Growth and development responses of soybean (Glycine max L.) under several combinations of inorganic and organic fertilizer

by 3921 3921 (2)

Submission date: 24-Nov-2022 10:05AM (UTC+0700)
Submission ID: 1962375716
File name: 3921-17972-1-CE_Netty_Fixed.docx_turnitin.docx (241.84K)
Word count: 3048
Character count: 16127

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ABSTRACT

Edamame is a green soybean vegetable that people in the middle and upper classes eat. Conventional farming must gradually transition to organic farming, by reducing the use of inorganic fertilizers. The objective of this study was to determine the ideal ratio of organic and inorganic fertilizers (compost) for the development and production of edamame soybeans. This study used a randomized block design that consist of seven combinations of inorganic fertilizers (150 kg per hectare Urea, 150 kg per hectare SP-36, 100 kg per hectare KCl) and compost, namely: (A) 100 percent inorganic fertilizers (control), (B) inorganic 75 percent + compost 10 ton per hectare, (C) inorganic 50 percent + compost 10 ton per hectare, (D) inorganic 25 percent + compost 10 ton per hectare, (E) inorganic 75 percent + compost 20 ton per hectare, (F) 50 percent inorganic + 20 ton per hectare compost, (G) 25 percent inorganic + 20 ton per hectare compost. There were 30 plants per plot, and each treatment was repeated three times. Data were evaluated using Tukey HSD post hoc analysis with a 5 percent margin of error and analysis of variance. The outcomes demonstrated that the effects of compost and inorganic fertilizers on four plant growth and development variables such as the plant height, the leaf count, the sum of productive branches, and the time to produce 50 percent flower. The plant height, the sum of productive branches, and leaf count all rose with the application of 50 percent and 75 percent inorganic fertilizers together with 10 tons of compost per hectare. All combinations of treatments have no influence on the quantity of seeded pods or the weight of the pods.

Keywords: organic fertilizers; inorganic fertilizers; plant height; leaf count; the sum of productive branches; soybean

INTRODUCTION

Edamame (Glycine max (L.) Merril.) is a plant species that belonged to the vegetable crop (green soybean vegetable)(Williams et al., 2022), and commonly consumed as a vegetable and healthy snack in Japan (Guo et al., 2020). Edamame contains a high nutritional value, rich in isoflavones which are organic compounds that are antioxidants and are efficacious in preventing cancer (Kim, 2021; Williams et al., 2022; Yu et al., 2021). The market opportunity for edamame soybeans is quite large, both for exports and locally (Wibowo et al., 2020). In fact, this type of soybean has the potential to reduce the volume of imports of raw materials for animal feed and the food industry in the country. The productivity of edamame soybeans can reach 3.5 tons per ha, which is higher than ordinary soybeans (Marwoto, 2007). To achieve the expected productivity, it is necessary to innovate cultivation technology such as providing nutrients or fertilizing.

The type of fertilizer that is often used in planting edamame soybeans is inorganic fertilizer. Edamame soybean farmers mostly use inorganic fertilizers at very high doses of 600 kg per hectare (Sudiarti et al., 2019). This has exceeded the threshold recommended by Indonesian National Standard (SNI), which is 300 kg per hectare. The utilize of inorganic substances in the form of fertilizers or pesticides that surpass the dose, this poses a serious problem. The utilize of inorganic fertilizers is not only harmful to agricultural land, but also endangers human health. Mostly farmers prefer to provide the high dose of inorganic fertilizer for their crops, and organic fertilizers applied to reduce the dosage of inorganic fertilizers that are too high (Maswar & Soelaeman, 2016).

In order to develop ecologically friendly agriculture, an alternative is to employ organic fertilizers. Organic fertilizers known by farmers are organic fertilizers in the form of Bokashi which are decomposed by microorganisms. Bokashi increases the binding capacity of sandy soil (light soil), improves the structure of loamy soil (heavy soil), increases water holding capacity, drainage and soil air conditioning, fertilization from artificial

fertilizers, the availability of nutrients and the binding capacity of the soil to nutrients(Tong et al., 2021). According to other researchers, giving compost in the form of Bokashi increasing plant development and growth, including the sum of productive branches, the sum of pods, the amount of empty pods, and the weight of seeds (Faozi et al., 2018).

Compost or Bokashi is expected to be able to substitute the inorganic fertilizers. *Chromolaena odorata* and *Lannea coromandaleca* are commonly materials that be used to produce bokashi. *Chromolaena odorata* contain nitrogen nutrients which are quite high (2.65 percent) and can produce high biomass so that they are potential to be used as a source of organic matter (Peniwiratri & Arbiwati, 2022). *Lannea coromandaleca* leaves includes dry matter 24.492 percent, crude protein 18.459, crude fat 1.338 and crude fiber 23.53 percent. Javanese wood, *Lannea coromandaleca* cortex contains flavonoids, tannins and terpenoids (Dian et al., 2021). The study's objectives were, (1) to analyze the effect of inorganic and organic fertilizers on the growth and production of edamame soybeans; (2) to obtain a dose of organic fertilizer that can substitute for inorganic fertilizers on the development and harvest of edamame soybeans.

MATERIALS AND METHODS

The research was conducted in Sanrobone Village, Sanrobone District, Takalar Regency. The implementation of this research was carried out from May to August 2020. The materials used were Edamame Ryokkoh Soybean seeds, Urea fertilizer, Sp-36 fertilizer and KCl fertilizer, materials for making bokashi fertilizer (which were made from *Chromolaena odorata* and *Lannea coromandelica*), a mixture of making bokashi (EM4, husk, bran, sugar) and water. While the tools used are water reservoirs, scales, tarpaulins, sacks, japanese ropes, machetes, buckets, labels, cutters, flush tools (spray), hoes, hand tractors, chopping machines, thermometers, cameras, meters, stationery, and ruler.

This research was carried out using the Randomized Block Design, consisting of seven combination treatments namely compost or bokashi and inorganic fertilizer (Urea: 150 kg per ha, SP– 36: 150 kg per ha and KCl: 100 kg per hectare). Each treatment was replicated three times therefore that there were 21 experimental units and every experimental unit included of 30 plants per plot, so there were 630 plants. The treatment combinations were: (A) 100 percent inorganic fertilizer (control) per plot; (B) 75 percent inorganic fertilizer + compost 10 ton per hectare (2.2 kg) per plot; (C) 50 percent inorganic fertilizer + compost 10 ton per hectare (2.2 kg) per plot; (D) 25 percent inorganic fertilizer + compost 10 ton per hectare (2.2 kg) per plot; (E) 75 percent inorganic fertilizer + compost 20 ton per hectare (4.4 kg) per plot; (F) 50 percent inorganic fertilizer + compost 20 ton per hectare (4.4 kg) per plot; (G) 25 percent inorganic fertilizer + compost 20 ton per hectare (4.4 kg) per plot.

The bokashi or compost made from two main of organic materials, namely *Chromolaena odorata* and *Lannea coromandelica*. Additional ingredients in the form of husks, bran, EM4 and granulated sugar. The EM4 solution was made by mixing one liter of EM4 solution, 40 liters of clean water and 1 kg of granulated sugar and pouring it on the chopped organic matter, until it reaches about 30-40 percent. The organic material is then fermented for approximately three weeks. Plots were made after the land has been processed. The plots used were 21 plots with a size of 1 m x 2.2 m. The application of compost was carried out according to the treatment and after that, one Edamame seed per planting hole was planted in a single way with a spacing of 20 cm x 25 cm. Inorganic fertilizers were applied to soybean plants twice, namely at the age of 14 days following planting and at the age of thirty days after planting. Inorganic fertilizers given for a 100 percent dose are Urea fertilizer: 150 kg per ha, SP-36 fertilizer: 150 kg per ha and KCl fertilizer: 100 kg per ha. The harvest time for edamame soybeans was 63-68 days after planting. Plant growth and development variables that observed were plant height (cm), leaf count, sum of productive branches, time of flower emergence 50 percent (days), sum of pods, weight of planted pods (g), weight of pods per plot (g), pod

production per hectare (tons per ha), fresh weight of plant parts (g) and sum of empty pods (percent).

Data was analyzed by analysis of variance (ANOVA) RM and Tukey HSD at 5 percent error. Boxplot was chosen to visualize the result of analysis. R studio was used as statistical software to run each analysis.

RESULTS AND DISCUSSION

Based on plant height, the application of 10 ton per hectare compost combined with 50 percent and 75 percent inorganic fertilizers showed the differences compared to the control and other treatments at 42 days after planting (dap). Both applications produced the highest values based on plant height variable. On the other hand, application of 20 ton per hectare compost combined with 75 percent inorganic resulted the lowest value of plant height significantly (Figure 1).

Plant height as one of the variable that related to the biomass production is affected by the combination application of organic and inorganic fertilizer (2016) The NPK fertilizer at 50 percent that combined with organic fertilizer increases the biomass production. In addition, combination between organic and inorganic fertilizers also increase the organic carbon fixation and grain yield on maize and rice (Ghosh et al., 2022; Maswar & Soelaeman, 2016; Moe et al., 2019; Roba, 2018). Combination of organic with inorganic fertilizers as nutrient supply and weed management significantly improved 9 percent biomass growth, 10 percent yield of the rice crop along with 3-7 percent higher nutrient uptake (Ghosh et al., 2022). The utilization of organic and inorganic fertilizers advances the productivity without negative influence on yield quality and remedies soil fertility than the values echieved by organic or inorganic fertilizers individually (Roba, 2018).

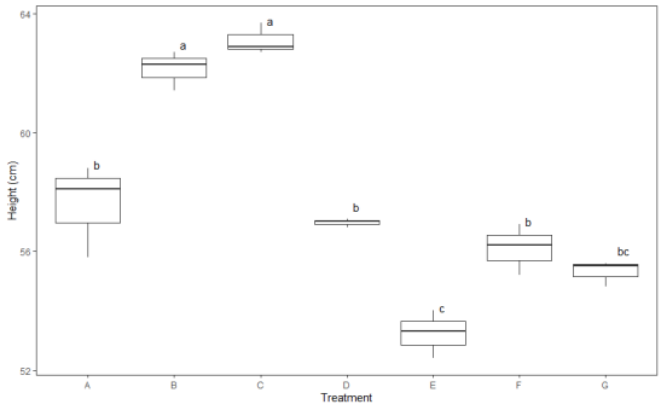

Figure 1. Comparation the average height of edamame plant (42 days after planting) for each treatment based on one way Analysis of variance RM and Tukey HSD 5 percent. Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C(50 percent inorganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E(75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost)

At 42 days after planting, the application of 10 ton per hectare compost combined with 75 percent and 50 percent inorganic fertilizers provided the highest leaf count. Utilize of 20 ton per hectare compost combined with 50 percent inorganic, and 10 ton per hectarecompost with 25 percent inorganic fertilizer are also higher than control significantly. The application 20 tonper hectarecompost with 75 percent inorganic fertilizer is significantly lower than control based on the leaf count (Figure 2). The application of 10 tonper hectarecompost combined with 50 percent and 75 percent of inorganic fertilizers produced the higher productive branches than control. Other treatments showed no differences compared to the control (Figure 4).

The leaf count, and the sum of productive branches are also closed to the biomass production of plants, and the combination application between organic and inorganic fertilizers increase the leaf count (Maswar & Soelaeman, 2016; Moe et al., 2019; Tong et al., 2021). Leaf is the important part of plant that facilitate photosynthesis. Soybean is categorized into C3 plant, and it produces the maximum conversion efficiency of solar energy to biomass approximately 4.6 percent at 30 °C and 380 ppm atmospheric [CO2] (Zhu et al., 2008). Amalgamation between organic and inorganic fertilizers that inoculated with rhizobia escalated nodulation, shoot biomass, haulms, harvest index (HI), P agronomic usefulness (P-AE), as well as rain water use efficiency (RUE) (Ulzen et al., 2020).

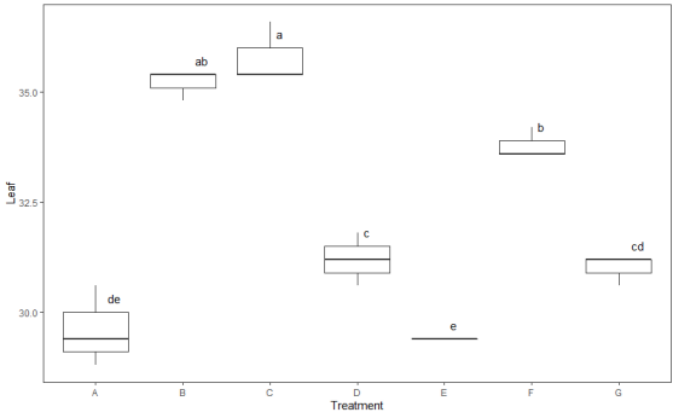

Figure 2. Comparation the average leaves of edamame plant for each treatment based on one way Analysis of variance RM and Tukey HSD 5 percent (42 days after planting). Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C (50 percent inorganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E (75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost)

Based on the pod weight, the application of 20 tonper hectarecompost combined with 75 percent inorganic fertilizer is significantly lower than the 10 tonper hectarecompost combined with 75 percent inorganic fertilizer. For the all combination of treatments in term of pod weight and seeded pods are no significantly different compared to the control (Figure 3 and 6).

The highest combination of organic and inorganic manures was not related to the yield productivity but it tends to increase the quality of yield. The addition of organic manure through with inorganic fertilizer (optimum NPK) significantly elevated the fruit quality as a result of upgrade fruit chemical composition, such as soluble solids and reduced sugar (Zhang et al., 2020). Roba (2018) stated that organic fertilizer remedies physical and biological activities of soil however nutrient content is lower. On contrary, the inorganic fertilizer provides all necessary nutrients that are directly reachable for plants (Roba, 2018).

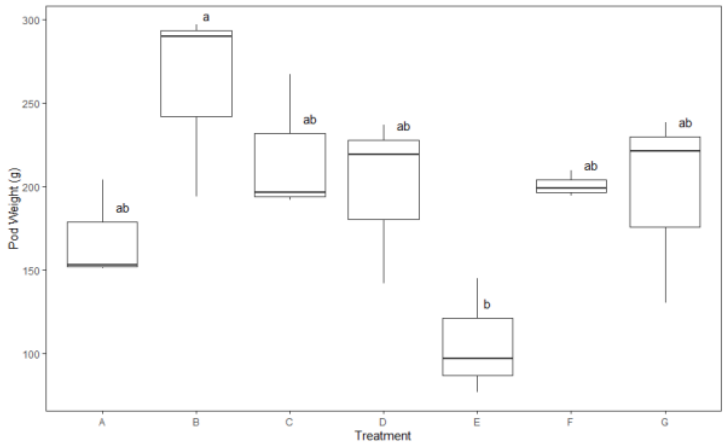

Figure 3. Comparation the average pod weight of edamame plant for each treatment based on one way Analysis of variance RM and Tukey HSD 5 percent. Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C (50 percent ino rganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E (75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost)

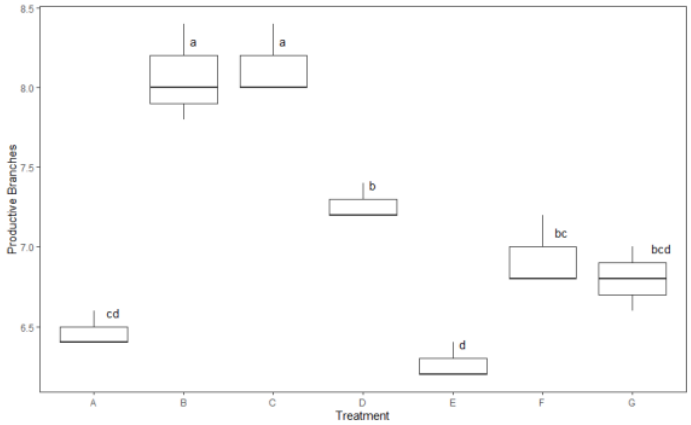

Figure 4. Comparation the average productive branches of edamame plant for each treatment based on one way Analysis of variance RM and Tukey HSD 5 percent. Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C (50 percent inorganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E (75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost).

Based on the average time to produce 50 percent flowers, the use of 10 ton per hectare compost combined with 50 percent inorganic fertilizer produces the shortest period. However, it is no significant compared to the 10 ton per hectare compost combined with 75 percent, and 25 percent of inorganic fertilizers, and also the application of 20 ton per hectare compost with 50 percent inorganic fertilizer (Figure 5).

The effect of some organic fertilizers produced an increase in all vegetative, flowering and characteristics, plant height 37.18 cm, leaf area 98.90 cm^2, leaf count 8.50 leave per plant, length of flower stalk 32.68 cm, fresh weight of flower stalk, and the diameter of the flower stalk 0.91 cm, the duration of the flowers on the plant 18.56 days (Altaee & Alsawaf, 2021). At the flowering phase, integrated (manure + fertilizer) and manure method had more N in two pools, indicating remove of plant-available N from the microbial biomass. The short period of flowering will promote fruiting stage. The quality of seed of fruit was as well significantly become betters with integrated fertilization, with fruit weight alike to that of conventional fertilisation (Darnaudery et al., 2018).

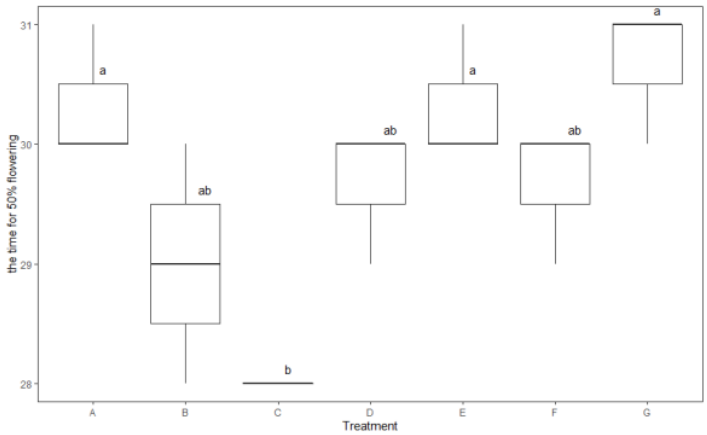

Figure 5. Comparation the average time to produce 50 percent flower of edamame plant for each treatment based on one way Analysis of variance RM and Tukey HSD 5 percent. Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C (50 percent inorganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E (75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost).

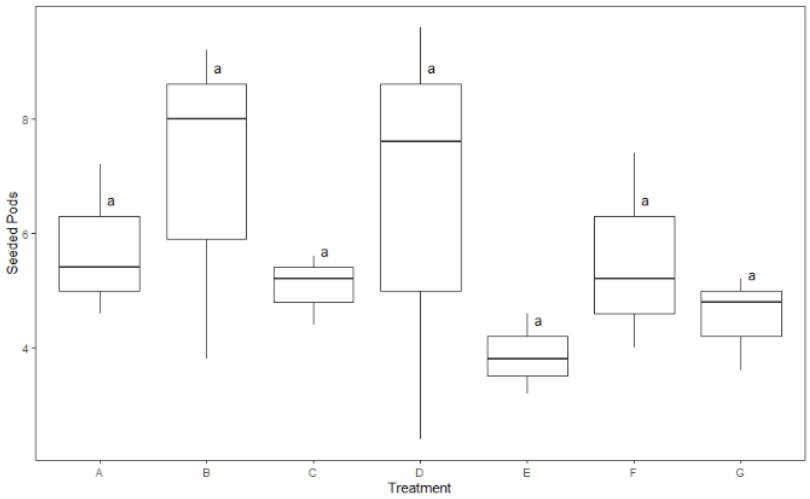

Figure 6. Comparation the average seeded pods of edamame plant for each treatment based on one way Analysis of variance RM and Tukey HSD 5 percent. Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C (50 percent inorganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E (75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost).

From six plant growth and development variables that observed in this research, the number of seeded pods and pod weight showed there were no-differences between treatments to the control. Four remaining variables showed the differences (Table 1).

Combination of organic and inorganic fertilizers as nutrient provide enhanced 9 percent biomass growth, 10 percent yield of the rice crop through with 3-7 percent higher nutrient uptake (Ghosh et al., 2022). Furthermore, the combination between both fertilizers escalates the productivity without negative effect on yield quality (Roba, 2018).

Table 1. Summary of organic (compost) and inorganic fertilizers effects on six plant growth and development variables compares to the control (inorganic fertilizer only), based on ANOVA at 5 percent error.

Each treatment to the control	Plant height	No. of leaves	No. of productive branches	Time to produce 50 percent flower	No. of seeded pods	Pod weight
B to A	+	+	+	0	0	0
C to A	+	+	+	-	0	0
D to A	0	+	+	0	0	0
E to A	-	0	0	0	0	0
F to A	0	+	0	0	0	0
G to A	0	0	0	0	0	0

Remarks: A (control), B (75 percent inorganic+10 ton per hectare compost), C (50 percent inorganic+10 ton per hectare compost), D (25 percent inorganic+10 ton per hectare compost), E (75 percent inorganic+20 ton per hectare compost), F (50 percent inorganic+20 ton per hectare compost), and G (25 percent inorganic+20 ton per hectare compost).

CONCLUSION

We deduce that combination between compost and inorganic fertilizers effects on the plant height, the sum of leaves, the sum of productive branches and the time to produce 50 percent flower. The sum of seeded pods and pod weight are not affected by all combination of treatments. The practice of 10 ton per hectare compost combined with 50 percent inorganic fertilizer produces the shortest period of flowering. At 42 days after planting, the application of 10 ton per hectare compost combined with 50 percent and 75 percent of inorganic fertilizers produced the higher productive branches than control. In addition, the application of 10 ton per hectare compost combined with 75 percent and 50 percent inorganic fertilizers provided the highest leaf count and plant height.

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GRADEMARK REPORT

FINAL GRADE

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GENERAL COMMENTS

Instructor

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THESIS 0 / 1

Thesis • The thesis may be more than one sentence, provided the sentences are in close proximity. • The thesis may be anywhere within the response. • For a thesis to be defensible, the passage must include at least minimal evidence that could be used to support that thesis; however, the student need not cite that evidence to earn the thesis point. • The thesis may establish a line of reasoning that structures the essay, but it needn't do so to earn the thesis point. • A thesis that meets the criteria can be awarded the point whether or not the rest of the response successfully supports that line of reasoning.

0 PTS. (0)	For any of the following: • There is no defensible thesis. • The intended thesis only restates the prompt. • The intended thesis provides a summary of the issue with no apparent or coherent claim. • There is a thesis, but it does not respond to the prompt. Responses that do not earn this point: Only restate the prompt. • Make a generalized comment about the passage that doesn't respond to the prompt. • Describe the passage or features of the passage rather than making a claim that requires a defense.
1 PT. (1)	Responds to the prompt with a thesis that presents a defensible interpretation of the passage. Responses that earn this point: Provide a defensible interpretation in response to the prompt.
2 PTS. (0)	n/a
3 PTS. (0)	n/a
4 PTS. (0)	n/a

EVID. & COMM. 0 / 4

Evidence and Commentary • Writing that suffers from grammatical and/or mechanical errors that interfere with communication cannot earn the fourth point in this row. • To earn the fourth point in this row, the response may observe multiple instances of the same literary element or technique if each instance further contributes to the meaning of the passage.

0 PTS. (0)	Simply restates thesis (if present), repeats provided information, or offers information irrelevant to the prompt. Typical responses that earn 0 points: • Are incoherent or do not address the prompt. • May be just opinion with no textual references or references that are irrelevant.
1 PT. (1)	EVIDENCE: Provides evidence that is mostly general. AND COMMENTARY: Summarizes the evidence but does not explain how the evidence supports the student's argument. Typical responses that earn 1 point: • Tend to focus on overarching narrative developments or description of a passage rather than specific details or techniques. • Mention literary elements, devices, or techniques with little or no explanation.
2 PTS. (2)	EVIDENCE: Provides some specific, relevant evidence. AND COMMENTARY: Explains how some of the evidence relates to the student's argument, but no line of

	reasoning is established, or the line of reasoning is faulty. Typical responses that earn 2 points: • Consist of a mix of specific evidence and broad generalities. • May contain some simplistic, inaccurate, or repetitive explanations that don't strengthen the argument. • May make one point well but either do not make multiple supporting claims or do not adequately support more than one claim. • Do not explain the connections or progression between the student's claims, so a line of reasoning is not clearly established.
3 PTS. (3)	EVIDENCE: Provides specific evidence to support all claims in a line of reasoning. AND COMMENTARY: Explains how some of the evidence supports a line of reasoning. AND Explains how at least one literary element or technique in the passage contributes to its meaning. Typical responses that earn 3 points: • Uniformly offer evidence to support claims. • Focus on the importance of specific words and details from the passage to build an interpretation. • Organize an argument as a line of reasoning composed of multiple supporting claims. • Commentary may fail to integrate some evidence or fail to support a key claim.
4 PTS. (4)	EVIDENCE: Provides specific evidence to support all claims in a line of reasoning. AND COMMENTARY: Consistently explains how the evidence supports a line of reasoning. AND Explains how multiple literary elements or techniques in the passage contribute to its meaning. Typical responses that earn 4 points: • Uniformly offer evidence to support claims. • Focus on the importance of specific words and details from the passage to build an interpretation. • Organize and support an argument as a line of reasoning composed of multiple supporting claims, each with adequate evidence that is clearly explained. • Explain how the writer's use of multiple literary techniques contributes to the student's interpretation of the passage.

SOPHIST. 0 / 1

Sophistication • This point should be awarded only if the sophistication of thought or complex understanding is part of the student's argument, not merely a phrase or reference.

0 PTS. (0)	Does not meet the criteria for 1 point. Responses that do not earn this point: • Attempt to contextualize of their interpretation, but such attempts consist predominantly of sweeping generalizations. • Only hint at or suggest other possible interpretations. • Make a single statement about how an interpretation of the passage comments on something thematic without consistently maintaining that thematic interpretation. • Oversimplify complexities in the passage. • Use complicated or complex sentences or language that is ineffective because it does not enhance the student's argument.
1 PT. (1)	Demonstrates sophistication of thought and/or develops a complex literary argument. Responses that earn this point may demonstrate a sophistication of thought or develop a complex literary argument by doing any of the following: 1. Identifying and exploring complexities or tensions within the passage. 2. Illuminating the student's interpretation by situating it within a broader context. 3. Accounting for alternative interpretations of the passage. 4. Employing a style that is consistently vivid and persuasive.
2 PTS. (0)	n/a

3 PTS. (0)	n/a
4 PTS. (0)	n/a