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The Response of Dwarf Banana Cavendish Growth and Production under Natural Shade

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Abstract : Banana is important commodity in Indonesia as source of food and energy. Naturally, banana grows in open areas. Planting dwarf banana *cavendish* under natural shade are is limited, because the growth of plant is inhibited due to the low light intensity. Developing dwarf banana *cavendish* that tolerant to shade is important. The tolerant cultivar can be planted on the stand either in the form agroforestry or plantation crops as interplanting. The dwarf banana *cavendish* were collected from various places in Southeast Sulawesi, Indonesia. The research was arranged in a split plot design with three replications. Two factors are considered (i) the existence of natural shade or without shade, and (ii) plant genotype. The parameters observed were the vegetative and the generative character. The results showed that there was different characteristic of the dwarf banana *cavendish* under shade condition base on the vegetative growth. On the generative character showed some variation but still below the threshold of acceptable tolerance. Therefore, it is recommended that dwarf banana accessions selected can be used as source to develop dwarf banana shaded tolerant.
Key word: Banana, Cavendish, Staple food, Shading.

Introduction

Bananas is member of the family Musaceae[1,2,3], generally accepted that is come from Southeast Asia, a biogeographically region including the Malay Peninsula, Indonesia, the Philippines and New Guinea was the primary centre and India was a secondary centre[4,5,6]. The centre of diversity has been placed in Malaysia or Indonesia[7]. The plants are distributed mainly on margins of tropical rainforests[8] and now widespread throughout the world.

Bananas are among the most important food crops worldwide[9,10] and is a major food staple in the tropics[11]. They include diverse types such as dessert, cooking and roasting bananas[12,13,14]. The general term ‘banana’ is used to encompass cultivated varieties of the genus Musa that fall into one of two sub-groups [15], the sweet or dessert banana which makes up approximately 43% of world production, and the cooking banana which makes up approximately 57%.

Banana is source of calorie and mineral, as well as most of the vitamins essential for human nutrition [16]. Bananas are not only rich in carbohydrate and vitamins[13], including vitamin A [17,18,19,20,21,22], vitamin C [18,23], and B6 [24,25,26], but also rich in mineral such as potassium, magnesium, phosphorus, iron and calcium [18,27,28]. They are a good source of dietary fibre[17] and are fat-free. Banana is often the first solid food fed to infant and that as food supplement [29]. It also contains high levels of flavones and antioxidants likes *lutein*, *zea-xanthin*, *alpha* and *beta-carotenes* [30,31]. Bananas also have several medicinal uses [26,32,33]. Banana in the form of banana peel is being use as biosorbent to remove chromium, the toxic heavy metals in waste water [34].

Banana is the best-known tropical fruit and Indonesia is the sixth top banana producer among the top 20 banana producing countries in the world [35]. Indonesia produces nearly 5.36 million tons of bananas annually [36]. The total per capita consumption in Indonesia is about 22 kg. Indonesia is the ranks 4th in level of banana consumption in the world after the Philippines with 56 kg, Brazil 31 kg and Kenya 24 kg per capita consumption [36]. In Indonesia, banana ranks first [35] becoming the most important food and cash crop in Indonesia and grown around the year in the country as a commercial purpose and homestead area for local consumption.

There is growing and enormous potential banana market in Indonesia. The Indonesian population reached 250 million people with banana consumption per capita reached 22 kg. It is predicted that future banana demand in Indonesia will increase sharply due to the increase in population, income and increased diversification in banana processing technology. As with all other crop species, banana production in Indonesia faces major challenges not only from biotic and abiotic stresses, but also from the availability of land to cultivate banana.

The increase banana production in Indonesia faced many obstacles, as a result of the low level implementation in recommended cultivation techniques, the presence of pests and diseases and also limited land that can be used to cultivate. The best alternative to overcome this problem is needed to improve the banana production system that can increase production, productivity and quality of bananas through agroforestry system or intercropping. Intercropping is an essential practice when several economic field crops are competing for the same limited land area [37].

Light has influence on the growth and yield of banana. The light is the main factor affecting on the growth and yield [38,39]. There is a close relationship between radiations with net photosynthesis [40]. Shade directly affects the intensity of the light that falls on the surface of the plant canopy[41]. Many physiological process in plants may affected by shade[39]. It included the rate of photosynthesis, transpiration, respiration and translocation of photosynthate[42], mineral absorption [43] and root growth[44,45].

Shade in plant agroforestry however also has the ability to affect plant growth positively through reduction of loss in soil moisture, retaining of nutrients, suppression of weeds, reduction of soil and plant temperature during the day, raising the night air temperature, reduce water runoff, reduce the decomposition of soil organic matter and enhanced humidity[16,39,46]. The adaptability of plants to the specified environmental conditions is depending on plant genetic trait [47]. The ability of plant to cope with shade depends on its ability to continue photosynthesis at light deficit conditions [39]. There are two mechanisms adaptation of plant to shading stress are avoidance and tolerance [48]. The avoidance mechanism is done by getting lighter, while the tolerance mechanism was to get a low light intensity efficiently.

The development of dwarf banana cultivar that tolerant to shade is very important. Because it is naturally to grow and better production, banana requires full sun light or illumination in the open area without shielded. The dwarf banana is the ideal type in agroforestry system [16], because with the dwarfing banana the population or plant density per unit area will be higher so that the potential production will be higher also. Therefore it is necessary screening to obtain the dwarf banana cultivar that shade tolerant and have a high potential production. The present study has provided an assessment of the banana's characteristics towards the existence of shade or low light intensity.

Experimental

The research was arranged in a split plot design with three replications. Two factors are considered (i) the existence of shade or without shade in as main plots, and (ii) the dwarf banana genotype or cultivar in subplots. Observations were made on the vegetative and generative parameter:

1. The vegetative variables include plant height and number of leaves that were measured every month.
2. The leaf characters include leaf length and leaf width on average, measured from one plant.
3. The generative characters include time of flowering, flowering age, harvesting age and weight of the harvest.

The observed data were then analyzed using analysis of variance. Duncan's Multiple Range Test (DMRT) at 95% confidence level was performed to see the effect of different soil conditions on vegetative and generative components.

Results and Discussion

A. Effect of Natural Shade of Vegetative Character

The results showed that there were significant differences in the parameter of plant height, leaf length and leaves width (Table 1 and 2). Based on the data it indicates that shade treatment can increase the characters of plant height, leaf length and leaves width. On the parameter number of leaves, there are no significant differences between plant growing under natural shade and that of without natural shade. The number of leaves usually almost identical between plants growing under natural shade, as well as with plants growing without natural shade (Table 2).

Table 1. The eeffect of natural shade against plant high and leaf length on the plant age up to 10 months after the transfer (MAT)

Age (month)	Plant height (cm)		Leaf length (cm)	
	No natural shade	Natural shade	No natural shade	Natural shade
1	14.67[a]	24.67[b]	21.39[a]	30.29[b]
2	30.28[a]	39.28[b]	30.92[a]	40.32[b]
3	40.72[a]	53.72[b]	48.37[a]	60.47[b]
4	60.70[a]	80.70[b]	53.20[a]	71.40[b]
5	71.20[a]	83.20[b]	69.80[a]	81.70[b]
6	82.10[a]	97.10[b]	79.30[a]	92.60[b]
7	96.40[a]	106.40[b]	107.80[a]	118.00[b]
8	109.30[a]	119.30[b]	142.00[a]	151.70[b]
9	117.50[a]	129.50[b]	162.00[a]	173.00[b]
10	118.50[a]	130.50[b]	164.00[a]	179.00[b]

Note: Means in the same line suffixed with different letters are different at 5% levels of significance according to DMRT.

Table 2. The effect of natural shade against plant number of leaves and Leaves Width on the plant age up to 10 months after the transfer (MAT)

Age (month)	Number of leaves		Leaves Width (cm)	
	No natural shade	Natural shade	No natural shade	Natural shade
1	3.19[a]	3.39[b]	12.20[a]	16.40[b]
2	4.40[a]	4.10[a]	15.54[a]	21.64[b]
3	6.00[a]	5.90[a]	18.20[a]	22.00[b]
4	6.92[a]	7.12[a]	25.70[a]	32.90[b]
5	7.80[a]	7.40[b]	34.80[a]	39.92[b]
6	8.20[a]	8.70[b]	48.50[a]	56.31[b]
7	9.20[a]	8.80[b]	57.60[a]	66.36[b]
8	9.60[a]	9.80[a]	69.40[a]	76.50[b]
9	10.20[a]	10.40[a]	73.00[a]	81.90[b]
10	11.20[a]	11.48[a]	76.54[a]	82.93[b]

Note: Means in the same line suffixed with different letters are different at 5% levels of significance according to DMRT.

In general, it appears that the natural shade can increase the plant height, leaf length and leaves width. While the parameter number of leaves there is no definite pattern. It is supposedly that in a higher level of shade, the plant has undergone etiolating so the parameter of plant height, leaf length and leaves width becomes higher.

B. Effect of Natural Shade of Generative Character

Based on the generative character appears that the harvesting time in natural shade conditions, generally longer than that the harvesting time on condition without shade (Table 3). In general, it appears that in the shaded conditions, the production parameters has decreased, especially in the character of total production, the number of combs, number of fruit in each comb and the banana grain size. Nevertheless, there is a tendency increasing in the number of bunches and bunches length increased, although the size and weight of fruit per banana tends to decrease.

Table 3. The effect of natural shade on several generative characters of dwarf banana Cavendish

No.	Character	No Natural Shade	Natural shade	± (%)
1	Time of flowering (month)	9.2[a]	9.8[b]	6.52
2	Time of ripening (month)	11.00[a]	11.6[b]	5.45
3	Bunch weight (kg/bunch)	14.26[a]	13.80[b]	3.23
4	Total comb (Fruit)	7.8[a]	8.1[b]	3.85
5	Bunches length (cm)	59.8[a]	68.72[b]	14.92
6	Banana amount for each comb (fruit)	17.2[a]	16.3	5.23
7	Total combs of bunch	7.8[a]	8.2[b]	5.13
8	Fruit length (cm)	13.5[a]	13.1[b]	1.48
9	Fruit width (cm)	3.2[a]	3.0[b]	3.13
10	Fruit diameter (cm)	31.3[a]	28.3	9.58
11	Banana amount for each bunch (fruit)	138.3[a]	134.5[a]	2.75
12	Banana weight (g fruit^{-1})	103.2[a]	92.8	10.08
13	Weight flesh (g)	62.6[a]	54.7	12.62
14	Edible portion of fruit (%)	60.45[a]	59.00[a]	2.40

Note: Means in the same line suffixed with different letters are different at 5% levels of significance according to DMRT.

In general, based on Table 3 it appears that there is a decline in the production of dwarf banana Cavendish under the natural shade condition. Decreasing or increasing of the production characters that occur on average only 6 percent and still below the threshold of decline that can be tolerated by 10 percent. Therefore the dwarf banana Cavendish accessions tested can be used as a source of germplasm for banana cultivation in agroforestry system or in polyculture as intercropping patterns.

Light is a key factor in the ultimate growth and production because it supplies the energy needed to fix carbon [49]. Most of the plant responses to shading are with lower dry matter production, photosynthetic retention in the stem, longer spear development and bigger or thinner leaves [50,51]The change in microclimate due to shade levels caused clear differences between growth and plant development [50,52,53] and plant height was higher under shaded conditions compared that of without shading.

Plants grown under low light levels have shown more apical dominance than those grown in high light environment resulting in taller plants under shade [54]. Shading produced taller plants due to shoot growth as they looked for light, indicating the activation of some phototropism responses [55], to modify plant leaf distribution in order to limit mutual shading. Enhancing plant height under shade represents a cost to resource acquisition through reduction in either root or leaf allocation [50,56,57,58,59]. Plants responses to light include a variety of adaptations at physiological levels [60]. Such responses are translated into alteration of growth rate and plant architecture [61]. The architecture of plant canopy influences the interception, absorption and scattering of solar radiation [62]. Reduced light quantity and/or quality also can cause accelerated stem elongation and branch reduction [63].

Irradiation is an important factor affecting crop photosynthesis, development and yield [64]. It is also an important factor helping plants to reach enough light [50]. Similar results also found in faba bean when exposure to shade [56]. Shading is reduced stomatal conductance and photosynthesis rate in *Salvia sclarea* [50], myrtle [65] and banana [66], therefore a reduction in the rate of growth [67,68].

Many physiological processes in plants are affected by irradiance, which is one of the most important environmental factors affecting plant survival, growth, reproduction and distribution [50,69]. The amount of light reaching inside the canopy and absorbed by the plant changes with plant density. Yield reduction by shading will depends upon crop species as well as the degree of shading. Shading occurs mainly due to dense plant population, intercropping, planting geometry and excessive vegetative growth, which affects the crop performance through reducing photosynthetic capacity of plant [70].

Limited land need to look for a solution through the use of land between tree crop forestry or perennial crops such as rubber, coconut and others to grow dwarf banana in agroforestry or polyculture farming system. Agroforestry has been designed to increases the yield of the land, combines the production of crops and forest plants simultaneously or sequentially on the same unit of land[71,72], to obtain economic, environmental, ecological, and cultural benefits [73].

Agroforestry options may provide a means for diversifying production systems and increasing the sustainability of smallholder farming systems, through growing food crops in the forests and establishing tree crop production systems on arable lands [74].

Conclusion

In conclusion it appears that there is significant different on the vegetative character between the dwarf bananas Cavendish that growth under the shade condition compare that of without shade. In the generative character tested, there is decrease or increase in several generative characters, but still below the threshold of acceptable tolerance decline by 10 percent. Therefore accessions selected plants can be used to source the development of banana plants in shaded conditions.

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