

Growth Response and Plant Yield Sweet Corn (*Zea mays saccharata* Sturt) Against Biological Organic Fertilizers and Planting Spacing

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Abstract

The use of biological organic fertilizers is currently highly recommended because the content of macro and micronutrients can be immediately available to plants and obtain high yields by adjusting the spacing. The purpose of this study was to determine the effectiveness of biological organic fertilizers on the growth and yield of sweet corn plants to support food security programs by providing quality and safe potential food products for the community while maintaining environmental sustainability. This study was conducted on land owned by farmers in Sukajaya Sub-District Sukarama Palembang city. The method used is a randomized design group (RAK) factorial consisting of 2 factors, namely: the first factor is biological organic fertilizer H1: biological organic fertilizer 200kg/ha, H2: biological organic fertilizer 300kg/ha, H3: biological organic fertilizer 400kg/ha, the second factor is the planting distance consists of 3 levels, namely: J1= 50 cm x 30 cm, J2= 60 cm x 30 cm, J3= 70 cm x 30 cm. The results showed that the biological organic fertilizer treatment can have the best effect on the growth and yield of sweet corn. Planting distance of 60 cm x 30 cm can have the best effect on the growth and yield of sweet corn. Interaction between biological organic fertilizer and planting distance can have the best effect on the growth and yield of sweet corn.

Keywords: Biological organic fertilizer, Spacing, Sweet corn

Introduction

Along with the emergence of the food industry and supermarkets whose needs are quite large both nationally and internationally for sweet corn, it is necessary to increase the production of sweet corn until it reaches sufficient potential. So that the government followed up the direction of economic development policies in the agricultural sector, then Agropolitan was established as a leading development program with corn-based competencies. In practice, there are still many obstacles faced by both farmers and the government (Adijaya, 2014).

Considering that the economic value of sweet corn is quite high, it is necessary to make efforts to increase the production of sweet corn. An important factor in increasing sweet corn production is fertilization (Marajo, 2016). The low production of sweet corn is partly due to land degradation due to the continuous and excessive use of inorganic materials such as fertilizers and pesticides. Therefore, to restore the quality of degraded land, it is necessary to

add organic matter to the soil (Rinata, 2016).

The fact shows that to pursue high production, farmers often use inorganic fertilizers continuously and even excessively without returning crop residues and organic matter to the soil. This will lead to a decrease in land quality which results in a decrease in crop productivity. Besides that, public awareness of quality and chemical-free food products is a consideration for reducing the use of inorganic fertilizers. Efforts are needed to overcome the above by maintaining soil fertility and health which play a role in increasing plant productivity so that they can produce good quality safe food products and be able to compete in the global market, namely by using biological organic fertilizers. Biological organic fertilizers are biological products that can increase fertilizer efficiency, fertility, and soil health. Biological organic fertilizers contain bacteria that are useful for stimulating plant growth so that crop production remains high and sustainable (Chusnia *et al.*, 2012). The application of this biological organic fertilizer can provide NPK nutrients, increase soil CEC and increase soil P solubility.

The nutrients needed by sweet corn plants are nitrogen, phosphorus, and potassium. The requirement for N nutrients ranges from 31.41 – 39.39 kg/ha, P nutrients range from 6.03 – 12.54 kg/ha, and K nutrients range from 37.50 – 41.70 kg/ha (Priyanto, 2016). This is supported by the research results of Marlina *et.al.*, (2016), that the application of biological organic fertilizers (chicken manure enriched with Azospirillum bacteria and 400 kg/ha phosphate solubilizing bacteria with 50% NPK organic fertilizer can increase the production of rice plants in the soil. ups and downs of 57.79 g/pot. Furthermore, Marlina and Asmawati (2017), that the application of a combination of 400 kg/ha biological organic fertilizer with 25% NPK inorganic can increase NPK nutrient absorption and rice production per plot by 1.46 kg/plot.

In addition to fertilization, spacing is one of the factors that can affect crop production. Increasing corn production can be done by improving the level of planting density to increase the yield of corn plant seeds. Increasing the level of planting density per unit area to a certain extent can increase seed yields, but increasing the number of plantings will result due to competition for nutrients, water, solar radiation, and space to grow so it will reduce the number of seeds planted. Plant population (planting distance) is one of the factors that can affect crop yields. Planting with spacing aims to population plants get an equal share of the necessary nutrients and sunlight, and facilitate maintenance (Probowati, 2014). Maximum production is achieved when using the appropriate spacing. The higher density level of a plant results in a higher level of competition between plants in terms of getting nutrients and light. To get the right spacing, several things need to be considered soil fertility, proper spacing, and balanced use of fertilizers. The purpose of this study was to determine the effect of biological

organic fertilizers and spacing on the growth and production of sweet corn (*Zea mays saccharata* Sturt).

Materials and methods

The methods used in this study are experimental methods with field trials belonging to farmers in Sukajaya Village, Sukarame District, Palembang Municipality. The research was conducted from July to November 2022. The materials used in this study were sweet corn seeds, biological organic fertilizers, urea fertilizer, KCL, SP-36, Furadan-3G, Azodrin-15WSC, Dithane M-45-80 WP, and dolomite. The tools used were: hoes, machetes, sickles, knives, buckets, dippers, raffia rope, bamboo, plastic sheets, tape measure, scales, calipers, scissors, and stationery. The experimental design used was a randomized block design which was arranged in a factorial manner consisting of 2 treatment factors, namely the treatment of biological organic fertilizers and the treatment of spacing, with 3 replications. The first is biological organic fertilizer H1 = 200 kg/ha biological organic fertilizer, H2 = 300 kg/ha biological organic fertilizer, and H3 = 400 kg/ha biological organic fertilizer. The second factor is the spacing consisting of 3 levels, namely: J1 = 50 cm x 30 cm, J2 = 60 cm x 30 cm, and J3 = 70 cm x 30 cm. Based on the treatment factors obtained as many as 9 treatment combinations. Each combination was repeated 3 times, resulting in a total of 27 experimental units or plots. Land preparation was cleared of weeds after that the soil was smoothed and plots were made with a size of 2 m x 3 m with a distance of 50 cm between plots, while the distance between groups which were replicates was 100 cm. Making biological organic fertilizer using 200 kg of chicken manure and 100 kg of straw incubated for 1 month, once every 4 days it is stirred back and forth then the manure and straw that have been incubated are added with bran and sugar then given *Azospirillum* and phosphate solubilizing bacteria after that the fertilizer is ready to be used.

Planting the planting hole is made by digging. Three seeds were planted per hole at a depth of 3 cm-5 cm, with spacing according to the treatment, namely: 50 cm x 30 cm (36 tons/plot), 60 cm x 30 cm (21 tons/plot), 70 cm x 30 cm (15 tons/plot). After two weeks of age the plants were selected, leaving two plants per hole. At the time of planting, the seeds were given Furadan-3G at a rate of 2 g/plant. Giving this furadan is to prevent pest attacks, watering is done twice a day, depending on weather conditions. The first weeding is done simultaneously with the second urea fertilization accompanied by growth when the plants are three weeks old. The second weeding is done when the plants are six weeks old accompanied by heaping. To protect plants from disease, given Dithane M-45 80 WP with a concentration of 2 g/l water. In eradicating pests, sweet corn is used, ready to be harvested at the age of 60 days to 70 days after planting or when the corn silk is brown and the cobs are full. Observation of plant growth is carried out every week. Variables observed included plant

height, flowering age, cob length, cob diameter, net cob weight per plant, and dry weight.

Results and Discussion

The results of the analysis of variance showed that biological organic fertilizers had a very significant effect on net cob weight per plant, had a significant effect on cob length, and cob diameter, but had no significant effect on plant height, flowering age, and dry matter weight. The spacing treatment had a significant effect on plant height and net cob weight per plant while flowering age, cob length, cob diameter, and dry cob weight had no significant effect. The application of several doses of biological fertilizers showed no significant effect on plant height, flowering age, or dry matter weight. From the administration of biological organic fertilizer doses of 200 kg/ha, 300 kg/ha, and 400 kg/ha, it turned out that the doses of biological organic fertilizers were 400 g/ha, also gave the highest average consistency showing positive linear (increase) in all parameters of growth and production of corn plants where biological organic fertilizers contain macro, micronutrients, hormones, humic acids, and microorganisms that benefit the soil. The benefits of the presence of microorganisms in the soil can increase soil fertility, produce important compounds such as nutrient solvents, microbial solubilizing phytohormones, fix N₂, dissolving P so that it becomes more available changing organic matter thereby increasing the availability of nutrients in the soil (Saraswati and Purwani, 2009). In the treatment, spacing affects the nutrients and growth space obtained by plants which in turn influences plant growth and production. Plant population affects the efficiency of water and nutrient use which affects plant growth and production.

The treatment of several spacings showed no significant effect on flowering time, cob length, cob diameter, and dry weight. This is presumably because the spacing between plants is very small so that the growth in height of the three spacings is almost uniform and always increases, then the spacing of 50 cm x 30 cm (J3) in sweet corn plants causes competition between plants in absorbing sunlight, water, extracting nutrients, and causing crowns and roots to overlap so that plants cannot grow properly and give maximum results. According to Bakkara (2010) which states that maximum production is achieved when using the appropriate spacing. The higher the level of density of a crop, the higher the level of competition between plants in terms of getting nutrients and light. Conversely, if the spacing is too far, evaporation of nutrients and water will occur and the processes of transpiration, evaporation, and respiration will be quite high so that the need for water and nutrients will decrease. The interaction had a significant effect on plant height and cob weight but had no significant effect on flowering time, cob length, cob diameter, and dry weight.

Table 1. Results of the analysis of the variation in the effect of biological organic fertilizers and spacing on all observed parameters

Observed Parameters	F count			KK (%)
	H	J	I	
Plant height (cm)	2,15 ^{tn}	4,24*	1,96 ^{tn}	4,00
Age of flowering (days)	2,85 ^{tn}	0,69 ^{tn}	8,72**	3,09
Cob length (cm)	5,14*	2,73 ^{tn}	3,00*	7,57
Ribbed cob diameter (cm)	4,23*	2,28 ^{tn}	1,59 ^{tn}	3,49
Net cob weight per plant (g)	6,27**	4,73*	3,72*	3,90
Dry chest weight (g)	2,90 ^{tn}	0,20 ^{tn}	0,82 ^{tn}	9,50

Description: * = Significant impact, ** = Very significant impact, tn = not significant effect, H = Bio-organic fertilizer, J = Spacing, I = Interaction, KK = Coefficient of diversity

Table 2, the J2 treatment gave the best results for plant height, which was 182.98 cm. At this spacing, there was no significant competition between plant leaves in getting the sunlight needed for the photosynthesis process and providing ideal growing space for the growth of corn plants. sweet. Plants with wider spacing get enough sunlight and nutrients because the competition between plants is smaller. Spacing is closely related to factors that play a role in plant growth, such as the efficient use of sunlight, especially for photosynthesis. If the spacing is too tight, the canopy leaves will lose the opportunity to receive light, so the amount of light absorbed is reduced, resulting in a reduced rate of photosynthesis. Likewise with spacing that is too rare, even though there is no competition for nutrients, the number of plant populations will affect crop production.

Table 2. Results of the analysis of the variation in the effect of spacing on plant height (cm)

Treatment	Average plant height (cm)	BNJ test	
		0,05 = 8,76	0,01= 11,47
J3	173,88	a	A
J1	175,05	ab	AB
J2	182,98	b	B

Note: Numbers followed by the same letter mean no significant difference at the 5% and 1% LSD test level

The results of the honestly significant difference test Table 3 shows that the dose of biological organic fertilizer and spacing has a very strong relationship between the treatment of biological organic fertilizer and the population of soil bacteria where the higher the dosage of biological organic fertilizer, the higher the number of bacterial populations the presence of the total population of bacteria in the soil influenced by the dose of fertilizer while the rest comes from other factors. Thus spurring faster release of flowers and this can accelerate the process of fruit formation. Biological organic fertilizers have a function as a material that

contains living cells that can fix nitrogen and so on to increase soil fertility and help plant growth through increasing microbial activity in the soil and helping plant growth through increasing microbial activity in the soil (Simangunkalit et al., 2006). While the spacing shows the best effect so that in the absorption of nutrients, sunlight will be maximized. This situation is made possible by a well-developed plant root system because the area of root development is sufficiently available and does not overlap so that the plant gets the adequate scope to achieve maximum growth and production. The honest significant difference test results for the treatment of biological organic fertilizers and spacing are mutually influential treatments, in line with Syarieff's statement (2005) which states that adequately available nutrients can stimulate plant growth, stimulate root system growth, increase production yields, and increase plant growth. leaves to increase the process of photosynthesis.

Table 3. Effect of biological organic fertilizers and Spacing on flowering age (days)

Treatments	Average age of flowering (days)	BNT test	
		0,05 = 2,79	0,01= 3,46
H1J3	30,66	a	A
H3J1	31,00	a	A
H1J2	31,33	a	A
H2J3	31,33	a	A
H3J2	31,66	a	AB
H1J1	32,33	ab	AB
H2J2	32,33	ab	AB
H2J1	33,00	ab	AB
H3J3	35,03	ab	B

Note: The numbers followed by the same letter mean that they are not significantly different at the 5% and 1% BNT test levels

Table 4 shows that the treatment of biological organic fertilizers besides being able to change the physical properties of the soil, there is also a change in chemical properties with an increase in the elements N, P, and K as a source of nutrients for plant growth and yield (Sari *et al.*, 2016; Dinesh *et al.*, 2010). In addition, the provision of nutrients needed by plants can be carried out by bacteria in biological fertilizers which can fix N from the air and phosphate solubilizing microbes which can increase P in the soil to become available P for plant growth, thereby affecting growth and yield components. besides that, it can save the use of chemical fertilizers (Moelyohadi *et al.*, 2012). contains beneficial bacteria and fungi such as *Azotobacter chococum*, *A. vinelandi*, *Azospirillum sp*, *Pseudomonas cepacia*, *Penicillium sp*, *Acinetobacter sp* with each population e” 10⁷ CFU/mL. *Azotobacter*, known as N₂-fixing rhizobacteria in plant roots, can produce phytohormones including cytokinins and gibberellins (Hindersah and Simarmata., 2004).

Table 4. Interaction of the effect of biological organic fertilizers and spacing on cob length parameters (cm)

Biological Organic Fertilizer	Spacing			Biological Organic Fertilizer
	J1	J2	J3	
H1	20,48a AB	19,64a AB	19,70a AB	19,94ab AB
H2	20,42ab AB	24,58b B	19,83a AB	21,61b AB
H3	19,57a A	19,42a A	19,03a A	19,34a A
BNJ	H and J 0,05 = 19,90 0,01 = 2,48		HJ 0,05 = 4,47 0,01 = 5,41	

Note: The numbers followed by the same letter mean that they are not significantly different at the 5% and 1% BNT test levels

Table 5 shows that the diameter of cobs with H2 treatment has larger diameter than other treatments, this is in line with Habibi L (2008) which states that biological organic fertilizers can decompose chemical residues, bind heavy metals, supply part of the N requirements for plants, dissolving phosphate compounds, releasing K compounds from soil colloidal bonds, producing natural enzymes, producing anti-pathogenic substances (specific to each type of microorganism). Biofertilizers function to increase production yields, increase the efficiency of the use of artificial fertilizers, reduce the dosage of artificial fertilizer use, improve the physical, chemical, and biological structure of the soil, suppress pest and disease attacks, create a good balance of flora and fauna in the soil which in turn brings goodness to all aspects of agriculture. This is the opinion of Palungkun and Budiarti (2012) that if there is a balance between the cobs in sweet corn plants in obtaining nutrient requirements, sunlight, water, and humidity, the cobs produced will have a large size.

Table 5. The effect of biological organic fertilizers on the diameter of cobs (cm)

Treatments	Average cob diameter (cm)	BNT Test	
		0,05 = 0,18	0,01 = 0,24
H1	13,26	a	A
H3	13,70	b	B
H2	13,90	c	B

Note: The numbers followed by the same letter mean that they are not significantly different at the 5% and 1% BNT test levels

The honest significant difference test results for the H2 biological organic fertilizer treatment had a net cob weight per plant, which was 190.63 grams, higher than the other treatments. This shows that the application of H2 biological organic fertilizer at a rate of 300 kg/ha can create better soil texture and structure conditions, and support the formation of crumb structure and soil aggregate stability. According to Suwahyono (2011), the microbes

contained in biological fertilizers when applied to plants can bind nitrogen from the air, dissolve phosphate bound in the soil and break down complex organic compounds into simpler compounds and stimulate plant growth. Then according to Soemarno (2011) that if the plant has conditions that support it with the appropriate nutrients and mineral elements, the plant will experience upward growth and become taller. Microbes contained in biological organic fertilizers such as *Azotobacter* and *Azospirillum* which are capable of fixing nitrogen to produce good plant height, Endophytic microbes which are capable of producing growth hormones, and phosphate solubilizing microbes capable of fixing P elements to increase the height growth of maize plants better thus affecting production. Spacing of 60 cm x 30 cm still gave better results in the growth of corn plants even though some plant parameters had a significant effect and some had no significant effect at $\alpha = 5\%$, but for all plant growth and production parameters, it gave the highest average consistency at the spacing plant 60 cm x 30 cm. This is because the corn plant is a C4 plant that is adaptive to sunlight so the spacing of 60 cm x 30 cm is the ability of the plants to get full sunlight and sufficient nutrients to carry out the assimilation process better. The spacing system affects light, CO₂, wind, and nutrients obtained by plants so it will affect the photosynthesis process which in turn has a different effect on the growth parameters and corn production.

Table 6. Interaction of the effect of biological organic fertilizers and spacing on the parameter of net cob weight per plant (g)

Biological Organic Fertilizer	Spacing			Biological Organic Fertilizer
	J1	J2	J3	
H1	174,07ab A	176,83a AB	182,49a AB	177,79ab A
H2	177,48ab AB	204,58b B	189,83a AB	190,63b AB
H3	182,57a A	182,42a A	188,03a A	184,34a A
Average spacing	178,03a A	187,94b A	186,78ab A	
BNJ	A and J 0,05 = 8,72		AJ 0,05 = 20,82	
	0,01 = 11,42		0,01 = 25,75	

Note: The numbers followed by the same letter mean that they are not significantly different at the 5% and 1% BNT test levels

The dry weight of each treatment tabulated showed that the biological organic fertilizers produced the highest body weight of 90.82 g. While the treatment of J1 spacing was 86.46 g. The interaction between biological organic fertilizers and H1J3 spacing resulted in the highest weight of 94.64 g while the lowest was achieved in the H3J3 treatment of 70.27 g.

The process of photosynthesis will determine the accumulation of photosynthate which is beneficial for plant growth. Plant growth is strongly influenced by the high and low photosynthate produced through the process of photosynthesis. In fertile soils, the spacing should be somewhat narrowed, and in infertile soils, the spacing should be extended, so that there is no competition for nutrients in the area around the roots with other plants, which can

affect optimum plant growth and yields. The application of biological organic fertilizers can create better soil texture and structure conditions, and support the formation of crumb structures and the stability of soil aggregates. Steady soil aggregates will provide good aeration so that sufficient oxygen is available for plant respiration, besides that it can increase the soil's ability to store water. Quansah (2010) states that the provision of organic matter can increase the quality and quantity of crop production. Fertilization of biological organic fertilizers can increase yields quantitatively and qualitatively. Lingga and Marsono (2007) stated that fertilizer is the key to soil fertility because it contains one or more elements to replace elements that have been absorbed by plants. Availability of nutrients which are essential elements needed by plants, because if one of the elements is not present, the metabolic process and plant growth will be disrupted and even result in death. Sufficient nutrient content in the soil will lead to good vegetative growth of corn plants (Retno and Darminanti, 2009). Corn plants give maximum yields when there are sufficient nutrients available for the plant because the vegetative phase also requires nutrients, no different from the generative phase. Plant yields will be optimal if the conditions are met, such as the availability of sufficient nutrients and appropriate environmental factors.

In other treatments, the results were low because, at the beginning of growth, the fertilizer had not been completely absorbed, so the results were not visible. The biological organic fertilizers that are given can make solid soil aggregates which will provide good aeration so that sufficient oxygen is available for plant respiration, besides that it can increase the soil's ability to store water. Physically it can improve soil structure to make it more friable making it easier for sweet corn plants to absorb nutrients, chemically this biological organic fertilizer can contribute nutrients and biologically can activate microorganisms in the soil in decomposing organic fertilizers.

Microorganisms present in biological organic fertilizers produce active compounds that play a role in decomposing organic matter, to accelerate the solubility of available nutrients in the soil. Plants that were given biological fertilizers gave a positive linear response with an increase in the dose given, this was suspected to be a phosphate solubilizing microorganism *Streptomyces* sp. contained in biological fertilizers help the availability of P. The element Phosphorus (P) is an essential macronutrient but slow release in the soil, with the application of biological fertilizers, so that the phosphate solubilizing microorganisms will break down the unavailable (potential) phosphate into available phosphate for plants where phosphate functions in seed formation. Agung and Rahayu (2004) stated that biological fertilizers have been able to increase the efficiency of nutrient uptake, improve growth and yield, and increase resistance to pests and diseases. Generally used microbes that can live together (symbiosis) with the host plant. Benefits are obtained by both parties, the host plant

gets the additional nutrients needed, while the microbe gets organic matter for its activity and growth.

Conclusions

Based on the results of this study it can be concluded as follows:

1. Treatment of 300 kg/ha biological organic fertilizer can give the best effect on the growth and yield of sweet corn (*Zea mays saccharata* Sturt).
2. Treatment spacing of 60 cm x 30 cm can give the best effect on the growth and yield of sweet corn (*Zea mays saccharata* Sturt).
3. Interaction treatment between biological organic fertilizers with a dose of 300 kg/ha and a spacing of 60 cm x 30 cm will have the best effect on the growth and yield of sweet corn (*Zea mays saccharata* Sturt).

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