Jurnal Agrinika: Jurnal Agroteknologi dan Agribisnis
Volume 08, Issue 02 (2024)
E-ISSN: 2721-2807

The Yield of Red Podded Yardlong Bean Genotypes (*Vigna unguiculata* L.) under Shading

Latifah Zulfaa[1], Syaiful Anwar[2*], Florentina Kusmiyati[2], Fajrin Pramana Putra[2]

[1]Agroecotechnology Study Program, Department of Agriculture, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Central Java, Indonesia

[2]Laboratory of Plant Physiology and Breeding, Department of Agriculture, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Central Java, Indonesia

*Corresponding author: syaifulanwar2011@lecturer.undip.ac.id

Keywords:
Agroforestry;
Shading;
Yardlong bean.

Submited:
01-09-2024

Accepted:
18-09-2024

Published:
29-09-2024

ABSTRACT

Yardlong bean is a plant with high nutritional value, but it is not considered a main crop. Land extensification with agroforestry is needed to overcome land limitations and maximize yardlong bean production. The research aims to produce yardlong bean varieties that adapt to shading conditions in agroforestry systems. The research was conducted from October 2023 to February 2024. The research design used a Split Plot based on a Completely Randomized Design (CRD). The main plot was shading with two levels, no shading (N0), and 50% paranet shading (N1). The subplots were parental FG genotypes of the F8 generation, namely FS 7-1-8, FS 10-1-8, FS 10-3-8, FS 14-2-8, and FS 8-2-8. Observation parameters included the time of 50% flowering, fresh harvest age, leaf stomata count, leaf chlorophyll and carotenoid content, number of fresh pods per plant, fresh pod weight per plant, and productivity. Data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level and Tukey's HSD test at 5%. The results showed that the genotype factor significantly affected the time of 50% flowering. Shading treatment significantly affected the number of leaf stomata. Shading and yardlong bean genotypes did not significantly differ in leaf chlorophyll and carotenoid content, fresh harvest age, the number of fresh pods per plant, fresh pod weight per plant, and productivity. The F8 generation yardlong bean plants showed tolerance to shading as they could maintain growth and yield. The FS 10-1-8 genotype has the fastest flowering speed compared to the FG parent.

1. Introduction

Indonesia, Yardlong bean (*Vigna unguiculata* L.), as one of the horticultural crops, has quite high economic value, so it has the potential to be developed. Yardlong bean plays a role in fulfilling community nutrition, especially the need for plant-based protein. Yardlong bean contains protein, fat, carbohydrates, calcium, phosphorus, iron, vitamins A, B, and C, and has benefits for aiding digestion and preventing fat absorption (Puspita *et al.*, 2021).

However, in practice, yardlong beans are often not prioritized as the main crop. It is often used as a complementary plant, only planted on a small scale in home gardens, fields, and paddy field ridges, resulting in low average productivity of around 9.4 tons/ha, while the potential yield is between 25-30 tons/ha (Hermawan *et al.*, 2017). To overcome land limitations and maximize yardlong bean production, it is necessary to expand cultivation areas by implementing an agroforestry system. Agroforestry, which integrates trees, food crops, and or livestock within a single land management unit, offers several significant advantages. This system not only optimizes land use but also enhances ecosystem diversity, improves soil quality, and increases resilience to climate change. By growing long beans under tree shade in an agroforestry system, the available land can be optimized, thereby increasing productivity and diversity of agricultural outputs. According to Thangata & Hildebrand (2012), agroforestry can enhance land use efficiency by leveraging the synergistic interactions between trees, food crops, and livestock. In the context of long beans, this system allows vertical space utilization through the integration of trees that can act as shade, enhancing the sustainability of the agricultural system. A study by Kiptot *et al.* (2014) showed that growing long beans in an agroforestry system can improve soil nutrient availability through more efficient nutrient cycling while also reducing the risk of soil erosion. The presence of trees in agroforestry systems can improve the microclimate, increase soil moisture, and provide organic matter that supports plant growth.

Planting under canopy trees requires attention to both the variety of plants and the level of shading, which can be a limiting factor for plant growth and yield (Saputra *et al.,* 2018). The impact of tree stand shading on the growth of understory plants is inhibiting gibberellin hormone distribution due to low light intensity (Lysandra & Purnamaningsih, 2019). The plant's phytohormone cycle can affect the processes of flower formation, fruiting, and apical cell elongation. Shading increases stem and petiole length, decreases leaf size due to changes in cell proliferation and enlargement, and alters hormone levels, including auxin, gibberellin, and cytokinin, which play crucial roles in regulating growth (Wu *et al*., 2017; Yang dan Li, 2017; Fiorucci *et al.,* 2022).

Based on the research by Putra *et al.* (2022), conducted on seven genotypes of yardlong beans (*Vigna unguiculata* subsp. sesquipedalis) grown under the shade of guava trees (*Psidium guajava*) and longan trees (*Dimocarpus longan*), it was found that two genotypes were able to adapt well under the shade of longan trees. Providing 50% shade to the yardlong beans allowed for optimal production, but at 75% shade, there was a significant reduction in the number of pods (Haque & Ahmed, 2010). However, so far, there is no information available on the adaptability of yardlong beans to shade in Indonesia, indicating the need for the development of shade-tolerant yardlong bean varieties.

A breeding program is necessary to produce yardlong bean varieties that are tolerant to shade. The resulting varieties are expected to adapt to low-light conditions, enabling them to grow well under the canopy of trees in an agroforestry system.

2. Methodology

This research was conducted from October 2023 to February 2024. The experiment took place in Dukuh Sirayu, Jatirejo, Gunungpati, and in the Plant Physiology and Breeding Laboratory, Department of Agriculture, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang.

The research tools used included hoes, sickles, stakes, hoses, labels, raffia strings, measuring tapes, scissors, an analytical balance, sprayers, mortar and pestle, filter paper, a spectrophotometer, writing instruments, and a camera. The materials used included FG yardlong bean seeds as the female parent, five F8 generation yardlong bean genotypes, manure, chemical fertilizers including KCL, SP-36, and Urea, pesticides, shade netting (paranet), bamboo, and silver-black plastic mulch.

The research design employed a Split Plot design arranged based on a Completely Randomized Design (CRD). The main plot was shading with two levels: without shading (N0) and 50% shade using shade netting (N1). Each plot was planted with 24 yardlong bean plants, including three replicates of the parent variety FG and five F8 generation genotypes: FS 7-1-8, FS 10-1-8, FS 10-3-8, FS 14-2-8, and FS 8-2-8.

The experimental plot was made with raised beds measuring 1 m × 6 m with a height of 30 cm. The spaces between the raised beds are 50 cm, and the plant spacing is 50 cm × 50 cm. The raised beds are prepared with the addition of 5 tons/ha of manure as a basic fertilizer and then covered with black silver plastic mulch (MPHP). Planting is done in each raised bed with two rows of plants, with each planting hole filled with 2-3 seeds. Staking around the plants is done when the plants start to grow and have a height of around ±25 cm, with a stake length of 2 meters. Supplementary fertilization is given when the plants are 2 weeks after transplanting (WAT) and 4 WAT. The fertilizer doses used are Urea 60 kg/ha, TSP 100 kg/ha, and KCl 100 kg/ha. (Setiawati *et al*., 2007). The urea fertilizer is applied in two equal doses, with half the dose at the beginning of planting and the other half at 3 weeks after transplanting (WAT). The research parameters observed include time of 50% flowering, fresh harvest age, number of leaf stomata, leaf chlorophyll content, leaf carotenoid content, number of fresh pods per plant, fresh pod weight per plant, and productivity.

The observation of leaf chlorophyll and carotenoid levels is done by extracting 0.25 g of leaves mixed with 25 ml of an 80% acetone solution. The filtrate is then measured for chlorophyll and carotenoid levels using the Spectrophotometric Method at wavelengths of 646 nm, 663 nm, and 470 nm.

$$\text{Chlorophyll content} = (22.7 \times A663 + 2.69 \times A646) + (1.29 \times A646 - 4.68 \times A663)$$

$$\text{Carotenoid Content} = \frac{(A480 + 0.114 \text{ x } A663 - 0.630 \text{ x } A645) \text{x } V \text{ x } 10^3}{112.5 \text{ x } W}$$

Information:
A480 = Absorbance at 480 nm wavelength
A645 = Absorbance at 645 nm wavelength
A663 = Absorbance at 663 nm wavelength
V = Extract volume (mL)
W = Sample weight (g)

The data obtained were then analyzed using Analysis of Variance (ANOVA) at a significance level of 5%. If the results showed significant differences, Tukey's HSD test at a 5% level was carried out to determine the best genotype.

3. Results and Discussion

Table 1 and Table 2 indicate that there is no interaction effect between shading treatments and genotypes, which is likely due to the presence of genetic tolerance to shading, allowing the plants to maintain stable characteristics. This genetic tolerance enables plants to sustain their normal growth and development despite being shaded. According to Mwangi *et al*. (2021), in mung bean plants, there is an increase in the expression of genes related to hormone biosynthesis and signaling pathways as a shade tolerance response, helping to maintain plant growth and development.

The shading treatment had a significant effect on the number of stomata on the leaves (Table 1). Plants without shading exhibited a higher number of stomata on the leaves, amounting to 339.72 stomata/mm² compared to 242.67 stomata/mm² under 50% shade. A reduction in stomatal count was observed as a result of shading treatment on yardlong beans. Shading influenced the number of stomata on the leaves of the yardlong beans. According to Putra *et al*. (2022), in a study on yardlong beans planted under longan trees (7,433 lux) and guava trees (12,467 lux), the number of stomata in genotypes planted under longan shade was higher than in those planted under guava shade. Based on Alam *et al*. (2018), in a study on the effects of Indian teak tree genotypes on cowpea growth, a higher number of stomata or more open stomata facilitated gas exchange (CO_2 and H_2O) between the leaves and the atmosphere, thereby enhancing the photosynthesis rate in cowpea plants.

Table 1. Growth Characteristics of Yardlong Bean FG and F8 Genotypes under Different Shading Conditions

Treatment	Time of 50% Flowering (days after sowing)	Number of Stomata (stomata/mm^2)	Chlorophyll Content (mg/g)	Carotenoid Content (mg/g)
Shading				
No Shading	45.48^a	339.72^a	45.66^a	83.38^a
50% Shading	45.57^a	242.67^b	47.49^a	84.80^a
Genotypes				
FG	48.33^a	274.83^a	49.26^a	86.95^a
FS 7-1-8	41.50^a	286.83^a	48.30^a	91.80^a
FS 10-1-8	46.50^b	300.67^a	46.32^a	75.58^a
FS 10-3-8	45.67^{ab}	289.17^a	43.85^a	82.89^a
FS 14-2-8	44.17^{ab}	299.50^a	45.99^a	82.54^a
FS 8-2-8	43.50^{ab}	296.17^a	45.72^a	84.78^a

Description: Numbers followed by the same letter in the same column are not significantly different according to the 5% Tukey's HSD test

Based on Table 1, it can be seen that the genotype factor significantly affects the days to 50% flowering. The latest flowering time was found in the FG parent, with 48.33 DAP. When compared to the flowering speed of the FG cross genotypes, the fastest flowering occurred in the FS 10-1-8 genotype at 41.50 DAP. However, the speed of flowering among the five tested genotypes was not significantly different. The speed of 50% flowering time in the F8 genotype is suspected to have been inherited from the FG parent. A study on the effect of phonska fertilizer doses on various long bean varieties by Kusuma & Bahri (2022) found that the flowering age of Fagiola IPB long bean varieties was 37-42 DAP. According to the research by Bakhtiar *et al*. (2020) on the cross of green and purple pod long beans, it was found that traits such as flowering age are influenced by high heritability values, indicating that these traits are inherited from the female parent. According to Paudel *et al*. (2021), in a study on the flowering of yardlong beans, light and temperature are the main environmental factors influencing flowering time by responding to changes in photoperiod (day length) and temperature, which can accelerate or delay flowering.

Based on the research results, it was explained that there is no significant effect of shade, genotype, and interaction on the chlorophyll and carotenoid content of long bean leaves (Table 2). Research on several legume plants by Umesh *et al*. (2022)found that chlorophyll content in legumes remains stable in shaded conditions due to higher concentration per unit weight and surface area, facilitating efficient photosynthesis despite reduced sunlight exposure. High chlorophyll content will positively correlate with carotenoid content. According to Sun *et al*. (2022), carotenoids are antioxidant compounds that act as auxiliary pigments that help chlorophyll absorb light.

Table 2. Yield Characteristics of Yardlong Bean FG and F8 Genotypes under Different Shading Conditions

Treatment	Fresh Harvest Time (days after sowing)	Number of Fresh Pods per Plant (pods/plant)	Weight of Fresh Pods per Plant (g)	Productivity (tons/ha)
Shading				
No Shading	51.89[a]	10.76[a]	218.15[a]	0.54[a]
50% Shading	52.00[a]	10.61[a]	213.64[a]	0.53[a]
Genotypes				
FG	55.33[a]	9.17[a]	177.18[a]	0.51[a]
FS 7-1-8	48.50[a]	10.72[a]	225.17[a]	0.58[a]
FS 10-1-8	53.50[a]	10.44[a]	198.49[a]	0.51[a]
FS 10-3-8	52.67[a]	10.94[a]	226.31[a]	0.55[a]
FS 14-2-8	51.17[a]	12.00[a]	270.40[a]	0.58[a]
FS 8-2-8	50.50[a]	10.83[a]	197.81[a]	0.48[a]

Description: Numbers followed by the same letter in the same column are not significantly different according to the 5% Tukey's HSD test

Shading and yardlong bean genotypes did not significantly differ in terms of fresh harvest time, number of fresh pods, weight of fresh pods, and productivity. Yield components of yardlong bean plants tend to show no significant changes under 50% shading compared to no shading. According to the study by Haque & Ahmed (2010) on yardlong beans with light intensity treatments ranging from 100% to 0%, yardlong beans are quite tolerant to light intensity reduction up to 50%, thus maintaining yield components such as fruit number and size without much difference compared to full light conditions.

Regarding shading factors, the plants tested fall into the category of shade-tolerant plants. This indicates that they can grow and develop well, even under limited sunlight exposure. Furthermore, based on the genotype factor, the similarity in growth characteristics across the plants indicates that the planted genotypes have good stability. This stability is important for ensuring consistent yield and plant quality over time, even under varying environmental conditions. Additionally, there are many environmental factors, such as temperature, humidity, and nutrient availability, which might explain why shading did not have a significant effect. According to Khusni *et al*. (2018), besides shading, many other environmental factors affect plant growth, such as temperature, humidity, and nutrient availability, so shading may not exert a strong enough effect to override the influence of these other factors, leading to no apparent changes in certain characteristics.

4. Conclusion

The shading did not affect the growth and yield of the F8 generation long bean genotypes from the crosses, indicating that the plants have tolerance to shade. Based on the genotype influence factor, the FS 10-1-8 genotype has the fastest flowering speed compared to the FG parent. The similar growth and yield among the F8 generation cross plants indicate that the planted genotypes have good stability. This stability is important to ensure consistency in crop yields and quality over time, even under varying environmental conditions.

References

Alam, B., Singh, R., Uthappa, A. R., Chaturvedi, M., Singh, A. K., Newaj, R., and Chaturvedi, O. P. (2018). Different genotypes of Dalbergia sissoo trees modified microclimate dynamics differently on understory crop cowpea (*Vigna unguiculata*) as assessed through ecophysiological and spectral traits in agroforestry system. Agricultural and Forest Meteorology, 249, 138–148. https://doi.org/10.1016/j.agrformet.2017.11.031

Alves, C. M. L., Chang, H.-Y., Tong, C. B. S., Rohwer, C. L., Avalos, L., and Vickers, Z. M. (2022). Artificial Shading Can Adversely Affect Heat-tolerant Lettuce Growth and Taste, with Concomitant Changes in Gene Expression. Journal of the American Society for Horticultural Science, 147(1), 45–52. https://doi.org/10.21273/JASHS05124-21

Bakhtiar, I. F., S. Anwar, and F. Kusmiyati. 2020. Analysis of Genetic Variability and Heritability of Agronomic Characters from Crossing Yardlong Bean of Fagiola IPB x Super Putih. Journal of Tropical Crop Science and Technology 2(1):13–20.

Fiorucci, A.-S., Michaud, O., Schmid-Siegert, E., Trevisan, M., Allenbach Petrolati, L., Çaka Ince, Y., and Fankhauser, C. (2022). Shade suppresses wound-induced leaf repositioning through a mechanism involving Phytochrome Kinase Substrate (PKS) genes. PLOS Genetics, 18(5), e1010213. https://doi.org/10.1371/journal.pgen.1010213

Haque, M. M., and Ahmed, J. U. (2010). Morpho-Physiological Changes and Yield Performance of Yard Long Bean Under Reduced Light Levels. J.Sher-e-Bangla Agric. Univ., 4(2), 88–93.

Hermawan, A., Rochdiani, D., and Hardiyanto, T. (2017). Analisis Usahatani Kacang Panjang (*Vigna sinensis* L.) Varietas Parade. Jurnal Ilmiah Mahasiswa Agroinfo Galuh, 1(2), 77. https://doi.org/10.25157/jimag.v1i2.246

Khusni, L., Hastuti, R. B., dan Prihastanti, E. (2018). Pengaruh Naungan terhadap Pertumbuhan dan Aktivitas Antioksidan pada Bayam Merah (Alternanthera amoena Voss.). Buletin Anatomi dan Fisiologi, 3(1), 62. https://doi.org/10.14710/baf.3.1.2018.62-70

Kiptot, E., Franzel, S., and Degrande, A. (2014). Gender, agroforestry and food security in Africa. Current Opinion in Environmental Sustainability, 6(1), 104–109. https://doi.org/10.1016/j.cosust.2013.10.019

Kusuma, A. B. A., dan Bahri, S. (2022). Pengaruh Dosis Pupuk Phonska terhadap Pertumbuhan dan Hasil Beberapa Varieta Kacang Panjang (*Vigna sinensis* L.). Innofarm: Jurnal Inovasi Pertanian, 24(1), 126–130.

Lysandra, C. L., dan Purnamaningsih, S. L. (2019). Respon dan Hasil Beberapa Genotipe Cabai Rawit (*Capsicum frutescens* L.) pada Naungan di Bawah Tegakan Pohon Jati (*Tectona grandis* L.F.). 7.

Mwangi, J. W., Okoth, O. R., Kariuki, M. P., and Piero, N. M. (2021). Genetic and phenotypic diversity of selected Kenyan mung bean (Vigna radiata L. Wilckzek) genotypes. Journal of Genetic Engineering and Biotechnology, 19(1), 142. https://doi.org/10.1186/s43141-021-00245-9

Paudel, D., Dareus, R., Rosenwald, J., Muñoz-Amatriaín, M., and Rios, E. F. (2021). Genome-Wide Association Study Reveals Candidate Genes for Flowering Time in Cowpea (*Vigna unguiculata* [L.] Walp.). Frontiers in Genetics, 12. https://doi.org/10.3389/fgene.2021.667038

Putra, F. P., Kusmiyati, F., Anwar, S., Widaryati, W., and Sas, M. G. A. (2022). Variation in leaf characters and agronomical traits of Yard-long bean genotypes between Dimocarpus longan and Psidium guajava stand. Biodiversitas Journal of Biological Diversity, 23(11), 5752–5758. https://doi.org/10.13057/biodiv/d231127

Puspita, D., Rahardjo, M., dan Kirana, S. F. (2021). Formulasi Food Bar dari Kacang Lokal Pulau Timor Sebagai Pangan Darurat. Science Technology and Management Journal, 1(2), 47–55. https://doi.org/10.53416/stmj.v1i2.18

Saputra, A. W., Roviq, Moch., dan Barunawati, N. (2018). Pengaruh Naungan pada Pertumbuhan dan Hasil Kacang Hijau (*Vigna radiata* L.). 6(10), 2453-2462.

Schulz, V. S., Munz, S., Stolzenburg, K., Hartung, J., Weisenburger, S., and Graeff-Hönninger, S. (2019). Impact of Different Shading Levels on Growth, Yield and Quality of Potato (*Solanum tuberosum* L.). Agronomy, 9(6), 330. https://doi.org/10.3390/agronomy9060330

Setiawati, W., Murtiningsih, R., Sopha, G. A., dan Handayani, T. (2007). Petunjuk Teknis Budidaya Tanaman Sayuran. Bandung: Balai Penelitian Tanaman Sayuran Pusat Penelitian dan Pengembangan Hortikultura Badan Penelitian Dan Pengembangan Pertanian.

Sun, T., S. Rao, X. Zhou, and L. Li. (2022). Plant carotenoids: recent advances and future perspectives. Molecular Horticulture 2(1):3.

Thangata, P. H., & Hildebrand, P. E. (2012). Carbon stock and sequestration potential of agroforestry systems in smallholder agroecosystems of sub-Saharan Africa: Mechanisms for ‘reducing emissions from deforestation and forest degradation’ (REDD+). Agriculture, Ecosystems and Environment, Complete (158), 172–183. https://doi.org/10.1016/j.agee.2012.06.007

Umesh, M., Angadi, S., Begna, S., Gowda, P., and Prasad, P. V. V. (2022). Shade tolerance response of legumes in terms of biomass accumulation, leaf photosynthesis, and chlorophyll pigment under reduced sunlight. Crop Science, 63(1), 278–292. https://doi.org/10.1002/csc2.20851

Wu, Y., Gong, W., and Yang, W. (2017). Shade Inhibits Leaf Size by Controlling Cell Proliferation and Enlargement in Soybean. Scientific Reports, 7(1), 9259. https://doi.org/10.1038/s41598-017-10026-5

Yang, C., and Li, L. (2017). Hormonal Regulation in Shade Avoidance. Frontiers in Plant Science, 8(1), 1527. https://doi.org/10.3389/fpls.2017.01527