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THE GROWTH AND YIELD OF SOYBEAN ON SHOOT CUTTING TIME AND APPLICATION OF GROWTH REGULATORS

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ABSTRACT

This research aimed to determine the effect of shoot cutting combined with spraying growth regulators on the growth and yield of soybeans. The experiment was arranged in a factorial randomized block design and was repeated three times. Shoot cutting treatments were performed 10, 20, and 30 days after planting. The growth regulators applied were Cytokinin, Auxin, and Gibberellin. The growth and yield of soybean plants were observed through plant height, number of branches, percentage of canopy coverage, leaf area, number of pods, weight of 100 seeds, and number of seeds per plot. The results showed that the interaction of the two treatments had no significant effect on soybean growth and yield. The Gibberellin treatment significantly affected plant height at 6 weeks after planting, number of branches at 4 weeks after planting, number of pods, and yield per plot.

Keywords: Apical dominance, food crop, plant cultivation

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is a food commodity with high economic value in Indonesia. As the primary source of vegetable protein, soybeans provide protein to meet nutritional needs, mainly because various groups of Indonesian people can access soy protein. Besides being rich in protein, soybeans contain bioactive components such as isoflavones, which have additional health benefits (Riswanto et al., 2021). The high demand for direct consumption and raw materials for the food industry makes soybeans a strategic commodity that needs to be developed in the national agricultural system.

However, soybean productivity in Indonesia still needs improvement, and efforts must be made to reach its productivity potential (Sagala et al., 2018; Sagala et al., 2021). Some problems are land fertility, climate, and pest and disease attacks. Apart from that, suboptimal cultivation techniques cause soybean plants' growth efficiency and productivity not to reach adequate results (Sagala et al., 2018; Sagala et al., 2018; Sagala et al., 2021; Sagala et al., 2024). As a result, domestic soybean production has been unable to meet national needs, so Indonesia still depends on soybean imports (Malik & Nainggolan, 2020; Central Statistics Agency, 2022).

Productivity can be raised by controlling soybean vegetative growth, such as using shoot-cutting procedures. Shoot-cutting aims to reduce apical dominance and encourage the growth of more lateral branches. The likelihood of pod formation rises with branch creation, which eventually boosts soybean yields. Several studies show that this method effectively increases crop yields through optimizing biomass distribution (Ibrahim et al., 2021; Kisman et al., 2021).

Apart from cutting, using plant growth regulators (PGR) or growth hormones is an

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important component in optimizing the growth and yield of soybean plants. Plant growth regulators, such as auxin and cytokinin, regulate plant physiological processes, such as cell division, stem elongation, and flower formation, which support overall plant productivity (Amoanimaa-Dede et al., 2022). Appropriate PGR application can increase growth efficiency and soybean yields in various land conditions.

The objective of this study is to investigate whether soybean plant development and yield are affected by shoot-cutting time and growth regulator application.

MATERIAL AND METHODS

This research was conducted in Bengkulu City, Bengkulu Province, Indonesia, from April to July 2023. The materials used included soybean seeds of the Derap 1 variety, growth regulators in cytokinins, auxins and gibberellins, dolomite lime, and cow manure.

The experiment was designed using a Randomized Block Design with a factorial pattern consisting of two factors with three replications. The first factor is shoot cutting time at 10, 20, and 30 days after planting (DAP). The second factor was the application of PGR, which consists of Cytokinin, Auxin, and Gibberellin. There were nine treatment combinations with three repetitions for 27 treatment combinations.

Land with an area of 10 m x 16 m was processed first by clearing it of plant or bush residues. Next, the land was hoed and levelled to loosen the soil and remove weed roots. The bed was made with dimensions of 1 m x 2 m and a height of 30 cm. Each bed was applied 1 ton/ha of dolomite lime (around 150 g/bed) when loosening the soil two weeks before planting. Cow manure of 10 tons/ha (2 kg/bed) was spread a week before planting by mixing it evenly in the bed.

Planting was done by making a planting hole 2 cm deep with a plant space of 40 cm x 15 cm. Each hole was filled with two soybean seeds and covered with soil. The land was watered until the soil became wet and moist.

Shoot-cutting treatment occurred at the 10, 20, and 30 DAP phases. Shoots were cut using sterilized scissors with 70% alcohol to prevent the spread of disease.

Plant growth regulators were applied by spraying the solution on plants. The doses used were cytokinin 2 ml/liter of water, auxin 1.5 ml/liter of water, and gibberellin 1 ml/liter of water.

Maintenance was carried out through weeding and pest control. Weeding was done manually to clean weeds in the beds or around the plants. Pest and disease control was carried out in the vegetative and generative phases.

Observations were made on several parameters: plant height, number of branches, plant canopy cover, leaf area, number of pods, weight of 100 seeds, and yield per plot. Canopy coverage was measured using the Hemispherical Photography method. Canopy photos were taken from above the plant with the rear camera of a Vivo smartphone with 8 MP resolution and HD resolution (1280 x 720) and analyzed using Image J software. Leaf area was measured using a destructive method using a scanner and Image J software.

RESULTS AND DISCUSSION

Effect of Shoot Cutting Time and PGR on Soybean Vegetative Growth

The analysis results show that cutting and PGR type significantly affect soybean plant height, with the interaction between the two not being significant at the 5% level (Table 1). Plants cut 10 days after planting

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(DAP) with auxin were given the highest plant height at 6 weeks after planting, namely 53.89 cm, followed by plants that received gibberellin with a height of 45.56 cm. The average plant height was higher at 10 DAP cutting (42.62 cm) compared to 20 and 30 DAP, which reached 19.14 cm and 16.33 cm, respectively (Table 2). Early cutting encourages the formation of plant height because, in this phase, plants are more responsive to auxin and gibberellin, which play a role in accelerating cell division and stem elongation.

Table 1. The Analysis of variance of the growth and yield of soybean on shoot cutting time and application of growth regulators.

Variable	Shoot cutting time	Plant growth regulator	Cutting-PGR Interaction
Plant height	0.000*	0.007*	0.057ns
Leaves area	0.962ns	0.290ns	0.405ns
Canopy coverage	0.000*	0.180ns	0.293ns
Branch number	0.089ns	0.831ns	0.631ns
Pod number	0.008*	0.726ns	0.260ns
Weight of 100 seeds	0.748ns	0.120ns	0.946ns
Yield	0.049*	0.327ns	0.051ns

ns Not significant; * Significant at 5% Fisher test (analysis of variance); PGR Plant growth regulator

Plant leaf area did not show significant differences due to cutting time or PGR treatments (Tables 1 and 2). However, canopy closure measured 6 weeks after planting showed that cutting at 10 DAP resulted in better canopy cover, namely 52.54%, compared to cutting at 20 DAP, which only reached 31.37% (Table 2). It is in accordance with the theory that shoot cutting in the early phase increases lateral branches' growth, producing a lusher canopy and helping increase photosynthetic efficiency (Ibrahim et al., 2021; Zhang et al., 2022).

Effect of Shoot Cutting and PGR on Soybean Yield Components

Cutting at 10 DAP resulted in the highest mean number of branches, although the difference was insignificant (Table 3). A more significant number of branches has the potential to support an increase in the number of pods, which is one of the main components in increasing soybean yields. Early cutting allows the plant to utilize more resources in forming branches, which provides more spots for pods to develop (Table 3).

Cutting and PGR treatments did not significantly affect the weight of 100 seeds, ranging from 16.78 to 19.44 g (Table 3). Seed weight is generally determined by genetics and other environmental factors, including soil conditions and water availability. Soybean seed weight is more resistant to agronomic treatment, in contrast to components such as pod number, which are very responsive to changes in plant physiology.

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Table 2. Effect of shoot cutting time and plant growth regulator on soybean vegetative growth.

Plant Growth Regulator	Shoot cutting time (days after planting/DAP)			Average
	10 DAP	20 DAP	30 DAP	
		Plant height (cm)		
Cytokinin	28.42	18.58	13.00	20.00c
Auxin	53.89	20.67	19.83	31.46a
Gibberellin	45.56	18.17	16.17	26.63b
Average	42.62A	19.14B	16.33B	
		Leaves area (cm^2)		
Cytokinin	45.33	45.33	46.67	45.78
Auxin	48.67	45.33	35.33	43.11
Gibberellin	48.33	47.33	58.67	51.44
Average	47.44	46.00	46.89	
		Canopy coverage (%)		
Cytokinin	53.95	42.72	58.04	51.57
Auxin	51.74	31.17	54.63	45.85
Gibberellin	51.93	20.22	57.58	43.25
Average	52.54A	31.37B	56.75A	

Note: Values followed by the same lowercase letter in the same column or the same uppercase letter in the same rows are not significantly different using the DMRT test at the 5% level.

Seed yield per plot showed significant differences between cutting times, where cutting at 30 DAP produced the highest seed yield (273.00 g), especially in the gibberellin treatment (Table 3). It shows that although early cutting supports vegetative growth, later cutting allows for more optimal seed yield formation. Gibberellins significantly affect the flowering and seed formation phases by increasing seed size and weight. It suggests that gibberellins can be used in the generative phase to optimize seed yield per plot.

The correlation between plant height, number of branches, and number of pods at initial cutting shows that this strategy effectively increases vegetative growth components and yield components. Cutting at 10 DAP with auxin PGR maximizes growth in height and number of branches, which is relevant to increasing the canopy area and number of pods. On the other hand, cutting at 30 DAP with gibberellin resulted in higher seed yields. This approach shows that optimal cutting timing accompanied by appropriate PGRs can increase resource utilization efficiency and overall soybean yield potential.

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Table 3. Effect of shoot cutting time and plant growth regulator on soybean yield component.

Plant Growth Regulator	Shoot cutting time (days after planting/DAP)			Average
	10 DAP	20 DAP	30 DAP	
		Branch number		
Cytokinin	3.42	3.00	2.17	2.86
Auxin	2.83	2.83	2.75	2.81
Gibberellin	2.92	3.00	2.08	2.67
Average	3.06	2.94	2.33	
		Pod number		
Cytokinin	45.33	15.67	33.00	31.33
Auxin	27.33	26.33	30.33	28.00
Gibberellin	42.50	18.00	35.08	31.86
Average	38.39a	20.00b	32.81a	
		Weight of 100 seeds (g)		
Cytokinin	17.33	15.67	17.33	16.78
Auxin	19.67	19.67	19.00	19.44
Gibberellin	19.00	18.00	19.33	18.78
Average	18.67	17.78	18.56	
		Plot yield		
Cytokinin	169.00	134.00	318.00	207.00
Auxin	164.00	183.00	281.00	209.33
Gibberellin	429.00	150.00	240.00	273.00
Average	254.00ab	155.67a	279.67b	

Note: Values followed by the same lowercase letter in the same rows are not significantly different using the DMRT test at the 5% level.

CONCLUSION

Cutting in the early phase supports vegetative growth and increases branch and pod components, while cutting in the late phase with gibberellin increases seed yield per plot. These results imply that cutting time accompanied by appropriate PGR is very important in the agronomic management of soybeans to obtain maximum results.

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