The effects of fertilizer composition and gibberellin on flowering and true shallot seed formation of three shallot varieties at the highlands

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Abstract. The flowering of shallot is influenced by low temperature and difference temperature between day and night. In Indonesia, to flowering shallot in low temperature are possible by planting in highlands. Because of climate change, the temperature difference in the highlands is very pronounced. This study aimed to determine the percentage of flowering and True Shallot Seed (TSS) production of three shallot varieties grown in the highlands. The research was conducted at Pancot Village, Tawangmangu, Karanganyar, Indonesia. The elevation of research site was 1,300 m asl. The research design used was Split Plot with three replications. The main plot was variety: Bali Karet, Bali Lancur, and Bima Brebes. The subplot was fertilizers composition (Manure, ZA, SP36, KCl) and gibberellins: farmer's dose (100% Inorganic and Organic) (P1G0), 100% Inorganic and Organic + Gibberellin 50ppm (P2G1), 50% Inorganic and 150% Organic (P3G0), 50% Inorganic and 150% Organic + Gibberellin 50ppm (P4G1), 200% Organic (P5G0), 200% Organic + Gibberellin 50ppm (P6G1). The results showed that fertilizer composition + gibberellins and varieties did not have significant effect on percentage of flowering, number of flowers and percentage of TSS formation. Fertilizer composition + gibberellins just influenced the number of TSS per stalks. Bima Brebes variety with P6G1 was able to flowering at 65 DAP with the flowering percentage reaching 88.87%.

1. Introduction
The productivity of shallots (Allium cepa L. Aggregatum group) in Indonesia is around 9-10 ton ha⁻¹, relatively far the potential of 20 ton ha⁻¹ [1]. Meanwhile, the production reached 1.45 million tons [2] and increased from around 1.23 tons in 2014 [3]. The need for shallots will be higher due to the increasing population, social welfare, and utilization as herbal medicines [4]. Shallot is potential as herbal medicines because it contains anti-bacterial compounds [5] and anticancer compounds [6].

The disruption of shallot productivity in Indonesia was caused by using planting material from consumption tubers that have been used for years [7,8]. Kurniawan and Suastika [9] said that planting material from consumption tubers was infected with viruses from various virus strains, such as Shallot Yellow Stripe Virus (SYSV), Shallot Latent Virus (SLV), and Onion Yellow Dwarf Virus (OYDV). The virus infection is degenerative and difficult to remove [10], resulting in the planting materials has low potential production.

One of the efforts to provide virus-free seedlings is through meristem tip culture [11] or planting by seed [12]. Using True Shallot Seeds (TSS) as the seed is healthier (pathogen-free), efficient,
and increases production by 61% [8]. But in Indonesia, it is difficult for shallots to flowering and producing TSS. Shallots are a two-season plant, where to flowering, shallots must through winter. With the climatic conditions in Indonesia, several shallot varieties have been able to adapt. Shallots can be flowering even though the percentage is still low. The impact of climate change affects the flowering of shallot plants. This is due to climate change, especially the ambient temperature. Extreme changes in temperature day and night affect the flowering of plants [13].

Low-temperature treatment (vernalization) is also one of the determinant factors of flowering [14]. Highlands have lower temperatures than lowlands. Highland’s temperature will influence the increase of flowering shallots. Biru Lancur and Bali Karet varieties are widely planted in the highlands. These varieties are able to produce flowers but the formation and viability of the seed are still low. Conversely, Bima variety is lowland variety that difficult to flower. It is expected that planting Bima varieties in the highlands will be able to produce flowers and seeds.

Efforts to increase flowering and seed formation can also be pursued through using Gibberellins. Gibberellins are plant growth regulators (PGR) as growth stimulants [15], this is line with Bernier and Perilleux [14] which stated that gibberellins are one of the determinants flowering factors. Sumarni et al. [16] said that 200ppm gibberellins were able to increase flowering and the number of TSS. Using of gibberellins is able to stimulate flowering as a result of increased subapical meristem activity.

The role of fertilization needs to be considered to stimulate seed formation with adequate and balanced nutrition. Fertilizers come from inorganic and organic. The balance of inorganic and organic fertilizers needs to be maintained to support soil and plant health. Fertilizing plants only using inorganic fertilizers resulted in an imbalance of the soil environment, although the use of fertilizers as needed provides beneficial results [17]. However, fertilization using only organic fertilizer will not meet the nutritional needs of plants [18].

Based on the explanation above, this study aims to determine how the effect of fertilizer composition and gibberellins planted in the highlands to increase flowering and seed formation of three shallot varieties.

2. Materials and methods
The study was conducted in June-October 2017 at the Pancot village, Tawangmangu, Karanganyar Regency (7°39’31.3128” S, 111°8’27.9636” E). The altitude of 1300 meters above sea level, and Grumosol soil type with Split Plot Design. The main plot was the shallot variety, namely Bali Karet (V1), Bali Lancur (V2), and Bima Brebes (V3), while fertilizers composition was the subplot, including (Manure, ZA, SP36 and KCl) and gibberellins: farmer’s dose (100% Inorganic and Organic) (P1G0), 100% Inorganic and Organic + Gibberellin 50ppm (P2G1), 50% Inorganic and 150% Organic (P3G0), 50% Inorganic and 150% Organic + Gibberellin 50ppm (P4G1), 200% Organic (P5G0), 200% Organic + Gibberellin 50ppm (P6G1). A total of 8 treatment combinations with 3 (three) replications was conducted. Organic (manure) was applied to the topsoil after tillage (1 week before planting), ZA, SP36, and KCl were spread the day before planting. 40% of fertilizer is given before planting, while 60% is given 30 days after planting (DAP). Seedlings are consumption tubers that have been stored for 40-60 days, planted with a distance of 20 x 20 cm. Before planting, the seedlings were cut off the ends and then soaked in gibberellin solution according to treatment. The variables observed were ambient temperature, rainfall, flowering time, the percentage of flowering, percentage of flower umbel per clump, the percentage of fruit set, the number of fruit per umbel, the percentage of TSS set and the number of TSS per umbel. Data obtained after tabulation were analyzed using F-test (Anova) with α=0.05, followed by Duncan 0.05 (if significant) and descriptive.
3. Results and discussion

3.1. Observation of ambient temperature

Table 1. Observation of ambient temperature and rainfall

| Month   | Temperatures (°C) | Rainfall (mm) |
|---------|-------------------|---------------|
|         | Average | Min | Max |                |
|         | Day      | Night |     |               |
| June    | 25.07   | 24   | 27  | 11.4 | 70 |
| July    | 23.32   | 21   | 26  | 11.7 | 13 |
| August  | 22.84   | 21   | 24  | 10.6 | 0  |
| September | 24.3   | 23   | 26  | 9.2  | 66 |
| October | 25.54   | 25   | 28  | 9.8  | 159 |

When planting, the microclimate conditions, especially temperature, were sufficient to support shallots growth, flowering and TSS formation. As shown in Table 1 that day temperatures ranged from 22°C to 25°C. While the average night temperature ranges from 9°C to 11°C. The temperature needed for shallots to grow ranges from 25°C to 32°C [19]. Whereas to produce flowers requires temperatures ranging from 7°C to 12°C [20].

The rainfall intensity was erratic because of climate change. June, September and October were dry season, but there was rather high rainfall such as 70mm, 66mm and 159 mm (Table 1). Rainfall in October inhibits fruit and seed formation.

3.2. Flowering of shallots

Table 2. Effect of fertilizer competition + gibberellins and variety on flowering

| Treatment | Flowering Time (DAP) | Percentage of Flowering (%) | Percentage of Flower Umbel per Clumps (%) |
|-----------|----------------------|------------------------------|------------------------------------------|
| P1G0      | 71                   | 56.08ab                      | 36.99a                                   |
| P2G1      | 78                   | 38.09a                       | 22.43a                                   |
| P3G0      | 75                   | 50.26ab                      | 28.89a                                   |
| P4G1      | 75                   | 46.03ab                      | 24.99a                                   |
| P5G0      | 76                   | 52.9ab                       | 25.69a                                   |
| V1        | 79                   | 41.53a                       | 22.44a                                   |
| V2        | 70                   | 52.11a                       | 23.97a                                   |
| V3        | 67                   | 90.84b                       | 39.62b                                   |

Note: the numbers in the column followed by the same letter are not significantly different based on Duncan's test of 5%.

Bima Brebes variety takes 67 DAP, Bali Karet variety takes 79 DAP, and Bali Lancur variety takes 70 DAP to 75% of umbel membrane broken and the flowers bloomed. In the fertilizer compositions treatment and gibberellin treatment, it takes 71-78 DAP to flowering. The time needed being longer than planting in the lowlands. Flowering shallots in the lowlands required a faster time around 61-63 DAP [21]. According to Rasul [22], plant growth and development in the lowlands was faster due to higher temperatures.

The highest percentage of flowering was Bima Brebes variety of 90.84%. In the lowlands, the highest percentage of the flowering of shallots in the dry season was 76.1%, while in the rainy season and the transition of seasons was 23-27% [8]. Planting in the highlands can increase the percentage of flowering in the dry season up to 18% and in the rainy season almost 400%. This is caused by environmental temperature. The results of observations of temperatures in the highlands obtained an
average daily temperature of 22-25°C and night temperatures of 9-11°C (Table 1). This temperature is a very favorable condition for flowering shallots [20]. The percentage of highland varieties (Bali Karet and Bali Lancur) is lower due to changes in temperature that occur due to climate change so that the varieties that initially can flower, the percentage has decreased.

The percentage of flower umbel per clump by each variety showed a significant difference (Table 2). Bima variety was the variety that produces the highest flower umbel (39.62%) compared to Bali Karet (22.44%) and Bali Lancur (23.97%). According to Khokhar at al. [20], the thing most needed for the flowering induction process is a temperature ranging from 17°C to 19°C.

Combination treatment of inorganic fertilizers, organic fertilizers and gibberellins had no impact on flowering shallots. This is because flowering initiation is more influenced by temperature. So that the balance of 50% Inorganic and 150% Organic fertilizers and using gibberellins 50ppm already provide sufficient nutrition for the benefit of flowering shallots (Table 2).

### 3.3. Fruit and seed set

#### Table 3. Effect of fertilizer composition + gibberellins and variety on fruit and seed set

| Treatment | Percentage of fruit set (%) | Number of Fruits per Umbel | Percentage of TSS Set (%) | Number of TSS per Umbel |
|-----------|-----------------------------|-----------------------------|---------------------------|-------------------------|
| P1G0      | 15.3a                       | 18.18a                      | 56.43a                    | 33.78a                  |
| P2G1      | 4.06a                       | 12.25a                      | 71.51a                    | 36.42a                  |
| P3G0      | 5.91a                       | 17.8a                       | 63.25a                    | 45.78a                  |
| P4G1      | 33.51a                      | 18.2a                       | 77.58a                    | 51.36a                  |
| P5G0      | 14.05a                      | 22.2a                       | 70.85a                    | 50.19a                  |
| P6G1      | 26.67a                      | 12.51a                      | 67.38a                    | 37.23a                  |

Note: the numbers in the column followed by the same letter are not significantly different based on Duncan’s test of 5%.

There was no interaction between fertilizer compositions and gibberellins with varieties on the percentage of fruit set, the number of fruits per umbel, the percentage of TSS set and the number of TSS per umbel (Table 3). According to Rosliani et al. [23], the increased percentage of flowering is not always followed by an increased percentage of fruit and seed set as well.

The results of this study indicate that the percentage of fruit set was less than 35% (Table 3), and the number of fruits set is also low. The low percentage of fruit set causes a low number of TSS set. Research results According to Hilman et al. [21], temperature affects the process of capsule formation and TSS as well as TSS quality of shallots. Altitude less than 700 m above sea level with the temperature around 25°C was more suitable for the formation of shallots seeds [24]. According to Sumarni et al. [16], there are indications that lowland with high temperatures are more suitable for capsule and seed formation.

As well as flowering, the composition of fertilizer and gibberellins have no effect on the percentage of fruit set, percentage of TSS set, number of fruits per umbel and number of TSS per umbel. This is because the formation of fruit and TSS are more influenced by the environment, especially temperature and rainfall.

The formation of flowers and TSS of three varieties (Bali Karet, Bali Lancur and Bima Brebes) was low due to rainfall. So the sunlight intensity was not sufficient. According to Sumarni et al. [16], rain causes disruption of the pollination process and seed formation. Climate change causing rain in the dry season.
4. Conclusion
Combination treatment of inorganic fertilizers, organic fertilizers and gibberellins had no impact on flowering and seed formation of shallots. The climate change makes day temperature higher causing highland varieties (Bali Karet and Bali Lancur) has a low percentage of flowering.

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