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Response of Hybrid Sweet Corn (*Zea mays* L. saccharata) Varieties to the Time of Planting String Bean (*Phaseolus vulgaris*) Intercrop

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One of the common approaches to increasing crop production is the intercropping system. This study assessed the response of sweet corn (*Zea mays* L. saccharata) varieties to the time of planting string bean intercrop (*Phaseolus vulgaris*). This was laid out in a split plot arranged in a randomized complete block design with two sweet corn varieties as the main plot and four times planting string bean intercrop as subplots. Two treatment plots of monoculture sweet corn and string bean were added for the calculation of the land and area time equivalent ratios. Variety did not significantly affect the agronomic, horticultural characteristics, yield, and yield components of sweet corn and string beans but the planting time did. Results revealed that sweet corn planted 1 wk later than string beans delayed its tasseling and silking. However, it produced the heaviest marketable and total green ear yield (5. 41 and 6.05 t ha^{-1}) but comparable to when both component crops are planted at the same time than when sweet corn was planted 2 wk ahead of string beans (6.03 t ha^{-1}). On the other hand, string beans were planted at the same time as sweet corn, 1 wk after sweet corn, and 1 wk before sweet corn flowered and harvested its pods earlier than when string beans were planted 2 wk after sweet corn. Land and area time equivalent ratios were greater than one in all treatments indicating that both crops can be grown together. In terms of yield characteristics, the Sweet Grande variety produced a relatively higher marketable green ear yield (5.07 t ha^{-1}) and string beans planted 1 wk before sweet corn (2.12 t ha^{-1}). Intercropping sweet corn with string beans is advantageous, as sweet corn provides a living trellis for the latter.

Keywords: area time equivalent ratio, corn, land equivalent ratio, string beans, time of intercropping

INTRODUCTION

Sweet corn (*Zea mays* L. saccharata) is also known as sugar corn because of the high sugar content (5–6%) of its kernels (Muhumed *et al.* 2014). It is cultivated annually in temperate, subtropical, and tropical countries as an annual field crop (Haghighat *et al.* 2012). It is distinguishable from other types of corn by its exquisite flavor, wrinkled, translucent kernels when dried, and is sold as green cob (Oktem and Oktem 2005). In the Philippines, Filipino farmers use it as food and cash crops. It contains 10–11% starch, 3% water soluble polysaccharides, 70% water, plus protein, vitamin, and potassium.

String beans are one of the popular vegetables in the Philippines, which can be produced all year round. It can withstand 25–35 °C and adapt well to lowland tropical climates. However, it can take some partial shade and be used as an intercrop to sweet corn. It is also a good source of protein, vitamin A, thiamin, riboflavin, iron, phosphorus, and potassium. It also contains manganese, magnesium, folate, and vitamin C. Moreover, it functions as an antioxidant, an

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anti-inflammatory, and a liver protector while stabilizing blood sugar levels and possibly even preventing diabetes.

Food security is one of the Philippines' most pressing issues today, owing to the rising population and shrinking arable land. In this regard, it is essential to implement production-boosting techniques such as shifting from monocropping to multiple cropping or intercropping could be one strategy to maximize the use of land resources. It is the most appropriate practice to increase production or yield without expanding the land area to sustain the food demand of humanity. One of the reasons for growing two or more crops together is to increase productivity per unit area of land. In terms of income per land area, the overall performance of the component crops outperforms pure stand or monoculture.

Intercropping cereal with legumes is beneficial as legumes are known to fix atmospheric nitrogen (N), thus supplying the needs of the former (Manna *et al.* 2003). Hence, it is a valuable component in cereal-based cropping systems to improve soil fertility and enhance the yield of companion crops (Latati *et al*. 2013).

However, for string bean intercrop, trellising costs constitute a significant portion of the production cost (Quirol 1986). Practices that can reduce trellising expenses will most probably increase the profitability of string beans. Intercropping with sweet corn + string bean at the right time may increase both crop's productivity.

There is a need to determine the best time for planting string bean intercrop for a more mutually beneficial combination. In sweet corn + string bean intercropping, sweet corn can serve as a trellis of string bean. Growing sweet corn as trellis would be a great advantage, considering that sweet corn can be harvested in 70–75 d and string beans in 52–55 d after planting (DAP). Observation also shows that sweet corn stover can last for more than a month in the field after ear harvesting. Thus, determining the appropriate time of planting string beans as intercrop to sweet corn is essential to ensure its growth and yield performance would not be adversely affected.

MATERIALS AND METHODS

Seed Preparation

This study used two hybrid sweet corn varieties (*Macho* and Sweet Grande) and string bean (*Bongga*).

Land Preparation

An area of 942.5 m^2 at the Department of Soil Science of the College of Agriculture and Food Science of Visayas State University (VSU) in Baybay City, Leyte, was plowed and harrowed twice on a weekly interval using a tractor. This was done to pulverize the soil and provide good soil conditions for seed germination. The area was divided into three replications with an area of 29 m x 32.5 m. Each plot was divided into six subplots with a plot size of 5 m x 4 m having four rows of sweet corn spaced 100 cm apart, whereas the string bean intercrop was planted in between rows of sweet corn. The treatments, subplots, and replications were separated by 0.5-m and 1-m alleyways to facilitate farm operations and data gathering.

Soil Chemical Property Determination

Before conducting the study, 10 composite soil samples at a depth of 20 cm were randomly collected from the experimental area before land preparation. The collected samples were air-dried, pulverized, and sieved using a 2.0-mm wire mesh. Samples were submitted to the Analytical Soil Laboratory National *Abaca* Research Center (NARC), VSU, Visca, Baybay City, Leyte. These were analyzed for soil pH, organic matter (%) (modified Walkley Black method; PCARR 1980), total N (%) (modified Kjeldhal method; PCARR 1980), and available phosphorus (mg kg^{-1}) (Bray 2).

Experimental Treatments and Design

The experiment was laid out in a split plot arranged in a randomized complete block design with three replications with two sweet corn varieties as the main plot and four different times of planting string bean intercrop as the subplot. The treatments were designated as follows:

[Main plot] Sweet corn variety (SV)

[V_1] *Macho*
[V_2] Sweet Grande

[Subplot] Time of planting string bean intercrop (TPI)

[T_1] String beans planted at the same time with sweet corn
[T_2] String beans planted one (1) week after the sweet corn
[T_3] String beans planted one (1) week before the sweet corn
[T_4] String beans planted two (2) weeks after the sweet corn

Two treatment plots were added sweet corn (*Macho* variety) alone (T_5) and string bean alone (T_6), which were used in determining and computing the land equivalent ratio (LER) and area time equivalent ratio (ATER) to measure the intercropping efficiency.

The figures 1 and 2 below shows how the monoculture and intercropping of sweet corn and string beans were done.

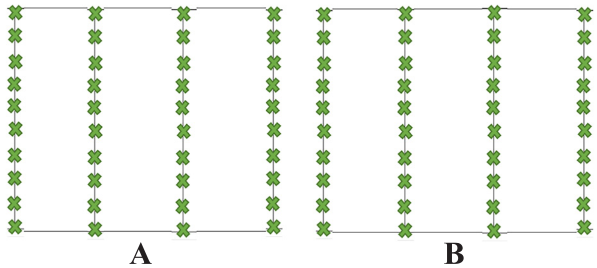

Figure 1. Monocropping of sweet corn (A) and string bean (B).

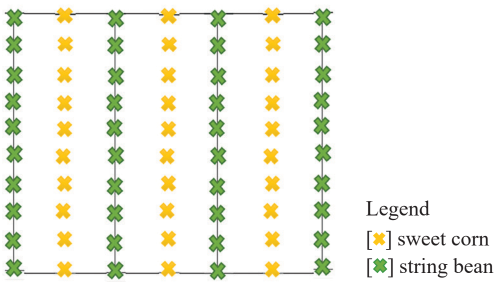

Figure 2. Intercropping of sweet corn and string bean.

Planting

Corn seeds were directly sown in the furrows spaced 100 cm between rows and 50 cm between plants at one seed per hill. The string bean intercrop was planted in between rows of sweet corn spaced 100 cm x 50 cm at 1 plant per hill. The seeds were covered with a thin layer of soil to protect them from harmful organisms. Missing hills were replanted 5 DAP.

Fertilizer Application

Sweet corn was applied with a recommended rate of fertilizer 90-60-60 N, P_2O_5 K_2O ha^{-1} using complete fertilizer (14-14-14) 14 DAP, and urea (46-0-0) at 35 DAP. Besides, string beans were applied with fertilizer at the recommended rate of 74-28-88 N, P_2O_5 K_2O ha^{-1} using complete fertilizer (14–14–14) 14 DAP, and urea (46-0-0) and muriate of potash (0-0-60) 25 DAP.

Weeding and Cultivation

Weeding and cultivation were done to keep the area from weeds throughout the duration of the experiment. The first and second weedings were done 4 and 7 wk after planting. Spot removal of the weeds was done every time weeds were seen in the respective treatment plots.

Water Management

Watering of sweet corn and string beans was done during the 10^{th}–11^{th} wk after planting. It was employed early in the morning and late in the afternoon, respectively.

Pest Management

Infestation of aphids was observed in string beans during the vegetative stage, whereas corn borer during the silking stage of sweet corn. String beans were sprayed once with Actara (Thiamethoxam 25% WG) at three tablespoons in 16 L of water. Sweet corn was sprayed once with Cymbush (cypermethrin 25% EC) at three tablespoons in 16 L of water to control aphids and corn borer.

Harvesting and Processing

Sweetcorn was harvested at the boiling stage or green cob stage. Sample plants were taken within the two inner rows, excluding two end plants in a row in the harvestable area of 8 m^2 for both crops. Ears gathered from the harvestable area were detached from the stalk and dehusked. Meanwhile, the young and tender pods were harvested from string beans 3–4 d after flowering. Harvesting was done manually at 2–3 d intervals up to seven primings (last priming).

Sweet Corn (Main Crop): Agronomic Characteristics

Number of days from sowing to tasseling. This was determined by counting the days from sowing until 85% of the plants in the treatment plot (8 m^2) produced tassels.

Number of days from sowing to silking. This was calculated by counting the days from the sowing to the time when 85% of the plants in a treatment plot (8 m^2) produced silk.

Plant height (cm). This was calculated by measuring the height of the 10 sample plants in each treatment plot (8 m^2) before harvesting from ground level to the tip of the tallest plant part.

Leaf area index (LAI). This was determined by measuring the length and the width at the broadest part of leaf number 8 (Pearce *et al.* 1975) starting from the apex (flag leaf) of 10 sample plants during silking stage days after planting. LAI was computed using the formula:

$$LAI = \frac{\text{Length x Width x 0.75 x 9.39}}{\text{Ground area allocated per plant}}$$

0.75 = correction factor for the leaf area
9.39= correction factor for leaf area no. 8

Fresh stover yield (t ha^{-1}). This was obtained by weighing the freshly harvested herbage within the harvestable area (8 m^2) of each treatment plot. The weight was converted into tons per hectare using the following formula:

$$\text{Stover yield (t ha}^{-1}) = \frac{\text{Stover yield (kg)}}{\text{Harvestable area (8 m}^2)} \times \frac{10{,}000 \text{ ha}^{-1}}{1000 \text{ kg t}^{-1}}$$

Sweet Corn (Main Crop): Yield and Yield Components

Ear length (cm). This was done by measuring the length of 10 sample ears in each treatment plot from the base to the tip of the ear using a ruler.

Ear diameter (cm). This was done by measuring the broadest part of 10 sample ears in each treatment plot using a vernier caliper.

Number of marketable ears and non-marketable ears/plot (8 m^2). This was obtained by classifying the dehusked ears into marketable and non-marketable. Ears were considered marketable when the following criteria were met (Biñas and Cagasan 2021).

1. The dehusked ear should be 15 cm and above in length.
2. The dehusked ear should be 5 cm and above in diameter.
3. The dehusked ear should be 0.25 kg and above in weight.
4. The kernels of the dehusked ear should be large and fill the ear.
5. The dehusked ear should be free of damage by insect pests, and diseases.
6. The dehusked ear should bear complete kernels in each cob row, firm, and with no soft spots and blemishes.

Weight of marketable and non-marketable ears (t ha^{-1}). This was taken by weighing separately the harvested corn ears of marketable and non-marketable within the harvestable area of 8 m^2. The weight was converted into tons per hectare.

Total green ear yield (t ha^{-1}). This was determined by combining the weight of yield of marketable and non-marketable ears within the harvestable area of 8 m^2. The total ear yield was converted into tons per hectare using the following formula:

$$\text{Total green ear yield (t ha}^{-1}) = \frac{\text{Total ear yield (kg)}}{\text{Harvestable area (8 m}^2)} \times \frac{10{,}000 \text{ ha}^{-1}}{1000 \text{ kg t}^{-1}}$$

Harvest index. This is the ratio of a crop's economic yield to its biological yield. The dehusked ears, husk, and stover of three sample plants from each treatment plot were weighed separately to obtain the data of harvest index using the formula:

$$\text{Harvest index} = \frac{\text{Fresh green cob yield (dehusked) (kg)}}{\text{Fresh stover (kg) + green cob yield (dehusked) (kg) + husk (kg)}}$$

String Bean (Intercrop): Horticultural Characteristics

Number of days from sowing to flowering. This was obtained by counting the number of days from sowing to the time when 85% of the plants produced flowers in each treatment plot (8 m^2).

Number of days from sowing to pod harvesting. This was obtained by counting the days from sowing to the time when 85% of the plants produced harvested pods in each treatment plot (8 m^2).

Number of lateral vines per plant. This was determined by counting the number of primary lateral vines from ten sample plants in each treatment plot (8 m^2) after the seven primings (last priming).

Length (cm) of main vines. This was measured from the base of the plant up to the shoot tip of the main vine of ten sample plants in each treatment plot (8 m^2) after the seven primings (last priming).

String Bean (Intercrop): Yield and Yield Components

Length (cm) of green pods. This was obtained by measuring ten sample-harvested pods in each treatment plot (8 m^2).

Number of marketable and non-marketable pods $plot^{-1}$ (8 m^2). These were taken by classifying the harvested pods into marketable and non-marketable ones from each treatment plot (8 m^2). Marketable pods include all well-developed pods not damaged by insects and diseases.

Weight (t ha^{-1}) of marketable and non-marketable pods. These were taken by weighing the marketable and non-marketable harvested pods within the harvestable area of 8 m^2 summing it up to seven priming.

Total green pod yield (t ha^{-1}). This was determined by combining the weight of marketable and non-marketable pods harvested from the harvestable area of 8 m^2. The total green pod yield was converted into tons per hectare using the formula:

$$\text{Total green pod yield (t ha}^{-1}) = \frac{\text{Total green pod yield (kg)}}{\text{Harvestable area (8 m}^2)} \times \frac{10{,}000 \text{ ha}^{-1}}{1000 \text{ kg t h}^{-1}}$$

Herbage yield (t ha^{-1}). This was determined by weighing the leaves and vines of all plants within the harvestable area in each treatment plot (8 m^2). The herbage yield was converted into tons per hectare using the formula:

$$\text{Herbage yield (t ha}^{-1}) = \frac{\text{Herbage yield (kg)}}{\text{Harvestable area (8 m}^2)} \times \frac{10{,}000 \text{ ha}^{-1}}{1000 \text{ kg t h}^{-1}}$$

Other Parameters Gathered

Land equivalent ratio (LER). This was measured to determine the total land productivity in an intercropping scheme. This is expressed as the sum of the fractions of the crop yield in a mixture relative to that of their monoculture. LER was computed using the formula:

$$LER = \frac{Xi}{Xj} + \frac{Yi}{Yj}$$

where:

Xi = yield of sweet corn in intercropping
Xj = yield of sweet corn in monoculture
Yi = yield of string beans in intercropping
Yj = yield of string beans in monoculture

Area time equivalent ratio (ATER). It is the comparison of the yield of intercropping over monocropping in terms of the time taken by the component crops in the intercropping scheme. ATER was calculated using the formula:

$$ATER = \frac{Yi/Ym\ (tms) + Si/Sm\ (tmb)}{\text{Duration of intercropping}}$$

where:

Yi = yield of sweet corn intercropping
Ym = yield of sweet corn monocrop
Si = yield of string bean intercropping
Sm = yield of string bean monocrop
Duration of intercropping = 80 d
tms = duration of sweet corn
V_1 = 79 d, V2 = 80 d
tmb = duration of string bean
T_1 = 66 d, T2 = 69 d
T_3 = 62 d, T4 = 75 d

Marginal Cost and Return Analysis

Variable cost. This was determined by recording all expenses incurred throughout the study, from land preparation to harvesting. These include chemicals, fertilizers, seeds, labor costs, and other materials that were used in the field operations.

Gross return. This was determined by multiplying the weight of marketable ears of sweet corn and marketable pods of string beans by their current price per kilogram basis with the following formula:

Gross return (sweet corn) = Weight of marketable ears (kg) x Price (PHP/kg

Gross return (string bean) = Weight of marketable pods (kg) x Price (PHP/kg)

Gross margin. This was determined by subtracting the gross return from the variable cost of sweet corn and string beans with the following formula:

Gross margin = Gross return (PHP) – Variable cost (PHP)

Statistical Analysis

Analysis of variance (ANOVA) was done on data gathered using the Statistical Tool for Agricultural Research (STAR) version 2.0.1. Tukey's honestly significant difference (HSD) test was used to compare significant means at a 5% level.

RESULTS

Table 1. Agronomic characteristics of sweet corn (*Zea mays* L. saccharata) as affected by variety and time of planting string bean (*Phaseolus vulgaris*) intercrop.

Treatment	Number of days from sowing		Plant height (cm)	Leaf area index	Fresh stover yield (t ha^{-1})
	Tasseling	Silking			
Sweet corn variety (V)					
[V_1] *Macho*	60.53	63.58	212.87	1.08	17.22
[V_2] Sweet Grande	60.17	62.67	216.47	0.98	16.43
Mean	60.38	63.13	214.67	1.03	16.82
Time of planting string bean intercrop (TPI)					
T_1	59.67^{b}	62.67^{ab}	219.80	0.99	16.32
T_2	59.17^{b}	62.17^{b}	210.22	1.00	16.42
T_3	62.33^{a}	65.17^{a}	214.22	1.12	17.68
T_4	60.33^{ab}	62.50^{b}	213.87	1.02	16.86
Mean	60.38	63.12	214.67	1.03	16.82
V x TPI	ns	ns	ns	ns	ns
CV (a) %	2.22	2.02	3.91	5.80	7.10
CV (b) %	2.22	2.40	4.57	15.04	12.23

Means within a column with the same letter and those without letter designations are not significantly different at the 5% level based on HSD
Legends: [T1] string beans planted at the same time with sweet corn; [T2] string beans planted 1 wk after the sweet corn; [T3] string beans planted 1 wk before the sweet corn; [T4] string beans planted 2 wk after the sweet corn

Table 2. Yield and yield components of sweet Corn (Zea mays L. saccharata) as affected by variety and time of planting string bean (Phaseolus vulgaris) intercrop.

Treatments	Ear size (cm)		Number of ears plot^{-1}		Weight (t ha^{-1}) of ears		Total ear yield (t ha^{-1})	Harvest index
	Length	diameter	Marketable	Non-marketable	Marketable	Non-marketable		
Sweet corn variety (V)								
[V$_1$] *Macho*	21.92	4.84	14.67	1.33	4.84	0.71	5.54	0.43
[V$_2$] Sweet Grande	21.10	5.23	14.58	1.42	5.07	0.66	5.59	0.46
Mean	21.51	5.03	14.63	1.38	4.95	0.68	5.57	0.45
Time of planting string bean intercrop (TPI)								
T$_1$	21.69	4.91	14.67	1.33	5.29^{a}	0.74	6.03^{a}	0.45
T$_2$	21.69	5.00	14.33	1.67	4.81^{ab}	0.67	5.49^{ab}	0.46
T$_3$	21.42	5.24	14.83	1.17	5.41^{a}	0.64	6.05^{a}	0.44
T$_4$	21.22	4.99	14.67	1.33	4.30^{b}	0.69	4.99^{b}	0.42
Mean	21.51	5.03	14.63	1.38	4.95	0.68	5.57	0.45
V x TPI	ns	ns	ns	ns	ns	Ns	ns	ns
CV (a) %	1.91	6.12	2.79	29.69	3.69	26.91	6.23	15.89
CV (b) %	5.11	6.05	3.60	38.33	11.20	22.54	10.45	14.60

Means within a column with the same letter and those without letter designations are not significantly different at the 5% level, based on HSD
Legends: [T1] string beans planted at the same time with sweet corn; [T2] string beans planted 1 wk after the sweet corn; [T3] string beans planted 1 wk before the sweet corn; [T4] string beans planted 2 wk after the sweet corn

Table 3. Horticultural characteristics of string bean (Phaseolus vulgaris) intercrop as affected by sweet corn (*Zea mays* L. saccharata) variety and time of planting.

Treatments	Number of days from sowing		Number of lateral vines	Length of main vines (cm)	Fresh herbage yield (t ha^{-1})
	Flowering	Harvesting			
Sweet corn variety (V)					
[V$_1$] *Macho*	49.68	52.50	2.75	234.03	3.46
[V$_2$] Sweet Grande	49.92	52.58	2.33	250.04	3.72
Mean	49.80	52.50	2.54	242.03	3.59
Time of planting string bean intercrop (TPI)					
T$_1$	47.67^{b}	50.17^{b}	2.67	258.00	3.53
T$_2$	48.33^{b}	50.50^{b}	2.67	241.36	3.70
T$_3$	48.17^{b}	51.00^{b}	2.16	239.36	3.37
T$_4$	55.00^{a}	58.33^{a}	2.67	229.42	3.76
Mean	49.80	52.50	2.54	242.03	3.59
V * TPI	ns	ns	ns	ns	ns
CV (a) %	1.88	1.03	8.03	6.64	10.93
CV (b) %	2.08	2.39	27.82	10.59	11.52

Means within a column with the same letter and those without letter designations are not significantly different at 5% level, based on HSD
Legends: [T1] string beans planted at the same time with sweet corn; [T2] string beans planted 1 wk after the sweet corn; [T3] string beans planted 1 wk before the sweet corn; [T4] string beans planted 2 wk after the sweet corn

Table 4. Yield and yield components of string bean (*Phaseolus vulgaris*) intercrop as affected by sweet corn variety and time of planting.

Treatments	Length of pods	Number of pods (8 m^2)		Weight of green pods (t ha^{-1})		Total green pod yield (t ha^{-1})
		Marketable	Non-marketable	Marketable	Non-marketable	
Sweet corn variety (SV)						
[V_1] *Macho*	57.91	102.92	15.67	1.72	0.31	2.61
[V_2] Sweet Grande	59.13	115.83	18.50	2.13	0.33	2.46
Mean	58.52	109.38	17.08	1.92	0.32	2.54
Time of planting string bean intercrop (TPI)						
T_1	58.84	113.33	16.67	1.87	0.28	2.40
T_2	58.73	103.33	16.00	1.93	0.32	2.42
T_3	58.85	116.17	16.83	2.12	0.34	2.94
T_4	57.68	104.67	18.83	1.78	0.35	2.38
Mean	58.52	109.38	17.08	1.92	0.32	2.54
V * TPI	ns	ns	ns	ns	Ns	ns
CV (a) %	5.30	8.68	8.36	21.27	11.32	17.53
CV (b) %	3.33	15.11	12.96	25.81	19.49	23.52

Means within a column with the same letter and those without letter designations are not significantly different at the 5% level based on HSD
Legends: [T1] string beans planted at the same time with sweet corn; [T2] string beans planted 1 wk after the sweet corn; [T3] string beans planted 1 wk before the sweet corn; [T4] string beans planted 2 wk after the sweet corn

Table 5. Land equivalent and area time equivalent ratios of sweet corn as affected by variety and time of planting string bean intercrop.

Treatments	LER	ATER
Sweet corn variety (SV)		
[V_1] *Macho*	1.62	1.53
[V_2] Sweet Grande	1.69	1.60
Mean	1.65	1.57
Time of planting string bean intercrop (TPI)		
T_1	1.70	1.68
T_2	1.63	1.58
T_3	1.80	1.65
T_4	1.50	1.49
Mean	1.65	1.57
V * TPI	ns	Ns
CV (a) %	6.92	7.00
CV (b) %	17.85	16.53

[LER] Land equivalent ratio
[ATER] Area time equivalent ratio
Means within a column with the same letter and those without letter designations are not significantly different at the 5% level, based on HSD
Legends: [T1] string beans planted at the same time with sweet corn; [T2] string beans planted 1 wk after the sweet corn; [T3] string beans planted 1 wk before the sweet corn; [T4] string beans planted 2 wk after the sweet corn

DISCUSSIONS

Agronomic Characteristics of Sweet Corn

Table 1 shows the agronomic characteristics of sweet corn as influenced by variety and the time of planting of string bean intercrop. ANOVA revealed that there was no significant effect on the number of days from sowing to tasseling and silking, plant height, leaf area index, and fresh stover yield of sweet corn variety. This result implies that any sweet corn variety could be grown regardless of the time of planting string bean intercrop because it did not affect the agronomic performance of sweet corn. However, significant differences were noted in the number of days from sowing to tasseling and silking by varying the time of planting string bean intercrop.

Sweet corn planted 1 wk later than string beans (T_3) took time in tasseling than T_1 and T_2 yet comparable when sweet corn are planted two weeks ahead of string beans (T_4). Consequently, this treatment delayed its silking than T_2 and T_4 but comparable to the usual practice of intercropping when sweet corn planted at the same time with string beans (T_1). These results indicate that string beans planted at the same time and 1 wk ahead of sweet corn provide the early establishment of its vines to the corn stalk; thus, it will be more competitive in terms of exploiting growth factors such as sunlight and soil resources which could have delayed in tasseling and silking of sweet corn. These

Table 6. Marginal cost and return analysis of sweet corn with string bean per hectare as affected by variety and time of planting in an intercropping scheme.

Treatments	Marketable yield (t ha^{-1})		Gross income (PHP) combined	Total expenses (PHP)	Gross margin (PHP)
	Sweet corn	String bean*			
Sweet corn variety (SV)					
[V_1] *Macho*	4.84	1.72	279,600.00	112,705.00	166,895.00
[V_2] Sweet Grande	5.07	2.13	309,300.00	111,705.00	197,595.00
Mean	4.95	1.92	294,450.00		
Time of planting string bean intercrop (TPI)					
T_1	5.29	1.87	300,700.00	114,705.00	185,995.00
T_2	4.81	1.93	278,900.00	112,205.00	166,695.00
T_3	5.41	2.12	318,000.00	117,205.00	200,795.00
T_4	4.30	1.78	266,400.00	110,705.00	155,695.00
Monoculture of sweet corn	4.78	–	191,200.00	79,180.00	112,020.00
Monoculture of string bean	–	3.41	170,500.00	82,525.00	87,975.00
CV (a) %	3.69	21.27			
CV (b) %	11.20	25.81			

*Up to seven priming only
Gross income is based on the current price in the market
Sweet corn price per kilo is PHP 40.00; price per kilo of string beans is PHP 50.00
Legends: [T1] string beans planted at the same time with sweet corn; [T2] string beans planted 1 wk after the sweet corn; [T3] string beans planted 1 wk before the sweet corn; [T4] string beans planted 2 wk after the sweet corn

findings conform with the findings of Saban *et al.* (2007) that common beans planted 1 wk before corn resulted in the delay of tasseling, silking, and maturity of corn in an intercropping scheme. These results further imply that string beans planted at the same time, 1 wk after sweet corn is the appropriate time for planting string beans intercrop, as it could not affect the performance of corn in tasseling and silking.

Yield and Yield Components of Sweet Corn

Table 2 shows the yield and yield components of sweet corn as affected by variety and the time of planting string bean intercrop. ANOVA revealed no significant differences on yield and yield components of sweet corn as influenced by variety. The result implies that any variety could be grown regardless of the time of planting string bean intercrop because it did not affect the yield performance of sweet corn. However, a significant variation was noted in the weight of marketable and total green ear yield of sweet corn by the time of planting string bean intercrop.

The highest marketable and total green ear yield were obtained from sweet corn planted 1 wk later than string beans (T_3) but comparable to the usual practice of intercropping when sweet corn is planted at the same time with string bean (T_1). Although, a numerically higher yield was recorded in T_3. The relatively lowest value was observed in sweet corn planted 2 wk ahead of string beans (T_4) but comparable to sweet corn planted 1 wk ahead of string beans (T_2). These results might be attributed to the mutual benefit of string beans planted at the same time and 1 wk before sweet corn than in string beans planted 1 wk after (T_2) and 2 wk after sweet corn (T_4) due to the utilization of fixed N. According to Devi *et al.* (2013), string beans has the symbiotic N-fixing capacity with a rate of 20–39% fixed N. The higher yield obtained in T_1 and T_3 supports the result of soil test after harvesting improved the N content from low (0.16%) to medium (0.21–0.43%) of N (Landon 1991) than T_4 remains low content of N at about (0.14%) (Table 3). This finding is in line with the results of Fininsa (1997), which discovered that delaying bean planting by 2 wk decreased corn grain yield because of lower utilization of fixed N. The results further imply that planting string beans at the same time and 1 wk before sweet corn were the appropriate time of planting regardless of the sweet corn variety.

Horticultural Characteristics of Stringbean

Table 3 shows the horticultural characteristics of string bean as affected by sweet corn variety and the time of planting string bean intercrop. ANOVA revealed that horticultural characteristics of string bean intercrop were not affected by sweet corn variety. This result implies that any sweet corn variety could be grown regardless of the time of planting string bean intercrop because it did not affect the performance of sweet corn. However, significant differences were shown in the number of days from sowing to flowering and its harvested pods by the time of planting string bean intercrop.

String beans planted at the same time (T_1), 1 wk after sweet corn (T_2), and 1 wk before sweet corn (T_3) flowered and harvested its pods earlier than when string beans was planted two weeks after sweet corn (T_4). It should be noted that in this treatment, string beans were planted 2 wk after sweet corn (T_4) probably the string bean intercrop was shaded by sweet corn, leading to competition between plants in terms of utilizing sunlight and soil resources. The string bean had to compete with the more established and taller sweet corn plants; thus, the former could not grow vigorously resulting in the delay in the growth performance of the string bean intercrop. According to Dangia *et al.* (2021), competition for nutrients, water, and light may occur under the intercropping system. This finding is similar to that of Dhima *et al.* (2007) that the intercropping effect is more pronounced because of competition for water, light, and soil resources. This result further implies that planting string beans at the same time, 1 wk after, and 1 wk before sweet corn was the best time of planting, as it would not affect the performance of sweet corn.

Yield and Yield Components of String Bean

Table 4 presented the yield and yield components of string bean as affected by variety and the time of planting string bean intercrop. ANOVA did not show significant differences in yield and yield components of string beans as affected by sweet corn variety. This result implies that any sweet corn variety could be grown regardless of the time of planting string bean intercrop because it did not affect the performance of sweet corn. No significant differences were also noted in the time of planting string bean intercrop. Though numerically, a slightly higher value was obtained in string beans planted 1 wk before sweet corn (T_3) on the length of green pods and number of marketable pods, which resulted in a slightly higher weight of marketable and total green pod yield. These results further imply that string bean planted 1 wk before sweet corn (T_3) is the most appropriate time of planting string bean intercrop to sweet corn.

Land Equivalent Ratio (LER)

LER is an expression of land use efficiency. In this experiment, the LER values in an intercropping scheme over monoculture were presented in Table 5. ANOVA revealed no significant differences in the LER as affected by the variety and time of planting string bean intercrop. The results implied that any sweet corn variety and time of planting string bean intercrop could be used in growing sweet corn and string beans in an intercropping scheme.

A slightly higher LER value of 1.69 was obtained in the Sweet Grande variety compared to the *Macho* variety. This value indicates a 69% advantage over monocropping in terms of land productivity. On the other hand, the time of planting string beans planted 1 wk before sweet corn (T_3) had a slightly higher LER value of 1.80 among other treatments. This value indicates 80% advantageous over monocropping in terms of land productivity. However, the LER was greater than one in all treatments, indicating that crops can be grown together compared to monocrop.

These findings are in line with the results of Sarcol and Cagasan (2016) that intercropping of peanut and sweet potato had an LER of greater than one, which means that this is a good combination in an intercropping scheme compared to planting peanut or sweet potato as a monocrop.

Area Time Equivalent Ratio (ATER)

ATER is a modification in the LER in measuring the productivity of the land, which includes the duration of the time the crop from planting to harvest. The duration of sweet corn–string bean intercropping was 80 d. ANOVA showed no significant differences by variety and the time of planting string bean intercrop in the intercropping scheme (Table 5). The result implies that any sweet corn variety regardless of time of planting string bean intercrop could be grown in intercropping scheme without significantly delaying the production period. A slightly higher ATER value was obtained in the Sweet Grande variety than in the *Macho* variety. Besides, planting string beans 1 wk before sweet corn (T_3) had a slightly higher ATER value of 1.65 among other treatments. This was due to highest yield obtained in this treatment plot. This results further implied that regardless of the sweet corn variety and time of planting string bean were profitable per unit area per unit time.

Marginal Cost and Return Analysis

The marginal cost and return analysis of sweet corn production intercropped with string bean as affected by variety and time of planting is presented in Table 6. Sweet Grande variety was obtained a higher gross margin of PHP 197,595.00 than *Macho*. This is attributed to a higher yield of this variety (5.07 t ha^{-1}) and string bean intercrop were also obtained a higher pod yield (2.13 t ha^{-1}).

Among the time of planting, string bean intercrop planted 1 wk before sweet corn (T_3) recorded a higher gross margin of PHP 200,795.00. This is attributed to a higher yield of sweet corn (5.41 t ha^{-1}) and the string bean intercrop (2.12 t ha^{-1}). The lowest gross margin recorded when string beans were planted 2 wk after sweet corn (T_4), which amounted to PHP 155,695.00. These results were due to lower yield of sweet corn (4.30 t ha^{-1}) and string bean intercrop (1.78 t ha^{-1}) at this time of planting. Planting sweet corn and string beans in an intercropping scheme is more profitable than using either sweet corn or string bean in the sole cropping system. The monoculture of sweet corn was generated a gross margin of PHP 112,020.00. At the same time, monoculture string beans incurred a gross margin of PHP 87,975.00. Monoculture string beans incurred a cost of PHP 10,000.00 in providing trellis. This further implied that intercropping of sweet corn + string beans is advantageous as the former provides living trellis for the latter. Moreover, string beans enriched the soil nutrients being a legume, as it would fix N from the atmosphere into usable form. Furthermore, herbage of string bean provides a good source of organic for the succeeding crop.

CONCLUSION

All the agronomic characteristics, yield, and yield components of sweet corn were not affected by variety. However, the number of days from sowing to tasseling and silking plus the weight of marketable and total green ear yield differed significantly by the time of planting string bean intercrop. Sweet corn planted 1 wk later than string beans (T_3) produced heavier marketable and total green ear yield than when sweet corn planted 2 wk ahead of string beans (T_4). Meanwhile, the horticultural characteristics, yield, and yield components of string beans were not affected by variety. However, number of days from sowing to flowering and pod harvesting differed by the time of planting string bean intercrop. String beans planted at the same time with sweet corn (T_1), 1 wk after sweet corn (T_2) and 1 wk before sweet corn (T_3) flowered and harvested its pods earlier. The LER and ATER were greater than one in all treatments indicating that both crops can be grown together. Slightly higher gross margin was generated in the Sweet Grande variety and when string bean intercrop was planted 1 wk before sweet corn (T_3). Intercropping sweet corn with string beans is advantageous, as sweet corn provides a living trellis for the latter.

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STATEMENT OF CONFLICT INTEREST

The authors state that there is no conflict of interest.

REFERENCES

BIÑAS JR. EE, CAGASAN UA. 2021. Profitability of hybrid sweet corn (*Zea mays* L. var Macho F1) production as applied with combined organic and inorganic fertilizers. International Journal of Applied Chemical and Biological Sciences 2(1): 24–38.

DANGIA N, JALATA Z, DABA G. 2021. Effects of Varieties and Population of Soybean Intercropped with Maize on Yield and Yield Components of Associated Crops. Journal Plant Science 9(4): 128–138.

DEVI M, SINCLAIR TR, BEEBE S, RAO IM. 2013. Comparison of String Bean (*Phaseolus vulgaris* L.) Genotypes for Nitrogen Fixation Tolerance to Soil Drying. Plant and Soil Journal. p. 29–37.

DHIMA KV, LITHOURGIDIS AS, VASILAKOGLOU IB, DORDAS CA. 2007. Competition Indices of Common Vetch and Cereal Intercrop in Two Seeding Ratio. Field Crops Research 100: 249–256.

FININSA C. 1997. Effects of Planting Pattern, Relative Planting Date, and Intra-row Spacing on a Haricot Bean/ Maize Intercrop. African Crop Science Journal 5: 15–22.

HAGHIGHAT A, RAD AHS, SEYFZADEH S, YOUSEFI M. 2012. Effect of Cattle Manure and Plant Density on Sweet Corn Yield Grown Different Cropping Methods. International Journal of Agronomy and Plant Production 3(Special Issue): 696–699.

LANDON JR. 1991. Booker Tropical Soil Manual: a Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Sub Tropics. Harlon: Longman Scientific & Technical Publication.

LATATI M, PANSU M, DREVON JJ, OUNANE S. 2013. Advantages of Intercropping Maize (*Zea mays* L.) and Common Bean (*Phaseolus vulgaris* L.) on Yield and Nitrogen Uptake in Northeast Algeria. Int J Res Appl Sci 01: 1–23.

MANNA MCPK, GHOSH CL, ACHARYA. 2003. Sustainable Crop Production through Management of Soil Organic Carbon in Semiarid and Tropical India. J Sustainable Agriculture 21(3): 85–114.

MUHUMED MA, JUSOP S, SUNG, CTB, WAHAB PEM, PANHWAR QA. 2014. Effects of Drip Irrigation Frequency, Fertilizer Sources, and Their Interaction on the Dry Matter and Yield Components of Sweet Corn. Australian Journal of Crop Science 8(2): 223.

OKTEM AG, OKTEM A. 2005. Effect of Nitrogen and Intra row Spaces on Sweet Corn (*Zea mays saccharata* Sturt) Ear Characteristics. Asian Journal of Plant Sciences 4(4): 361–364.

QUIROL AT. 1986. Determination of the Optimum Level of NPK and Population Density for the Production of String Bean [BS Thesis]. Visayas State University, Leyte, Philippines. 78p.

PEARCE RB, MOCK JJ, BAILEY TB. 1975. Rapid Method for Estimating Leaf Area per Plant in Maize 1. Crop Science 15(5): 691–694.

SABAN Y, MEHMT A, MUSTAFA E. 2007. Identification of Advantages of Maize Legume Intercropping over Solitary Copping through Competition Indices in the East Mediterranean Region. Turk Journal Agriculture 32: 111–119.

SARCOL B, CAGASAN U. 2016. Performance of Peanut (*Arachis hypogea* L.) as Influenced by the Time of Planting Sweet Potato (*Ipomea batatas* L) as Intercrop. Annals of Tropical Research 38(1): 122–133.