An Analysis on the Effect of Atonik Plant Growth Regulator on the Growth and Yield of Several Early Maturing Soybean (Glycine Max L.) Genotype

Andhika Bara Alhuda[1*], Aman Suyadi[2], Gayuh Prasetyo Budi[3], Heru Kuswantoro[4]

[1,2,3]Agrotechnology Study Program, Faculty of Agriculture and Fisheries, Universitas Muhammadiyah Purwokerto. Jl. KH. Ahmad Dahlan, Dusun III, Dukuhwaluh, Kembaran, Banyumas Regency 53182, Jawa Tengah, Indonesia

[4]Research Center for Food Crops - Research Organization for Agriculture and Food, National Research and Innovation Agency – BRIN. Cibinong Science Center-Botanical Garden, Jl. Raya Jakarta-Bogor Km. 46 Cibinong – Bogor Regency – 16911 – Indonesia

*Corresponding Author

Received:- 02 July 2023/ Revised:- 10 July 2023/ Accepted:- 19 July 2023/ Published: 31-07-2023

Abstract— *This research aims to determine the effect of Atonik plant growth regulator (PGR) on the growth and yield of early maturing soybean (Glycine max L.) genotype. The study was conducted as a field experiment using polybags and employed a split plot design (SPD) with two factors. The main factor was four concentrations of Atonik PGR (Z), namely ZO (0 ml/l), Z1 (0.5 ml/l water), Z2 (1 ml/l water), and Z3 (1.5 ml/l water). The sub-factor was the soybean genotypes (G), which were G1 (GH 8 soybean line), G2 (GH 63 soybean line), G3 (GH 73 P soybean line), and G4 (Dega 1 soybean variety). The combinations of treatments were replicated three times. The observed variables included the number of leaves, the number of productive branches, the number of seeds each plant, the weight of seeds each plant, and the weight of 100 seeds. The research findings showed that the concentration of Atonik PGR at 1 ml/l water resulted in the highest number of productive branches, which is 5.25 branches, the highest number of seeds each plant, which is 55.14 seeds, and the heaviest weight of seeds each plant, which is 9.34 g. The concentration of Atonik PGR at 1.5 ml/l water produced the heaviest weight of 100 seeds, which is 23.21 g. The GH 63 soybean line produced the highest number of leaves each plant, which is 92.77 leaves, and the highest number of productive branches each plant, which is 5.25 branches. The GH 8 soybean line produced the highest number of seeds each plant, 62.16 seeds, and the heaviest weight of 100 seeds each plant, 20.49 g. The Dega 1 soybean variety produced the heaviest weight of seeds each plant, which is 9.90 g.*

Keywords— Soybean (Glycine max L.), PGR, GH 8, GH 63, GH 73 P, Dega 1.

I. INTRODUCTION

Soybean (*Glycine max* (L) Merril) is an essential commodity in agriculture, particularly as a source of raw materials for industries, feed, and food. Soybeans are a food source with numerous benefits, providing plant-based protein and fats, while soybean oil produces vitamin E (Sunarto, 2000). Soybean is a significant commodity alongside rice and corn due to its high nutritional content, mainly plant-based protein (Jusniati, 2013).

The demand for soybeans in Indonesia is high, but its supply needs to be increased due to low production, leading to heavy reliance on imports. Low cultivation technology, reduced planting areas, cheap imported soybeans, and prolonged dry seasons have contributed to low domestic soybean production (Rahmasari et al., 2016).

The increasing population in Indonesia has resulted in a higher demand for soybeans (Permadi, 2015). One way to optimize soybean productivity is by using plant growth regulators (PGRs). PGRs are non-nutritional organic compounds that are active in optimal concentrations to stimulate, inhibit, or modify plant growth and development. The use of PGRs aims to control plant growth. Some commonly used PGRs are relatively expensive and difficult to obtain. Thus, alternative synthetic PGRs are needed (Lestari, 2011).

Atonik is a liquid plant growth regulator (PGR) with a brownish color, belonging to the group of auxins. It contains active ingredients such as triacontanol, sodium phenolic (Na-Ortonitrophenol 0.2%, (C6H4NO3Na) 0.3%), Na-paranitrophenol (CP6H4NO3Na) 0.1%, Na-5 nitroquaniakol (C7H6NO3Na), and 0.5% Na-2,4 dinitrophenol (CP6H3N2O5Na). The Na+ ion functions as a carrier of metabolites in the metabolic process and can partially replace the function of the K+ ion. The primary function of Atonik is to stimulate plant growth (Ritonga, 2020).

Several studies have shown that applying plant growth regulators (PGRs) through leaves enhances plant growth and yield compared to soil application (Hanolo, 1997). This is because the use of Atonik PGR can affect the number of plant leaves. Atonik is a synthetic growth-promoting substance that stimulates root growth, activates nutrient uptake, increases bud emergence, and improves plant quality (Trisna, 2013).

Ismail and Effendi (1985) stated that early-maturing soybeans benefit farmers as they allow crop rotation with rice and help avoid water shortages during soybean growth. Furthermore, early-maturing soybeans can provide advantages such as reducing pest attacks and increasing the crop index yearly. In some soybean production centers, early-maturing varieties with larger seed sizes are preferred by farmers (Krisnawati and Adie, 2007).

Based on the information above, it is necessary to conduct research using Atonik PGR to analyze its effect on the growth and yield of early-maturing soybean genotypes (*Glycine max* L.).

II. MATERIALS AND METHODS

2.1 Research Location

The research was conducted at the Indonesian Legume and Tuber Crops Research Institute (BALITKABI) or Kendalpayak Village, Pakisaji District, Malang Regency. It is located at coordinates 8° 2' 56.4"LS 112° 37' 30"BT with an elevation of 445 meters above sea level. The Applied Agrotechnology Laboratory, Faculty of Agriculture and Fisheries, Universitas Muhammadiyah Purwokerto, was also used for the research. The research was conducted from September 2022 to January 2023.

2.2 Procedure

The research was a polybag field experiment and employed a split plot design (SPD) with two factors. The main factor consisted of four concentrations of Atonik PGR (Z): ZO (0 ml/l), Z1 (0.5 ml/l water), Z2 (1 ml/l water), and Z3 (1.5 ml/l water). The sub-factor was the soybean genotypes (G): G1 (GH 8 soybean line), G2 (GH 63 soybean line), G3 (GH 73 P soybean line), and G4 (Dega 1 soybean variety), with each treatment replicated three times. The observed variables included the number of leaves, the number of productive branches, the number of seeds each plant, the weight of seeds each plant, and the weight of 100 seeds.

The research procedure involved the preparation of the planting medium, which was a mixture of compost and inceptisol soil in polybags. Two soybean seeds were planted in each polybag, and the Atonik PGR was applied according to the specified concentrations. The PGR was sprayed onto the entire plant every 10 days until 60 days after planting. PGR application began 10 days after sowing (das), and the solution was sprayed on the entire plant until it dripped onto the soil.

2.3 Data Analysis

The data obtained from the observations were analyzed using the F-test at a 95% confidence level. The analysis continued with the Duncan Multiple Range Test (DMRT) at a 5% confidence level using Costat Statistical Software if significant differences were found.

III. RESULT AND DISCUSSION

TABLE 1
THE RESULTS OF THE ANALYSIS OF THE VARIABLE NUMBER OF LEAVES OF THE FOUR LINES OF SOYBEAN AND THE ADMINISTRATION OF GROWTH REGULATORS

Treatment	21 Das	28 Das	35 Das	42Das	49 Das	56 Das	63 Das	70 Das
Atonik Growth Regulatory Substances								
Atonik 0 ml/l (Z0)	12.83 a	19,10 a	28.20 a	39,16 a	55.00 a	65.89 a	74,16 a	79.47a
Atonik 0.5 ml/l (Z1)	12.58 a	19.02 a	28,16 a	39.45 a	55,64 a	68.50 a	76,29 a	80.77a
Atonik 1 ml/l (Z2)	12,18 a	19.62 a	29,18 a	40.85 a	59.02 a	70,70 a	79.33 a	83.95a
Atonik 1.5 ml/l (Z3)	12.72 a	18.83 a	29,29 a	38.77 a	58,16 a	69.52 a	76.79 a	80.08a
Soybean lines								
GH 8 (G1)	12.79 ab	19.02 a	28.43 b	40.91 b	56.91b	69.87 b	78.12 b	81.68 b
GH 63 (G2)	13.91 a	21.93 a	33,64 a	44.72 a	67,29 a	78.41 a	87.52 a	92.77 a
GH 73 P (G3)	11.43c	16.70 c	22.97 c	33.33 c	48.14c	61.33 c	68.75 c	72.95 c
Dega 1 (G4)	12.18 bc	18.91b	29.79 b	39,27 b	55,47 b	65.00 c	72.18 c	76.87 bc
DMRT 5%	1.25	1.48	2.59	3.75	4,27	4.84	5.08	5,24

Numbers followed by the same letter in the same column and treatment indicate no significant differences in the DMRT test at the 5% confidence level

3.1 The number of leaves

Table 1 shows that the concentration of PGR has no significant effect on the number of leaves at all observation ages. This suggests that the given concentration of Atonik may not have been sufficient to increase the leaf count and accelerate leaf formation, potentially due to suboptimal Atonik concentration. This aligns with the statement made by Uluputty (2015), which suggests that applying PGR in the appropriate concentration yields favorable results, but excessive concentrations might hinder plant growth.

The difference in soybean genotypes significantly affected the number of leaves at 21 DAS, 28 DAS, 35 DAS, 42 DAS, 49 DAS, 56 DAS, 63 DAS, and 70 DAS. This can be attributed to the distinct genetic characteristics of the four pure genotypes, as genes affect the traits and attributes of living organisms, including plant body shape, flower color, and fruit taste. Genes also determine metabolic capabilities, greatly impacting plant growth and development.

The difference in soybean genotypes significantly affects the number of leaves at 21 HST, 28 HST, 35 HST, 42 HST, 49 HST, 56 HST, 63 HST, and 70 HST. This is likely because the four pure genotypes have distinct genetic characteristics. Genes play a crucial role in determining the traits and characteristics of living organisms, including plants, influencing their body shape, flower color, and fruit taste. Genes also govern the metabolism's capability, thus significantly impacting plant growth and development.

The study revealed that the GH 63 (G2) soybean genotype exhibited the highest number of leaves at each observation age. At 21 days after sowing (DAS), it produced 13.91 leaves, which is 8.75% more compared to the GH 8 (G1), 21.70% more and significantly different from the GH 73 P (G3), and 14.20% more and significantly different from the Dega 1 (G4). At 28 DAS, it produced 21.93 leaves, which is 15.30% more and not significantly different from the GH 8 (G1), 31.31% more and significantly different from the GH 73 P (G3), and 15.97% more and significantly different from the Dega 1 (G4). At 35 DAS, it produced 33.64 leaves, which is 18.33% more and significantly different from the GH 8 (G1), 46.45% more than the GH 73 P (G3), and 16.76% more than the Dega 1. At 42 DAS, it produced 44.72 leaves, which is 9.31% more and significantly different from the GH 8 (G1), 34.17% more than the GH 73 P (G3), and 16.35% more than the Dega 1. At 49 DAS, it produced 67.29 leaves, which is 18.24% more and significantly different from the GH 8 (G1) line, 39.78% more than the GH 73 P (G3), and 24.55% more than the Dega 1. At 56 DAS, it produced 78.41 leaves, which is 12.22% more and significantly different from the GH 8 (G1), 27.85% more than the GH 73 P (G3), and 21.87% more than the Dega 1. At 63 DAS, it produced 87.52 leaves, which is 12.03% more and significantly different from the GH 8 (G1) line, 27.30% more than the GH 73 P (G3), and 22.31% more compared to the Dega 1. At 70 DAS, it produced 92.77 leaves, which is 13.58% more and significantly different from the GH 8 (G1), 27.17% more than the GH 73 P (G3), and 20.68% more compared to the Dega 1.

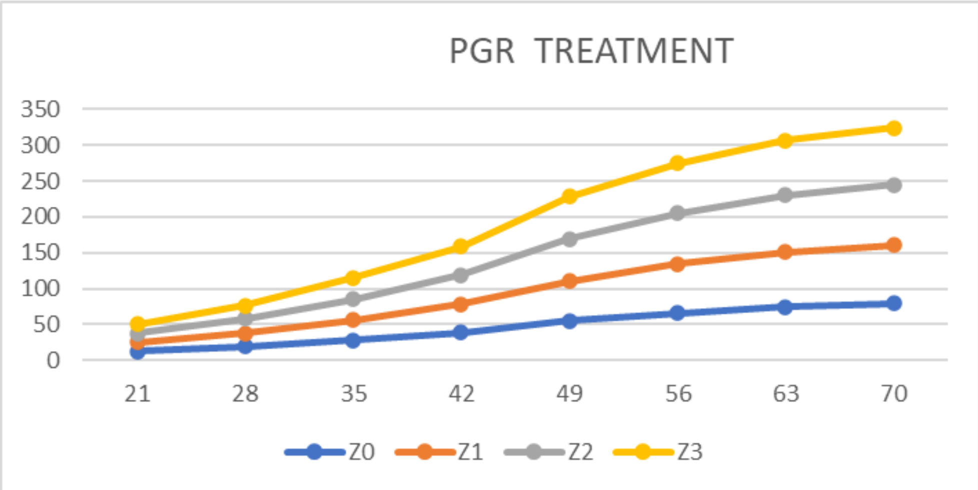

FIGURE 1: The effect of Atonik PGR concentration on the growth of the number of leaves of soybean plants

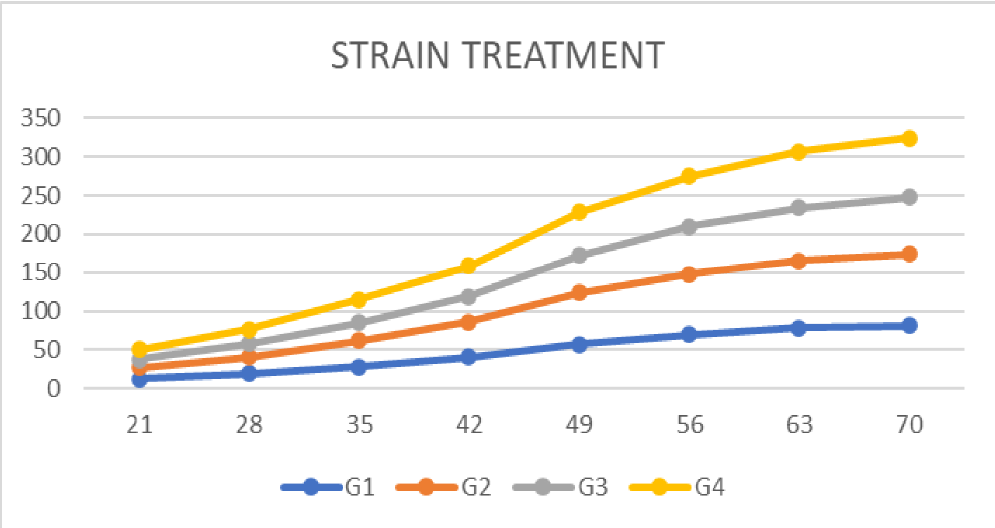

FIGURE 2: The effect of different expected ED lines on the growth of the number of leaves of soybean plants

The data illustrates that the GH 8 (G2) has the greatest number of leaves, so its photosynthetic ability is higher and will increase vegetative and generative growth. Umarie (2001) states that there are real variations and differences in all the plant characteristics observed. This is because the lines tested come from various sources and have gone through selection.

The results of data analysis on the effect of Atonik PGR and soybean lines on productive branch variables, number of seeds, seed weight, and weight of 100 seeds are presented in table 2. Table 2 shows that Atonik PGR and soybean lines significantly affect productive branches, number of seeds, seed weight, and drilled 100 seeds.

TABLE 2
THE ANALYSIS OF NUMBER OF PRODUCTIVE BRANCHES, NUMBER OF SEEDS, WEIGHT OF SEED, AND WEIGHT OF 100 SEEDS FOR FOUR SOYBEAN GENOTYPES WITH THE APPLICATION OF PLANT GROWTH REGULATOR

Treatment	Number of Productive Branches	Number of Seeds Each Plant	Seed Weight Each Plant	Weight of 100 Seeds
Atonik Growth Regulatory Substances				
Atonik 0 ml/l (Z0)	4.75 ab	52.89 a	9.08 ab	17.30 c
Atonik 0.5 ml/l (Z1)	4.68 ab	43.37 b	7.60 b	18.83 bc
Atonik 1 ml/l (Z2)	5,25 a	55.14 a	9.34 a	19.25 b
Atonik 1.5 ml/l (Z3)	4.60 b	53,52 a	8.91 ab	23,21 a
Soybean lines				
GH 8 (G1)	4.97 ab	62,16 a	9.61 ab	20,49 a
GH 63 (G2)	5.39 a	47.70 b	8.27 bc	19.65 ab
GH 73 P (G3)	4.64 bc	44.16 b	7,16 c	19.92 ab
Dega 1 (G4)	4.27 c	50.89 b	9.90 a	18.52 b
DMRT 5 %	0.58	9,15	1.50	1.80

Numbers followed by the same letter in the column and the same treatment showed no significant difference in the 5% DMRT test

3.2 The Number of Productive Branches

Table 2 shows that the concentration of Atonik plant growth regulator significantly affects the number of productive branches. This is likely because the auxin hormone present in Atonik can affect the growth of productive branches. As Pollard and Walker (1990) stated, the physiological role of auxin is to promote cell elongation, differentiation of xylem and phloem tissues, and root formation. The increase in the number of branches in plant genotypes is affected by the concentration of auxin in the region of the branch primordial (Naeem et al., 2004).

The research results show that the treatment with Atonik at a concentration of 1 ml/l (Z2) resulted in the highest number of productive branches, which is 5.25 branches. This is not significantly different from the concentration of 0 ml/l of Atonik (Z0), the concentration of 0.5 ml/l of Atonik (Z1), but significantly different from the concentration of 1.5 ml/l of Atonik (Z3). The concentration of 1 ml/l of Atonik resulted in 10.53% more productive branches compared to the concentration of 0 ml/l of Atonik (Z0), 12.18% more productive branches compared to the concentration of 0.5 ml/l of Atonik (Z1), and 13.89% more productive branches compared to the concentration of 1.5 ml/l of Atonik (Z3).

Table 2 also indicates that the difference in soybean lines significantly affects the number of productive branches. This is likely because photosynthesis results affect the varying number of branches. The GH 63 (G2) produced the highest number of leaves, producing photosynthates more. The allocation of photosynthates to the branch parts also increased, leading to the highest number of branches. The higher the number of branches in one variety, the more leaves are produced, increasing photosynthates (Sa'diyah et al., 2016).

The research results show that the GH 8 (G2) produced the highest number of productive branches, which is 5.39 branches, significantly different from the GH 73 P (G3), the Dega 1 (G4), but not significantly different from the GH 8 (G1). The GH 63 (G2) produced 8.45% more productive branches compared to the GH 8 (G1), 16.16% more productive branches compared to the GH 73 P (G3), and 24.14% more productive branches compared to the Dega 1 (G4).

3.3 Number of Seeds Each Plant

Table 2 shows that the concentration of Atonik plant growth regulator significantly affects the number of seeds each plant. This is likely because the plant quickly absorbs Atonik, stimulates protoplasmic flow in cells, and accelerates germination and rooting. However, if the concentration is excessive, it can inhibit plant growth. The optimal concentration of Atonik when sprayed through the leaves increases protein synthesis, and the synthesized proteins are used as building materials for the plant. Atonik in an optimum concentration, stimulates the growth of branches and productive nodes, thus increasing the number of pods and seeds each plant. Atonik functions inside the plant to promote plant growth, increase yield, improve quality, and enhance crop productivity (Lestari, 2011).

The research results show that the PGR treatment with Atonik at a concentration of 1 ml/l (Z2) resulted in the highest number of seeds each plant, which is 55.14 grains. This is not significantly different from the concentration of 0 ml/l of Atonik (Z0), the concentration of 1.5 ml/l of Atonik (Z3), but significantly different from the concentration of 0.5 ml/l of Atonik (Z1). The concentration of 1 ml/l of Atonik resulted in 4.25% more seeds each plant compared to the concentration of 0 ml/l of Atonik (Z0), 27.14% more seeds compared to the concentration of 0.5 ml/l of Atonik (Z1), and 3.74% more seeds compared to the concentration of 1.5 ml/l of Atonik (Z3).

Table 2 also indicates that the difference in soybean lines significantly affects the number of seeds each plant. This is likely due to the different flowering factors and environmental conditions that support each strain, as stated by Somaatmadja (1993), indicating that flowering factors and supportive environmental conditions during pod filling determine the number of formed seeds. According to Hakim (2010), the weight of seeds each plant correlates positively with the number of seeds each plant, indicating that more leaves result in more seeds and heavier seed weight.

The research results show that the GH 8 (G1) produced the highest number of seeds each plant, which is 62.16 grains, significantly different from the GH 63 (G2), the GH 73 P (G3), and the Dega 1 (G4). The GH 8 (G1) produced 30.31% more seeds compared to the GH 63 (G2), 40.76% more seeds compared to the GH 73 P (G3), and 25.52% more seeds compared to the Dega 1 (G4).

3.4 The Weight of Seed Each Plant

Table 2 indicates that the PGR concentration of the plant growth regulator Atonik has a significant effect on the weight of seeds each plant. This is likely because Atonik stimulates the process of photosynthesis. When photosynthesis is functioning well, it results in higher levels of carbohydrates, fats, and proteins. Carbohydrates, fats, and proteins are the components that make up soybean seeds, and the higher their levels, the greater the number of seeds produced, thus affecting the weight of seeds produced (Anisa et al., 2022).

The research results show that the PGR treatment with Atonik at a concentration of 1 ml/l (Z2) resulted in a weight of seeds each plant of 9.34 g, which is not significantly different from the concentration of 0 ml/l of Atonik (Z0), the concentration of 1.5 ml/l of Atonik (Z3), but significantly different from the concentration of 0.5 ml/l of Atonik (Z1). The concentration of 1 ml/l of Atonik (Z2) produced 2.86% more weight compared to the concentration of 0 ml/l of Atonik (Z0), 22.89% more weight compared to the concentration of 0.5 ml/l of Atonik (Z1), and 5.66% more weight compared to the concentration of 1.5 ml/l of Atonik (Z3).

Table 2 also shows that the difference in soybean lines significantly affects the weight of seeds each plant. This is likely due to the variations and results of each genotype caused by their different adaptation abilities, even when grown in the same area. The genotypes respond differently to environmental conditions, such as water availability (Josipović et al., 2011). The GH 8 line (G1) produced the highest number of seeds each plant, which is 62.16 g, resulting in the heaviest weight of seeds each plant, which is 9.61 g, not significantly different from the Dega 1 (G4) at 9.90 g.

The research results show that the treatment with the Dega 1 soybean (G4) resulted in the highest weight of seeds each plant, which is 9.90 g, significantly different from the GH 63 (G2), the GH 73 P (G3), but not significantly different from the GH 8 (G1). The Dega 1 produced 3.02% more weight compared to the GH 8 (G1), 19.71% more weight compared to the GH 63 (G2), and 33.13% more weight compared to the Dega 1 (GH 4).

3.5 Weight of 100 Seeds

Table 2 shows that the Atonik PGR concentration significantly affects the weight of 100 seeds. This is likely related to the individual seed weight produced each plant. At a concentration of 1 ml/l of Atonik (Z2), the weight of seeds each plant is 9.34 g, which is not significantly different from the concentration of 1.5 ml/l of Atonik (Z3), resulting in a weight of 8.91 g each plant. However, the concentration of 1.5 ml/l of Atonik (Z3) produced a weight of 100 seeds amounting to 23.21 g, indicating that individual seed weight at this concentration is heavier than that of 1 ml/l of Atonik (Z2). The use of plant growth regulators containing auxin can affect the photosynthesis process in plants.

The research results demonstrate that the PGR treatment with Atonik at a concentration of 1.5 ml/l (Z3) resulted in a weight of 100 seeds of 23.21 g, significantly different from the concentration of 0 ml/l (Z0), the concentration of 0.5 ml/l of Atonik (Z1), and the concentration of 1 ml/l of Atonik (Z2). The concentration of 1.5 ml/l produced 34.16% more weight compared to GH 8 (G1), 23.26% more weight compared to GH 63 (G2), and 21.03% more weight compared to GH 73 P (G3).

Table 2 also indicates that the different soybean lines significantly affect the weight of 100 seeds. This is related to the weight of seeds each plant each strain produces. The GH 8 (G1) produced a weight of 9.61 g each plant, which is not significantly different from the Dega 1 (G4) producing 9.90 g each plant. The GH 8 (G1) had the highest weight of 100 seeds, which is 20.49 g. The difference in seed weight is affected by genetic and environmental factors, where the instability in seed size of each genotype is simultaneously affected by genetic and environmental factors (Liu et al., 2004).

The research results show that the GH 8 (G1) produced the highest weight of 100 seeds, which is 20.49 g, not significantly different from the GH 63 (G2), the GH 73 P (G3), but significantly different from the Dega 1 (G4). The GH 8 produced 4.27% more weight compared to the GH 63 (G2), 2.86% more weight compared to the GH 73 P (G3), and 9.89% more weight compared to the Dega 1 (G4).

IV. CONCLUSION

Based on the results of the discussion above, the following conclusions can be drawn: A concentration of 1 ml/l of the plant growth regulator Atonik in water resulted in the highest number of productive branches each plant, which is 5.25 branches. It also led to the highest number of seeds each plant, 55.14 seeds, and the heaviest seed weight each plant, 9.34 g. On the other hand, a concentration of 1.5 ml/l of Atonik in water resulted in the heaviest weight of 100 seeds each plant, which is 23.21 g. Among the soybean lines tested, GH 63 produced the highest number of leaves each plant, which is 92.77 leaves, and the highest number of productive branches each plant, which is 5.25 branches. GH 8 produced the highest number of seeds each plant, 62.16 grains, and the heaviest weight of 100 seeds each plant, 20.49 g. Lastly, the soybean Dega 1 resulted in the heaviest seed weight each plant, which is 9.90 g.

ACKNOWLEDGEMENTS

The author would like to thank the PKKM Agrotechnology (Independence Campus Competition Program), Universitas Muhammadiyah Purwokerto, which has funded the author in the internship program at BSIP Malang.

REFERENCES

[1] Anisa, A., Budiasih, R., & Amalia, L. (2022). Pengaruh Konsentrasi Zat Pengatur Tumbuh Alami Asal Bekicot terhadap Pertumbuhan dan Hasil Kedelai Hitam (Glycine max (L) Merril) Varietas Mallika. *Orchid Agro*, *2*(2), 31.

[2] Hakim, L. 2010. *Komponen Hasil dan Karakter Morfologi Penentu Hasil Kedelai*. Pusat Penelitian dan Pengembangan Tanaman Pangan. Bogor.

[3] Hanolo, W. 1997. Tanggapan tanaman selada dan sawi terhadap dosis dan cara pemberian pupuk cair stimulan. Dalam *Agrotropika* 1(1). Hal. 25-29.

[4] Ismail, I.G. dan Effendi. 1985. Pertanaman Kedelai pada Lahan Kering. Hlm 103–119. Dalam S. Somaatmaja, M. Ismunadji dkk (Eds). Kedelai. Pusat Penelitian dan Pengembangan Tanaman Pangan, Bogor.

[5] Josipović, M., A. Sudarić, V. Kovačević, M. Marković, H. Plavšić, I. Liović. 2011. Irrigation and nitrogen fertilization influences on properties of soybean [*Glycine max* (L.) Merr.] varieties. Poljoprivreda. 17:9-15.

[6] Jusniati, 2013. *Pertumbuhan Dan Hasil Varietas Kedelai* (*Glycine Max* L.) *Di Lahan Gambut Pada Berbagai Tingkat Naungan*. Fakultas Pertanian, Universitas Tamansiswa, Pasaman.

[7] Krisnawati, A. dan M.M. Adie. 2007. Identifikasi galur kedelai F5 biji besar dan umur genjah. hlm 51–57. Dalam D. Harnowo, A.A.Rahmianna, Suharsono, M.M.Adie, F. Rozi, Subandi and A.K. Makarim (eds.), Inovasi teknologi kacang-kacangan dan umbi-umbian mendukung kemandirian pangan & kecukupan energi. Prosiding Seminar Hasil Penelitian Kacang-kacang dan Umbi-umbian Tahun 2007.

[8] Lestari, B. L. (2011). Kajian PGR Atonik dalam Berbagai Konsentrasi dan Interval Penyemprotan terhadap Produktivitas Tanaman Bawang Merah (*Allium ascolanicum* L .). Rekayasa, 4(1), 33–37.

[9] Lestari, E. G., 2011. Peranan Zat Pengatur Tumbuh Dalam Perbanyakan Tanaman Melalui Kultur Jaringan. *Jurnal Agro Biogen*. Vol 7 No 1.

[10] Liu, F., C.R. Jensen, M.N. Andersen. 2004. Drought stress effect on carbohydrate concentration in soybean leaves and pods during early reproductive development: its implication in altering pod set. Field Crop. Res. 86:1-13.

[11] Naeem, M.I. Bhatti, R.H. Ahmad, M.Y. Ashraf. 2004. Effect of some growth hormones (GA 3, IAA, and Kinetin) on the morphology and early or delayed initiation of bud of lentil (*Lens Culinaris Medik*). *Pakistan J. Bot*. 36:801-809.

[12] Permadi, G. S. (2015). Analisis Permintaan Impor Kedelai Indonesia. *Eko-Regional, 10(1).*

[13] Pollard, J. W. and J. M. Walker. 1990. Plant cell and tissue culture, method in molecular biology. Humana Press. Clifton, New Jersey 6:237-372

[14] Rahmasari, D. A., Sudiarso, S., & Sebayang, H. T. (2016). Pengaruh Jarak Tanam dan Waktu Tanam Kedelai TerhaDOS Pertumbuhan dan Hasil Tanaman Kedelai (*Glycine max*) Pada Baris Antar Tebu (*Saccharum officinarum* L.). *Jurnal Produksi Tanaman*, 4(5), 392-398.

[15] Ritonga L.B. 2020. Aplikasi Zat Pengatur Tumbuh Atonik TerhaDOS Keberhasilan Perkecambahan dan Pertumbuhan Benih Jeruk (*Japansche Citroen* (JC)). *Skripsi.* Prog Studi Agroteknologi, Fakultas Pertanian dan Peternakan, Universitas Suska Riau

[16] Sa'diyah N, Zulkarnain J, Barmawi M. 2016. Uji Daya Hasil Beberapa Galur Kedelai (*Glycine max* [L.] Merrill). *Agrotek Tropika*. 4(2): 117–123.

[17] Somaatmadja, S. 1993. Sumber Daya Nabati Asia Tenggara 1 kacang-kacangan. PT. Gedia Pustaka utama, Jakarta.

[18] Sunarto. 2000. *Peluang dan prospek pemuliaan kedelai sebagai sumber pangan di Indonesia. Seminar Sehari Kedelai.* Prospek Peningkatan Kedelai. 22 November 2000. Bogor.

[19] Trisna, N., U. Husain, dan Irmasari. 2013. Pengaruh Berbagai Jenis Zat Pengatur Tumbuh Terhadap Pertumbuhan Stump Jati (*Tectona Grandis* L.F). *Jurnal ilmiah kehutanan,* 1 (1) :7-9.

[20] Uluputty, M. R. 2015. Pertumbuhan dan Hasil Seledri (*Apium grafeolens* L.) pada Media Pasir Setelah Diberikan Gandasil D dan Atonik. *Agrologia*, 4 (1): 28-33.

[21] Umarie, I. 2001. *Potensi Hasil dan Kontribusi Karakter Agronomi TerhaDOS Hasil Padi Gogo*. Universitas Unmuh Jember. Jember.