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The effect of Gibberellin (GA_3) concentration on flower loss and yield in the soybean (*Glycine Max (L.)* Merril) Anjasmoro Cultivar

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ABSTRACT

Soybean (*Glycine max (L.)* Merril) is one of the main crops widely grown around the world and can affect various aspects of the ecosystem. One of the efforts to increase soybean production and prevent flower loss is the use of plant growth regulators (PGRs). The purpose of this research is to reduce flower loss and increase production yields in the Anjasmoro cultivar of soybean plants. This study aims to: (1) determine the significant influence of gibberellin (GA_3) concentration on flower shedding, the number of pods per plant, the dry pod weight (per plant (g) and per plot (g), and the dry seed weight (pt)) of soybean. The study was carried out at Beberan Village, Palimanan District, Cirebon Regency, Indonesia. The research used Randomized Group Design (RGD) with one treatment factor and 4 replications. The results showed that the concentration of gibbelliin (GA_3) significantly influenced flower loss (p0.05) and yield ($p>0.05$). The application of 100 ppm (N2) of GA_3 can produce the highest dry weight of 901.25 g/plot or 2,815.625 kg/ha and is significantly different from other treatments. In addition, the study identified the optimal concentration that minimizes flower loss while maximizing production yield under non-stress conditions, contributing valuable insights to enhance agricultural practices aimed at improving soybean productivity in Indonesia.

INTRODUCTION

Soybean (*Glycine max (L.)* Merril) is one of the main crops widely grown around the world and can affect various aspects of the ecosystem. Some countries that dominate world soybean production are subtropical, such as Brazil, the United States, Argentina, China, and India (Pagano & Miransari, 2016). Soybean is the third most significant food crop in Indonesia, following rice and corn. Most Indonesians consume soybeans as a source of vegetable protein in the form of processed tempe and tofu (Harsono et al., 2022).

Based on FAO data in 2022, Brazil can produce 134 million tons of soybeans, the United States 120 million tons, Argentina 46 million tons, China 16 million tons, and India 12 million tons. Indonesia's soybean production amounts to about 2 million tonnes annually, fulfilling merely one-third of the nation's soybean requirements. Consequently, Indonesia is need to import soybeans to satisfy its demands (Pasaribu & Salbiah, 2017). The loss of soybean flowers is a contributing factor to reduced yield. Intrinsic physiological mechanisms inside the plant may lead to floral abscission (Taiz & Zeiger, 2002). The physiological factors contributing to flower and fruit abscission include the lack of photosynthesis, inadequate environmental nutrients, and hormonal control inside the abscission zone (Herdiandika, 2015). The abscission zone of the flower is situated beneath the flower stalk.

One of the efforts to increase soybean production and prevent flower loss is the use of plant growth regulators (PGRs). One of the plant growth regulators (PGRs) is gibberellin. Gibberellins can regulate plant development processes, such as accelerating plant growth and affecting the genetic characteristics and physiological processes of plants. Giving gibberellin hormone (GA_3) can increase the percentage of flowers into pods, because giving gibberellin hormone (GA_3) to plants can reduce flower miscarriage (Nazaruddin & Irmayanti, 2020). The purpose of giving gibberellin hormone (GA_3) to soybean plants is to increase plant productivity, including reducing the loss of flowers and pods that have been formed (Septian, 2018). This is due to the ability of gibberellin hormone (GA_3) to reduce flower loss by indirectly increasing auxin content (Sahur, 2021).

The purpose of this research is to reduce flower loss and increase production yields in soybean plants (*Glycine max (L.)* Merril) of the Anjasmoro cultivar. Specifically, this study aims to: (1) determine the significant influence of gibberellin (GA_3) concentration on flower loss and yield; and (2) identify the optimal gibberellin (GA_3) concentration that results in the least flower loss and the highest yield in the Anjasmoro cultivar of soybean plants. The research contributes to the field of agronomy and soybean cultivation by providing valuable insights into the effects of gibberellin (GA_3) on flower loss and yield in the Anjasmoro cultivar of soybean plants (*Glycine max (L.)* Merril). By identifying the optimal concentration of GA_3 that minimizes flower loss while maximizing production yields, the study offers practical recommendations for farmers and agronomists aiming to enhance soybean productivity. Additionally, this research adds to the existing body of knowledge regarding plant growth regulators and their application in crop management, potentially leading to improved agricultural practices and increased economic returns for soybean producers. Overall, it supports the development of sustainable agricultural strategies that can help address challenges in soybean production.

The research presented in the document addresses the effects of varying gibberellin (GA_3) concentrations on flower loss and yield in the Anjasmoro cultivar of soybean (*Glycine max (L.)* Merril), highlighting physiological mechanisms behind flower abscission. In contrast, studies by Calvin et al. (2019) and Girsang et al. (2020) focus on the impact of waterlogging on soybean growth, incorporating both gibberellic acid and salicylic acid under stress conditions, while Karyawati & Cahya (2023) examine GA_3 application solely for flower drop prevention without extensive analysis of yield outcomes. This creates a gap in understanding the relationship between GA_3 concentration, flower loss, and yield during normal growth conditions. The novelty of the current research lies in its targeted exploration of the optimal GA_3 concentration that minimizes flower loss and maximizes yield under non-stress conditions, contributing valuable insights to enhance agricultural practices aimed at improving soybean productivity in Indonesia.

METHOD

The research project was carried out at Beberan Village, Palimanan District, Cirebon Regency. The duration of this research is from June to September 2024. The materials and tools used in this research are: Anjasmoro cultivar soybean seeds, Gibberellin plant growth regulator, aquades, water, Urea fertilizer, KCl fertilizer, and other supporting materials. The tools used in this research are hoes, sprayers, measuring tapes or rulers, labels, scales, measuring cups, watering cans, paper, pens, raffia strings, calculators, cameras, and other supporting tools.

This study used Randomized Group Design (RGD) with one treatment factor and 4 replications. The treatments were N0: Gibberellin 0 ppm, N_1: Gibberellin 50 ppm, N_2: Gibberellin 100 ppm, N_3: Gibberellin 150 ppm, N_4: Gibberellin 200 ppm, N_5: Gibberellin 250 ppm. There were 6 treatments and repeated four times, so that in total there were 24 experimental units.

The research began with clearing the soil of weeds and turning it over with a hoe. Next, we made beds measuring 50 cm in height, 160 cm in width, and 200 cm in length, with a spacing of 40 cm x 20 cm. There were 40 plant holes in one bed and each plant hole was filled with two seeds. Watering, transplanting, fertilizing, hilling, controlling weeds, pests, and installing stakes are all aspects of plant maintenance. During the growth phase, watering is done every day. However, from the third week onwards, watering is no longer occurs daily. This is due to the process of watering, which involves running or ponding until the water slightly rises. Replanting is done on days 4-7 days after planting (DAP). The first fertilization was given at planting time, 27 DAP, and 40 DAP. The activity of adding soil around the roots and controlling weeds is carried out as needed, for example, at 14, 28, and 42 DAP. For pest control, spraying is done using vegetable pesticides, but if it is less than optimal, switch to chemical pesticides. The use of pesticides is used according to the pests in the field. When soybeans show signs of flowering, we install stakes on them to prevent them from easily falling until harvest.

The application of gibberellin hormone (GA_3) is performed by direct spraying onto soybean blossoms using a sprayer. Spraying is done twice according to the dose that has been determined. The first spraying is calculated after 4 days of flower blooms, then after a week exactly, on the 11th day, the soybean flowers are sprayed again for the second time. Spraying is done in the morning at 06:00-08:00 WIB.

Harvesting is done when the plants were 77 DAP, executed by severing the stem base above the soil level using pruning shears. We obtained data on the number of flowers (remaining flowers, fallen flowers, and total flowers), the quantity of dry pods per plant, the weight of dry pods per plant (g) and per plot (g), the weight of dry seeds per plant (g) and per plot (g), and the weight of 100 dry seeds (g). Then, the data obtained were tested with ANOVA (Analysis of Variance) test at 5% significance level. If the results effect of treatment is significantly different (F-value > F 5%), it is continued with the LSR (Least Significant Ranges) test at the 5% significance level.

RESULTS AND DISCUSSION

Number of Flowers (Fallen Flowers, Remaining Flowers, and Total Flowers)

The results of average observations and analysis of variance indicated a significant effect on the number of flowers (fallen flowers, remaining flowers, and total flowers) at the age of 36 DAP and 39 DAP. The number of flowers (fallen flowers, remaining flowers, and total flowers) on soybean plants resulting from the application of gibberellin (GA_3) concentration is presented in Table 1.

Table 1. Effect of gibberellin (GA_3) concentration on the number of flowers (fallen flowers, remaining flowers, and total flowers) in soybean (*Glycine max* (L.) Merril) Anjasmoro cultivar at the observation of 36 DAP and 39 DAP

Gibberellin Treatment (ppm)	**Observation Variable**					
	Number of Fallen Flowers		***Number of Remaining Flower***		***Total Interest Amount***	
	36 DAP	**39 DAP**	**36 DAP**	**39 DAP**	**36 DAP**	**39 DAP**
N_0 (0 ppm)	5,40ab	3,75bc	51,15bc	13,05ab	56,30bc	17,25ab
N_1 (50 ppm)	4,60ab	2,90b	54,30c	16,70bc	60,45cd	21,75bc
N_2 (100 ppm)	**3,30a**	**1,50a**	**56,50c**	**20,80c**	**64,45d**	**26,05c**
N_3 (150 ppm)	5,85abc	4,55cd	46,20b	12,10ab	51,65b	16,15ab
N_4 (200 ppm)	7,55bc	5,75d	43,80b	11,70ab	48,75b	15,60ab
N_5 (250 ppm)	**9,00c**	**7,75e**	**33,10a**	**8,95a**	**38,70a**	**11,50a**

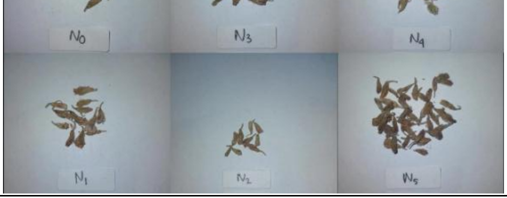
Description: Numbers followed by the same letter in the same column indicate not significant difference according to the LSR Test 5% level.

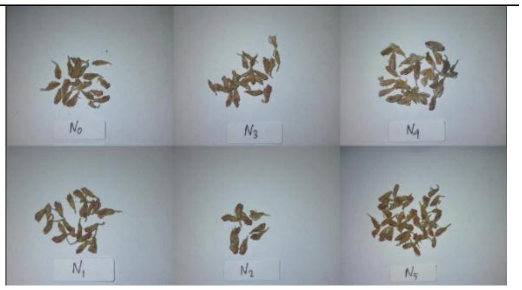
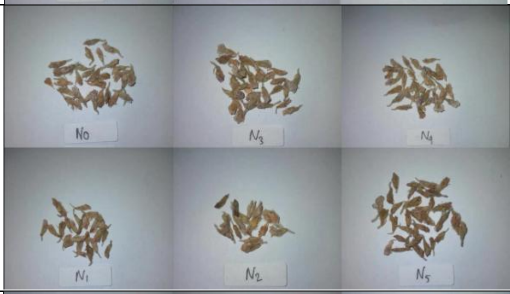
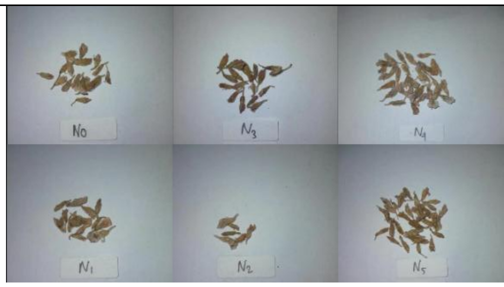
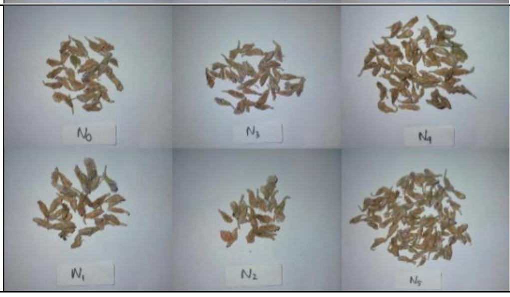
Table 1 demonstrates that at the ages of 36 DAP and 39 DAP, the gibberellin N_2 (100 ppm) treatment resulted in an average of fewer fallen flowers compared to the other treatments, specifically 3,30 flowers at 36 DAP and 1,50 flowers at 39 DAP. In line with the number of fallen flowers, the N_2 treatment also produced a higher number of remaining flowers and total flowers compared to the other treatments. This is likely due to the fact that exogenous gibberellin application, applied at the appropriate dosage and spraying time, can effectively reduce flower loss, thereby increasing the number of live flowers and total flowers.

The addition of exogenous plant growth regulators (PGRs), such as GA_3, into plants would elevate their auxin levels by inducing proteolytic enzymes that initiate the synthesis of tryptophan molecules, which serve as precursors to auxin. Elevated auxin concentrations will impede the abscission process (Herdiandika, 2015). Exposure of the abscission zone to ethylene induces the detachment of flowers and fruits (Bangerth, 2000). Different plant organs disseminate ethylene, a hormone that induces abscission. Ethylene stimulates the production and release of hydrolases that degrade the cell wall. This affects transcription and increases hydrolase-encoding mRNA. Increased secretion of hydrolase enzymes leads to cell wall damage and organ loss (Salisbury & Ross, 1995). In the abscission zone, elevated ethylene levels and diminished auxin concentrations induce abscission (Taiz & Zeiger, 2002).

According to (Karyawati & Cahya, 2023) the application of GA_3 at 100 ppm on Anjasmoro cultivars yielded a higher bloom count (27.16%) compared to the application of GA_3 at 400 ppm.

Table 2. Number of Fallen Flowers 1st (36 DAP) and 2nd (39 DAP)

	1st Fallen Flowers	**2nd Fallen Flowers**
Repeat 1		

Repeat 2		
Repeat 3		
Repeat 4		

Number of Pods Per Plant

The results of average observations and analysis of variance showed that there was a significant effect on the number of pods per plant. The number of pods per plant on soybean plants resulting from the application of gibberellin (GA_3) concentration is presented in Table 3.

Table 3. Effect of gibberellin (GA_3) concentration on the observation variable number of pods per plant of soybean (*Glycine max* (L.) Merril) Anjasmoro cultivar

Gibberellin Treatment (ppm)	**Number of Pods Per Plant (fruit)**
	Average
N_0 (0 ppm)	74.35bc
N_1 (50 ppm)	79,10c
N_2 (100 ppm)	**109,10d**
N_3 (150 ppm)	69.55bc
N_4 (200 ppm)	63.10ab
N_5 (250 ppm)	**55,35a**

Description: Numbers followed by the same letter in the same column indicate not significantly different according to the LSR Test 5% level.

The results of Table 3 show that there are differences in the number of pods per plant due to the application of various concentrations of gibberellin hormone to soybean plants. The treatment of N_2 (100 ppm) was significantly different from all treatments. The average value of the highest number of pods per plant is 109,10 fruit (N_2). Because in N_2 the number of fallen flowers is less than the other treatments, the flowers that will form into pods are more. This is thought to be because the number of pods is influenced by the number of flowers, the more flowers formed, the higher the potential to become pods. The number of pods produced by soybean plants is directly proportional to the number of flowers produced.

The application of gibberellin (GA_3) on soybean plants at a concentration of 100 ppm is capable of increasing the number of flowers that turn into pods and boosting production. According to the research by Yasmin et al. (2014), the administration of gibberellin hormone (GA_3) at a concentration of 100 ppm at the onset of flowering has the potential to enhance the production of chili peppers compared to the absence of this hormone treatment. This is because the application of gibberellin increases the auxin content, which in turn reduces the number of flowers that fall to form pods.

The plant environment and plant metabolism can affect the formation of assimilates resulting from the photosynthesis process (Nazaruddin & Irmayanti, 2020). This is supported by the research of Widiwurjani et al. (2019), showing that the use of gibberellin 125 ppm can produce 38,22 tomato fruits on average compared to control plants (27,67 fruits).

Dried Pod Weight (Per Plant (g) and Per Plant (g))

The results of average observations and analysis of variance showed a significant effect on dry pod weight (per plant (g) and per plot (g)). Dry pod weight (per plant (g) and per plot (g)) of soybean plants affected by the application of gibberellin (GA_3) concentration is presented in Table 4.

Table 4. Effect of gibberellin (GA_3) concentration on observation variables of dry pod weight (per plant (g) and per plot (g) of soybean (*Glycine max* (L.) Merril) Anjasmoro cultivar

Gibberellin Treatment (ppm)	Observation Variable	
	Dry Pod Weight Per Plant (g)	***Dry Pod Weight Per Plot (g)***
	Average	***Average***
N_0 (0 ppm)	45,95c	870.00bc
N_1 (50 ppm)	48,70c	1005,75c
N_2 (100 ppm)	**55,75d**	**1161,75d**
N_3 (150 ppm)	40,00b	763,25b
N_4 (200 ppm)	35.05ab	573,75a
N_5 (250 ppm)	**33,20a**	**434,50a**

Description: Numbers followed by the same letter in the same column indicate not significantly different according to the LSR Test 5% level.

The application of gibberellin at a concentration of 100 ppm (N_2) was significantly different from the other treatments. The results of Table 4 also show that the treatment with 100 ppm (N_2) gibberellin concentration has higher dry pod weight per plant (g) and per plot (g), with an average of 55,75 g for dry pod weight per plant and 1161,75 g for dry pod weight per plot, compared to all treatments.

Based on the data above, gibberellin (GA_3) had a significant effect on dry pod weight (per plant (g) and per plot (g)). Disruption of the cell membrane releases the amino tryptophan, which functions as an auxin precursor. Since both are responsible for cell division and expansion, the synergy of auxin and gibberellin can cause cell growth. This indicates that exogenously added gibberellin hormones can cause cells to expand and grow, thereby increasing the overall cell size (Wahyuningsih et al., 2023). The number of fruits significantly contributed to the weight of fruits per plant (Hapsari et al., 2017). Plants that produce more fruit will yield heavier fruit per plant.

Dried Seed Weight (Per Plant (g) and Per Plot (g))

The results of average observations and analysis of variance indicated a significant effect on dry seed weight (per plant (g) and per plot (g)). Dry seed weight (per plant (g) and per plot (g)) in soybean plants following the application of gibberellin (GA_3) concentration is presented in Table 5.

Table 5. Effect of gibberellin (GA_3) concentration on observation variables of dry seed weight (per plant (g) and per plot (g)) of soybean (*Glycine max* (L.) Merril) cultivar Anjasmoro

Gibberellin Treatment (ppm)	Observation Variable	
	Dry Seed Weight Per Plant (g)	***Dry Seed Weight Per Plot (g)***
	Average	***Average***
N_0 (0 ppm)	32.75cd	665,00c
N_1 (50 ppm)	35.00de	788,75d
N_2 (100 ppm)	**40,00e**	**901,25d**
N_3 (150 ppm)	29.10bc	558,25c
N_4 (200 ppm)	25.55ab	395,00b
N_5 (250 ppm)	**23,10a**	**243,25a**

Description: Numbers followed by the same letter in the same column indicate not significantly different according to the LSR Test 5% level.

Table 5 shows that the treatment with 100 ppm gibberellin (N_2) had higher dry seed weight per plant (g) and per plot (g), which was significantly different from the other concentrations. The N_2 treatment achieved the highest average dry seed weight per plot (g) of 901,25 g or 0,901 kg.

Based on the data above, gibberellin (GA_3) gave a significant effect on dry seed weight (per plant (g) and per plot (g)). This is in line with the results of research(Sudirman et al., 2015), which states that the provision of gibberellins tends to increase the weight of seeds per plant compared to control plants. Yasmin et al. (2014) assert that the effective concentration of plant growth regulators (GA_3) in plants significantly influences their growth and development. High doses of the substance can stop plant growth and development, while low doses are ineffective as growth regulators. Therefore, it's crucial to administer it at the correct dosage for a favorable outcome. According to the results of research by Permanasari (2007), the provision of gibberellin at a concentration of 100 ppm can increase the number of seeds and seed weight per plant.

Weight of 100 Dry Prints (g)

The results of average observations and analysis of variance indicate that gibberellin had no significant effect on the weight of 100 dry seeds (g). The weight of 100 dry seeds (g) in soybean plants following the application of gibberellin (GA_3) concentration is presented in Table 5.

Table 5. Effect of gibberellin (GA_3) concentration on the observation variable of 100 dry seed weight (g) of soybean (*Glycine max* (L.) Merril) Anjasmoro cultivar

Gibberellin Treatment (ppm)	**Weight of 100 Dry Grains (g)**
	Average
N_0 (0 ppm)	18,50
N_1 (50 ppm)	19,00
N_2 (100 ppm)	**19,50**
N_3 (150 ppm)	19,00
N_4 (200 ppm)	18,25
N_5 (250 ppm)	**17,25**

Description: Numbers followed by the same letter in the same column indicate not significantly different according to LSR Test 5% level.

The results of variance analysis in Table 5 show that the application of gibberellin treatment did not significantly effect on the weight of 100 dry seeds (g). This is thought to be due to the process of selecting dry seeds to be weighed, randomly selected, not based on seed size (large or small seeds). According to Kamil (1996), the high and low weight of 100 seeds is strongly influenced by the genes contained in the plant itself and depends on the amount of dry matter contained in the seeds. This indicates that the weight of 100 soybean seeds is more controlled by genetic factors.

CONCLUSION

Research on the impact of gibberellin concentration (GA_3) on flower loss and yield in the Anjasmoro cultivar of soybean (Glycine max (L.) Merril) concluded that GA_3 significantly affects flower shedding, pod numbers, dry pod weight, and dry seed weight, with a concentration of 100 ppm yielding the highest dry seed weight of 901.25 g/plot or 2,815.625 kg/ha. Future studies could focus on the long-term effects of GA_3 application on soil health and yield stability, optimal timing of GA_3 applications during critical growth stages, comparative efficacy with other plant growth regulators, interactions with environmental stressors, and genetic variability among soybean cultivars in response to GA_3 treatment. These avenues could enhance the understanding of GA_3's role in soybean cultivation and lead to improved agricultural practices.

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