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Research Article

Effect of Paclobutrazol Application Field on Seed Rhizome Quality of Ginger during Storability

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Abstract

Background and Objective: Maintaining the availability of high quality of seed on-time is one of the major problems in the production of large white ginger seed rhizomes (LWG). LWG seeds cannot be stored for a long period of time because it is easily wrinkled and sprouted during the storage. This study aimed to understand the effect of PBZ treatment time and concentration on the quality of LWG seeds during storage. **Materials and Methods:** This study used a randomized square experimental design with three replications. The main plot is the time of application of paclobutrazol: 1) 4 months after planting (MAP) and 2) 5 MAP, and as subplots are five levels of PBZ concentration : 0, 100, 200, 300 and 4 00 ppm. **Results:** The results showed the treatment of PBZ 400 ppm at 4 and 5 MAP was the best concentration in increasing the shelf life of LWG seeds: growth speed (4.8% / etmal), seedling height (60.38 cm) and dry weight of seedlings (1.51 g) after stored for 4 months compared with no PBZ treatment.

Keywords: Zingiber officinale, seed viability, shoot dormancy, weight loss, and water content

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Introduction

The demand for large white ginger seeds (LWG) increases with the development of the herbal medicine industry and diversification of ginger-based food products and functional drinks. The request spread to outside Java such as Sumatra and Kalimantan. The demand for LWG seed rhizomes comes from seed halls, breeder farmers, and private seed entrepreneurs.

The main problem in the production of the LWG seed rhizome is the difficulty of maintaining sufficient availability of quality seeds on-time. These problems are caused, among other things, by the nature of the seeds that are easily wrinkled, and sprout when stored for the long period. The nature of the ginger rhizome which is easily wrinkled is a big disadvantage as it can reduce the weight of the seed rhizome 30% for 3 months (Sukarman et al ., 2008). LWG seed rhizomes are easy to germinate (3-4 cm) in 4 months of storage in non-optimal condition (Sukarman et al ., 2007), causing difficulty in packaging and shipping for long-distance.

Improving the quality and shelf life of LWG seed rhizomes can be done with the application of Growth Regulating Substances (GRS) during seed production in the field. One GRS that can be used to improve the quality and power of seed rhizomes is through the retardant application. Retardant compounds that are widely used to improve the quality of seed rhizomes are paclobutrazol (PBZ). PBZ is a type of retardant from the class of triazoles compounds that play a role in inhibiting gibberellin biosynthesis so that vegetative growth of plants is inhibited. Gibberellins play a role in promoting division, cell elongation and stem lengthening (Arteca, 1996; Davies, 2004; Chaney, 2005). Inhibition of gibberellin biosynthesis by PBZ by blocking three steps of terpenoids in producing gibberellins, which is by inhibiting oxidation of entkaurene, entkaurenol, and entkaurenal become acidic entkaurenat (Chaney, 2005). The decrease in gibberellin content by PBZ can increase production of abscisic acid (ABA) because gibberellin biosynthesis and ABA are present in one terpenoid pathway with the same precursor, namely isopentenyl Phosphophosphate. High endogenous ABA content can trigger dormancy. According to Suttle and Hultstrand (1994), ABA plays a role in inducing and maintaining dormancy in mini potato tubers. Suttle (2004) reports that there are three groups of hormones that play a role in the regulation of dormancy in potato tubers, namely abscisic acid, cytokine, and ethylene. ABA and ethylene play a role in inducing dormancy, but to maintain the dormancy period only ABA is needed. Furthermore, Hamadina (2011) reported that high endogenous ABA content caused Yam tubers to experience shoot dormancy.

This dormancy period is needed so that LWG does not sprout during storage. Horvath et al. (2003) reported that shoot dormancy is stalled or delayed growth that appears from organs containing meristems. This dormancy phenomenon is a very complex process that is needed for the survival of plants from non-optimal environmental conditions. The dormancy period is also very much needed to solve problems in agriculture including the storage and distribution of vegetative organs in the form of tubers such as potatoes, cassava, and onions.

PBZ application has been proven to increase the production of ginger plants in the field. This increase in production is obtained by pressing plant height, increasing the number of tillers, leaves, chlorophyll and starch content (Rusmin et al ., 2018). PBZ application on seed rhizomes before storage has not been able to increase the intersection of the seeds of the LWG rhizome (Melati et al ., 2005 and Rusmin et al ., 2015a). PBZ applications when producing in the field are expected to increase the shelf life of ginger seed rhizomes. The study aims to determine the effect of application time and PBZ concentration in the field on the quality of the LWG seed rhizomes during storage.

Materials and Methods

The experiment was arranged with a divided plot design with three replications. The main plot is the PBZ application time, namely: 1) age 4 months after planting (MAP) and 2) age 5 MAP, and as subplots are five levels of PBZ concentration, namely : 0, 100, 200, 300 and 4 00 ppm. The combination of treatments tested were 10 treatments with three replications so that 30 experimental units were obtained. The s each experimental unit consists of 12 plants. Determination of application time and PBZ concentration based on the experimental results of Melati (2010).

Seed Preparation

The rhizome of the seeds used with the criteria is high, weighing 30–40 g with 2–3 shoots and free from pests and diseases. Seed rhizomes were soaked in fungicide and bactericidal solution (2 gl -1) before nursery. Nurseries are carried out in plastic tubs with cocopit for about 1 month to get healthy seeds and grow uniformly.

Planting

The experiment was carried out by planting LWG seed rhizomes in the field with a spacing of 50 cm x 40 cm, three replications according to the treatment. Experimental plot measuring 150 cm x 170 cm. Fertilization is carried out according to recommendations, namely 500 kg ha -1 urea (12.5 g per plant), 400 kg ha -1 SP36 (10 g per plant) and 400 kg ha -1 KCl (10 g per plant). SP36 and KCl fertilizers were given at planting time, while Urea fertilizer was given 3 times at 1, 2 and 3 months after planting, each 1/3 dose at each administration. Cow manure is ripe given 2-4 weeks before planting 1 kg per plant (20 tons ha -1). At the age of 4 months after planting the second manure is given as much as 1 kg per plant.

Application of Paclobutrazol

PBZ application starts to be carried out according to the treatment, namely (4 MAP and 5 MAP). PBZ application is given every 2 weeks (each of the five applications) for each treatment tested. PBZ application is carried out in the morning by pouring into the rhizome, with a volume of 500 ml per plant with concentration according to treatment.

Observation

Observation of storage was carried out on shrinkage of weight, moisture content, the percentage of sprouted rhizomes, length of shoots, which were observed every month until 4 months of storage. Growing power observations are carried out at the beginning and end of storage (0 and 4 months of storage).

The data obtained were analyzed for diversity with diversity analysis (ANOVA). If it is significantly different, proceed with the Duncan test (Duncan Multiple Range Test / DMRT) at the level of 5%.

Results

In Table 1 it can be seen that the depreciation of the weight of the LWG seed rhizomes during storage (1, 2, 3, and 4 months after storing (MAS) and total weight depreciation) was not affected by the application time and PBZ concentration applied.

The total depreciation of rhizome weights to 4 MAS ranges from 17.5 - 19.4%. This is far lower than Sukarman et al. (2008) and Rusmin et al. (2015b), which states that the depreciation of the LWG rhizome weight reaches 30% after 3-4 months is saved. PBZ application, both the time of administration and concentration does not affect the shrinkage of seed rhizome weight, due to the high starch content of LWG seeds (50%) at harvest time or the beginning of storage. so the seed rhizomes are dense and not easily shrunk.

Table 1. Effect of each application time and PBZ concentration on shrinking the weight of the LWG seed rhizome

Treatment	Weight Shrinkage (%)				
	1 BSS	2 BSS	3 BSS	4 BSS	Total
Application Time (MAP)					
4	10.4	2.9	2.4	2.4	18.2
5	10.9	2.9	2.3	2.5	18.6
Concentration PBZ (ppm):					
0	10.9	3.2 a	2.5 a	2.7	19.4 a
100	10.3	3.0 ab	2.4 ab	2.4	18.1 ab
200	10.4	2.6 b	2.2 b	2.3	17.5 b
300	10.7	3.0 ab	2.3 b	2.4	18.4 ab
400	10.5	3.1 a	2.3 ab	2.5	18.6 a

The numbers followed by the same letters in the same column in each treatment were not significantly different from the DMRT test level of 5%

The initial water content and water content in 4 MAS are not affected by the PBZ application time. The PBZ concentration applied only affects the moisture content at the time of 4 MAS. Water content at 4 MAS began to decrease at a PBZ concentration of 400 ppm (Table 2). The lowest water content in PBZ concentrations of 400 ppm after 4 months was stored, caused by an increase in the number of shoots more than other treatments. The growth of shoots requires energy taken from the reshuffle of starch in the storage organ. This physiological process will then increase the transpiration rate so that the rhizome water content decreases.

The percentage of rhizomes sprouting and the number of shoots at 4 MAS during storage are also not affected by the PBZ application time. The PBZ concentration applied only affects the number of shoots at the time of 4 MAS. The number of shoots increased in PBZ 400 ppm compared to without PBZ (Table 2). The high number of shoots in the 400 ppm application is thought to be due to starch content due to PBZ application to plants. The content of starch is used as a food reserve for initiating germination and growth of shoots during storage. This result is in accordance with

Rusmin's research results et al. (2015c) that the application of 400 ppm PBZ in LWG plants aged 4 and 5 MAP can increase starch content and LWG seed production. Application of 250 ppm PBZ on turmeric is applied PBZ at the age of 4 months produce a high dry weight of the rhizomes and starch content (Rosita et al . 1993a). Next is Rosita et al. (1993b), reported that the application of 250 ppm PBZ in Kencur plants at the age of 6 MAP could increase rhizome starch levels. PBZ application in increasing seed rhizome starch content is thought to be due to increased chlorophyll content and number of leaves, resulting in an increase in photosynthesis.

Table 2. Effect of each application time and PBZ concentration on shrinking the weight of the LWG seed rhizome

Treatment	Water content First day (%)	Water content 4 BSS (%)	Rhizome sprout 4 BSS (%)	Total of Sprout 4 BSS (Sprout)
Application time (MAP)				
4	84.2	83.1	64.7	2.4
5	83.8	82.5	68.0	2.3
Concentration PBZ (ppm):				
0	83.5	83.9 ab	55.0	2.0 b
100	84.0	81.9 bc	56.7	2.0 b
200	84.1	84.2 a	68.3	2.3 ab
300	83.9	82.3 abc	75.0	2.4 ab
400	84.4	81.7 c	76.7	2.9 a

The numbers followed by the same letters in the same column in each treatment were not significantly different from the DMRT test level of 5%

The effect of application time and PBZ concentration on growth power and growth speed at the beginning of storage (0 MAS) and 4 MAS are shown in Table 3. PBZ application time does not affect growth power, and LWG seed rhizome growth rate, both at 0 MAS and 4 MAS after seeded in a glass room. The PBZ concentration applied affects the growth power at 0 MAS, while the growth speed is at 0 and 4 MAS. Growing power starts to increase at 300 ppm PBZ concentrations, while the growth speed starts to increase at 400 ppm PBZ.

At the beginning of storing (0 MAS) the application of 400 ppm, PBZ has a higher growth and growth speed than other PBZ concentrations. This is due to higher starch content than other PBZ concentrations so that the LWG seed rhizome has a higher energy reserve for germination and shoot growth.

In general, growing strength and rate at the beginning of storage (0 MAS) are lower than 4 MAS for all treatments. This is because the ginger seed rhizome has a period of dormancy and a high level of dormancy. Rusmin et al. (2015b) reported that the dormancy period of the LWG seed rhizome began to break after the seed rhizome was stored for 2 months. The longer it is stored until 4 MAS power grows and the growth speed gets higher, past 5 MAS power grows and the growth speed begins to decline. Next is Rusmin et al ., (2018) reported that the level of seed rhizome dormancy was determined by the ratio of ABA/cytokinin.

Table 3. Effect of application time and PBZ concentration on growth power and growth rate of LWG seed rhizomes at 0 and 4 months after storage

Treatment	Growth strength (%)		Growth rate (%/ etmal)	
	0 BSS	4 BSS	0 BSS	4 BSS
Application time (MAP)				
4	85.1	100	1.9	4.6
5	82.0	100	1.8	4.6
Concentration PBZ (ppm):				
0	73.3 c	100	1.7 b	4.3 b
100	78.9 bc	100	1.6 b	4.5 ab
200	84.4 abc	100	1.9 ab	4.6 ab
300	86.1 ab	100	2.0 ab	4.7 ab
400	95.0 a	100	2.4 a	4.8 a

The numbers followed by the same letters in the same column in each treatment were not significantly different from the DMRT test level of 5%

Seedling height and dry weight of seedlings of LWG seed rhizomes at 0 and 4 MAS after sowing in greenhouses were only influenced by PBZ concentration. At 0 MAS, the height and dry weight of LWG seedlings began to increase at a PBZ concentration of 400 ppm, whereas in 4 MAS the LWG seedling height and dry weight had increased at a 300 ppm PBZ concentration (Table 4).

In general, it was seen that the height and dry weight of LWG seedlings at 0 MAS were higher than 4 MAS for all treatments. This has something to do with the dormancy period as in the variable power growth and growth speed (Table 4). At 0 MAS the seed rhizome dormancy degree is still high so that the seed rhizomes grow longer. At 4 MAS dormancy has broken so that the seed rhizomes grow earlier and simultaneously.

Table 4. Effect of each application time and PBZ concentration on seed height and LWG seed dry weight after being stored for 0 and 4 months

Treatment	Seed Height (cm)		Dry weight seed (gram seed^{-1})	
	0	4	0	4
Application time (MAP)				
4	27.27	55.62	0.67	1.30
5	27.18	52.55	0.67	1.23
Concentration PBZ (ppm):				
0	23.66 b	48.09 c	0.62 b	1.05 c
100	26.14 b	49.60 bc	0.65 b	1.08 bc
200	24.03 b	54.25 abc	0.62 b	1.21 b
300	28.01 ab	58.11 ab	0.62 b	1.46 a
400	34.28 a	60.38 a	0.84 a	1.51 a

The numbers followed by the same letters in the same column in each treatment were not significantly different from the DMRT test level of 5%

In Table 4 it is also seen that the LWG seedling height after PBZ application is higher than without PBZ. This is presumably because of the higher starch content which results in stronger seeds and vigor. This also shows that there is no effect of PBZ residue in inhibiting plant height after being re-planted (LWG seeds produced normally and not shortened). This result was supported by Rusmin's research et al. (2015a), the LWG seed rhizome that was applied with PBZ up to 1500 ppm to increase storage capacity, yielded the same seed height as without PBZ after replanting. Satjapradja et al. (2006) also reported that Agathis seeds applied with PBZ to improve storage capacity did not reduce seed quality (seedling height) after being replanted.

Conclusion

Application of PBZ 400 ppm at age 4 and 5 MAP is the best concentration in increasing the shelf life of LWG seeds: growth speed (4.8% / etmal), seedling height (60.38 cm) and dry weight of seedlings (1.51 g) after being stored for 4 months.

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