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Original Article

Effect of gibberellin to honeydew severity and agronomical characters of soybean genotypes attacked by *Bemisia tabaci*

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Abstract

One of the factors that reduces soybean production is pest attack such as *Bemisia tabaci*. To increase soybean production, the physiological processes of the plant have to grow well causing optimal plant growth. It can be optimized by adding gibberellin. The research aimed to study the influence of gibberellin concentrations to honeydew severity and agronomical characters of soybean genotypes attacked by *Bemisia tabaci*. The gibberellin was given when the soybean plant was 35 days after planting. The gibberellin concentrations were 0, 25, 50, and 75 ppm. The result showed that the difference gibberellin concentrations did not affect honeydew severity, but the genotypes affected honeydew severity. The most susceptible genotype was shown by Gumitir. In the agronomical characters, UM 4-1 had the highest number of filled pods, but it was not significantly different from the variety of Wilis and UM 2-4. It was closely related to the number of total pods in which UM 4-1 also became the genotype producing the greatest number of total pods, although the yield was not quite different from the variety of Wilis and UM 2-4. Genotype of UM 4-1 also showed the highest number of total reproductive nodes per plant. The seed thickness was also influenced by genotype × gibberellins interaction. UM 2-4 at 50 ppm resulted the thickest seed. The 50 ppm concentration can provide an impact with the greatest number of total reproductive nodes per plant than the other concentrations. UM 2-4 also showed the highest number of total pod at 75 ppm concentration. The 50 ppm concentration is recommended to be given since it can influence the number of filled pod, number of total pods, seed thickness and number of total reproductive nodes per plant. The gibberellin concentration significantly influenced the number of filled pods, number of total pods, and number of total reproductive nodes per plant.

Keywords: agronomical characters, *Bemisia tabaci*, gibberellin, honeydew, soybean

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Introduction

Some factors cause the reduction of soybean production. One of them is pest attack (Chamzurni et al., 2011). One of the pests causing the decrease of soybean production is *Bemisia tabaci* (Zubaidah et al., 2009; Tay et al., 2012), the most harmful insect in the tropic and sub-tropic areas (Moreno et al., 2015; Padro et al., 2015). The harmful effect of *B. tabaci* attack to the soybean plant happens may due to the transmission of the virus (Brito et al., 2012). *B. tabaci* also indirectly affects plant growth by producing honeydew (Vieira et al., 2016) which is excreted by the adults and nymphs of *B. tabaci* and colonized by *Capnodium sp*. (Oliviera et al., 2001). Such damages influence some agronomy characters. The agronomy character is closely related to the soybean harvest. The agronomy characters are, for example, the unformed pods, the small size of the pod, the number of branches and reproductive nodes and the few pods (Kuswantoro et al., 2009). The damage of agronomy character can give impact to the reduction of soybean productivity (Zubaidah et al., 2010).

Some ways can be done to reduce the impact of the soybean plant suffering by reducing whitefly attack using a technique of integrated pest management (Firdaus et al., 2011), and artificial insecticide spraying that cause harmful effect to the environment (Cruz et al., 2016). Resistant variety can be developed through intercrossing technique that can produce genotype having the resistant character to *B. tabaci* attack. The plant also has a character of tolerant to the pest attack. Tolerant means a mechanism of compensation to the pest attack. Tolerant occurring in a plant, for example, is increasing the growth rate and photosynthesis rate after *B. tabaci* attack, increasing the production of hormone, allelochemical and enzyme oxide (Cruz et al., 2016). These cases explain that the adding of hormone production is one of the plant mechanisms to overcome the harmful effect insect attack.

Gibberellin is a hormone that responsible for the cell division and germination process of soybean (Kimbball, 1983), so that the plant can grow well, the bloom and fruit can grow well, the pods are big, the plant changes and increases the content of protein in the nut pods so that the quality of the pod increases as well (Ghalandare et al., 2011). Gibberellin can influence the process of protein content involved in secondary metabolism, cell cycle, and protein synthesis in the soybean so that the metabolism in the cell can run well (Oh, 2014). Gibberellin can return and recover the dwarf plant suffering from a particular disease (Hedden et al., 2015) as well as increase the soybean resistance of extreme environment (Hamayun, 2014; Jasim et al., 2016).

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Gibberellin is a beneficial growth hormone, and it can be found in all plant tissues. Naturally, a plant can produce gibberellin, but the number of the concentration of gibberellin in the plant is difficult to be studied (Gupta and Chakarabharty, 2013). The concentration of gibberellin given to the plant must be in proper concentration. If we give improper gibberellin hormone, either it is too little or too much, it can cause a harmful effect. Therefore, it is essential to differentiate the concentration of gibberellin to the plant; the right concentration of gibberellin influences high plant response (Ameeta and Nikita, 2016). The objectives of the research were to study the effect of gibberellin concentrations to honeydew severity and agronomical characters of soybean genotypes which attacked by *B. tabaci*.

Method

Site and Plant Materials

This research was conducted in the Indonesian Legume and Tuber Crops Research Institute, Malang, Indonesia from June to September of 2016. The plant materials of this research were genotypes of UM 4-1, UM7-2, UM 2-4, UM 7-6, UM 6-2 and two varieties of Gumitir and Wilis.

Research Design

The design of this research was factorial that was arranged in the randomized complete block design. The different concentration of gibberellin became the main factor and genotype became the second factor. This treatment was replicated three times.

Soil Preparation and Cultural Practice

This research was begun by preparing the planting media that was the soil scarified put into a polybag, and 10 kg of soil was mixed with 500 g manure per polybag. Planting was conducted by putting four seeds of soybean into the polybag. Thinning was carried out at 14 days after planting becoming 2 plants per polybag. Fertilizing was done at the beginning of planting with 0.363 g N, 0.917 g P, and 0.55 g K. The plants were watered at least twice in a week with about 1 liter of water for every polybag. Weeding was done manually by removing the weed.

Gibberellin Treatment

Application of gibberellin was conducted when the plant was 35 days after planting (DAP). The concentrations used were 0 ppm (K0), 25 ppm (K1), 50 ppm (K3), and 75 ppm (K4). The gibberellin was applied by spraying all parts of the plant.

Observation

The honeydew severity was measure using the score in Table 1.

Table 1.

Score	Symptom
1	The leave are looked healthy, there is no blackspot on the upper or lower of leaves surface, or the slight blackspot is found only on one of the leave surfaces
2	Slight blackspot is found on one of the leaves surfaces (upper or lower surface)
3	Medium blackspot on the entire leaves surfaces (upper and lower surface)
4	Medium blackspot covers one of the leaves surfaces, while dark blackspot covers the other leaf surface
5	The dark blackspot covers the entire surfaces of the leaves (upper and lower surfaces)

The honeydew severity is calculated as follows:

$$S = \frac{\Sigma(n.v)}{N.Z} \text{ X } 100\%$$

Where:
S = honeydew severity (%)
n = number of leaves in a certain score
v = score on a certain leaf
N = number of leaves per plant
Z = the highest score

The agronomical characters were observed at harvesting covering 1) pod length, 2) pod width, 3) pod thickness, 4) seed length, 5) seed width, 6) seed thickness, 7) number of branches, 8) number of total reproductive nodes per plant, 9) number of filled pods, 10) number of unfilled pods, 11) seed weight per plant, 12) weight of 100 seeds, 13) plant height, days to flowering, days to maturity. The seed and pod thickness were measured by using digital screw micrometer.

Statistical Analysis

The data were analyzed by using two ways ANOVA. If there was significant effect, the analysis was then continued by LSD at 5% significant level. The program for perform the analysis was SPSS 7.0.

Results

The analysis of the honeydew severity on the soybean leaf showed that there was a significant difference of different genotype of soybean from the honeydew severity. Besides the honeydew severity, the significant difference of genotypes was indicated by the character of number of filled pods, the number of total pods, number of total reproductive nodes per plant, the weight of 100 seeds and the seed weight per plant (Table 2). The analysis result showed that the significant interaction between the difference of genotype and the difference of gibberellin was found only in the seed thickness and seed weight per plant.

Honeydew severity was significantly different among the genotypes. The variety of Gumitir had the highest honeydew severity compared to the other genotypes. UM 7-2 had the second highest honeydew severity (Fig. 1). The lower honeydew severity indicates the higher resistance to honeydew or *B. tabaci* because honeydew is resulted by *B. tabaci* infestation

Table 2. Analysis of variance of agronomy character and honeydew severity on soybean

Character	MS of G×K	MS of Genotype	MS of Concentration	MS of error
Honeydew severity	14.2711	120.0612**	23.4292	24.2582
Plant height	376.525	137.496	297.488	1.194
Number of branches of the main stem	1.314	1.604	0.123	1.278
Pod length	0.501	0.647	0.507	1.194
Pod width	2.173	2.333	4.576	5.101
Pod thickness	0.782	0.935	1.781	2.301
Number of filled pods	242.125	1185.538*	918.877**	230.588
Number of unfilled pods	23.836	67.934	17.262	16.453
Number of total pods	199.188	856.431*	963.880**	209.148
Number of total reproductive nodes per	10.719	56.261*	35.786*	10.081
Seed length	849.472	758.489	854.621	829.244
Seed width	486.069	460.569	484.962	502.789
Seed thickness	2.081**	2.623	0.896	0.958
Weight of 100 seeds	1.034	15.604**	1.845	1.221
Seed weight per plant	5.975*	23.092**	4.842	3.189
Days to flowering	8.906	8.656	3.430	20.817
Days to maturity	0.906	0.751	0.513	0.804

Notes:
*significant at the rate of 5%
**significant at the rate of 1%

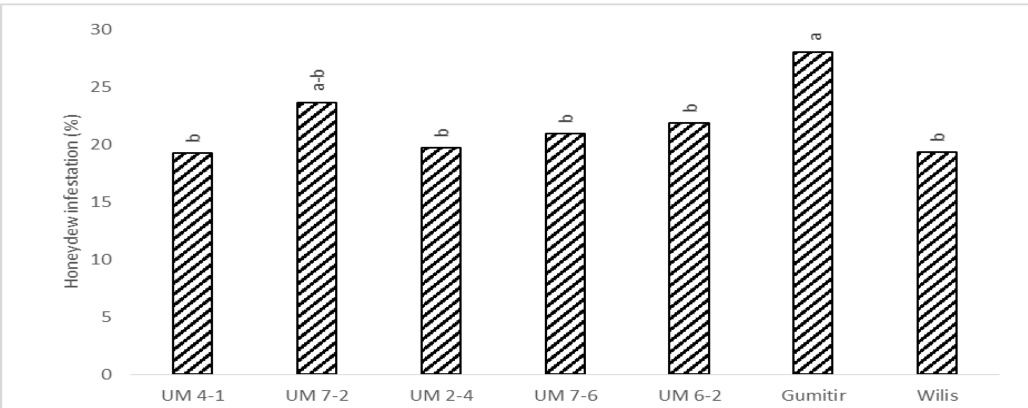

Figure 1. Honeydew severity of five soybean lines and two varieties

Data analysis of the number of total reproductive nodes showed that there was an influence of the difference of soybean genotype to the number of total reproductive nodes per plant. UM 4-1 had the highest number of total reproductive nodes per plant and it was significantly different from the other genotypes. UM 7-6 had the lowest number of total reproductive nodes per plant compared to the other genotypes. Gibberellin with different concentrations also affected the soybean reproductive node in which the concentration of 50 ppm could produce soybean with the highest number of reproductive nodes per plant (Fig. 2 and 3).

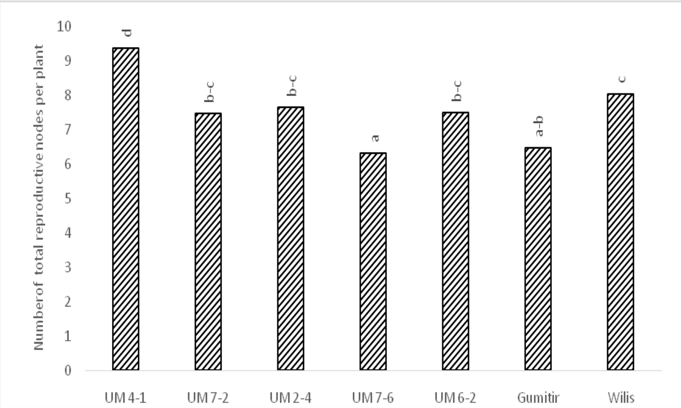

Figure 2. Number of reproductive nodes per plant of soybean genotypes

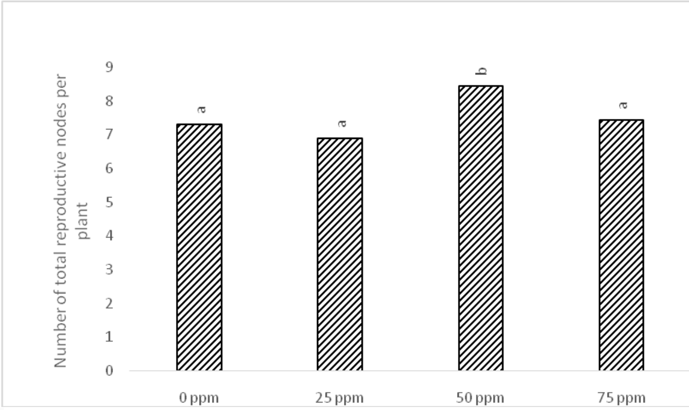

Figure 3. Effect of gibberellin on the number reproductive nodes

Based on the data analysis, the genotype difference significantly influenced the number of filled pods (Fig. 4). UM 4-1 showed the greatest number of the filled pod but was not significantly different from the variety of Wilis and UM 2-4, while UM 7-6 revealed the lowest number of filled pods. The gibberellin also showed significant influence (Fig. 5). In the treatment with the gibberellins concentration of 50 ppm, the plant could produce soybean with the most number of filled pods, but the number was not significantly different from the soybean with 75 ppm of gibberellin.

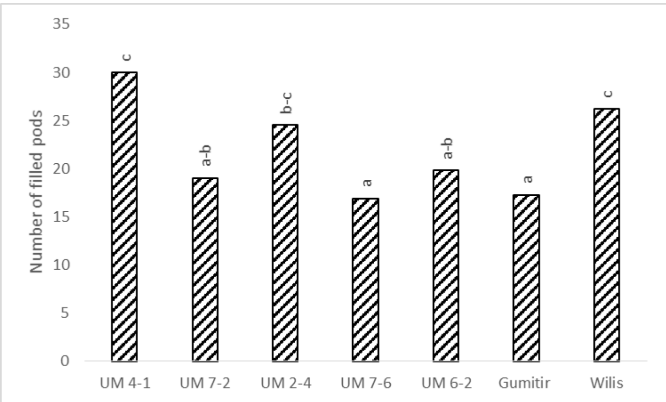

Figure 4. Number of filled pods of soybean genotypes

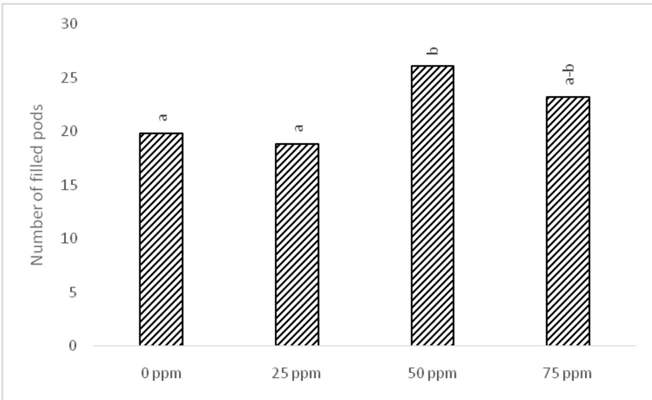

Figure 5. Effect of gibberellin on the number of filled pods

The data analysis of a number of total pods per plant shows that there was an influence of different soybean genotype on the number of total pods (Fig. 6). Based on the analysis, we can see that UM 4-1 was the genotype with the highest number of total pod, but this result was not significantly different from the variety of Wilis and UM 2-4. The treatment of gibberellin with different concentration also influenced the number of total pods significantly (Fig. 7). The treatment of gibberellin at 50 ppm could produce soybean with the highest number of total pods. Concentration of 25 ppm also showed the lowest number of total pods, but this case was not significantly different from the concentration of 0 ppm.

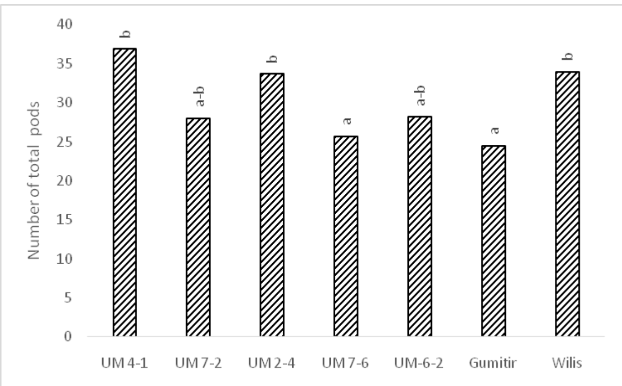

Figure 6. Number of total pods of soybean genotypes

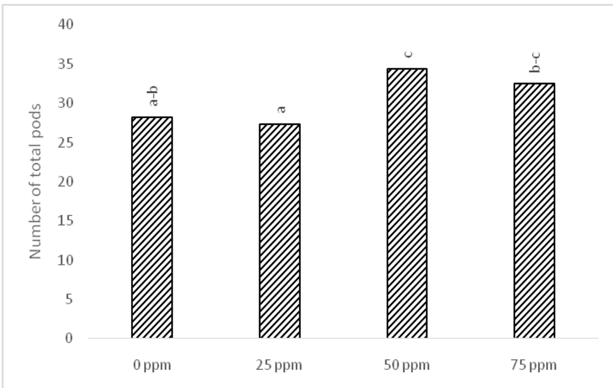

Figure 7. Effect of gibberellin on the number of total pods

The combination treatment of different genotype and gibberellin concentrations affected the soybean seed thickness significantly. Based on two ways ANOVA test which was continued with BNT test, it was found that UM 2-4 at 50 ppm showed the thickest seed and this was not significantly different from the variety of Gumitir. However, it was not only at 50 ppm, but 25 ppm also showed the same result. The data analysis also revealed that UM 7-2 at the 25 ppm produced the thickest seed, and it was significantly different from the other genotypes (Fig. 8).

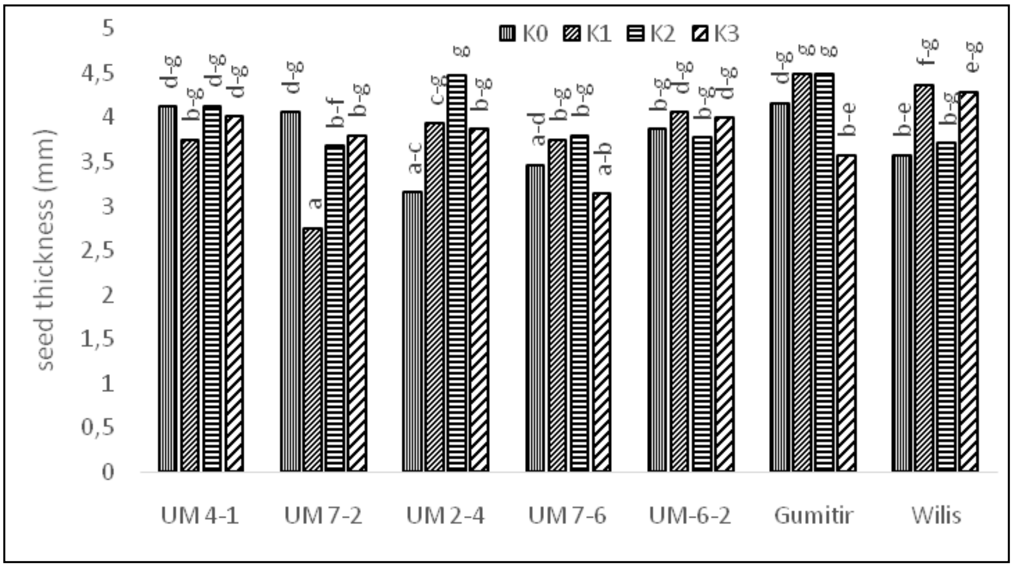

Figure 8. Interaction between genotype × gibberellin concentration on the seed thickness

The data of weight of 100 seeds showed significantly different on the genotype. Fig. 9 indicates that UM 4-1 produced the heaviest weight of 100 seeds, but this result was not different from the check variety of Gumitir and Wilis. Genotype of UM 7-2 was found as a genotype with the lightest seed. The other genotype of UM 2-4, UM 7-2 and UM 6-4 were not significantly different with UM 7-2 (Fig. 9).

The influence appeared in the seed thickness also affected the seed weight per plant. Interaction between genotype and gibberellin showed the effect of the seed weight per plant. Based on the LSD test, UM 2-4 showed the highest seed weight per plant at concentration of 75 ppm. However, UM 2-4 at 75 ppm was not different from the variety of Wilis at 50 ppm. UM 7-6 at the concentration of 0 ppm showed the lowest seed weight per plant, and it was not significantly different with UM 6-2 at 25 ppm (Fig. 10).

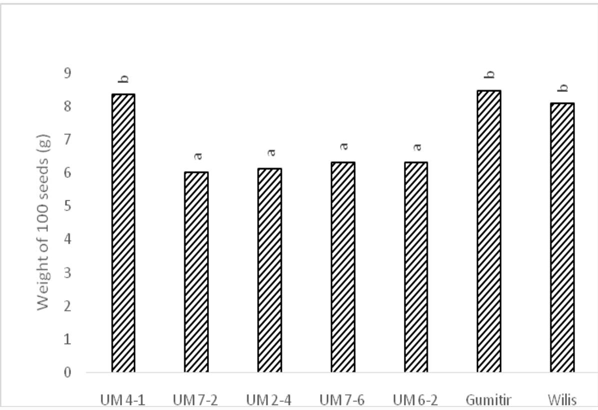

Figure 9. Weight of 100 seeds of soybean genotypes

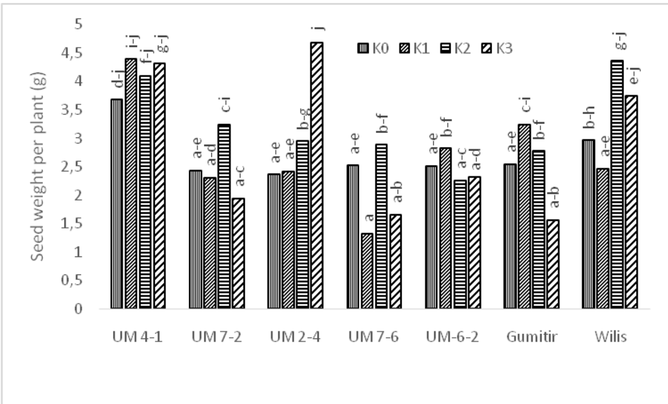

Figure 10. Interaction between genotype × gibberellin concentration on the seed weight per plant

Discussion

B. tabaci can damage the host plant directly and indirectly. The intensity of *B. tabaci* also affected the rise of honeydew on the soybean leaf surface. It is caused by the accumulation of honeydew, and then it becomes a media of fungi to live (Cruz et al., 2016; Chaubey, 2014). The result of observation of the honeydew severity showed that the variety of Gumitir was the one got the highest attack. The variety of Gumitir in this research was the checker variety which was susceptible to the whitefly attack. The intensity rate of *B. tabaci* was directly correlated to the production of soybean pod or seed (Sulistyo and Nugrahaeni, 2014). The number of filled pods and total pods per plant of Gumitir variety were lower than the other genotypes. The factor of the intensity of *B. tabaci* attack also became one of the factors influencing the appearance of some variations of soybean character (Sutrisno and Kuswantoro. 2016).

The different genotype resulted the different number of filled pods. The highest number of filled pods was shown by UM 4-1. The second was the variety of Wilis. Gibberellin at the concentration of 50 ppm achieved the highest number of filled pods. Gibberellin is useful in enhancing the forming of pod indirectly through photosynthetic way (Raoofi et al., 2014; Rana and Kumar, 2005). The number of filled pods is an agronomy character of soybean influencing the seed weight per plant (Kuswantoro et al., 2016). Gibberellin can stimulate the cell expansion and division, and later it affects the plant height as well as the leaf area. This leaf expansion can stimulate the maximum photosynthesis, and then it contributes to the production of vegetative part of the plant including plant height (Khan et al., 2006).

The number of filled pods was correlated to the number of total pods. The higher the number of filled pods produced, the number of total pods is getting higher as well. UM 4-1 became the genotype resulting the highest number of filled pods and the number of total pods. Gibberellin is beneficial in increasing the pod forming and pod filling (Moeller et al., 2012). The number of total pods was different in every genotype although some genotypes showed not significantly different on total pods. The soybean genotypes with different genetic constitution significantly influences the yield (Chamzurni et al., 2012). For instance, UM 4-1 had significantly different on number of total pods than the check variety of Wilis and Gumitir.

UM 2-4 with the gibberellin concentration of 50 ppm showed the influence that could produce the seed thickness. Gibberellin to the nuts plant can increase the content of protein in the nut seed so that the quality of the seed increases as well (Ghalandare et al., 2011). The substance to set the growth in the form of gibberellin is very important to help the process of creating the seed and seed germination (Patel and Mankad, 2014; Ajalfew, 2016). Gibberellin is a hormone stimulating the growth, and it shows positive contribution in enhancing the plant production such as pods and seed (Bello et al., 2015). In this study, the concentration of 50 ppm was the concentration causing the thickest seed although the result was different in other genotypes.

The ability of gibberellin in increasing the quality of soybean seed influences the weight of 100 seeds. Analysis of the weight of 100 seeds showed genotype difference affected the weight of 100 seeds but the effect of concentration variation and combination of genotype and concentration did not appear. Weight of 100 seeds describes the largeness of soybean seed (Kuswantoro et al., 2016). Weight of 100 seeds is one of the agronomical characters related positively to harvest since it is closely linked to the seed weight per plant (Alakhder et al., 2015; Firdaus et al., 2011). This research showed that gibberellin could influence the soybean seed thickness and it directly influenced the weight of 100 seeds.

The number of total reproductive nodes per plant is correlated to the potential of soybean plant in flowering that later becomes the pod and influences seed yield (Chamzurni et al., 2012). Gibberellin sprayed to the plant can induce the forming of the branch and reproductive nodes (Khan et al., 2006). Gibberellin, through its mechanism in stimulating cell division in meristem areas can stimulate the forming of a vegetative branch of the plant (Kwiatkowska and Godlewski, 2008; Moeller et al., 2012). UM 4-1 became the genotype with the highest number of filled pods and a number of total pods as well as the genotype with the greatest number of total reproductive nodes per plant. It means that the higher the number of total reproductive nodes per plant, the potential of soybean production is getting higher as well.

The concentration of gibberellin in this study could not influence the agronomical characters such as pod length, pod width, pod thickness, seed length, seed width, the number of branches, the number of unfilled pod, the days to flowering, days to maturity, and plant height. It may be due to the gibberellin concentration is not suitable to influence these characters. For example, Sajid et al. (2016) reported that gibberellin could increase the number of branches of *Crysanthemun* plant at the high concentration about 250 mg. Therefore, gibberellin concentration should be added to reach such condition.

Gibberellin is a useful hormone to escalate the dormancy period to germination period (Rana and Kumar, 2005; Brian, 2008) in which this acceleration influences the flowering time and pods maturity; the flowering process to seed maturity are related each other (Alakhder et al., 2015). Gibberellin can stimulate the early flowering of the plant, but the gibberellin concentration should be at the high level; gibberellin can stimulate the flowering at the concentration of 200-300 mg (Sajid et al., 2016). Therefore, the concentration given in this study might be too low to stimulate the flowering acceleration.

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