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Photoperiod and gibberellins effect on True shallot seed formation

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Abstract. Photoperiod play an important role on plant flowering while gibberellins were reported to increase vegetative growth and seed production on intact plants. True shallot seed is an alternative way to get shallot seedlings, and has more benefit than used bulb seedling. But, how to produce good true shallot seed in Indonesia it is not clear yet. This research was aimed to determine the effect of photoperiod and gibberellins on shallot (*Allium cepa* var *aggregatum*) flowering and true shallot seed production. The experiment was conducted at the Experimental Garden of Indonesian Vegetable Research Institute (IVEGRI) Lembang at altitude of 1,250 m above see level from December 2011 to August 2012. The research was arranged in split plot design with the first factor was photoperiod *i.e*. 10, 12, 14 and 16 hour, while the second factor was concentration of GA_3 *i.e*. 0, 50, 100 and 200 ppm. The analysis of variance indicated that photoperiod and GA_3 independently affected shallot flowering and true shallot seed production. The results also showed that, planting shallot at 12 hour day length increase flowering and this factor could not be substituted by GA_3 application. However, sowing in a photoperiod of 16 hours and application of 200 ppm GA_3, increase number of flower per umbel and true shallot seed production, do to both factors.
Key Words: Plant physiology, GA_3, flowering, true shallot seed, *Allium cepa* var *aggregatum*.

Introduction. Shallot (*Allium cep*a var *aggregatum* also known as *Allium cepa* L var *ascalonicum* Backer) belonging to family Alliaceae became one of the most important vegetables in Indonesia (Fritsch & Friesen 2002). It is used as spices vegetables on almost all Indonesian food. Shallot production in 2011 was 893,124 kg with yield area about 93,667 ha (Pusdatin 2012). Like a population growth, demand of shallot increase year by year. But, there's lack to fill it because potential land was limited and there was a problem on shallot seedlings. Bulb was common used as a shallot seedling has numerous disadvantages such as high of bulb seedling price, high volume, high transportation cost, needs big storage places, and contaminated seedling from the parental plants make shallot productivity low (Suherman & Basuki 1990; Permadi 1993; Sulistyaningsih 2004).

True shallot seed is alternative way to get shallot seedlings. It has more benefit than used bulb seedling *i.e*. healthier plant, bigger product, and higher yield (Putrasamedja 1995; Basuki 2009). But, how to produce good true shallot seed in Indonesia it is not clear yet. Indonesia is a tropic country but common Allium need long day and vernalization to get flowering (Rabinowitch & Kamenetsky 2002). Short day could delay flowering, but long day improved flowering on sub tropic onion and garlic (Khokar et al 2007; Mathew et al 2011). A long photoperiod had given than normal photoperiod can cause faster and simultaneous flowering (Lewis 2000). However, a response to photoperiod could be different inter species and varieties. Flowering also can be improved by plant growth regulators application *i.e*. gibberellins. 100 ppm of GA_3 able to increase flowering on local Warso variety, but couldn't replace vernalization (Sumarni & Sumiati 2001). Long daylight and GA_3 it is suspected to improve growth and flowering of shallot. The present study thought to evaluate the effects of photoperiod and GA_3 on

shallot flowering and true shallot seed production. It was assumed that long daylight and GA_3 application increase shallot flowering and true shallot seed production.

Material and Method. A field study of shallot was conducted at Experimental Garden of Indonesian Vegetable Research Institute (IVEGRI) Lembang in December 2011 to April 2012. The materials used the bulb seedlings of shallot cultivar Bali Karet, GA_3, chicken manure, NPK (15-15-15) fertilizer, energy saving lamps 23 watt (equivalent to 100 watt). Light intensity from lamps was measured by lux meter to make sure that the light intensity it is closed to the sun light intensity.

In the experiment split plot design with three replicates was used. The main plot was photoperiod *i.e*. 10, 12, 14 and 16 hour, while the sub plot was concentration of GA_3 *i.e*. 0, 50, 100 and 200 ppm. Additional to the long daylight night break was given at 22.00 - 24.00 (for 14 hours) and at 22.00 - 02.00 (for 16 hours). While termination photoperiod was performed by covering the plant with black plastic at 16.00 and open at 06.00 in the next day (for 10 hours). Photoperiod treatments given during 2 weeks from 3 weeks after planting until 5 weeks after planting. Each unit consists of three pots size diameter 30 cm and volume 8 kg soil, and each pot planting three sets shallot seedlings.

Before planting, Bali Karet bulb seedlings were selection higher than 5 g and lesser than 20 g and got vernalization about 3 weeks on 10 ^oC. Fertilizer dosage is 10 tons per ha chicken manure and 1000 kg per ha NPK 15-15-15. Data were subjected to analyses of variance (ANOVA) using SAS software.

Results and Discussion. Photoperiod and GA_3 effect on rate of plant growth can be seen in figure 1. Effect of photoperiod on shallot growth rate without GA_3 and with GA_3 in all concentration is displayed. But all of them have same trends *i.e*. rate of plant growth increase while photoperiod time increase too.

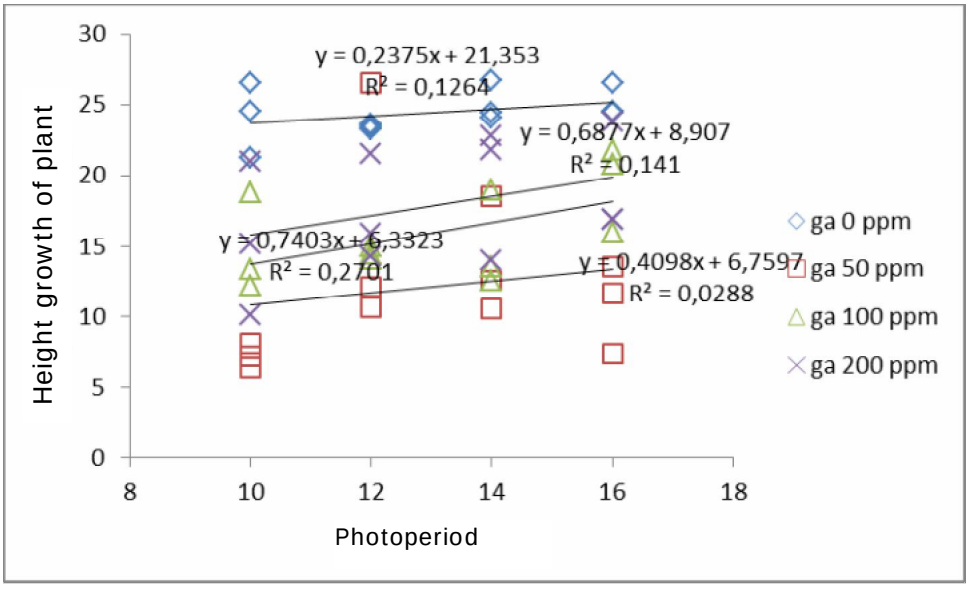

Figure 1. Effect of photoperiod on different GA_3 concentration to growth rate of shallot.

Photoperiod and GA_3 effect on flowering independently are shown in table 1. Long day treatments (14 and 16 hours) show number of umbel per plant higher than in normal photoperiod (12 hours). But, short day (10 hours) shows a percentage of flowering plant and number of umbel per plant lower than in a normal photoperiod. First flowering time for long day and normal day treatment was earlier than in the short day treatment. Rates of flowering percentage are shown in figure 2 & 3.

Table 1

Effect of photoperiod and GA_3 on shallot flowering

Treatments	*First flowering time (dap)*	*Percentage of flowering plant (%)*	*Number of umbel per plant*
Photoperiod:			
10 hours	35 b	3.70 b	0.42 c
12 hours	29 a	48.14 a	1.45 b
14 hours	29 a	50.92 a	1.96 a
16 hours	29 a	50.92 a	1.98 a
GA_3:			
0 ppm	31	30.55	1.68
50 ppm	30	38.89	1.40
100 ppm	30	43.51	1.59
200 ppm	30	40.74	1.13

dap – day after planting.

Photoperiod and GA_3 have a strong effect on vegetative growth and true shallot seed production. Effect of photoperiod on plant growth various in many species and cultivars (Farooqi et al 1999; Ekmekci & Terzioglu 2000; Yursak 2003). Recent research shows that long photoperiod increase plant growth. It was suggested because photoperiod was one of the direct factors that affect photosynthesis. On long photoperiod (14 hours and 16 hours) light reaction longer than a short day, so ATP and NADPH production increase. ATP and NADPH were used to convert carbon dioxide into organic molecules than eventually became plant biomass (Gardner et al 2008). This was caused vegetative growth on long photoperiod higher than in short photoperiod. Conversely, plants with short photoperiod experiencing slower growth than plants in normal and long photoperiod.

GA_3 increase vegetative plant growth. GA_3 application treatments had plant height, number of sets and number of leaves higher than without GA_3 (control), this means the plants grow faster. The same effect was found on other intact plant such as lettuce and jasmine (Rai & Laloraya 1967; Bey et al 2006). GA_3 could improve cell fragmentation and development (Mandang 2003).

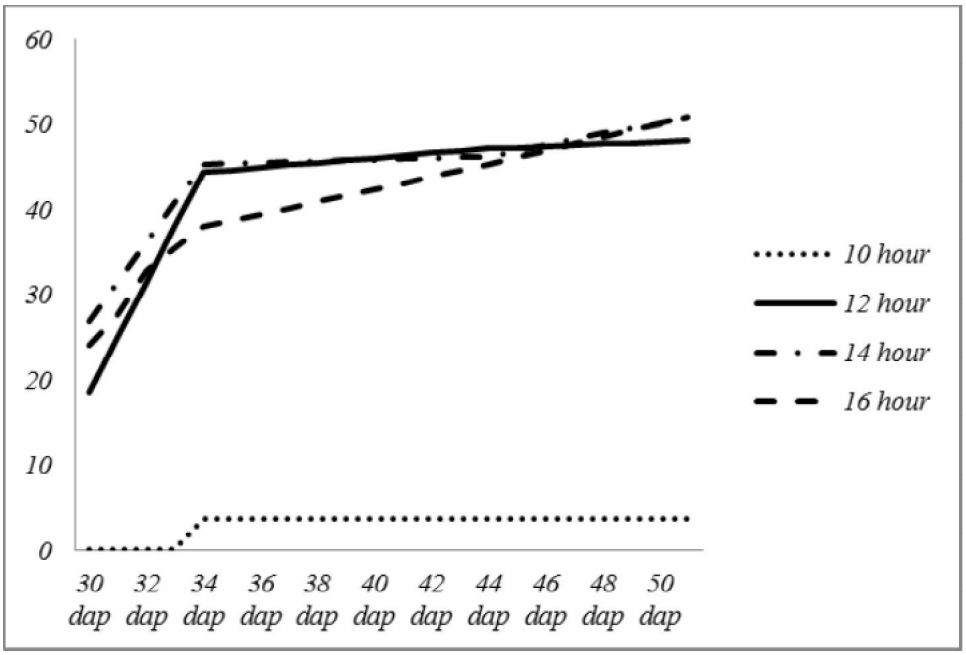

Figure 2. Rate of flowering percentage under different photoperiod.

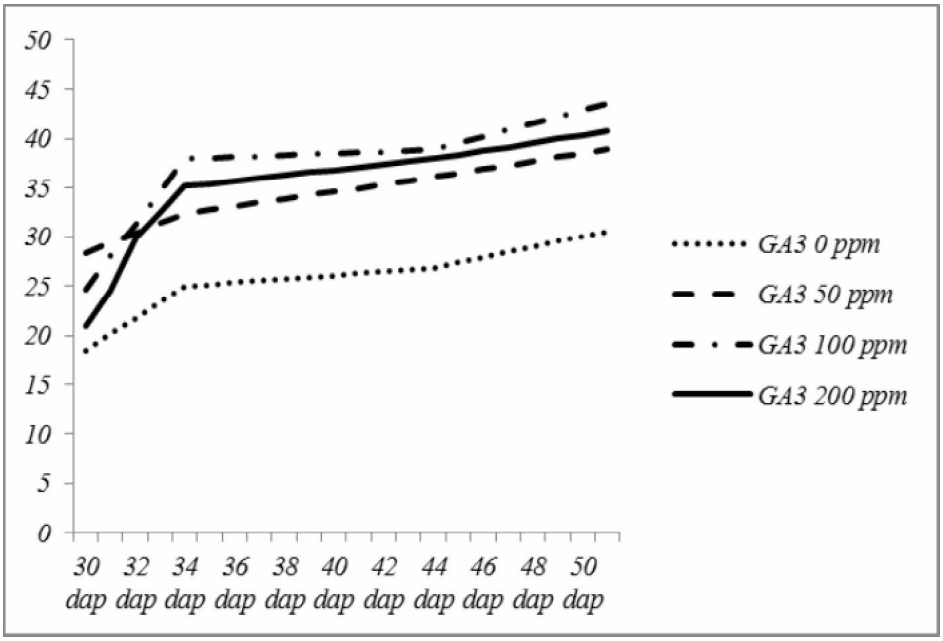

Figure 3. Rate of flowering percentage under different concentration of GA_3.

There was different response of GA_3 on different photoperiod. On short day condition (10 hours photoperiod) the best percentage flowering plant was without GA_3 or control, on normal day (12 hours photoperiod) was 100 ppm GA_3 and on long day (14 and 16 hours photoperiod) was 200 ppm GA_3. But, the results show that GA_3 application can't replace photoperiod on shallot. To investigate effect of photoperiod and GA_3 on true shallot seed production, 10 hours treatments were not determined. Photoperiod and GA_3 affect true shallot seed production varies independently (Table 2). Long photoperiod gave number of fruit per umbel and number of seeds per umbel higher than normal, but number of seeds per fruit not different.

Table 2

Effect of photoperiod and GA_3 on true shallot seed production

Treatments	*Number of harvested umbel*	*Number of fruits per umbel*	*Number of fill fruits per umbel*	*Number of seed per fruit*	*Number of seed per umbel*	*Weight of seed per umbel*
Photoperiod:						
10 hours	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
12 hours	6.3	68.0 b	31.9 c	2.9	90.8 c	0.33 c
14 hours	8.5	112.0 a	44.4 b	2.9	127.9 b	0.48 b
16 hours	8.1	134.1 a	55.9 a	3.2	175.2 a	0.66 a
GA_3:						
0 ppm	7.8	95.6 b	32.6 b	2.9	95.2 c	0.32 d
50 ppm	6.9	100.2 ab	44.0 a	3.0	131.4 b	0.49 c
100 ppm	9.9	113.4 a	48.3 a	2.9	140.0 ab	0.51 b
200 ppm	6.0	109.7 ab	51.4 a	3.1	158.6 a	0.62 a

n.d. – not determined.

Results shows that long day increase flowering and true shallot seed production. The best yield was found on 16 hours treatments (Figure 4). Dark period cut by light so the results is long day, but long day cut by dark period not affects on flowering (Gardner et al 2008). Long day could induce a faster flower initiation than normal (Sutisna 2010).

Effect of GA_3 on vernalization plant to flowering is various. Vernalization induced flowering with arranged GA_3 and inhibitor balance (Badr et al 1970). Thus GA_3 could

bolting effect and promote to flowering (Audus 1972). Vernalization results a hormone as a GA_3 precursor, in long day situation the hormone is transformed to GA_3 which promote to flowering, but in short day the transformation not occurring so the plant is still in vegetative phase (Chailakhyan 1968). On pea, GA_3 content depend on light intensity (Protasova et al 1980). On shallot, effect of vernalization on flowering shows when photoperiod is equal or higher than 12 hours but not on lower photoperiod. Just like on LDP plant *Craspedia globossa* where was shown that GA_3 is not able to replace long day effect to get flowering on short day (Annis et al 1992). Shallot needs minimum 12 hours to flowering.

GA_3 affect on flowering via number of fruit per umbel but not via number of umbel per plant. GA_3 also affect on number of filled fruit per umbel so weight of seed per umbel increase. The highest weight of seed per umbel can be achieved by 200 ppm GA_3 treatment. Contradictory with Sumarni & Sumiati (2001) where results showed that 100 ppm GA_3 is the best concentration for TSS production. The differences about the best concentration was because of the different cultivar which was used on the trials. But, the same effect found on them, that GA_3 application did not effect on increasing number of umbel per plant but increase weight of true shallot seed per umbel. This research also shows that GA_3 application increased shallot fruit set. It is suggested that GA_3 increase number of floret per umbel. GA_3 concentration effect weight of seed per umbel, when high concentration increase weight of seed per umbel. Effect of gibberellins on weight of seed was also found on other plants such as snap bean (Christiningsih 2008).

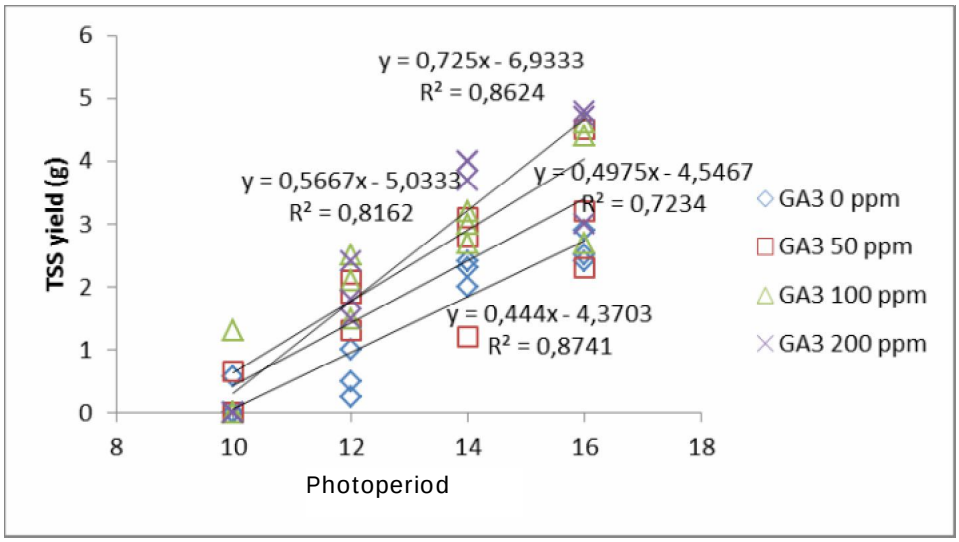

Figure 4. TSS yield per 9 plants.

Conclusions. Results from this study suggest that shallot need minimum 12 hours long day period to flowering, but fertilization increase when long daylight also increases. In particular, differences were observed in photoperiod and GA_3 level. Long photoperiod stimulates the shallot flowering, and this factor could not be substituted by GA_3 application. These differences in photoperiod effects may have an impact on true shallot seed production. The longer photoperiod must be further assessed in prospective trials.

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