Effects of Application Intervals and Foliar Fertilizer Concentrations on the Growth and Yield of Soybean (*Glycine max* L.)

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Abstract

Soybean (*Glycine max L.*) is an important food crop and a source of plant-based protein. This study aimed to determine the effects of application intervals and concentrations of Catomi foliar fertilizer on soybean growth and yield. The study was conducted at the Experimental Farm of the Faculty of Agriculture, Universitas Graha Nusantara, Padangsidimpuan Selatan, Padangsidimpuan City, Indonesia. A factorial randomized block design with three replications was used. The treatments consisted of fertilizer application intervals of 7, 10, and 14 days and concentrations of 2, 4, and 6 cc/L of water. The observed parameters were plant height, number of branches, days to flowering, number of pods per plant, and seed yield per plot. The results showed that application interval significantly affected days to flowering, number of pods per plant, and seed yield per plot, but did not significantly affect plant height or number of branches. Fertilizer concentration significantly affected seed yield per plot, but did not significantly affect the other parameters. The interaction between application interval and concentration was not significant for any observed parameter. The 7-day interval produced the highest mean seed yield for the interval factor (335.04 g per plot), while the 6 cc/L concentration produced the highest mean for the concentration factor (335.60 g per plot). Further research is needed to test the consistency of these results under different environmental conditions.

Keywords: *Soybean, Catomi Foliar Fertilizer, Application Interval, Fertilizer Concentration, Seed Yield.*

A. INTRODUCTION

Soybean is an important food crop that contributes to meeting people's food needs. Soybean seeds contain plant-based protein and various nutrients, making them a major raw material for tofu, tempeh, soy sauce, and other processed food products. Soybean is also used in animal feed and various industrial products. Its widespread use makes increasing soybean productivity an important objective in agricultural development. However, efforts to increase soybean production need to be supported by appropriate cultivation practices, including nutrient management that matches crop requirements and growing conditions. Fertilizer management is one component of cultivation that can affect vegetative growth, pod formation, and soybean seed yield.

Soybean growth and yield are influenced by genetic factors, environmental conditions, water availability, and adequate nutrient supply throughout growth. Nitrogen (N), phosphorus (P), and potassium (K) play important roles in plant physiological processes. Nitrogen is involved in protein and chlorophyll formation, phosphorus supports energy transfer and reproductive development, and potassium

contributes to water balance, enzyme activity, and plant metabolism. An imbalance in nutrient availability can limit plant growth and potentially affect seed formation and filling. Hasibuan et al. (2018) showed that fertilizer management and soil improvement are important for increasing soybean productivity. Hapsoh et al. (2019) reported that applying compost and NPK fertilizer can affect several soybean yield components, including seed number and seed weight. These findings indicate that nutrient management deserves attention in efforts to improve soybean growth and yield.

One alternative for meeting plant nutrient requirements is foliar fertilization. Foliar fertilizers are applied as a solution sprayed onto leaf surfaces, allowing nutrients to be absorbed through leaf tissues. Foliar application can supplement soil fertilization, particularly to support nutrient requirements during specific growth stages. Fernández and Eichert (2009) explained that the uptake of dissolved substances through leaves is influenced by leaf-surface characteristics, solution chemistry, environmental conditions, and the ability of substances to penetrate protective leaf layers. Thus, the effectiveness of foliar fertilizer depends not only on its nutrient content but also on solution concentration and application conditions. Appropriate foliar fertilization may help meet plant nutrient requirements, but application instructions must be followed to avoid leaf-tissue injury.

The effectiveness of foliar fertilization is also related to application frequency or interval. The application interval determines the time between successive fertilizer applications. An interval that is too long may result in an additional nutrient supply that does not match crop requirements at a particular growth stage. Conversely, more frequent applications do not necessarily improve growth and yield if nutrient requirements have already been met or absorption conditions are unfavorable. Application intervals should therefore be adjusted to crop characteristics, growth stage, fertilizer nutrient content, and environmental conditions. Mulatsih et al. (2000), in a study of the timing and method of nitrogen application in soybean, showed that application timing and the proportion of nutrients supplied through soil and leaves can affect crop responses. That study also reported leaf damage under foliar nitrogen application, highlighting the importance of application method and timing. These findings support the need to test foliar fertilizer intervals to identify an appropriate application schedule for soybean.

In addition to application interval, foliar fertilizer concentration is an important factor that can determine crop response. Concentration refers to the amount of fertilizer dissolved in a given volume of water and is related to the amount of nutrients delivered through spraying. A concentration that is too low may not provide sufficient supplemental nutrients, whereas an excessively high concentration may increase the risk of leaf-tissue injury, depending on fertilizer composition and application conditions. Foliar fertilizer concentration should therefore balance nutrient sufficiency with crop safety. Fernández and Eichert (2009) emphasized that the uptake of dissolved substances through leaves is influenced by various physical and chemical factors; consequently, crop responses cannot be

predicted solely from an increase in solution concentration. Testing several concentration levels is necessary to determine crop responses under specific cultivation conditions.

Foliar fertilizer application interval and concentration should also be considered together because both factors may affect the availability of supplemental nutrients to plants. The interval relates to application frequency, while concentration relates to the strength of the solution used. In theory, their combination may produce different crop responses, but such effects must be established through experimentation and statistical analysis. Previous studies on soybean fertilization have examined NPK fertilizer, organic fertilizers, and the timing and method of nutrient application. Nevertheless, responses to fertilization can vary depending on fertilizer type, soil conditions, the research environment, and application method. Previous findings can therefore provide a basis for comparison but cannot directly establish the optimal interval and concentration for Catomi foliar fertilizer without further testing.

Based on these considerations, this study evaluated the effects of application intervals and concentrations of Catomi foliar fertilizer on soybean growth and yield. The application-interval treatments were every 7, 10, and 14 days, while the concentration treatments were 2, 4, and 6 cc/L of water. Plant responses were assessed using plant height, number of branches, days to flowering, number of pods per plant, and seed yield per plot. These vegetative and reproductive parameters were expected to provide an overview of crop growth and yield-component responses to the tested treatments.

This study aimed to determine the effects of Catomi foliar fertilizer application interval, the effects of fertilizer concentration, and the interaction between these two factors on soybean growth and yield. The results are expected to provide scientific information on soybean responses to different Catomi application intervals and concentrations and to inform the development of more effective fertilization practices. The study is expected to contribute to the field of agrotechnology, particularly foliar nutrient management in soybean cultivation.

Foliar fertilizer application interval and concentration are important factors in fertilizer management. This study investigated the effects of Catomi foliar fertilizer application intervals and concentrations on soybean growth and yield. The observed parameters included plant height, number of branches, days to flowering, number of pods per plant, and seed yield per plot.

B. METHOD

The study was conducted at the Experimental Farm of the Faculty of Agriculture, Universitas Graha Nusantara, Padangsidimpuan City, Indonesia, beginning in May 2026 and continuing until completion. The materials included soybean seeds (Glycine max L.), Catomi foliar fertilizer, water as the fertilizer solvent, and other materials used during crop cultivation. Catomi foliar fertilizer was applied at the concentrations specified by the experimental treatments. The

equipment included land-preparation tools, a fertilizer sprayer, a plant-height measuring instrument, stationery, and other tools used for crop maintenance, observation, and harvest measurements. The types and specifications of materials and equipment should be completed using the original research records.

The study used a factorial randomized block design (RBD) with two treatment factors and three replications. The first factor was the Catomi foliar fertilizer application interval, with three levels: every 7 days (I_1), every 10 days (I_2), and every 14 days (I_3). The second factor was fertilizer concentration, with three levels: 2 cc/L of water (K_0), 4 cc/L of water (K_1), and 6 cc/L of water (K_2). These factors produced nine treatment combinations. With three replications, the experiment consisted of 27 experimental units.

The experiment began with land preparation and preparation of the planting area in accordance with soybean cultivation practices. Soybean seeds were planted in the prepared plots, and the plants were maintained through watering, weeding, and other necessary cultivation activities. Catomi foliar fertilizer was applied according to the designated interval and concentration for each treatment combination. The fertilizer solution was prepared by dissolving the specified amount of fertilizer in one liter of water and then applying it with a sprayer. Applications followed the interval assigned to each treatment. Technical details such as basal fertilizer rates, spray volume per plant, planting distance, and the first application date should be reported from the original research records to ensure reproducibility.

The soil was tilled and cleared of weeds, and plots measuring 1.5 × 1.5 m were prepared. Basal fertilizer was applied at planting at rates of 20 g urea, 40 g TSP, and 20 g KCl per plot. Additional fertilizer was applied 30 days after planting, consisting of 30 g urea and 10 g KCl per plot. Seeds were planted at a depth of 2–3 cm with a spacing of 20 × 30 cm; three seeds were placed in each planting hole, after which two plants were retained. Crop maintenance included weeding, watering, and pest control as needed. Foliar fertilizer was applied according to the assigned interval and concentration treatments.

The observed parameters were plant height, number of branches, days to flowering, number of pods per plant, and seed yield per plot. Plant height was used to assess vegetative growth, while branch number represented the development of plant structure. Days to flowering indicated the time at which plants entered the reproductive phase. Number of pods per plant was used as an indicator of yield formation, while seed yield per plot was used to evaluate harvested yield for each treatment combination. Measurements followed the procedures used in the original study, and units were recorded consistently for each parameter.

C. RESULT AND DISCUSSION

1. Plant Height and Number of Branches

The results showed that application interval and Catomi foliar fertilizer concentration produced different responses across soybean growth and yield

parameters. For plant height, the analysis indicated that application interval, fertilizer concentration, and the interaction between the two factors had no significant effects. At five weeks after planting, mean plant height was 29.71 cm for both the 7-day and 10-day intervals, while the 14-day interval produced a mean of 29.59 cm. By concentration, mean plant height was 29.46, 29.62, and 29.93 cm at 2, 4, and 6 cc/L, respectively. Although the 6 cc/L concentration produced the highest mean plant height, the difference was not statistically significant. These results indicate that the tested Catomi application intervals and concentrations did not produce significant differences in plant height at the observation time.

The absence of a significant treatment effect on plant height may be associated with several factors, including nutrient availability in the growing medium, environmental conditions, and crop nutrient requirements during the vegetative stage. Plant height does not necessarily increase with fertilizer concentration because growth depends on nutrient balance and other environmental factors. Fernández and Eichert (2009) explained that foliar uptake of dissolved substances is affected by leaf-surface characteristics, solution properties, and environmental conditions during application. Therefore, differences in fertilizer concentration do not always produce significant growth responses. In this study, the relatively similar mean plant heights indicate that the treatments did not produce statistically demonstrable differences in plant height.

At five weeks after planting, mean plant height ranged from 29.59 to 29.71 cm across application intervals and from 29.46 to 29.93 cm across fertilizer concentrations.

Table 1. Mean plant height at five weeks after planting (cm) under different Catomi foliar fertilizer application intervals and concentrations.

Treatment	K0 (2 cc/L)	K1 (4 cc/L)	K2 (6 cc/L)	Mean
I_1	29.82	29.44	29.88	29.71
I_2	29.13	30.32	29.69	29.71
I_3	29.44	29.10	30.23	29.59
Mean	**29.46**	**29.62**	**29.93**	**-**

The reported analysis showed that application interval, concentration, and their interaction did not significantly affect plant height. The source document attributed this result to what was considered sufficient soil nutrient availability, although soil nutrient-analysis results were not provided.

The number of branches was not significantly affected by application interval, Catomi foliar fertilizer concentration, or the interaction between the two factors. Mean branch numbers at the 7-, 10-, and 14-day intervals were 3.41, 3.43, and 2.98 branches per plant, respectively. At concentrations of 2, 4, and 6 cc/L, mean branch numbers were 3.19, 3.31, and 3.32 per plant, respectively. The 10-day interval produced the highest mean branch number, while the 6 cc/L concentration produced the highest mean among concentration treatments. However, because the statistical

analysis showed no significant effects, these numerical differences cannot be interpreted as statistically established treatment advantages.

Table 2. Mean number of branches per plant under different Catomi foliar fertilizer application intervals and concentrations.

Treatment	K0 (2 cc/L)	K1 (4 cc/L)	K2 (6 cc/L)	Mean
I_1	3.33	3.50	3.40	3.41
I_2	3.33	3.47	3.51	3.43
I_3	2.90	2.97	3.07	2.98
Mean	**3.19**	**3.31**	**3.32**	

Branch formation in soybean is a vegetative process influenced by genetic factors, light intensity, water availability, and adequate nutrient supply. Foliar fertilization may support plant metabolism when the supplied nutrients meet crop requirements, but the response depends on overall growing conditions. In this study, increasing the concentration from 2 to 6 cc/L did not significantly change branch number. Similarly, the application intervals did not have a significant effect on branch formation. The effect of Catomi foliar fertilizer on soybean vegetative growth should therefore be interpreted using all measured parameters rather than mean differences alone.

Days to Flowering

Unlike plant height and branch number, the Catomi foliar fertilizer application interval significantly affected days to flowering. The mean number of days to flowering was 37.33 days at the 7-day interval, 38.22 days at the 10-day interval, and 38.44 days at the 14-day interval. Thus, the 7-day interval produced the earliest flowering. Fertilizer concentration and the interaction between application interval and concentration did not significantly affect days to flowering. Under the conditions of this study, application frequency was associated with flowering time, whereas the tested concentration levels did not produce a significant effect.

The foliar fertilizer application interval significantly affected days to flowering. Application every 7 days resulted in the earliest flowering, at a mean of 37.33 days, and differed significantly from the 14-day interval, which reached 38.44 days.

Table 3. Mean days to flowering under different Catomi foliar fertilizer application intervals and concentrations

Treatment	K0 (2 cc/L)	K1 (4 cc/L)	K2 (6 cc/L)	Mean		
I_1	37.67	37.33	37.00	37.33	b	A
I_2	38.33	38.00	38.33	38.22	ab	A
I_3	39.00	38.33	38.00	38.44	a	A
Mean	38.33	37.89	37.78	-		

The 10-day interval produced a mean of 38.22 days and, according to the reported multiple-comparison test, did not differ significantly from the other intervals. Fertilizer concentration and the interaction between interval and

concentration were not significant for days to flowering. Under the conditions of this study, more frequent application was associated with earlier flowering.

Physiologically, the transition from the vegetative to reproductive phase is influenced by genetic and environmental factors, including day length, temperature, water availability, and plant nutritional status. Shorter application intervals may provide more frequent opportunities to supply supplemental nutrients. However, this study did not establish a specific physiological mechanism explaining why the 7-day interval resulted in earlier flowering. The result should therefore be interpreted as an observed response under the experimental conditions, rather than evidence that applying fertilizer every 7 days will always accelerate flowering in soybean. The lack of a significant concentration effect also indicates that increasing fertilizer concentration does not necessarily change flowering time.

Number of Pods per Plant

Application interval significantly affected the number of pods per plant. The mean number of pods was 67.71 per plant at the 7-day interval, 69.90 at the 10-day interval, and 56.82 at the 14-day interval. Thus, the 10-day interval produced the highest mean number of pods, while the 14-day interval produced the lowest. Pairwise differences between treatments should be interpreted according to the multiple-comparison results reported in the original statistical tables. For fertilizer concentration, mean pod numbers at 2, 4, and 6 cc/L were 59.12, 66.09, and 68.93 per plant, respectively. Although the mean increased with concentration, the concentration effect was not statistically significant. The interaction between interval and concentration was also not significant.

The foliar fertilizer application interval significantly affected the number of pods per plant. The highest mean was recorded at the 10-day interval (69.90 pods per plant), whereas the 14-day interval produced 56.82 pods. The 7-day interval produced 67.71 pods and did not differ significantly from the 10-day interval.

Table 4. Mean number of pods per plant under different Catomi foliar fertilizer application intervals and concentrations

Treatment	K0 (2 cc/L)	K1 (4 cc/L)	K2 (6 cc/L)	Mean		
I_1	58.93	71.91	71.41	67.71	ab	A
I_2	63.60	70.47	75.65	69.90	a	A
I_3	54.85	55.88	59.73	56.82	b	A
Mean	**59.12**	**66.09**	**68.93**	**-**		

Fertilizer concentration and the interaction between the two factors were reported as nonsignificant. Although the 6 cc/L concentration produced the highest numerical mean (68.93 pods per plant), the difference was not statistically significant according to the source document. More frequent applications may provide a more continuous supply of nutrients from Catomi foliar fertilizer, but this interpretation requires further testing.

Pod number is an important component of soybean yield because it is related to the potential number of seeds harvested. Pod formation is affected by successful flowering and fertilization, nutrient availability, water supply, and environmental conditions during the reproductive phase. The higher mean pod number at the 10-day interval indicates that pod formation did not necessarily increase with the most frequent fertilizer application. This suggests that crop responses to fertilization may differ across growth stages and measured parameters. Nevertheless, because fertilizer concentration did not significantly affect pod number, the present results do not establish that increasing Catomi concentration directly increases pod formation. Interpretation should take variation among replications and the statistical test results into account.

Seed Yield per Plot

For seed yield per plot, application interval and Catomi foliar fertilizer concentration each had a significant main effect, whereas their interaction was not significant. Mean seed yield was 335.04 g per plot at the 7-day interval, 325.30 g at the 10-day interval, and 312.66 g at the 14-day interval. The reported multiple-comparison test showed that the 7-day interval differed significantly from the 14-day interval but not from the 10-day interval. Thus, the 7-day interval produced the highest mean yield, although its statistical advantage over the 10-day interval was not established. The 7-day interval may be considered a potential option under the conditions of this study, while also considering fertilizer-use efficiency and application costs.

Application interval and fertilizer concentration each significantly affected seed yield per plot, while their interaction was not significant. The 7-day interval produced the highest mean yield (335.04 g per plot), followed by the 10-day interval (325.30 g) and the 14-day interval (312.66 g). The 7-day interval differed significantly from the 14-day interval but not from the 10-day interval.

Table 5. Mean seed yield per plot (g) under different Catomi foliar fertilizer application intervals and concentrations.

Treatment	K0 (2 cc/L)	K1 (4 cc/L)	K2 (6 cc/L)	Mean		
I_1	320.53	337.17	347.43	335.04	a	A
I_2	319.50	322.20	334.20	325.30	ab	AB
I_3	303.10	309.70	325.17	312.66	b	A
Mean	**314.38 b**	**A323.02**	**abA335.60aA**	**-**		

For the concentration factor, 6 cc/L produced the highest mean yield (335.60 g per plot) and differed significantly from 2 cc/L, which produced 314.38 g per plot. The 4 cc/L concentration produced a mean of 323.02 g per plot and did not differ significantly from 6 cc/L. Therefore, the highest mean for each main factor was recorded at the 7-day interval and 6 cc/L concentration. However, because the interaction between the factors was not significant, the results do not establish that

this particular combination was statistically superior to all other treatment combinations.

The findings indicate that application interval and Catomi foliar fertilizer concentration significantly affected soybean seed yield. Nutrients applied through foliar spraying may be absorbed directly by plant tissues and can support vegetative and reproductive growth. However, broad claims that Catomi accelerates growth or increases yields across different crops should be supported by product-composition data and independent evidence; the present study specifically evaluated soybean under the conditions described.

The macronutrients phosphorus, potassium, and sulfur in foliar fertilizers may contribute to flowering, seed and fruit maturation, flower and fruit retention, and the formation of proteins and carbohydrates. Overall, significant responses were more consistently observed for some reproductive and yield parameters than for plant height and branch number. Interpretation is limited by the information available in the document because complete raw data and statistical outputs were not provided. Further research with complete statistical reporting is needed to test the consistency of these results under different environmental conditions.

Seed yield is the final outcome of a series of plant growth and development processes, including flower formation, successful pod formation, seed filling, and dry-matter accumulation. The differences in responses among parameters show that the treatment with the highest mean for one parameter does not necessarily produce the highest mean for another. The 10-day interval produced the highest mean number of pods, whereas the 7-day interval produced the highest mean seed yield per plot. These differences may be related to other yield components, such as seeds per pod and seed weight, but this mechanism cannot be confirmed without additional observations. Therefore, the discussion of yield should be based on measured parameters and should not infer mechanisms that were not tested.

Interaction between Application Interval and Catomi Foliar Fertilizer Concentration

Overall, the analysis showed that the interaction between Catomi foliar fertilizer application interval and concentration did not significantly affect the observed parameters. This means that the study did not provide sufficient statistical evidence that the effect of an application interval depended on the fertilizer concentration, or vice versa. Although a particular combination may have produced a higher mean, it cannot be identified as the best combination without a significant interaction effect. The results should therefore be interpreted primarily in terms of the main effects of each factor on parameters that showed significant responses.

Overall, the 7-day application interval was associated with earlier flowering and the highest mean seed yield per plot, whereas the 10-day interval produced the highest mean number of pods. For the concentration factor, 6 cc/L produced the highest means for plant height, branch number, pod number, and seed yield per plot, but a statistically significant concentration effect was found only for seed yield

per plot among these parameters. These findings indicate that the effectiveness of Catomi foliar fertilizer should be assessed in relation to the intended cultivation objective and priority yield parameters. Further trials at different locations, seasons, and soil conditions are needed to assess consistency and develop broader recommendations.

D. CONCLUSION

Under the conditions of this study, Catomi foliar fertilizer application interval significantly affected days to flowering, number of pods per plant, and seed yield per plot, but did not significantly affect plant height or branch number. Fertilizer concentration significantly affected seed yield per plot, while its effects on the other parameters were not significant. The interaction between application interval and concentration was not significant for the observed parameters. The highest mean seed yield for the interval factor was obtained with application every 7 days, while the highest mean for the concentration factor was obtained at 6 cc/L. Further studies under different environmental conditions are needed before general recommendations for soybean cultivation can be established.

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