Effect of Brassin-like Substance on Fruit Size of Arabica Coffee

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ABSTRACT

The study emphasized on the effects of brassin-like substance (BS) on fruit size of Arabica coffee (Coffea arabica L.). The experiment designed in randomized complete block design (RCBD) with 5 treatments and 4 replications (one tree per replication). The trees were sprayed with BS at the concentrations of 0, 0.1, 0.5, 1.0 and 1.5 mgL^{-1} every four weeks after fruit set until harvesting stage (10 spraying times). The results showed that the coffee in BS 1.5 mgL^{-1} treatment gave the largest fruit and bean sizes. It also gave the heaviest fruit and green beans. All of BS concentrations did not affect percentage of bean dry weight. The highest percentage of the best grade (A grade) coffee beans was found in BS 1.0 and 1.5 mgL^{-1} treatments. BS 0.5, 1.0 and 1.5 mgL^{-1} could hasten fruit ripening. However, BS 0.5, 1.0 and 1.5 mgL^{-1} decreased the percentage of fruit set and yield.

Key words: Arabica coffee, Brassin, Brassin-like substance, Coffee bean

INTRODUCTION

Coffee is one of the most important cash crops in the world market. Thailand is the third largest coffee producer in Asia (after Vietnam and Indonesia). Arabica coffee is produced in the cooler highland areas of the northern part. It is worth up to $80 billion annually (Angkasith, 2002). This is exported as the raw, roasted, or soluble product to more than 165 countries worldwide. In 2008/2009, the total area covered by coffee was about 4,000 hectares. Total production was 3,500 tons (Office of Agricultural Economics, 2009). Small fruit size is one of the limiting factors in coffee fruit marketing. Consumers also prefer large coffee bean (>5.5 mm), making this a very important marketing consideration, and economic benefits from treatment capable of improving average fruit size are potentially very high. Only the beans that have the best grade, good flavor and aroma can be sold at a high price. As a result, growers who produce high-quality coffee can get better prices for their crops from market and coffee companies that buy only premium beans. In view of expected increases in production effective strategies for improving fruit size and quality are needed.

Achieving good sized fruit is a complex process and can be affected by a wide range of variables, such as variety, rootstock, tree health, nutrition, irrigation, orchard management, and environmental factors. Several techniques are used to improve coffee fruit and bean size, for example, girdling, fertilization, shading, irrigation, pruning and fruit thinning (Vaast et al., 2005). However, the high labor cost for hand thinning does not suggest using this technique.

Brassinosteroids (BRs) are a new classified group of plant hormones that are essential for normal plant development (Clouse and Sasse, 1998). Extensive research over the past two decades has revealed the importance of BRs involved in numerous processes, including cell elongation, cell division, vascular differentiation, reproductive development, and pathogen and abiotic tolerance (Clouse, 2002). Many investigators evaluated and recommended this substance for increasing flowering, fruit, crop yield, stress tolerance, and diseases resistance. Shalaby and Abdel-Halim (1995) also reported that foliar spray of faba bean plants with brassinosteroids significantly increased plant height, number of branches, number of pods, pod dry weight, number of seeds per plant, and yield.

Also Helmy et al. (1997) reported that foliar application of brassinosteroids significantly promoted the growth and yield characters of broad bean plants. Pankasemsuk (2007) reported that application of brassin-like substance (BS) made by Department of Horticulture, Faculty of Agriculture, Chiang Mai University at the concentration between 0.01 to 0.50 mgL^{-1} on longan, papaya, and mango could increase fruit size and quality. The objectives of this study were to investigate the effect of BS on fruit size, maturation, quality, and yield of Arabica coffee.

MATERIALS AND METHODS

The experiments were conducted on five year old coffee, *Coffea arabica* L. 'Catimor'. Trees of similar vigor, age and size were selected for spray treatments. Trees were grown at the Highland Coffee Research and Development Center (Chang Kian station: site A), Chiang Mai University, Chiang Mai, Thailand, at the altitude 1,200 m above mean sea level. The experimental design was a randomized complete block design. The contour lines of the plantation were used as blocks. One tree per experimental unit and each treatment were replicated four times. BS was foliar sprayed on coffee plants at the concentrations of 0 (the control), 0.1, 0.5, 1.0 and 1.5 mgL^{-1} at 7 days after full bloom. Fruits were randomly collected every four weeks after full blossom until cherry fruit maturity (15 May to 15 December 2010).

Fresh weight and dry weight of the whole fruit and bean

Four bearing lateral branches per tree were randomly tagged. The sampled fruits were separated into bean, and oven dried at 70 °C for 48 hours to determine dry weight. At the harvesting stage, coffee bean samples were prepared by the wet processing method (wet de-pulping, anaerobic fermentation for 24 hours, sun drying, de-husking) to obtain green coffee or green beans.

Grading procedure

Grading of coffee bean was determined after harvesting, according to the method described by (Angkasith and Warrit, 1999). Grading of coffee was done by passing the beans over screens with different diameter holes. Grade A; bean size must be not less than 5.5 mm and the sample must not contain more than 1.5% damaged beans, 13% broken or immature beans, 0.5% of impurities and not more than 13% moisture; Grade X; same quality as Grade A but the beans are discolored and stained. Grade Y; smaller beans and has the same quality as Grade A. Grade P, the damaged and broken beans of any size.

RESULTS

Growth of the coffee fruit throughout the growing season was typical double-sigmoid curve pattern. It could be separated in to five stages:

1) The pinhead stage: the stage which spreads over the 1^{st} to 5^{th} weeks after flowering with phase of slow growth. There were no significant difference in fresh weight and dry weight of fruit among all treatments (Table 1 and Table 2).

2) The rapid swelling stage: between 5^{th} to 9^{th} weeks after flowering; size and fresh weight and dry weight of fruit increased rapidly. However, there were no significant differences among all treatments (Table 1 and Table 2).

Table 1. The effect of brassin-like substance on fresh weight of Arabica coffee fruit.

Treatment	Fresh weight of Arabica coffee fruit (g)									
	Weeks after spraying									
	1	5	9	13	17	21	25	29	33	37
Control	0.0077	0.06	0.91	1.07^{b}	1.22^{b}	1.34^{b}	1.50^{b}	1.59^{c}	2.24^{d}	2.26^{d}
BS 0.1 mgL^{-1}	0.0074	0.07	1.03	1.24^{a}	1.38^{a}	1.45^{a}	1.54^{b}	1.63^{c}	2.26^{d}	2.26^{d}
BS 0.5 mgL^{-1}	0.0076	0.07	1.07	1.27^{a}	1.37^{a}	1.49^{a}	1.57^{b}	2.34^{b}	2.46^{c}	2.46^{c}
BS 1.0 mgL^{-1}	0.0072	0.06	1.09	1.33^{a}	1.47^{a}	1.55^{a}	1.68^{a}	2.42^{b}	2.67^{b}	2.67^{b}
BS 1.5 mgL^{-1}	0.0073	0.07	1.13	1.33^{a}	1.43^{a}	1.53^{a}	1.68^{a}	2.55^{a}	2.81^{a}	2.81^{a}
$LSD_{0.05}$	ns	ns	ns	0.13	0.11	0.11	0.10	0.11	0.12	0.12

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

Table 2. The effect of brassin-like substance on dry weight of Arabica coffee fruit.

Treatment	Dry weight of Arabica coffee fruit (g)									
	Weeks after spraying									
	1	5	9	13	17	21	25	29	33	37
Control	0.003	0.01	0.14	0.15^{c}	0.22^{c}	0.35^{c}	0.47^{c}	0.49^{c}	0.63^{c}	0.64^{d}
BS 0.1 mgL^{-1}	0.003	0.01	0.16	0.18^{b}	0.24^{b}	0.37^{c}	0.49^{bc}	0.50^{c}	0.65^{c}	0.66^{d}
BS 0.5 mgL^{-1}	0.003	0.01	0.15	0.18^{b}	0.24^{b}	0.40^{b}	0.51^{b}	0.75^{b}	0.75^{b}	0.75^{c}
BS 1.0 mgL^{-1}	0.003	0.01	0.16	0.20^{b}	0.29^{a}	0.45^{a}	0.55^{a}	0.77^{b}	0.78^{b}	0.80^{b}
BS 1.5 mgL^{-1}	0.003	0.01	0.15	0.22^{a}	0.28^{a}	0.45^{a}	0.55^{a}	0.82^{a}	0.86^{a}	0.87^{a}
$LSD_{0.05}$	ns	ns	ns	0.01	0.01	0.01	0.02	0.03	0.04	0.0^{4}

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

3) The stage of suspended and slow growth (lag phase): between 10^{th} to 16^{th} weeks after flowering, when the final size of the fruit were attained, but dry weight of fruit and bean were still low. In this stage, spraying coffee trees with BS of 0.5, 1.0 and 1.5 mgL^{-1} could significantly increase fresh and dry weight of fruit (Figure 1).

4) The endosperm filling stage: from approximately the 17^{th} to 25^{th} weeks after flowering. For BS at 0.5, 1.0 and 1.5 mgL^{-1} treatments, the endosperm filling were greater than the control. The dry weight of bean was also heavier than the control (Table 3).

5) The ripe stage: from approximately 26^{th} to 37^{th} weeks after flowering. The fruit and bean weights were increased rapidly in this stage. For BS at 0.5, 1.0 and 1.5 mgL^{-1} treatments, the rapid growths were determined one month before BS at 0.1 and control. BS at 0.5, 1.0 and 1.5 mgL^{-1} accelerated the fruit ripening approximately one month (Table 4).

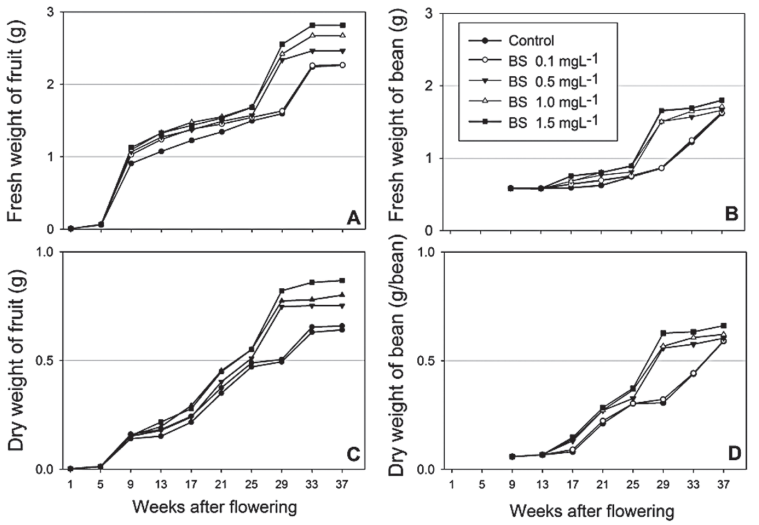

Figure 1. The effect of brassin-like substance on growth of Arabica coffee fruit from 7th days after flowering to fruit maturity; A) Fresh weight of fruit (g/plant) B) Fresh weight of bean (g/fruit) C) Dry weight of fruit (g/tree) D) Dry weight of bean (g/fruit).

Table 3. The effect of brassin-like substance on dry weight of Arabica coffee bean.

Treatment	Dry weight of Arabica coffee bean (g)									
	Weeks after spraying									
	1	5	9	13	17	21	25	29	33	37
Control	N.A.	N.A.	0.06	0.07	0.08^{e}	0.21^{d}	0.30^{d}	0.31^{e}	0.44^{d}	0.59^{d}
BS 0.1 mgL^{-1}	N.A.	N.A.	0.06	0.07	0.09^{d}	0.22^{c}	0.30^{d}	0.32^{d}	0.44^{d}	0.59^{d}
BS 0.5 mgL^{-1}	N.A.	N.A.	0.06	0.07	0.13^{c}	0.27^{b}	0.33^{c}	0.56^{c}	0.58^{c}	0.60^{c}
BS 1.0 mgL^{-1}	N.A.	N.A.	0.06	0.07	0.14^{b}	0.27^{b}	0.37^{b}	0.57^{b}	0.61^{b}	0.62^{b}
BS 1.5 mgL^{-1}	N.A.	N.A.	0.06	0.07	0.15^{a}	0.28^{a}	0.37^{a}	0.63^{a}	0.63^{a}	0.66^{a}
$LSD_{0.05}$	N.A.	N.A.	ns	ns	0.01	0.01	0.01	0.01	0.01	0.01

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

N.A. = not available

Table 4. The effect of brassin-like substance on harvesting time of Arabica coffee.

Treatment	Days to ripening	Percentage of fruit set	Yield (g/tree)
Control	252^{a}	79.79^{a}	2392.50^{a}
BS 0.1 mgL^{-1}	252^{a}	80.24^{a}	2195.50^{a}
BS 0.5 mgL^{-1}	224^{b}	80.54^{a}	1617.25^{b}
BS 1.0 mgL^{-1}	224^{b}	69.88^{b}	1605.75^{b}
BS 1.5 mgL^{-1}	224^{b}	70.33^{b}	1554.75^{b}
$LSD_{0.05}$	0.75	0.79	550.85

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

At the harvest stage, the fresh weight of fruit from 1.5 mgL^{-1} BS treatments were higher than other treatments. Fresh weight and dry weight of bean presented significantly differences between treatments, which the highest fruit size was in 1.5 mgL^{-1} BS treatment (Table 5). However, the percentage of bean dry weight did not affected by BS treatments (Table 6). Concentrate BS application (1.0 and 1.5 mgL^{-1}) also significantly decreased the percentage of fruit set (69.82 and 70.33%) compared to the control, BS at 0. 1 and 0.5 mgL^{-1} (79.79, 80.24, and 80.54%, respectively) (Figure 2). The percentage of grade A bean were higher in BS at 1.0 and 1.5 mgL^{-1} than the lower BS concentrations treatments (Table 7). There were larger proportions of best grade bean from treatment when BS was applied but there were no significant differences in the percentage of grade Y and P between the BS and control treatments. Fruit yields were decreased by BS treatment. Fruit yields in BS at 0.5, 1.0 and 1.5 mgL^{-1} (1,617.25, 1,605.75 and 1,554.75 g respectively) were lower than the control and 0.1 mgL^{-1} BS treatments (2,392.5 and 2,195.5 g/tree respectively) (Table 8).

Table 5. The effect of brassin-like substance on size of Arabica coffee fruit and bean.

Treatment	Size of coffee fruit				Size of coffee bean			
	Width (cm)	Length (cm)	Thickness (cm)	Volume (cm^3)	Width (cm)	Length (cm)	Thickness (cm)	Volume (cm^3)
Control	1.34^b	1.54^c	1.57^c	3.24^d	0.70^d	0.94^c	0.40^b	0.13^c
BS 0.1 mgL^{-1}	1.35^b	1.55^c	1.57^c	3.27^d	0.70^d	0.97^c	0.40^b	0.14^c
BS 0.5 mgL^{-1}	1.37^b	1.64^b	1.58^c	3.54^c	0.73^c	1.03^b	0.43^b	0.16^b
BS 1.0 mgL^{-1}	1.47^a	1.65^b	1.65^b	4.00^b	0.75^b	1.03^b	0.43^b	0.17^b
BS 1.5 mgL^{-1}	1.49^a	1.71^a	1.69^a	4.31^a	0.82^a	1.08^a	0.51^a	0.23^a
$LSD_{0.05}$	0.05	0.04	0.03	0.23	0.01	0.04	0.04	0.02

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

Table 6. The effect of brassin-like substance on dry weight percentage of Arabica coffee bean at harvesting stage.

Treatment	% Dry weight of bean
Control	36.40
BS 0.1 mgL^{-1}	36.30
BS 0.5 mgL^{-1}	36.31
BS 1.0 mgL^{-1}	36.27
BS 1.5 mgL^{-1}	36.72
$LSD_{0.05}$	ns

Table 7. The effect of brassin-like substance on percentage of green coffee bean grades.

Treatment	Percentage of grade green coffee bean (%)			
	A	X	Y	P
Control	62.72^c	24.51^a	9.21	3.56
BS 0.1 mgL^{-1}	62.44^c	23.51^a	10.92	3.13
BS 0.5 mgL^{-1}	66.83^b	19.32^b	9.15	4.70
BS 1.0 mgL^{-1}	73.28^a	14.61^c	7.72	4.40
BS 1.5 mgL^{-1}	73.92^a	13.76^c	7.58	4.74
$LSD_{0.05}$	3.46	3.19	ns	ns

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

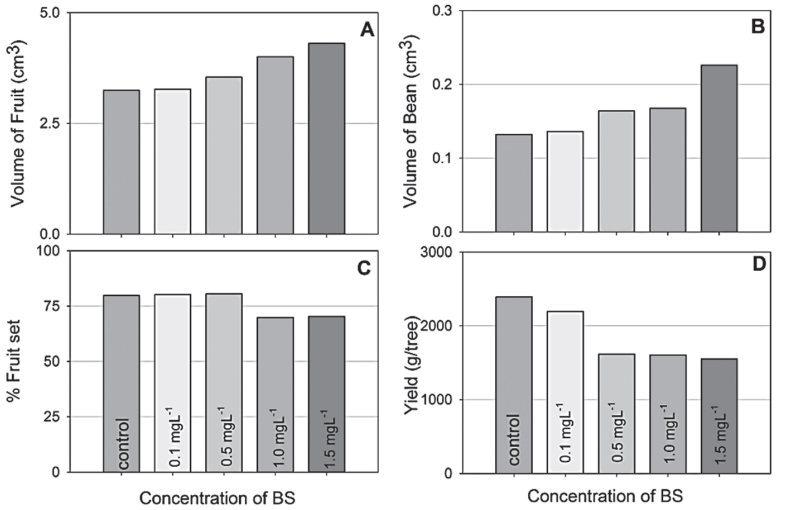

Figure 2. The effect of brassin-like substance on A) Volume of fruit, B) Volume of bean, C) Percentage of fruit set, D) Yield (g/tree) of Arabica coffee.

Table 8. The effect of brassin-like substance on fresh weight of Arabica coffee bean.

Treatment	Fresh weight of Arabica coffee bean (g)									
	Weeks after spraying									
	1	5	9	13	17	21	25	29	33	37
Control	N.A.	N.A.	0.59	0.58	0.59^{d}	0.62^{d}	0.74^{d}	0.86^{c}	1.22^{e}	1.62^{d}
BS 0.1 mgL^{-1}	N.A.	N.A.	0.58	0.58	0.64^{c}	0.69^{c}	0.76^{c}	0.86^{c}	1.25^{d}	1.63^{d}
BS 0.5 mgL^{-1}	N.A.	N.A.	0.58	0.58	0.68^{b}	0.77^{b}	0.81^{b}	1.51^{b}	1.57^{c}	1.66^{c}
BS 1.0 mgL^{-1}	N.A.	N.A.	0.58	0.58	0.68^{b}	0.80^{a}	0.89^{a}	1.50^{b}	1.65^{b}	1.71^{b}
BS 1.5 mgL^{-1}	N.A.	N.A.	0.58	0.58	0.75^{a}	0.80^{a}	0.89^{a}	1.66^{a}	1.69^{a}	1.80^{a}
$LSD_{0.05}$	N.A.	N.A.	ns	ns	0.01	0.01	0.01	0.03	0.02	0.03

Means followed by the same letters in the same column are not significantly different at the $\alpha = 0.05$ by LSD.

N.A. = not available

DISCUSSION AND CONCLUSION

The results revealed that the growth pattern of the fruits was not affected by BS. The fruits still had a typical double-sigmoid curve growth pattern which agreed with a report of Geromel et al. (2006). The stage of fruit development which appropriated to treat with BS should be in the third stage of fruit development, the stage of suspended and slow growth (lag phase) (Barros et al., 1999). BS could significantly increase the fruit and bean fresh and dry weight in this stage. It should be caused by the effect of BS on increasing cell division which led to the increasing of fresh and dry weight. These results agreed with Clouse (2002). BRs involved in numerous processes, cell elongation, cell division, vascular differentiation and reproductive development. The high concentrations of BS (1.0 and 1.5 mgL^{-1}) could induce fruit drop when sprayed during the pinhead stage. Therefore, the fruit yields of these treatments were lower than other treatments. BS could increase fresh and dry weight of coffee bean (gram per bean) but the percentage of dry weight of bean still did not significant from the control (36.27 to 36.72%). This result agreed with Pankasemsuk (2007) who reported that BS could increase fruit size of longan, banana, and mango but BS did not affect the fruit textures and flavors.

BS at 1.0 and 1.5 mgL^{-1} could significantly increase the Arabica coffee fruit and bean sizes. BS at 1.0 and 1.5 mgL^{-1} induce fruit drop when they were sprayed at pinhead stage. For further study, BS at 1.0 and 1.5 mgL^{-1} should be sprayed to the coffee trees at the third stage of coffee fruit development which could avoid the fruit drop.

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