Exogenous Polyazole (PP333) Regulated Flower Physiology to Promote Early Bud Extraction of Pisang Awak (ABB)

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Abstract
In this study, the first and second harvesting Pisang Awak in the field were sprayed with different dosage of paclobutrazol in order to analyze the mechanism of its induction of flowering. The results showed that there was no significant difference in the total number of newly extracted leaves between treatments. The first harvesting was 3.0 g/plant, and the second one was 2.0 g/plant. The pumping speed of leaves is the fastest and the accumulation of leaves number is the earliest. The 3.0 g/plant treatment of first harvesting Pisang Awak had the earliest bud extraction stage, and the bud extraction rate reached 62.5% at 170 days after treatment, about 40 days earlier than control group. Within the range of 1.0~5.0 g/plant, PP333 promoted carbohydrate synthesis in leaves of Pisang Awak, significantly reduced the accumulation of nitrogen, significantly increased the carbon-nitrogen ratio (C/N), and significantly reduced the contents of GA3 and IAA in the leaves. The results showed that the exogenous polyazole could accelerate the pumping speed of leaves, promote flowering and early bud extraction by regulating the distribution of carbon and nitrogen nutrients and the content of endogenous hormones, thus providing technical guidance for the management of early bud extraction culture of Pisang Awak.

Keywords
Paclobutrazol; Flowering; Endogenous hormone; Carbon and nitrogen nutrient; Pisang Awak

Pisang Awak (Musa spp. ABB, Pisag Awak subgroup) is an important type of banana cultivation species (Wang et al., 2019), also known as Saigon banana, Annan banana, and Milk banana in Chinese, etc., which is one of the characteristic fruits of Lingnan. It is widely loved by consumers due to its unique flavor. Land sales price is 50%~200% higher than ordinary banana. Pisang Awak has stronger cold resistance, drought resistance, disease resistance (virus disease and foliar disease) and infertility tolerance than ordinary banana (AAA). Therefore, it is suitable for planting in a wider area than ordinary banana. It is planted in Guangdong, Guangxi, Hainan, Yunnan, Guizhou and Laos, Vietnam, Cambodia and other ASEAN countries. Pisang Awak has a long growth period and tall pseudostem, which are the common characteristics of existing Pisang Awak. In Guangxi producing areas, the growth period of Pisang Awak is generally 4~6 months longer than that of ordinary banana, and the plant reaches 4.5~5 m (Zou et al., 2009), which leads to many problems in production, such as long field management period, high-cost input, and high risk of natural disasters such as typhoons, which has been a major challenge for the Pisang Awak industry for many years. Short growth period is one of the key objectives of crop breeding and cultivation research (Deng et al., 2019). Whether an effective method can be adopted to shorten the field growth period and reduce the height of Pisang Awak is of great significance to the safe production of Pisang Awak, the reduction of production cost and the improvement of planting benefits. Coordinating the relationship between vegetative growth and reproductive growth of Pisang Awak has been a hot topic for many years. At present, the production practice of using physical methods of cut stem to shorten the growth duration, decrease plant height (Yu et al., 2015), the method played a role in the production, but there is large amount of labor, high technical requirements, the production cost is higher, affect the shortcomings, such as production, with high yield, stable yield, high quality cultivation goal. Paclobutrazol is a kind of high efficiency, low toxicity, plant growth retardant main precursor by inhibiting the synthesis of gibberellin (sterols) in plant (Huang, 1988), which control the level of hormone level, minerals and nutrients absorption, accumulation, and distribution, as well as enzyme activity.
and other ways to affect plant morphological structure and a series of physiological and biochemical changes. It is often used to control the vegetative growth of woody fruit trees such as apple (Cao et al., 2001), litchi (Tang et al., 2006), longan (Xu et al., 2013) and mango (Xue et al., 2004), promote flower formation and improve fruit setting rate, which can partially replace pruning. However, the studies on the application of PP333 on Pisang Awak mainly focus on the application methods and techniques of regulating plant height, yield and quality, but there is little research on the mechanism of promoting the early bud extraction of Pisang Awak. Based on this, in this study, the first and second harvesting Pisang Awak were used as experimental material, 6 different individual plants were sprayed with PP333 when the plant height was about 1.5 m through the field experiment combined with indoor determination. Analyzed the different dosage of PP333 on leaf growth and budding of Pisang Awak, and the changes of carbon and nitrogen compounds and Endogenous hormones in leaves of Pisang Awak. And explored the promoting mechanism of PP333 on Pisang Awak flowering, to regulate the reproductive development process of Pisang Awak, and to provide technical guidance for the management of early bud extraction and cultivation of Pisang Awak.

1 Results and Analysis

1.1 PP333 significantly increased the extraction rate of Pisang Awak leaves

There was no significant difference in the total number of newly extracted leaves among different treatments after PP333 treatment with different dosage per plant (1.0 g, 1.5 g, 2.0 g, 3.0 g, 4.0 g and 5.0 g). The time required for the total number of leaves was significantly shortened, and the speed of leaf extraction (the time required for each new leaf) was accelerated (Table 1). In the first harvesting Pisang Awak experiment, from PP333 treatment to bud extraction, the total number of newly extracted leaves ranged from 28.8 to 30.1, and there was no significant difference between treatments. However, the time required for the extraction of these leaves was different, the least needed only 147.5 d (3.0 g/ plant), and the time required for each new leaf was 5.1 d, which was significantly lower than that of the control. However, CK1 needed 192.2 d to extract these leaves, which was the longest and significantly different from other treatments. The time required for each new leaf was 6.4 d, which was significantly higher than that of each PP333 treatment.

| Treatment (g/plant) | First harvesting | Second harvesting |
|---------------------|------------------|-------------------|
|                     | Number of blades | Duration time (d) | Leaves speed | Number of blades | Duration time (d) | Leaves speed |
| 1.0                 | 30.1±1.3 a       | 170.8±2.0 b       | 5.7±0.2 b    | 28.5±0.7 a       | 178.2±2.4 b       | 5.9±0.1 b    |
| 1.5                 | 29.8±1.1 a       | 157.6±2.0 c       | 5.3±0.1 b    | 29.7±0.5 a       | 178.4±2.0 b       | 5.8±0.1 b    |
| 2.0                 | 28.8±0.3 a       | 157.4±1.9 c       | 5.5±0.2 b    | 30.3±1.1 a       | 152.3±2.0 c       | 5.0±0.1 b    |
| 3.0                 | 29.1±1.0 a       | 147.5±2.1 d       | 5.1±0.1 b    | 30.8±1.0 a       | 177.9±2.2 b       | 5.4±0.2 b    |
| 4.0                 | 29.7±0.5 a       | 169.7±2.1 b       | 5.7±0.1 b    | 30.6±0.8a        | 157.9±2.5 c       | 5.3±0.2 b    |
| 5.0                 | 29.9±0.2 a       | 158.1±2.4 c       | 5.3±0.1 b    | 30.2±0.7 a       | 155.5±2.1 c       | 5.1±0.1 b    |
| CK (1, 2)           | 30.0±1.3 a       | 192.2±2.7 a       | 6.4±0.1 b    | 31.1±1.3 a       | 193.7±3.0 a       | 6.2±0.1 a    |

Note: Different small letters in the same column represent significant difference at 0.05 level (p<0.05)

In the second harvesting Pisang Awak (plantana with buds) experiment, from PP333 treatment to bud extraction, the total number of newly extracted leaves ranged from 28.5 to 30.8, with no significant difference between treatments. The time required for leaf extraction was 152.3–193.7 d, and there were differences among treatments. The fastest leaf extraction rate was 2.0 g/ plant, which required 152.3 d, and the time required for each new leaf was 5.0 d, which was significantly lower than that of the control. However, CK2 needed the longest time to extract these leaves (193.7 d), and the time needed for each new leaf was 6.2 d, which was significantly higher than PP333 treatments. The results of the first Pisang Awak test and the second Pisang Awak test were generally consistent. Smoke is the total number of leaf blade banana from vegetative growth to reproductive growth of material basis, different dosage of PP333 processing and CK1 and CK2 there was no significant difference between the total leaf number, but the dwarf Pisang Awak leaf treated by PP333 smoke born faster than CK1 and CK2 significantly speed up, take the shorter the time needed for the leaf blade processing, its leaf speed is faster. In this
way, the rated number of leaves can be reached earlier to achieve bud extraction in advance. Among the PP\textsubscript{333} treatments, the first Pisang Awak 3.0 g/plant and the second Pisang Awak 2.0 g/plant had the fastest leaf pumping speed and the earliest accumulation of leaf number, and the bud pumping period was significantly earlier than that of other treatments.

1.2 PP\textsubscript{333} promotes early bud extraction of Pisang Awak

Compared with the control (CK1, CK2), PP\textsubscript{333} treatments with different dosage per plant significantly advanced the bud extraction stage (the bud extraction rate was greater than 50%) (Table 2). When PP\textsubscript{333} was used to treat the first harvesting Pisang Awak, there were differences in the bud extraction stage among different treatments, and the sequence of bud extraction stage was as follows: 3.0 g/plant, 2.0 g/plant, 1.5 g/plant, 5.0 g/plant, 4.0 g/plant, 1.0 g/plant, CK1, 3.0 g/plant had the earliest bud extraction stage, and the bud extraction rate of 170 days after treatment was more than 50%, up to 62.5%, which was significantly different from other treatments. The second treatments were PP\textsubscript{333} 2.0 g/plant, 1.5 g/plant and 5.0 g/plant, and the buds extraction rate was also over 50% 180 days after treatment, reaching 61.4%, 60.4% and 58.7%, respectively. At this time, no buds were found in CK1, and the buds extraction rate was 0, which was significantly lower than those in PP\textsubscript{333}. In CK1, the bud extraction rate exceeded 50% (62.5%) at 210 d after treatment, which was about 40 d later than that of the 3.0 g/plant treatment with the earliest bud extraction. By this time, the bud extraction rate of PP\textsubscript{333} treatment group had been completed and reached 100%. When PP\textsubscript{333} was used to treat the second harvesting Pisang Awak, there were differences in the bud extraction stages among different treatments, and the order of bud extraction was as follows: The bud extraction stage of 2.0 g/plant, 5.0 g/plant, 4.0 g/plant, 3.0 g/plant, 1.0 g/plant, CK2, 2.0 g/plant and 5.0 g/plant was the earliest, and the bud extraction rate of 190 days after treatment was more than 50%, 59.1% and 57.6%, respectively. Compared with other treatments, the bud extraction rate of CK2 was 23.5%, which was significantly lower than that of PP\textsubscript{333} treatments. The bud extraction rate of CK2 was more than 50% (75.5%) at 210 d after treatment, which was about 20 d later than that of 2.0 g/plant and 5.0 g/plant at the earliest stage of bud extraction. The above results indicated that PP\textsubscript{333} treatment could promote early Pisang Awak bud extraction to different degrees, and the bud extraction stage was the earliest under the treatment of 3.0 g/plant of the first harvesting Pisang Awak, and the bud extraction stage was the earliest under the treatment of 2.0 g/plant and 5.0 g/plant of the second harvesting Pisang Awak.

Table 2 Effects of different dosages of PP\textsubscript{333} on bud extraction rate (%) of Pisang Awak

| Harvesting time | Treatment (g/plant) | October 11 | October 21 | November 1 | November 11 | November 21 | December 1 |
|-----------------|---------------------|------------|------------|------------|-------------|-------------|------------|
| First harvesting | 1.0                 | 33.3±2.0 b | 44.4±2.9 c | 66.7±1.9 c | 92.0±3.5 b  | 100.0±0.0 a | 100.0±0.0 a |
|                 | 1.5                 | 0.0±0.0 d  | 60.4±3.5 b | 90.0±3.3 b | 100.0±0.0 a | 100.0±0.0 a | 100.0±0.0 a |
|                 | 2.0                 | 37.5±1.3 b | 61.4±2.3 b | 100.0±0.0 a| 100.0±0.0 a | 100.0±0.0 a | 100.0±0.0 a |
|                 | 3.0                 | 62.5±3.1 a | 87.5±4.0 a | 100.0±0.0 a| 100.0±0.0 a | 100.0±0.0 a | 100.0±0.0 a |
|                 | 4.0                 | 12.5±1.9 c | 47.5±3.5 c | 87.5±2.5 b | 95.7±1.6 a  | 100.0±0.0 a | 100.0±0.0 a |
|                 | 5.0                 | 0.0±0.0 d  | 58.7±3.7 b | 75.0±1.2 c | 88.2±2.0 b  | 100.0±0.0 a | 100.0±0.0 a |
|                 | 0.0                 | 0.0±0.0 d  | 0.0±0.0 d  | 22.2±3.0 d | 40.1±3.5 c  | 62.5±3.7 b  | 100.0±0.0 a |
| Second harvesting| 1.0                 | 5.0±2.0 b  | 21.5±5.5 b | 35.1±4.4 b | 50.8±3.1 b  | 85.7±3.3 b  | 100.0±0.0 a |
|                 | 1.5                 | 5.0±2.3 b  | 28.7±2.3 b | 40.5±3.1 b | 55.0±2.0 b  | 90.0±3.0 a  | 100.0±0.0 a |
|                 | 2.0                 | 20.0±2.1 a | 46.8±2.3 a | 59.1±2.3 a | 80.9±2.4 a  | 100.0±0.0 a | 100.0±0.0 a |
|                 | 3.0                 | 6.7±2.7 b  | 30.0±2.0 b | 45.6±2.7 b | 62.1±3.5 b  | 88.6±3.5 b  | 100.0±0.0 a |
|                 | 4.0                 | 7.9±2.2 b  | 33.0±2.7 b | 45.9±3.2 b | 62.4±1.7 b  | 95.0±2.2 a  | 100.0±0.0 a |
|                 | 5.0                 | 17.0±3.0 a | 46.7±1.7 a | 57.6±3.2 a | 86.7±2.0 a  | 100.0±0.0 a | 100.0±0.0 a |
|                 | 0.0                 | 3.3±4.3 b  | 3.3±3.5 c  | 23.5±1.5 c | 47.6±1.5 b  | 75.5±4.1 b  | 100.0±0.0 a |

Note: Different small letters in the same column represent significant difference at 0.05 level (p<0.05)

1.3 PP\textsubscript{333} regulates the physiological indexes of Pisang Awak flowering

PP\textsubscript{333} treatment significantly promoted carbohydrate synthesis in Pisang Awak leaves, significantly reduced nitrogen accumulation, and significantly increased C/N ratio (Table 3). The soluble sugar content of Pisang Awak leaves treated with PP\textsubscript{333} for 30 days was significantly higher than that of control (CK1), and there was no
significant difference in the soluble sugar content among treatments. The soluble sugar content of 3.0 g/plant treatment was the highest, reaching 176.2 mg/g, which was 18.3% higher than that of control. The starch content was slightly higher than that of the control, and the difference was not significant. The accumulation of carbohydrates increases, which is the energy guarantee for flower and fruit setting. The total nitrogen content of PP333 treatment was significantly lower than that of CK1, which was 27.7%–42.4% lower than that of CK1, and the total nitrogen content of 2.0 g/plant treatment was the lowest. The total carbon content of 3.0 g/plant, 1.5 g/plant, 5.0 g/plant and 4.0 g/plant were significantly higher than that of other treatments, followed by 2.0 g/plant and 1.0 g/plant. The total carbon content of CK1 was the lowest, significantly lower than that of PP333 treatments. The C/N of all treatments was significantly higher than that of CK1, and the C/N of 2.0 g/plant treatment was the highest, which was 100% higher than that of CK. After PP333 treatment, Pisang Awak leaves could increase the accumulation of carbohydrate and reduce the absorption of nitrogen. The accumulation of carbohydrate was superior to that of nitrogen compounds in quantity, which was the nutritional basis of Pisang Awak bud extraction earlier. After PP333 treatment, the contents of endogenous hormones in Pisang Awak leaves were significantly different from those in the control group, and the contents of endogenous hormones ABA and ZR were increased, while the contents of GA3 and IAA were significantly decreased (Table 4). The GA3 content of PP333 treatment was significantly lower than that of CK1 and decreased to 27.5–59.2 μg/g, which was 15.7%–60.8% lower than that of CK1. GA3 content of 3.0 g/plant treatment was the lowest, followed by 2.0 g/plant treatment, which was significantly lower than that of other treatments. The content of IAA was significantly lower than that of CK1, which was 9.8–11.8 μg/g, and 24.8%–37.6% lower than that of CK1. There was no significant difference in the content of IAA among PP333 treatments. Compared with the control, the contents of ABA and ZR in leaves of PP333 treatment were slightly increased, but there was no significant difference between treatments. GA3 and IAA played a negative role in the differentiation of flower buds. PP333 treatment significantly reduced the contents of GA3 and IAA in Pisang Awak leaves, which promoted the differentiation of flower buds and accelerated bud germination. This may be one of the physiological bases that PP333 treatment can promote premature Pisang Awak bud extraction to varying degrees.

Table 3 Effects of different dosages of PP333 on carbon and nitrogen nutrients of Pisang Awak

| Treatment (g/plant) | Soluble sugar (mg/g) | Starch (mg/g) | Total nitrogen (mg/g) | Total carbon (mg/g) | C/N |
|---------------------|----------------------|---------------|-----------------------|---------------------|-----|
| 1.0                 | 160.9±1.2 a          | 4.7±0.1 a     | 24.6±2.0 b            | 171.2±1.5 b         | 7.0±0.2 a |
| 1.5                 | 160.1±2.3 a          | 4.7±0.1 a     | 26.1±1.7 b            | 190.6±2.4 a         | 7.3±0.2 a |
| 2.0                 | 161.7±2.0 a          | 4.8±0.2 a     | 23.1±1.3 b            | 177.7±1.9 b         | 7.7±0.1 a |
| 3.0                 | 176.2±2.5 a          | 4.9±0.5 a     | 25.1±0.9 b            | 190.7±1.7 a         | 7.6±0.2 a |
| 4.0                 | 170.0±2.7 a          | 5.2±0.2 a     | 29.0±1.5 b            | 185.6±2.1 a         | 6.4±0.3 a |
| 5.0                 | 165.5±2.1 a          | 5.0±0.2 a     | 28.7±2.0 b            | 190.2±3.2 a         | 6.7±0.3 a |
| CK1                 | 149.0±3.0 b          | 4.2±0.2 a     | 40.1±2.1 a            | 153.2±3.5 c         | 3.8±0.5 b |

Note: Different small letters in the same column represent significant difference at 0.05 level (p<0.05)

Table 4 Effects of different dosages of PP333 on content of endogenous hormones of Pisang Awak

| Treatment (g/plant) | GA3 (μg/g) | IAA (μg/g) | ABA (μg/g) | ZR (μg/g) |
|---------------------|------------|------------|------------|-----------|
| 1.0                 | 59.2±1.9 b | 11.8±0.2 b | 29.8±1.0 a | 13.3±0.1 a |
| 1.5                 | 37.6±0.4 b | 10.1±0.2 b | 26.2±1.3 a | 14.7±0.2 a |
| 2.0                 | 28.3±1.3 c | 9.8±0.2 b  | 31.1±1.2 a | 15.6±0.1 a |
| 3.0                 | 27.5±1.5 c | 11.7±0.2 b | 27.2±1.2 a | 13.9±0.2 a |
| 4.0                 | 35.6±0.9 b | 11.3±0.2 b | 23.8±1.4 a | 11.9±0.2 a |
| 5.0                 | 47.4±1.0 b | 11.1±0.2 b | 22.2±1.5 a | 13.4±0.1 a |
| CK1                 | 70.2±2.1 a | 15.7±0.2 a | 20.4±0.1 a | 11.4±0.2 a |

Note: Different small letters in the same column represent significant difference at 0.05 level (p<0.05)
2 Discussion

Long growth period and tall pseudostem are the common characteristics of existing Pisang Awak varieties. Many problems are likely to occur in production, such as long field management period, high-cost input and high risk of natural disasters such as typhoons, which have been a major challenge faced by Pisang Awak industry for many years. PP$_{333}$ is a widely effective plant growth regulator, which can coordinate the vegetative and reproductive growth of fruit trees and make the plants dwarf, which is conducive to flower formation and fruit setting (Liu et al., 2013). Zhou et al. (2016) showed that the application of paclobutrazol treatment in the fast vegetative growth stage of Korla fragrant pear could effectively inhibit the longitudinal growth of the new stem and promote the transverse growth. Yuan et al. (2020) Foliar spraying PP$_{333}$ can effectively promote the number of megaspore lobes of Taxus chinensis. Wang et al. (2019) found in the experiment of using PP$_{333}$ in peach-smoked strawberry that PP$_{333}$ can make strawberry plant shorter, stolon, increase the number of stolons, and thicken and increase the number of seedling roots. In this study, when Paclobutrazol was applied within a certain dosage range, there was no significant difference in the total number of newly extracted leaves, but only in the extraction speed of leaves, which was consistent with the research results of Sun et al. (2016). Paclobutrazol had no significant effect on the number of leaves and crown width of snapdragons and could effectively inhibit the plant height and internode of snapdragons. With the treatment of 3.0 g/plant in the first Pisang Awak and 2.0 g/plant in the second Pisang Awak, the leaf extraction speed was the fastest, the accumulation of the number of vegetative growth leaves was completed at the earliest, and the bud extraction period was the earliest. It can be used for reference in production to promote the growth of leaves and achieve bud extraction in advance by reaching the rated number of leaves earlier. In practical application, the suitable mass concentration and spraying times should be selected according to the production purpose and local conditions.

Spraying PP$_{333}$ can significantly regulate the relative contents of endogenous hormones IAA, GA, ZR and ABA (Zhou, 2012). Chen et al. (2012) applied PP$_{333}$ treatment in the early stage of flower bud differentiation of Lignosalis officinalis, which significantly reduced the contents of endogenous hormones IAA and GA3, increased the contents of ABA and ZT, and advanced flowering. High ABA/IAA, ABA/GA, ZR/IAA and ZR/GA ratios promoted the flowering of Mohan fruit (Qin et al., 2010). Wu et al. (2011) treated Western Rhododendron with PP$_{333}$, which significantly reduced the contents of GA3 and IAA in the plant, as well as the contents of ZT, increased ABA content and delayed the flowering date. Exogenous PP$_{333}$ treatment has different effects on the changes of endogenous hormones and the response of plants to flowering in different plant species. Flowering of Planana is closely related to the levels of endogenous hormones. PP$_{333}$ can affect flower bud differentiation by changing the contents of endogenous hormones GA, IAA, ABA and ZR in vivo. In this study, PP$_{333}$ treatment increased the contents of endogenous hormones ABA and ZR, which promote flower bud inoculation, in the leaves of Planana. The contents of GA3 and IAA, which had negative effects on flower bud differentiation in Pisang Awak leaves, were significantly reduced, thus promoting flower bud differentiation and gestation in Pisang Awak leaves, and buds were picked earlier.

Carbohydrates and nitrogenous compounds provide the energy needed for plant growth and metabolism of flower bud differentiation. Liu et al. (2016) concluded that PP$_{333}$ could significantly increase the soluble sugar content of Amorpha pseudoacacia in the study on the regulating effect of PP$_{333}$ on the growth of Amorpha pseudoacacia. Zou et al. (2015) conducted a study on the effects of PP$_{333}$ at different concentrations on the growth and development of tobacco seedlings. The results also showed that PP$_{333}$ could significantly increase the soluble sugar content of tobacco seedlings. PP$_{333}$ treatment resulted in a large amount of soluble sugar accumulation in the seedling, and a significant increase in starch content in leaves and roots (Yang et al., 2018). Paclobutrazol spraying can promote the transformation of sweet potato carbohydrates to root tubers, improve the accumulation rate of starch and significantly increase the yield of starch (Chen et al., 2012). In this study, after PP$_{333}$ treatment, soluble sugar content and starch content in Pisang Awak leaves were significantly higher than those in the control group, and the accumulation of soluble sugar and starch content was conducive to flower bud differentiation, which was consistent with previous studies. According to the C/N theory, flowering can be promoted in an internal environment where carbohydrate accumulation is more abundant than nitrogen compounds, and PP$_{333}$ treatment
can maintain the C/N balance of bamboo seedlings (Yang et al., 2018). Pang et al. (2018) showed that high C/N ratio could promote flower bud differentiation of waxberry and peach tree, which was consistent with the results of this experiment. PP333 treatment significantly promoted carbohydrate synthesis, significantly reduced nitrogen accumulation, and significantly increased C/N ratio in Pisang Awak leaves.

3 Materials and Methods
3.1 Experimental materials
The experiment was carried out in the test base of Nanning Comprehensive Test Station of National Banana Industry Technology System. The first harvesting Pisang Awak is in Ganwei Town, Wuming District, Nanning City, Guangxi. And the second harvesting Pisang Awak is in Taiping Town, Wuming District. A healthy and consistent Pisang Awak variety "Jinfen1" (first and second harvesting) was selected as the experimental material, which is the leading variety of banana during the 12th five-year Plan in China. PP333 was used as the suspension agent with 25% active component content (produced by Jiangsu Sevencontinent Green Chemical Co., Ltd.).

3.2 Experiment design
In this experiment, PP333 was sprayed on the whole plant as treatment, and the dosage per plant (active ingredient) was set at gradients of 1.0 g, 1.5 g, 2.0 g, 3.0 g, 4.0g and 5.0 g, and water was sprayed as control (CK). Completely random block design, labeled, each treatment of 30 plants, repeated 3 times. On April 20, 2016, when the tested plants grew to about 1.5 m, the whole plant was sprayed, and other field management was routine.

3.3 Method of sampling
After PP333 treatment for 30 d, 2 leaf samples of the first Pisang Awak plant were taken. Some of the samples were frozen with liquid nitrogen and brought back to the laboratory and stored in a refrigerator at -80°C for the determination of endogenous hormone (ABA, GA3, IAA, ZR) content in plant leaves. The other part was washed with clean water, processed in the oven at 105°C for 20 min, then dried at 80°C, crushed and screened, and put into a sealed bag for the determination of carbon and nitrogen compounds.

3.4 Assay method
The soluble total sugar content was determined by anthrone colorimetric method of Liu et al. (2013). Starch content was determined by spectrophotometry (Li et al., 2016). Total carbon content was determined by heavy K2Cr2O7-H2SO4 oxidation method, and total nitrogen content was determined by H2SO4-HClO4 deboiling method (Huang et al., 2017). The contents of ABA, GA3, IAA and ZR were determined by gradient elution HPLC.

3.5 Data statistics and analysis
The total number of newly extracted leaves and the time (days) required for leaf extraction after PP333 treatment until plant bud extraction were counted, leaf extraction speed=time/total number of leaves. The bud extraction rate was counted once every 10, and 6 times successively. C/N=total carbon/total nitrogen.

Authors’ contributions
ZM is the person who designed and executed the experimental study of this study. LF and HHW completed the data analysis and the writing of the first draft of the paper. WP and MTL participated in the test design and analysis of test results; ZY was the architect and the person in charge of the project, guiding the experimental design, data analysis, paper writing and revision. All authors read and approved the final manuscript.

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