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2. Researchers: Benjamin G. Manlapaz
   Supervising Science Research Specialist

   : Rose Diane A. Locaba
   Science Research Specialist I

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Prepared by:	Endorsed by:
BENJAMIN G. MANLAPAZ Supervising Science Research Specialist - ASSD	**RAPHAEL HENRI B. MUNDO, RCh** Chief Science Research Specialist – AARD
Noted by:	Certified Completed:
ENGR. LAVERNE C. OLALIA Manager III, RDE L&M	**ATTY. IGNACIO S. SANTILLANA** Deputy Administrator II, RDE

POTENTIAL YIELDS OF VARIETAL MIXTURE PLANTING FOR SUSTAINABLE SUGARCANE PRODUCTION

B.G.Manlapaz, N. C. Guiyab, R,D, Locaba, R,J.Sarol and Ma. V.A.Serrano

Abstract

Varietal mixture planting refers to the use of two or more cultivars. The lack of nurseries and supplies of planting materials left some farmers seeking any varieties nearby. However, more information is needed on the response of varietal mixtures in sugarcane growing. Hence, this study evaluated the potential of varietal mixture planting and its practicality as a viable strategy for the sustainable and profitable sugarcane industry. The study was laid out in a randomized complete block design (RCBD) under sandy soil conditions. One-way ANOVA analysis showed that planting of varietal mixtures of sugarcane produced comparable yields, and the varietal mixture treatments and the single variety planting had no significant influence or effect on the varieties' sugar rendements and sugar yields in the plant and ratoon crops. Thus, in times of insufficient planting materials of a specific variety, varietal mixture planting could be considered to achieve a sustainable crop yield, given the combinations and tested varieties in this study.

Keywords: Varietal mixture planting, single variety planting, sustainable sugarcane yield

Introduction

Sugarcane production decreased due to several factors such as planters shifting to other crops and reduced area due to land conversion from agricultural to commercial land. The lowest average production per hectare and the inadequate number of planting materials contributed to this drop and uncertainty in the productivity per unit area, despite several new high-yielding varieties developed by the government and other private institutions to improve sugar yield per hectare. However, sugarcane growers are dependent on the planting materials available per variety during crop establishment. The varietal mixture planting could resolve the need for cane points. The apparent advantages of varietal mixtures over monoculture include better yield and quality, more stable growth performance, and improved resistance to insects, pests, and diseases. Increasing the supply and distribution of cane points. It helps increase biodiversity and lessen the probability of production losses (Matsuoka et al. 2006, and Kikuchi et al. 2009). Varietal mixtures refer to planting two or more cultivars that differ in many characteristics, including disease resistance. However, they are similar enough to be cultivated together in a mixture or separately in a monoculture (Smithson et al. 1996).

A study by Takaragara et al. (2016) showed that varietal mixtures have the potential as a new strategy to achieve a high and substantial yield in some crops. Varietal Mixtures with different traits of tolerance to stresses or different growth rates create cultural breaks in the field to prevent diseases and harmful insects from spreading and use the positive effects of competition and compensation between varieties to increase growth and yield. Additionally, the Takaragawa study mentioned some observations on positive yield effects with the cultivar mixtures in sugarcane production. According to Newton et al. (1999), this type of strategy has increased crop yields and quality through competition and compensation effects between cultivars. Cadet et al. (2007) observed reduced damage from harmful nematodes through varietal mixture planting of nematode-tolerant and nematode-sensitive sugarcane cultivars. Kapur et al. (1988) showed that some mixtures of sugarcane varieties increased yield and added to yield stability compared with pure stands. Although this yield improvement is not yet fully understood, it could be attributable to a change in crop canopy structure (Tsuchiya and Kinoshita 1984). In addition, Smithson et al. (1996) mentioned that growing varietal mixtures persist because they extend the harvest and income flow and provide food diversity. Generally, they concluded that varietal mixture planting is a viable strategy for sustainable productivity in subsistence agriculture. It has the potential for improvement without the sacrifice of diversity, is an essential resource for future global food production, and may have an expanding role in modern agriculture in situations where qualitative uniformity is not the guiding priority.

Reiss et al. (2018) investigated the yield stability of cultivar mixtures that differed from single cropping. They found that the yield increased by 2.2% in cultivar mixtures relative to their monoculture components. Mixtures with more cultivars and those with more functional trait diversity showed higher yields Kapur et al. (1988) also reported an increase of 25% in cane and sugar yield in some varietal mixtures planting than in pure and single varieties. The cane and sugar yield parameters in the varietal mixture planting were more stable than in the monoculture. The response of the mixed variety planting may also vary with the change in cultural practices and climate/environmental conditions. Generally, these results suggest that cultivar mixtures are a viable strategy to increase diversity in agroecosystems, promoting increased output and stable production with less ecological influence. Moreover, Set-Tow et al. (2019) study stated that sugarcane is a monoculture plant that requires continuous cultivation without competing with other crops and takes a long cultivation period to ratoon crops. Consequently, the theory of mixed varietal planting altogether in the same area may be an alternative approach for sugarcane production to increase ratooning ability.

The Sugar Regulatory Administration's 2002 annual report noted that about 20% of sugarcane planters in the Pampanga, Tarlac, and Balayan Mill districts have successfully used cultivar mixture planting in sugarcane production. The shortage of planting materials with known variety names and characteristics forces planters to plant various varieties in a mixture to meet the demand in the farming area. The planter's recorded yield was 40 TC/Ha, comparable with the district average of 47 TC/Ha and 45 TC/Ha, respectively.

Besides, the study by Kapur et al. (1987) stated that the limited use of mixtures includes varietal differences in maturity, tillering capacity, and disease susceptibility. It may affect cane growth and development. However, the concerned government agency and some sugarcane planters' groups have refused to accept varietal mixture technology. Since there was limited information on the response of varietal mixtures in sugarcane, the present study investigates the performance of six sugarcane varieties in single and mixed culture planting in Angeles sandy loam soil. Hence, the main goal of this study is to collect more scientific-based information to support the varietal mixture's potential and practicality as a viable strategy for the sustainable and profitable sugarcane industry.

Objectives,

1. To determine the influence of planting varietal mixtures on the growth and yield of six high-yielding sugarcane varieties in the plant crop.
2. To evaluate the cost and return analysis of using varietal mixtures as a new feasible strategy to attain better yield for a sustainable sugarcane industry.

METHODOLOGY

Time and Place of the Study

The study was conducted at the Sugar Regulatory Administration-Luzon Agricultural Research and Extension Center (SRA-LAREC). Paguiruan, Florida Blanca, Pampanga located at 14°59 "22.0.04" N and 120°31 "39.04" E under sandy loam soil with an elevation of 27 meters above sea level from January 2021 to February 2022.

Variety characteristics and crop type

1. **Phil 06-1899**, erect to recumbent and a moderate grower. Its leaves are narrow, erect with drooping tips, and self-detrashing. It is resistant to smut, downy mildew, and leaf scorch but susceptible to yellow spots. Which has a medium to high sucrose content (1.89 L-Kg/TC and above) and high tonnage (100 TC/Ha and above),
2. **Phil 06-2289**, erect to recumbent and a fast grower. The leaves are medium, erect with drooping tips, and have a short inner lanceolate. It is self detrashing. Which has a high sucrose content (2.15 L-Kg/TC and above) and high tonnage (100 TC/Ha and above).
3. **Phil 04-1011**, erect to recumbent and a fast grower. The leaves are medium size, erect with no auricle. It is highly self detrashing. Which has a medium (1.89-2.14 L-Kg/TC to high sucrose 2.5 above) and high tonnage (100 TC/Ha above),

4. **Phil 7544***,* fast grower, erect to recumbent; leaves broad and drooping; sheath green w/ purple base and profuse trichomes; stalk medium- thick in size, cylindrical; TC/Ha: 80-99; LKg/TC: 2.15 & up.
5. **VMC 71-39,** moderate tillering habit, average germination, slow growth habit and good ratooner, semi-self detrashing, profuse flowering, erect stalks, mature at 10-12 months, moderate tonnage, high sweetness, moderately susceptible to smut, resistant to downy mildew, leaf scorch, and rust.
6. **VMC 84-524**, heavy tillering habit, average germination, and growth habit, semi-self-detrashing, reluctant in flowering, the stalk is reclining to lodging, mature at 10-11 months, high tonnage and moderately high sweetness, moderately resistant to smut, resistant to downy mildew, and highly resistant to leaf scorch and rust.

Experimental Designs and Treatments

The study was laid out in a randomized complete block design with four replications of 9 m x 6 rows and a 1.5 m furrow distance. The distance between plots was 3.0 m and 3.0 m between blocks. Test varieties were identified based on similar and different agronomic traits. Four cane points per linear meter in mixtures (alternate by the plant within the furrow or alternate by furrow per variety) and either single planting or in monoculture containing equal proportions of the component were followed in this study.

The different mixture treatments were tested as follows.

<u>Mixture planting</u>

T1 = Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524 (alternate varieties within furrow)

T2 = Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524 (alternate by furrow)

T3 = Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899 (alternate varieties within furrow)

T4 = Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899 (alternate by furrow)

T5 = Phil 75-44 + Phil 06-2289 (alternate by furrow)

T6 = Phil 75-44 + Phil 04-1011 (alternate varieties within furrow)

<u>Single planting</u>

T7 = Phil 7544

T8 = VMC 71-39

T9 = Phil 04-1011

T10 = Phil 06-1899

T11 = VMC 84-524

T12 = Phil 06-2289

Care and Maintenance

The usual cultural practices in Pampanga Mill District were undertaken during land preparation, proper care, and management for growing sugarcane in the plant and ratoon crop. The replanting of missing hills per plot was established with chipped tillers. However, strictly monitoring the planting combinations of the component varieties per treatment was employed. The required fertilizer of 180 kg N/Ha was applied in a split dosage. The first dose was applied one and a half months after planting and the remaining half dosage three months after planting or before the canopy closes.

Data Collection at Harvest

Data taken from the four inner rows per plot were: number of millable stalks/plots, stalk diameter (cm), stalk length (cm), weight per stalk, ton cane per hectare (TC/Ha), sugar rendements (L-Kg/TC). The Sugar yield (L-Kg/Ha) was computed using the TC/ha x LKG/TC formula. The data were analyzed using ANOVA and HSD at the 5% level of significance. Harvesting was done 12 months after planting (MAP).

Results and Discussion

Millable stalk attributes of six sugarcane varieties as influenced by varietal mixture planting in the plant and ratoon crops.

In the Plant crop**,** the data analysis of the length, diameter, and weight per stalk of the samples collected revealed that only the weight per stalk had significant differences, compared with the statistically similar values obtained from the length and diameter from plots between the mixtures and the single planted variety (Table 1). It was revealed that the mixture of Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524 (T3) within furrows had the significantly heaviest stalks, on par with the stalks obtained from T10: Phil 06-1899 and T11: VMC 84-524, respectively. On the other hand, the significantly smallest weight value was obtained from the single planting of VMC 71-39.

In the Ratoon crop, the results of the ratoon crop data analysis highlight the significant differences in the diameter and weight per stalk when comparing mixture planting treatments with single-planted varieties. Specifically, the data demonstrates that Phil 06-2289 (T10) exhibits a significantly larger stalk diameter compared to other varieties, Phil 7544 (T7), VMC 71-39 (T8), and Phil 04-1011 (T9). Additionally, the study identifies that the heaviest stalks were associated with specific treatments, particularly T12: Phil 06-2289, T8: VMC 71-39, and T9: Phil 04-1011. The heavy stalks are advantageous for sugarcane production, as they are directly linked to higher sugar and fiber content in each millable cane, further emphasizing the potential of these varieties in enhancing overall crop productivity.

The study's results reveal that despite the significant variations in stalk diameter and weight observed in the tested sugarcane varieties, the values of these notably larger and heavier millable stalks remained comparable to those from treatments involving varietal mixture or single variety planting. It shows that the choice of planting method, whether a mixed variety or a single variety approach, does not compromise the overall productivity potential of the crop when it comes to the stalk size and weight of the varieties.

Table 1. Millable stalk attributes of six sugarcane varieties as influenced by varietal mixture and single variety planting in the plant crop in Angeles Loam sand at SRA-LAREC

Treatments	Length (cm)	Diameter (cm)	Weight per Stalk (kg)
T1: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	262.60	3.14	2.02ab
T2: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	267.05	3.16	1.93ab
T3: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	276.47	3.25	2.32a
T4: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	263.45	3.06	2.03ab
T5: Phil 75-44 + Phil 06-2289	261.37	3.09	2.09ab
T6: Phil 75-44 + Phil 04-1011	280.15	2.96	1.90ab
T7: Phil 7544	279.72	3.07	2.13ab
T8: VMC 71-39	259.05	2.74	1.64b
T9: Phil 04-1011	266.50	2.98	1.93ab
T10: Phil 06-1899	272.82	3.15	2.33a
T11: VMC 84-524	266.30	3.08	2.22a
T12: Phil 06-2289	277.75	3.04	2.01ab
F-Test value	n. s	n. s	**
C.V. %	6.74	5.92	10.13

Means with the same letter are not significantly different.

Table 2. Millable stalk attributes of six sugarcane varieties as influenced by varietal mixture and single variety planting in the *ratoon crop* in Angeles Loam sand at SRA-LAREC

Treatments	Length (cm)	Diameter (cm)	Weight per Stalk (kg)
T1: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	257.35	2.84abc	1.69 ab
T2: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	241.25	3.00 ab	1.61 ab
T3: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	268.40	2.75 abc	1.66 ab
T4: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	244.30	2.89 ab	1.65 ab

T5: Phil 75-44 + Phil 06-2289	251.70	2.76 abc	1.60 ab
T6: Phil 75-44 + Phil 04-1011	266.75	2.76 abc	1.66 ab
T7: Phil 7544	257.35	2.72 bc	1.73 ab
T8: VMC 71-39	237.46	2.51 c	1.29 b
T9: Phil 04-1011	250.85	2.30 bc	1.29 b
T10: Phil 06-1899	259.62	3.10 a	2.10 a
T11: VMC 84-524	246.28	2.78 abc	1.61 ab
T12: Phil 06-2289	237.00	2.75 abc	1.52 b
F-Test value	n. s	**	**
C.V. %	6.72	**5.13**	**12.33**

Means with the same letter are not significantly different.

Cane tonnage, sugar rendements, and sugar yield of six sugarcane varieties as influenced by varietal mixture planting in the Plant and Ratoon crops.

In the plant crop, the varietal mixture and single variety planting significantly influenced the cane tonnage yield of the test varieties. The Phil 7544 (T7) single planting produced significantly more cane tonnage than T8 (VMC 7139) and was comparable to the other varietal mixtures and single-planted treatments (Table 3). There were no significant variations in sugar rendements and sugar yield.

In the ratoon crop, the number of millable stalks per plot, cane tonnage yield, sugar contents, and sugar yield per hectare of the test varieties in the ratoon crop were not significantly influenced by the varietal mixture or single variety planting (Table 4). The VMC 7139 (T8) produced more millable stalks, while the Phil 75-44 mixtures + Phil 06-2289 + Phil 04-1011 + Phil 06-1899 (T3) had the least. The Phil 7544 (T7) single planting produced higher cane tonnage, but VMC 71-39 (T8) produced the lowest. Phil 06-2289 (T12) gave a higher sugar content, yet Phil 7544 (T7) gave up the smallest. The mixture of T4: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899 (T4) provides a better yield. Besides, the mixtures of Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899 (T3) come up with a lesser yield.

The result implies that the varietal mix of sugarcane produced comparable yields and that the varietal mixture treatments and the single planting had no significant influence or effect on the varieties' sucrose content and sugar yields. Statistics show that the output of varieties planted in alternate rows, alternate by plants, or furrows is the same as that of the production of a single cultivar.

Takaragawa et al. (2016) study revealed that the results demonstrate the influence of cultivar mixtures may introduce a compensation effect for the yield reduction of one cultivar by the yield increment of another cultivar and contribute to a more uniform overall yield. However, according to J. B. Smithson et al. (1996), in their review of research on agronomic and disease aspects of mixtures in modern agriculture, it is also clear that improved stability and disease severity are common characteristics of mixed variety when compared to their components in monoculture. Such benefits are valuable in both modern and subsistence agriculture. In these cases, the yield advantage of mixtures to monoculture is negligible.

In contrast, Reiss et al. (2018) found that the yield increased by 2.2% generally in cultivar mixtures relative to their monoculture components. Combinations with more cultivars and those with more functional trait diversity showed higher comparable production. Under biotic stressors, such as disease pressure, and abiotic stressors, such as low soil organic matter levels and nutrient availability, this diversity effect was extreme, resulting in higher relative yields. Lastly, cultivar mixtures usually had more stable production than monocultures, mostly when the weather at a site changed regularly.

Table 3. Cane tonnage, sugar contents, and sugar yield of six sugarcane varieties as influenced by varietal mixture and single variety planting in the *plant crop* in Angeles Loam sand at SRA-LAREC

Treatments	Millable Stalk	Cane yield	Sugar rendements	Sugar yield
T1: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	336.25	94.94 ab	1.88	179.82
T2: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	365.00	93.98 ab	1.99	187.96
T3: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	336.50	90.36 ab	1.83	166.58
T4: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	332.25	93.71 ab	1.83	172.77
T5: Phil 75-44 + Phil 06-2289	367.25	106.28 ab	1.82	195.03
T6: Phil 75-44 + Phil 04-1011	380.75	107.62 ab	1.87	201.31
T7: Phil 7544	327.50	114.03 a	1.88	215.38
T8: VMC 71-39	335.75	81.84 b	2.02	165.00
T9: Phil 04-1011	326.25	93.21 ab	1.90	178.43
T10: Phil 06-1899	316.75	84.71 ab	1.86	158.78
T11: VMC 84-524	303.75	102.53 ab	1.93	196.89

T12: Phil 06-2289	324.00	87.60 ab	1.99	174.37
F-Test value	n. s	**	n. s	n. s
C.V. %	14.02	13.42	5.54	14.79

Means with the same letter are not significantly different.

Table 4. Cane tonnage, sugar contents, and sugar yield of six sugarcane varieties as influenced by varietal mixture and single variety planting in the *ratoon crop* in Angeles Loam sand at SRA-LAREC

Treatments	Millable Stalk	Cane yield	Sugar rendements	Sugar yield
T1: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	435.50	84.51	1.90	160. 01
T2: Phil 75-44 + VMC 71-39 + Phil 06-2289 + VMC 84-524	427.00	75.45	1.99	150. 24
T3: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	400.75	71.32	1.88	134. 99
T4: Phil 75-44 + Phil 06-2289 + Phil 04-1011 + Phil 06-1899	419.75	93.89	2.02	191.11
T5: Phil 75-44 + Phil 06-2289	417.50	84.71	2.09	177.41
T6: Phil 75-44 + Phil 04-1011	425.75	84.64	1.98	167.48
T7: Phil 7544	416.50	97.70	1.84	178.92
T8: VMC 71-39	461.25	69.11	2.10	145.97
T9: Phil 04-1011	425.75	83.71	2.01	168.30
T10: Phil 06-1899	417.50	75.58	1.92	146.05
T11: VMC 84-524	409.25	70.62	2.16	152.41
T12: Phil 06-2289	420.50	78.82	2.18	171.48
F-Test value	n. s	n. s	n. s	n. s
C.V. %	7.39	16.31	7.24	19.22

Means with the same letter are not significantly different.

CONCLUSIONS

This study evaluates the potential yields of varietal mixture planting for sustainable sugarcane production in plant and ratoon crops. Among the different millable stalk attributes measured, only the stalk weight and diameter per stalk resulted in a significant difference in the plant and ratoon crops and cane tonnage in the plant crop. All other parameters were on par for both cropping seasons.

The results show that the varietal mixture planting of sugarcane produced comparable yields, and the varietal mixture treatments and the single planting had no significant influence or effect on the varieties' sucrose content or sugar yields. Hence, varietal mixture planting could be one way to address the lack of planting materials during crop establishment and achieve a sustainable crop yield, given the combinations and tested varieties in this study. Furthermore, similar studies could also recommend using different variations and mixtures to assess further possible combinations of mixed variety planting.

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