Research Article

Combination Test of Organic Fertilizer with Inorganic and Use of Insecticide on Sweet Corn (*Zea mays saccharate* Sturt.) Production

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Abstract.
The continuous and excessive use of inorganic materials such as fertilizers and pesticides in maize cultivation can cause land degradation. Therefore, to restore the quality of degraded land, it is necessary to add organic matter to the soil. This study aims to determine the growth and production of sweet corn (Zea mays saccharata Sturt) by reducing the use of inorganic fertilizers and chemical insecticides. This research was carried out in Langsat Permai Village, Bunga Raya District, Siak Sri Indrapura Regency, Riau Province from July to October 2020, using a completely randomized design (CRD) factorial, consisting of two factors. The first factor is fertilization consisting of four levels, namely 100% inorganic fertilizer + 16 ton.ha^{-1} organic fertilizer, 75% inorganic fertilizer + 20 ton.ha^{-1} organic fertilizer, 50% inorganic fertilizer + 24 ton.ha^{-1} organic fertilizer, and 25% inorganic fertilizer + organic fertilizer 28 ton.ha^{-1}. The second factor is the type of insecticide, which consists of three levels, namely chemical insecticides, semivegetable insecticides, biological insecticides. The results showed that the use of 25% inorganic fertilizer with 25 ton.ha-1 organic fertilizer and the use of semi-vegetable and biological insecticides showed better production in the parameters of weight per ear with husk, weight per ear without husk, and weight of cob with husk per plot. Therefore, organic fertilizers and bioinsecticides can be used to support environmentally friendly maize farming.

Keywords: insecticide, plant growth, production

1. Introduction

Sweet corn production in 2019 based on the Riau Province Food Crops and Horticulture Service 2020 is 29.734 tons with a harvest area of 15.674.1 Ha while in 2020 it is 35.850 tons with a harvest area of 11.133.5 Ha. Considering the high economic value of sweet corn, efforts need to be made to increase sweet corn production [1]. Sweet corn production has increased because the use of inorganic fertilizers has met the nutrient needs of plants, but the continuous and excessive use of inorganic materials such as fertilizers and pesticides can cause land degradation. Therefore, to restore the quality of degraded land, it is necessary to add organic matter to the soil [2]. An important factor in increasing sweet corn production is fertilization [3].

Other factors causing the low production of sweet corn can be caused by several factors, including pest and disease attacks. Pest control efforts carried out by local farmers to date still rely on the use of chemical insecticides, which are carried out on a scheduled basis with frequencies and doses exceeding the recommended ones. The use of chemical insecticides can lead to the emergence of secondary pests, environmental pollution, and cause insecticide residues in commodities that can be harmful to consumers. Control that can be done to reduce the cost of using insecticides is by using environmentally friendly controls [4].

Biological control can also control pests permanently and can help create a balanced agricultural ecosystem and sustainable agriculture. Natural enemies can function to regulate biological balance permanently in nature [5]. One alternative control that can be used is Beauveria bassiana, which is one of the natural enemies in the form of entomopathogenic fungi. The purpose of the study was to determine the growth and production of sweet corn (Zea mays saccharata Sturt) plants by reducing the use of inorganic fertilizers and chemical insecticides.

2. Materials and Methods

The research was conducted in Langsat Permai Village, Bunga Raya District, Siak Regency. The research was conducted for four months from July to October 2020. The research used a factorial complete randomized design (CRD) with two factors. The first factor is fertilizer formula with four levels, namely 100%, 75%, 50% and 25%. (100% inorganic fertilizer consisted of 450 kg.ha^{-1} urea, 100 kg.ha^{-1} phonska, 200 kg.ha^{-1} SP-36, 50 kg.ha^{-1} ZA, 150 kg.ha^{-1} KCl, 100 kg.ha^{-1} NPK) + organic fertilizer 16 ton.ha^{-1}. The second factor is the type of insecticide, namely chemical insecticides, semi-plant-based insecticides and biological agent insecticides. From these two factors, 12 treatment combinations were obtained. Each treatment was carried out three times to obtain 36 experimental units with 20 sweet corn plants in each experimental unit. The total number of plants used was 720.

2.1. Implementation of research

2.1.1. Fertilizer application

Organic fertilizer is given in the form of compost and liquid organic fertilizer. Compost is used based on cow dung and empty bunch ash. Compost is given when applying basic fertilizer according to the treatment dose, namely 100% compost, 125% compost, 150% compost and 175% compost. Liquid organic fertilizer is applied to plants as much as 10ml per plant once every two weeks by pouring the fertilizer on the surface of the soil around the plant. Inorganic fertilizer is given during follow-up fertilization. The fertilizers used in the supplementary fertilization are Urea, NPK, SP-36 and KCl according to the treatment dose, namely 100%, 75%, 50% and 25%. Fertilization is applied three times (7, 20, 45 days after planting).

2.1.2. Insecticide application

Chemical insecticides used are various brands of insecticides on the market. The vegetable insecticides used were extracts from plants around the research site such as papaya leaves, neem, soursop, bandotan and gadung tubers. Each ingredient is extracted separately and a solution is made according to the recommended dosage of each. The biological agent used was Beauveria bassiana which was propagated from a starter. This control is carried out if a pest attack occurs. Application is carried out by spraying once every two weeks using a sprayer in the afternoon.

2.1.3. Observation and data analysis

Research observations consisted of plant height, stem diameter, leaf length, leaf width, time male flowers appeared, time female flowers appeared, harvest age, weight per ear with husks, weight per ear without husks, weight of cobs with husks per plot (6 m^2), ear length, ear diameter, number of seed rows per ear, root volume, and attack intensity. The percentage of pests was calculated using the formula:

$$\frac{number\ of\ affected\ sample\ plants}{number\ of\ sample\ plants} \times 100\%$$

The data obtained were analyzed using variance analysis with a factorial CRD linear model, if the results of the analysis of variance are significantly different, it will be continued with the Duncan New Multiple Range Test (DNMRT) test at the 5% level.

3. Results and discussion

3.1. Result

3.1.1. Observation of sweet corn plant growth (Zea mays saccharata Sturt)

The interaction between the use of fertilizers and insecticides, the use of fertilizers and the use of insecticides is not significantly different in the observations of plant height, stem diameter, leaf length, and leaf width (Table 1). The observation of the age of male flowers showed that the interaction between the use of fertilizers and insecticides and the use of insecticides was not significantly different, while the use of fertilizers was significantly different. The observation of the age of female flowers showed that the interaction between the use of fertilizers and insecticides and the use of insecticides was not significantly different.

The soil used has been classified as fertile so that the application of high or low doses of fertilizer gives results that are not different or tend to be the same. Decreasing the dose of inorganic fertilizer and increasing the dose of organic fertilizer did not give different results on the average plant height, stem diameter, leaf length, and leaf width. According to Lubis [6], the application of fertilizer to plants clearly influences growth, but if excessive application will suppress growth, while a little fertilizer can cause nutrient deficiencies for plants.

The existence of semi-plant-based insecticides and biological insecticides helps reduce the use of chemical insecticides and prevent pests from damaging leaf growth. Control is carried out by utilizing biological agents, namely Beauveria bassiana. According to Todorava et al. [7], B. bassiana isolates are very effective in killing pests from the Lepidoptera family.

Table 1: Interaction between fertilizer and insecticide use, fertilizer and insecticide use on sweet corn plant growth observation.

			Fertilizer (P)				
No.	**Observation**	**Insecticide (I)**	**100% inorganic fertilizer and 16 tons.ha-1 organic fertilizer**	**75% inorganic fertilizer and 20 tons.ha-1 organic fertilizer**	**50% inorganic fertilizer and 24 tons.ha-1 organic fertilizer**	**25% inorganic fertilizer and 28 tons.ha-1 organic fertilizer**	**Insecticide average**
1	Sweet corn plant height (cm)	chemical	224,33	210,92	208,92	203,92	212,02
		semi plant based	219,25	228,67	211,58	205,33	216,21

Table 1: Continued.

			Fertilizer (P)				
No.	**Observation**	**Insecticide (I)**	**100% inorganic fertilizer and 16 tons.ha-1 organic fertilizer**	**75% inorganic fertilizer and 20 tons.ha-1 organic fertilizer**	**50% inorganic fertilizer and 24 tons.ha-1 organic fertilizer**	**25% inorganic fertilizer and 28 tons.ha-1 organic fertilizer**	**Insecticide average**
		biological	210,58	202,17	217,50	218,08	212,08
	fertilizer average		218,05	213,91	212,66	209,11	
2	Sweet corn stem diameter (cm)	chemical	4,11	3,96	4,15	3,48	3,93
		semi plant based	3,31	4,22	4,06	4,01	3,90
		biological	3,89	4,21	4,43	4,04	4,14
	fertilizer average		3,77	4,13	4,21	3,84	
3	Sweet corn leaf length (cm)	chemical	86,68	93,50	90,16	90,50	90,21
		semi plant based	92,91	94,58	91,41	92,91	92,95
		biological	93,75	91,41	92,91	92,41	92,62
	fertilizer average		91,11	93,16	91,50	91,94	
4	Sweet corn leaf width (cm)	chemical	10,05	9,95	10,05	9,99	10,01
		semi plant based	10,30	10,15	10,25	9,90	10,15
		biological	10,01	10,27	10,10	10,31	10,17
	fertilizer average		10,12	10,12	10,13	10,07	
5	Age at male flower emergence (HST)	chemical	45,00 a	45,66 a	44,66 a	45,66 a	45,25 a
		semi plant based	44,66 a	45,00 a	45,00 a	46,00 a	45,16 a
		biological	45,00 a	45,33 a	44,66 a	45,33 a	45,08 a
	fertilizer average		44,88 b	45,33 ab	44,77 b	45,66 a	
6	Age of female flowers (HST)	chemical	46,33 a	47,66 a	47,33 a	47,66 a	47,25 a
		semi plant based	46,33 a	47,33 a	47,66 a	47,66 a	47,25 a
		biological	46,33 a	47,00 a	46,33 a	47,33 a	46,75 a
	fertilizer average		46,33 b	47,33 a	47,11 a	47,55 a	

Note: The numbers in the row followed by the same lowercase letter are not significantly different according to the DNMRT test at the 5% level.

3.2. Types of pests attacking maize plants

Sweet corn cultivation is inseparable from the attack of plant disrupting organisms (PDO), namely pests, weeds and diseases. Some pests that attacked during the research of sweet corn cultivation were caterpillars (Agrotis ipsilon Hwfn.), stem borers (Ostrinia furnacalis Guenee) and armyworms (Spodoptera frugiperda and Spodoptera litura). The most dominant pest during the study was S. frugiperda. The loss caused by S. frugiperda is that the plant cannot form shoots or young leaves because the growth point of the plant is damaged. The larvae of S. frugiperda have a high feeding ability, the larvae will enter the plant and actively eat there, so if the population is still small it will be difficult to detect its presence. The imago is a strong flier and has a high cruising range [8].

S. frugiperda attacks corn plants in the vegetative phase to the generative phase [9] and the highest level of damage is found in the vegetative phase [10]. The part that is damaged by S. frugiperda is the shoot of the plant, if the shoot of the plant has not fully opened, holes and feces from the larvae can be seen and if it has opened, the leaves can be seen damaged due to larval burrows. Larvae usually settle on the tops of plants but can also attack corn cobs [11]. Damage occurs due to eating leaves, large pest populations can cause defoliation and result in yield loss [12].

The use of synthetic chemical insecticides can have negative impacts such as the occurrence of pest resistance, pest resurgence, secondary pest blasting and the death of natural enemies. Reducing the impact caused by synthetic insecticides, it is necessary to have alternatives in control techniques, namely by using vegetable and biological insecticides. Plant-based and biological insecticides are insecticides whose basic ingredients are plants and microorganisms that are easy to make. Plant-based and biological insecticides are easily decomposed in nature so they do not pollute the environment. The vegetable and biological insecticides used are papaya leaves (Carica papaya L.) and the entomopathogenic fungus Beauveria bassiana. Papaya is a plant that has potential as a vegetable pesticide to control insect pests. Papain contained in papaya leaves is toxic to caterpillars and sucking pests. Papaya sap also produces compounds in the class of alkaloids, terpenoids, flavonoids and pest acids through the natural holes of its body.

3.3. Observation of sweet corn (Zea mays saccharata Sturt.) crop production

The interaction between the use of fertilizers and insecticides, the use of fertilizers and the use of insecticides was not significantly different in the observation of harvest age and root volume of sweet corn plants (Table 2). The interaction between the application of 100% inorganic fertilizer and 16 tons.ha-1 organic fertilizer increased the weight per cob with tares unnoticeably at each treatment dose given to the observation of weight per cob with tares and without tares. While the observation of the weight of cob with cob per plot showed that the interaction between the use of fertilizers and insecticides, the use of fertilizers and the use of insecticides was significantly different.

The weight of cob with cob per plot of sweet corn is influenced by the optimal supply of nutrients, especially N, P, K. According to Kriswantoro et al. [13] stated that one of the limiting factors of sweet corn plant growth is nutrients. The state of nutrients in the soil determines the yield of sweet corn. To achieve optimum yield, sweet corn plants require adequate nutrient inputs. Nutrients are one of the important factors affecting plant growth and development. According to Prayogo et al. [14], the availability of macro elements such as N, P and K can support plant growth such as the formation of different cobs to cob weight will potentially affect production.

Reducing the impact caused by chemical insecticides, it is necessary to have alternatives in control techniques, namely by using vegetable and biological insecticides. The fungus B. bassiana plays a more important role in suppressing pest attacks on plants. According to Wahyudi [15], the fungus B. bassiana produces toxins that can kill plant pests. The low attack of leaf-eating pests makes photosynthesis in plants run well. The observation of pest attack intensity showed that the use of chemical insecticides gave results that were not significantly different from biological insecticides, namely 37.50% and 58.33%, but significantly different from semi-plant insecticides, namely 45.83%. The use of chemical insecticides still plays an important role in controlling pests in sweet corn plants, but the use of these insecticides can be replaced with semi-plant and biological insecticides.

Table 2: Interaction between fertilizer and insecticide use, fertilizer and insecticide use on sweet corn croprp oduction observations.

			Fertilizer (P)				
No.	**Observation**	**Insecticide (I)**	**100% inorganic fertilizer and 16 tons.ha-1 organic fertilizer**	**75% inorganic fertilizer and 20 tons.ha-1 organic fertilizer**	**50% inorganic fertilizer and 24 tons.ha-1 organic fertilizer**	**25% inorganic fertilizer and 28 tons.ha-1 organic fertilizer**	**Insecticide average**
1	Sweet corn harvest age (DAP)	chemical	64,33	64,66	64,66	64,66	64,58
		semi plant based	64,00	64,66	64,33	64,33	64,33
		biological	64,00	64,66	64,66	64,66	64,5
	fertilizer average		64,11	64,66	64,55	64,55	

Table 2: Continued.

No.	Observation	Insecticide (I)	Fertilizer (P) 100% inorganic fertilizer and 16 tons.ha-1 organic fertilizer	75% inorganic fertilizer and 20 tons.ha-1 organic fertilizer	50% inorganic fertilizer and 24 tons.ha-1 organic fertilizer	25% inorganic fertilizer and 28 tons.ha-1 organic fertilizer	Insecticide average
2	Weight per cob with tares (g)	chemical	408,33 a	378,92 a	355,83 a	364,67 a	376,94 a
		semi plant based	377,58 a	328,25 a	343,67 a	361,42 a	352,73 a
		biological	386,92 a	344,25 a	336,92 a	350,50 a	354,65 a
	fertilizer average		390,94 a	350,47 b	345,47 b	358,86 b	
3	Weight per cob without tares (g)	chemical	300,17 a	264,33 a	274,75 a	262,17 a	275,35 a
		semi plant based	278,58 a	255,33 a	275,92 a	265,00 a	268,70 a
		biological	280,17 a	247,08 a	241,17 a	245,92 a	253,58 a
	fertilizer average		286,31 a	255,58 b	263,94 ab	257,69 b	
4	Weight of cob with tares per plot (kg)	chemical	10,66 a	8,23 b	8,06 b	8,03 b	8,75 a
		semi plant based	8,30 b	8,20 b	8,30 b	8,06 b	8,21 ab
		biological	8,00 b	8,00 b	8,03 b	8,03 b	8,01 b
	fertilizer average		8,98 a	8,14 b	8,13 b	8,04 b	
5	Sweet corn cob length (cm)	chemical	19,60 a	19,43 a	19,25 a	19,23 a	19,38 a
		semi plant based	19,25 a	18,80 a	18,00 a	19,04 a	18,77 b
		biological	19,41 a	18,58 a	18,35 a	19,06 a	18,85 b
	fertilizer average		19,42 a	18,93 ab	18,53 b	19,11 ab	
6	Sweet corn cob diameter (cm)	chemical	9,05 a	8,35 a	8,22 a	8,39 a	8,50 a
		semi plant based	8,39 a	8,05 a	8,03 a	8,29 a	8,19 a
		biological	8,69 a	7,91 a	7,77 a	7,61 a	8,00 a
	fertilizer average		8,71 a	8,10 b	8,01 b	8,10 b	
7	Number of seed rows per cob (rows)	chemical	16,37 a	17,16 a	16,16 a	16,08 a	16,44 a
		semi plant based	15,33 a	16,00 a	15,33 a	16,16 a	15,70 b
		biological	16,66 a	16,66 a	16,25 a	16,25 a	16,45 a
	fertilizer average		16,12 a	16,61 a	15,91 a	16,16 a	

Table 2: Continued.

No.	Observation	Insecticide (I)	Fertilizer (P) 100% inorganic fertilizer and 16 tons.ha-1 organic fertilizer	75% inorganic fertilizer and 20 tons.ha-1 organic fertilizer	50% inorganic fertilizer and 24 tons.ha-1 organic fertilizer	25% inorganic fertilizer and 28 tons.ha-1 organic fertilizer	Insecticide average
8	Sweet corn root volume (cm^3)	chemical	72,66	71,66	71,66	72,33	72,83
		semi plant based	72,00	71,66	71,33	72,00	71,5
		biological	71,66	71,66	72,66	71,33	71,33
	fertilizer average		72,11	71,66	71,88	71,88	
9	Pest attack intensity (%)	chemical	50,00 a	33,33 a	33,33 a	33,33 a	37,50 b
		semi plant based	58,33 a	58,33 a	33,33 a	33,33 a	45,83 ab
		biological	58,33 a	50,00 a	58,33 a	66,67 a	58,33 a
	fertilizer average		55,556 a	47,22 a	41,66 a	44,44 a	

Note: The numbers in the row followed by the same lowercase letter are not significantly different according to the DNMRT test at the 5% level.

4. Conclusion

The use of 25% inorganic fertilizer with 28 tons.ha-1 organic fertilizer and the use of semi-plant and biological insecticides showed better production in the parameters of weight per cob with cob, weight per cob without cob, and weight of cob with cob per plot.

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