Original Research Article

Response of Growth and Yield of Sweet Corn Plants(*Zea mays*saccharataSturt) in Rainfed Land to Plant Growth Promoting Rhizobacteria (PGPR) Bamboo Roots

ABSTRACT

Sweet Corn is one of the important food crops because it serves as a source of food, feed, and industrial raw materials. Demand for corn (Zea mays) continues to increase from year to year as a result of the high rate of world population growth which reaches 1.4% per year. Efforts to increase corn production require input technology on plants to obtain optimal and environmentally friendly results by providing Plant Growth growth-promoting rhizobacteria (PGPR) that play a role in increasing soil fertility and increasing crop yields. This research aims to determine the response of growth and yield of sweet corn plants on rainfed land to the application of PGPR bamboo root crop and to determine the appropriate PGPR concentration for the growth and yield of sweet corn plants. This research was carried out from February to June 2020 in RantauPanjang, Sambaliung District, Berau Regency. East Kalimantan, Indonesia. The research used a Randomized Completely Block Design consisting of 6 treatments of bamboo root PGPR concentration, namely treatment: p0 = control; p1 = 5.0 ml l^{-1} water; p2 = 7.5 ml l^{-1} water; p3 = 10.0 ml l^{-1} water; p4 = 12.5 ml l^{-1} water; and p5 = 15.0 ml l^{-1} water. Each treatment was repeated 4 times. Data analysis used variance analysis and Duncan's Multiple Range Test at a 5% level. The results of the research showed that: (1) The responses of ear diameter and ear production were significantly different, while the responses of plant height, number of leaves, age at flowering, ear length, and number of rows of seeds per ear were not significantly different to PGPR application; and (2) giving PGPR with a concentration of 10 ml l^{-1} water (p3) resulted in high cob production, namely 12.80 Mg ha^{-1}.

Keywords: PGPR Bamboo Roots, Sweet Corn, Rainfed Land

INTRODUCTION

Corn (Zea mays) is an important food crop because it functions as a source of food, feed, and industrial raw materials. This commodity has a strategic role in the national economy and society which is competitive in the quality of production results.

The demand for corn continues to increase from year to year as a result of the high rate of world population growth which reaches 1.4% per year. Progress in the food processing industry and the increasing need for raw materials for animal feed, especially poultry, from corn, have also contributed to the increase in national and world consumption of corn. Currently, national corn production is not sufficient for needs, so Indonesia is still importing with a volume of up to 1 million tons per year [1].

East Kalimantan is one of the provinces in Indonesia with a relatively high level of diversity of flora, especially rice and secondary crops, including corn. The Regional Government of Berau Regency has implemented a policy of increasing corn production since 2000.

The rate of productivity of corn commodities in East Kalimantan tends to decline, low corn productivity is mainly caused by: seeds labeled free, fertilization and amelioration not following recommendations, attacks by plant pests, and land management, planting and harvesting not being implemented properly. Rainfed land is a resource that can be managed for the development of sweet corn because most of it has not been utilized optimally [2].

In this modern era, people are aware of the negative impact of the continuous use of chemical fertilizers on the environment. However, in Indonesia, farmers still apply a lot of inorganic fertilizer, excessive and continuous use of inorganic fertilizer has a negative impact, namely it can cause land productivity to decrease [3]. To reduce the use of inorganic fertilizers, you can use organic fertilizers.

Efforts to increase land productivity for cultivating sweet corn require the use of organic fertilizer and plant input technology to obtain optimal and environmentally friendly results. One way is by providing Plant Growth growth-promoting rhizobacteria (PGPR). which plays a role in increasing plant resistance from pathogen attacks, increasing soil fertility, and increasing plant yields.

Plant Growth Promoting Rhizobacteria (PGPR) are bacteria that colonize with roots. Can increase plant growth and development thanks to its ability to produce growth regulators (PGR) and biocatalysts to support the availability of NPK and other important organic acids for plants. PGPR as an environmental conservation agent, maintains root microbial biodiversity to support environmentally friendly agriculture which can increase agricultural yields. This is very important to support sustainable national food security as planned by the government [4]. PGPR is a group of bacteria that are beneficial to plants play an important role in increasing root development and have an impact on plant growth, crop yields, and land fertility [5].

This research aims to determine the response of growth and yield of sweet corn plants on rainfed land to the application of PGPR bamboo root crop and to determine the appropriate PGPR concentration for the growth and yield of sweet corn plants.

RESEARCH METHODS

1. Time and Place

This research was carried out from February to June 2020 in RantauPanjang, Sambaliung District, Berau Regency. East Kalimantan, Indonesia.

2. Materials and Tools

Ingredients: sweet corn seeds, bamboo roots, bran, shrimp paste, sugar, lime, clean water, compost; and tools: hoe, machete, stake, jerry can/bucket, water sprinkler container,fermentation container, meter, measuring cup, stationery, label paper, camera, ruler and raffia rope.

3. Experimental Design

The research used a randomized block design (RAK) consisting of 6 treatments of bamboo root PGPR concentration, namely as a treatment: p0 = control; p1 = 5.0 ml l^{-1} water; p2 = 7.5 ml l^{-1} water; p3 = 10.0 ml l^{-1} water; p4 = 12.5 ml l^{-1} water; and p5 = 15.0 ml l^{-1} water. Each treatment was repeated 4 times.

4. Research Procedures

a. PGPR creation

Soak the bamboo roots in cold boiled/clean water for three nights, strain, and take the water as a source of PGPR. Once the starter is ready, mix all the ingredients except the starter, then bring to a boil. Once cool, filter, discard the dregs, place in a jerry can/bucket then mix 1 liter of PGPR starter, and cover tightly. Then leave it for one to two weeks using a simple fermenter made from a jerry can and an air hose.

A fermenter is a piece of equipment or system that is capable of providing a biological system that can support biochemical reactions from raw materials to the desired materials. Ready to use solution.

b. Preparation and application of PGPR solution

The preparation of PGPR concentration for bamboo root crops consists of 6 concentrations, namely without administering PGPR or control, 5, 7.5, 10, 12.5, and 15 ml l^{-1} water. Application of PGPR bamboo root crop is done by soaking the seeds for approximately 15 minutes, giving to the land 3 days before planting, and watering evenly over the plants at 7, 14, 21, and 28 days after planting. Watering the PGPR solution is done using a water sprinkler containerby watering around the plant root area.

c. Land preparation

The land is cleared of weeds, then the land is cultivated and loosened using a hoe. A plot is made according to the required size, 1.5m x 1.5m.

d. Seed preparation

The seeds are soaked in the bamboo root PGPR solution for 3 hours, then drained and the seeds are ready to be planted.

e. Seed planting

Seeds are planted individually, 2 per planting hole, then covered again with soil.

f. Sample labeling

Before treatment was given, treatment labels were given to each research plot.

g. Maintenance includes watering, replanting, and controlling weeds, pests, and diseases.

h. Harvest

Harvesting is done when the sweet corn hairs have started to dry and turn brown.

5. Parameters

Data collected were: plant height aged 4, 8, and 11 weeks after planting, number of leaves aged 4, 8, and 11 weeks after planting, age of the plant at flowering, ear length, ear diameter, number of rows of seeds in the ear, and ear yield.

6. Data Analysis

Data analysis used variance and continued with Duncan's multiple range test at the 5% level.

Comment [DAL1]: Where did you inspire? In the literature? Please indicate an author!

RESULTS AND DISCUSSION

A. Plant Height and Number of Leaves

The results of variance analysis showed that the response of plant height and number of leaves at 4, 8, and 11 weeks after planting was not significantly different from the administration of various concentrations of PGPR. The results of research on plant height and number of leaves are presented in Table 1.

Table 1. Plant Height and Number of Sweet Corn Leaves in Various PGPR Solution Concentration Treatments

Treatment	Plant Height (cm)			Number of Leaves(sheet)		
	4 WAP	8 WAP	11 WAP	4 WAP	8 WAP	11 WAP
Control (p0)	28,54	96,00	156,00	6,13	7,38	7,88
5,0 ml l^{-1}water (p1)	33,50	113,31	166,28	6,50	8,50	8,50
7,5 ml l^{-1}water (p2)	30,44	103,00	160,50	6,00	7,625	8,25
10,0 ml l^{-1}water (p3)	28,81	97,79	161,06	6,38	7,75	8,25
12,5 ml l^{-1}water (p4)	23,56	82,19	142,56	5,50	6,88	7,75
15,0 ml l^{-1}water (p5)	26,19	94,25	148,20	5,25	7,75	7,75

Note : WAP = Week After Planting

Based on Table 1 above, it shows that the response to growth in plant height and number of sweet corn leaves at 4, 8, and 11 weeks after planting was not significantly different from PGPR administration. According to [6]; and [7] increased plant growth by PGPR can occur through one or more mechanisms related to its functional characteristics and rhizosphere environmental conditions.

Based on research data, shows that giving increasing concentrations of PGPR to bamboo roots tends to inhibit the growth of plant height and number of leaves, especially at concentrations > 7.5 ml l^{-1} water. The best growth in plant height and number of leaves was produced in the treatment of 5.0 ml l^{-1} water (p1). This is because the p1 treatment has the availability of organic fertilizer as a supplier of nutrients originating from the treatment of providing homogeneous fertilizer and the availability of biological fertilizer as a supplier of sufficient microorganisms so that the two support each other. As stated by [8] PGPR is a bacteria that colonizes with roots and can provide benefits to support immunity, growth, and development of plants thanks to its ability to produce growth regulators (ZPT), biocatalysts to support the availability of NPK and acid-other important organic acids for plants. As an environmental conservation agent, maintaining root microbial biodiversity to support environmentally friendly agriculture can increase agricultural yields. This is very important to support sustainable national food security as planned by the government. Then it was stated by [9] that PGPR treatment on plants will provide healthier, longer, and more root growth than without PGPR treatment. Healthy roots cause more absorption of nutrients needed by plants. So plant growth is also better. Besides that, roots colonized by PGPR bacteria are generally more resistant to plant pathogen infections caused by the ability of Pseudomonas sp bacteria. PGPR produces siderophores and antibiotics to prevent the development of plant pathogens. [10] states that the principle of giving PGPR is to increase the number of active bacteria around plant roots so that it provides benefits for plants. The advantages of using PGPR are increasing mineral and nitrogen levels, providing plant tolerance to environmental stress, and as a biofertilizer, and biological agent. control, and protect plants from plant pathogens.

B. Flowering Age and Yield of Cob

The results of variance analysis showed that the responses of ear diameter and ear yield were significantly different, while the responses of age at flowering, ear length, and number of seed rows in the ear were not significantly different to the administration of various concentrations of PGPR. The results of research on flowering age, cob components, and sweet corn cob yield are presented in Table 2.

Table 2. Plant Height and Number of Sweet Corn Leaves in Various PGPR Solution Concentration Treatments

Perlakuan	Flowering Age (DAP)	Cob Lenght (cm)	Cob Diameter* (cm)	Number of Rows of Seeds	Cob Production* (Mg ha^{-1})
Control (p0)	50,00	17,25	15,34 b	13,13	10,53 c
5,0 ml l^{-1}water (p1)	50,00	19,25	16,04 b	13,75	10,90 c
7,5 ml l^{-1}water (p2)	49,25	18,98	15,63 b	13,38	10,58 c
10,0 ml l^{-1}water (p3)	50,00	18,31	15,31 b	14,00	12,80 c
12,5 ml l^{-1}water (p4)	50,00	13,93	13,56 a	13,00	4,30 a
15,0 ml l^{-1}water (p5)	50,00	16,01	15,13 b	13,50	7,58 b

Note: The average number followed by the same lowercase letter is not significantly different based on the DMRT results at the 5% level; * = test results are significantly different; and HST = week after planting.

The parameters of plant age at flowering showed no significant differencein response to PGPR administration. The research results in Table 2 show that plant age at flowering ranged from 49.25 to 50.00 days after planting. This is because the age of a plant when it flowers is influenced by environmental factors (external factors) and the genetic factors of the plant itself (internal factors). The results of this research are not different from the description of sweet corn varieties, namely the age at flowering is between 50 - 54 days after planting. As stated by [11] the transition from the vegetative period to the generative period (marked by the appearance of flowers) is partly determined by the genotype or internal factors and partly determined by external factors such as temperature, light, water, and nutrients. and others.

The parameters of ear length and number of rows of seeds per ear gave a non-significantly different response, while diameter gave a real response to PGPR treatment. The research results presented in Table 2 show that in general PGPR with a concentration of between 5.0 - 10.0 ml l^{-1} water produces better cob components compared to other treatments. Giving PGPR with a concentration of 5 ml l^{-1} water (p1) for the longest cob (19.25 cm) and the largest diameter (16.04 cm), while the shortest cob (13.93 cm), the smallest cob diameter (13.56 cm) and the smallest number of rows of seeds per cob (13.00 rows) were produced in the treatment of 12.50 ml l^{-1} water (p4). This is explained by [12] that the function of PGPR in increasing plant growth is: (1) as a growth promoter/stimulant (biostimulant) by synthesizing and regulating various growth regulatory substances (phytohormones) such as indolic acetic acid (AIA), gibberellins and cytokinins in the root environment, (2) as a nutrient provider by fixing N2 from the air symbiotically and dissolving P nutrients bound in the soil and as a nutrient provider, fixing N2 and growth stimulant which is an inseparable whole.

In terms of cob production parameters, the results of the study showed that administration of PGPR with a concentration of between 5.0 – 10.0 ml l^{-1} of water resulted in cob production of between 10.58 – 12.80 Mg ha^{-1} which was higher compared to the control and treatment concentrations. other. The highest cob production was produced in the 10.0 ml l^{-1} water (p3) treatment, namely 12.80 Mg ha^{-1}, but this result was not significantly different compared to cob production in the 5 ml l^{-1} water (p1) and 7,50 ml l^{-1} water (p2) treatments are respectively 10.90 Mg ha^{-1} and 10.58 Mg ha^{-1}. The results of this study are in line with the results of the research reported by [13] that the administration of PGPR with a concentration of 10 and 20 ml l^{-1} water combined with the application of manure resulted in better cob length, cob diameter, and cob production compared to treatment without PGPR. The results of another study reported by [14] showed that the yield of sweet corn cobs increased with increasing PGPR concentration given 10 - 30 ml l^{-1} of water, namely between 20.0067 - 21.0733 Mg ha^{-1}, while the treatment without PGPR is only 17.6333 Mg ha-1. This situation is explained by [15] that PGPR are bacteria around the roots and live in colonies covering the roots which function to increase plant growth, namely as stimulating growth (biostimulants) by synthesizing and regulating the concentration of various growth regulators. such as gibberellins, indole acetic acid, ethylene, and cytokinins, as nutrient providers by binding N_2 in the air symbiotically and playing a role in increasing cob yields, and as control of soil pathogens (bioprotectants) by producing various anti-pathogenic metabolites such as siderophore, chitinase, β1,3-glucanase, cyanide, and antibiotics. Furthermore, it was stated by [16] that the use of PGPR can be beneficial for soil fertility because the bacteria contained in PGPR can activate microorganisms in the soil which causes organic matter to decompose due to the activity of decomposing microorganisms. Bacteria decompose organic materials that are difficult for plants to absorb into inorganic materials that are easily absorbed by plants. The presence of these microorganisms will affect the level of soil fertility because microorganisms play an important role in the weathering process of organic material so that nutrients are available to plants.

The research results also showed that administering PGPR with a concentration of > 10 ml l^{-1} water tended to reduce the yield of sweet corn plants (length and diameter of cobs, number of rows of seeds per cob, and cob production). This is because if the concentration given exceeds the maximum capacity it will hurt the plants, and vice versa if the concentration given is insufficient it can hurt plant growth and yield.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Based on the results of the research and discussion, it can be concluded as follows:

1. The responses of ear diameter and ear production were significantly different, while the responses of plant height, number of leaves, age at flowering, ear length, and number of seed rows per ear were not significantly different to PGPR administration.
2. Giving PGPR with a concentration of 10 ml l^{-1} water (p3) resulted in high cob production, namely 12.80 Mg ha^{-1}.

B. Suggestions

It is recommended to use a concentration of PGPR bamboo roots with a concentration of 10 ml l^{-1} water.

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