Adaptation of six shallots varieties to phosphate solubilizing bacteria on the flower formation, seeds fromation, and yields on the lowland

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Abstract. Using seeds as planting materials is a solution to improve the quality and quantity of shallot. This study aims to determine the interaction between shallot varieties and Phosphate-Solubilizing Bacteria (PSB) on the flowering and shallot yield on the lowlands. The research was conducted in Mijil Village, Jaten, Karanganyar, 98 m altitude with Vertisol-type soil order in June to December 2016, using Randomized Complete Block Design (RCBD) with two factors. Shallot varieties used as factors are Bima, Manjung, Ilokos, Bima (bulb seeds), Mentes and Rubaru. PSB factors are control and with PSB inoculation. Observed variables included plant height, number of leaves, flowering percentage, seed formation and shallot bulb yield. Results showed that there was no interaction between varieties and PSB inoculation on all observed variables. However, PSB inoculation were able to increase the number of flowering plants and seed weight per plot. Bima variety have the highest average yield compared to other varieties in terms of number of leaves, number of bulbs per plant and bulb weight per plot (fresh harvest weight 317.74 g equivalent to 17.65 ton per hectare and dry weight 288.16 g consumption equivalent to 16 ton per hectare).

1. Introduction
Shallot is a horticulture commodity with a lot of utilities, high economic value and good market prospect. The demand for shallot in the Indonesia is always increasing but not balanced with the production. The need for shallot consumption in 2014 was 1.35 million tons, while the production was 1.234 million tons resulting in a deficit of shallot [1]. Shallot cultivation can be done with vegetative (bulbs) or generative (seeds) manners.

Generally, farmers use bulbs seedlings because it has advantages such as planting ease, seedless and shorter harvest time when compared to using seeding materials. However, the weakness of bulb seeding is prone to infectious diseases from fungus such as Fusarium sp and viruses such as Onion Yellow Drawf Virus (OYDV) (ranging from 53-93% crop, correspondently) thereby decreasing the quality and quantity of shallot [2]. Meanwhile, seeding material or True Shallot Seed (TSS) has the advantage that the less usage of planting materials, transport and easy storage [3], and relatively safe from disease transmission. However, the use of TSS has not developed because flowering of shallot is still difficult and the seeds produced have low viability [4]. Flowering shallot is difficult because the shallot is biannual plant (two seasons region) [5].

Flowering problems can be overcome by inoculation of Phosphate-Solubilizing Bacteria (PSB). The role of PSB in this study was to increase the absorption of P element so as to increase the flower
formation [6], as biocontrol [7] and to produce phosphatase enzymes to hydrolyze organic P into inorganic P [8]. The objective of this research is to study the ability of shallot varieties, PSB inoculation and their interaction in yielding flowers and seeds in lowland.

2. Methods
The experiment was conducted in the paddy field of Gunung Mijil Village, Jaten Sub-district, Karanganyar District with 98 m altitude and Vertisol-type soil. The experiment was carried out from June to December 2016. The material included are shallot seed, PSB, SP 36 250 kg/ha, Urea 50 kg/ha, ZA 100 kg/ha and KCl 200 kg/ha. The tools used are hoe, trowel, ruler, hemacytometer, microscope, scales and term slide.

The experiment used Randomized Complete Block Design (RCBD) with 2 treatment factors. The first factor is shallot varieties include Bima variety, Manjung, Ilokos, Bima (bulb from seed yield), Mentes and Rubaru. The second factor was PSB 1,10^6 cells/g of soil and without PSB, in total there were 12 treatment combinations and 3 replication. Implementation includes soil preparation, preparation of PSB, application of PSB, preparation of planting materials, planting, maintenance and harvesting. The data were analyzed using analysis of variance (ANOVA) based on F test with 5% confidence level, if there are significant differences, further analysis using Duncan Duncan (DMRT) test with 5% confidence level were implemented.

3. Result and discussion

3.1 General condition of research location
The soil used in the study was classified as Vertisol soil. The soil analysis used for the study showed pH of 7.43 (slightly alkaline), organic matter was 1.99% (low), total N was 0.29% (medium), available P is 2.39 ppm (very low) and available K is 0.124 me/100g (low). Based on these results, this soil can be included in the low soil fertility category. Environmental conditions during the period are 26.7-38.7 °C of air temperature, 78.1-79% of air humidity (RH) and 36.5-255.5 mm/month rainfall. Based on these weather conditions, conclude that this are not a proper condition for shallot cultivation. Shallot plants grow well in the dry season with rainfall of 25-125 mm/month [9].

3.2 Plant vegetative growth
Plant height were significantly differ among varieties (P<0.05), whereas PSB inoculation has no significant effect on plant height. Figure 1 shows that Rubaru varieties have the shortest plants that this does not match the description which it can reach 35-44 cm. This might be due to Rubaru varieties derived from the highlands and have not been able to adapt in the lowlands. In variables of leaf number, shallot varieties gave significant effect while PSB inoculation had no significant effect. Bima variety had the highest number of leaves of 32.17 leaflets (Figure 2), according to the product description potentially 15-50 leaf were formed. The number of leaves was not only influenced by PSB but also by nutrients such as N. Nitrogen main role is to stimulate overall growth, especially stems, branches and leaves [10].
3.3 Flowering

3.3.1 Flower induction period. Flowering of shallot varieties is particularly difficult in Indonesia, especially in the lowlands. Based on Table 1, flower induction period of Manjung variety inoculated with PSB was 49 days whereas without PSB inoculation was not flowering. Flower induction period of Ilokos variety without bacteria inoculation was 48 days while using PSB inoculation was 56 days. It is assumed that PSB was able to increase the P element, but its ability is different [11]. In addition, flowering is influenced by the ability of each variety to flower and correspondent to weather conditions during planting.

3.3.2 The number of plant per plot. Based on Table 1 the percentage of flowering plants per plot of Manjung variety without inoculation of PSB was 0%, whereas as with inoculation PSB was 1.23%. The percentage of Ilokos variety without PSB inoculation was 1.23%, whereas where with PSB inoculation was 2.47%. Inoculation of PSB tends to increase the percentage of flowering, it is assumed that PSB can increase uptake of P. Sumarni et al. [12] states that to produce flower, shallot plants require more P fertilizer.

3.3.3 Number of flower stalks per plant cluster. Table 1 shows the number of flower stalks per cluster was one. The number of flower stalks is categorized as good if there are 2-4 flower stalks per cluster. The low number of flower stalks per plant was thought to be due to unsuitable environmental factors, genetic factors (varieties) and the availability of nutrients P which was still low. This is aligned with the results of Nkaa et al. [13] study that the role of P in plants can stimulate the formation of flowers.

3.3.4 The number of flower per stalk. Bima variety without PSB had flower per stalk rate of 46.8, while with PSB treatment was 46.4. Ilokos variety without PSB inoculation resulted in the number of flowers per stalk of 44.5 whereas with inoculation PSB was 42.75 (Table 1). PSB inoculation tends to decrease the number of flowers per stalk, it is assumed that PSB was not optimum in increasing P so that P availability was still lacking. According to Purba [14] the ability of PSB in improving the uptake of P elements vary.

Table 1. Effect of interaction of varieties and Phosphate-Solubilizing Bacteria on flowering of shallot

| Treatment                      | Flower induction period (days) | Number of plant/plot (%) | Number of flower stalks per cluster | Number of flower per stalk |
|--------------------------------|-------------------------------|--------------------------|-------------------------------------|---------------------------|
| Bima – Bacteria                | 45.80                         | 4.32                     | 1.40                                | 46.80                     |
| Bima + Bacteria                | 45.80                         | 3.09                     | 1.20                                | 46.40                     |
| Manjung – Bacteria             | 0.00                          | 0.00                     | 0.00                                | 0.00                      |
| Manjung + Bacteria             | 49.00                         | 1.23                     | 1.00                                | 47.00                     |
| Ilokos – Bacteria              | 48.00                         | 1.23                     | 1.00                                | 44.50                     |
| Ilokos + Bacteria              | 56.00                         | 2.47                     | 1.00                                | 42.75                     |
| Bima (Bulb Seed) – Bacteria    | 0.00                          | 0.00                     | 0.00                                | 0.00                      |
| Bima (Bulb Seed) + Bacteria    | 0.00                          | 0.00                     | 0.00                                | 0.00                      |
| Mentes – Bacteria              | 0.00                          | 0.00                     | 0.00                                | 0.00                      |
| Mentes + Bacteria              | 0.00                          | 0.00                     | 0.00                                | 0.00                      |
| Rubaru – Bacteria              | 0.00                          | 0.00                     | 0.00                                | 0.00                      |
| Rubaru + Bacteria              | 0.00                          | 0.00                     | 0.00                                | 0.00                      |

3.4 Seed formation

3.4.1 The number of seed per stalk. The number of seeds per flower stalk ranged from 0 to 116 seeds. Based on Table 2, the highest number of seeds comes from Ilokos variety without PSB inoculation of
116 seeds, while the variety which not produce any seeds are Bima (bulb seed), Rubaru and Mentes varieties. The number of seeds per stalk is influenced by the number of pollinated flower stalks.

3.4.2 Seed weight per flower stalk. Table 2 shows the highest seed weight per stalk produced by Ilokos variety without PSB of 0.253 g. The weight of the seeds per stalk is influenced by the number of flowers that produce the seed, the more seeds are formed and the size of the seeds, the weight of the seeds per stalk is heavier. The formation of flowers and seeds is influenced by environmental factors, varieties and nutritional needs in early stage of seed filling.

3.4.3 Seed weight per plot. The highest seed weight per plot produced by Bima variety with PSB is 0.409 g / plot (Table 2). This is because the variety of Bima has the largest number of flower stalks. PSB inoculation tends to increase seed weight per plot, because it can increase the number of flowering plants per plot so as to increase the weight of seeds per plot.

| Treatment                      | Number of seed per stalk (gram) | Seed weight per flower stalk (gram) | Seed weight per plot (gram) |
|--------------------------------|---------------------------------|------------------------------------|-----------------------------|
| Bima - Bacteria                | 93.60                           | 0.23                               | 0.38                        |
| Bima + Bacteria                | 94.80                           | 0.22                               | 0.41                        |
| Manjung - Bacteria             | 0.00                            | 0.00                               | 0.00                        |
| Manjung + Bacteria             | 91.00                           | 0.23                               | 0.23                        |
| Ilokos - Bacteria              | 116.00                          | 0.25                               | 0.17                        |
| Ilokos + Bacteria              | 107.75                          | 0.23                               | 0.33                        |
| Bima (Bulb Seed) - Bacteria    | 0.00                            | 0.00                               | 0.00                        |
| Bima (Bulb Seed) + Bacteria    | 0.00                            | 0.00                               | 0.00                        |
| Mentes - Bacteria              | 0.00                            | 0.00                               | 0.00                        |
| Mentes + Bacteria              | 0.00                            | 0.00                               | 0.00                        |
| Rubaru - Bacteria              | 0.00                            | 0.00                               | 0.00                        |
| Rubaru + Bacteria              | 0.00                            | 0.00                               | 0.00                        |

3.5 Plants yield

3.5.1 Bulb weight per plant. The highest bulb weight per plant was produced by Bima variety (bulb from seed yield) without PSB inoculation (Figure 3) of 62.63 g/plants cluster. Shallot varieties treatments have no significant effect on bulb weight per plant cluster variable, as well as inoculation of PSB treatment. Bulb weight can be influenced by the size of bulb plant material and the need of K elements [12]. Role of K element is increasing bulb size and bulb yield per plant cluster. Deficiency of K element will inhibit the process of leaf growth, so the process of photosynthesis is hampered causing small bulb size [14].

![Figure 3](image)

**Figure 3.** Effect of shallot varieties on bulb weight per plant on lowland.
3.5.2 The number of bulb per plant cluster. Table 3 shows that shallot varieties significantly affect the number of bulbs per plant cluster. The largest number of bulbs is Bima variety of 8.4 bulbs. According to Sofiari et al. [15] the number of bulbs of Bima shallot varieties ranged from 1-9 bulbs. Bulb is as a place to store food. The more leaves are, the more leaf midrib, so the number of bulbs will be plentiful [16].

3.5.3 Bulb weight per plot. Bulb weight per plot includes fresh weight and dry weight. Bulb weight per plot is related to the number of bulb, the weight, and size of the bulb per plant. Bima varieties produce fresh weight equivalent to 17.65 ton / ha fresh weight (Table 3). Fresh weight is influenced by the abundance of water absorption of photosynthesis resulting abundance photosyntate translocation to bulbs, thus affecting fresh weight of bulbs.

Shallot varieties have a significant effect on bulb weight, while PSB inoculation has no significant effect. Table 3 shows the Bima variety have dry weight of bulb equivalent to 16 ton / ha. This is due to the interaction between genetic and environmental factors, so that the shallot is able to grow well.

Table 3. Effect of shallot varieties on the number of bulb per plants cluster and weight of shallot bulb grown on lowland vertisol.

| Varieties         | Number of bulb / plant | Fresh weight of bulb/plot (g/0.18 m²) | Fresh weight of bulb/ha (ton/ha) | Dry weight of bulb/plot (g/0.18 m²) | Dry weight of bulb/ha (ton/ha) |
|-------------------|------------------------|---------------------------------------|----------------------------------|------------------------------------|-------------------------------|
| Bima              | 8.40 c                 | 317.74 b                              | 17.65 b                          | 288.16 c                           | 16.00 c                       |
| Manjung           | 8.10 bc                | 256.73 ab                             | 14.26 ab                         | 227.56 bc                          | 12.64 bc                      |
| Ilokos            | 7.53 bc                | 214.91 a                              | 11.94 a                          | 186.00 ab                          | 10.33 ab                      |
| Bima (Bulb Seed)  | 6.37 ab                | 241.71 ab                             | 13.43 ab                         | 206.39 abc                         | 11.47 abc                     |
| Mentes            | 8.30 bc                | 209.32 a                              | 11.63 a                          | 174.20 ab                          | 9.68 ab                       |
| Rubaru            | 5.23 a                 | 163.65 a                              | 9.09 a                           | 121.93 a                           | 6.77 a                        |

3.5.4 Large bulb diameter. Based on figure 4, Ilokos variety have the highest percentage in large bulb which is 83.61%. The diameter of the shallot bulb is influenced by the K element. According to Ispandi [17] K element is needed in the formation, enlargement and lengthening of the bulbs. According to Prajapatu and Mohidi [18], the role of element K is to increase the yield on shallot crops. The characteristics of shallot bulbs that are preferred by farmers are round bulb, dark red, 2 cm in diameter and have strong aroma [19].

Figure 4. Effect of shallot varieties on % of large bulb diameter on lowland.

3.5.5 Small bulb diameter. Figure 5 shows that the varieties of Bima (bulb from seed yield) without PSB produce 0% of small bulbs, that this is in accordance with the description that shows Bima...
variety has a large bulb size. This is because the seeds of Bima variety bulb (bulb from seed yield) larger than other varieties. Large bulb has a relatively larger bulb layer and has a larger cross-sectional area so it can improve the nutrient and water absorption capacity [20]. This is in line with Purwanto [21] research, large bulbs have relatively more food reserves for the formation of plant growth energy. Akliiu and Lemma [22], stated that bulbs grown from seed have large bulb size, with ranging from 1 to 3 bulb per plant cluster.

Figure 5. Effect of shallot varieties on % of small bulb diameter of shallot on lowland.

4. Conclusion
From this research of Adaption of some shallot variety with phosphate-solubilizing bacteria on the flower formation, seeds fromation, and yields on the lowland, can be conclude that Bima variety was able to produces dry bulb per plot of 288.16 g equal to 16 ton/ha and percent of big bulb 86.34%. PSB inoculation could trigger the increasing rate of the number of plants flowering per plot, increasing the number of seeds per stalk and seed weight per plot in flowering plants. Bima variety with PSB inoculation was able to produce the highest seed weight per plot of 0.409g.

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