.03aAB
Sriti	7.95dB	5.73cA	4.43bA	3.78aC
Kenari	8.56dB	5.97cA	4.12bA	3.55aBC
Perkutut	6.34dA	5.33cA	3.96bA	2.82aA

LSD test 5% 0.68, numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column, are not significantly different based on the LSD test at 5% level

Table 6: An average yield of seeds ha^{-1} (t) in various shade percentages and 4 varieties at harvest

	Shading (%)			
Treatments	0 (control)	20	40	60
Varieties				
Murai	1.33dBC	0.92cAB	0.71bA	0.51aAB
Sriti	1.32cB	0.95bAB	0.74aA	0.63aC
Kenari	1.43cC	1.00bB	0.69aA	0.59aBC
Perkutut	1.06dA	0.89cA	0.66bA	0.47aA
LSD 5% 0.11				

Numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column, are not significantly different based on the LSD test at 5% level

respectively for the varieties of Murai, Sriti, Kenari and Perkutut. The lowest in the use of 60% of the shade, each as many as 4.82, 5.26, 5.30 and 4.68 pods/plant, for the varieties of Murai, Sriti, Kenari and Perkutut.

Weight of seed/plant: Table 5 presented an average weight of seed/plant due to the interaction between the percentage of shade and varieties.

Table 5 shows that in all varieties (Murai, Sriti, Kenari and Perkutut), the highest seed weight/plant was obtained in the treatment without shade (control) compared to shade treatment, each at 7.97, 7.95, 8.56 and 6.34 g/plant. At the use of 20% shade, seed weight/plant was higher at p>5% compared to 40 and 60% shade. While the provision of 40% shade, seed weight/plant higher at p>5% compared to 60% shade. Seed weight/plant with the use of 20% shade for the varieties of Murai, Sriti, Kenari and Perkutut is 5.53, 5.73, 5.97 and 5.33 g/plant. Whereas with the application of 40% shade is 4.29, 4.43, 4.12, 3.96 g/plant and the lowest was obtained in the provision of 60% shade, each of 3.03, 3.78, 3.55 g/plant and as much as 2.82 g/plant for the varieties of Murai, Sriti, Kenari and Perkutut. When viewed from the effect of varieties on various percentages of shade, it shows that all four varieties have the same response to various percentages of shade. Generally, the highest shade percentage (60%) causes the lowest weight of seeds/plant. The decrease in seed weight/plant is in line with the increment of shade percentage, from control to the provision of 60% shade.

Seed yield ha^{-1}: There was a significant interaction between the percentage of shade and varieties on the seed yield ha^{-1} (Table 6).

Table 6 shows that the highest seed yield ha^{-1} was obtained in the no shade treatment for all varieties, compared to the shade treatment. The provision of shade causes lower yields of seeds ha^{-1} obtained for all varieties. Murai and Perkutut varieties show the same pattern of seed yield ha^{-1} in various shade percentages. Generally, the highest seed yield was obtained in the treatment without shade, each of 1.33 t ha^{-1} seed for the Murai variety and as much as 1.06 t ha^{-1} seed for the Perkutut variety. Given 20% shade, the yield of seeds ha^{-1} produced was higher (p>5%) than the use of 40 and 60% shade, although it was lower than the control. These results amounted to 0.92 and 0.89 t ha^{-1} for the varieties of Murai and Perkutut. While for the use of 40% shade, the yield of seeds ha^{-1} is higher (p>5%) compared to 60% shade, although it is lower when compared to control and 20% shade. The yield was 0.71 and 0.66 t ha^{-1} for the Murai and Perkutut varieties, respectively. The lowest seed yield ha^{-1} was 0.51 t ha^{-1} for the Murai variety and 0.47 t ha^{-1} for the Perkutut variety was obtained at 60% shade. The same yield pattern for seed yields ha^{-1} is also shown by the Kenari and Sriti varieties. Lower seed yields ha^{-1} (p>5%) were obtained at 40 and 60% shade compared to controls and 20% shade and both showed no significant difference at p>5%. Seed yields ha^{-1} in the Sriti variety are 0.74 and 0.63 t ha^{-1}, respectively for 40 and 60% shade. As for the Kenari variety, respectively 0.66 and 0.47 t ha^{-1} for 40 and 60% shade. The application of 20% shade produced higher seed weight ha^{-1} (p>5%) compared to 40 and 60% shade, although the yield was still lower (p>5%) compared to control. These yields were 0.95 t ha^{-1} for the Sriti variety and 0.89 t ha^{-1} for the Kenari variety. The highest yield of seeds ha^{-1} was obtained in the control treatment, each at 1.32 t ha^{-1} for the Sriti variety and at 1.43 t ha^{-1} for the Kenari variety. The regression analysis proved the formation of a linear relationship between the percentage of shade and varieties on seed yield ha^{-1}, is presented in Fig. 3.

The regression equation as presented in Fig. 3 shows that with the use of shade, it causes a decrease in seed yield ha^{-1} by increasing the percentage of shade. The highest decrease occurs when 60% shade is used and the highest yield is obtained in the treatment without shade.

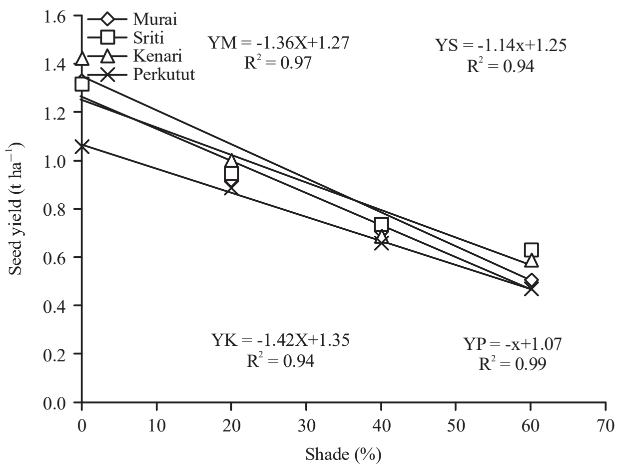

Fig. 3: Relationship between the percentage of shade and seed yield ha^{-1}

DISCUSSION

The results showed that the highest radiation intensity values were produced in the controls at various age of observation. This is because radiation energy can be accepted directly by a surface without any barrier. In the shade treatment, the energy transmitted under the shade decreases proportionally to the percentage of the shade. This is in line with the results of research by Gaurav *et al.*[17] which showed that at the 90% shade level, the energy transmitted to the surface under the shade was 90.49% lower (128.155 µmol m^{-2} sec^{-1}) than control which reached 1343.1 µmol m^{-2} sec^{-1}. The results of this study also show things like this and the truth has been proven through a regression analysis that shows a linear relationship between the percentage of shade (X) with radiation intensity (Y) through the equation:

$$Y = -1345.3 X+1347.6, R^2 = 0.99*$$

The high coefficient of determination (R^2) proves that the high intensity of radiation received by the surface (99%) is strongly influenced by the percentage of its shade. Thus it can be said that the higher the percentage of shade applied, causes the lowest intensity of radiation received under the surface. Whereas, there is no significant effect of the variety on the intensity of radiation energy under the shade, because the intensity measurements carried out at the same measurement level at the same conditions in each shade treatment. Measurements were made 1.5 m above the plant canopy in all treatments, so there was no effect of the variety on these measurements.

The effect of shade on the formation of the leaf area is strongly influenced by the percentage of shade. At a high level of shade (60%) causes the lowest radiation energy received by the surface under the shade, which is 579.70 cal.cm^{-2}/day, whereas in the treatment without a shade of 1398.35 cal.cm^{-2}/day. In low light conditions, the leaves are formed wider, thinner and greener than the control. The third thing is the reaction of plants to cope with stress shade[10,18]. The increase in leaf area and chlorophyll content is in an effort to enable plants to efficiently capture light energy for photosynthesis normally under conditions of low light intensity[12,18]. The results showed that with the use of 40% and 60% shade, causes the leaf surface area increased by 64.9 cm^2 (10.76%) and 79.94 cm^2 (10.76%) than the control (Table 2). While the results of Manurung and Suminarti's[19] research found that the provision of 75, 50 and 25% shade, caused a reduction in leaf thickness respectively by 2.2 g cm^{-2} (32.98%), 1.02 g cm^{-2} (15.29%) and 0.69 g cm^{-2} (9.15%) compared to controls. The impact arising from shading stress is the inhibition of the physiological processes of plants, especially photosynthesis. Yanti[20] reported that at low photosynthesis rates, plant growth rates are disrupted due to the low available growth energy due to low carbohydrate synthesis. As a result, the maximum leaf area is not formed.

Radiation energy is the main energy source of plants for photosynthesis, so at low light intensity, the rate of photosynthesis decreases due to reduced photosynthetic enzymes that function as catalysts in CO_2 fixation. As a result, light compensation point also decreases. In addition, with limited light energy, palisade tissue and mesophyll tissue are thinner, resulting in a lower total dry weight produced[11,20]. In this study also showed that the treatment of 40 and 60% shade, causing a reduction in total dry matter of plants, each of 1.3 g/plant (15.42%) and 1.94 g/plant (15.42%) compared to controls (without shade). The low yield is not only due to the low light compensation point, the reduction in photosynthetic enzymes, it is also caused by the disruption of plant metabolic activity, causing a decrease in the rate of photosynthesis and carbohydrate synthesis[12].

The gross economic yield of green beans in the form of pods, both in number and weight and greatly influenced by the amount of dry matter (weight) produced. Meanwhile, dry weights reflect assimilates and these assimilate contain a certain amount of energy. Some of the energy has been used for growth which causes an increase in the size, volume and total dry weight produced. Some of them will be stored in the sink in the form of pods or seeds[21]. The results showed that the highest number of pods/plant on different varieties obtained at treatment without shade (control) and the lowest was produced in the use of 60% shade (Table 4). Provision of 60% shade, causes the lower total dry weight of plants, which is about 7.79 g plant^{-1} due to the lack of radiation energy received by the surface (579.70 cal.cm^{-2}/day). At low light intensity, photosynthetic capacity decreases due to reduced cell volume. The decrease in cell volume results in a thinner palisade layer that forms[11]. As a result, the net assimilation rate is reduced due to a decrease in plant growth rate. The impact of both of these activities is fewer pods are formed.

The net yield of green beans in the form of seeds and this yield is determined by the number of pods/plant and pod weight/plant. The results showed that the highest seed weight/plant was obtained on the treatment without shade in all varieties (Table 5). This is closely related to the amount of radiation energy available on the surface, on average 1398.35 cal.cm^{-2} day^{-1} compared to the 60% shade treatment which only reached 579.70 37cal.cm^{-2}/day (Table 1). At the level of sufficient light energy, photosynthesis will run normally is causing quite a lot of assimilates produced[22]. It has also been proven through regression analysis which showed that the higher percentage of shade, total plant dry weight was also reduced in line with its shade level (Fig. 3). However, seed weight is not only influenced by the amount of assimilates formed, but is also determined by the large proportion of assimilates that will be allocated to the seeds (sink), commonly known as the harvest index (HI)[23,24]. In the treatment without shade, HI value obtained was 0.47 and this value is still below normal (>0.50), although is still higher than the treatment of 20, 40 and 60% shade, respectively amounted to 0.40, 0.31 and 0.27. Her lower the HI values can be a trigger lower grain weight/plant produced.

Seed weight/plant can be used as a guideline for determining seed yield ha^{-1} and from this study, it was found that the highest seed weight ha^{-1} was obtained in the treatment without shade (control). This is quite relevant because seed weight ha^{-1} is a function of the weight of seeds/plant. Even the regression analysis has proven that there is a very close relationship between the weight of seeds/plant (Y) and the yield of seeds ha^{-1} (X) given through an equation:

$$Y = 0.17\ X-0.005,\ R^2 = 1$$

The equation explains that the greater the weight of seeds/plant, the yield ha^{-1} was also higher.

CONCLUSION

Based on the results of the study it can be concluded that in the treatment without paranet shade, the intensity of solar radiation received under the shade is highest, as well as the total dry weight of plants, the number of pods/plant, seed weight/plant and seed yield ha^{-1}, but followed by narrower leaf size.

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SIGNIFICANCE STATEMENT

This study discovers the effect of the use of paranet shade and varieties on the growth and yield of green bean plants in dry land which could be useful as a guideline in the implementation of green bean crop cultivation in dry land. This study will help researchers to uncover the need for light in green bean plants in dry land. Thus, with the discovery of the needs of light to green bean crops in dry land, it will simplify the management of green bean plants in dryland.

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