Can Wider Furrows Reduce Cane and Sugar Yield?[1]

Jojit A. Demaraye, Haydee P. Villariez, and Rosalyn T. Luzaran[2]

ABSTRACT

To provide a concrete scientific data that willgauge the effect of wider furrow spacing oncane and sugar yield, PHILSURIN conducted a Furrow Spacing x Variety Trial. The trialtested six furrow spacings including the 1.3 m, 1.5 m, 1.8 m single-row planting, 1.8 m-double row planting, 2.2 m-single row planting, and 2.2 m-double row planting. Three varieties were tried: VMC 84-524, PSR 02-247 and PSR 03-171.

Results showed that 1.8 mspacing with single row plantinggave slightly lower stalk population than the 1.3 m and 1.5 m spacings;but it had bigger size and heavier stalks. Likewise, the 1.8 m-double row planting showed generally similar stalk measurements and population with the 1.3 m and 1.5 m spacings. Over-all, TC/Ha, LKg/TC and LKg/Ha were similar under 1.3 m, 1.5 m, and both the single and double row plantings under the 1.8 m spacing. On the other hand, both single and double row plantings under the 2.2 m spacing had low population per unit areathat drasticallyreduced tonnage and sugar yield.

Based on these results, 1.8 m furrow spacing both in single or double rows could be recommended on a low tillering variety like PSR 02-247, and on moderately high tillering varieties like PSR 03-171 and VMC 84-524, without sacrificing cane and sugar yield per hectare. Likewise, due to lesser number of rows, 1.8 m spacingcould reduce fuel consumption during inter-row cultivation by 26.5% and 16.7% respectively versus 1.3 m and 1.5 m spacings.

---

[1] ***A paper presented during the 66th PHILSUTECH Annual Convention at Waterfront Hotel,Cebu City.***

[2] ***Agronomist, Senior Agronomist, and Station Manager/Pathologist respectively of the Philippine Sugar Research Institute Foundation, Inc..***

I. INTRODUCTION

Scarcity of labour is an enormous challenge that the sugar industry now faces. These recent years witnessed the deterioration of some sugarcane crop due to over maturity because of the dire lack of cane cutters. Most of them are now hired as construction workers and some are in the advanced age that cannot withstand hard work.Very minimal batches of younger sugarcane farm workers are forthcoming.Thus, thereis a need to embrace predominantly mechanized farm operations.

Conventional furrow spacing in the Philippines ranges from 1.0 to 1.3 meters. Those that employ a semi-mechanized farming, that is, utilizing tractor-driven implements mostly for weeding and cultivation, are using the 1.3 m. spacing. Those that cannot afford tractor cultivation opted to stick to 1.0 m. With the necessity of mechanized sugarcane farming, wider furrows are required to efficiently operate the machines for the varied activities involved from planting until harvest. However, most sugarcane planters are apprehensive to adapt furrow spacing as wide as 1.8m or 2.2m because these might significantly reduce tonnage and sugar yield due to lesser population resulting from lower number of rows per hectare.A trialdone in Ethiopia reported higher cane and sugar yield at wider furrow spacings of 1.65 and 1.85 cm compared to 1.45 cm (WorkuBurayu. 2001). Another field experiment showed significantly higher cane and sugar yield at 180 cm furrow spacing over the 60 cm spacing (Sami Ullah et. al. 2016).In Australia, a study conducted showed that sugarcane possesses a capacity to compensate for different row spacings and planting densities through its response in stalk number and individual stalk weight. Furrow spacings ranging from 1.5m single rows (the current industry standard) to 1.8m dual rows (50 cm between duals), 2.1-m dual (80 cm between duals) and triple (65 cm between triples) rows, and 2.3-m triple rows (65 cm between triples) produced similar yields. These experiments underscore the physiological and environmental plasticity that exists in sugarcane.

Thus, PHILSURIN had conducted a Furrow Spacing x Variety trial in order also to have a concrete data as to the effect of wider furrows on cane and sugar yield on its newly released varieties: PSR 02-247and PSR 03-171 in comparison with the existing commercial variety, VMC 84-524.

II. MATERIALS AND METHODS

The trial was set-up in a field with sandy loam soil at Hda Sta. Cruz, Victorias City, Negros Occidental. This was laid down in a strip plot design and replicated three times. Six different furrow spacings were tried (Table 1 and Figures 1 and 2). The size of each plot varied from 104 to144 m^2; while planting rate was pegged at 4.5 lacsas/hectare.

Three sugarcane varieties were used:VMC 84-524, PSR 02-247 and PSR 03-171.

Table 1. Furrow spacings tried, planting rate, number of seedpieces and plot size used for this trial.

Furrow spacings tried	Planting rate /ha	Number of Canepoints/linear Meter	No. and length of rows/plot	Plot Size
1.3 m- single row	4.5 Lacsas	5.85	8 rows x 10 m	104 sqm
1.5 m- single row	4.5 Lacsas	6.75	8 rows x 10 m	120sqm
1.8 m- single row	4.5 Lacsas	8.09	8 rows x 10 m	144 sqm
1.8 m- double row spaced at .30 cm.	4.5 Lacsas	8.09	8 double rows x 10 m	144 sqm
2.2 m- single row	4.5 Lacsas	10.0	6 rows x 10 m	132 sqm
2.2 m- double row spaced at .30 cm.	4.5 Lacsas	10.0	6 double rows x 10 m	132 sq.m

Fertilizers were applied based on recommendation from soil analysis. Weed management employed herbicide spray at one week after planting and handweeding three times until closing of canes.Most of the cultivations were done using carabao-drawn plow with only one pass of tractor-drawn ripper at 2 months after planting.

All growth and yield data were taken from the inner 6 rows of the 1.3 m to 1.8m spacing, and from the inner 4 rows of the 2.2 m spacing (for both single and double rows). The trial was harvested at 10.5 months. Stalk count, size, length, and average weight were taken at harvest. Plots were weighedto compute TC/Ha. LKg/TC was determined from juice analysis of ten stalk samples per plot. Sugar yield or LKg/Ha was computed from TC/Ha x LKg/TC. All data were subjected to statistical analysis using ANOVA and treatments means were compared using $LSD_{0.05}$.

Replicate I					
1.5 m Single	1.3 m Single	2.2 m Double	2.2 m Single	1.8 m Double	1.8 m Single
V1- PSR 03-171	V1	V1	V1	V1	V1
PSR 02-247	V2	V2	V2	V2	V2
V3- VMC 84-524	V3	V3	V3	V3	V3
3 meter gap					
Replicate II					
2.2 m Double	2.2 m Single	1.8 m Double	1.8 m Single	1.5 m Single	1.3 m Single
V2- PSR 02-247	V2	V2	V2	V2	V2
V3- VMC 84-524	V3	V3	V3	V3	V3
V1- PSR 03-171	V1	V1	V1	V1	V1
3 meter gap					
Replicate III					
1.3 m Single	1.5 m Single	1.8 m Single	1.8 m Double	2.2 m Single	2.2 m Double
V2- PSR 02-247	V2	V2	V2	V2	V2
V3- VMC 84-524	V3	V3	V3	V3	V3
V1- PSR 03-171	V1	V1	V1	V1	V1

Fig. 1. Field Lay-out of the Variety x Furrow Spacing Trial

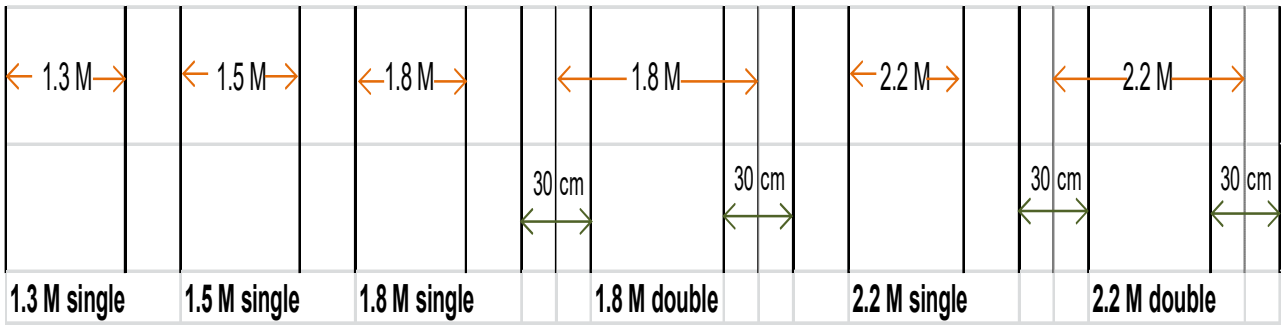


Figure 2. Graphical representation of the furrow spacings tried

III. RESULTS AND DISCUSSION

A. Growth Parameters from 3.0 to 7.0 Months

Germination count taken at 1.0 month after planting showed minimal missing hills which were immediately re-planted. Tillering and stalk population counts andmeasurements ofplant height and size were takenand compared starting 3.0 until 7.0 months.

1. Tiller and stalk population

Regardless of furrow spacing, all three varieties showed statistically similar tiller counts at 3.0 months, but it was highest under PSR 03-171 at 5.0 moths. At 7.0 months, PSR 03-171 and VMC 84-524 exhibited similar stalk population. Due to its inherently lower tillering ability, PSR 02-247 gave the lowest tiller and stalk counts at 5.0 and 7.0 months after planting (Table 2).

On the other hand, among furrow spacings, the 1.8 m-double row planting gave the highest tiller and stalk counts from 3.0 until 7.0 months regardless of varieties. It was followed by 1.3m and 1.5 m spacings. Lower tiller and stalk population was taken from 1.8 m-single row planting; but the lowest counts at all observation times were taken from 2.2 m-single row planting (Table 3).

Table 2. Tiller and stalk counts per m^{2}of the three varieties at 3.0 to 7.0 months regardless offurrow spacing.

Variety	3 MAP	5 MAP	7.0 MAP
VMC 84-524	10.4 *a*	9.1 *b*	8.2 *a*
PSR 02-247	10.3 *a*	8.4 *c*	7.7 *b*
PSR 03-171	10.8 *a*	9.9 *a*	8.1 *a*
% C.V.	*18.25*	*9.66*	*4.94*

Means with the same letter are not significantly different at LSD $_{0.05}$

Table 3. Tiller and stalk counts per m^{2}under the different furrow spacing at 3.0 to 7.0 monthsregardless of varieties.

Furrow Spacing	3 MAP	5 MAP	7.0 MAP
1.3 m	11.0 *ab*	9.5 *bc*	8.8 *b*
1.5 m	10.0 *bc*	9.6 *b*	8.3 *c*
1.8 m single	8.9 *bc*	8.5 *d*	7.5 *e*
1.8 m double	13.2 *a*	11.1 *a*	9.2 *a*
2.2 m single	8.7 *c*	7.3 *e*	6.3 *f*
2.2 m double	11.1 *ab*	8.8 *cd*	8.0 *d*
% C.V.	*21.18*	*7.66*	*9.60*

Means with the same letter are not significantly different at LSD $_{0.05}$

2. Plant height and size

The three varieties showed generally similar height at 3.0 and 7.0 months, although PSR 02-247 was taller compared to the other two at 5.0 months. Comparing the different furrow distances, the 1.3 m and 1.5 m were similar at all observation times; and these were generally taller compared to the other spacings. The 1.8 m-single row planting was shorter compared to 1.3 m and 1.5 m at 3.0 and 5.0 months but was similar with these two spacings at 7.0 months. On the other hand, the 1.8 m-double row planting and both single and double row planting under the 2.2 m spacing were shorter compared to the 1.3 m and 1.5 mspacings at 3.0 and 7.0 months. It can be inferred that there was stiff competition for sunlight under the1.3 m and 1.5 mspacings; thus, taller height was noted under these furrow spacings(Tables 4 and 5).

Table 4.Plant height(cm.) of the three varieties at 3.0 to 7.0 months regardless of furrow spacing.

Variety	3 MAP	5 MAP	7 MAP
VMC 84-524	88 *a*	199 *b*	257 *a*
PSR 02-247	90 *a*	210 *a*	261 *a*
PSR 03-171	89 *a*	195 *b*	258 *a*
% C.V.	*5.11*	*10.12*	*7.23*

Means with the same letter are not significantly different at LSD $_{0.05}$

Table 5. Plant height (cm.) under the different furrow spacings at 3.0 to 7.0 months regardless of varieties.

Furrow Spacing	3 MAP	5 MAP	7.0 MAP
1.3 m	101 *a*	209 *a*	265 *a*
1.5 m	103 *a*	203 *ab*	265 *a*
1.8 m single	77 *c*	196 *b*	259 *a*
1.8 m double	85 *b*	200 *ab*	256 *bc*
2.2 m single	82 *bc*	202 *ab*	253 *c*
2.2 m double	87 *b*	199 *b*	254 *bc*
% C.V.	*10.98*	*5.72*	*7.23*

Means with the same letter are not significantly different at LSD $_{0.05}$

In stalk size, PSR 03-171 was bigger compared to the other two varieties which were similar in diameterfrom 5.0 to 7.0 months. Among furrow spacings, stalk size wasgenerally statistically similar at 5.0 and 7.0 months,except forthe 1.8 m-double row planting which was thinner at 7.0 months (Tables 6 and 7).

Table 6. Stalk size (cm.) of the three varieties at 5.0 and 7.0 months regardless of furrow spacing.

Variety	5 MAP	7.0 MAP
VMC 84-524	2.9 *a*	2.9 *b*
PSR 02-247	2.9 *a*	2.9 *b*
PSR 03-171	3.0 *a*	3.0 *a*
% C.V.	*9.36*	*7.37*

Means with the same letter are not significantly different at LSD $_{0.05}$

Table 7. Stalk size (cm.) under the different furrow spacings at 5.0 and 7.0 months regardless of varieties.

Furrow Spacing	5 MAP	7.0 MAP
1.3 m	2.9 *a*	2.9 *a*
1.5 m	3.0 *a*	3.0 *a*
1.8 m single	3.0 *a*	3.0 *a*
1.8 m double	2.9 *a*	2.7 *b*
2.2 m single	3.0 *a*	2.9 *a*
2.2 m double	2.9 *a*	2.9 *a*
% C.V.	*3.37*	*5.92*

Means with the same letter are not significantly different at LSD $_{0.05}$

B. Stalk Parameters at Harvest (Size, Length, Average Weight and Stalks/m^2)

Regardless of furrow spacing, all three varieties were similar in stalk size at harvest. PSR 02-247 got the longest stalks but the lowest population. On the other hand, PSR 03-171 and VMC 84-524 were similar in length and stalk population, but VMC 84-524 was lighter in average weight compared to the other two varieties (Table 8).

Table 8. Average stalk parameters at harvest of three varieties regardless of furrow spacing

Variety	Size (cm.)	Length (cm.)	Stalk Weight (Kg.)	Stalks/M^2
VMC 84-524	2.8 *a*	281 *b*	1.80 *b*	7.11 *a*
PSR 02-247	2.9 *a*	292 *a*	1.95 *a*	6.54 *b*
PSR 03-171	2.9 *a*	280 *b*	1.97 *a*	7.19 *a*
%C V.	*5.88*	*3.66*	*12.24*	*7.62*

Means with the same letter are not significantly different at LSD $_{0.05}$

Regardless of varieties, the 1.8m-single row spacing gave the biggest size and the heaviest weight per stalk; while the 1.3m showed the thinnest and tallest stalks. The 1.5 m was smaller in size compared to the 1.8 m-single row, but was similar in all other parameters with the 1.3 m and with the 1.8 m-double row planting. On the other hand, the 2.2m both at single and double row plantings were comparable in size, length and average weight with the 1.5 m; but both plantings under the 2.2m showed the lowest stalk population per square meter(Table 9).

Table 9. Average stalk parameters at different furrow spacing regardless of varieties

Furrow Spacing	Size (cm.)	Length (cm.)	Stalk Weight (Kg.)	Stalks/M^2
1.3 m	2.7 *c*	292 *a*	1.89 *ab*	7.32 *a*
1.5 m	2.8 *bc*	285 *abc*	1.93 *ab*	7.19 *a*
1.8 m single	3.0 *a*	288 *ab*	2.05 *a*	7.14 *a*
1.8 m double	2.8 *bc*	282 *bc*	1.89 *b*	7.23 *a*
2.2 m single	2.8 *bc*	282 *bc*	1.92 *ab*	6.43 *b*
2.2 m double	2.9 *ab*	278 *c*	1.90 *ab*	6.37 *b*
%C V.	*4.04*	*9.07*	*13.09*	*22.48*

Means with the same letter are not significantly different at LSD $_{0.05}$

C. TC/Ha, LKg/TC and LKg/Ha

Among varieties, PSR 03-171 showed the highest tonnage but the lowest LKG/TC; while PSR 02-247 gave the highest LKG/TC and comparable tonnage with VMC 84-524.Hence, regardless of furrow spacing, PSR 02-247 was highest in sugar yield at 237 LKg/Ha; while PSR 03-171 ended up similar with VMC 84-524 at 209 and 204 LKg/Ha respectively (Table 10).

Table 10. Average TC/Ha, LKg/TC and LKg/Haof the three varieties regardless of furrow spacing

Variety	TC/Ha	LKg/TC	LKg/Ha
VMC 84-524	92 *b*	2.23 *b*	204 *b*
PSR 02-247	91 *b*	2.61 *a*	237 *a*
PSR 03-171	102 *a*	2.06 *c*	209 *b*
%C V.	*13.60*	*9.39*	*17.35*

Means with the same letter are not significantly different at LSD$_{0.05}$

Comparing furrow spacings, the 1.8 m-single row plantingshowedcomparabletonnage with the 1.3 m and the 1.5 mspacings. This is attributed to its bigger size and heavier stalks,although it was slightly lower in stalk population compared to the 1.3 mand 1.5 mspacings. In contrast, the 1.3 mspacing showed the highest number of stalk population but it was thinner and lighter in weight. Moreover, the 1.8 m-double row planting exhibited similar stalk size, weight and stalk population with the 1.3 m, thus, it also showed similar tonnage with it. Likewise, the 1.5 m which showed generally similar length, average weight and population with the 1.3 m and 1.8 m-double row, eventually showed similar tonnage with these latter two spacings. On the other hand, both single and double row plantings at 2.2 mspacing exhibited the lowest tonnage due to lower stalk population per unit area(Table 11).

LKg/TC was not affected by furrow spacings; thus, the effect on TC/Ha was reflected in sugar yield. The 1.3 m, 1.5 m and both the single and double rows under the 1.8 m spacing were statistically similar in LKg/Ha; while the 2.2 m both at single and double rows were lowest in sugar yield.

Table 11. Average TC/Ha, LKg/TC and LKg/Ha under different furrow spacings regardless of varieties

Furrow Spacing	TC/Ha	LKg/TC	LKg/Ha
1.3 m	95 *a*	2.31 *a*	219 *a*
1.5 m	99 *a*	2.31 *a*	227 *a*
1.8 m single	100 *a*	2.27 *a*	225 *a*
1.8 m double	99 *a*	2.31 *a*	227 *a*
2.2 m single	88 *b*	2.31 *a*	201 *b*
2.2 m double	88 *b*	2.28 *a*	200 *b*
%C V.	*14.88*	*10.43*	*19.69*

Means with the same letter are not significantly different at $LSD_{0.05}$

Looking at the response of each variety under the different furrow spacings, it was noted that VMC 84-524, PSR 02-247, and PSR 03-171 behaved almost similarlyalthough they have different tillering capacity. PSR 02-247 is a low tillering cane while VMC 84-524 and PSR 03-171 have moderately high tillering. It wasapparent that all three varieties got similar tonnage at 1.3 m, 1.5 m and 1.8 m spacings; and all showed the lowest tonnage at 2.2 m furrow spacingboth at single and double row plantings(Table 11).

Table 11. TC/Ha of different varieties at different furrow spacing

Furrow Spacing (m.)	VARIETY		
	VMC 84-524	PSR 02-247	PSR 03-171
1.3 m	96	91	99
1.5 m	95	95	108
1.8 m single	96	95	110
1.8 m double	97	92	108
2.2 m single	83	87	93
2.2 m double	86	87	93

D. Computed reduction in fuel cost during mechanical cultivation

After establishing the 1.8 m spacing as comparable in tonnage and sugar yield with the 1.3 m and 1.5 m spacings, the economic benefit due to reduced fuel consumption during cultivation was computed. Four cultivation activities were included such as ripping, passing of chisel plow, interrow disc cultivation and hilling-up. Due to lesser number of passes and turns of tractor, the 1.8 m spacing will have a 26.5% reduction in fuel cost compared to 1.3 m spacing and 16.7% reduction versus the 1.5 m spacing (Table 12).

Table 12. Cost of fuel during mechanical cultivation at different furrow spacing

Furrow Spacing	No. of rows to be cultivated per hectare (100m length)	Diesel Consumption[a] (L/Ha/pass)	Diesel Price/L (₱)	No. of Cultivation	Fuel cost (₱)	% Reduction in Fuel Cost compared to	
						1.3 m	1.5 m
1.3 m	77	17	43	4	2,924.00	-	-
1.5 m	67	15	43	4	2,580.00	11.8 %	-
1.8 m	56	12.5	43	4	2,150.00	26.5 %	16.7 %
2.2 m	45	10	43	4	1,720.00	41.2 %	33.3 %

[a] *- 90 HP Tractor*

SUMMARY AND RECOMMENDATIONS

To determine the effect on cane and sugar yield of wider furrows as a requirement for mechanized harvesting, PHILSURIN conducted a Furrow spacing x Variety trial. Six furrow spacings were tried including the 1.3 m 1.5 m, 1.8 m-single row planting, 1.8 m-double row planting, 2.2 m-single row planting, and 2.2 m-double row planting. An existing commercial variety(VMC 84-524) and two recently released varieties (PSR 02-247 and PSR 03-171)were used.

Results showed that although the 1.8 m. single row planting gave slightly lower stalk population than the 1.3 m and 1.5 mspacings, it showed bigger size and heavier stalks compared to the latter spacings; thus it ended up having similar tonnage with them. Moreover, the 1.8 m-double row planting showed generally similar stalk measurements, population and tonnage with 1.3 m and 1.5 m spacings. Over-all, there were no significant differences in TC/Ha, LKg/TC andLKg/Ha between 1.3 m, 1.5 m, and both the single and double row plantings under the 1.8 mspacing. On the other hand, both single and double row plantings under the 2.2 mspacingexhibited the lowest population per m^2drastically resulting tolower tonnage and sugar yield. The three varieties responded similarly to the different spacings regardless of theirinherent tillering capacity. PSR 02-247 is a low tillering cane while VMC 84-524 and PSR 03-171 have moderately high tillering.

Based from these results it could be recommended that Planters could go into 1.8 mfurrow spacing either in single or double-row planting without sacrificing the yield. With wider furrows, more mechanized field operation could beemployedwhich is faster, practical, and economical than intensive manpower usage. Likewise, with 1.8 m spacing, fuel consumption during inter-row cultivation could be reduced by 26.5% and 16.7% respectively compared to 1.3 m and 1.5 m spacings,due to lesser number of passes andturns of tractor in a hectare of field.

Additionally, further study will be done on furrows wider than the 1.8 m using a heavy tillering variety to determine how wide a furrow could go without reducing the tonnage and sugar yield.

DOCUMENTATIONof ACTIVITIES and OBSERVATIONS

Field Lay-outing and Furrowing

Set-up of Trial

Field Ripping at 2.0 months

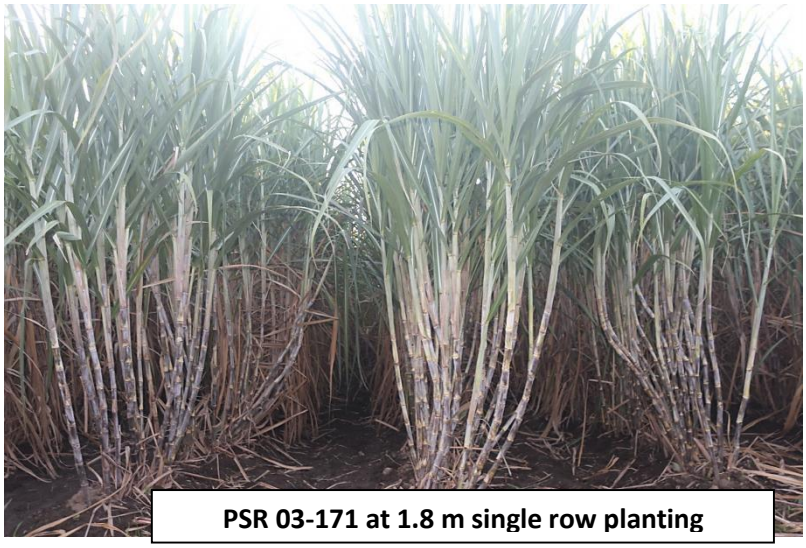
Tillering and stand at 3.0 months

PSR 03-171 at 1.8 m spacing- single row planting

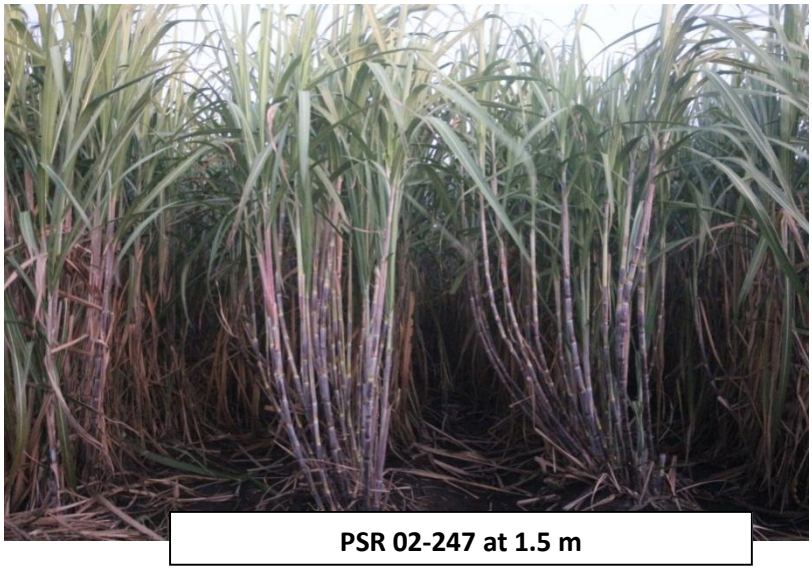
PSR 02-247 at 1.5 m furrow spacing

PSR 02-247 at Double vs single row planting (2.2m)

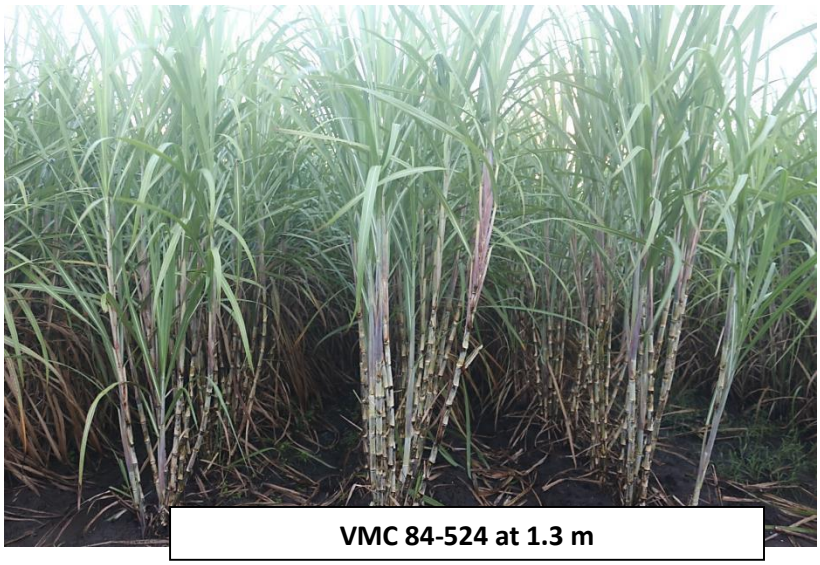
Crop stand at 6.5 months



PSR 03-171 at 1.8 m single row planting

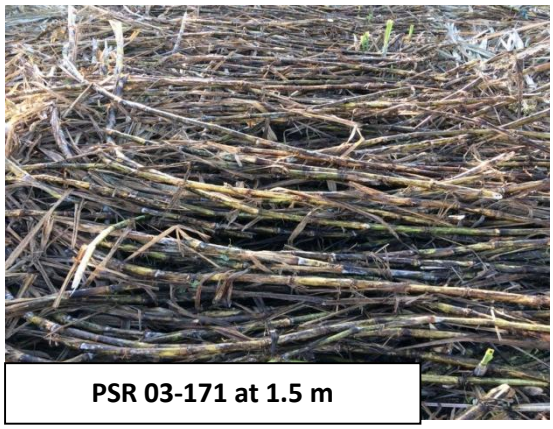


PSR 02-247 at 1.5 m

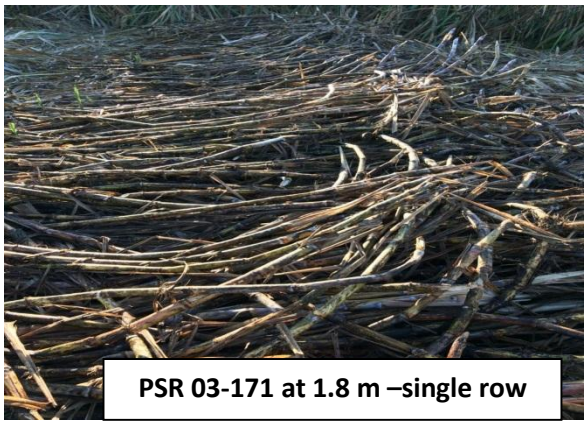


VMC 84-524 at 1.3 m

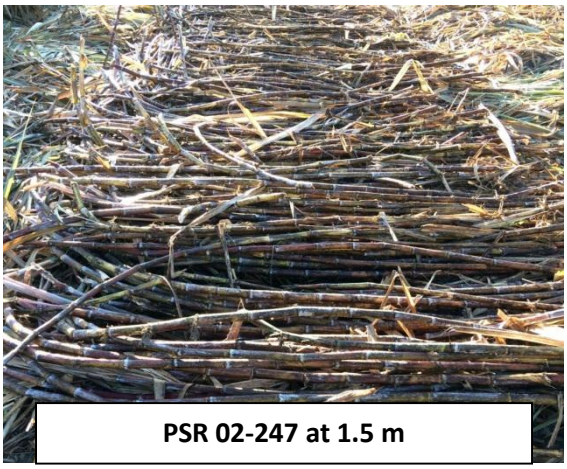
Cane piles at harvest



PSR 03-171 at 1.5 m



PSR 03-171 at 1.8 m –single row



PSR 02-247 at 1.5 m

PSR 02-247 at 1.8 m –single row

VMC 84-524 at 1.5 m

VMC 84-524 at 1.8 m-single row

REFERENCES:

.

_____. Variety Brochure. PHILSURIN's New Variety Releases for 2014- PSR 01-105, PSR 01-136, and PSR 02-247.

_____. Variety Brochure. PHILSURIN's Variety Release for 2018- PSR 03-171 and PSR 07-195.

_____. January 2009. Row spacing and planting density effects on the growth and yield of sugarcane. 2. Strategies for the adoption of controlled traffic.AustralianCrop and Pasture Science.60(6)

Burayu, Worku. 2001. The Effect of Furrow Spacing on Sugarcane Stalk Population and Yield. Melkassa Research Center, Melkassa, Ethiopia.

Ghaffar, Abdul et. al. 2011. Influence of Zinc and Iron on Yield and Quality of Sugarcane Planted under Various Trench Spacings.

Ullah, Sami et. al. 2016. Optimizing Row Spacing to Ameliorate the Productivity of Spring Sugarcane(*Saccharumofficinarum L.)*.Agricultural Sciences, 7531-538. http://dx.doi.org/10.4236/as.2016.78053