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Response of Soybean Growth (*Glycine max* (L.) Merril) on the Treatment of Refugia Plant and Nanosilica Fertilizer

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***Abstract*—This study aims to analyse the growth response of soybean (*Glycine max* (L.) Merrill) to the treatment of refugia plants and Nano silica fertilizer. The research was conducted at the Unit of Palawija Seed Development and Paddy, Agriculture Office of West Java Province, Plumbon, Cirebon Regency, from December 2018 to May 2019. The materials that were used include soybean varieties Grobogan, sunflowers, Zinnia elegant and marigolds, Nano silica fertilizers and NPK. This study uses a split plot design with the main plot was kind of refugia plants and sub-plots was Nano silica fertilizer concentration. The observed variables included plant height, stem diameter, number of leaves and number of branches, observations were made at the age of 14, 21, 28 and 35 days after planting (dap). The results showed that refugia plants had no effect on soybean growth, while the application of Nano silica fertilizer concentration of 1.75 ml/l and 3.50 ml/l gave the best effect on all components of soybean growth observed.**

Keywords: nanosilica, refugia, soybean

I. INTRODUCTION

Soybean is the third important food commodity after rice and corn. Soybean needs continue to increase from year to year in line with an increase in population, while the production achieved has not been able to offset the needs [1]. Soybean productivity in Indonesia is lower than productivity in other producing countries. One obstacle in soybean farming is high pest and disease attacks and if not controlled can cause yield losses up to 80%.

At this time, it is necessary to cultivate healthy plants by paying attention to the environment that can support sustainable farming systems. Silica (Si) is a building block for plants which has proven to be a useful element, namely increasing plant resistance to pests and diseases, improving abiotic stress, and increasing plant growth [2]. Silica can increase plant resistance, especially grasses (*Gramineae*) against disease and pests because it can specifically affect epidermal cells and thicken cell walls, and reduce transpiration so that pest attacks and disease infections will be reduced [3,4].

Refugia plants are plantations of several types of plants that can provide shelter, food sources or other resources for natural enemies such as predators and parasitoids [5-7]. Generally, refugia plants are planted on the edge of mounds or outside plantations in longitudinal and striking flowering. Some types of refugia plants commonly used are *Helianthus annuus, Cosmos caudatus, Mirabilis jalapa, Tagetes erecta, Zinnia elegans, Catharanthus roseus, Vigna unguiculata etc.* Plants that can be used as refugia plants should have the characteristics of flowering and broadleaf, because it can lure natural predators with flower nectar as well as a shelter [8]. It is hoped that with the application of silica fertilizer and planting of microhabitat refugia, natural enemies will be maintained so as to increase soybean growth and ultimately have implications for increasing crop yields.

II. METHOD

The research was carried out at the Plumbon Palawija Seed Development Centre (PSDC) Cirebon Regency. The location is located at an altitude of ± 17 meters above sea level (asl), from December 2018 to May 2019. Materials used in this experiment include: Grobogan cultivar soybean seeds, NPK pearl fertilizer, nanosil 99 liquid fertilizer, seeds of refugia plants: sunflowers (*Helianthus annuus*), kanop flowers (*Zinnia elegans*) and marigolds (*Tagetes erecta*).

This study used an experimental method with a Split Plot Design, as the main plot is the type of refugia plants, namely p1: sunflowers (*Helianthus annuus*), p2: paper flowers (*Zinnia elegans*) and p3: marigolds (*Tagetes erecta*), while the subplots are Nano silica fertilizer concentrations consisting of four treatment levels namely k1= 0 $ml l^{-1}$, k2= 1.75 $ml l^{-1}$, k3= 3.50 $ml l^{-1}$ and k4= 5.25 $ml l^{-1}$. Each treatment combination was repeated 3 times so that the number of treatment units in the study was 3 x 4 x 3 = 36 treatment units with a plot size of 5 m x 5 m.

The observed variables included plant height, number of leaves, stem diameter and number of branches. Observation data were processed using analysis of variance (ANOVA), if there were significant differences from the treatments tested or the F-count value was greater than the F table at 5% level then the test was continued with the LSD test [9].

III. Results and Discussion

The results of the analysis of variance showed that there was no interaction of effect between refugia plants and the concentration of Nano silica fertilizer on all observed growth components. There is an independent effect of Nano silica fertilizer treatment on all growth components.

A. Plant Height

Based on the results of the analysis of variance showed that there was no influence of interactions between refugia plants and the concentration of Nano silica fertilizer on soybean plant height at each observation period. refugia plants did not have a significant effect on plant height in all observation periods, while the concentration of Nano silica fertilizers had a significant independent effect on plant height at ages 21, 28 and 35 dap.

Table 1 shows that refugia plants did not have a significant effect on plant height at all observation periods. This is presumably because sunflowers (*Helianthus annuus*), paper flowers (*Zinnia elegans*) and marigolds (*Tagetes erecta*) have the same effect on soybean plant height due to the fact that refugia plants have a function as nectar providers for predator insects and soybean pests. This is in line with the opinion of [7], that Refugia is a microhabitat that provides a spatial and / or temporal shelter for natural enemies of pests, such as predators and parasitoids, and supports biotic interaction components in ecosystems, such as pollinators or pollinating insects, so pest disorders during the study were relatively low <5%.

TABLE I. Effects of Refugia Plants and Nanosilica Fertilizers on Average Height of Soybean Plants

Treatment	Plant Height (cm)			
	14 dap	*21 dap*	*28 dap*	*35 dap*
Main plot (refugia):				
p_1 (Helianthus annuus)	13.48	18.10	27.28	37.54
p_2 (Zinnia elegans)	13.42	18.24	26.53	37.33
p_3 (Tagetes erecta)	13.81	18.61	27.58	38.10
Subplot (consentration of nanosilica):				
k_1 (0.00 ml^{-1})	13.78	17.37 a	25.45 a	35.39 a
k_2 (1.75 ml^{-1})	13.76	18.46 b	27.50 b	38.43 bc
k_3 (3.50 ml^{-1})	13.25	19.04 b	28.24 b	39.30 c
k_4 (5.25 ml^{-1})	13.49	18.39 b	27.31 b	37.52 b

Note: The average number accompanied by the same letter in the column shows no significant difference based on the LSD Test at 5% significance level.

The application of Nano silica fertilizer has not shown their effect on the age of the 14 dap, therefore at the age of 14 HST the plant height does not show any significant difference at the age of 14 dap. Starting at the age of 21 dap, the effect of applying Nano silica fertilizer began to appear, indicated by plant height in the treatment without silica fertilizer obtained plant height lower than the height of soybean plants that were given silica fertilizer, at the age of 28 dap and 35 dap Nano silica fertilizer applications 1.75 - 3.50 ml^{-1} can significantly increase plant height compared to controls. This shows that the best concentration for producing plant height is 1.75 $ml^{-1}$to 3.50 ml^{-1}. Plants with sufficient supply of silica will have good growth, such as upright stems and leaves and will reduce tolerance to biotic and abiotic stresses [9,10].

B. Number of Leaves

The results of the analysis of variance showed that there was no interaction effect between refugia plants and the concentration of Nano silica fertilizer on the number of leaves per plant in each observation period. Independently, refugia plants did not have a significant effect on the number of leaves per plant in all observation periods, while the concentration of Nano silica fertilizers had a significant independent effect on the number of leaves per plant at the age of 21, 28 and 35 dap.

Table 2 shows that refugia plants did not have a significant effect on the number of leaves per plant in all observation periods. This is presumably because refugia plants both sunflowers, paper flowers and marigolds have the same function, namely as a provider of nectar for predatory insects and soy pests. From the visual observations, pest insect attack is very low at less than 2%, so that differences in refugia plant species do not provide a significant difference in the number of leaves per plant formed. According to [11] that the selection of plants or flowering plants in the polyculture system must pay attention to the functions and roles of these plants in the environment, for example the potential to increase the arrival of natural enemies, increase soil fertility, or suppress weed populations.

TABLE II. EFFECT OF REFUGIA PLANTS AND NANOSILICA FERTILIZERS ON THE AMOUNT OF LEAVES OF SOYBEAN

Treatment	The number of leaves			
	14 dap	*21 dap*	*28 dap*	*35 dap*
Main plot (refugia):				
p_1 (Helianthus annuus)	7.96	12.93	27.82	47.78
p_2 (Zinnia elegans)	8.31	12.56	24.47	51.65
p_3 (Tagetes erecta)	7.99	12.76	25.68	49.71
Subplot (consentrations of nanosilica):				
k_1 (0.00 mll^{-1})	8.07	12.07 a	23.65 a	45.44 a
k_2 (1.75 mll^{-1})	8.13	13.11 b	26.61 b	50.59 bc
k_3 (3.50 mll^{-1})	8.11	12.85 b	27.61 b	53.07 c
k_4 (5.25 mll^{-1})	8.02	12.96 b	26.09 b	49.74 b

Note: The average number accompanied by the same letter in the column shows no significant difference based on the LSD Test at 5% significance level.

The application of Nano silica fertilizer has not shown its effect on the age of 14 dap, the average number of leaves per plant formed does not show any significant difference. Starting at the age of 21 dap, the effect of applying Nano silica fertilizer began to appear, indicated by plant height in the treatment without Nano silica fertilizers obtained an average number of leaves per plant lower than the number of leaves per soybean plant given Nano silica fertilizer.

At the age of 21 and 28 dap the number of leaves per plant in the treatment of Nano silica fertilizer with a concentration of 1.75 mll^{-1}, 3.50 mll^{-1} and 5.25 mll^{-1} did not show any significant difference, whereas at age 35 dap a high number of leaves per plant was obtained at the treatment of Nano silica fertilizer 3.50 mll^{-1} but not significantly different from the number of leaves per plant in the Nano silica fertilizer treatment 1.75 mll^{-1}. At the age of 35 dap, it was also seen that increasing Nano silica fertilizer to the limit of 3.50 mll^{-1}increased the number of leaves per plant formed. If the application of Nano silica fertilizer exceeds 3.50 ml/l will produce a smaller number of leaves per plant. This shows that the best concentration to produce the number of leaves per plant is 1.75 mll^{-1} to 3.50 mll^{-1}. Plants with sufficient supply of silica will have good growth [7], such as upright stems and leaves and will reduce tolerance to biotic and abiotic stresses, Savant et al also believes that silica can improve plant growth by increasing resistance to decay, drought, disease and pests, and enforcing leaves [12].

C. Diameter of Stem

The results of the variety analysis showed that there was no interaction effect between refugia plants and the concentration of Nano silica fertilizer on the stem diameter of soybean plants. Likewise, refugia plants did not significantly affect the stem diameter of plants in all observation periods, this shows that by planting flowering plants (insectary plants) that function as feed sources, hosts / prey, and refugia for natural enemies [13], so pest attacks are very small.

TABLE III. EFFECT OF REFUGIA PLANTS AND NANOSILICA FERTILIZERS ON THE STEM DIAMETER OF SOYBEAN

Treatment	Diameter of stem (mm)			
	14 dap	*21 dap*	*28 dap*	*35 dap*
Main plot (refugia):				
p_1 (Helianthus annuus)	2.30	2.73	3.97	5.13
p_2 (Zinnia elegans)	2.36	2.65	3.51	5.02
p_3 (Tagetes erecta)	2.26	2,62	3.,63	5.11
Subplot (consentrations of nanosilica):				
k_1 (0.00 mll^{-1})	2.21 a	2.57 a	3.44 a	4.74 a
k_2 (1.75 mll^{-1})	2.35 b	2.76 c	3.75 b	5.25 c
k_3 (3.50 mll^{-1})	2.35 b	2.67 b	3.85 b	5.36 c
k_4 (5.25 mll^{-1})	2.31 b	2.67 b	3.76 b	5.00 b

Note: The average number accompanied by the same letter in the column shows no significant difference based on the LSD Test at 5% significance level.

Table 3 shows that at the ages of 14, 21 and 28 dap the stem diameter of plants in the treatment of Nano silica fertilizers with concentrations of 1.75 mll^{-1}, 3.50 $mll^{-1}$and 5.25 mll^{-1} did not show any significant difference, whereas at age 35 dap it was seen that increasing the application of Nano silica fertilizer to the limit of 3.50 ml/l, the diameter of the stem of the plant formed is greater. If the application of Nano silica fertilizer exceeds 3.50 mll^{-1} will produce a smaller stem diameter of the plant. This shows that concentrations of 1.75 mll^{-1} to 3.50 mll^{-1} produce the largest stem diameter of 5.30 mm, an increase of 12% when compared with the application without Nano silica fertilizer.

D. Number of Branches per Plant

The results of the variety analysis showed that there was no interaction effect between refugia plants and the concentration of Nano silica fertilizer on the number of branches per plant. Likewise, refugia plants did not significantly affect the number of branches per plant in all observation periods. The concentration of Nano silica fertilizer had a significant independent effect on the number of branches per plant at 28 dap and 35 dap while at 14 dap and 21 dap did not have a significant effect.

TABLE IV. EFFECT OF REFUGIA PLANTS AND NANOSILICA FERTILIZERS ON THE NUMBER OF BRANCHES PER PLANT

Treatment	The number of branches			
	14 dap	*21 dap*	*28 dap*	*35 dap*
Main plot (refugia):				
p_1 (Helianthus annuus)	0.0	0.14	2.38	2.92
p_2 (Zinnia elegans)	0.0	0.08	1.79	3.13
p_3 (Tagetes erecta)	0.0	0.00	1.71	3.15
Subplot (consentrations of nanosilica):				
k_1 (0.00 ml^{-1})	0.0	0.00	1.61 a	2.70 a
k_2 (1.75 ml^{-1})	0.0	0.15	2.04 b	3.24 b
k_3 (3.50 ml^{-1})	0.0	0.09	2.15 b	3.24 b
k_4 (5.25 ml^{-1})	0.0	0.06	2.04 b	3.07 b

Note: The average number accompanied by the same letter in the column shows no significant difference based on the LSD Test at 5% significance level.

Table 4 shows that refugia plants did not have a significant effect on the number of branches per plant in all observation periods. As already stated, the three types of refugia plants have the same function, namely as a provider of nectar for predator insects and soybean pests. Thus the effect of refugia plants is not directly on growth, both plant height, number of leaves, stem diameter and number of branches formed, but determines the height and low population and intensity of pests in the crop. From the visual observations, insect attack is very low at less than 2%, therefore differences in types of refugia plants do not provide a real difference in the number of branches per plant formed.

The application of Nano silica fertilizer had no significant effect on the number of branches per plant at the age of 14 and 21 dap. This is because plants up to the age of 21 dap are still at an early growth stage, so the number of branches formed does not show any significant difference. At the age of 28 dap and 35 dap the application of Nano silica fertilizer had a significant effect on the number of branches per plant. The number of branches per plant in the treatment of Nano silica fertilizer with concentrations of 1.75 ml^{-1}, 3.50 ml/l and 5.25 ml^{-1} was more than without the application of Nano silica fertilizer, but the number of branches in the three treatments did not show any significant difference. This shows that the best concentration of Nano silica 1.75 ml^{-1} produce 3.24 branches is 20% higher than without Nano silica fertilizer (control) treatment

IV. CONCLUSION

There was no interaction between refugia plants and Nano silica fertilizer on all growth variables observed, but the presence of refugia was needed as a microhabitat for natural enemy insects, predators or host pests in soybeans. Nano silica fertilizer gives a real independent effect on all growth components observed, Nano silica concentration 1.75 - 3.50 ml / l can increase plant height by 10%, number of leaves 14%, stem diameter 12% and number of branches 20% compared without Nano silica fertilizer (control).

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