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Physiological and yield parameters of sweet corn (*Zea mays* L. var. rogusa) in response to biofertilizer application under low elevation condition

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Abstract The effects of different biofertilizers on sweet corn did not show any significant difference in the parameters, days to 50% tasseling and silking, partitioning coefficient, relative chlorophyll content, total dry matter yield, and harvest index (P=>0.05). However, it revealed significant results in ear yield production (P=<0.05). The sweet corn applied with fermented seaweed produced the highest ear yield at 12.60 t ha^{-1}, followed by commercial organic foliar fertilizer at 11.32 t ha^{-1}. Results provided additional information to the farmers and other researchers who want to engage sweet corn production with the supplementation of biofertilizers, it is safe and friendly to the environment. Further studies may be conducted in different locations to compare the results.

Keywords: Maize, Organic, Relative chlorophyll content, Seaweed, Yield

Introduction

The demand for sweet corn is increasing because of its palatable taste, nutritional benefits, and economic values. Aside from corn ears, farmers can earn additional income through its stalks and husks as livestock feeds for 75 – 80 days after planting (DAP). Growing sweet corn must be in the right farm size and time to meet the demand of people in the locality. Ideally, a farm size of 2,000 m^2 in staggered planting is highly advised (Guo *et al*., 2018).

The farmers may encounter some challenges during the production of sweet corn. During the seedling stage, whorl maggot infestation is very prevalent. In low and mid-elevated areas, they are prone to Asiatic corn borer (ACB), earworm, and fall armyworm (FAW) infestation. Some hybrids are susceptible to diseases like stalk rot, banded leaf and sheath blight (BLSB), physoderma, and southern rust. Farmers believed that their losses in growing corn were due to inevitable weather conditions, low soil fertility, and pests and

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diseases (Gerpacio, *et al*., 2004). To increase their productivity, farmers used inorganic fertilizers and chemical pesticides, not knowing on negative impacts on the environment. Consumers’ health is also threatened due to the residues from the continuous application of chemical-based products (Garcia-Reyes *et al*., 2008).

Today, there is a need to find ways to mitigate the utilization of chemical pesticides. The information regarding the usage of organic should be strengthened and widely disseminated. However, factual evidence as proven by science should be gathered and presented to capture farmers' attention. Sweet corn can be produced using organic-based inputs, although most farmers are hesitant to adopt it due to limited evidence. Some farmers also claimed that composting is costly and laborious (Villaver *et al*., 2019). An organic method of production in crops is a very important task that needs to be considered by the politicians and agriculture sectors to address global issues on health and environmental problems. This study focused on the effects of different biofertilizers in terms of physiological and yield parameters of sweet corn. This study would provide additional evidence on the effects of biofertilizers in improving the physiological and yield performance of sweet corn.

Materials and methods

This study was conducted on October 15, 2020 to December 31, 2020 at the crop production area of the Zamboanga del Sur Provincial Government College, Aurora, Zamboanga del Sur, Philippines. The area is located at 7°56’45.86” North latitude, 123º35’15.33” East longitude with an elevation of 260.60 meters above sea level. Based on the report of Villaver (2019), the area was identified as acidic with soil pH of 5.30, 2.13% organic matter, 0.107% nitrogen, 0.47 ppm phosphorus, and 222 ppm potassium. The area was laid out in a Randomized Complete Block Design (RCBD) consisting of four treatments and three replications. Treatments were assigned at random using the Statistical Tools for Agricultural Research (STAR) layout technique. The treatments used are T_1 – commercial organic foliar fertilizer, T_2 – fish amino acid, T3 – fermented plant juice, and T_4 - fermented seaweed. The biofertilizers were produced by the researcher. Chopped fish was combined with molasses at a 1:1 ratio to create a fish amino acid. For fermented plant juice preparation, *Ipomoea aquatica* tops were cut into 1-inch length, combined with molasses in a 1:1 ratio. Additionally, chopped seaweed was mixed with molasses at a 1:1 ratio to create fermented seaweed. The mixtures were put into the bamboo poles and let to ferment for seven days in a dark room. The concoctions were harvested after 7 days of fermentation and then put in a clean container before being used in the field. The field area of 400 m^2 was prepared by plowing and harrowing for two times using an animal-drawn plow for a one-week interval to improve the porosity and aeration. The indigenous microorganism (IMO) 7 at the recommended rate of 15 t ha^{-1} was broadcasted evenly in the field three days before planting. Biofertilizers (commercial organic foliar fertilizer, fish amino acid, fermented plant juice, and fermented seaweed) were applied at 14, 21, 28, 35, and 42 DAP at a dilution rate of 20:1,000 or 20 ml L^{-1}. Each plot was applied with biofertilizers using a one-liter capacity hand sprayer. Furrows were prepared 75 cm apart using the animal-drawn plow. The researcher planted the furrows with sweet corn seeds at the rate of two seeds per hill at a distance of 25 cm between hills then covered them with soil at a depth of one cm. Thinning was done at 15 DAP and leaving only one seedling per hill. The researcher and the laborers did the weeding operations at 10, 25, and 40 DAP. Pests and diseases were monitored closely. Biological control agent like *Trichogramma evanescens* was distributed in the field at 25 and 45 DAP to minimize Asiatic corn borer infestation. Fall armyworms were controlled manually by picking the larvae from the whorl. The corn ears were harvested at 75 DAP. Ears were dehusked and sorted according to sizes-small, medium, and large. Ear yield was computed using the equation (Ngoune Tandzi & Mutengwa, 2019) and (Villaver *et al*., 2020):

$$Ear\ yield\ \left(\frac{t}{ha}\right) = \frac{Plot\ weight\ (kg)}{Plot\ size\ (sq.m.)}\ x\ \frac{10{,}000\ sq.m.}{ha}\ x\ \frac{1\ t}{1{,}000\ kg}$$

The days to 50% tasseling and days to 50% silking were taken. Four plants per plot were subjected to destructive sampling to determine the dry matter production. Sample plants were separated into leaves, stems, and ears taken at 55, 65, and 75 DAP for partitioning coefficient using the formula below (Wang *et al*., 2020):

$$Partitioning\ coefficient = \frac{Dry\ weight\ of\ plant\ organ\ (g)}{Dry\ weight\ of\ whole\ plant\ (g)}$$

Total dry matter yield was also taken. Plant samples were placed in the plastic net for aeration and to avoid fungal infection. Harvest index was based on the dry matter, which was calculated using the formula (Gonzaga, 2018):

$$Harvest\ index = \frac{Economic\ yield\ (kg)}{Biological\ yield\ (kg)}\ x\ 100$$

The plant parts were dried for four days at 80 ℃ in a ventilated oven or until constant weight was achieved. The relative chlorophyll content was recorded as a mean from the ten representative plants per plot using the SPAD chlorophyll meter (SPAD – 502, Minolta, Japan). The measurement was done at 45, 55, and 65 days after planting for each selected individual leaf from 8:00 AM to 3:00 PM. The data were analyzed following variance in RCBD, and post hoc analysis was done using Tukey's test in Minitab 7.

Results

Days to tasseling and silking

The days to tasseling and silking are shown in Table 1. The data showed that the tassel and silk initiation of sweet corn was one day earlier when applied with fermented seaweed compared to other treatments. Statistical analysis did not reveal any significant differences in the effects of biofertilizers on the timing of tasseling and silking formation of sweet corn.

Table 1. Days to 50%tasseling and 50%silking

Treatments	Days to 50% Tasseling	Days to 50% Silking
T1 - COFF	51	53
T2 - FAA	51	53
T3 - FPJ	51	53
T4 - FS	50	52
F-test	ns	ns
c.v. (%)	2.28	1.92

ns- non-significant

Relative chlorophyll content (RCC)

The RCC of sweet corn at 45, 55, and 65 DAP is shown in Table 2. Fermented seaweed was consistent as highest in RCC from 45, 55, and 65 DAP as revealed by 47.36, 46.32, and 45.82, respectively. The relative chlorophyll content is very important in measuring chlorophyll level to determine its efficacy in the production of photosynthates and assimilates. In statistics, the data in RCC did not reveal any significant differences in the different treatments at 45, 55, and 65 DAP.

Partitioning coefficient

The partitioning coefficient of sweet corn at 55, 65, and 75 DAP is presented in Table 3. The data showed a declining pattern in the development of leaves and ears as the plants grow older. On the other hand, the development of ears increases as the plants reach the reproductive stage. The sweet corn applied with fermented seaweed influenced the development of ears more, as revealed by 0.45 compared to the rest of the treatments. In statistics, there is no significant difference in the effects of biofertilizers on the partitioning coefficient of sweet corn at 55, 65, and 75 DAP.

Table 2. Relative chlorophyll content of sweet corn at 45, 55, and 65 DAP in response to biofertilizers

Treatments	**Relative Chlorophyll Content**		
	45 DAP	55 DAP	65 DAP
T1 - COFF	46.27	45.02	43.03
T2 - FAA	46.05	44.02	43.73
T3 - FPJ	45.90	44.59	43.75
T4 - FS	47.36	46.32	45.82
F-test	ns	ns	ns
c.v. (%)	4.66	8.24	8.34

Table 3. Partitioning Coefficient of sweet corn at 75 DAP as influenced by biofertilizers

Treatments	**PC at 55 DAP**			**PC at 65 DAP**			**PC at 75 DAP**		
	Leaf	Stem	Ears	Leaf	Stem	Ears	Leaf	Stem	Ears
T1 - COFF	0.41	0.37	0.21	0.37	0.33	0.29	0.30	0.27	0.43
T2 - FAA	0.43	0.38	0.19	0.36	0.34	0.30	0.30	0.26	0.44
T3 - FPJ	0.43	0.38	0.19	0.37	0.34	0.29	0.30	0.27	0.43
T4 - FS	0.41	0.38	0.21	0.36	0.34	0.29	0.29	0.27	0.45
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	10.30	7.64	17.28	4.69	5.30	5.87	2.72	4.11	4.11

ns- non-significant

Ear yield and total dry matter yield of sweet corn in (t ha^{-1})

The ear yield of sweet corn is shown in Table 4. The data showed that when applied with fermented seaweed, the ear significantly gave the highest weight at 12.60 t ha^{-1} compared to fish amino acid and fermented plant juice. The yield of commercial organic foliar fertilizer is not far from fermented seaweed. Fermented seaweed obtained the highest yield for the total dry matter yield at 10.67 t ha^{-1}.

Table 4. Ear yield and total dry matter yield (TDMY) in response to biofertilizers

Treatments	Ear Yield (t ha-1)	TDMY(t ha-1)
T1 - COFF	11.32ab	10.03
T2 - FAA	11.00b	9.68
T3 - FPJ	11.03b	9.77
T4 - FS	12.60a	10.67
F-test	*	ns
c.v. (%)	11.48	12.15

ns- non-significant; *-significant at 5% level of Tukey's test

Harvest index (HI)

The harvest index of sweet corn is presented in Figure 1. The harvest index increased when applied with fermented seaweed, as revealed by 29.93, and fermented plant juice closely follows it. Statistical analysis did not reveal any significant differences in the harvest index of sweet corn as influenced by biofertilizers.

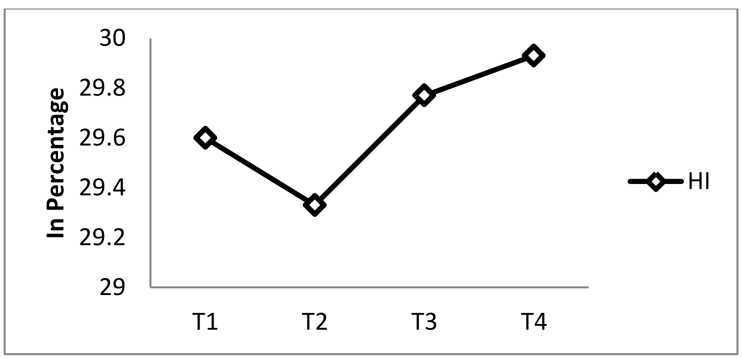

Figure 1. Harvest index of sweet corn in response to different biofertilizers (T_1 – COFF, T_2 – FAA, T_3 – FPJ, T_4 – FS)

Discussion

The experiment was determined the effects of different biofertilizers on sweet corn's different agronomic and physiological parameters. Results revealed that fermented seaweed influenced ear yield. Fermented seaweed was consistent as the highest harvest index, total dry matter yield, and relative chlorophyll content at 45, 55, and 65 DAP. Fermented seaweed also hastened the tassel and silk initiation. Fermented seaweed contains 0.06% Nitrogen, < 0.07% Phosphorus, and 1.27% Potassium (Villlaver, 2019). The yield of corn was significantly affected with biofertilizers due to N, P, K, and additional micronutrients necessary for plant growth and development (Monem *et al*., 2001; Peng *et al*., 2013). Sweet corn responded favorably to applying organic foliar fertilizer because the plants can readily absorb it through their stomatal opening (Bulalin *et al.*, 2015; Llamelo *et al*., 2016). Biofertilizers are very important in improving crop production while reducing other inputs. Butay and Calpatura (2017) proved that the organic fertilizer at 3 tons in supplementation of seaweed improved corn production. An increase in sweet corn yield was due to macro and micronutrients present in the seaweed (Pal *et al*., 2015). Some biofertilizers possessed a high capacity for nitrogen fixation, phosphate, and potassium solubilization and produced auxin hormone that improved corn's yield (Leaungvutiviroj *et al*., 2010). The findings of Ranjan *et al*. (2020) and Rathod *et al*. (2018) mentioned that biofertilizers improved the yield of corn.

The study provided vital information for organic-based sweet corn production. Supplementary application of biofertilizers is very important to meet the nutrient requirements to improve the production and sweetness of sweet corn (Fahrurrozi *et al*., 2020). Among the biofertilizers, fermented seaweed proved the best to improve the fresh ear yield. The other parameters of the total dry matter yield, relative chlorophyll content, and 50% tasseling and silking of sweet corn had not significantly resulted. However, a slight difference was noticed when applied with fermented seaweed. The fermented seaweed as organic foliar fertilizer would be useful at the farmers' level since its ingredients are available in the local market.

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