Available at: https://ejournal.unib.ac.id/index.php/JIPI p-ISSN 1411-0067
DOI: https://doi.org/10.31186/jipi.26.1.1-7 e-ISSN 2684-9593

JIPI Jurnal Ilmu-Ilmu Pertanian Indonesia
INDONESIAN JOURNAL OF AGRICULTURE SCIENCES

ENHANCING RED ONION (*Allium cepa* L.) GROWTH AND YIELD THROUGH CONTROLLED TUBER CUTTING AND PLANT GROWTH REGULATOR APPLICATION

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ABSTRACT

The synergistic effects of tuber cutting and PGR application on red onion growth and yield have not been extensively studied. Therefore, this study aimed to determine the most effective combination of tuber cutting and plant growth regulator (PGR) application for enhancing red onion growth and yield. Conducted between January and April 2023 in the greenhouse of the Agronomy Department, Faculty of Agriculture, University of Palangka Raya, the experiment utilized a completely randomized design (CRD) with seven treatments, each repeated five times. Treatments included: no cutting, cutting ¼ part of the bulb + 3 mL/L PGR, cutting ¼ part of the bulb + 6 mL/L PGR, cutting ¼ part of the bulb + 9 mL/L PGR, cutting ⅓ part of the bulb + 3 mL/L PGR, cutting ⅓ part of the bulb + 6 mL/L PGR, and cutting ⅓ part of the bulb + 9 mL/L PGR. Results indicate that red onion growth and yield can be significantly optimized through the strategic combination of tuber cutting and PGR application. The treatment involving cutting one-third of the tuber with 6 mL/L PGR concentration yielded the most favorable outcomes. Plants in this treatment displayed an average height of 45.84 cm, 51.4 leaves per plant, 10.6 bulbs per plant, 12.4 tillers per plant, a fresh weight of 42.79 g, a tuber dry weight of 18.34 g, and a bulb diameter of 2.18 cm. These findings suggest that cutting one-third of the bulb, in conjunction with specific PGR concentrations, enhances both yield and nutrient content in red onion bulbs, offering valuable insights for optimizing cultivation practices and maximizing crop productivity.

Keyword: *crop yield optimization, plant growth regulator application, red onion growth, tuber cutting,*

ABSTRAK

[PENINGKATAN PERTUMBUHAN DAN HASIL BAWANG MERAH (Allium cepa L.) MELALUI APLIKASI PEMOTONGAN UMBI DAN REGULATOR PERTUMBUHAN TANAMAN]. Efek sinergis dari pemotongan umbi dan aplikasi Regulator Pertumbuhan Tanaman (PGR) pada pertumbuhan dan hasil bawang merah belum banyak dikaji. Oleh karena itu, penelitian ini bertujuan menentukan kombinasi pemotongan umbi dan aplikasi PGR yang paling efektif untuk meningkatkan pertumbuhan dan hasil bawang merah. Dilaksanakan antara Januari dan April 2023 di rumah kaca Departemen Agronomi, Fakultas Pertanian, Universitas Palangka Raya, penelitian ini menggunakan rancangan acak lengkap (RAL) dengan tujuh perlakuan, masing-masing diulang lima kali. Perlakuan meliputi: tanpa pemotongan, pemotongan ¼ bagian umbi + 3 mL/L PGR, pemotongan ¼ bagian umbi + 6 mL/L PGR, pemotongan ¼ bagian umbi + 9 mL/L PGR, pemotongan ⅓ bagian umbi + 3 mL/L PGR, pemotongan ⅓ bagian umbi + 6 mL/L PGR, dan pemotongan ⅓ bagian umbi + 9 mL/L PGR. Hasil menunjukkan bahwa pertumbuhan dan hasil bawang merah dapat dioptimalkan secara signifikan melalui kombinasi strategis pemotongan umbi dan aplikasi PGR. Perlakuan yang melibatkan pemotongan sepertiga umbi dengan konsentrasi PGR 6 mL/L memberikan hasil paling baik. Tanaman dalam perlakuan ini menunjukkan tinggi rata-rata 45,84 cm, 51,4 daun per tanaman, 10,6 umbi per tanaman, 12,4 anakan per tanaman, berat segar 42,79 g, berat kering umbi 18,34 g, dan diameter umbi 2,18 cm. Temuan ini menyarankan bahwa pemotongan sepertiga umbi, bersama dengan konsentrasi PGR yang spesifik, meningkatkan hasil dan kandungan nutrisi dalam umbi bawang merah, memberikan wawasan berharga untuk mengoptimalkan praktik budidaya dan meningkatkan produktivitas tanaman.

Kata kunci: *aplikasi regulator pertumbuhan tanaman, bawang merah, optimasi hasil tanaman, pemotongan umbi*

INTRODUCTION

Indonesia, a major producer of horticultural crops, is known for its distinctive aroma and taste. Red onions, originating from the Central Asian region, are the second largest commodity in the country (Edy & Jayanti, 2022). They have potential health benefits, supporting the circulatory and digestive systems, neutralizing toxic substances, and providing potassium and phosphorus minerals, making them a valuable source of food and medicine (Aryanta, 2019).

The ministry of Agriculture reports that red onion consumption in Indonesia reached 2.76 kg per capita per year in 2019, with productivity increasing by up to 5.74% over the last five years (Sopian, 2021). Central Kalimantan Province's red onion production reached 396 t/ha in 2019, 79 t/ ha in 2020, and 34 t/ha in 2021 (BPS, 2021). However, production in Palangka Raya city has decreased, leading to a decrease in the supply of red onion available to consumers and an increase in it prices. To addres this issue, cultivation techniques like bulb cutting technology and PGR application should be considered.

The tuber cutting treatment also has obvious growth and yield (Siagian *et al*., 2021). The growth of red onion plants can be enhanced by cutting bulbs between ¼ and 1/3 of their length, promoting even distribution of growth. This process stimulates the emergence of shoots, accelerates the growth, and encourages the formation of red onion tillers (Nazirah & Maulana, 2020). Additionally, Jones (2021) found cutting one-third of the bulbs increased shoot growth and the number of red onion tillers. The bulb cutting combined with small amounts of PGR can further increase the growth of side bulbs, forming red onion seedlings (Nazirah & Libra, 2019). Bista *et al*. (2021) investigated the deep effect on plant growth regulators on onion (*Allium cepa* cv. Nasik-53) and discovered that combining NAA and GA3 resulted in highest plant height, leaves number, stem and bulb diameter, and fresh weight of onion.

PGR "Hantu" is a plant hormone that accelerates plant growth and development. It contains macro and micro nutrients necessary for plants, including nitrogen, phosphorus, potassium, magnesium, sodium, copper, iron, manganese, and zinc (Efendi & Purba, 2019). Growth hormones like Gibberellic Acid, Indole Acetic Acid, Kinetin, and Zeatin are also present. PGR "Hantu" stimulates root multiplication, leaf, stem, and flower growth in plants, and enhances their resistance to viral and bacterial attacks. Its composition is crucial for plant growth and development including cell division, elongation, and enlargement as well as flowering stimulation (Prayoga *et al*., 2022). According to Nurdianti *et al*. (2019), the application of PGR "Hantu" had a significant effect on the height, biomass weight, and production of lemongrass clumps at nine weeks after planting attributing to its significant ability to control biological processes in the apllied tissue. Hence, investigating the growth and yield of red onion plants after bulb cutting and applying PGR at varying concentrations is expected to yield positive results.

MATERIALS AND METHODS

Study site and materials

The research was conducted between January to April 2023 at a green house of the Agronomy Department, Faculty of Agriculture, University of Palangka Raya with an altitude 40 m above sea level. The red onion was obtained from Tangkiling's farm namely Bima Brebes variety. Analysis of initial planting media was performed at an Integrated Laboratory of University Palangka Raya. The bulb tissue analysis was carried out at a Laboratory of Physics and Biological Soil of University of Lambung Mangkurat, Banjarbaru, South Kalimantan. The PGR used was "Hantu", which was taken from the farm shop. The "Hantu" contains 65 ppm N, 6 ppm P, 14 ppm K, <0.01 ppm Mg, 0.22 ppm Na, 0.55 ppm Cu, 0.68 ppm Fe, 0.02 ppm Mn, and 0.10 ppm Zn. In addition, "Hantu" contains growth hormones including Gibberellic Acid 0.210 g/L, Indole Acetic Acid 0.130 g/L, Kinetin 0.105 g/L and Zeatin 0.100 g/L.

Treatments

This study was designed using completely randomized design consisting of seven treatments and repeated 5 times to obtain 35 experimental units, namely : P0 (without cutting), P1 (cutting ¼ part of the bulb + 3 ml/L PGR), P2 (cutting ¼ part of the bulb + 6), P3 (cutting ¼ part of bulb + 9 mL/L PGR), P4 (cutting ⅓ bulb part + 3 mL/L PGR), P5 (cutting ⅓ part of bulb + 6 mL/L PGR), P6 (cutting ⅓ part of bulb + 9 mL/L PGR).

Planting media

The peat soil used as a planting media was obtained from Kalampangan village at a depth of 20 cm. Prior to use, an initial analysis of the planting media was conducted, resulting in 3.09 pH (1:5), 52% N-total, 57.44% C-org, 87.96 ppm P, 1.18 me/100g K, and 89.15 me/100 g CEC. A base fertilizer of chicken manure was mixed with dolomite, and was then incubated for 14 days before being placed into polybag as 2 kg for each.

Cutting onion bulbs

The onion bulbs were cut to different sizes for each treatment, namely P_0 (without cutting), P_1, P_2, and P_3 (cutting ¼ parts), and P_4, P_5, and P_6 (cutting 1/3 part). The size of the cut was determined using a caliper.

Planting of onion seedings

Anthracol 70 WP was given at a dosage of 100 g/kg to prevent pests and diseases attacks. Planting involved immersing the bulbs 0.5 cm above the surface of the incubated planting media.

PGR applications

PGR application was carried out every 10 days after planting (dap) until 60 dap. The spraying volume was 2.5 mL per plant at 10 days, 5 mL at 20 days, 7.5 mL at 30 days, 10 mL at 40 days, 12.5 mL at 50 days, and 15 mL at 60 days after planting.

Fertilizing

Supplementary fertilisation was applied twice. The first application (7 dap) consisted of NPK 16:16:16 at a rate of 75 kg/ha (0.4 g/polybag) and KCl at a rate of 37.5 kg/ha (0.2 g/polybag). The second application (21 dap) also consisted of NPK 16:16:16 at a rate of 75 kg/ha (0.4 g/polybag) and KCl at a rate of 37.5 kg/ha (0.2 g/polybag). The fertiliser was applied in a circle around the plant at a distance of 5 cm.

Harvesting

Harvesting occurred at 75 dap attributing with yellowing leaves, softened stems, tuber appearance, and shiny red skin on tubers.

Variable observed

The observed variables included plant height, leaves number, tillers number per clump, bulbs number per clump, plant fresh weight, bulbs dry weight, diameter of tubers, and nutrient of bulbs tissue.

Data analysis

An analysis of variance at the 5% significance levels was performed on all observation data, except tissue analysis data. HSD test was subjected to determine the effect between treatment levels.

RESULTS AND DISCUSSIONS

The variance analysis revealed a significant effect of bulb cuttings with various concentration of PGR on the red onion plant height, leaves number, number of tillers, and plant fresh weight $p<0.05$ (data not shown). The results were then subjected to the HSD 5% test, which is presented in Table 1.

Table 1 shows that the P5 treatment gave the best results in plant height, leaves number, tillers number, and the weight of fresh red onion plants. It is possible to enhance plant growth and development by cutting one-third of onion bulbs before planting, resulting in even growth and increased yields. This is in line with Jones *et al*. (2021) who stated that 1/3 cutting of the bulb increases the height of the red onion plant bay accelerating the production of trigger growth enzymes .

Table 1. The growth of red onion plants

Treatments	Plant height at 49 dap (cm)	Leaves number at 49 dap	Number of tillers	Plant fresh weight (g)
P_0	36.86 a ± 4.9	36.0 a ± 1.9	7.6 a ± 2.3	24.36 a ± 2.7
P_1	39.24 ab ± 0.8	40.4 b ± 2.7	8.4 a ± 1.5	29.57 ab ± 4.7
P_2	40.24 ab ± 1.9	42.6 b ± 2.3	10.4 ab ± 1.5	26.84 ab ± 1.8
P_3	40.98 ab ± 1.3	41.2 b ± 1.9	10.0 ab ± 2.2	32.02 b ± 3.9
P_4	41.16 ab ± 1.2	41.2 b ± 1.8	9.0 ab ± 1.0	27.23 ab ± 5.4
P_5	45.84 c ± 0.9	51.4 c ± 1.5	12.4 b ± 2.3	42.79 c ± 3.5
P_6	43.22 bc ± 1.0	44.2 b ± 1.5	9.8 ab ± 1.3	25.33 ab ± 2.5
HSD 5%	4.34	3.98	3.63	7.36

Note: Numbers followed by the same letter in the same column indicate no significant difference 5% HSD test.

Providing red onion plants with 6 mL/L of PGR affected their height. Enita *et al*. (2019) found that applying PGR at the concentration promoted the growth of red onions, suggesting that 6 mL/L was the best concentration to balance the nutrients that promote plant growth. Plants gain a balanced effect from these nutrients when it comes to photosynthesis and cell differentiation. Additionally, Lidar & Mutryarny (2017) report that gibberellic acid found in “Hantu”, promotes cell division and elongation, leading to an increase in plant height. Therefore, auxin and gibberellin interact to cause apical budding, leading to elongation of the plant. The one-third cutting combined with 6 mL/L PGR application had the greatest leaves number at all ages observed (Table 1). Cutting bulbs before planting can increase the leaf's number by stimulating shoot growth. A 1/3 cut size accelerates the growth of buds, thus allowing optimal leaf growth. As a result of this process, as well as the stimulation of shoots, the plant becomes robust and healthy (Nazirah & Libra, 2019). In addition, the leaves number was closely related to the efficient capture of sunlight, leading to an increase in the rate of photosynthesis. Thus, it affected the production of tillers and tubers. A significant number of leaves was required to produce the number of tillers, tubers, fresh weight, and dry-weight of plants (Nazirah & Maulana, 2020).

The PGR concentration of 6 mL/L significantly impacted the number of leaves in red onion plants, compared to other treatments (Table 1). This is because "Hantu", which contains natural ingredients such as auxin, gibberellin, and kinetin (zeatin and cytokinin), affects the number of leaves. Rahmawati *et al*. (2019) reported the levels of various hormones, including GA3-98, GA5-107, GA7-131, Auksin (IAA)-156, and Sitokinin (Kinetin 128 and Zeatin 106) in "Hantu". Cytokinin content could enhance cell division in meristematic plant parts, such as an axillary bud, increasing the number of leaves (Surtinah & Lidar, 2017). Moreover, Hamid (2016) demonstrated that auxin stimulated plant meristem growth, and that cytokinin stimulated cell division and enlargement.

The P_5 was the most effective treatment for increasing the number of tillers by 38.71% when compared to the control, and this increase was significantly greater than all other treatments except P1, implying that 1/3 of bulb cuttings could regenerate more buds or tillers. Jones *et al.* (2021) and Palupi & Alfandi(2018) found that cutting 1/3 of the bulbs in red onion plants produced the highest number of tillers due to its ability to regenerate buds, triggering the growth tillers in each bulb. The faster shoots or tillers grow, the more tillers are produced. Thus, cutting bulbs in red onion triggers the growth of tillers, as each layer produces tillers.

Table 2. The growth and development of red onion bulbs

Treatments	Bulb number	Bulb diameter (cm)	Bulb dry weight (g)
P_0	6.0 a ± 1.9	0.62 a ± 0.26	5.33 a ± 3.7
P_1	7.4 ab ± 1.3	1.27 ab ± 0.34	6.45 a ± 3.5
P_2	8.2 ab ± 1.3	1.85 bc ± 0.31	9.54 a ± 1.7
P_3	8.0 ab ± 2.2	1.51bc ± 0.48	11.00 ab ± 1.3
P_4	7.0 a ± 1.2	1.40 abc ± 0.51	8.15 a ± 3.0
P_5	10.6 b ± 1.8	2.18 c ± 0.37	18.34 b ± 6.4
P_6	7.8 ab ± 1.5	1.53 bc ± 0.42	9.09 a ± 2.8
HSD 5%	3.31	0.79	7.14

Note: Numbers followed by the same letter in the same column indicate no significant difference 5% HSD test.

The 6 mL/L of PGR had a significant impact on the growth of tillers. This is due to the presence of N, P, and K, which are sufficient for the growth of red onion (Efendi & Purba, 2019). Adequate amount of nutrients is essential for plants to carry out vital functions such as chlorophyll, carbohydrate and protein formation as well as the growth of meristematic tissue. These nutrients could stimulate the growth of tillers in red onion (Enita & Harimurti, 2019). Furthermore, there is a close relationship between the number of tillers and tubers produced and the plant height and number of leaves. Higher production is associated with taller plants.

The P_5 treatment yielded the highest plant fresh weight among the treatments (Table 1), indicating that cutting 1/3 of the tuber uninhibited budding or reduced food reserves in seedlings, thus promoting unrestricted growth and photosynthesis. Nazirah & Maulana (2020) found that red onion plants with a higher number of leaves produced more tillers, bulbs, and fresh and dry-weight of plants. The number of tillers and bulbs determined how effectively these plants capture light energy. Additionally, Sari *et al*. (2022) found 6 mL/L PGR exhibited the highest fresh weight of plants observed, presuming that the concentration was thought to provide a balance of nutrients to support red onion growth.

Treatment P5 resulted in the highest number of bulbs, bulb diameter, and bulb dry weight in red onion, increasing by 43.4%, 251.62%, and 244.09%, respectively, compared to the control (Table 2). The formation of bulbs was linked to the optimal vegetative phase. Plant height was directly proportional to growth components, such as leaf organs. A sufficient number of leaves increased the absorption of solar radiation energy, enhancing the rate of assimilation in plants. Optimal plant height and leaf count support the formation of yield components, resulting in high-quality bulbs (Iswahyudi *et al.*, 2022). The one-third cutting with 6 mL/L PGR "Hantu" influenced the size of a plant's bulb, which was determined by the distribution of photosynthate for food reserves in new plant shoots, and the amount of carbohydrates produced during the growth process (Rambe, 2019). Agrotan & Nurhidayah (2016) apparently found the 1/3 cutting was the best cut, while, Sari *et al*. (2022) stated that PGR at 6 mL/L was the best concentration for red onion bulb diameter. In case of bulb dry weight produced, our findings were in line with Sari *et al*. (2022) and Nazirah & Libra (2019). Faldu *et* *al*. (2023) also recorded that superior bulb diameter, bulb weight, and marketable yield of onions were produced by foliar application of PGR of GA3 combined with Zn, attributing on onion quality parameters (Jangre & Deepshikha, 2023). According to the Standard Operating Procedure for red onion (2010), plants could be produced with a bulbs dry weight of 18.34 g and spacing of 15 cm x 20 cm, resulting in a yield of 6.1 t/ha.

Plant's bulbs tissue analysis revealed that bulb cutting with various concentrations of PGR "Hantu" increased N-total (9.12%), P (11.40%), and K (5.83%) of red onion bulbs (Table 3), raising the possibility that bulb cutting had a direct effect on the red onion's ability to absorb nutrients. This was thought to be due to uncut bulbs experiencing delays in shoot release because they were covered by the driest membrane of the bulb layer, resulting in suboptimal onion growth (Sumini *et al*., 2022). Treatment P_5 produced the highest C-org (29.30%). The higher C-org was believed to be linked to the greater biomass content of red onion bulbs (Tables 1 and 2). According to Muksin & Anasaga (2021), there was a positive correlation between biomass and C-org. Therefore, Darma *et al*. (2020) found that C-org levels in fruit plant leaves were considered very high at ≥7.55%. Jones (1969) demonstrated that vegetables were considered to have sufficient levels of nitrogen nutrients when they contained between 3.00-6.00%, phosphorus (0.25-0.80%), and potassium (2.25-8.0%). Nemtinov *et al*. (2020) measured the distribution of element accumulation variation in onion leaves as follows: Zn>Fe, Si>Na, P>Cl, Mo>Mg, S>Ca, Cu>K.

Table 3. Bulb tissue macro elements of red onion

Treatments	C-org	N-total	P_2O_5	K_2O
	Walkley & Black	H_2SO_4 destruction		
	---------------- % -----------------			
P_0	24.33	3.69	1.14	1.23
P_1	23.46	3.73	1.16	1.27
P_2	20.02	4.09	1.26	1.30
P_3	22.88	3.88	1.32	1.27
P_4	20.73	4.66	1.48	1.44
P_5	29.30	3.06	1.13	1.19
P_6	21.23	4.76	1.27	1.34

CONCLUSIONS

Red onion growth and yield were significantly optimized through the strategic combination of tuber cutting and PGR application. Cutting one-third of the bulb with a PGR concentration of 6 mL/L yielded the most favorable outcomes. Plants treated with this combination exhibited significant improvements in height, leaf count, bulb count, tiller count, fresh weight, dry weight, and bulb diameter. These findings suggest that specific tuber-cutting proportions, coupled with tailored PGR concentrations, can enhance both yield and nutrient content in red onion bulbs, offering valuable insights for optimizing cultivation practices and maximizing crop productivity.

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