The yield potency of various types of garlic planting materials

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Abstract. Climate change is causing garlic cultivation problems almost all over the world. One of the efforts that can be made to obtain high yields is the use of quality planting materials. Planting material from bulbil and tuber second generation (G2) from bulbil is feasible to study for use as planting material. This study aims to examine the yield potential of various kinds of garlic planting material. The study used a randomized complete block design with 2 treatment factors. Factor 1 were the type of bulbs (parent bulb, parent bulbil, bulb G2, and bulbil G2), and factor 2 were the immersion concentration of GA3 (0 ppm, 50 ppm, 100 ppm, 150 ppm) and repeated 3 times. The results showed that conditions of high extreme temperatures caused abnormal growth of garlic, low plant vigor, decreased growth and yield and high plant mortality. Although the plant growth is not normal, the planting material for bulbs G2 and bulbil G2 has the potential to be developed as planting material. This can be seen from the variables of plant fresh weight, plant dry weight, bulbs dry weight and bulbs diameter.

1. Introduction
Currently, about 95% of garlic consumed in Indonesia is imported from China [1]. Domestic production has not been able to make a significant contribution. This is because the productivity of garlic is still low. Even productivity in 2015-2019 in Java and Outside Java decreased by 5.43% and 5.46%. Lack of technological innovation and the impact of climate change are the causes that hinder garlic production. One of the efforts to increase productivity is the availability of quality planting materials. The continued use of planting material from consuming tubers for decades has resulted in viral infections in the planting material. Viruses carried from the tuber planting material include onion yellow Dwarf virus (OYDV), Leek Yellow Stripe Virus (LYSV) [2]. The results of research in Greece showed that tubers from consumption planting material tended to be infected with OYDV 98.5% [3]. On the other hand, the decrease in productivity is caused by climate change. Increases in temperature that often occur in an extreme manner due to climate change cause abnormal plant growth.

Some varieties of garlic can produce bulbils that arise from the axillary nodes on the artificial stem. Bulbil has the potential to be used as planting material that is free from viruses. This is because bulbils form in the axillary nodes. The axillary node is the part that is still actively dividing (meristematic). Plant tissue that is still actively dividing or restoring is virus-free [4]. The results of the study [5] using bulbil planting material were able to produce tubers with good productivity. However, the tuber yields were not uniform in size, so further studies were needed on the use of air tubers as planting material.

The problem faced in planting with bulbil in the field is that it is susceptible to high mortality rates [6]. This is due to factors of temperature and sunlight intensity. Direct planting of bulbils in the field requires shade at the beginning of growth and black silver plastic mulch. Planting through nurseries needs to be done research in order to avoid high mortality. Efforts to produce high quality seedlings using growth regulators need to be studied. Gibberellin acid (GA3) is a growth regulator that can be
used to promote the growth of plant seeds [7]. GA3 plays a role in accelerating the breakdown of seed and shoot dormancy, accelerating plant vegetative growth, and overcoming plant stunting. Garlic cloves immersed in a solution of gibberellin acid were able to break dormancy and increase tuber yield[8]. This study aims to examine the potential growth and yield of several kinds of tuber planting material and the concentration of GA3 immersion in the growth and yield of garlic.

2. Materials and methods
The research was conducted at Pancot, Tawangmangu District, Karanganyar, Indonesia at an altitude of 1200 MASL with andosol soil types. The materials used include cloves and bulbils of garlic varieties Tawangmangu Baru, vermicompost fertilizer, single fertilizers N, P, K, and Za, and GA3 solution. The study used a completely randomized block design (RCBD) factorial. The first factor is the type of tuber treatment which consists of parent bulb, parent bulbil, bulb G2, and bulbil G2. The second factor was immersion of GA3 with concentrations: 0 ppm, 50 ppm, 100 ppm, and 150 ppm. Each was repeated 3 times. The observation variables included: monthly average temperature, number of leaves, fresh tuber weight, dry tuber weight, fresh stover weight, dry stover weight, and tuber diameter. The data analysis used analysis of variance with a level of 5% and if there was a real effect, it was continued with the DMRT level of 5% difference test.

3. Result and discussion

3.1. General conditions of the research environment
At the time of the research, the weather conditions occurred very extreme changes in contrast to habits. In normal conditions, although there is an increase in temperature due to climate change, from May to October when the research was carried out, there was an extreme increase in temperature. The weather conditions that occurred at the research location tended to increase (Table 1). The temperature rise is extreme. This condition makes plants unable to grow normally. Garlic plants can grow optimally in a temperature range of 15–20°C with rainfall ranging from 100–200 mm/month [9].

Table 1. Recapitulation of the monthly average temperature in Tawangmangu District from May to October 2020.

| Months   | Average Low | Average High |
|----------|-------------|--------------|
| May      | 26          | 33           |
| June     | 25          | 33           |
| July     | 24          | 33           |
| August   | 24          | 34           |
| September| 25          | 35           |
| October  | 25          | 34           |

Source: Climate-data.org [10].

As a result of the increase in extreme temperatures, plant conditions experienced abnormal growth. Low plant diversity, smaller apparent stem size, dry leaves, and high plant mortality. In Figure 1, there is a very significant difference that the growth under normal temperature conditions, the plant grows well. The majority of plants are high, the mortality rate is very low, and the leaves grow without experiencing drought. In contrast to the growth in extreme temperature conditions.
Figure 1. Comparison of plant growth under conditions of normal and extreme temperatures.

Plant conditions that grow abnormally occur in all plants. In the growing season, the period from May to October 2020 can be said to be harvest failure (Figure 2). Extreme temperatures can cause stress in plants and have a negative impact on crop production. Stress at extreme temperatures has an impact on immunity and becomes susceptible to disease [11]. The impact of extreme temperatures will have an effect on a significant reduction in crop yields in hot temperature areas [12].

3.2. Number of leaves per plant
Types of bulb treatment had a significant effect on the number of leaves in the plant. Meanwhile, GA3 immersion treatment did not significantly affect the number of leaves per plant (Table 2). The treatment affected the number of leaves due to the size of the bulbs where the parent bulbs and G2 bulbs had a larger size than bulbil. The size affects the growth rate of the seedlings so that they can grow faster and produce more leaves. Dominant genetic factors influence the number of leaves. The number of leaves in the parent tubers and G2 bulbs ranged from 9 - 12, this is in accordance with the description of the new Tawangmangu variety of garlic plants. The description states that the number of leaves is 8-10 [13]. The interaction between treatments of different types of planting material and immersion treatment of GA3 was not significant. This is due to the extreme temperature factor. Temperature is an environmental
factor that greatly influences plant growth. Garlic plants require temperatures ranging from 15 to 20 °C. If there is an increase in temperature, it will reduce growth and increase the mortality rate of the plant.

Table 2. The average number of leaves in the type of bulbs treatments and GA3 concentration.

| Type of bulbs | Concentration of GA3 (ppm) | Average |
|---------------|-----------------------------|---------|
|               | 0 ppm | 50 | 100 | 150 |
| Parent Bulb   | 12.00 | 11.67 | 10.67 | 12.67 | 11.75<sup>a</sup> |
| Parent Bulbil | 7.67  | 7.00  | 7.00  | 8.33  | 7.50<sup>a</sup> |
| Bulb G2       | 11.67 | 11.00 | 12.33 | 9.33  | 11.58<sup>a</sup> |
| Bulbil G2     | 9.33  | 7.67  | 9.33  | 9.88  | 8.67<sup>b</sup> |
| Average       | 10.17 | 9.33  | 9.83  | 10.17 | (-) |

Note: numbers followed by different letters in the column show the results are significantly different at the 5% level. (-) no interaction.

3.3. The weight of fresh and dry bulbs

Bulbs type treatment significantly affected the weight of the fresh bulb of the plant. Plant growth is severely stunted which represents an abnormal plant size (Figure 3). The potential for planting material from bulbil and G2 as the second generation of bulbil parents was not able to provide optimal growth and yield. In previous research, the use of bulbil planting material that was directly planted showed that the potential for bulbil planting material produced the same results as its parents [5].

The variety of planting materials shows that the elders are better able to adapt better to extreme temperature conditions than the G2 and bulbil planting materials. This proved that the parents were able to produce 10.09 g of fresh bulbs per plant followed by 7.28 g of G2 tubers 5.26 g of bulbil G2 and 2.91 g of old bulbs (Table 3). Although the yield of these bulbs is very low compared to the yield at normal temperature conditions where the fresh weight of the parent bulbs is 16.9 - 39 g and the bulbil ranges from 11.31 to 16.44 g [5]. Research on the use of air tubers as planting material in shallots shows better results than the parent bulbs. Where the yield of tubers from bulbil planting material is higher than that of the parents' consumption [14]. The use of bulbil planting material is also carried out on lily plants. One plant can produce 1-20 bulbils [15].

Table 3. Average fresh bulbus weight and bulbs dry weight per plant (g) of garlic under various bulbs treatments and concentration of GA3.

| Type of bulbs | Concentration of GA3 (ppm) | Average |
|---------------|-----------------------------|---------|
|               | 0   | 50 | 100 | 150 | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight |
| Parent Bulb   | 10.12 | 6.04 | 10.04 | 6.27 | 10.19 | 6.46 | 10.00 | 6.28 | 10.09<sup>d</sup> | 6.24<sup>d</sup> |
| Parent Bulbil | 2.55  | 1.92 | 2.67  | 2.53 | 3.31  | 1.63 | 3.10  | 1.56 | 2.91<sup>a</sup> | 1.91<sup>a</sup> |
| Bulb G2       | 9.72  | 6.12 | 6.33  | 4.33 | 6.80  | 4.28 | 6.29  | 4.17 | 7.28<sup>a</sup> | 4.72<sup>a</sup> |
| Bulbil G2     | 5.81  | 4.07 | 3.95  | 2.54 | 6.74  | 4.62 | 4.53  | 1.97 | 5.26<sup>ab</sup> | 3.30<sup>b</sup> |
| Average       | 7.05<sup>a</sup> | 4.53<sup>a</sup> | 5.75<sup>a</sup> | 3.92<sup>a</sup> | 6.76<sup>a</sup> | 4.25<sup>a</sup> | 5.98<sup>a</sup> | 3.47<sup>a</sup> | (-) | (-) |

Note: numbers followed by different letters in the column show the results are significantly different at the 5% level. (-) no interaction.
Figure 3. Comparison of yields of dry tubers at normal and extreme temperatures.

3.4. Stover weight: fresh weight & dry weight
The use of planting material from different types of bulbs gave a significant difference to the fresh weight and dry weight of plant stover (Table 4). Planting material for parent bulbs and bulbs G2 gave the higher weight of fresh and dry stover than bulbi. Water is the main factor affecting the fresh weight of stover [16]. The fresh and dry weight of stover produced from planting material of parent tubers was not significantly different from that of bulbs G2 but was significantly different from the fresh and dry weight of plant stover from bulbil. Observation of the number of leaves showed that the parent bulbs and G2 bulbs gave more leaves. The number and size of the crown will affect the photosynthesis process. The higher the intensity of the photosynthesis process, the higher the photosynthate is produced, as the result, will affect the weight of the plant stover [17].

Table 4. Average fresh weight and dry weight of stover (g) of garlic in the treatment of bulb type and concentration of GA3.

| Type of bulbs   | Concentration of GA3 | Average |
|----------------|----------------------|---------|
|                | 0 ppm                | 50 ppm  | 100 ppm | 150 ppm |         |
|                | Fresh weight         | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight |
| Parent Bulb    | 1.98                 | 1.50     | 2.39     | 1.78     | 2.08     | 1.44     | 2.04     | 1.48     | 2.12b     | 1.55b     |           |
| Parent Bulbil  | 0.98                 | 0.63     | 0.65     | 0.50     | 1.50     | 0.99     | 0.78     | 0.56     | 0.98a     | 0.67a     |           |
| Bulb G2        | 1.60                 | 1.30     | 1.63     | 1.42     | 1.41     | 1.13     | 2.09     | 1.28     | 1.68b     | 1.28b     |           |
| Bulbil G2      | 0.67                 | 0.64     | 0.98     | 0.79     | 1.09     | 1.91     | 0.79     | 0.71     | 0.88a     | 0.76a     |           |
| Average        | 1.31a                | 1.02a    | 1.41a    | 1.12a    | 1.42a    | 1.12a    | 1.52a    | 1.01a    | (-)       | (-)       |           |

Note: numbers followed by different letters in the column show the results are significantly different at the 5% level. (-) no interaction.

3.5. Bulbs diameter
The results showed that the GA3 concentration treatment did not give significantly different results on bulbs diameter (Table 5). Meanwhile, the type of tuber treatment gave significantly different results. The treatment of the parent tuber planting material was not significantly different from that of the G2 tuber and the G2 bulbil planting material. In G2 bulb, although the tuber size is smaller. It is able to produce tubers with the same size compared to the parent and G2 tubers. This provides information that bulbil G2 has the potential to be used as planting material.
GA3 treatment at the four levels gave no significant difference in bulb diameter. This is because larger seeds have more food reserves, they also have larger embryos so that they have the potential to provide better growth and ultimately will give better yield [13], [18]. Bulbil G2 can produce diameter sizes that are not significantly different from the planting material because the planting material of a higher class has better productivity [19].

Table 5. Average bulbs diameter in the type of bulbs treatments and GA3 concentration.

| Type of bulbs | The concentration of GA3 (ppm) | Average |
|---------------|--------------------------------|---------|
|               | 0 ppm | 50 | 100 | 150 |         |
| Parent Bulb   | 2.80  | 2.94 | 2.75 | 2.71 | 2.80 b |
| Parent Bulbil | 1.79  | 2.11 | 2.12 | 2.42 | 2.11 a |
| Bulb G2       | 2.87  | 2.64 | 2.52 | 2.63 | 2.67 b |
| Bulbil G2     | 2.56  | 2.60 | 2.75 | 2.48 | 2.60 b |
| Average       | 2.51  | 2.57 | 2.54 | 2.56 | (-)    |

Note: numbers followed by different letters in the column show the results are significantly different at the 5% level. (-) no interaction.

4. Conclusion

Based on the growth variables of stover weight and plant height as well as yield variables on tuber weight, G2 tuber planting material which is the second generation of tubers is expected to be developed as plant material. The yield of tubers from G2 bulbs showed no different results compared to the treatment of parent tubers and tubers. Bulbils growth is strongly influenced by climate change.

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References

[1] Sandrakirana R, Baswarsiati and Hadiatry M 2020 The diversity of garlic bulbs and cloves quantitative characteristics of local garlic collection of East Java AIAT The diversity of garlic bulbs and cloves quantitative characteristics of local garlic collection of East Java AIAT IOP Conf. Ser. Earth Environ. Sci. 591 01209

[2] Aradottir G I and Crespo-herrera L 2021 Host plant resistance in wheat to barley yellow dwarf viruses and their aphid vectors : A review Curr. Opin. Insect Sci. 45 59–68

[3] Kereša S, et al. 2021 Production of virus-free garlic plants through somatic embryogenesis Agronomy 876(11) 1–13

[4] Putri A H, Haryanto E E. T and Purnomo D 2015 Optimization of garlic tissue culture with variations in yeast extract concentration Caraka Tani J. Sustain. Agric. 30(1) 30–2

[5] Dinda W P, Triharyanto E and Samanhudi 2020 Effects of mulch on growth and yield of garlic bulbils at various fertilizing doses IOP Conf. Ser. Earth Environ. Sci. 423 012033

[6] Schnittler M., Pfeiffer Æ T and Harter Æ D 2009 Bulbils contra seeds : Reproductive investment in two species of Gagea (Liliaceae) Plant Syst Evol 179 29–40

[7] Mornya P M P and Cheng F 2018 Effect of combined chilling and GA 3 treatment on bud abortion in forced ‘Luoyanghong’ Tree Peony (Paeonia suffruticosa Andr.) Hortic. Plant J. 4(6) 250–6

[8] Guan Y, Xue J, Xue Y, Yang R, Wang S and Zhang X 2019 Effect of exogenous GA3 on flowering quality, endogenous hormones, and hormone- and flowering-associated gene expression in forcing-cultured tree peony (Paeonia suffruticosa) J. Integr. Agric. 18(6) 1295–311
[9] Sun J, et al. 2018 Effects of forest structure on hydrological processes in China J. Hydrol. 561 187–99

[10] Climate-data.org 2021 Temanggung climate (Indonesia) [Online] Available: https://en.climate-data.org/asia/indonesia/central-java/tawangmangu-614477/

[11] Ju H, van der Velde M, Lin E, Xiong W and Li Y 2013 The impacts of climate change on agricultural production systems in China Climatic Change 120(1–2) 313–24

[12] Xu A, Buchanan R L and Micallef S A 2016 Impact of mulches and growing season on indicator bacteria survival during lettuce cultivation Int. J. Food Microbiol. 224 28–39

[13] Hirata S, Abdelrahman M, Yamauchi N and Shigyo M 2016 Characteristics of chemical components in genetic resources of garlic Allium sativum collected from all over the world Genet. Resour. Crop Evol. 63(1) 35–45

[14] Triharyanto E and Purnomo D 2020 Yield potential of shallots (Allium cepa L. Aggregatum Group) from several sources of planting material in tropical region J. Agron 19(3) 138–44

[15] He G et al. 2020 Mechanism of exogenous cytokinins inducing bulbil formation in Lilium lancifolium in vitro Plant Cell Rep. 39 861–72

[16] Yang L, Ru Y, Xu S, Liu T and Tan L 2021 Bioresource technology features correlated to improved enzymatic digestibility of corn stover subjected to alkaline hydrogen peroxide pretreatment Bioresour. Technol. 325 124688

[17] Rosales M A and Diaz-espejo A 2019 Chloride as a macronutrient increases water-use efficiency by anatomically driven reduced stomatal conductance and increased mesophyll diffusion to CO2 Plant J. 99(5) 1–17

[18] Stavělíková H 2008 Morphological characteristics of garlic (Allium sativum L.) genetic resources collection - Information Hortic. Sci. 35(3) 130–5

[19] Dugan F M, Lupien S L and Hellier B C 2019 Infection by Fusarium proliferatum in aerial garlic bulbils is strongly reduced compared to rates in seed cloves when both originate from infected bulbs Crop Prot. 116 43–8