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The Evaluation of Production, Chlorophyll Content and Number of Flower of Samosir Local Shallots through Application of Gibberellin and Boron in the Highlands

Jupri Simamora [a], Yaya Hasanah [a,*], Diana Sofia Hanafiah [a]

[a] *Faculty of Agriculture, Universitas Sumatera Utara, Jl. Prof. A. Sofyan No 3 Kampus USU Medan, 20155, Indonesia*
Corresponding author: [*]yaya@usu.ac.id

***Abstract*—Shallot is a leading horticultural commodity with good seasoning and medicinal properties prospects. In increasing local Samosir shallot production, growth regulators and micronutrients are needed. Gibberellin (GA_3) is a plant growth-stimulating hormone that can simultaneously trigger the appearance of flowers and flowering when applied as an exogenous hormone. Applying boron on shallots could increase the quality of seeds and the number of flowers. The study's objective was to evaluate the production and quality of Samosir local shallots by applying gibberellin and boron in the highlands. The research was conducted at Humbang Hasundutan, North Sumatera Province, Indonesia, from August to October 2022. A factorial randomized block design was used with two-factor and three replications. The first factor is the application of Gibberellin (0, 100, 200, and 300 ppm), and the second is Boron (0, 3, and 6 kg/ha). The result showed that applying gibberellin until 200 ppm increased the content of chlorophyll a, chlorophyll b total chlorophyll, bulb wet weight, and number of flowers of Samosir local shallots. The application of boron until 3 kg/ha increased plant length 2-8 weeks after planting (WAP), leaf number 4-8 WAP, number of tillers 4-8 WAP, the content of chlorophyll a, chlorophyll b and total chlorophyll of Samosir local shallot. The combination treatment of 100 ppm gibberellin and boron 6 kg increased bulb wet weight and bulb dry weight of Samosir local shallots.**

***Keywords*— Shallot; Samosir; gibberellin; boron; chlorophyll; production.**

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I. INTRODUCTION

Shallots are considered horticultural commodities having high economic value in Indonesia. The use of true shallot seed (TSS) in North Sumatera, especially in the area around Lake Toba with an altitude of > 900 m above sea level, is generally not maximized due, among other things, to the lack of availability of healthy and high yielding seeds suitable for highlands.

Shallots are usually cultivated using bulbs as planting material. The use of tubers as seeds has cost constraints. The provision of seeds is relatively high, namely ± 40% of the total production costs. There is no guarantee of tuber quality due to tuber-borne pathogens such as *Alternaria* sp., *Colletotrichum* sp., *Fusarium* sp., and viruses from infested native plants can reduce yield productivity [1]. The solution to this problem is to use true shallot seeds (TSS) [2], [3]

The results showed that using TSS can increase the yield of shallot bulbs up to two times compared to using bulbs as seeds [3], [4]. Another advantage is that the requirement for shallot TSS seeds is less (3–6 kg/ha) compared to bulb seeds (1–1.2 t/ha) [5]. Samosir local shallots cultivated in the Lake Toba area are grown at 925 ± 1131 m altitude. Altitude and local shallot production in Samosir are negatively correlated, meaning the higher the altitude, the less the production will decrease [6], [7]. Therefore, it is necessary to experiment to increase production with appropriate technical cultivation treatment for the highlands.

Gibberellin (GA_3) is a plant growth-stimulating hormone that, when applied as an exogenous hormone, can simultaneously trigger the appearance of flowers. Naturally occurring gibberellins are found in onion bulbs. Application of 100 – 200 ppm GA3 and 50 ppm NAA can increase the percentage of the number of flowers and TSS in the Lembang highlands [8]–[10]. Based on the results of the study, it was found that the application of boron at a dose of 3 kg/ha could increase the number of seed, seed weight, seed weight per clump, and total seed weight per plot of the control [8] and

boron can improve the seed quality of Okra [11].

To enhance product quality and the number of flowers in Samosir local shallots, a comprehensive cultivation treatment package must be implemented to ensure the production of high-quality tubers and TSS. This approach aims to yield both consumable tubers and seed tubers. One of the growth regulators that can increase flowering as an exogenous hormone is gibberellins (GA3) and boron, which increase flower production and shallot quality.

Until now, there is still limited research examining the effect of gibberellin and boron on the production, chlorophyll content, and number of flowers of Samosir local shallots. Previous studies have investigated the physiological characteristic of shallot in highlands and lowlands [12], the effect of plant growth regulator [13], [14] the impact of ecoenzymes [15], the role of sulfur and paclobutrazol on shallot productivity from true shallot seed [16], [17], the effect of cultivation methods on shallot production [18] and genetic diversity of shallot using RAPD marker [19].

Based on the background, the objective of the research was to evaluate the production and quality of the Samosir local shallot by applying gibberellins and boron in the highlands. Cultivation with proper treatment for Samosir local shallots will increase production and produce quality TSS, so the planting material must be of higher quality.

II. Materials and Method

The research was conducted at Humbang Hasundutan Regency, North Sumatera Province, and Biotechnology Laboratory, Faculty of Agriculture, Universitas Sumatera Utara, from August to November 2022. The materials used were shallot bulbs of the local Samosir shallots collected from the farm, gibberellins, boron, NPK 16-16-16, pesticide Antracol 70 WP, distillate water, and silver, black plastic mulch. The tools used in the research were a hoe, sample pack, meter, analytical scale, watering can, roller, camera, and tissue.

A factorial randomized block design was used with two factors and three replications. The factor is gibberellin (0, 100, 200, and 300 ppm), and the second factor is boron (0, 3, and 6 kg/ha). The planting material used is Samosir local shallot. The soil was covered with black plastic mulch with a spacing of 20 m x 20 cm and a plot size of 1 x 1 meter. The fertilizer used is essential in the form of 15 tons of chicken manure/ha, applied three weeks before planting. NPK (16-16-16) at a dose of 600 kg/ha was applied 3 times in 0, 3, and 6 weeks after planting [20], [21]. Gibberellins were applied by dissolving at four levels, namely 0 ppm, 100 ppm, 200 ppm, and 300 ppm, then soaked for 30 minutes before planting and sprinkled on plants with a dose of 50 ml solution per plant at the age of 1 week after planting (WAP) according to the treatment level. Boron fertilizer was applied by dissolving the boron and then watering the plants two times at the age of 3 and 5 WAP. Soil analysis is shown in Table 1.

TABLE I
RESULT OF SOIL ANALYSIS OF THE RESEARCH LOCATION*

Characteristic	Result analysis
pH-H_2O	5.7
pH-KCI	4.1
Carbon (%)	0.66
Nitrogen (%)	0.08
C / N	8
Phosphorous (ppm)	166.74
Potassium (m.e/100g)	0.46
Cation Exchange Capacity (m.e/100g)	15.10
Sulfur (ppm)	5.98
Boron (ppm)	< 0.001

*Soil analysis conducted in the Indonesian Oil Palm Research Institute

The observed variables include plant length (cm), number of leaves, and number of tillers 2, 4, 6, and 8 WAP, chlorophyll a, chlorophyll b and total chlorophyll, bulb number, bulb coils, bulb wet weight, bulb dry weight and number of flowers. was calculated, and the bulb coils were observed. Data were analyzed using analysis of variance (ANOVA), and if there was a significant effect, it was followed by Duncan's Multiple Range Test at $\alpha = 5\%$.

III. Results and Discussion

A. Plant Length, Number of Leaves, Number of Tillers

Based on Table 2, gibberellin had no significant effect in increasing the plant length 2-8 WAP of Samosir local shallots as indicated by the application of G0 treatment (0 ppm), which was more significant than the G1 (100 ppm), G2 (200 ppm) and G3 (300 ppm)

Boron increased the plant length by 2-8 WAP of Samosir local shallots as indicated by boron 3 kg/ha (B1) treatments, and 6 kg/ha (B2) were more significant than the control at boron 0 kg/ha. Treatment B1 (3 kg/ha) was the largest compared to control and treatment B2 (6 kg/ha). The interaction of gibberellin and boron had no significant effect on increasing the plant length of Samosir local shallots. The best interaction was obtained in treating 200 ppm gibberellins and 3 kg/ha boron.

Based on Table 3, gibberellins until 100 ppm increased the number of leaves per clump 2-8 WAP. Applying boron until 3 kg/ha increased the number of leaves by 2-8 WAP of Samosir local shallots. The interaction of gibberellin and boron had no significant effect on increasing the number of leaves per clump of Samosir local shallots. The best interaction to expand the number of leaves of Samosir local shallots was the application of gibberellin 100 ppm and boron 6 kg/ha.

Based on Table 4, applying gibberellin until 100 ppm increased the tillers perclump 2-8 WAP applying boron until 3 kg/ha increased the number of tillers per clump 2-8 WAP of local Samosir shallots. There is a tendency that the application of gibberellin 100 ppm and 6 kg/ha boron increased the number of tillers per clump 2-8 WAP.

TABLE II
EFFECT OF GIBBERELLIN AND BORON TREATMENT ON PLANT LENGTH OF LOCAL SAMOSIR SHALLOTS

WAP	Gibberellin	Boron (kg/ha)			Mean
		B0 (0)	B1 (3)	B2 (6)	
2	G0 (0)	15.83	15.63	16.02	15.83a
	G1 (100)	15.01	14.57	13.83	14.47bc
	G2 (200)	13.85	16.49	13.81	14.71b
	G3 (300)	13.59	13.67	14.73	14.00c
	Mean	14.57	15.09	14.60	
4	G0 (0)	27.50	29.35	30.19	29.01a
	G1 (100)	27.62	26.76	27.51	27.30c
	G2 (200)	25.87	30.05	27.74	27.89b
	G3 (300)	27.29	28.23	27.00	27.50bc
	Mean	27.07b	28.60a	28.11a	
6	G0 (0)	34.36	34.52	35.44	34.77a
	G1 (100)	31.17	32.03	32.61	31.93b
	G2 (200)	29.63	36.15	32.17	32.65b
	G3 (300)	32.71	32.85	31.39	32.31b
	Mean	31.97c	33.89a	32.90b	
8	G0 (0)	43.95	41.63	42.61	42.73a
	G1 (100)	35.84	39.40	40.02	38.42b
	G2 (200)	34.77	44.68	38.90	39.45b
	G3 (300)	40.29	39.81	36.79	38.96b
	Mean	38.71b	41.38a	39.58b	

Note: Numbers followed by the same notation in the same column group showed no significant difference according to Duncan's Multiple Range Test at the 5% level.

TABLE III
EFFECT OF GIBBERELLIN AND BORON TREATMENT ON NUMBER OF LEAVES OF SAMOSIR LOCAL SHALLOTS

WAP	Gibberellin	Boron(kg/ha)			Mean
		B0 (0)	B1 (3)	B2 (6)	
2	G0 (0)	14.63	14.56	15.37	14.85c
	G1 (100)	17.59	17.37	16.26	17.07a
	G2 (200)	14.96	15.04	16.22	15.41b
	G3 (300)	14.59	16.30	15.41	15.43b
	Mean	15.44	15.81	15.81	
4	G0 (0)	24.93	25.63	26.59	25.72b
	G1 (100)	27.63	27.96	29.15	28.25a
	G2 (200)	23.33	25.33	25.96	24.88b
	G3 (300)	24.74	27.89	24.37	25.67b
	Mean	25.16b	26.70a	26.52a	
6	G0 (0)	39.78	40.67	42.48	40.98a
	G1 (100)	40.89	42.96	45.11	42.99a
	G2 (200)	33.19	42.89	38.33	38.14b
	G3 (300)	35.59	41.15	37.22	37.99b
	Mean	37.36b	41.92a	40.79a	
8	G0 (0)	60.52	60.41	64.00	61.64a
	G1 (100)	59.04	62.15	66.48	62.56a
	G2 (200)	46.11	64.52	55.67	55.43b
	G3 (300)	50.70	59.41	54.48	54.86b
	Mean	54.09b	61.62a	60.16a	

Note: Numbers followed by the same notation in the same column group showed no significant difference according to Duncan's Multiple Range Test at the 5% level.

TABLE IV
EFFECT OF GIBBERELLIN AND BORON TREATMENT ON NUMBER OF TILLER OF SAMOSIR LOCAL SHALLOTS

WAP	Gibberellin	Boron (kg/ha)			Mean
		B0 (0)	B1 (3)	B2 (6)	
2	G0 (0)	4.74	4.63	5.19	4.85b
	G1 (100)	5.44	5.44	5.33	5.41a
	G2 (200)	4.78	4.85	4.96	4.86b
	G3 (300)	4.67	5.22	4.63	4.84b
	Mean	4.91	5.04	5.03	
4	G0 (0)	6.67	6.74	7.04	6.81b
	G1 (100)	7.11	7.63	7.33	7.36a
	G2 (200)	6.44	6.85	6.89	6.73b
	G3 (300)	6.52	7.41	6.41	6.78b
	Mean	6.69b	7.16a	6.92ab	
6	G0 (0)	10.78	10.78	11.63	11.06a
	G1 (100)	10.63	11.56	11.63	11.27a
	G2 (200)	9.00	11.37	10.30	10.22b
	G3 (300)	9.59	11.15	9.78	10.17b
	Mean	10.00b	11.21a	10.83a	
8	G0 (0)	17.11	16.74	18.19	17.35a
	G1 (100)	16.15	17.52	18.52	17.40a
	G2 (200)	13.26	17.96	15.48	15.57b
	G3 (300)	14.37	16.70	14.85	15.31b
	Mean	15.22b	17.23a	16.76a	

Note: Numbers followed by the same notation in the same column group showed no significant difference according to Duncan's Multiple Range Test at the 5% level.

In this study it was found that the application of gibberellins up to 100 ppm increased the number of leaves (Table 3), the number of tillers (Table 4), and bulb wet weight (Table 6), while the application of gibberellins up to 200 ppm increased chlorophyll a, chlorophyll b, total chlorophyll (Table 5), bulb dry weight (Table 6), and flowering number (Table 7). This is understandable because gibberellin is a plant hormone that stimulates growth and development, stimulating the transition from meristem to shoot growth. Previous researchers stated that gibberellin is a plant hormone that plays a role in the growth of flowers and fruit. Gibberellins can control the stages of vegetative and generative growth and flower development and encourage more intensive flowering [22]–[26]. Elshyana's research [26] showed that treatment gibberellin application of 100 ppm on shallot variety increased plant height and the number of leaves on shallots.

The boron treatment affected increasing plant length (Table 2), number of leaves (Table 3), and number of tillers per clump (Table 4). It may be due to the enhanced enzymatic and photosynthetic activity and greater translocation rate due to the influence of boron. The favorable effects of boron might be attributed to its involvement in cell division and cell expansion, which resulted in better growth [27].

B. Chlorophyll Content

Based on Table 5, gibberellins significantly affected the content of chlorophyll a, chlorophyll b, and the total chlorophyll of Samosir local shallots. Applying gibberellin until 200 ppm increased the chlorophyll a, chlorophyll a, chlorophyll b, and the total chlorophyll of Samosir local shallots. Boron had a very significant effect on the content of chlorophyll a, chlorophyll b, and total chlorophyll of Samosir local shallots as indicated by treatment boron 3 and 6 kg/ha were greater than boron 0 kg/ha (control). The interaction of gibberellins and BORONS had no significant effect on the content of chlorophyll a, chlorophyll b, and a total of chlorophyll of Samosir local shallots. There is a tendency for applying gibberellin 200 ppm and 6 kg/ha boron to increase the chlorophyll and total chlorophyll.

The chlorophyll content in the leaves increased with gibberellin treatment (Table 5); this was shown in chlorophyll a and chlorophyll b, and the total chlorophyll content was more significant than the control. Similarly, the boron treatment has a very substantial effect on increasing the total chlorophyll content [28], [29].

C. Production and Component of Production Variable

Until 100 ppm, Gibberellins significantly increased the bulb number, bulb coils, bulb wet weight, and bulb dry weight of Samosir local shallots (Table 6). The increase is due to the role of the hormone gibberellin in the process of vegetative growth [8], which can increase production variables. However, boron has no significant effect on production variables because it has more influence on the vegetative phase [9].

Boron had no significant effect on increasing the variable of bulb number, bulb coils, bulb wet weight, and bulb dry weight of Samosir local shallots. The interaction of gibberellin and boron had no significant effect on all production and component of production variables (Table 6).

TABLE V
EFFECT OF GIBBERELLIN AND BORON TREATMENT ON SHALLOT CHLOROPHYLL CONTENTS.

Chlorophyll	Gibberellin	Boron (kg/ha)			Mean
		B0 (0)	B1 (3)	B2 (6)	
a	G0 (0)	22.51	26.21	24.89	24.54b
	G1 (100)	23.85	23.63	25.38	24.28b
	G2 (200)	26.08	26.82	28.37	27.09a
	G3 (300)	24.38	25.03	25.91	25.10b
	Mean	24.20b	25.42a	26.13a	
b	G0 (0)	15.41	23.21	17.52	18.71c
	G1 (100)	21.10	19.10	31.04	23.74b
	G2 (200)	22.86	31.98	30.57	28.47a
	G3 (300)	17.90	19.42	23.87	20.39c
	Mean	19.32b	23.42a	25.75a	
total	G0 (0)	37.92	49.42	42.41	43.25c
	G1 (100)	44.95	42.72	56.41	48.03b
	G2 (200)	48.94	58.79	58.94	55.55a
	G3 (300)	42.28	44.44	49.77	45.50ab
	Mean	43.52b	48.84a	51.88a	

Note: Numbers followed by the same notation in the same column group showed no significant difference according to Duncan's Multiple Range Test at the 5% level.

TABLE VI
EFFECT OF GIBBERELLIN AND BORON TREATMENT ON PRODUCTION AND COMPONENT OF PRODUCTION VARIABLE

Variable	Gibberellin (ppm)	Boron (kg/ha)			Mean
		B0 (0)	B1 (3)	B2 (6)	
Bulb number	G0 (0)	33.56	30.33	33.00	32.30a
	G1 (100)	30.89	33.33	34.11	32.78a
	G2 (200)	26.67	28.56	28.89	28.04b
	G3 (300)	28.33	32.00	26.22	28.85b
	Mean	29.86	31.06	30.56	
Bulb coils	G0 (0)	4.98	4.67	4.58	4.74ab
	G1 (100)	4.37	4.51	4.72	4.53b
	G2 (200)	4.90	4.98	4.28	4.72ab
	G3 (300)	5.07	5.37	4.40	4.95a
	Mean	4.83	4.88	4.50	
Bulb wet weight	G0 (0)	78.72	117.56	115.89	104.06b
	G1 (100)	120.56	89.11	142.00	117.22a
	G2 (200)	124.11	121.22	109.67	118.33a
	G3 (300)	118.78	116.89	99.33	111.67ab
	Mean	110.54	111.19	116.72	
Bulb dry weight	G0 (0)	56.11	82.00	82.56	73.56b
	G1 (100)	89.33	65.11	106.33	86.93a
	G2 (200)	90.44	83.56	77.33	83.78ab
	G3 (300)	87.67	84.33	71.56	81.19ab
	Mean	80.89	78.75	84.44	

Note: Numbers followed by the same notation in the same column group showed no significant difference according to Duncan's Multiple Range Test at the 5% level.

D. Number of Flower

Gibberellins and boron significantly affect the flowering of shallots, while the interaction between gibberellins and boron has no significant effect on shallots flowering (Table 7). Applying gibberellin up to 200 ppm increased the number of flowers of shallots. Applying 0 and 6 kg/ha of boron had the same effect on the number of flowers. Gibberellin and boron affected the number of flowering plants (Table 7) and increasing the dose of boron to 6 kg/ha did not improve the number of flowering plants [9]. This increase was influenced by the rise in the number of tillers by the gibberellin treatment and the application of boron, which increased the percentage of flowering plants.

The response to growth regulator treatment differs for each genetic plant [30]–[33]. Based on research by Fahrianty et al. [34], a concentration of 100 ppm GA3 can provide 100% of flowering plants in the highlands (1250 m asl) in the Bima variety. GA3 treatment might be due to its stimulation for conversion of stored polymers (polysaccharides, proteins, and fats) into sucrose or mobile amino acids to facilitate their translocation via phloem into and throughout the young root and shoot system and thus influencing flower production [28].

TABLE VII
EFFECT OF GIBBERELLIN AND BORON TREATMENT ON FLOWERING NUMBER

Gibberellin(ppm)	Boron (kg/ha)			Mean
	B0 (0)	B1 (3)	B2 (6)	
G0 (0)	12.50	0.00	8.33	6.94c
G1 (100)	12.50	0.00	8.33	6.94c
G2 (200)	0.00	25.00	20.83	15.28a
G3 (300)	20.83	0.00	8.33	9.72b
Mean	11.46a	6.25b	11.46a	

Note: Numbers followed by the same notation in the same column group showed no significant difference according to Duncan's Multiple Range Test at the 5% level.

When the cultivation was carried out, high rainfall was prevalent from August to October 2022, which could reduce the production and flowering potential of shallot plants [6], [21]. Shallot plants have high production and flowering potential during the dry season [7], [35].

Applying boron up to 6 kg/ha influenced increasing plant length, number of leaves, and tillers per clump, chlorophyll a, chlorophyll b, total chlorophyll, and flowering number. This is due to the role of Boron in the vegetative growth and reproductive phase. Previous researchers stated that Boron is an essential micro-nutrient that forms cell walls and strengthens fast-growing tissues and chlorophyll formation. Boron requirements increase during the reproductive phase. Boron deficiency during flowering can inhibit pollen tube growth, resulting in sterility and flower abortion. During flowering, a continuous supply of Boron must be provided because Boron is relatively immobile and cannot be easily transported to the reproductive organs [36]- [39].

This study has found the effect of gibberellins and boron on the production and chlorophyll content of shallots. The research will help researchers and farmers use the best dose of Boron and the best concentration of gibberellin to increase the production of local Samosir shallots in the highlands. Based on the research, the new theoretical research has found that applying Gibberellins at 100 ppm increased the dry weight of the bulbs by 15.12%, while the application of Boron up to 6 kg/ha increased the dry weight of shallot bulbs. Application of Gibberellin 200 ppm increases flowering success by up to 54.58% and increases total chlorophyll by up to 21.82%.

IV. Conclusion

Application of gibberellin until 200 ppm increased the content of chlorophyll a, chlorophyll b, and total chlorophyll, bulb wet weight, and number of flowers of Samosir local shallots. The application of boron until 3 kg/ha increased plant length 2-8 weeks after planting (WAP), leaf number 4-8 WAP, number of tillers 4-8 WAP, the content of chlorophyll a, chlorophyll b and total chlorophyll of Samosir local shallot. The combination treatment of 100 ppm gibberellin and boron 6 kg increased bulb wet weight and bulb dry weight of Samosir local shallots.

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