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ISCM PROJECT ON

"MODELLING WORLD-WIDE GXE INTERACTION"

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CONTENTS

1. INTRODUCTION

The goal of the project is to gain a better understanding of the physiological mechanisms underlying the genetic variation in crop response to environmental factors by monitoring key plant processes contributing to yield and quality in a common set of diverse cultivars grown in diverse environments from around the world. Specific objectives are to:

- measure canopy development, radiation interception, water use, water stress sensitivity and, biomass accumulation and partitioning for a number of diverse cultivars (from different countries) in diverse environments (in different countries),
- determine model trait parameters (genetic coefficients) for each cultivar, derived from development, growth and water use measurements,
- identify and formulate underlying mechanisms of genotype response to environmental factors, and
- evaluate models' ability to simulate genotypic differences in crop performance.

The following organizations are participating in the project: SASRI, ZSAES, SIRC, and CIRAD and the following cultivars will be used in the trials: N41, R570, CP88-1762, HoCP96-540 and ZN7. In some cases NCo376 and Q183 will also be planted. The main activities in the project so far have been to generate and distribute genetically-true, disease-free seed material of the relevant cultivars to each of the participating countries, to propagate for the experiments, to plant experiments and to collect data on crop development, growth and yield. Plant crop experiments have been completed in three countries and captured data are currently being processed and analysed. Ratoon crop experiment have also commenced in these countries. Experiments have also been planted in Reunion Island. The modelling aspects of the project are due to start in 2016.

2. PROGRESS IN SOUTH AFRICA (SASRI)

2.1 Ratoon crop trial operations

Plant cane from the five cultivars (N41, ZN7, R570, CP88-1762 and HoCP96-540) was harvested at the SASRI Research Station in Pongola in March 2015 and left to ratoon for 12 months until March 2016. Each cultivar was ratooned in four replicated plots (5 cultivars x 4 replicates = 20 plots) that consisted of 5 rows per plot (with 1.5m row spacing) and each plot was 21m in length, with a 1m break between plots.

Non-destructive measurements of fractional interception (Fig 2.1), shoot population, stalk height and the total number of green leaves were performed monthly until March 2016. Figure 1 shows fractional interception (FIPAR, %) of PAR by the five cultivars. Cultivar N41 initially intercepted more radiation than the other cultivars (although not significantly), presumably due to a higher leaf area. At 12 months, cultivars achieved a FIPAR of 87.1 – 89.2 % and no significant difference in crop canopy cover was found between cultivars at harvest.

Destructive measurements of total fresh and dry mass of green leaves, stalks, sheath, tops and trash residue; and total leaf area were performed at 3, 6, 9 and 12 months after planting. Cane quality characteristics (dry matter content, fibre %, BRIX %, sucrose % and thus calculated non-sucrose %) were performed at the Pongola millroom at 9 and 12 months after planting when the cane stalks were greater than 0.5m in length.

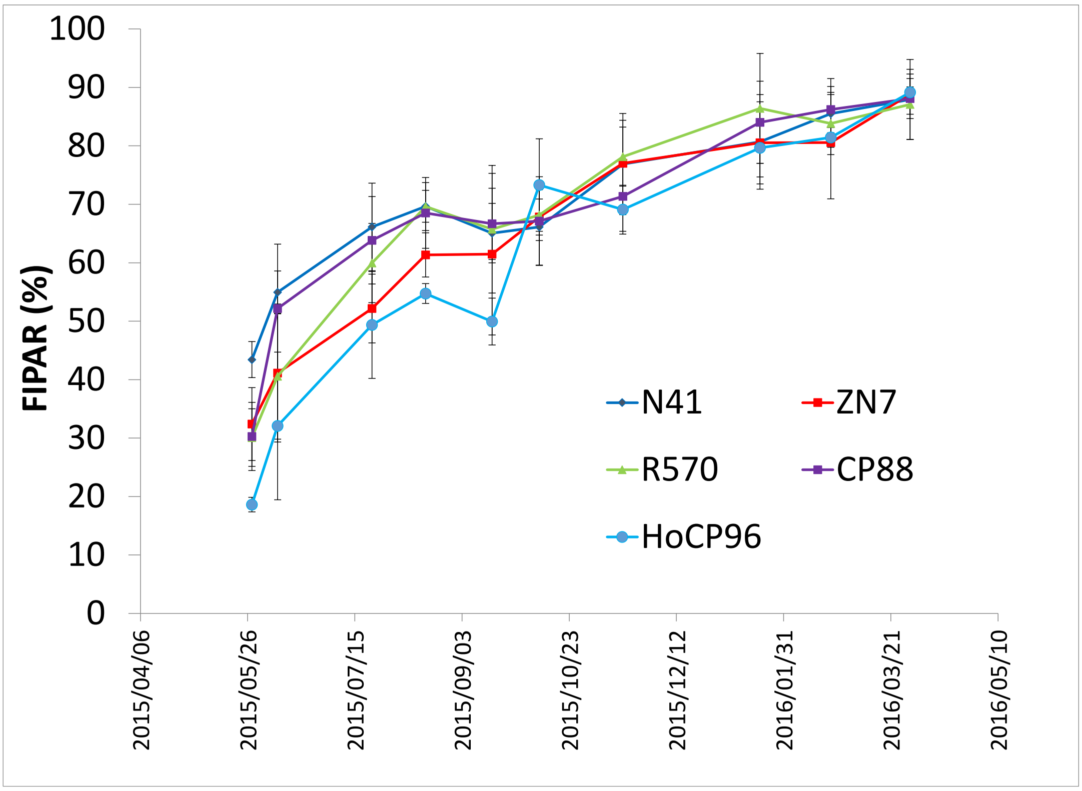


Figure 2.1: Fractional interception of photosynthetically active radiation (FIPAR, %) of the different sugarcane cultivars grown at Pongola, South Africa during the ratoon crop season (2015_2016).

2.2 Destructive harvest at 12 months

Figure 2.2 shows a collection of the destructive harvest operations at 3 and 12 months after ratooning the plant crop for the ratoon crop season (2015_2016). Four meters of three rows (per plot) were cut and weighed in-field with a tractor fitted with a loadcell. Cane yield and sucrose yield (Fig 3) were calculated for each plot for the ratoon crop and compared with plant crop. Cane yield was approximately 101 t ha^{-1} for N41 for ratoon crop, a decrease from 122 t ha^{-1} for the plant crop. Cane yield decreased by 15 – 25% for all five cultivars for the ratoon crop (when compared with the plant crop), which can be explained by low annual rainfall and irrigation water restrictions which were applied periodically in Pongola during the ratoon crop season.

N41 attained the highest sucrose yield of 13.2 t ha^{-1}during the ratoon crop season, followed by HoCP96, which despite the lower cane yield, attained a sucrose yield of 11.0 t ha^{-1} because it had higher sucrose content than cultivars ZN7 and R570. Cane quality characteristics in the ratoon crop were not signifcantly different from the plant crop (data not shown here) and the final sucrose yield attained by the five cultivars was reduced by between 0 - 22% due to a reduction in cane yield, not cane quality.
Two meters of the third row were subsampled for total dry biomass and biomass partitioning (Fig 2.4).

Concurrent with cane yield, N41 achieved the highest total dry biomass yield at 12 months crop growth. At 3, 6 and 12 months growth, cultivar HoCP96 had attained significantly less dry biomass than N41. The proportion of biomass allocated to plant components was not significantly different between cultivars, with the exception of cultivar R570, which allocated a significantly higher proportion of it’s dry biomass to green leaves and less dry biomass to stalks, compared with the other cultivars.

Figure 2.2: Destructive harvest operations for the different cultivars at 3 and 12 months after plant crop harvest at Pongola, South Africa for the ratoon crop season (2015_2016).

2.3 Challenges

HoCP96-540 was a poor emerging variety for the ratoon crop trial during 2015_2016. HoCP96-540 was initially infested by *Sesamia spp* (dead hearts). The total dry biomass was reduced by the poor emergence and pest infestation.

The trial was affected by tawny rust during the warm autumn season in Pongola, with moderate leaf symptoms appearing on cultivars N41 and CP88-1762 in particular. All plots were sprayed with Abacus fungicide in September and again October 2015 (as per pathology recommendations). Leaf area at 6 months growth appeared to be significantly reduced in the ratoon crop compared with plant crop as a result, however leaf area was not reduced at 9 or 12 months growth. In order to prevent infestation during the ratoon 2 season in 2016_2017, all plots will be sprayed with Abacus at the end of winter.

Irrigation water restrictions in the Pongola region were enforced periodically during the ratoon crop season, and the total amount of water supplied (rainfall plus irrigation) was 1178 mm during the plant crop as opposed to 891 mm during the ratoon crop. As a result of the low rainfall and slightly less irrigation water applied, cane yield was decreased for all five cultivars by 15 – 25% in the ratoon crop when compared with the plant crop.

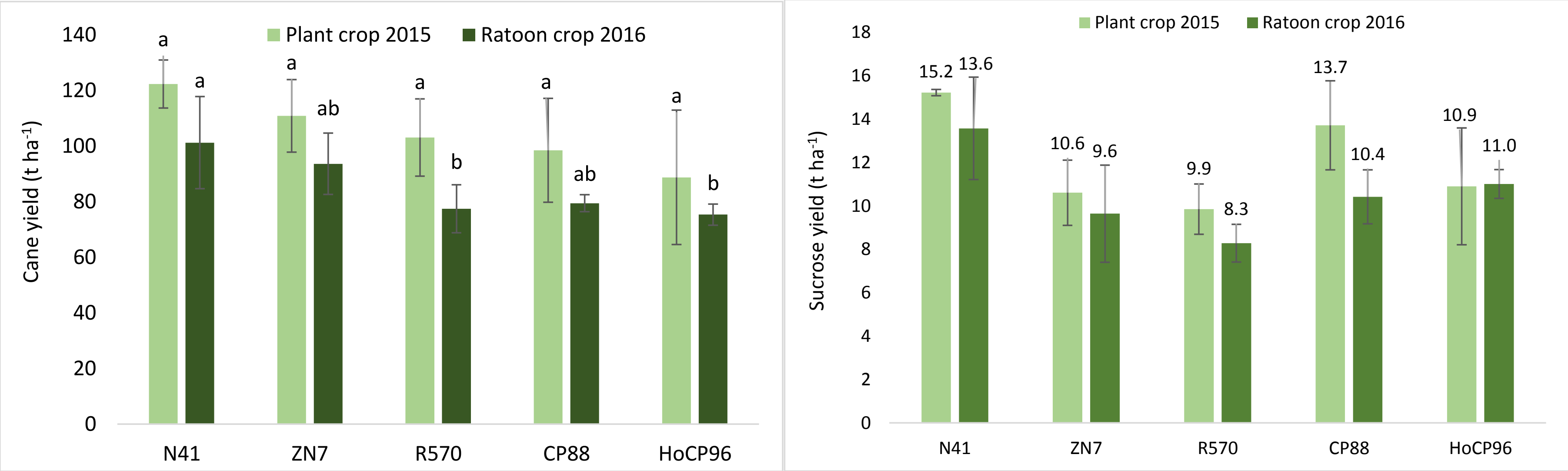


Figure 2.3: Sugarcane yield and sucrose yield of the different cultivars at Pongola, South Aftrica, 12 months after ratooning for the ratoon crop season. Statistical significance is represented by different letters ($p < 0.05$). Vertical error bars represent one standard deviation from the mean.

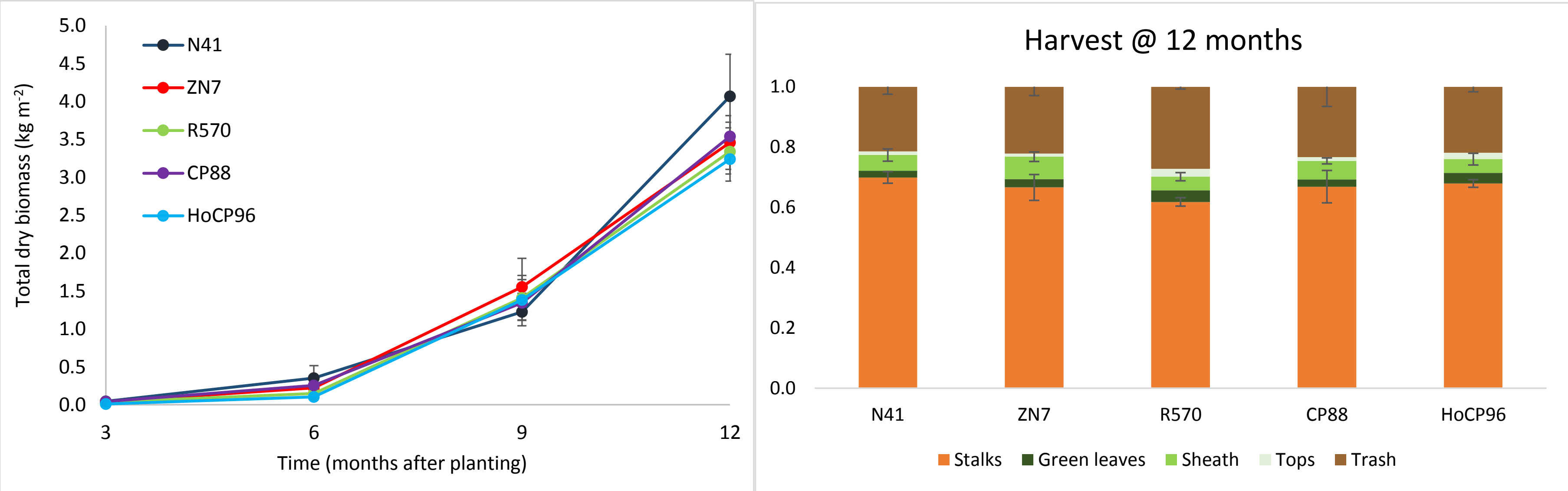


Figure 2.4: Total dry biomass and biomass yield plant components of the different cultivars at Pongola, South Aftrica, 12 months after ratooning for the ratoon crop season.

3. PROGRESS IN REUNION ISLAND (CIRAD)

3.1 Plant crop

Seedcane from the bulking plots from five varieties (CP88-1762, N41, NCo376, Q183, R570) was planted into plant crop and ratoon crop fields at the Cirad LaMare station in February 2015. Seedcane from each variety was planted into four replicate plots (5 varieties x 4 replicates = 20 plots) that consisted of 9 rows per plot (with 1.5m row spacing) and each plot was 10.5 m in length, with a 1m break between plots.

Supplementary irrigation was applied with a sprinkling irrigation system. Unfortunately, due to a severe breakdown of the underwater pump deeply located and a long delay to get a new one , irrigation was stopped 3 months after planting The total water applied was 630 mm for irrigation and 1817 mm for rainfall.

Climate data are shown in Figure 3.1.

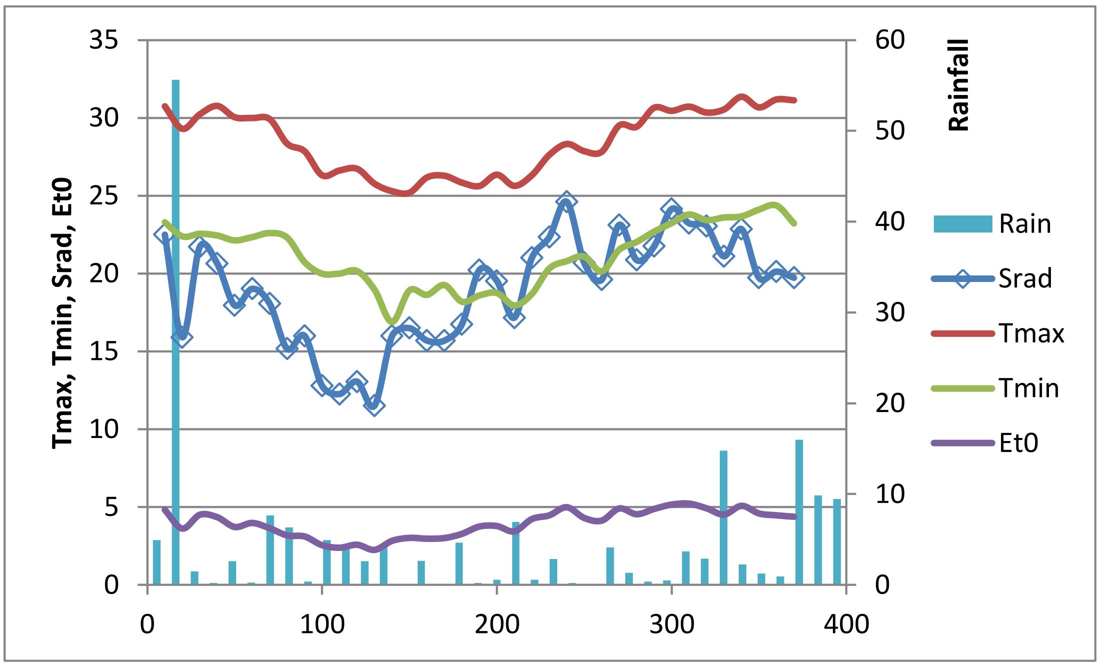


Figure 3.1. 10 days average daily maximum and minimum temperature (Tmax, Tmin), daily solar radiation (Srad), daily reference evapotranspiration (Et0), and daily rainfall over the trial plant crop period at La Mare Station.

Non-destructive measurements of shoot population and emergence % (Fig 3.2 and 3.3), stalk height (HTVD Fig 3.4) and the number of total and green appeared leaves were performed until 250 DAP (days after planting). Measurements of fractional interception (FIPAR Fig 3.5) were performed until canopy closure. Shoot population and FIPAR were measured on a sub-plot of 8 m long ($12m^2$). Stalk height from ground to TVD and leaves appearance were measured on 8 labelled primary stalks within the same subplot.

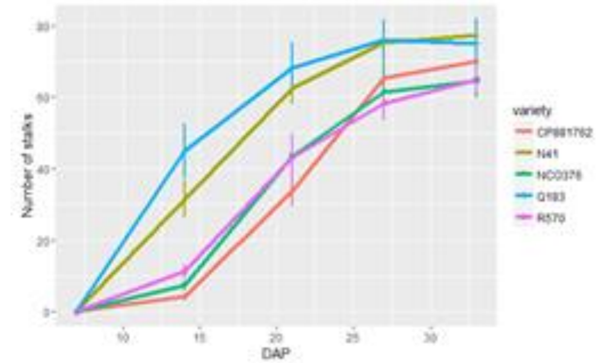


Fig 3.2 Shoot emergence (%) of the different sugar cane varieties grown at La Mare, Réunion Island, during the plant crop season 2015-2016.

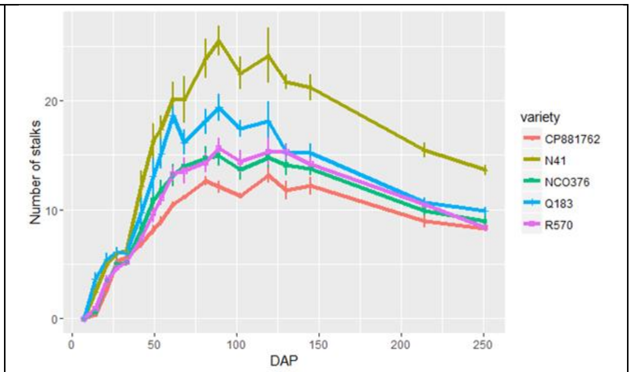


Fig 3.3 Live shoot population (Stalk Number/m2) of the different sugar cane varieties grown at La Mare, Réunion Island, during the plant crop season 2015-2016.

Shoot emergences % (Fig 3.2) were higher for Q183 and N41 than for other varieties. Dynamics of live shoot populations (Fig 3.3) were different between varieties, with high appearance rates and tillering at the beginning for N41 and Q183. At 230 DAP, only N41 showed a higher live shoot population than the other varieties. Unlike N41, higher emergence % of Q183 didn't show a higher live shoot population at 250 DAP.

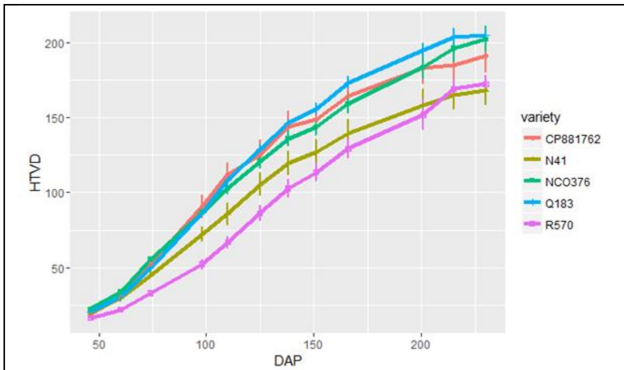


Fig 3.4 Stalk height up to terminal visible dewlap (HTVD in cm) on 8 labelled stalks of the different sugar cane varieties grown at La Mare, Réunion Island, during the plant crop season 2015-2016.

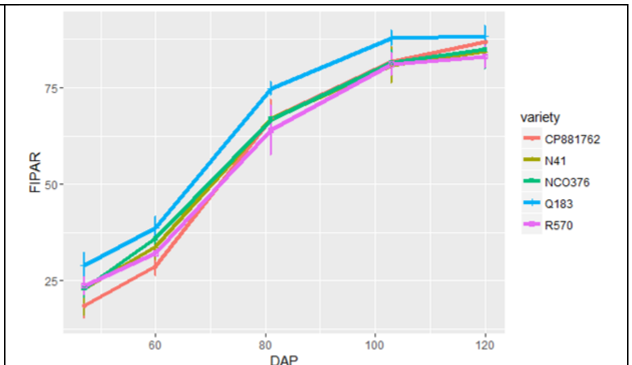


Fig 3.5 Fractional interception of PAR (FIPAR in %) of the different sugar cane varieties grown at La Mare, Réunion Island, during the plant crop season 2015-2016.

Stalk heights (Fig 3.4) were higher for Q183, CP881762 and N41 and lower for R570. Stalk elongation has to be calculated for variety comparison to confirm or not results found on heights. Differences found about shoot emergence % (starting date) can affect beginning of stalk growth.

FIPAR (Fig 3.5) was slightly different between the varieties from the beginning up to 100 DAP and equal at 123 DAP. From 0 to 100 DAP, FIPAR of Q183 was higher than other varieties. FIPAR, a very important integrative trait for biomass accumulation is presently difficult to relate with all the other described simple traits (measured blades numbers and surfaces should will be also included). However for Q183 its higher shoot emergence % and higher observed total number of leaves can explain its higher FIPAR during the plant crop season.

Destructive measurements of fresh and dry above ground biomass and its components green blades, stalks, green sheath + tops, trash residue and total leaf area were performed at 3, 6, 9 and 12 months after planting. At each sampling date, in subplots of 12m long (3 lines of 4m : 18m^2) above ground fresh mass were weighted on a 10m long sub-subplot and biomass components and its dry matter contents were measured on a 2m long sub-subplot. A sub sample of green blades was used to measure specific leaf area (SLA) and then calculate LAI.

At 6, 9 and 12 months, millable stalk quality characteristics (fibre %, Brix %, sucrose % and thus calculated non-sucrose %) were analysed on millable stalks (height > 0.5m) at the eRcane laboratory using both press and Nirs methods. At 3 months only manual Brix was measured.

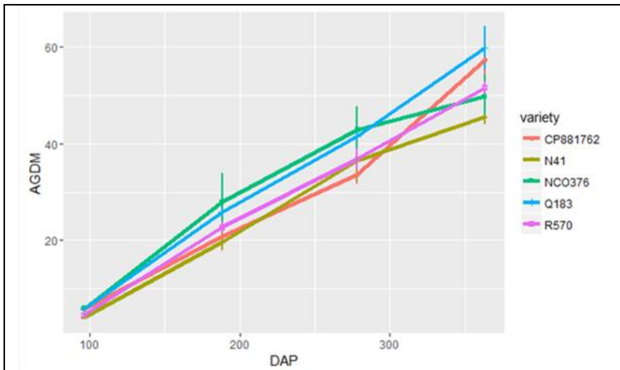


Fig 3.7 Above ground dry matter (AGDM in T/Ha) of the different sugar cane varieties grown at La Mare, Réunion Island, during the plant crop season 2015-2016.

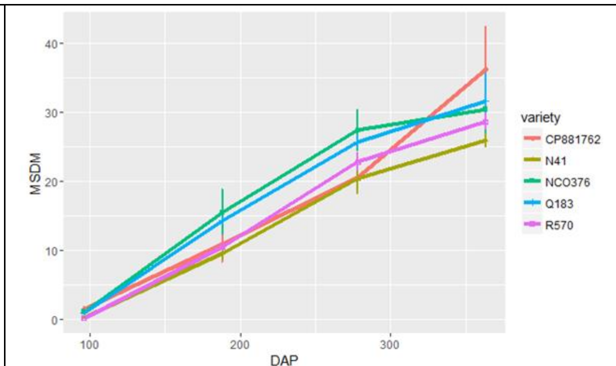


Fig 3.8 Millable stalk dry matter (MSDM in T/Ha) of the different sugar cane varieties grown at La Mare, Réunion Island, during the plant crop season 2015-2016.

Up to 9 months old, NCO376 and Q183 produced the highest dry mass of above ground and millable stalk biomasses. Behavior of CP881762 between 9 and 12 months has to be checked. Millable stalk quality characteristics are being evaluated in eRcane laboratory.

3.2 Ratoon crop

Plant crop of the trial used for Ratoon measurements was harvested in January 2016. Phenology measurements have commenced and the 3 months destructive sampling was achieved.

	
Plant Crop Trial (Reunion Island – La Mare)	Plant Crop Sampling (Reunion Island – La Mare)
	
Plant Crop Sub Samples (Reunion Island – La Mare)	Ratoon Canopy Development (Reunion Island – La Mare)

4. PROGRESS IN FLORIDA (SIRC)

4.1. Field operations

Varieties N41, NCo376, CP 88-1762, R 570, Q183, and HoCP 96-540 were planted manually on Dec 12, 2013 at the Everglades Research and Education Center (EREC) of the University of Florida at Belle Glade, FL in randomized complete block design (RCBD) with four replications. Each plot consisted of 9 rows, each 11m long with 1.5m row spacing. This trial was mechanically harvested on January 23, 2015 and left to ratoon for the 2015-2016 crop season in order to collect data in first-ratoon crop. No data were collected in plant crop in these plots, as separate set of plots were used for that purpose. Standard management practices for sugarcane cultivation on high organic soils of south Florida were employed during the season. Soil type for this trial was Lauderhill muck (euic, hyperthermic Lithic Haplosaprist).

Field was under sub-surface irrigation with drainage ditches surrounding the field. Moisture level in the field was kept optimum by pumping water in and out of the ditch. Weather data for 2014 and 2015 seasons are presented in Figure 4.1. No hard freeze was observed during first-ratoon crop (Figure 1). The average daily T_{max} and T_{min} for the first-ratoon crop season (Jan 23, 2015 to Jan 25, 2016) was 29.2 and 18.9 °C, respectively. Total rainfall during the crop season was 942 mm, received over 134 days (out of 368 days of crop duration). This was very similar to plant crop, with 950mm of total rainfall over 125 days out of a total of 369 days crop cycle.

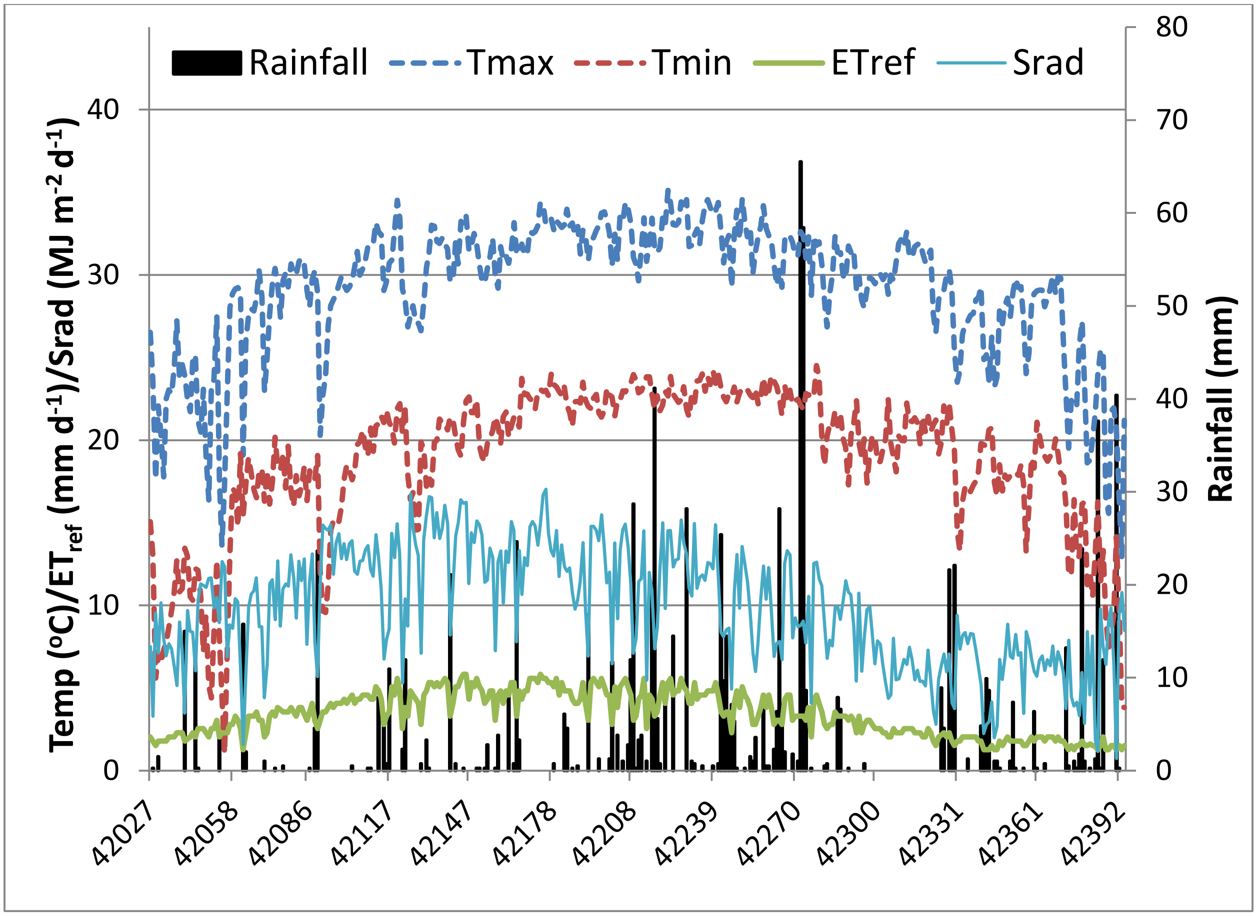
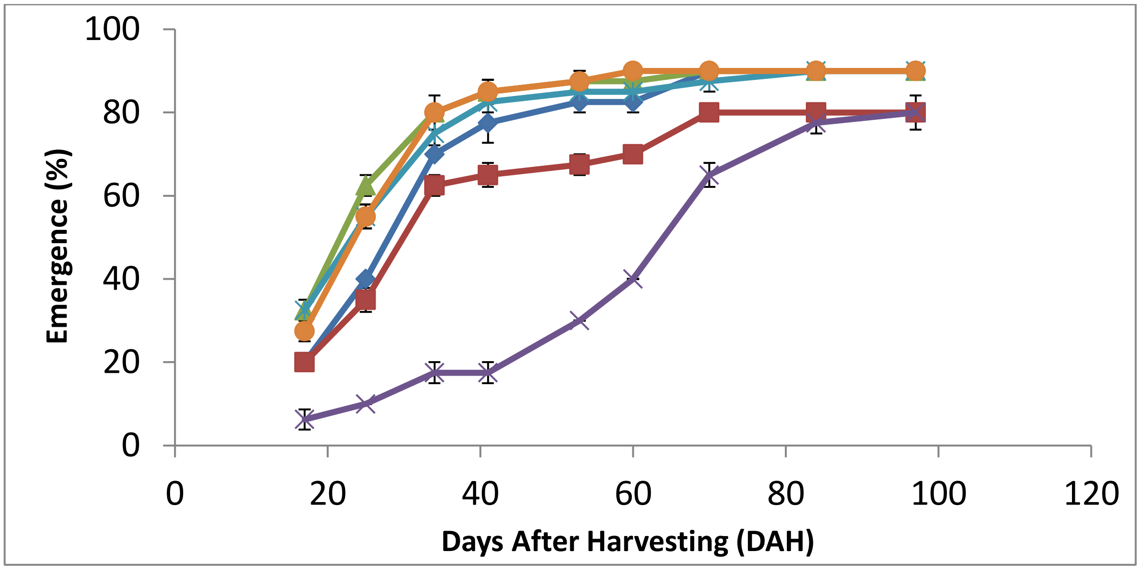


Figure 4.1. Daily average maximum and minimum temperature (Tmax, Tmin; °C), reference evapotranspiration (ET, mm d^{-1}), solar radiation (Srad, MJ m^{-2} d^{-1}) and total rainfall (mm) over the study period (Jan23 , 2014 to Jan 25, 2016) at Florida Automated Weather Network (FAWN) station at Belle Glade, FL, USA (26.65678° N, 80.63001° W).

Data were collected on sugarcane emergence, tiller count, stalk height, and total number of leaves in all the varieties throughout the season. All varieties except R570 showed faster initial growth. However, R570 lagged behind all other varieties in the early emergence and growth (Figure 4.1). Tiller count data was collected in two 4m row section in the area marked for final destructive harvest. Again, variety R570 showed lowest tiller count in the early phase of growth (Figure 4.1). Eight plants were tagged in each plot (in the section marked for final harvest) to collect data on green leaf count and stalk height.



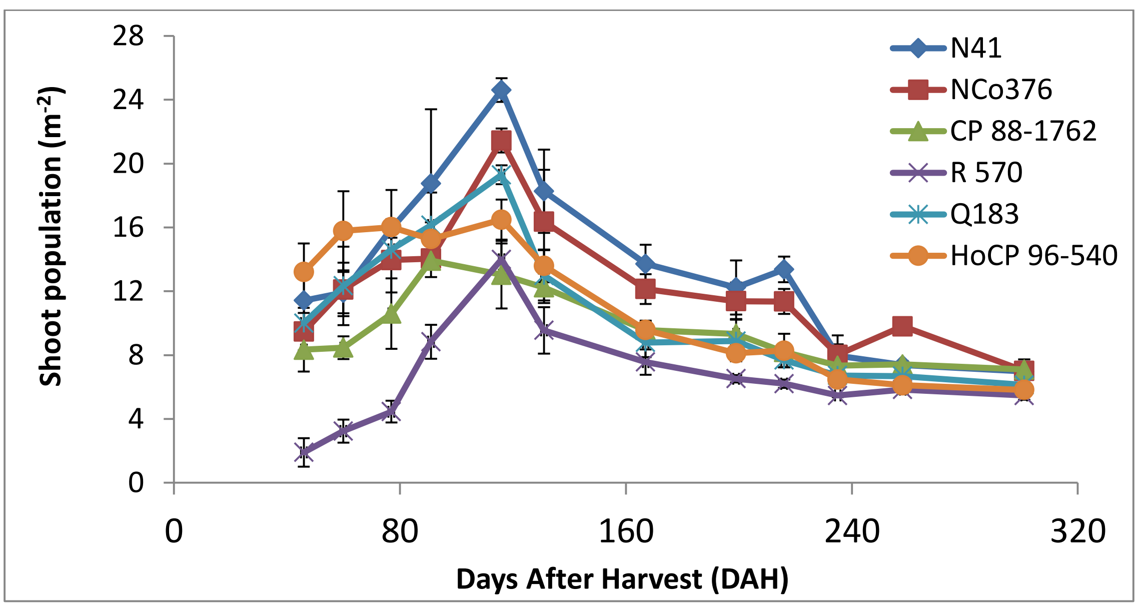


Figure 4.2. Sugarcane emergence (top panel) and shoot population (bottom panel) in six varieties in the first-ratoon crop at various days after harvest (DAH).

Photosynthetically active radiation (PAR) intercepted by the crop canopy was also measured non-destructively using a Sunscan Canopy Analysis System (Dynamax Inc., Houston, TX). R570 and NCo376 intercepted lower amount of radiation early in the season (Figure 4.3), due to slow emergence and early growth compared to other varieties (Figure 4.2).

Destructive harvests were performed on April 30 (97 days after harvest, DAH), July 29 (187 DAH), October 22 (272 DAH), and January 26 (368 DAH) during the first-ratoon crop. During these harvests, data were collected on total fresh biomass and biomass partitioning to stalks, green leaves, tops, and dead leaves. Subsamples were dried to calculate data on total dry biomass and biomass partitioning to various plant parts. Data were also collected on number of green leaves, nodes, stalk height, and stalk diameter during each of these harvests on 10-subsampled plants.

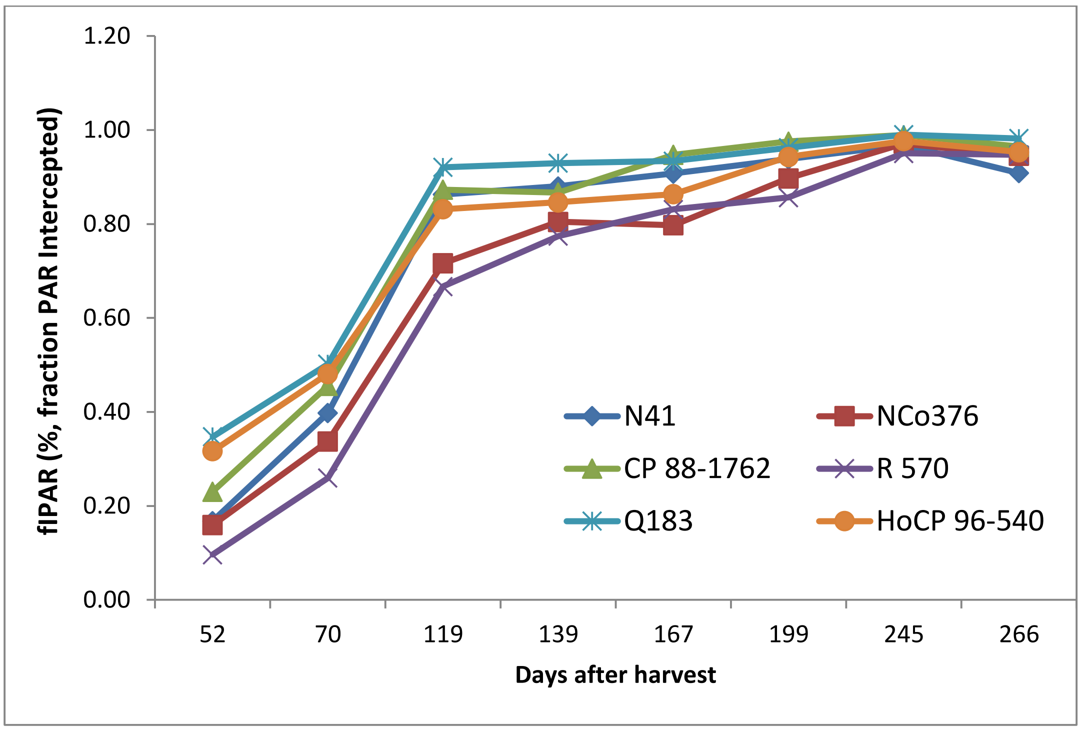


Figure 4.3. Fraction of Photosynthetically Active Radiation intercepted (FIPAR, %) in six sugarcane varieties in the first-ratoon crop at various days after harvest (DAH).

4.2. Data on destructive harvests

Data on various destructive harvests is shown in Table 4.1 and Figures 4.1-4.7. A 2-3m row section was selected in 2 rows in the area marked for each harvest, millable (>0.5m) and non-millable stalk were counted and then harvested to measure total fresh biomass yield. A 10-plant subsample was collected from each plot for biomass partitioning on fresh and dry weight basis and for count data on green leaves, nodes, stalk length and diameter. All individual subsamples (green leaf, dead leaf, tops, and stalks) were weighed fresh and dried in oven at 80 ^{o}C until constant weights were achieved to determine dry matter content. Stalk weights were used to calculate TCH (tonnes of cane per hectare). Subsampled stalks were juiced using a roller press and juice analyzed for Brix and POL. Commercial recoverable sucrose (CRS, g per kg) was calculated based on brix, POL, fiber, and theoretical recoverable sucrose. Sucrose yield (TSH, tonnes of sucrose per hectare) was calculated from TCH and CRS.

Cane yield (TCH) did not differ significantly between varieties in first-ratoon crop (Table 4.1). Contrasting stalk number and stalk count values (e.g. NCo376 and R570) might have contributed to no difference between TCH. Moreover, there were apparent numerical differences between TCH, with CP 88-1762 showing highest and HoCP 96-540 showing lowest TCH. This trend was similar to plant crop. NCo376 attained highest stalk count but lowest stalk weight, as found in plant crop as well. Similar to cane yield, highest sucrose yield (TSH) was obtained in CP 88-1762, which was statistically to all varieties except N41. Lower CRS in N41 contributed to low TSH in N41. R570 showed highest CRS in first-ratoon crop compared to CP 88-1762 in plant crop, indicating improved natural ripening due to late January harvest in R570 in ratoon crop.

Table 4.1. Sugarcane yield parameters (millable stalk number, stalk weight, TCH: tonnes of cane per hectare, CRS: commercial recoverable sucrose, and TSH: tonnes of sucrose per hectare) at final harvest for six varieties in first-ratoon crop at Belle Glade, FL, USA. Numbers with different letters within a column signify a difference at P <0.05.

Variety	Stalk no.	Stalk wt.	TCH	CRS	TSH
	stalk ha^{-1}	kg stalk^{-1}	Mg ha^{-1}	g kg^{-1}	Mg ha^{-1}
N41	131234ab	0.91ab	120a	83.4c	10.0b
NCo376	149278a	0.87b	126a	103.5b	13.2ab
CP 88-1762	139025ab	1.08ab	150a	105.9ab	15.9a
R 570	111959b	1.13a	127a	118.3a	15.0a
Q183	118930ab	1.06ab	126a	108.5ab	13.7ab
HoCP 96-540	120981ab	0.93ab	112a	101.7b	11.5ab
P value	*0.0497*	*0.03*	*0.16*	*<0.001*	*0.010*

Values within a column not followed by the same letter are different at P <0.05.

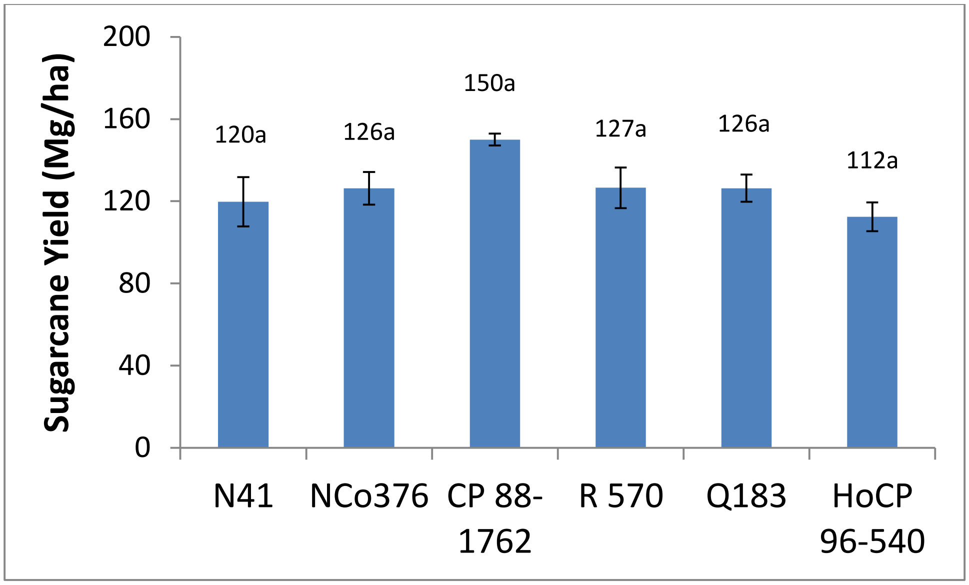


Figure 4.4: Sugarcane yield (TCH, tonnes of cane per hectare, Mg ha^{-1}) at final harvest for six varieties in first-ratoon crop at Belle Glade, FL, USA. Vertical error bars represents ±1 standard error. Bars with different letters signify a difference at P <0.05.

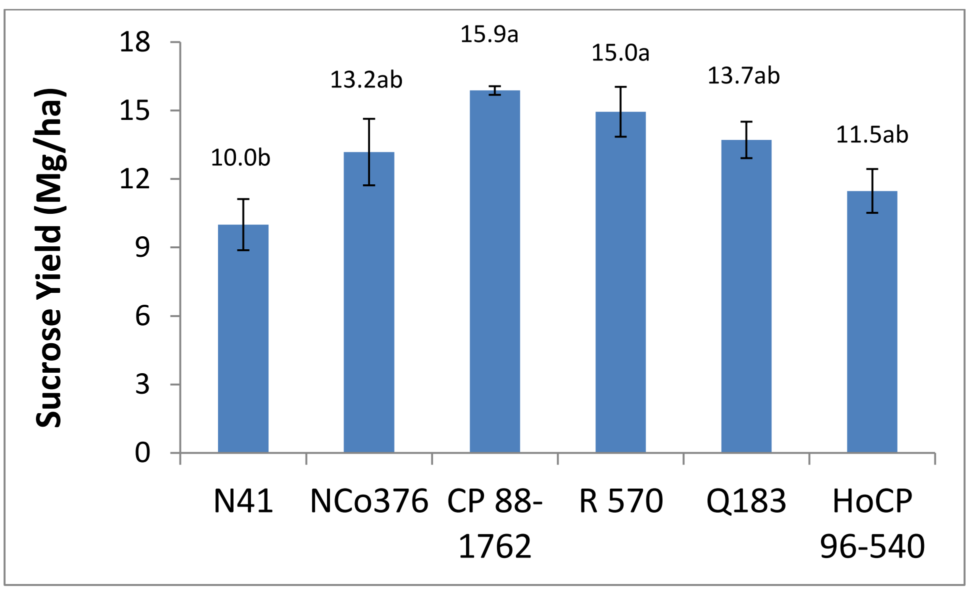


Figure 4.5: Sucrose yield (TSH, tonnes of sucrose per hectare, Mg ha^{-1}) at final harvest for six varieties in first-ratoon crop at Belle Glade, FL, USA. Vertical error bars represents ±1 standard error. Bars with different letters signify a difference at P <0.05.

Figure 4.6 shows total dry biomass accumulated throughout the growing season. R570 showed a continuous increase in biomass over the growing season compared to other varieties, resulting in high biomass at final harvest even though it had a slow growth early in the season (Figure 4.2). Both CP 88-1762 and N41 showed no increase in biomass from 3rd to final harvest. Severe lodging in these varieties might have inhibited ideal growth conditions, resulting in this trend.

The proportion of the dry biomass allocated to various plant parts did not change considerably between varieties throughout the growing season (Figure 4.7). At final harvest, HoCP 96-540 had the highest proportion of dry biomass allocated to stalks (0.92) while NCo376 and R570 had the lowest allocation to stalks (0.78 and 0.76, respectively; Figure 5). Fiber content at final harvest was significantly lower in R570 (10.3%) compared to N41 (12.8%), CP 88-1762 (13.0%) and Q183 (13.1%). HoCP 96-540 (11.5%) and NCo376 (11.7%) did not differ from other varieties.

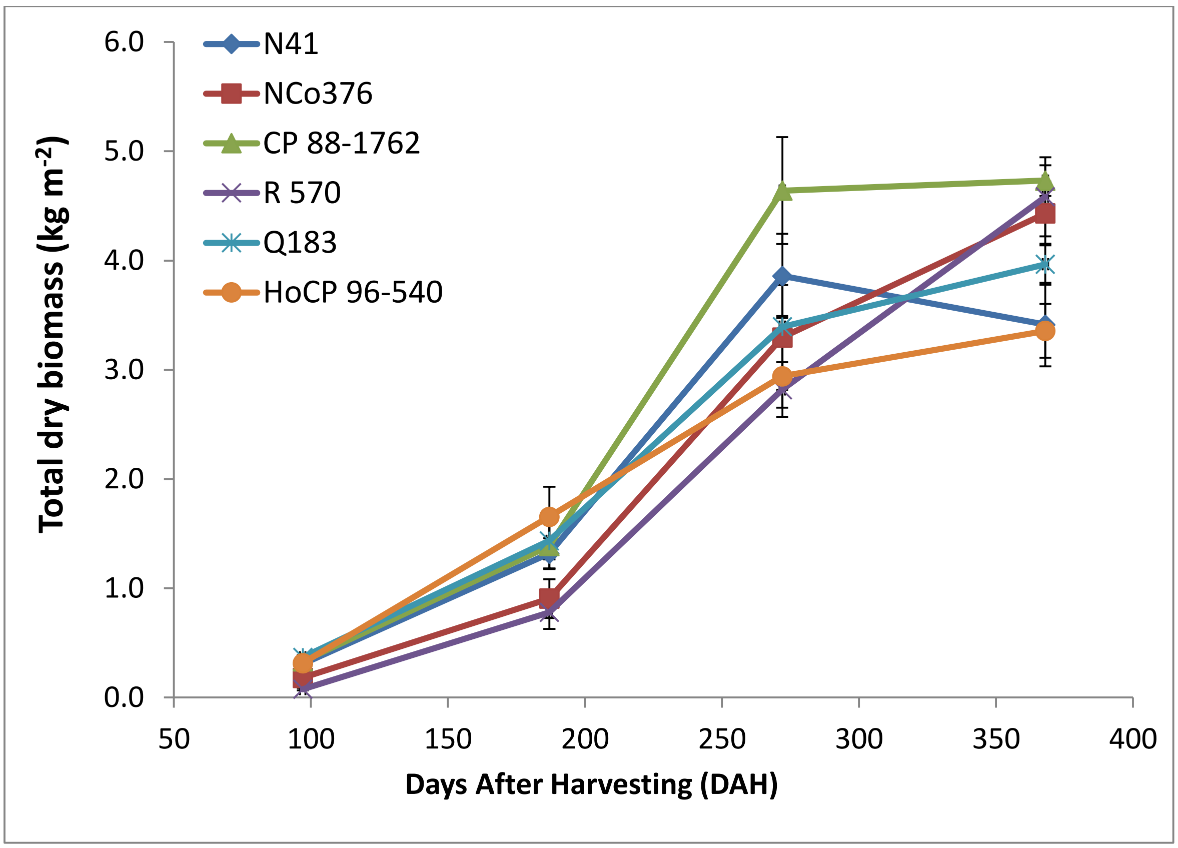


Figure 4.6: Total dry biomass for six varieties in first-ratoon crop at Belle Glade, FL, USA. Vertical error bars represents ±1 standard error.

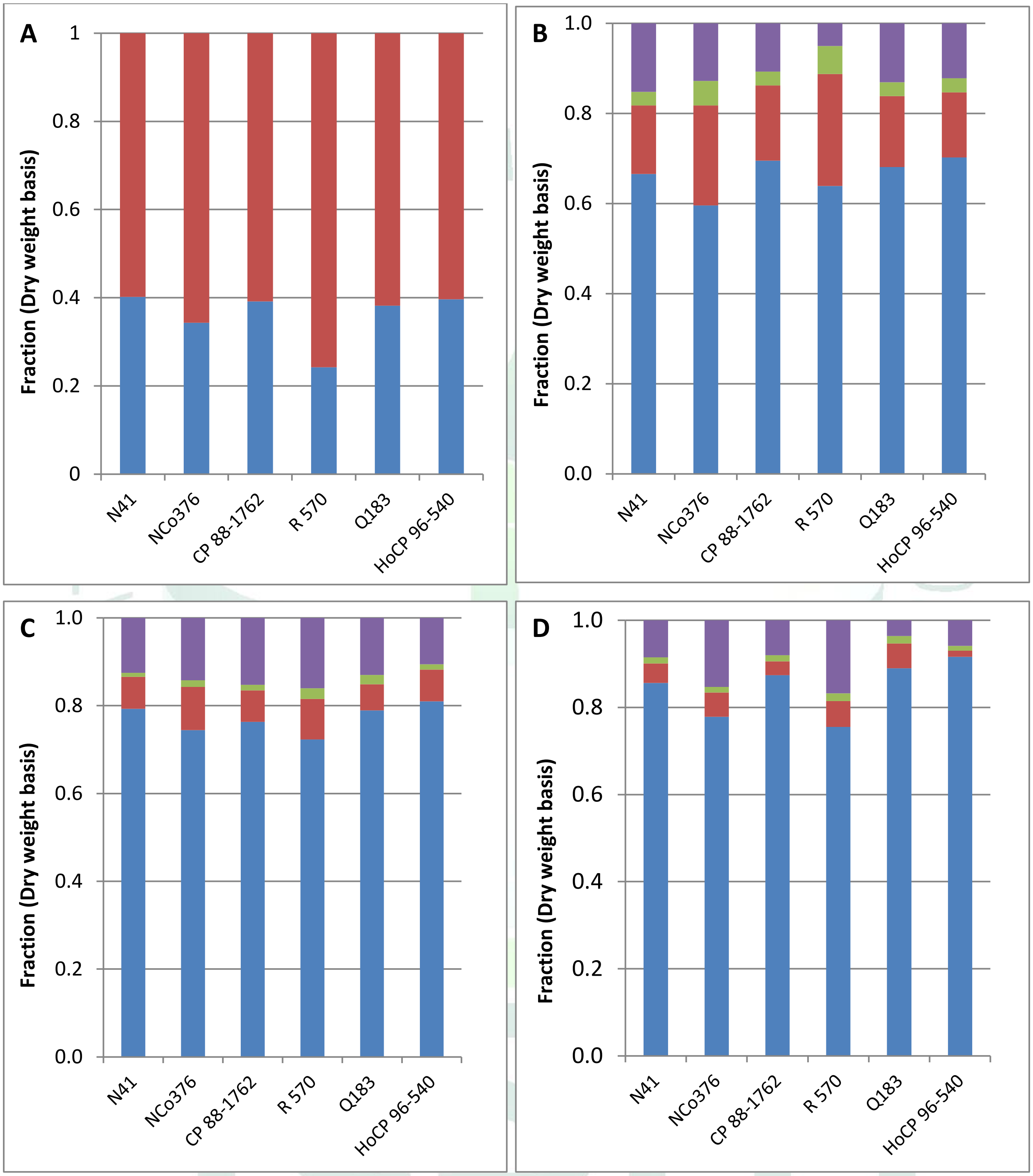


Figure 4.7: Dry matter partitioning for six varieties in first-ratoon crop at Belle Glade, FL, USA. (A) April 30-97 DAP; (B) July 29- 187 DAP; (C) Oct. 22- 272 DAP; (D) Jan. 26- 368 DAP. Legends: Stalk fraction Green leaf fraction Tops fraction Dead leaf fraction

4.3. Challenges

Severe lodging in study plots resulted in difficulties with destructive harvesting at 272 and 368 DAH. Lodging was particularly severe in N41, CP 88-1762 and HoCP 96-540 (Figure 4.8). R570 and Q183 showed minimal lodging. Row length harvested at final sampling (368 DAP) had to be decreased from 3-m sections to 2-m sections due to difficulty with harvesting lodged plants.

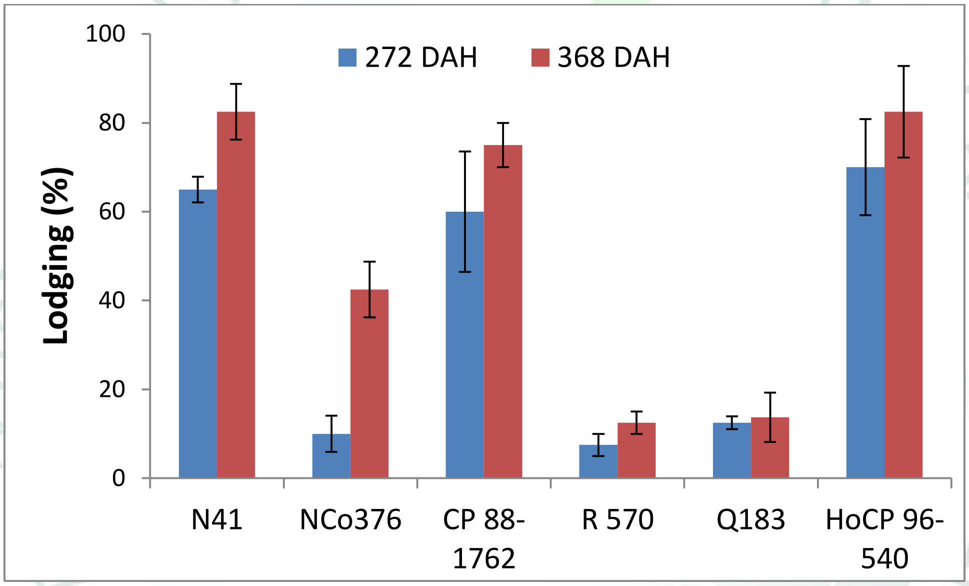


Figure 4.8: Lodging (%) in various varieties at 3rd and 4th destructive harvests during first-ratoon crop.

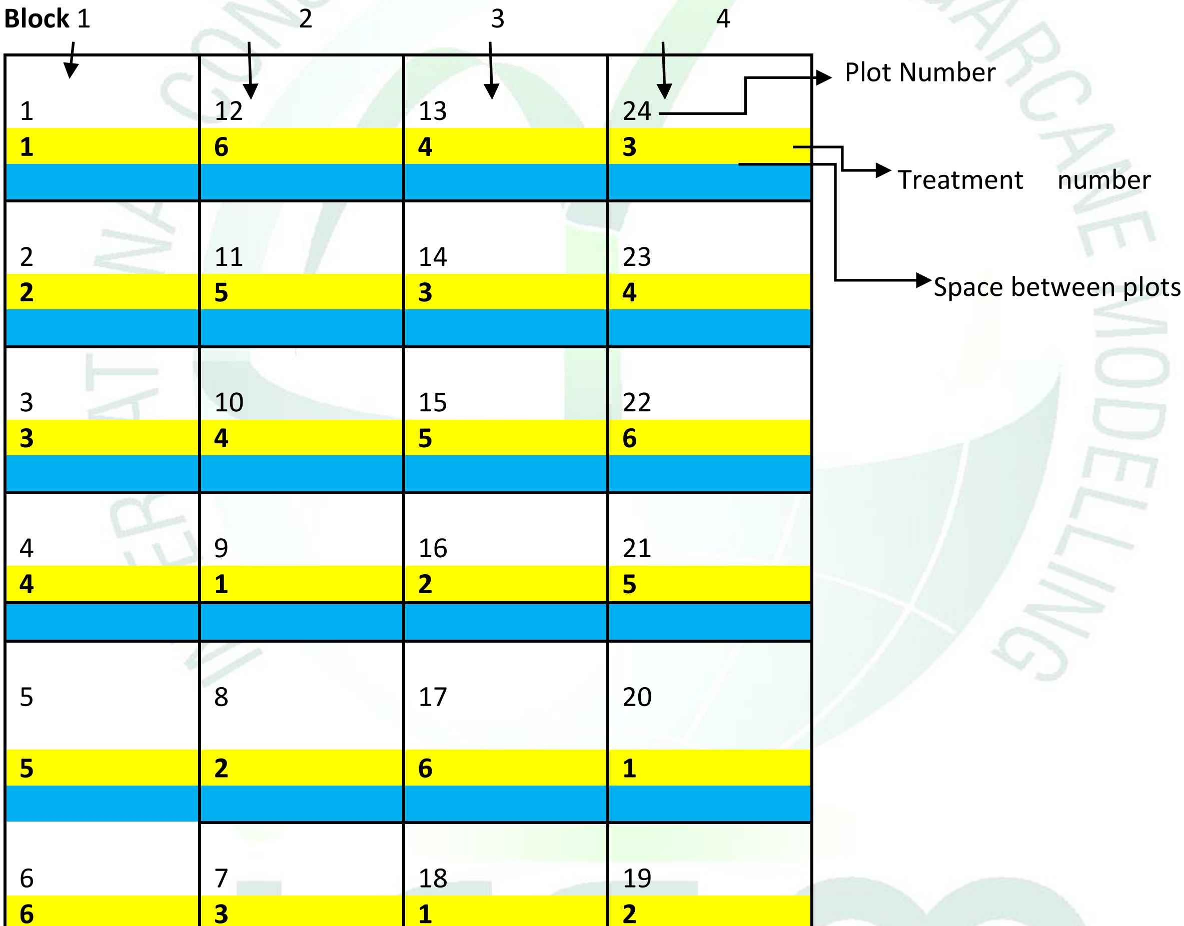
In data collection, we did not collect leaf sheaths separately in the biomass partitioning. For dead leaves, sheaths were part of leaves while for green leaves, sheaths were part of the stalk. After drying stalk samples, we were able to separate sheaths from the stalks, so data on dry sheath weight will be available from our study for the first-ratoon crop.

In this trial, variety HoCP 96-540 showed severe symptoms of brown rust. Fungicide Headline (Pyraclostrobin) was sprayed in the study area to control brown rust. No symptoms were seen in other varieties. Manganese nutrient deficiency symptoms were observed in some varieties as well (Q183, NCo376, and N41) in this trial, due to inherent low Mn levels in high organic soils.

5. PROGRESS IN ZIMBABWE (ZSAES)

5.1. Site of the ratoon crop

The plant cane site was at Field L3 Sable Block, ZSAES and the ratoon cane trial was established at Field B 1-24 Impala Block, ZSAES. In December 2014, six cultivars namely N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 were planted at the ratoon site. Harvesting of the plant crop was done on 3 June 2015 and the ratoon crop was managed as from 3 June 2015 to 1 June 2016 when the last destructive samplings [at 12 months] were done. Each plot consisted of 9 rows spaced at 1.5 m apart and 11 m long.



1	N41
2	ZN7
3	R570
4	CP88-1762
5	HoCP96-540
6	Q183

Figure 5.1: Four randomized blocks for the ratoon trial at Field B1-24 Impala Block, ZSAES. Harvesting of plant crop was done on 3 June 2015 and the ratoon crop was harvested on 3 June 2016. Each plot provided for four destructive sampling points at 3, 6, 9 and 12 months after first harvest.

5.2. Climate

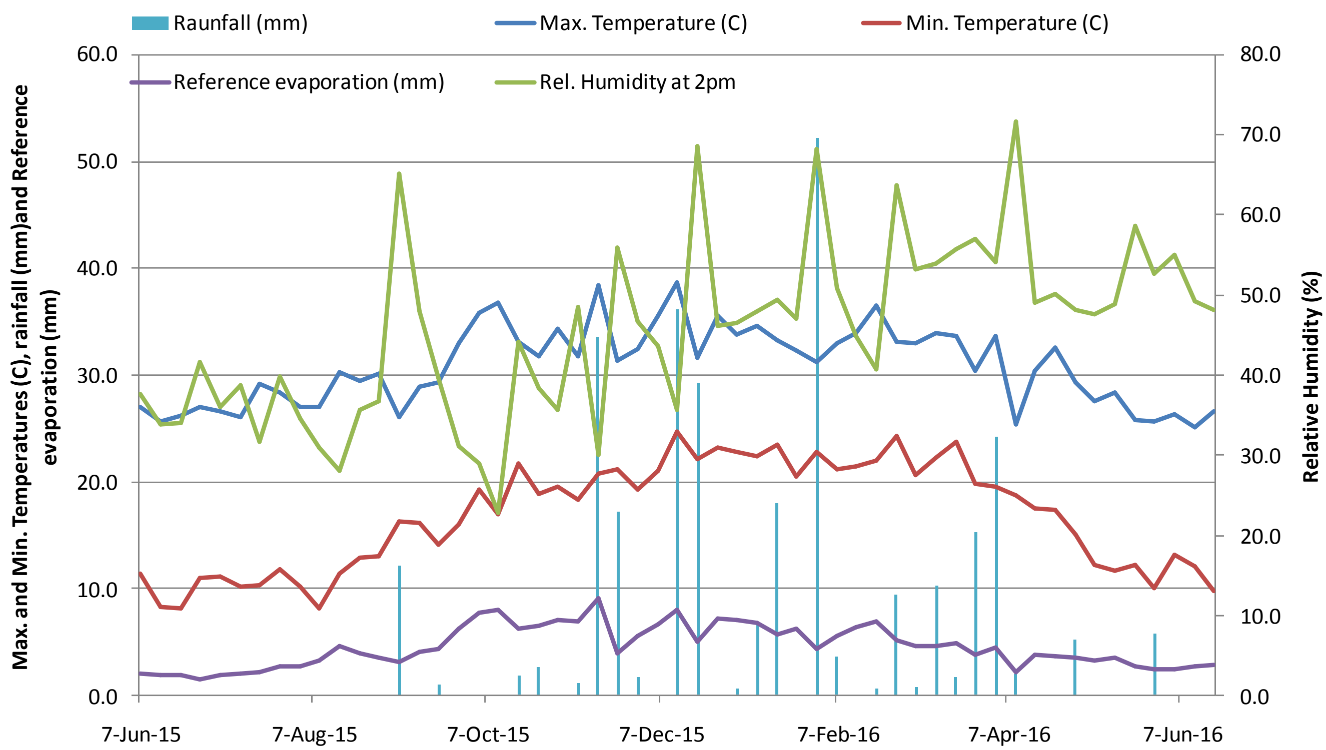


Figure 5.2: Weekly average maximum and minimum temperatures (Tmax, Tmin), weekly daily reference evapotranspiration (Et_0), and weekly total rainfall at ZSAES [the ratoon trial site].

The climate of Chiredzi is characterised by hot summers and cool dry winters. Rainfall is received mainly from November to March. Supplementary irrigation is necessary throughout the growing season. Weather data was recorded at the manual ZSAES meteorological station. Open pan evaporation as measured from the Class A pan and crop factors were used at different stages of growth to calculate crop water use. The ratoon crop [Field B1-24 Impala Block], which is adjacent to the Meteorological Station was irrigated using Floppy Sprinkler Irrigation system at 50% depletion of total available water (TAW) in the 0–120 cm depth. Moisture depletion was calculated as Epan x Crop Factor.

5.3. Non destructive measurements

Non-destructive measurements of green and dead leaves, shoot population [Figure 5.3], canopy and stalk heights [Figure 5.4] and chlophyll measurements on the leaves showing the top visible dewlap [TVD] were done during the ratoon trial.

Shoot population development

From when counting of shoots began in July 2015, shoot population decreased and then increased to a peak in October for all varieties that was about four months from harvest. The highest peak population of shoots were attained by variety HoCP96-540 whereas variety Q183 attained the lowest shoot peak population during the same period. The varieties then attained a constant shoot phase until harvest [Figure 5.3].

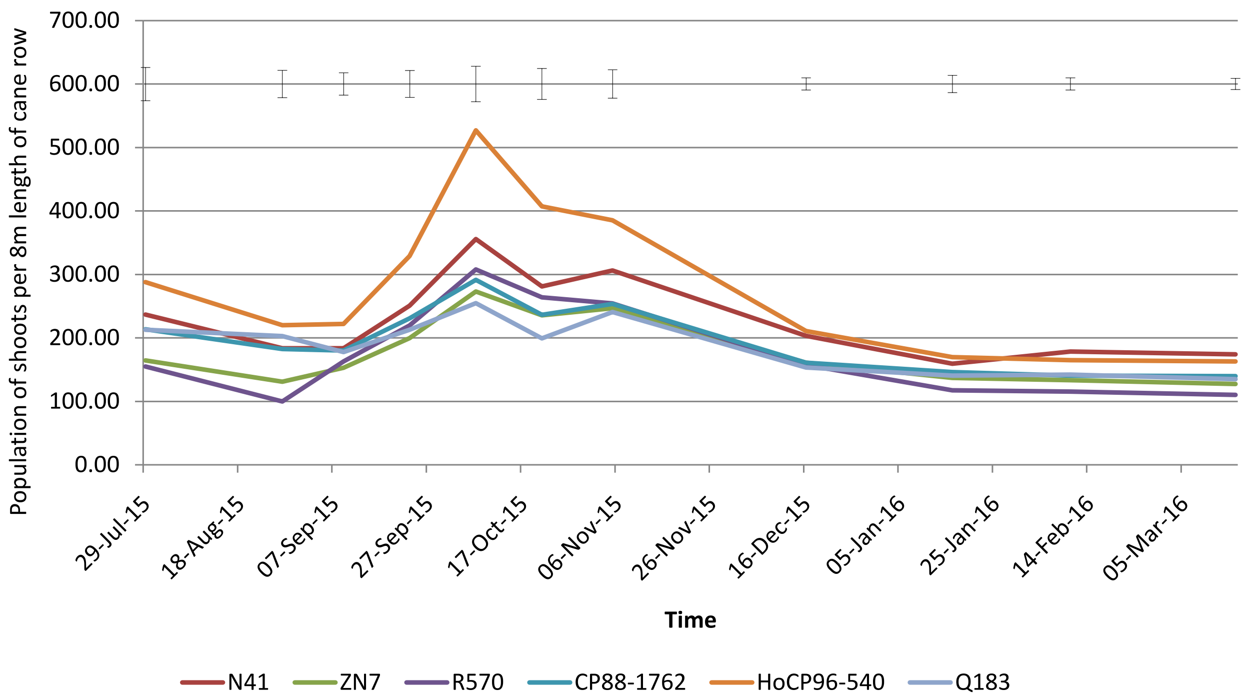


Figure 5.3: Variation of shoot populations for varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 during the ratoon crop at Field B 1-24 Impala Block, ZSAES.

Stalk heights

Heights of 8 tagged stalks in each plot were measured using a tape measure from ground level [fixed base] to the leaf showing the Topmost Visible Dewlap [TVD]. When data on heights of stalks were plotted against days after harvest, the data showed a general sigmoid growth pattern (Figure. 5.4). There were three phases of stalk elongation; initial slow increase followed by rapid stalk elongation and then another slow stalk elongation phase. There were generally small differences in height of stalks among the varieties during the period of measurement.

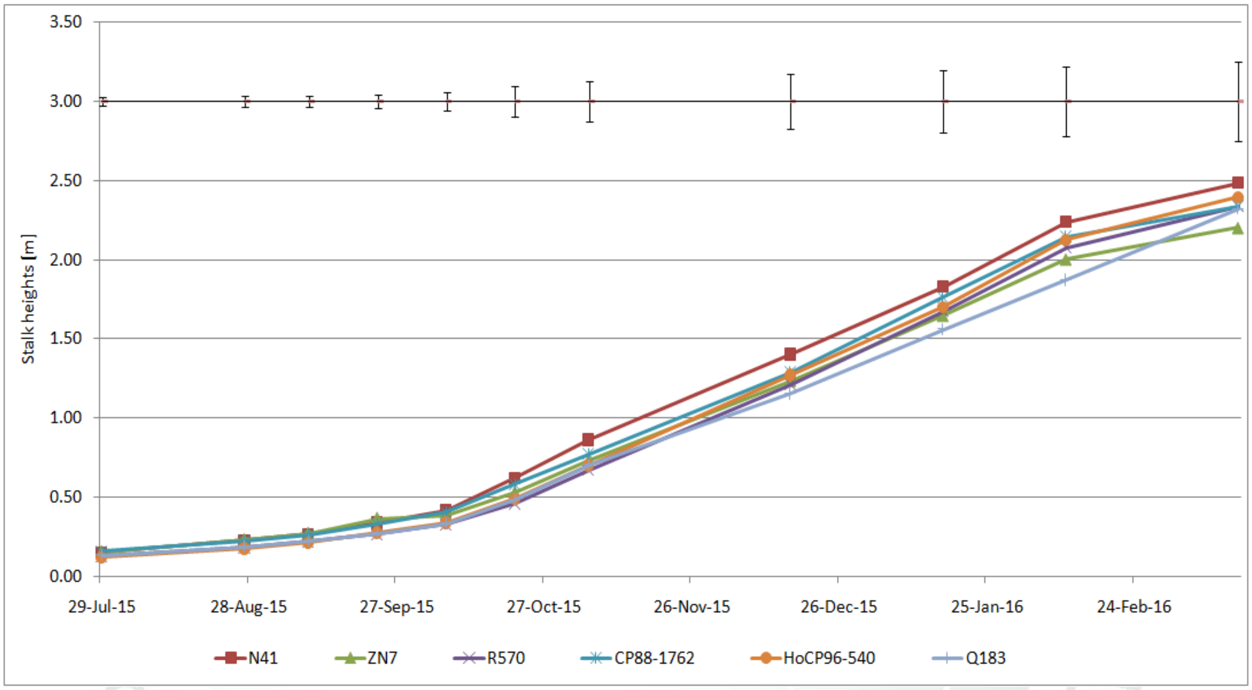


Figure 5.4: **H**eight of stalks for varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 during the growth cycle at Field B 1-24 Impala Block, ZSAES. Harvesting of plant crop was done on 3 June 2015 and measurements of heights of stalks were done from July 2015 to March 2016.

5.4. Destructive measurements

Total dry biomass

Destructive measurements of total fresh and dry mass of green leaves, stalks, leaf sheaths, tops and dead leaves [trash residues] were done. Total dry mass was the mass of dried green leaves, stalks, tops and trash. Leaf area measurements were also performed at each destructive sampling at 3, 6, 9 and 12 months after first Plant Crop harvest [Figure 5.7].

Total dry mass increased gradually from 3 to 6 months and sharply from 6 to 9 months [Figure 5.5.]. Above ground dry mass at 12 months was not available at the time of writing the report. Cane quality characteristics, fibre % cane, BRIX % cane and sucrose % cane were performed at the ZSAES Agric Chemistry and Soils Laboratory at 6, 9 and 12 months after harvest when the cane stalks were greater than 0.5 m in length. The data was used in determing the contribution of biomass fractions by variety.

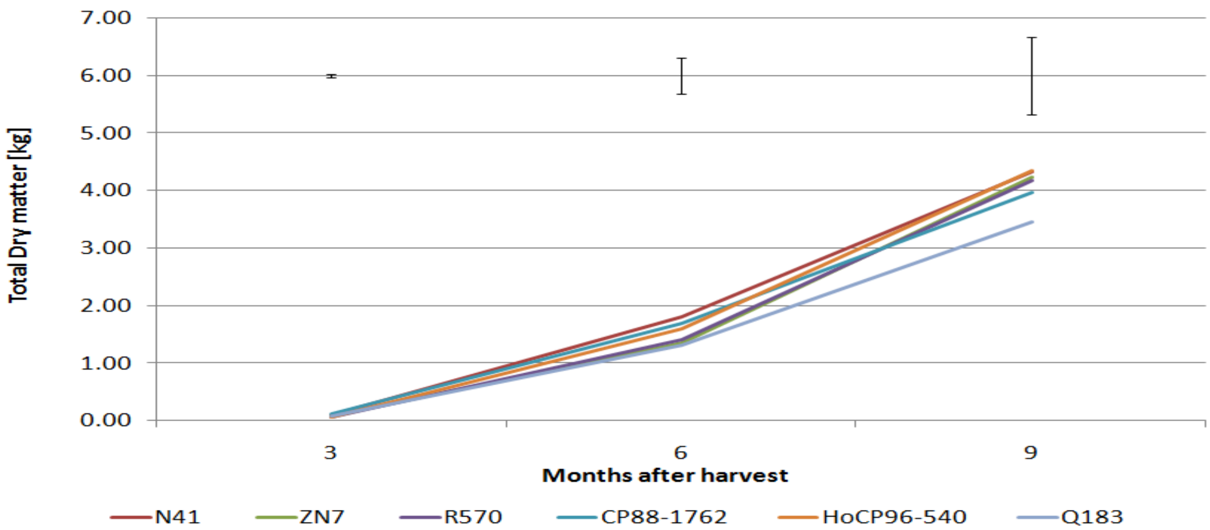


Figure 5.5: Above ground dry biomass for varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 in the ratoon crop at Field B 1-24, Impala Block, ZSAES. Above ground dry mass at 12 months is not included.

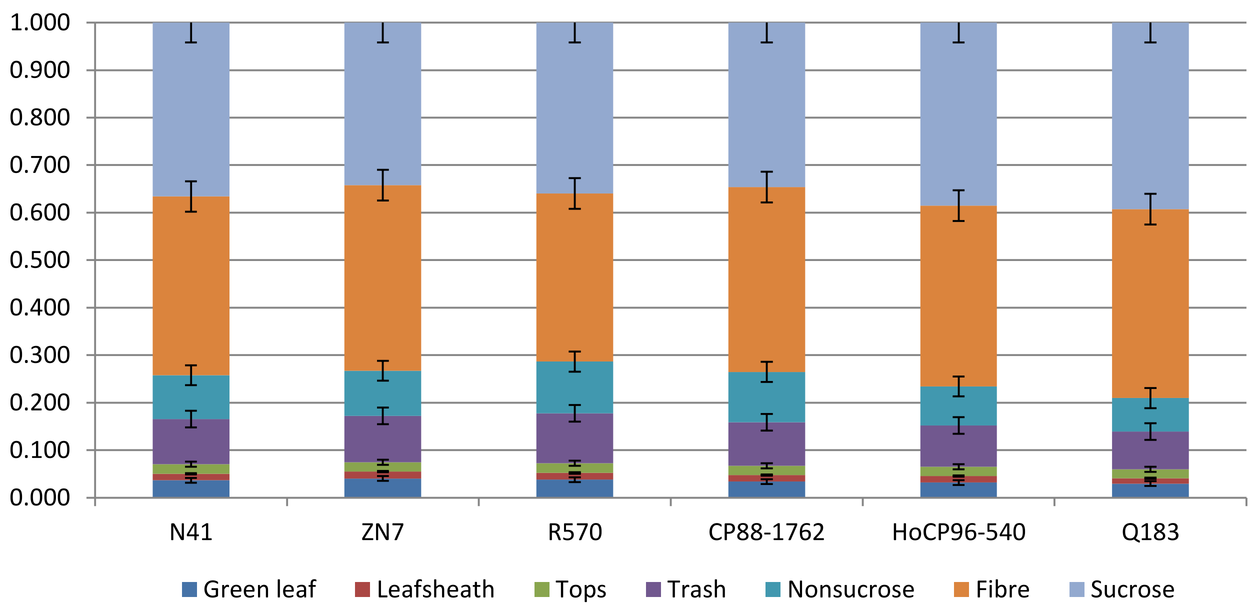


Figure 5.6: Biomass yield components of varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 for the ratoon trial at Field B 1-24 Impala Block, ZSAES at the third destructive sampling [9-months from harvest].

Biomass fractions
At 9 months after harvesting, the greatest proportion of biomass was allocated to the stalks; fibre and sucrose contributed the highest proportions. Also relatively high at this stage was the proportion of biomass allocated to trash [Figure 5.6]. Biomass fractions at 3, 6 and 12 months will be described in the Technical report.

Leaf Area Index
Leaf area was determined using a calibrated leaf area meter (Delta-T Devices Ltd., Burwell, Cambridge, UK). It was defined as the one-sided green leaf area per unit ground surface area. Leaves from 1 m length of row were measured. When crop leaf area index (LAI) was plotted against time after harvesting, four varieties namely ZN7, Q183, CP88-1762 and R570 showed three phases of LAI development; a rapid increase from three to six months, gradual increase up to nine months and a decrease in LAI from nine to 12 months. On the other hand, varieties HoCP96-540 and N41 had two phases, sharp increase in LAI up to six months followed by a decline up to 12 months (Figure 5.7).

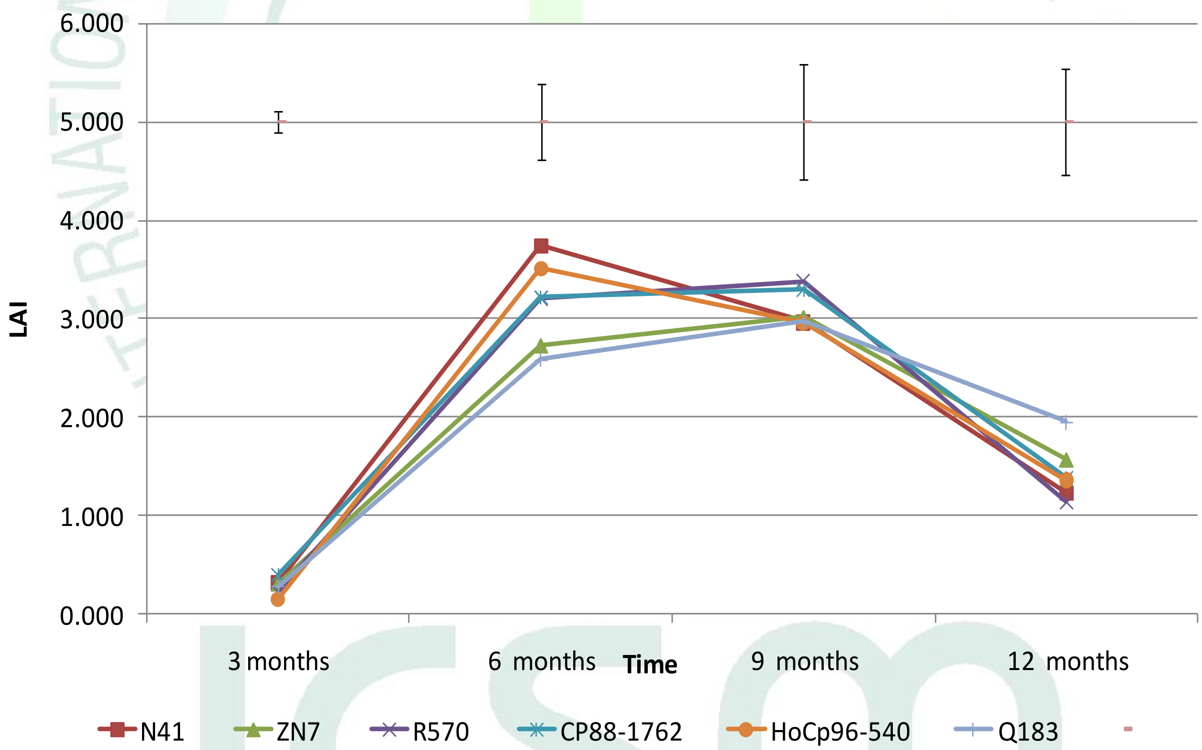


Figure 5.7: Leaf Area Index [LAI] for varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 at 3, 6, 9 and 12 months from planting where destructive samplings were done at Field B1-24 Impala Block, ZSAES.

5.5. Cane, sucrose yields and other agronomic traits.

Data on cane and sugar yields at 12 months from the harvest of the Plant Crop were obtained from an adjacent site where destructive sampling was not done. At harvest, cane stalks were cut at ground level (base cutting) and topped at the natural breaking point. Stalks from a plot were weighed and the weight converted to yield per hectare.

Generally, cane yield was higher in the first ratoon compared to the plant crop except for variety HoCP96-540. In the first ratoon, varieties ZN7, N41 and R570 attained the heaviest cane yields of respectively 144.3, 141.6 and 132.4 t●ha^{-1}. The worst cane yields were from varieties Q183 and HoCP96-540 respectively 66.6 and 121.2 t●ha^{-1}. The highest sugar contents [ERC % cane] were from varieties HoCP96-540 and Q183 while variety ZN7 had the lowest sugar content [Figure 5.8]. Only Q183 had sucrose yield statistically lower [P=0.05] than all the other varieties. With regards to other agronomic attributes, Q183, R570 and ZN7 had the lowest stalk populations while N41 had the highest number of stalks per hectare. Besides their low stalk populations, Varieties ZN7 and R570, had thicker and longer stalks [Figure 5.9] resulting in among the best in cane yields.

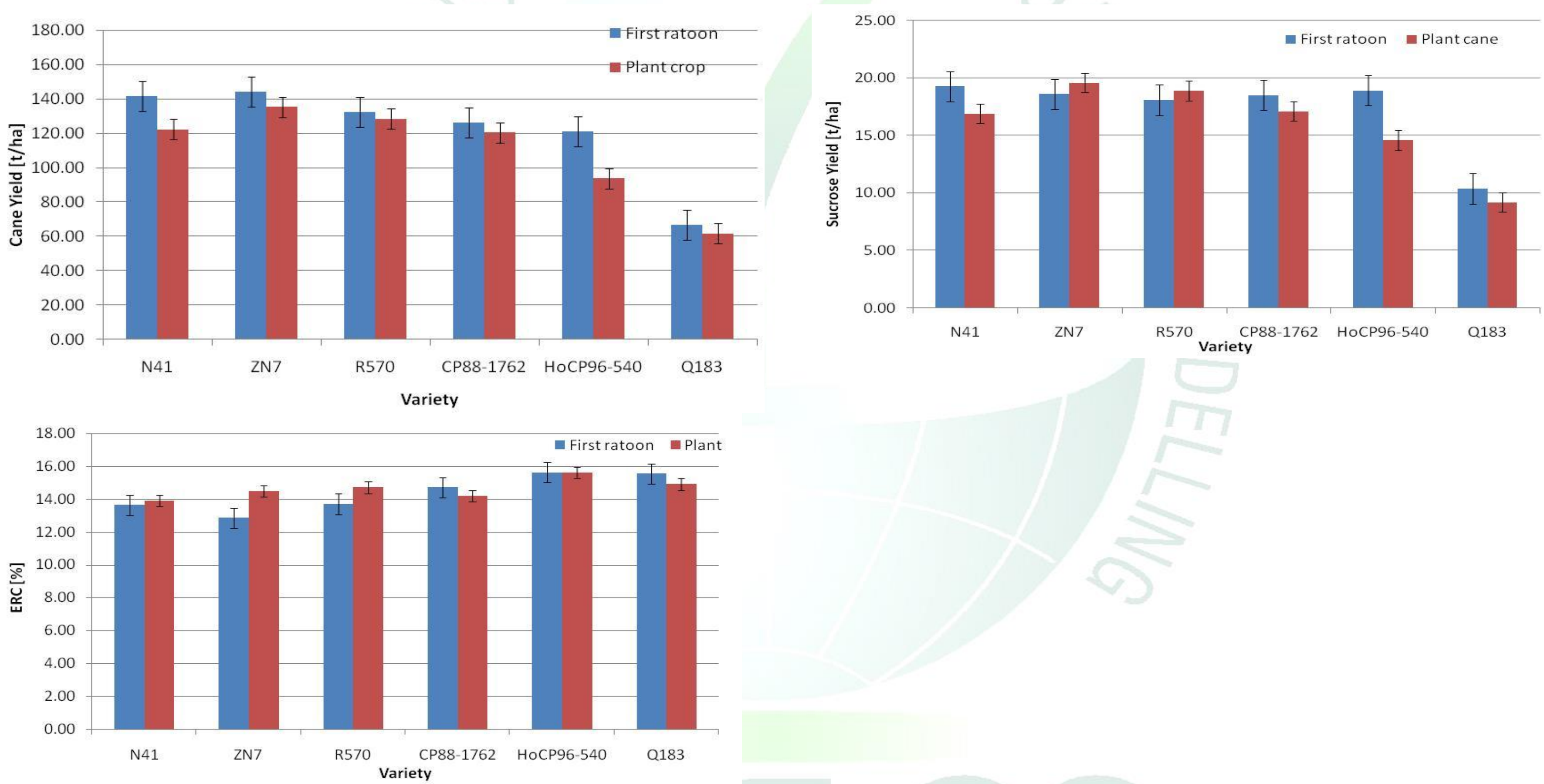


Figure 5.8: Sugarcane yield, ERC% cane and sucrose yield of varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 at Field B1-24 B-Block, ZSAES at 12 months after ratooning. Vertical error bars represent $LSD_{0.05}$.

Figure 5.9: Length, population and diameters of stalks of varieties N41, ZN7, R570, CP88-1762, HoCP96-540 and Q183 at Field B1-24 B-block, ZSAES. Measurements were done at 12 months after ratooning. Vertical error bars represent $LSD_{0.05}$.

5.6. Challenges

All the varieties had poor emergence in the plant crop at Field B 1-24 Impala Block in December 2013 to January 2014. Plant crop trial was at L3 and the ratoon site was at Field B 1-24. Same seed cane was used to establish the crop at Field L3 in October and Field 1-24 in December. The same seed cane was used on the two sites and by December it was old [about 13 months] resulting in the slow and reduced emergence.

There were challenges in measuring canopy and stalk heights after March 2016. The cane was tall and lodged as a result the measurements were discontinued.

Samples, especially stalks took long to dry at an oven drying temperature of 60 degrees celcius. The problem was further exacerbated by frequent power cuts. At the time of compiling the report, the samples collected at 12 months from harvest of the Plant Crop were not quite dry, about 4 weeks after sampling.

6. CROP MODELLING

Matthew Jones has been appointed as the Ph.D. student responsible for the modelling work. He has started assembling trial data and metadata preparatory to setting up model runs and for facilitating data analysis across sites. A review of scientific literature has commenced and a Ph.D. proposal is under development.

7. PROJECT ADMINISTRATION

The memorandum of agreement that governs this project has been revised to reflect the new arrangements for the modelling work. The part time Ph.D. student will conduct the modelling phase from 2016 to 2020 and will receive a bursary of US$ 15 000 per year. Costs will be shared in equal parts between the four participants. The project is scheduled to finish in 2020.

8. CONCLUDING SUMMARY

Trial work has progressed well in 2015/16 in all of the participating countries.

In South Africa the ratoon crop experienced some drought stress due to restricted water supply and cane yields were relatively low (60-100 t/ha) with cultivar N41 producing the highest yield. Data has been captured in the prescribed format and technical report was compiled. The plan is to repeat the experiment on the second ratoon crop and to focus on monitoring the response of the different cultivars to water stress that is expected to occur.

In Reunion Island the plant crop trial was completed with yields varying around 110 t/ha, and the ratoon crop trial commenced. Data was captured in the prescribed Excel format and a report on the methodology was compiled.

In Florida, USA, the ratoon crop trial was completed. Yields were high compared to the other sites, varying from 110 to 150 t/ha, with CP88-1762 yielding the highest. Data capture into the prescribed format still needs to be done.

In Zimbabwe, the ratoon crop trial was completed. Yields were higher in the ratoon crop than the plant crop and varied between 60 and 140 t/ha, with local cultivar ZN7 yielding the highest. Data capture into the prescribed format and the compilation of a technical report are under way.

Interesting aspects emerging from the global data set are (1) N41 generally produced the highest stalk population and R570 the lowest, (2) Q183 often developed canopy cover the quickest, (3) cultivars often produced the highest cane yield in the environment that they were selected for (N41 in South Africa, CP88-1762 in Florida and ZN7 in Zimbabwe), and (4) although differences in yield were often not statistically significant, the ranking of cultivars were different for the different environments.

There are mow enough data available to proceed with global analysis and modelling with a suite of sugarcane models to gain a better understanding of genetic control of growth and development responses to environmental factors.