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Response of various growth regulators and shade intensity to the growth of arabica coffee seedlings of Sigarar Utang variety

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Abstract. *Damanik RIM, Hanum C, Sembiring LJ. 2023. Response of various growth regulators and shade intensity to the growth of arabica coffee seedlings of Sigarar Utang variety. Nusantara Bioscience 15: 85-89.* The productivity of Arabica coffee (*Coffea arabica* L.) of the Sigarar Utang variety in Indonesia is still relatively low, especially in Simalungun District, North Sumatra Province, Indonesia. Growth regulators and shade are some factors that must be considered in nurseries. This research aims to determine the best growth regulators type and shade intensity for Arabika coffee seedling growth. The experiment was conducted from March to June 2022 in Nagori Ujung Bawang, Simalungun District, and the Central Laboratory of Agriculture Faculty, Universitas Sumatera Utara, Medan, North Sumatra. The study used a Split Plot design of 2 factors and 3 replications. The first factor (main plot) consists of 4 levels, namely 0, 50, 70, and 90% shade intensity. The second factor (sub-plot) consists of the three growth regulator treatments, i.e., auxin, cytokinin, and the combination of auxin and cytokinin. The results showed that the interaction between shade intensity and growth regulators had a significantly different effect on increasing root length. The shade treatment significantly affected plant height, leaf area, and total chlorophyll content of leaves. However, it did not affect the stem diameter. A shade intensity of 90% significantly increased plant height, leaf area, and total chlorophyll content of leaves.

Keywords: Auxin, coffee, cytokinin, light intensity

INTRODUCTION

Coffee is one of the plantation crops to produce coffee. Coffee is a popular and favorite beverage for many people and has relatively high economic value. Coffee can be processed into a delicious productive drink with a distinctive aroma as a refresher for the body and mind. For Indonesia, Coffee is a commodity that contributes significant foreign exchange after palm oil, rubber, and timber in the non-oil and export of gas (FAO 2003).

Coffee is one of the most important economic commodities in the province of North Sumatra, Indonesia (Sitompul et al. 2018). Simalungun District is the second number largest Arabica coffee-producing area in North Sumatra, Indonesia according to statistical data from the Directorate General of Plantations (2018), with production reaching 9,744 t/year in a total area of 7,843 ha with an average annual production of only 1,443 kg/ha of fresh fruit or around approximately 481 kg grain/ha. Compared with coffee-producing countries such as China and Vietnam, the productivity of coffee fields in Indonesia is only a quarter of the productivity of these countries, which are capable of producing more than 2.2 t/ha of grain annually (FAO 2014). The plantation area and productivity of arabica coffee in Indonesia still need to be improved due to the market potential and a high selling price. Some farmers still use seeds from the natural seedling because have no knowledge to factors affecting to the seed quality, so coffee productivity is not optimal (Harahap et al. 2015).

Coffee is a plant that requires shading throughout its life cycle. The degree of shading varies according to the growth phase of the coffee. The shade level in the seeding phase or young age is higher than in the generative phase. Improper shade levels in the seedling phase could produce low-quality coffee seedlings (Arief et al. 2011).

Coffee breeding is a comprehensive activity in preparing seeds for distribution to be planted in the field. Although the seeds used come from superior seeds, if the seeding is not following the correct operational standards, it will produce low-quality seedlings ready for distribution (Anita et al. 2016). One of the critical things in coffee nurseries, besides watering, fertilizing, and controlling pests/diseases, is adjusting the light intensity as needed. A previous study by Muliasari et al. (2016) showed that the optimum shade intensity for the growth of arabica coffee seedlings of the Catimor variety is 66%. Meanwhile, Artina et al. (2021) recommended 80% shade as the best shade intensity used in Gayo variety arabica coffee varieties in Gayo coffee nurseries.

Another factor that influences the growth of coffee seedlings is growth regulators. Growth regulators are non-nutrient organic compounds that can support, prevent and change plant physiological processes in small amounts. Auxins support cell extension, and gibberellin stimulates cell division, elongation or both. Cytokinin supports cell division, ethylene plays a role in fruit ripening process, and the mechanisms of quality generation by abscisic acid. Plant growth regulators are likened to coordinators in growth and development processes (Asra et al. 2020).

A study by Hidayati and Subroto (2018) showed that 2 ppm of auxin and cytokinin at a concentration significantly affects the number of leaves and roots, root length, and growth rate of seedlings from hypocotyl responses during development. The highest number of leaves is obtained from cytokinin, while the root length and the highest number of roots are obtained from auxin. Besides that, the highest growth rate was obtained from a combination of auxin and cytokinin. Cytokinin and auxin synergize for plant tissue differentiation (Febriyanti 2016). Therefore, this research aims to determine the best type of growth regulators and shade intensity to improve the growth and quality of Arabica coffee seedlings of the Sigarar Utang variety.

MATERIALS AND METHODS

Sampling site

This research was conducted from March to June 2022 in Nagori Ujung Bawang, Simalungun District and the Central Laboratory Agriculture Faculty, Universitas Sumatera Utara, Medan, North Sumatra, Indonesia.

Materials and equipment

The materials used in this research were coffee seedlings of Sigarar Utang variety, growth regulators (auxin and cytokinin), net (50%, 70%, 90%), soil planting medium with a ratio of 1:1:1 (top soil andosol soil, sand, and compost), rice husks, polybags of size 20 x 20 cm, bamboo, rope, water, chemical fertilizer. The equipment used in this research were stationery, paper, bars, cameras, buckets, drills, lux meters, micrometers, calipers, sprayers, machetes, knives, hoes, scales, spectrophotometers UV/VIS, Whatman 40 filter paper, and other tools that support research.

Design experiment

This research was conducted experimentally using a split-plot design consisting of 12 treatments, and each treatment had 3 replications, so there were 36 experimental units. Each unit consisted of 5 seedlings, and there were 180 seedlings. Observations were made for all seedlings. The shade intensity uses paranet as the main plot, i.e., N0: no shade, N1: 50% shade, N2: 70% shade, and N3: 90% shade. Growth regulators were used as a sub-plot, i.e., Z1: 2 ppm auxin, Z2: 2 ppm cytokinin, and Z3: 2 ppm auxin + 2 ppm cytokinin.

Data analysis

Data were analyzed by Analysis of Variance, followed by Multiple Range Test (MRT) at a level of 5%.

RESULTS AND DISCUSSION

Plant height

The results showed no interaction between growth regulators and shade intensity to the height of coffee seedlings. The application of various growth regulators has no significant effect on increasing the growth of coffee seedlings. In contrast, shade intensity significantly increased the growth of coffee seedlings at 8 Weeks After Planting (WAP). The average height of coffee seedlings with the treatment of various growth regulators and shade intensity was presented in Table 1.

Leaf area

The results of growth regulators and shade intensity treatments on the leaf area of coffee seedlings (Table 2), showed no interaction between the treatment of various growth regulators and shade intensity. The application of different growth regulators has no significant effect on increasing the leaf area of coffee seedlings. In contrast, shade intensity significantly affects the leaf area of coffee seedlings.

Table 1. Plant height of coffee seedlings at 2-8 WAP with the treatment of growth regulator and shade intensity

Time	Growth regulators	Shade				Average
		N_0 (0%)	N_1 (50%)	N_2 (70%)	N_3 (90%)	
				(cm)		
2 WAP	Z_1 (auxin)	14.80	14.33	14.17	14.27	14.39
	Z_2 (cytokinin)	14.67	13.93	14.27	14.13	14.25
	Z_3 (auxin + cytokinin)	14.20	14.07	14.13	14.27	14.17
	Average	14.56	14.11	14.19	14.22	14.27
4 WAP	Z_1 (auxin)	15.40	14.77	15.40	16.03	15.40
	Z_2 (cytokinin)	14.80	14.10	15.73	16.23	15.22
	Z_3 (auxin + cytokinin)	14.67	14.90	15.23	15.63	15.11
	Average	14.96	14.59	15.46	15.97	15.24
6 WAP	Z_1 (auxin)	16.17	17.13	17.43	18.50	17.31
	Z_2 (cytokinin)	15.80	16.03	18.13	19.10	17.27
	Z_3 (auxin + cytokinin)	15.50	18.60	16.87	18.13	17.28
	Average	15.82	17.26	17.48	18.58	17.28
8 WAP	Z_1 (auxin)	17.40	21.57	21.40	22.83	20.80
	Z_2 (cytokinin)	18.30	19.57	22.73	22.80	20.85
	Z_3 (auxin + cytokinin)	17.30	21.93	22.03	23.17	21.11
	Average	17.67d	21.02c	22.06b	22.93a	20,92

Note: The number followed by the same letter indicates no significant difference on Multiple Range Test of 5%

Root length

The treatment of various growth regulators and shade intensity on root length showed a significant difference between the treatment of different growth regulators and the intensity of shade to the root length of coffee seedlings. The average root length of coffee seedlings with the treatment of various growth regulators and shade intensity can be seen in Table 2.

Stem diameter

The results showed no interaction between the growth regulators type and shade intensity on the stem diameter of the coffee seedlings. The application of the growth regulators type had no significant effect on increasing the diameter of the stem of coffee seedlings, and the shade intensity treatment also had no significantly effect on the stem diameter of the coffee seedlings. The average stem diameter of coffee seedlings treated with treatment of various growth regulators and shade intensity was presented in Table 2.

Total chlorophyll content of leaves

The results showed no interaction between the treatment of growth regulators and shade intensity to the total chlorophyll content of coffee seedling leaves. Different growth regulators did not significantly affect the total chlorophyll content of coffee seedling leaves. At the same time, shade intensity significantly increased the total chlorophyll content of coffee seedling leaves. The average total chlorophyll content of coffee leaves with the treatment of various growth regulators and shade intensity can be seen in Table 2.

Discussion

The results showed that applying 90% shade increased the highest height of coffee seedlings up to 22.93 cm at 8 WAP. Meanwhile, the lowest growth in coffee seedlings was found in the treatment of no shading, which was 17.67 cm. There was a slow increase in plant height at 2 WAP - 6 WAP, where the shade intensity did not significantly affect plant height. It is due to the process of transferring plant seedlings on different planting media so that they require acclimatization (Sudrajat and Siagian 2014). At the end of the study (8 WAP), shading intensity significantly affect plant height. The treatment of 90% shading intensity resulted in the best plant height, and it shows that 10% sun intensity can produce the best plant height of 22.93 cm. Artina et al. (2021) showed that 80% shade intensity improved the size of coffee seedlings than the no-shade treatment. The higher height of seedlings on the shade treatment was due to the etiolation of the plant seedlings (Alridiwirsah et al. 2015). A previous study by Arisandi (2015) showed that coffee at the beginning of the growth phase required higher shading intensity than the adult or generative growth phase.

Leaves have an essential role in photosynthesis. The results showed that 90% shading intensity results in the highest leaf area of coffee seedlings (24.85 cm) at 8 WAP, and no-shading treatment results in the lowest leaf area (16.35 cm). It shows that the low light intensity in coffee seedlings causes a higher leaf area than coffee seedlings with full light intensity. A study by Ferita et al. (2009) also showed that seedlings planted at low light intensity had wider and longer leaves than seedlings planted at 100% light intensity (no shade). Bote and Struik (2011) also stated that coffee plants grown under shade with lower light intensity had a higher photosynthetic rate and had relatively higher leaf area and growth rate than higher light intensity.

Table 2. Growth characteristics of coffee seedlings at 8 WAP with the treatment of growth regulator and shade intensity

Growth regulators	Shade				Average
	N_0 (0%)	N_1 (50%)	N_2 (70%)	N_3 (90%)	
Leaf area			(cm^2)		
Z_1 (auxin)	12.93	22.13	22.23	21.92	19.80
Z_2 (cytokinin)	19.17	17.82	28.40	24.34	22.43
Z_3 (auxin + cytokinin)	16.95	25.60	22.60	28.30	23.36
Average	16.35c	21.85b	24.41a	24.85a	21.87
Root length			(cm)		
Z_1 (auxin)	18.13ab	17.13c	16.03d	17.80abc	17.28
Z_2 (cytokinin)	18.30ab	17.63bc	15.37e	15.33e	16.66
Z_3 (auxin + cytokinin)	17.80abc	17.63bc	16.37d	18.40a	17.55
Average	18.08	17.47	15.92	17.18	17.16
Stem diameter			(mm)		
Z_1 (auxin)	2.59	2.81	2.70	2.64	2.68
Z_2 (cytokinin)	2.75	2.78	2.78	2.72	2.76
Z_3 (auxin + cytokinin)	2.68	2.83	2.77	2.72	2.75
Average	2.67	2.81	2.75	2.69	2.73
Total chlorophyll content			(mg/g)		
Z_1 (auxin)	13.97	13.91	14.50	16.25	14.66
Z_2 (cytokinin)	13.71	13.72	13.50	17.75	14.67
Z_3 (auxin + cytokinin)	13.88	14.73	15.13	13.84	14.39
Average	13.85c	14.12bc	14.38b	15.95a	14.57

Note: The number followed by the same letter indicates no significant difference on Multiple Range Test of 5%

Based on Table 2, shows that the highest growth rate of coffee seedling root (18.40 cm) was obtained from the treatment combination of 90% shading intensity and the combination of auxin and cytokinin. It was followed by no shade + cytokinin treatment of 18.30 cm, no shade + auxin treatment of 18.13 cm and the lowest as obtained in 90% shade + cytokinin treatment of 15.33 cm. It shows that the root length of coffee seedlings is related to plant height. The highest plant height (Table 1) is obtained with 90% shading intensity and the combination of auxin and cytokinin. Ferita et al. (2009) stated that well-shoot growth results in well-root growth. Good root growth, would affect the balance of the seedlings. The excellent growth of the upper part influences the number of photosynthesis results translocated to all parts of the plant, including the roots. A relationship exists in plant tissues between root formation, endogenous auxin, and cytokinin in plant tissues. Low light intensity stimulates endogenous growth regulators to be more effective in root growth and development (Widiastoety 2014).

Roots are essential in the metabolism of the plant to form new organs. The formation of new organs is influenced by the interaction between endogenous growth regulators (natural) and exogenous growth regulators (synthetic) in plants. The combination effect of auxin and cytokinin on root growth showed that it causes cell division and stimulates the formation and development of roots in arabica coffee seedlings of the Sigarar Utang variety. Mahadi et al. (2015) stated that the combination of auxin and cytokinin causes the concentration of endogenous growth regulators in cells to increase because these two growth regulators are factors that trigger the process of growth and development of tissue. Auxin and cytokinin act synergistically. Cytokinin enhances cell numbers and cell division through mitosis, while auxin plays a role in cell elongation (Hidayati and Subroto 2018).

The treatment of the growth regulators type and various shade intensities did not affect the stem diameter (Table 2). Growth regulators, light intensity, and other factors influence the growth of coffee seedling stems. A previous Suherman and Kurniawan (2015) study showed that sufficient nutrients and good soil media enhance plant stems. Due to the age of coffee seedlings, the application of growth regulators did not affect the stem diameter. In line with Sudrajat and Siagian (2014), seeds require acclimatization in transferring to planting media.

The 90% shade intensity treatment resulted in the highest chlorophyll content in coffee seedling leaves (15.95 mg/g) at 8 WAP. No-shade treatment yielded the lowest total chlorophyll content (13.85 mg/g). The leaf chlorophyll results were similar to the leaf area (Table 2), significantly affected by low light intensity. It shows that the low light intensity in coffee seedlings (90% shade treatment) significantly increased chlorophyll content compared to the coffee seedlings with full light intensity (no shade). Chlorophyll serves as a light catcher that plants need for the process of photosynthesis to take place. Sholikhah et al. (2015) stated that the high chlorophyll content indicates high photosynthesis. Bote and Struik (2011) also reported that coffee plants under shade had higher photosynthesis than those under no shade. The results are similar to the results of Soleh et al. (2021), that the treatment of 80% shade intensity resulted in the highest leaf chlorophyll index of coffee seedlings at 12 weeks after seeding (46.73 mg/g) and the lowest was in no shade (35.97 mg/g).

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