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Effects of Indigenous Microorganisms (IMO) 7 on the Growth and Yield of Sweet Corn 'Sugar King F1' Variety–Peanut Intercropping System in Aurora, Zamboanga del Sur, Philippines

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Abstract

Indigenous microorganism (IMO) 7 is an organic fertilizer produced from a series of fermentation to make the nutrients more available to plants. This study was conducted to determine the effects of IMO 7 on the growth and yield of sweet corn 'Sugar King F1' variety–peanut intercropping system in Aurora, Zamboanga del Sur, Philippines. The study was laid out using four treatments with four replicates. The data were analyzed using the General Linear Model ANOVA, and treatment differences were determined using Tukey's test or HSD in IBM SPSS version 21. Results showed significant growth and yield increase in sweet corn and peanut with the application of IMO 7. Treatment 4 (15 tons of IMO 7 per ha.) produced the highest plant height in sweet corn and peanut. Ear height was highest, and tassel and silk formation came earlier in sweet corn with Treatment 4. Yield components and projected yield of sweet corn and peanut also increased significantly with Treatment 4. Results suggest that IMO 7 at a total of 30 tons per hectare is suitable for the sweet corn-peanut intercropping system in Aurora, Zamboanga del Sur.

Keywords: ear, fertilizer, height, silk, tassel

Introduction

Farmers always claim failure every time they harvest the crop due to climate change and land degradation (Laube et al., 2012). The common problems encountered by the farmers are low production, high cost of inputs, low soil fertility, leaching, and the occurrence of pests and diseases. Hence, the majority of the farmers are still struggling with poverty. Only a few farmers can adopt the latest technologies which will augment the production and income (Muchena & Hilhorst, 2000; Veisi et al., 2017).

As mentioned by Kashyap et al. (2017) and Carvalho (2006), the use of synthetic fertilizer and hybridization improved the crop production and chemical pesticides control pests and diseases. Poor farmers can also adopt the said technologies with the aid of cooperatives, rural banks, and other institutions offering credit services but the result is a minimal return on investment.

Another problem that needs immediate attention, as stated by Edwards (2013) is the residual effects of synthetic chemicals. Agriculture products with pesticide residues can harm the consumer's health (Damalas & Eleftherohorinos, 2011). Not only human beings but also the useful microorganisms and other beneficial insects will be impaired too (Altieri 2018, 1999). Chemical compounds from pesticides survive in the environment for a more extended period (Girard, 2013). The continuous use of pesticides also aggravates global warming and climate change (Tilman et al., 2001; Richardson et al., 2017).

Ecological balance is essential for crop production (Don et al., 2012). It is vital to feed the soil microorganisms to feed the crops (Treonis et al., 2010). The application of indigenous microorganisms can be the best option for the farmers as an alternative to commercial fertilizers (Kumar & Gopal, 2015) because it converts nutrients into a usable form in a natural way without altering the normal functions of the environment (Connor et al., 2011; Altieri, 2018).

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Higher crop production can also be achieved through good practices and management in farming (Mariano et al., 2012). Intercropping of cereals and legumes is a good practice in agriculture (Lithourgidis et al., 2011; Rusinamhodzi et al., 2012) because it controls weed infestation, minimize the occurrence of insect pests and diseases, and improve the farmer's income as well (Eskandari et al., 2009; Mutegi et al., 2018).

Corn–peanut intercropping system has been proven effective by the studies of Su et al. (2005) and Galera (1999), because of its higher land equivalent ratio (Belel et al., 2014). In the study of Jiao et al. (2008), sweet-corn peanut intercropping system at 2-row maize and 4-row peanut pattern showed higher land equivalent ratio.

Sweet corn is one of the most important vegetables in the world because of its high demand and cash value (Rubatzky & Yamaguchi, 2012). It is propagated from seeds, and it grows well at an optimum temperature range of 21 °C to 32 °C. It thrives in a well-fertilized and well-drained soil (Sharma, 2011). Sweet corn yields can be increased if planted together with peanut. The land equivalent ratio also increased which means that there is a greater advantage of the sweet corn-legume intercropping system compared to monocropping (Crookston & Hill, 1979; Seran & Brintha, 2010; Yong et al., 2017).

Indigenous microorganisms (IMO) are used primarily to improve the soil fertility that is ideal for farming and to prevent plant diseases (Singh et al., 2011; Chaparro et al., 2012). Indigenous microorganisms are applied to the soil to make the nutrients available to the plants as practiced in natural farming (Kumar & Gopal, 2015). In organic agriculture, they nurture the soil, and the soil nurtures the plant through the action of indigenous microorganisms (Mendoza & Villegas, 2015).

In this study, the effects of the different rates of indigenous microorganisms (IMO) 7 on the growth and yield of sweet corn–peanut intercropping system in Aurora, Zamboanga del Sur has been investigated. The results of this study would serve as a guide for farmers in the area who want to engage in the organic production of sweet corn with peanut as intercrop.

Materials and Methods

Time and place of the study

This study was conducted at the crop science experimental area of the Zamboanga del Sur Provincial Government College, Aurora, Zamboanga del Sur from December 21, 2017 to March 2018 covering 73 days for sweet corn (*Zea mays* L.) and 90 days for peanut (*Arachis hypogaea* L.).

Experimental design and treatments

This study was carried out in Randomized Complete Block Design (RCBD) with four treatments and four replicates. The treatments were as follows:

T1	-	Sweet corn	+	peanut	(no fertilization)
T2	-	Sweet corn	+	peanut	(9 tons + 9 tons IMO 7)
T3	-	Sweet corn	+	peanut	(12 tons + 12 tons IMO 7)
T4	-	Sweet corn	+	peanut	(15 tons + 15 tons IMO 7)

Statistical analysis

The General Linear Model ANOVA and Tukey's or HSD test were the statistical tools for multiple comparisons. Statistical analysis is carried out through the IBM SPSS version 21.

Land preparation

The area was prepared by plowing and harrowing the field two times using the animal-drawn plow for two weeks interval to destroy the weeds and to incorporate plant residues. This preparation is also done to minimize the rapid emergence of weeds and obtained fine tilt. A total of 264 square meters were used as the experimental area, excluding the buffer zones.

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Preparation of seeds

Hybrid sweet corn (*Z. mays*) variety "Sugar King F1" and peanut *(A. hypogaea*) seeds were procured from reputable suppliers in Pagadian City, Zamboanga del Sur. The seeds were planted directly to the experimental area.

Furrowing and planting

Furrows were prepared at one meter apart. The seeds of sweet corn were planted at the rate of one seed per hill at a distance of 25 cm between plants. Peanut was planted in between rows of corn at a distance of 30 cm with the rate of one seed per hill.

Preparation of Indigenous Microorganisms (IMO)

The methods adopted from the Nature Farming Technology System (Catholic Relief Services, 2008) were carried out to prepare the IMO. The methods were used as the standard for the formulations of IMO 7 as organic fertilizer.

Preparation of IMO 1

One and a half kg (1½ kg) of rice was cooked for 30 min. and then placed in the basin for one hour to cool it down. After cooling, the rice was placed in a bamboo pole. The cooked rice was not tampered to facilitate the growth of indigenous microorganisms. After putting the rice in the bamboo pole, it was covered with cellophane and then tied with twine. The bamboo with rice was buried in the Indigofera farm for five days. Harvesting of IMO 1 was done five days after burying. A whitish color of molds/spores in the rice was observed during harvest indicating that the fermentation of IMO 1 was successful.

Preparation of IMO 2

One kg (1.0 kg) of IMO 1 was placed in the basin then added with 1.0 kg of molasses. The two ingredients were mixed using the bare hands then placed in the bamboo pole and allowed to ferment for seven days. After seven days, IMO 2 was strained, and the concoction was placed in a clean container.

Preparation of IMO 3

One liter of IMO 2 was mixed in 10.0 l of water and stirred thoroughly. The solution was poured gradually into the rice bran and mixed using a spade. The mixture was covered with a canvass for three days to undergo anaerobic fermentation. After three days, the whitish molds were visible in the rice bran indicating that the process for IMO 3 was successful.

Preparation of IMO 4

A 40 ml of FPJ (Fermented Plant Juice) and 40 ml of FAA (Fish Amino Acid) were mixed into two liters of water. The canvass was removed in the IMO 3, and the solution was sprinkled evenly in the IMO 3 to cool it down. Two sacks or 100 kg of chicken dung were placed and mixed in the IMO 3. After mixing with a spade, the materials were covered with a canvass for one day.

Preparation of IMO 5

A 40 ml FPJ and 40 ml FAA were mixed into 2.0 l of water. The IMO 4 was opened then sprinkled with two-liter solution to cool it down. Two sacks of top soils and IMO 4 were mixed thoroughly with a spade then covered with a canvass for one day.

Preparation of IMO 6

A 40 ml FPJ and 40 ml FAA were mixed into 2.0 l of water. The IMO 5 was sprinkled with the solution to cool it down. The two sacks of CRH (Carbonized Rice Hull) were mixed into the IMO 5 using a spade then covered with a canvass for one day.

Preparation of IMO 7

A 40 ml FPJ and 40 ml FAA were mixed into 2.0 l of water. The canvass in the IMO 6 was removed and the 2.0 l solution of FPJ and FAA was sprinkled evenly on the surface. The two sacks vermicompost were mixed into IMO 6 with a spade and then covered with a canvass for one day. A day after, IMO 7 was applied in the field as organic fertilizer.

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Application of IMO 7

The recommended rates of IMO 7 were applied in the experimental plots three days before planting as the basal application. No side-dressing was done. The rates of IMO 7 per plot for a particular treatment were as follows: Treatment 1 (no fertilization), Treatment 2 (16.9 kg for sweet corn, *Z. mays* and 9.18 kg for peanut, *A. hypogaea*), Treatment 3 (22.5 kg for sweet corn, *Z. mays* and 9.18 kg for peanut, *A. hyogaea*), and Treatment 4 (28.1 kg for sweet corn, *Z. mays* and 9.18 kg for peanut, *A. hypogaea*).

Cultivation and weed control

Cultivation was done 14 and 28 days after planting (DAP) to both corn and peanuts using blunt bolo. Hand weeding was done as the need arises.

Insect pest control

Trichogramma evanescens cards from the Regional Crop Protection Center (RCPC), Molave, Zamboanga del Sur were distributed in experimental plots at 47 DAP to prevent Asiatic corn borer infestation.

Harvesting

Ears of sweet corn were harvested at 73 DAP. The peanuts were harvested at 90 DAP.

Data gathered

A. Agronomic parameters (Sweet corn and peanut)

Plant height

In every plot, ten representative plants were selected and marked at random. Plant height was measured from the ground level to the base of the tassels ten days before harvesting. For the peanut, height was measured from the ground level to the terminal portion of the plant.

Ear height (cm)

The average ear height was measured from the base to the node bearing the first ear using ten sample plants taken at random from the three sample rows per plot.

Days of tasseling

This period was determined by counting the days from the date of emergence up to the time when 50% of the plants in the plot have the tassel.

Days of silking

This period was determined from the date of emergence up to the time when 50% of the plants in the plot have silked (1 cm long).

Yield components and yield

Sweet corn

Number of ears per plot

The component was obtained by counting the number of ears harvested within the plot.

Ear diameter (cm)

This parameter was measured from ten randomly selected ears per plot using the measuring tape.

Total ear weight per plot (kg)

This variable was taken by weighing all the ears harvested in a given plot.

Weight per ear

The average weight was obtained from the weight of the ten randomly selected ears per plot.

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Number of marketable ears

This parameter was taken by counting the number of marketable ears (big and disease-free) harvested per plot.

Projected yield (kg/ha)

This parameter was taken by harvesting and weighing all marketable ears in every plot at the green stage and was expressed in kg/ha using the formula:

$$\text{Yield (ears kg/ha)} = \text{marketable ears/plot (kg)} \times \frac{\text{10,000 sqm}}{\text{sample area}}$$

Ear length (cm)

This parameter was obtained from the same sample used for ear diameter. A foot rule was used to measure the base of the ear up to the space covered by kernels.

Peanut

Yield (kg/ha)

This parameter was taken by harvesting all the pods in a given plot and adjusted to kg/ha using the formula:

$$\text{Pod yield} = \frac{\text{plot yield (kg)}}{\text{1,000g/kg}} \times \frac{\text{10,000m}^2\text{/ha}}{\text{plot size}}$$

Number of pods per plant

This variable was taken by counting the number of pods from ten randomly selected plants per plot at harvest.

Number of seeds per pod

This component was taken by counting the number of seeds from the ten randomly selected pods in the plot at harvest.

Results and Discussion

Sweet corn

Plant height (cm)

Figure 1 presents the mean height of sweet corn as affected by the rates of indigenous microorganisms (IMO) 7. As shown, Treatment 4 (15 tons per hectare) obtained the highest mean followed by Treatments 3, 2, and 1. Treatment 4 differed significantly from Treatment 1. Treatments 2, 3, and 4 did not vary significantly with each other.

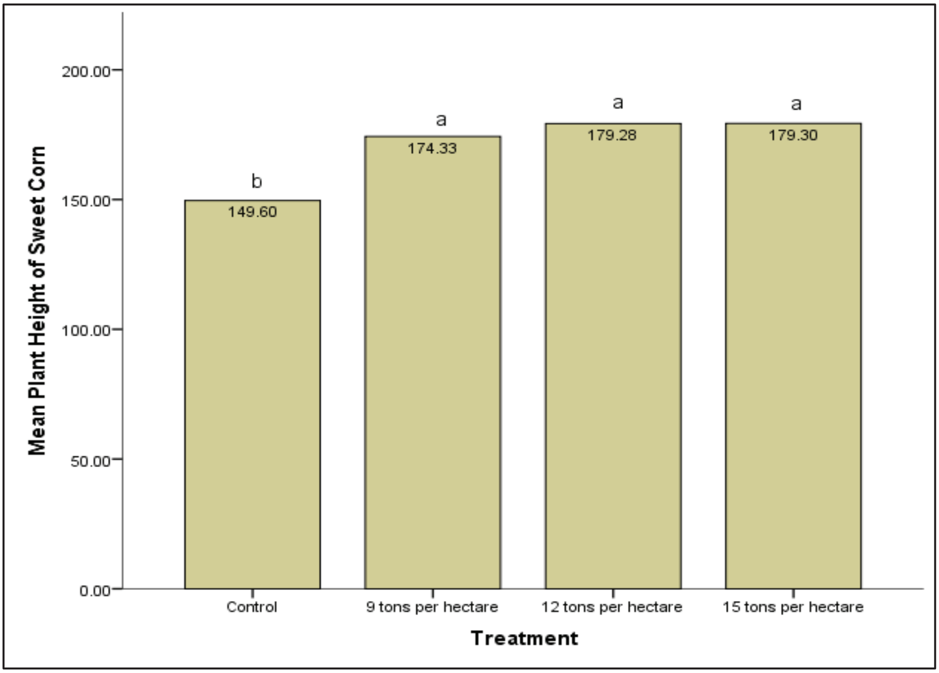

Figure 1. Plant height of sweet corn.

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Ear height (cm)

As reflected in Figure 2, Treatment 4 obtained the highest ear height of sweet corn, followed by Treatments 3, 2, and 1. Statistical analysis revealed significant differences in all treatments. Treatment 4 significantly gave the highest mean of ear height on sweet corn.

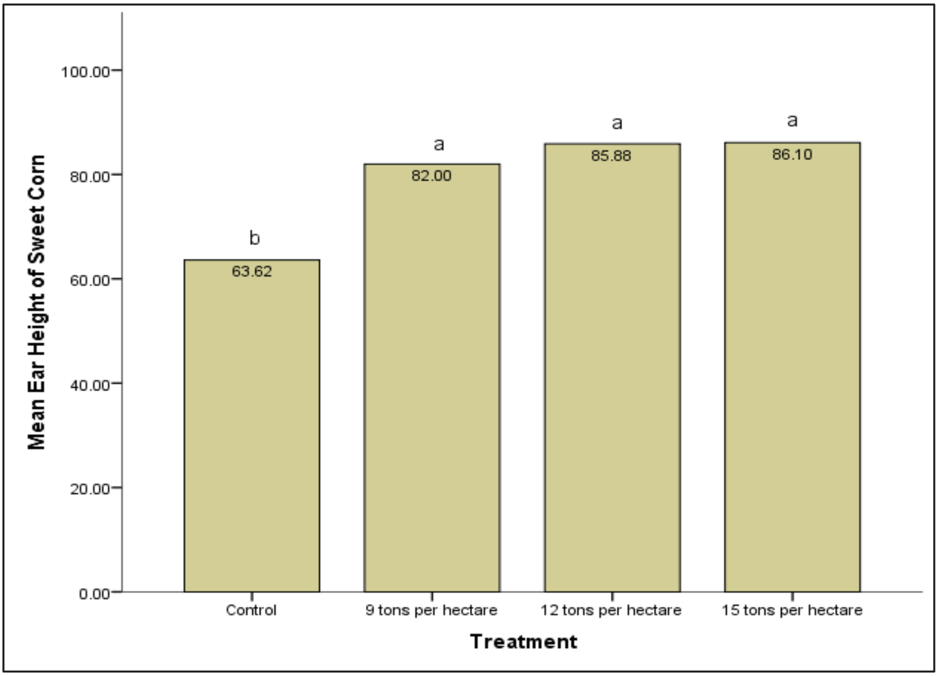

Figure 2. Ear height of sweet corn.

Number of days to tassel formation

In terms of the number of days to tassel formation, T1 had the highest number of days to tassel formation, followed by Treatments 2, 3, and 4 with the same number of days (47) (Table 1). Statistical analysis revealed significant differences (P=0.000) in all treatments and Tukey's test revealed that it was Treatment 1 that significantly differed from the rest of the treatments. The results showed that the rates of indigenous microorganisms affect the early tassel formation compared to the control treatment.

Table 1. Number of days to tasseling.

Treatments	Days to tasseling Sweet Corn
T1 - Control	51.00[a]
T2 – 9 tons/ha + 9 tons/ha	47.00[b]
T3 – 12 tons /ha + 9 tons/ha	47.00[b]
T4 – 15 tons/ha + 9 tons/ha	47.00[b]
P-value	0.00
F-Test	**
cv	4.03

Means within the same column followed by a common letter are not significantly different at 5% level based on Tukey's test or HSD.
* – Significant
** – Highly significant
ns – Not significant

Number of days to silk formation

The number of days to silk formation is presented in Table 2. Treatment 1 had the highest number of days to silk formation, followed by Treatments 3, 2, and 4. Statistical analysis revealed a significant difference (P=0.000) in all treatments. Tukey's test revealed that it was Treatment 1 that differs significantly from the other treatments. The results indicate that the silk formation of sweet corn plants with the IMO 7 was significantly earlier compared to the control treatment.

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Table 2. Number of days to silking.

Treatments	Days to silking Sweet Corn
T1 - Control	5.500[a]
T2 – 9 tons/ha + 9 tons/ha	49.50[b]
T3 – 12 tons /ha + 9 tons/ha	50.00[b]
T4 – 15 tons/ha + 9 tons/ha	49.25[b]
P-Value	0.00
F-Test	**
cv	4.94

Means within the same column followed by a common letter are not significantly different at 5% level based on Tukey's test or HSD.
 * – Significant
** – Highly significant
ns – Not significant

Peanut

Plant height (cm)

Figure 3 presents the mean height of peanut with regard to the rates of indigenous microorganisms (IMO) 7. Treatment 4 obtained the highest mean followed by Treatments 3, 2, and 1. Statistical analysis revealed a significant difference in all treatments. Treatment 4 significantly produced the highest height of peanut compared to all other treatments.

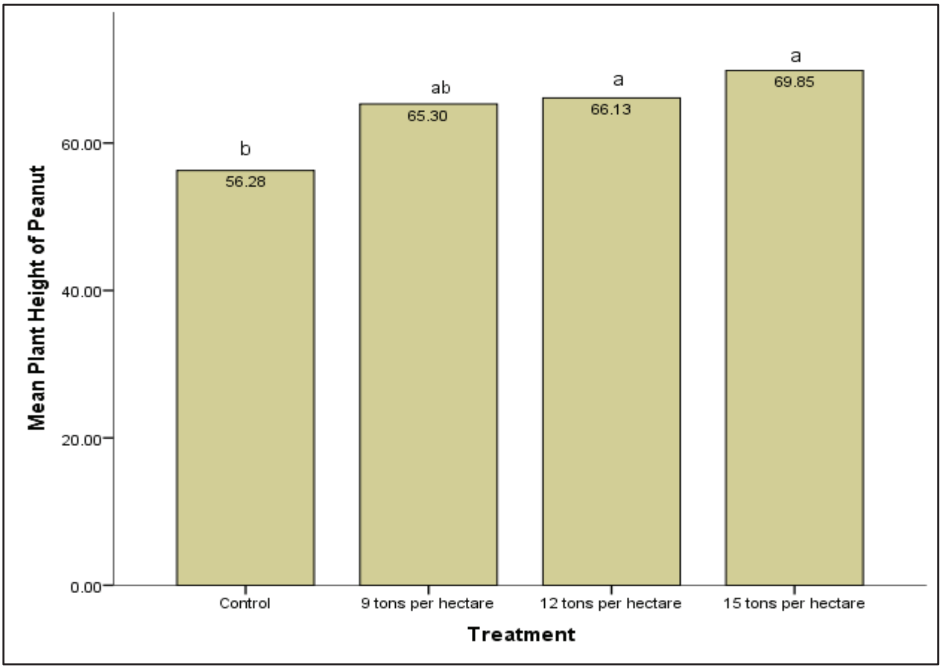

Figure 3. Plant height of peanut

Number of days to flowering

Treatment 4 bore flower earlier with an average of 26.5 days after planting, closely followed by Treatment 4 with 26.75 days, Treatment 2 with 27 days and Treatment 1 with 27.75 days (Table 3). Statistical analysis revealed no significant differences (P=>05) in all treatments. The results revealed that the early flowering formation of peanut was not influenced significantly by the rates of indigenous microorganisms.

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Table 3. Number of days to flowering.

Treatments	Days to flowering Peanut
T1 - Control	27.75
T2 – 9 tons/ha + 9 tons/ha	27.00
T3 – 12 tons /ha + 9 tons/ha	26.50
T4 – 15 tons/ha + 9 tons/ha	26.75
F-Test	ns
cv	3.02

Means within the same column followed by a common letter are not significantly different at 5% level based on Tukey's test or HSD.
* – Significant
** – Highly significant
ns – Not significant

Yield components and projected yield

Sweet corn

Table 4 shows the values of the yield components of sweet corn (*Z. mays*) 'Sugar King 1' variety as influenced by the application of the different rates of IMO 7. Treatment 4 significantly gave the highest values of all yield components. Statistical analysis revealed a significant difference in the average number of ears, and Tukey's test was able to point that Treatment 4 significantly gave the highest average number of ears, followed by Treatments 3, 2, and 1. The result indicates that the sweet corn had developed more number of ears when applied with IMO 7 at the rate of 15 tons per hectare.

Results of the ANOVA tests revealed highly significant differences in all other yield components when applied with different rates of IMO treatment. Further, results of the Tukey's tests showed that Treatment 4 significantly gave the highest number of double ears, total number of kernels per ear, average weight of ears per plot, weight per ear, and weight of marketable ears of sweet corn with 15 tons of IMO per hectare, followed by Treatments 3, 2, and 1.

Table 4. Effects of rates of Indigenous Microorganisms (IMO) 7 on the yield components of sweet corn (*Z. mays*) 'Sugar King 1' variety.

Treatments	Ave. no. of ears	Ave. no. of double ear	Ear diameter (cm)	Total kernel per ear	Ave. weight of ears per plot (kg)	Weight per ear (grams)	Weight of marketable ears (kg)
T1 - Control	43.25^{b}	5.00^{c}	15.95^{b}	542.60^{b}	6.56^{b}	141.68^{b}	3.08^{c}
T2 – 9 tons/ha + 9 tons/ha	48.00^{ab}	7.00^{bc}	17.65^{a}	657.82^{a}	10.20^{a}	216.89^{a}	6.91^{b}
T3 – 12 tons /ha + 9 tons/ha	48.25^{ab}	8.25^{b}	17.71^{a}	671.25^{a}	10.46^{a}	221.07^{a}	8.20^{b}
T4 – 15 tons/ha + 9 tons/ha	55.75^{a}	10.75^{a}	17.98^{a}	702.00^{a}	11.74^{a}	248.93^{a}	9.75^{a}
P-value	0.027	0.000	0.006	0.000	0.000	0.000	0.000
F-Test	*	**	**	**	**	**	**
cv	13.0	31.43	6.09	10.57	23.04	20.99	37.79

Means within the same column followed by a common letter are not significantly different at 5% level based on Tukey's test or HSD.
* – Significant
** – Highly significant
ns – Not significant

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The projected yield of sweet corn is shown in Figure 4. Treatment 4 gave the highest yield in weight, followed by Treatment 3, Treatment 2, and Treatment 1, respectively. Statistical analysis revealed a significant difference in yields with the rate of IMO treatment, and Tukey's test determined that Treatment 4 was significantly the highest regarding yield per hectare. In the study of Meena et al. (2014), indigenous microorganisms contribute to the solubilizing of potassium compounds to make it available in the plants. Nitrogen and phosphorus can be acquired through the presence of the indigenous microorganism in the soil (Richardson et al., 2009). The yield of sweet corn increases as the rate of indigenous microorganisms increases further. As reported by De Ponti et al. (2012), the yield of crops increased when a sufficient amount of nutrients are met. Considering the rate of 15 tons of indigenous microorganisms per hectare, it is the best rate for the soil condition in Aurora, Zamboanga del Sur.

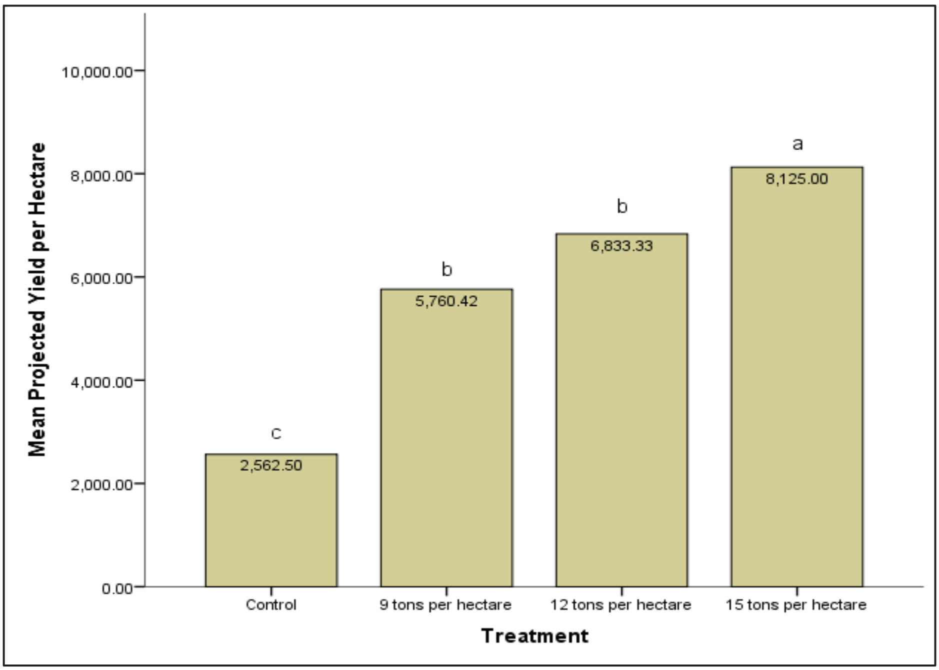

Figure 4. Projected yield of sweet corn.

Peanut

Table 5 shows the values of the yield components of peanut (*A. hypogaea*) as influenced by the application of the different rates of IMO 7. Treatment 4 significantly gave the highest values of all yield components followed by Treatments 3, 2, and 1. Statistical analyses revealed highly significant differences in plot yield, number of pods per plot, and number of pods per plant with varying rates of IMO 7. The ANOVA test also showed a significant difference in the number of seeds per pod for peanuts treated with IMO 7 at different rates. Tukey's test was able to determine that Treatment 4 was significantly the best compared to the other treatments. Peanuts without IMO 7 produced fewer pods due to insufficient amount of nutrients (Veeramani & Subrahmaniyan, 2011) present in the soil.

Table 5. Effects of rates of Indigenous Microorganisms (IMO) 7 on the yield components of peanut (*Arachis hypogaea* L.)

Treatments	Plot yield (g)	No. of pods/plot	No. of pods/plant	No. of seeds per pod
T1 - Control	435.75^{c}	372^{c}	15.50^{b}	2.02^{b}
T2 – 9 tons/ha + 9 tons/ha	1004.25^{b}	489.75^{b}	18.25^{b}	2.15a^{b}
T3 – 12 tons /ha + 9 tons/ha	1,127^{b}	586^{b}	21.25^{ab}	2.18^{ab}
T4 – 15 tons/ha + 9 tons/ha	1,655.75^{a}	824.25^{a}	26.75^{a}	2.52^{a}
P-Value	0.000	0.000	0.009	0.039
F-Test	**	**	**	*
cv	46.82	31.15	27.45	12.01

Means within the same column followed by a common letter are not significantly different at 5% level based on Tukey's test or HSD.
* - Significant
** - highly significant
ns – not significant

Figure 5 presents the projected yield of peanut. Treatment 4 gave the highest yield of about 1,379.79 kg, followed by Treatments 3 with 939.17, 2 with 836.88, and 1 with 363.13. Statistical analysis revealed significant differences in all treatments. Tukey's test was able to determine that it was Treatment 4 that differed significantly from the rest of the treatments. The difference between Treatments 3 and 2 was

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not relatively wide. Peanut produced more pods when a sufficient amount of nutrients and effective microorganisms are present in the soil (Badawi et al., 2011). Indigenous microorganisms increased the fixing of nitrogen from the root nodules of peanuts (Kumar et al., 2015). Thus the yield of peanut increases as the rates of IMO 7 increase further.

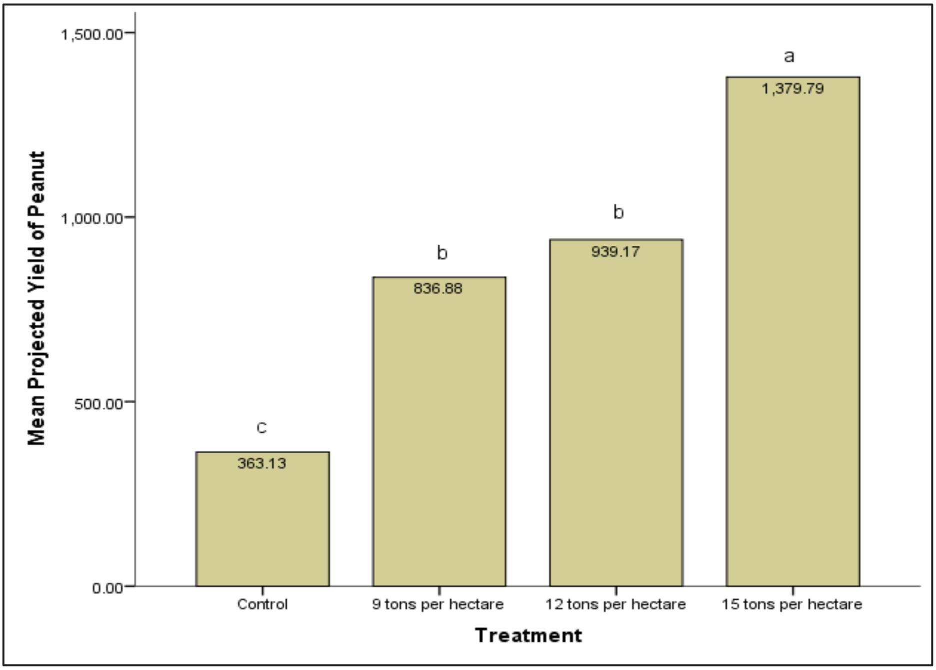

Figure 5. Projected yield of peanut.

Overall results showed that ear height, plant height, the weight of marketable ears, and the projected yield per hectare increased significantly when applied with IMO 7. Plant height, plot yield, and projected yield of peanut per hectare were also significantly higher when applied with IMO 7. Results suggested that the IMO 7 clearly shows positive effects in improving the growth and yield of sweet corn "Sugar King" Variety and peanut intercrop compared to the control treatment.

Conclusion and Recommendation

A significant growth and yield increase in sweet corn 'Sugar King F1' variety–peanut intercropping system in Aurora, Zamboanga del Sur was observed with the application of IMO 7 at the total rate of 30 tons per hectare (15 tons for sweet corn and 15 tons for peanut). Hence, the sweet corn and peanut responded favorably to the application of IMO 7 at a higher rate of 30 tons per hectare as shown in their growth and yield performance. The IMO 7 is highly recommended to all farmers and organic practitioners since its effects had been proven in improving the overall performance of sweet corn and peanut intercrop. It is recommended further to test the effects of IMO 7 on other agronomic and horticultural crops. Replication of this research to other localities is also recommended to further confirm the results.

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Literature Cited

Altieri, M. A. (1999). The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems & Environment*, *74*(1), 19–31. doi: https://doi.org/10.1016/B978-0-444-50019-9.50005-4

Altieri, M. A. (2018). *Agroecology: The science of sustainable agriculture*. Florida, USA: CRC Press.

Badawi, F. S. F., Biomy, A. M. M., & Desoky, A. H. (2011). Peanut plant growth and yield as influenced by co-inoculation with Bradyrhizobium and some rhizo-microorganisms under sandy loam soil conditions. *Annals of Agricultural Sciences*, *56*(1), 17–25. doi: https://doi.org/10.1016/j.aoas.2011.05.005

Belel, M. D., Halim, R. A., Rafii, M. Y., & Saud, H. M. (2014). Intercropping of corn with some selected legumes for improved forage production: A review. *Journal of Agricultural Science*, *6*(3), 48-62. doi: doi:10.5539/jas.v6n3p48

Carvalho, F. P. (2006). Agriculture, pesticides, food security and food safety. *Environmental Science & Policy, 9*(7), 685–692. doi: https://doi.org/10.1016/j.envsci.2006.08.002

Catholic Relief Services (CRS). (2008). *Natural Farming Technology Systems (NFTS)* (Second, Vol. 2). Catholic Relief Services - USCCB, Philippine Program, 470, General Luna St., CBCP Intramuros Manila, Philippines/Mindanao Regional Office, 4th Floor, PhilAm Life Building, Rizal St., Davao City, 8,000 Philippines: Davao City, Philippines.

Chaparro, J. M., Sheflin, A. M., Manter, D. K., & Vivanco, J. M. (2012). Manipulating the soil microbiome to increase soil health and plant fertility. *Biology and Fertility of Soils*, *48*(5), 489–499. doi: 10.1007/s00374-012-0691-4

Connor, D. J., Loomis, R. S., & Cassman, K. G. (2011). *Crop ecology: Productivity and management in agricultural systems*. Cambridge, United Kingdom: Cambridge University Press.

Crookston, R. K., & Hill, D. S. (1979). Grain yields and land equivalent ratios from intercropping corn and soybeans in Minnesota 1. *Agronomy Journal*, *71*(1), 41–44. doi: 10.2134/agronj1979.00021962007100010010x

Damalas, C. A., & Eleftherohorinos, I. G. (2011). Pesticide exposure, safety issues, and risk assessment indicators. *International Journal of Environmental Research and Public Health*, *8*(5), 1402–1419. doi: https://doi.org/10.3390/ijerph8051402

De Ponti, T., Rijk, B., & Van Ittersum, M. K. (2012). The crop yield gap between organic and conventional agriculture. *Agricultural Systems*, *108*, 1–9. doi: https://doi.org/10.1016/j.agsy.2011.12.004

Don, A., Osborne, B., Hastings, A., Skiba, U., Carter, M. S., Drewer, J., … Jones, M. B. (2012). Land-use change to bioenergy production in Europe: Implications for the greenhouse gas balance and soil carbon. *Global Change Biology Bioenergy*, *4*(4), 372–391. doi: https://doi.org/10.1111/j.1757-1707.2011.01116.x

Edwards, C. A. (Ed.). (2013). *Environmental pollution by pesticides* (Vol. 3). Berlin, Germany: Springer Science & Business Media.

Eskandari, H., Ghanbari, A., & Javanmard, A. (2009). Intercropping of cereals and legumes for forage production. *Notulae Scientia Biologicae*, *1*(1), 07-13.

Galera, V. P. (1999). *Performance glutinous corn intercropped with different legumes* (Unpublished thesis). Central Mindanao University, Musuan, Bukidnon.

Girard, J. E. (2013). *Principles of environmental chemistry*. Massachusetts, USA: Jones & Bartlett Publishers.

Jiao, N., Ning, T., Zhao, C., Hou, L., Li, Z., Li, Y., … Han, B. (2008). Effect of nitrogen application and planting pattern on N and P absorption and use in maize-peanut intercropping system. *Acta Agronomica Sinica*, *34*(4), 706.

Kashyap, A. S., Pandey, V. K., Manzar, N., Kannojia, P., Singh, U. B., & Sharma, P. K. (2017). Role of plant growth-promoting rhizobacteria for improving crop productivity in sustainable agriculture. In *Plant-microbe interactions in agro-ecological perspectives* (pp. 673-693). Singapore: Springer.

Kumar, A., Bahadur, I., Maurya, B. R., Raghuwanshi, R., Meena, V. S., Singh, D. K., & Dixit, J. (2015). Does a plant growth-promoting rhizobacteria enhance agricultural sustainability. *Journal of Pure and Applied Microbiology*, *9*(1), 715–724.

Kumar, B. L., & Gopal, D. S. (2015). Effective role of indigenous microorganisms for sustainable environment. *3 Biotech*, *5*(6), 867–876. doi: https://doi.org/10.1007/s13205-015-0293-6

Laube, W., Schraven, B., & Awo, M. (2012). Smallholder adaptation to climate change: Dynamics and limits in Northern Ghana. *Climatic Change*, *111*(3–4), 753–774.

Lithourgidis, A. S., Dordas, C. A., Damalas, C. A., & Vlachostergios, D. (2011). Annual intercrops: an alternative pathway for sustainable agriculture. *Australian Journal of Crop Science*, *5*(4), 396-410.

Mariano, M. J., Villano, R., & Fleming, E. (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agricultural Systems*, *110*, 41–53. doi: https://doi.org/10.1016/j.agsy.2012.03.010

Meena, V. S., Maurya, B. R., & Verma, J. P. (2014). Does a rhizospheric microorganism enhance K+ availability in agricultural soils? Microbiological Research, 169(5–6), 337–347. doi: https://doi.org/10.1016/j.micres.2013.09.003

Mendoza, T. C., & Villegas, P. M. (2015). *The Opportunities and Challenges of GREEN Agriculture in the ASEAN: Focus on the Philippines*. Bangkok: Chulalongkorn Univercity Press.

Muchena, F. N., & Hilhorst, T. (Eds.). (2000). *Nutrients on the move: Soil fertility dynamics in African farming systems*. London, United Kingdom: International Institute for Environment and Development.

Mutegi, J., Ameru, J., Harawa, R., Kiwia, A., & Njue, A. (2018). Soil health and climate change: Implications for food security in Sub-Saharan Africa. *International Journal of Development and Sustainability*, *7*(1), 21-33.

Richardson, A. E., Barea, J.-M., McNeill, A. M., & Prigent-Combaret, C. (2009). Acquisition of phosphorus and nitrogen in the rhizosphere and plant growth promotion by microorganisms. *Plant and Soil, 321*(1–2), 305–339. doi: https://doi.org/10.1007/s11104-009-9895-2

Richardson, M. J., Madrigal, D. S., Wilkie, A., Wong, M., & Roberts, E. (2017). Environmental health tracking improves pesticide use data to enable research and inform public health actions in California. *Journal of Public Health Management and Practice*, *23*, S97-S104. doi: 10.1097/PHH.0000000000000595

Rubatzky, V. E., & Yamaguchi, M. (2012). *World vegetables: Principles, production, and nutritive values*. Berlin, Germany: Springer Science & Business Media.

Rusinamhodzi, L., Corbeels, M., Nyamangara, J., & Giller, K. E. (2012). Maize–grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crops Research*, *136*, 12–22. doi: https://doi.org/10.1016/j.fcr.2012.07.014

Seran, T. H., & Brintha, I. (2010). Review on maize based intercropping. *Journal of Agronomy*, *9*(3), 135–145.

Sharma, R. (2011). *Introgression of quality protein opaque 2 gene into maize using marker assisted selection* (Unpublished doctoral dissertation). Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India.

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Singh, J. S., Pandey, V. C., & Singh, D. P. (2011). Efficient soil microorganisms: A new dimension for sustainable agriculture and environmental development. *Agriculture, Ecosystems & Environment*, *140*(2011), 339–353. doi: doi:10.1016/j.agee.2011.01.017

Su, Y., Huang, G., Liu, X., & Liu, L. (2005). Studies on the mechanism of Increasing yield and income of the intercropping system with maize and soybean in upland of red soil. *Acta Agriculturae Universitatis Jiangxiensis*, *27*(2), 210-213.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., … Swackhamer, D. (2001). Forecasting agriculturally driven global environmental change. *Science*, *292*(5515), 281–284. doi: 10.1126/science.1057544

Treonis, A. M., Austin, E. E., Buyer, J. S., Maul, J. E., Spicer, L., & Zasada, I. A. (2010). Effects of organic amendment and tillage on soil microorganisms and microfauna. *Applied Soil Ecology*, *46*(1), 103–110. https://doi.org/10.1016/j.apsoil.2010.06.017

Veeramani, P., & Subrahmaniyan, K. (2011). Nutrient management for sustainable groundnut productivity in India – A review. *International Journal of Engineering Science and Technology*, *3*(11), 8138–8153.

Veisi, H., Carolan, M. S., & Alipour, A. (2017). Exploring the motivations and problems of farmers for conversion to organic farming in Iran. *International Journal of Agricultural Sustainability*, *15*(3), 303–320.

Yong, Y., Hu, Y., Shahrajabian, M. H., Ren, C., Guo, L., Wang, C., & Zeng, Z. (2017). Organic matter, protein percentage, yield, competition and economics of oat-soybean and oat-groundnut intercropping systems in Northern China. *Cercetari Agronomice in Moldova*, *L, No. 3*(171), 25–35. doi: 10.1515/cerce-2017-0023