AGROSAINS
Jurnal Penelitian Agronomi
pISSN: 1411-5786; eISSN: 2655-7339

tAgrosains : Jurnal Penelitian Agronomi 27(1): 47-53, 2025
https://jurnal.uns.ac.id/agrosains/article/view/100603
DOI: http://dx.doi.org/10.20961/agsjpa.v27i1.100603

The Effect of Growth Regulator Formulation and Boron on The Growth and Yield of Shallot Varieties

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Received: March 19, 2025; Accepted: June 6, 2025; Published: June 31, 2025

ABSTRACT

Regulators (PGRs) are used to stimulate the development and growth of bulbs in order to produce a large number of bulbs. This study aims to identify the effect of PGRs and boron formulations that can increase the growth and yield of several variety of shallots. This research took place in the cultivation field of Ngringo Village, Jaten District, Karanganyar Regency from April-August 2023. The method used was a Complete Randomized Blok Design (CRBD) consisting of two factors with four replications. The first factor was PGRs and Boron formulation (without and with GA_3 200 ppm+BAP 50 ppm+NAA 50 ppm+ IAA 300 ppm + 1500 ppm boron formulation). The second factor was variety (Bima Brebes, Maja Cipanas, Batu Ijo and Tajuk). Data were analyzed by F test with 95% confidence level followed by Duncan's Multiple Range Test (DMRT) with 95% confidence level. The results showed that the application of PGRs formulations GA_3 200 ppm + BAP 50 ppm + NAA 50 ppm +IAA 300 ppm + 1500 ppm boron on shallots of Tajuk varieties was able to increase number of leaves by 5 leaves and able to increase number of bulbs per clump of 3 bulbs compared to without the aplication of PGRs and boron formulations. The Tajuk variety provides the best growth in fresh weight of 16 g higher stalks and in the yield of fresh weight of bulbs per clump 23 g compared to the Batu Ijo variety. Shallots treated with 200 ppm GA_3 + BAP 50 ppm + NAA 50 ppm +IAA 300 ppm + 1500 ppm boron have not shown an increase in growth and yield accros various shallot varieties.

Keywords: *Allium cepa*; bulb; grumusol; liliaceae; micronutrient

Cite this as: Harsono, P., Putri, A. W., Haryanto, E. T., & Handoyo, G. C. (2025). The Effect of Growth Regulator Formulation and Boron on The Growth and Yield of Shallot Varieties. *Agrosains: Jurnal Penelitian Agronomi, 27*(1), 47-53. DOI: http://dx.doi.org/10.20961/agsjpa.v27i1.100603

INTRODUCTION

Shallot (*Allium cepa* L. aggregatum group) is a horticultural commodity that can grow both in lowlands and highlands. Shallots are very important both in terms of economic and nutritional benefits. According to Harahap et al. (2022), shallot bulbs contain 1.5 protein, 0.3 fat and 9.2% carbohydrate. Shallots contain glutamic acid, arginine, and aspartic acid, flavonoids, saponins, alkaloids and tannins. According to Hartoyo (2021), shallots function as traditional medicine that can affect health, namely the immune system and can increase immunity. Shallots in Indonesia are widely used as a food flavoring ingredient.

The demand for shallots in Indonesia tends to increase every year. The need for shallot consumption in households in Indonesia in 2018-2021 continues to increase (Azhari et al. 2022). This is supported by BPS data in 2021, shallot consumption in 2020 was 729.82 thousand tons while in 2021 shallot consumption was 790.63 thousand tons. Onion consumption in 2021 in the household sector increased by 8.33% or 60.81 thousand tons from 2020. Based on BPS data, the population in Indonesia in 2021 was 272.7 million people, increasing in 2022 to 275.7 million people. The increase in population in Indonesia increases the demand for shallots. According to data from the Subdirectorate of Domestic Trade Statistics (2020), the amount of shallot consumption by the population in Indonesia can reach an average of 27.72 kg/capita/year. However, the increase in demand in Indonesia has not been matched by an increase in shallot production.

The obstacle that occurs in Indonesia is still the low production of shallots among farmers. Based on BPS data (2021), shallot production in 2021 was 2 million tons, then in 2022 it decreased to 1,982 tons. One way to increase shallot production is by stimulating the development and growth of bulbs in order to produce many bulbs, namely by providing Growth Regulators (PGRs) and also nutrients. Giving PGRs will have a good impact if given in the right amount if given too much will be detrimental to plant growth (Pamungkas and Puspitasari, 2019). Increasing the productivity of shallots can also be overcome by using PGRs, one of which is gibberellin. According to Devi et al. (2018), gibberellins are compounds that have a gibbane skeleton and that stimulate cell division or cell elongation or both, increase plant height, encourage plant growth and secondary metabolite production, increase dry weight.

Cytokinins have a function to spur meristemastic cells and stimulate differentiation in cells, stimulate the formation of buds, dominance of leaf expansion. Indole Acetid Acid (IAA) will increase cell wall permeability in the absorption of nutrients to form chlorophyll which is indispensable in increasing photosynthesis so that it can affect plant production (Tuhuteru et al. 2019). The addition of Naphthalene Acetic Acid (NAA) in shallot cultivation is useful for root elongation so that shallot

plants can obtain more nutrients.

In addition to giving PGRs to increase the growth and yield of shallot plants, it is necessary to provide essential microelements that are important for plants. Boron can increase the number of bulbs per clump of shallots. Sudaryono (2017), in his research, stated that its specific function in supporting plant growth and development, and its function cannot be replaced by other nutrients. Research on PGRs and Boron formulations has not been widely studied so it is necessary to conduct research on PGRs and Boron formulations on the growth and yield of several shallot varieties. The use of shallot varieties among farmers also needs to be considered in order to provide maximum results. The purpose of this study is to examine the interaction between PGRs and Boron on the growth and yield of several varieties of shallots, get the formulation of PGRs and Boron that can affect the growth and yield of shallots, and compare the growth and yield of several varieties of shallots.

MATERIALS AND METHOD

The research was conducted in April-August 2023. Field research was conducted on experimental land located in Ngringo Village, Jaten District, Karanganyar Regency, Central Java Province. Coordinate point -7.5492742º (LS), 110.8690992º (BT) with an altitude of 129 meters above sea level. Grumusol soil type. The process of drying the dry weight of the stalks was carried out at the Laboratory of Ecology Management and Crop Production, Faculty of Agriculture, Sebelas Maret Surakarta. The formulation of PGRs and Boron was conducted at the Laboratory of Plant Physiology and Biotechnology, Faculty of Agriculture, UNS.

This study used a Randomized Group Design (RGD) arranged factorially consisting of two treatment factors. The first factor is the formulation of PGRs and Boron which consists of two levels, namely Z0 = Without formulation of PGRs and Boron, Z1 = Formulation of GA3 200 ppm + BAP 50 ppm + NAA 50 ppm + IAA 300 ppm + Boron 1500 ppm. The second factor is the variety consisting of four types, namely Bima Brebes (V1), Maja Cipanas (V2), Batu Ijo (V3) and Tajuk (V4). The study consisted of 8 treatments and 4 replications so that 32 experimental units were obtained.

The tools and materials used in this study include hoes, hand sprayers, paddles, bamboo stakes, bottles, digital vectors, rulers or meters, digital scales, calculators, cameras, luxmeters, labels, stationery, nameplates, electric ovens, knives, mortars and pestles, measuring cups, drop pipettes, filter paper, thermohygrometers, UV-visible spectrophotometers, image raster version 2.1. The materials used in this study consisted of varieties of Bima Brebes, Maja Cipanas, Batu Ijo, Tajuk. Growth regulators used in the study used GA3 200 ppm, BAP 50 ppm, NAA 50 ppm, IAA 300 ppm with 80% alcohol solvent, NaOH, distilled water. Potassium fertilizer 200 kg ha-1, Boron fertilizer 1500 ppm, water, fungicide with active ingredient Mankozeb 80% with WP formulation, insecticide with active ingredient Profenofos 500 g l-1 EC formulation, cow manure 5 tons ha-1, inorganic fertilizer SP-36 250 kg ha-1, compound NPK fertilizer 600 kg ha-1, Urea 150 kg ha-1 and ZA 300 kg ha-1.

The research stages include land processing by making beds and then applying basic fertilizer (cow manure) as much as 5 tons.ha-1. Planting material in the form of shallot bulbs (cloves). Shallots are sliced into the tops of the cloves without peeling the skin of the cloves until the growing point is visible or this method is called microcutting, then the shallots are soaked using a fungicide with the active ingredient Mankozeb 80% to reduce the risk of mold. Planting shallot bulbs is done by planting shallot cloves by immersing the bulbs in the soil 2/3 of the cloves that have been prepared at the time of seeding. The purpose of planting 2/3 of the clove is to accelerate the growth of shallot shoots. Maintenance stages include watering, replanting, pest control, fertilization, formulation, application, harvesting. The parameters observed include plant height, number of leaves, stomta opening width, fresh weight of plant stems, dry weight of plant stems, bulb diameter, fresh weight of bulbs per clump, dry weight of bulbs per clump, number of bulbs per clump.

Observation data were analyzed using Anova variance test (Analysis of variances) with 95% confidence level to test the difference between two mean values. If the Anova variance test shows significant results, it is continued with Duncan's Multiple Range Test (DMRT) at the 95% confidence level which aims to compare responses between treatments.

RESULT AND DISCUSSION

Plant Height

Based on Table 1 shows that the variety has a significant effect on plant height 5 weeks after planting. Plant height of Batu Ijo variety when compared to Maja Cipanas variety is 5.74 cm higher Triharyanto et al. (2020), in addition to genetic factors, tubers are also influenced by planting environmental factors. According to Jasmi et al. (2013), variety is the main factor that determines the high and low production supported by environmental factors. Plant height is influenced by genetic factors of each plant.

Table 1. Effect of several shallot varieties on shallot plant height 5 weeks after planting

Variety	**Plant Height** (cm)
Bima Brebes	40.57 a ± 1.63
Maja Cipanas	35.65 b ± 1.84
Batu Ijo	41.39 a ± 2.22
Tajuk	35.42 b ± 2.01
Sig.	0.05
KK (%)	6.11

Notes: Numbers followed by the same letter in the same column are not significantly different based on DMRT (α = 0.05). Sig: Significance. KK (%): Coefficient of Variance.

Table 2. Interaction effect of growth regulator formulation and Boron on the number of leaves and stomatal opening width of several shallot varieties

PGRs Formulation and Boron and Variety	Number of leaves (blade)	Stomatal opening width (µm)
Without formulation + Bima Brebes	39.50 b ± 3.40	11.10 a ± 1.80
Without formulation + Maja Cipanas	30.70 cd ± 2.80	7.00 e ± 1.09
Without formulation + Batu Ijo	25.40 d ± 6.60	8.00 d ± 0.30
Without formulation + Tajuk	41.40 ab ± 4.70	8.50 d ± 0.00
Formulation + Bima Brebes	43.70 ab ± 6.30	6.46 e ± 1.40
Formulation + Maja Cipanas	32.90 c ± 1.30	8.00 d ± 0.30
Formulation + Batu Ijo	17.50 e ± 12.10	9.25 c ± 0.50
Formulation + Header	46.70 a ± 8.40	9.80 b ± 0.90
Sig. PGRs and Boron Formulation	0.006	0.04
Sig. Variety	0.07	0.06
Sig. PGRs and Boron Formulation and Variety	0.06	0.08
KK (%)	10.5	12.70

Notes: Numbers followed by the same letter in the same column are not significantly different based on DMRT (α = 0.05). Sig: Significance. KK (%): Coefficient of Variance.

According to Manjunathagowda and Anjanappa, (2021) the expression of characteristics observed in plants does not accurately reflect the genetic potential inherent in the genotype because there is an environmental influence on genotype response.

Number of Leaf

Based on Table 2 shows that the interaction of PGRs and Boron formulations and varieties has a real effect on the number of shallot leaves at 5 weeks after planting. The effect of the interaction of PGRs and Boron formulations and varieties on the number of shallot leaves 5 weeks after planting can be seen in Table 2. Auxin hormones such as IAA can affect agronomic characters in shallot plants (Solano et al., 2023; Beye et al., 2024). The use of PGRs can affect plant growth. This is in line with Acharya et al. (2015) that the positive effect of Boron on shallot plant growth not only depends on soil chemical characteristics, but is also influenced by genetic factors and specific varieties. Selection of the right variety can be the key to maximizing the benefits of PGRs and Boron formulations on shallot production. The occurrence of interactions is due to the compatibility between varieties and PGRs and Boron formulations.

The diversity in the number of leaves of each variety is influenced by the genetics of each variety. According to Purwasi et al. (2022), the difference in the number of leaves of each variety is caused by genetic interaction with the surrounding environment that affects the number of leaves. The increasing number of leaves indicates good growth in shallot plants. The difference in the number of leaves on shallot plants occurs due to genetic factors from each plant. Based on the description of the variety and the Tajuk variety is in accordance with the description of the variety. Giving formulations to the Tajuk variety shows the most significant response. Tajuk varieties are able to adapt well influenced by genetic factors. The Tajuk variety is known to have the most leaves that show optimal growth. The more the number of leaves, the photosynthesis process will run optimally.

Based on Table 2, the number of shallot leaves of the Tajuk variety with the provision of PGRs and Boron formulations (46.70 strands) is not significantly different from the Bima Brebes variety with the provision of PGRs and Boron formulations (43.70 strands) and the Tajuk variety with no PGRs and Boron formulations (41.40 strands). However, the Tajuk variety with no PGRs and Boron formulation (46.70 strands) was not significantly different from the Bima Brebes variety with no PGRs and Boron formulation (39.50 strands). Manik (2019), differences in varietal characteristics affect the diversity of the number of leaves. The increase in the number of leaves can also be seen from the provision of formulations, because one of them is contained in the formulation given.

Stomatal Opening Width

The width of stomatal openings is influenced by the availability of water which affects the condition of groundwater in cell turgor, especially in guard cells. Table 2 shows that the interaction of PGRs and Boron formulation significantly influenced the width of stomatal openings. The width of stomatal openings with Bima Brebes variety and without the application of PGRs and Boron formulations had wider openings compared to other treatments. According to Khoiroh et al. (2014), stomatal openings are influenced by the regulation of plant turgor pressure. High stomatal opening width will result in high production. Stomata that open wide will affect photosynthesis. Increased photosynthesis process will result in increased carbohydrate accumulation which also affects the increase in tuber weight (Galgaye and Deresa, 2023). According to Sholihatun et al. (2014), through K+ ion transport Boron can maintain the width of stomatal openings. However, this does not apply to the Bima Brebes variety because the Bima Brebes variety is more responsive without the application of PGRs and Boron formulations to the width of stomatal openings.

Fresh Wirght of Plant Stems

Table 3 shows that varieties have a significant effect on the fresh weight of shallot plant stems. The highest fresh weight of plant stems of the Tajuk variety has a higher weight compared to other varieties. Octoarie and Anggrowati, (2019) one of the factors that affect the fresh weight of plants is the process of cell division followed by enlargement of plant cells, the better the cell division, the growth will increase. According to Nurholis and Fatimah, (2023) the number of leaves on the plant will affect the fresh weight of the crop. The increasing number of plant leaves such as in the Tajuk variety will increase the fresh weight of the crop.

Table 3. Effect of several shallot varieties on plant stalk fresh weight, plant stalk dry weight, bulb diameter, bulb fresh weight per clump and bulb dry weight per clump

Variety	plant stalk fresh weight (g)	plant stalk dry weight (g)	bulb diameter (cm)	bulb fresh weight per clump (g)	bulb dry weight per clump (g)
Bima Brebes	17.90 c ± 0.48	3.02 a ± 0.15	2.91 b ± 0.09	96.16 ab ± 2.81	87.60 ab ± 1.94
Maja Cipanas	19.74 b ± 0.82	2.98 a ± 0.12	2.80 b ± 0.17	87.18 bc ± 3.54	81.76 bc ± 2.19
Batu Ijo	10.59 d ± 5.65	2.22 b ± 0.41	3.81 a ± 0.54	81.35 c ± 7.66	74.45 c ± 7.36
Tajuk	26.11 a ± 5.32	3.02 a ± 0.15	2.65 b ± 0.28	104.06 a ± 8.40	95.61 a ± 7.61
Sig	0.0003	0.02	0.05	0.001	0.001
KK (%)	16.21	19.63	8.88	11.18	11.07

Notes: Numbers followed by the same letter in the same column are not significantly different based on DMRT (α = 0.05). Sig: Significance. KK (%): Coefficient of Variance.

The high fresh weight of the stalks indicates the high water content in the stalks. The lowest fresh weight is in the Batu Ijo variety.

Plant Stalk Dry Weight

Table 3 shows that varieties significantly affect the dry weight of plant stems. The dry weight of plant stalks in the Bima Brebes variety was the same as the Tajuk and Maja Cipanas varieties, but had a higher dry weight of stalks compared to the Batu Ijo variety. Siregar et al. (2013) that, the use of varieties has a significant effect on the dry weight of the stalk. Damte et al. (2017), different cultivars have different values in dry weight, the dry weight of the crown which is the remaining leaves of the onion plant has a smaller value than the dry weight of the bulbs.

Bulb Diameter

Table 3 shows that varieties significantly affect the diameter of shallot bulbs. The diameter of shallot bulbs of Batu Ijo variety has a larger diameter than the diameter of other varieties. Qomariah and Zainuddin, (2023) that, the standard size of shallot bulbs of Batu Ijo variety has a relatively large diameter which is about 4 cm. The size of the bulbs of each variety is different, one of the main factors is the genetics of the variety. Irfan (2013) states that, factors that affect the appearance of plant phenotypes are plant age, species, physiological conditions, plant genetics, and other factors. Varieties have variations and diversity in their development so that each variety has different quality and superior yields (Gowd et al., 2024; Solouki et al., 2023).

The quality of the crop can be known through the quality of the tuber, one of which is by knowing the size of the tuber. The size of tubers is classified into several sizes, namely small, medium and large sizes. Sumarni and Hidayat, (2005) grouped the diameter of the bulbs into 3 groups into the following: large seedling bulbs > 1.8 cm, medium seedling bulbs > 1.5 cm, small seedling bulbs < 1.5 cm.

Bulb Fresh Weight Per Clump

The fresh weight of tubers per clump is related to the number of tillers produced by the plant. The fresh weight of bulbs per clump of all varieties showed greater results than the description of potential varieties. Bulb formation in shallots depends on the photosynthesis of plants. Varieties have a significant effect on the fresh weight of bulbs per clump of shallots.

The fresh weight of bulbs per clump of shallots of the Tajuk variety has a fresh weight of bulbs per which is not much different from the fresh weight of bulbs per clump. However, the fresh weight of bulbs per clump of shallots of the Bima Brebes variety is not lighter than the Maja Cipanas variety (87.18 g). The fresh weight of bulbs per clump of shallots of the Maja Cipanas variety is not significantly different from the Batu Ijo variety (81.35 g).

Varietal differences can give different responses, both in bulb diameter to bulb productivity (Tabor, 2018). According to Sugirno et al. (2021), the weight of bulbs per clump is related to the number of bulbs, the higher the number of cloves, the higher the weight of the bulbs. Bulb formation in shallots depends on the results of plant photosynthesis.

Bulb Dry Weight Per Clump

Table 3 shows that varieties significantly affect the dry weight of bulbs per clump of shallots. The results of Duncan's multiple range test show that the dry weight of bulbs per clump of shallot plants of the Tajuk variety is not significantly different from the Bima Brebes variety but significantly different from the Maja Cipanas and Batu Ijo varieties. The Tajuk variety produces a higher dry weight of bulbs per clump than the Maja Cipanas and Batu Ijo varieties, 13.85 g and 21.16 g, respectively. The better dry weight is obtained due to one of the contributions of the dominant carbohydrate content in onion bulbs (Putnik et al., 2019). This is in line with Elisabeth et al. (2013), the greater the number of leaves will have the opportunity to produce high fresh weight and dry weight. The number of shallot tillers affects the dry weight of shallot bulbs per plot.

The high dry weight of tubers per hectare in crown varieties is due to the contribution of high tuber weight of crown varieties as well, such as Elizani and Sulistyaningsih, (2019) that a significant increase in productivity per hectare is positively correlated with tuber weight. According to Baehaki et al. (2019), tuber shrinkage is caused by the loss of water in the tuber. The tuber weight is caused by the number of layers and content in the tuber after drying the water in the tuber layer will evaporate. Differences in dry weight in each variety are influenced by genetic factors. The difference in dry weight in each variety is influenced by genetic factors.

Table 4. Effect of the interaction of Growth Regulator formulations and Boron on the number of bulbs per clump of several shallot varieties

PGRs Formulation and Boron	Variety			
	Bima Brebes	Maja Cipanas	Batu Ijo	Tajuk
Without formulation	9.30 bc ± 0.6	9.40 bc ± 0.70	3.80 d ± 3.1	10.30 b ± 1.40
Formulation	9.38b c ± 0.70	8.20 c ± 0.06	2.90 d ± 3.80	13.10 a ± 3.40
Sig. PGRs and Boron formulation	0.001			
Sig. Variety	0.06			
Sig. PGRs and Boron Formulation and Variety	0.08			
KK (%)	11.3			

Notes: Numbers followed by the same letter in the same column and row are not significantly different based on DMRT (α = 0.05). Sig: Significance. KK (%): Coefficient of Variance.

Based on the dry weight of tubers, the Tajuk variety and the Bima Brebes variety are capable of high production. Tajuk and Bima Brebes varieties have a high number of tubers.

Number of Bulb Per Clump

Table 4 shows that the interaction of PGRs and Boron and varieties significantly affects the number of bulbs per clump of shallots. Table 4 shows that the number of bulbs per clump of Tajuk varieties and with the provision of PGRs and Boron formulations (13.10 bulbs) is significantly different from other treatments. Firmansyah and Atikah, (2019), that the Tajuk variety has relatively many bulbs but the size of the bulbs is small. This is appropriate if the variety has a large number of tubers due to the combined effect of the PGRs formulation, where PGRs can actually affect directly into the plant's natural hormone system (Rademacher, 2015). Karo and Manik, (2020) stated that the number of tubers per clump can be an indicator of the plant's ability to form tillers or shoots.

CONCLUSION

The provision of PGRs and boron formulations (GA3 200 ppm + BAP 50 ppm + NAA 50 ppm +IAA 300 ppm + 1500 ppm Boron) on shallot varieties Tajuk able to increase the number of leaves and the number of bulbs per clump compared without the provision of PGRs and Boron formulations. Shallot given the formulation of PGRs and boron (GA3 200 ppm + BAP 50 ppm + NAA 50 ppm +IAA 300 ppm + 1500 ppm Boron) has not been able to increase the growth and yield of several shallot varieties. The Tajuk variety gives better growth in fresh and dry weights of plant stems, and fresh and dry weights of bulbs per clump of shallots.

Suggestions that can be given for future research are that further research should be carried out regarding the provision of PGRs and Boron formulations in the cultivation of shallot varieties Tajuk ahead of the wet month to increase shallot growth and yield.

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