Application of biological fertilizers on growth and yield of sweet corn (*Zea mays saccharata* Sturt) in dry land

A Sabur¹, L Pramudyani¹, M Yasin¹ and J Purnomo²

¹Assessment Institute for Agricultural Technology, South Kalimantan, 70711, Indonesia
²Lambung Mangkurat University, South Kalimantan, 70123, Indonesia

E-mail: lelyahya@yahoo.co.id

Abstract. Sweet corn (*Zea mays saccharata* Sturt.) is such a popular commodity that it has good market opportunities. Increasing productivity of sweet corn, necessary through improving its physical, chemical, and fertility properties. Continuous use of inorganic fertilizers can reduce soil fertility. Biofertilizer is an alternative to improve and enhance soil quality to increase growth and increase plant’s yield and quality significantly. The study aimed to determine the effect of biofertilizers' application on the growth and yield of sweet corn on the upland. The research was conducted in 2016 in Tapin district, South Kalimantan Province. It is using a randomized block design with four treatments and eight replications. The treatments consisted of Po without biofertilizer + NPK fertilizer at a dose of 100%, P1 biofertilizer + NPK fertilizer at a dose of 100%, P2 biofertilizer + NPK fertilizer at a dose of 75%, P3, biofertilizer + NPK fertilizer at a dose of 50 %. The variables observed were plant height, cob weight with husk, cob weight without husk, cob diameter, cob length, number of seed columns, and production. The results showed that applying biofertilizer increase cob weight and sweet corn production.

1. Introduction

Sweet corn is a commodity that can be cultivated intensively because it is so popular that it opens up good market opportunities [1]. Market demand for sweet corn continues to increase with the emerging number of supermarkets and the purchasing power of the community [2]. The high demand for sweet corn has spurred farmers to increase sweet corn production [3]. The increasing market demand and high sweet corn prices can stimulate farmers to develop sweet corn farming [4]. Sweet corn is also a food that can replace staple food [5]. Besides being used as food, sweet corn is also used as raw material for the corn sugar industry [6, 7].

Efforts to increase sweet corn production by expanding the crop area decrease because it is used for crop cultivation. Sweet corn is very suitable to grow in Indonesia because the conditions for growing sweet corn are in accordance with the characteristics of Indonesia’s climatic and soil conditions [8]. Increasing production is a major concern [9]. Microbes (biofertilizer) is also an alternative that can improve the production of sweet corn in an environmentally sustainable way. The application of biological fertilizer (biofertilizer) has ecological and economic advantages. Because biological fertilizers contain active soil microbes that can help in certain nutrient fixation and facilitate nutrient availability in the soil for plants [10]. Likewise, [11] also said that the biological fertilizer is isolated microbes given into the ground to increase the availability of nutrients for plants. Depletion of soil nutrients by plants is usually compensated by supplying inorganic fertilizers. The dosage is expected
to increase from year to year due to the low-efficiency level of the inorganic fertilizer [12]. The research objective was to determine the effect of biological fertilizers on the growth and yield of sweet corn on acidic, dry land.

2. Methods

Research of biological fertilizers for sweet corn crops was conducted in farmer groups “Mekar Bersama” in Sabah village, Bungur District, Tapin Regency, South Kalimantan. The farmer group leader is Mr. Jahidi. The altitude is between 25 - 100 meters above sea level [13]. The corn is planted in an area of 1 ha. The assessment was conducted using a randomized block design with four treatments and eight replications (see table 1).

| Code | Treatment |
|------|-----------|
| P0   | manure application without biofertilizer + NPK fertilizer at a dose of 100 % x 1,000 kg ha⁻¹ |
| P1   | manure application with biofertilizer + NPK fertilizer at a dose of 100 % x 1,000 kg ha⁻¹ |
| P2   | manure application with biofertilizer + NPK fertilizer at a dose of 75 % x 1,000 kg ha⁻¹ |
| P3   | manure application with biofertilizer + NPK fertilizer at a dose of 50 %, x 1,000 kg ha⁻¹ |

The biological fertilizers contain several microbes, such as Azotobacter sp, Azospirillium sp, Bacillus sp, and Trichoderma sp. Azotobacter sp and Azospirillium sp have a non-symbiotic nitrogen-fixing function that produces phytohormones. Bacillus sp has a role as a solvent for soil Phosphorus. Trichoderma sp has a role as a decomposer of organic matter and protects plants from soil-borne pathogens.

The observed variables are (1) plant height (cm), (2) cobs weight, (3) weight of peeled cobs, (4) length of cobs, (5) diameter of peeled cobs and (6) production. Soil samples were taken from the area in a diagonal composite on land given lime and then analyzed at the Soil Laboratory of the Swamp Agricultural Research Institute. The results are shown in table 2.

| Description               | Code | Value  | Criteria         |
|---------------------------|------|--------|------------------|
| pH H₂O                    | -    | 5.55   | acid moderate    |
| C organic                 | %    | 0.52   | very low         |
| N                         | %    | 0.107  | low              |
| C/N                       | %    | 4.87   | very low         |
| K exchangable             | cmol(+).kg⁻¹ | 0.249 | medium           |
| Na exchangable            | cmol(+).kg⁻¹ | 0.288 | low              |
| Ca exchangable            | cmol(+).kg⁻¹ | 2.985 | low              |
| Mg exchangable            | cmol(+).kg⁻¹ | 1.294 | medium           |
| Cation exchange capacity  | cmol(+).kg⁻¹ | 9.73  | low              |
| P Bray 1                  | ppm P | 65.906 | Very high        |
| Fe                        | ppm  | 6.232  |                  |

Texture :

- Sand : % 60.31 Sandy clay loam
- Silt : % 19.13
- Clay : % 20.56

The type of soil in Sabah village is sandy clay loam with a pH level of about 5.5 (acidic soil) with very low organic matter content (table 2). The source of water is rainwater. Application of dolomite as much as 2 tons/ha at two weeks before planting by distributing it evenly over the entire planting area. Meanwhile, the manure application was carried out after the dolomite application considering that
there were different treatments, in which some part of the land was given manure which had been fermented with biological fertilizers, and some other parts were given manure without biological fertilizers. The chicken manure is used in this research. After that, the TSP fertilizer was applied at a dosage of 200 kg/ha.

3. Results and discussion

3.1. Results
The results showed that the biological fertilizers application had a significant effect on the weight of the unpeeled cobs (with the husks); weights of peeled cobs (without husks); cobs length, and cobs diameter, but had no significant effect on plant height at harvest, the number of seed columns and total yield (table 3 and table 4).

Table 3. Average plant height (cm), the weight of unpeeled cobs (with husks) (g), and the weight of cobs without husks (g).

| Treatment                     | plant height (cm) | Cob weight (g) |          |          |
|-------------------------------|-------------------|----------------|----------|----------|
|                               |                   | With husks     | Without husks |
| With biological fertilizer    | 173 a             | 476.58 b       | 320.75 b |
| 100 (P1)                      | 174 a             | 471.33 b       | 345.25 b |
| 75 (P2)                       | 174 a             | 472.25 b       | 348.25 b |
| 50 (P3)                       | 172 a             | 399.13 a       | 290.00 a |
| Without biological fertilizers|                   |                |          |          |
| (P0)                          | 172 a             |                |          |          |

Note: the numbers followed by the same letter in the same column are not significantly different based on the 5% DMRT test.

The crops with biological fertilizer have the unpeeled cob (with husks) that are heavier than the weight of the unpeeled cob of the crop without applying biological fertilizer. In comparison, the difference in the dose of NPK fertilizer on crops with biofertilizer application produces the unpeeled cob that was not significantly different. Likewise, crops that are given biological fertilizers have a heavier weight of peeled cobs than the weight of peeled cobs of crops grown without biological fertilizers. The different dosages of NPK fertilizer on the crops given biological fertilizers resulted in no significant difference in the weight of peeled corn cobs (table 4).

Table 4. Data on the average length of peeled cobs (cm), a diameter of peeled cobs (cm), number of seed columns, and total yield (tons/ha) of Bonanza corn varieties.

| Dosage of NPK | Peeled cob length | Peeled cob diameter | Number of seed columns | Result |
|---------------|-------------------|---------------------|------------------------|--------|
|               |                   |                     |                        |        |
| With biofertilizer |         |                     |                        |        |
| 100 (P1)      | 21.78 b           | 4.86 b              | 16 a                   | 9.43 a |
| 75 (P2)       | 21.79 b           | 4.85 b              | 16 a                   | 9.52 a |
| 50 (P3)       | 22.14 b           | 4.98 b              | 17 a                   | 10.00 a|
| Without biofertilizer | 20.44 a | 4.48 a              | 17 a                   | 8.08 a |

Note: the numbers followed by the same letter in the same column are not significantly different based on the 5% DMRT test.

From table 4, it can be seen that the sweet corn plants treated with biological fertilizers produced peeled cobs that were longer than the peeled cobs of sweet corn plants that were grown without biological fertilizers. Likewise, the peeled cobs of sweet corn plants with biological fertilizer are larger than the diameter of the peeled cobs of sweet corn plants without biological fertilizer. However, the NPK dosage difference did not significantly affect both the peeled cobs length and the peeled cobs
diameter in sweet corn plants that were given biological fertilizers. The results in Table 4 indicate that the NPK dose difference did not significantly affect the number of seed columns and the yield of sweet corn plants with biological fertilizer.

3.2. Discussion
Plant growth and development is an important process in the life cycle of species. Growth and development take place continuously throughout the life cycle of a plant [14]. Growth is an addition of cells accompanied by cell enlargement followed by an increase in plant size and weight. Plant growth is strongly influenced by environmental, physiological, and plant genetic factors [15]. The result showed that biological fertilisers have significant effects on both weight of unpeeled cobs and peeled cobs and the length and diameter of the peeled cob. Fertilization is one way to improve soil fertility that can increase the growth and yield of sweet corn [16], [17] states that the amount of nutrients absorbed by plants is highly dependent on applied fertilizers, where the absorbed nutrients will be used for the photosynthesis process that will ultimately affect the growth and the total yield. The use of biological fertilizers helps plants obtain nutrients because biological fertilizers contain microorganisms that decompose organic matter. The soil becomes porous, able to hold more water, and plant roots can have optimal development. Biological fertilizers also play a role in stimulating plant roots' development as they can produce plant-growth-regulator substances [18]. Biofertilizer is a fertilizer made from microbes that can provide nutrients for plants, for example, the need for N, P, Mg, Zn, and Cu [19]. [20] also said that the beneficial microorganisms that live in the soil are very important in plant growth as the accelerator of soil nutrient availability and soil organic matter. The beneficial microorganisms also contribute to the decomposition of plant debris into elements that can be used for plant growth. With the optimum supply of nutrients, the assimilates produced by photosynthesis are also optimised to be used by plants for the growth of cells and organs of plants, such as the weight of the cobs, and the length of the cobs. The corn husk is a modification of the leaf organ of the sweet corn plant, so it also has the same function as a leaf, which is to carry out photosynthesis. The corn husk has chlorophyll that use the light to break down water molecules in the photosynthesis process, produce photosynthesize that will be stored in plant storage organs such as cobs, and be allocated during the generative process, which is the growth and development of seeds [21]. It is following the study of [22], which states that the cob diameter was significantly affected by nitrogen supply.

The results also show that the biological fertilizer treatment combined with the NPK fertilizer in three different dosages did not significantly affect plant height, the number of seed columns, and yield of sweet corn. It is presumably because the plant height, number of seed columns, and yields of sweet corn were more affected by N's availability in plants. The N element in plants is used to generate amino acids and proteins, used to spur growth in the vegetative phase [23]. Besides, environmental factors, especially light, are also suspected to be the main cause. It is following the research of [24], which states that forming plant assimilates requires sufficient light and water. Lack of light and water can cause a decrease in the formation of assimilates, so that plant growth is inhibited.

On the other, the light intensity was relatively similar on the treatment, did not show a significant effect on the plant height growth. According to [25] that plant growth is highly affected environmental factors such as light and temperature. Both of these factors play an important role in the production and transportation of assimilates so that with the same light intensity, the plant growth is also relatively the same. Plant growth, especially plant height, is strongly affected by phytohormones, namely auxins. The activity and the way auxin works are greatly influenced by light conditions and the earth’s gravity. If the auxin is exposed to sunlight (in the open field), it will be easily damaged. Because the plant stems are exposed to sunlight, the cell elongation will stop. Besides, the other parts that are not exposed to sunlight will continue to lengthen so that the plant bends toward the direction of the sunlight [26]. Interception of sunlight is also affected by the population density were planting at a specific distance aimed for the plant population to get the same portion of the necessary nutrients and sunlight and make the maintenance easier [27]. According to [28], increasing plant density per unit area to a certain extent can increase seed production.
On the other hand, a reduction in plant density per hectare can result in microclimate changes that affect corn growth and total yield. A high-density plant population will affect crop growth and significantly affect the plant's development because of competition in light interception, intake of water and nutrients, and absorption of CO₂ and O₂ [29]. Sweet corn production in the form of cobs will determine the amount of yield obtained from a cultivation process. One of the factors that affect the filling of dry matter into the corn cobs is the plant's vegetative phase [30]. According to [31], plants that do not undergo pruning will produce a low number of seeds per cob. It is because the photosynthate produced during the vegetative phase is not only used for seed development but also for plant organs that are not pruned, so that resulting in competition among organs in the plant body itself. The results of cobs and seed columns on sweet corn cobs in this research did not show any significant difference because of the caterpillar attack on the cobs, so that some plants produced imperfect corn cobs. It affects the number of plants that have cobs and affects the production of corn cobs per hectare.

4. Conclusion
The application of biological fertilizers had a significant effect on unpeeled cobs weight (with husk), peeled cobs weight (without husk), cobs length, and cobs diameter but had no significant effect on plant height at harvest, a number of seed columns, and total yield. It is due to microbes in biological fertilizers that can provide nutrients for plants, making it easier for plants to get nutrients and induce their growth.

Acknowledgments
The authors would like to thanks Mr. Suyamto and Mrs. Juni Pieter for the research grant, thanks to AIAT South Kalimantan for the facility, Achnaf Hawari and Mukhyar for their technical assistance also special thanks to biological fertilizer inventor,

References
[1] Noviarini M, Subadiyasa N N and Dibya I N 2017 Production and quality of sweet corn (Zea mays saccharata Sturt.) due to chemical, organic, mineral fertilization and their combination in inceptisol soil experimental garden faculty of agriculture udayana university E-Journal of Tropical Agroecotechnology 6 (4) p 469 - 480
[2] Hayawanti E, Amir N and Exelen M 2015 Supply of biological fertilizer types and their effects on growth and production of sweet corn (Zea mays saccharata Sturt.) in Tanah Lebak Chlorophyll X (1) p 32-35
[3] Septian N A W, Aini N and Herlina N 2015 The effect of organic fertilizer on growth and yield of sweet corn (Zea mays saccharata) in intercropping with kangkung plants (Ipomaea reptans) Journal of Plant Production 3 (2) p 141 – 148
[4] Hayati N 2006 Growth and yield of sweet corn at various application times of cocoa pod skin waste bokashi and inorganic fertilizer Journal Agroland 13 (3) p 256 - 259
[5] Surtinah 2018 Phenotype correlation and yield of sweet corn (Zea mays saccharata Sturt) in Rumbai Sub-District, Pekanbaru Journal of Agricultural Science 15 (1) p 7-12
[6] Bakhri S2007 Technical Guidelines for Corn Cultivation with the Concept of Integrated Crop Management (Sulawesi Tengah: Research Center for Agricultural Technology Research and Development Agency of the Ministry of Agriculture)
[7] Iriany R N, Sujiprihati S, Syukur M, Koswara J and Yunus M 2011 Evaluation of combining ability and heterosis of five strains of sweet corn (Zea mays var. Saccharata) of crossbred dialal Journal Agron. Indonesia 39 (2)
[8] Kartika T 2018 The Effect of planting distance on growth and production of non-hybrid corn (Zea Mays L) in the land of the integrated agro technology center (IATC) Journal Sainmatika 15 (2)
[9] Hutasoit R I, Chozin M and Setyowati N 2020 Growth and Yield of Eight Genotypes of Organically
[10] Simanungkalit R D M, Suriadi Karta D A, Saraswati R, Setyorini D and Hartatik W 2006 Organic Fertilizer and Biological Fertilizer (Bogor: Center for Research and Development of Agricultural Land Resources)

[11] Nusantara A D, Bertham Y H, Junedi A, Pujiwati H and Hartal 2019 Utilization of microbes to increase growth and yield of soybean in Coastal Soil Journal Indonesian Agricultural Sciences 21 (1) p 37-43

[12] Herman M and Pranowo D 2013 Effect of phosphate solubilizing microbes on growth and phosphorus uptake of cocoa seedlings (Theobroma cacao L.) Bulletin RISTRI 4 (2) p 129-138

[13] BPS Statistics 2019 South Tapin District in Figures (Central Bureau of Statistics of Tapin Regency) p 1-257

[14] Herlina N and Fitriani W 2017 Effect of pruning percentage of leaves and male flower on corn yields (Zea mays L.) Biodjati Journal 2 (2) p 115-125

[15] Anderson J W and Beardall J 1991 Molecular activities of plant cell An Introduction to Plant Biochemistry Oxford ed (Blackwell Scientific Publication) 384

[16] Mutaqin Z, Saputra H and Ahyuni D 2019 Growth response and production of sweet corn towards potassium fertilizer and rice husk charcoal Journal of Planta Simbiosia 1 (1) p 39-50

[17] Sudjijo 1996 Dosage of Gandapan Fertilizer on Hydroponics Tomato Plants (Solok: Research Institute)

[18] Laiya R, Bahua I and Nurmi 2013 Growth and production of hybrid corn through the application of biological fertilizers Journal of Hybrid Corn Research 1 (1) p 1-12

[19] Achmadi, Mahdianoor and Istiqomah N 2017 Growth and yield of two sweet corn varieties on provision of biological fertilizer on swamp lands Swamp Science 7 (1) p 493-5

[20] Firmansyah, Liferdi I., Khairiyatun N and Yufdy M P 2015 Growth and yield of shallots by application of organic fertilizers and biological fertilizers on Alluvial Soil Journal Hort. 25 (2) p 133-141

[21] Surtinah 2017 Yield Potential of sweet corn (Zea mays saccharata, Sturt) with the provision of fertilizer technology packages and growth regulators J. BibiT 2 (1) p 37-44

[22] Valikelari F and Asghari R 2014 Maize yield and yield components affected by defoliation rate and applying nitrogen and vermicompost Indian Journal of Foundamental and Applied Life Sciences 4 (4) p 369-403

[23] Novizan 2002 Guidelines for Effective Fertilization (Jakarta: Agromedia Pustaka)

[24] Invendi 2016 Growth and yield of sweet corn (Zea mays Saccharata Sturt.) varieties in peanut intercropping (Arachis Hipogaeae L.) J.of Biological Agrotropics 3 (3)

[25] Fitter A H and Hay R J M 1994 Environmental Physiology of Plants (Yogyakarta: Gajah Mada University Press)

[26] Azra R, Ririn A S and Mariana S 2020 Plant Hormones (Uki Press) p 1-176

[27] Probowati R A, Gurtino B and Sumarni T 2014 Effect of ground cover crops and spacing on weeds and corn yields (Zea mays L.) Journal of Crop Production 2 (8)

[28] Kartika T 2018 Effect of planting distance on growth and production of non-hybrid corn (Zea Mays L) in the land of integrated agro technology center scientific Journal of Mathematics and Natural Sciences 15 (2) p 129-139

[29] Indrayanti L A 2010 Effect of Spacing and Number of Seeds on vegetative growth of young corn Journal of Science Media 2 (2) (Kalimantan Tengah: Faculty of Agriculture PGRI Palangka Raya University)

[30] Surtinah S dan Ledar S 2017 Vegetative growth and sugar content of sweet corn kernels (Zea mays saccharata, Sturt) in Pekanbaru Journal of Agricultural Science 13 (2)

[31] Surtinah 2005 The Relationship between Pruning of the upper organs of corn (Zea mays L.) and urea dosages towards the filling of corn kernel J. of Agricultural Science 1 (2) p 27-35