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Geraldo Veríssimo de Souza Barbosa, João Messias Dos Santos*, José Vieira Silva, Lailton Soares, Carlos Assis Diniz, Edjane Gonçalves De Freitas, Adeilson Mascarenhas de Oliveira Silva, Danilo Eduardo Cursi, Hermann Paulo Hoffmann

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BP7 **Nitrogen use efficiency – a tool for screening drought tolerant sugarcane varieties at early growth stage**
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BP8 **Selection of energy cane clones by logistic model**
J Borella, B P Brasileiro, Ricardo Augusto De Oliveira, Joao Carlos Bespalhok Filho*

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Patcharin Songsri*, Saranya Chumphu, Nuntawoot Jongrungklang

BP10 **Physiological traits related to high sugar yield of 40 sugarcane genotypes grown under rainfed condition**
Patcharin Songsri*, Jiraporn Nata, Nuntawoot Jongrungklang, Nam-aoi Bootprom

BP11 **Association of the physiological responses on yield and agronomic traits of 19 sugarcane genotypes grown under rainfed condition**
Patcharin Songsri*, Jiraporn Nata, Nuntawoot Jongrungklang

BP12 **Leaf anatomical traits of sugarcane F1 hybrid derived from parents having different genetic background**
Supaporn Jumkudling*, Worasitikulya Taratima, Patcharin Songsri, Nuntawoot Jongrungklang

DETERMINING BREEDING VALUES OF PARENTAL GENOTYPES FOR SUGARCANE YIELD

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Breeding values (BV) refer to the ability of a genotype to produce superior progenies when crossed with other genotypes. The BV are used to predict the breeding performance of parental genotypes. The objective of this study was to use best linear unbiased prediction (BLUP) in order to determine breeding values of parental genotypes for cane yield. Data were collected from family evaluation (40 female, 26 male parents) trial, planted in Midlands region of KwaZulu-Natal in 2013. A randomized complete block design (RCBD) was used with three replicates per family. Cane yield was estimated from stalk number, height and diameter measured from the first 20 progenies per plot. BLUP analysis, which provides comparison of genotypes to population means, was done using SAS mixed models. There were significant female ($P=0.0003$) and male ($P=0.0145$) variances, indicating that large genetic variability among progenies was associated with parents. Genotypes 00B1741 (6.35, $P<0.0001$), 82H0397 (5.71, $P<0.0001$), 90H0525 (2.21, $P=0.0273$), 85H0428 (2.81, $P=0.0050$), N52 (2.94, 0.0033), 01B0742 (3.98, $P<0.0001$), 95H0464 (2.43, $P=0.0152$) and 86H0437 (1.98, $P=0.0473$) had significantly higher BV. Progenies from cross combinations of diverse parents with 00B1741 (+10%), 82H0397 (+16%), N52 (+16%) and 93H0460 (+26%) produced higher cane yield. Genotypes N52 (14% - 38%), 82H0397 (16% - 33%) and 85H0428 (20% - 45%) when crossed with diverse parents from coastal, Midlands humic and sandy soil regions produced higher cane yield suggesting broad general combing ability. Testing BV of genotypes with diverse populations is expected to identify parents suitable in breeding for general adaptability and for use as tester parents in sugarcane breeding.

Keywords: Breeding values, SAS mixed models, BLUP, Diverse parents, Sugarcane

ESTIMATING BREEDING VALUES IN SUGARCANE BREEDING USING SAS MIXED MODELS

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Parent evaluation is an important requirement prior to use in plant breeding. Sugarcane breeding programmes generally utilise additive genetic effects in breeding for cane yield. In order to effectively utilise additive genetic effects, estimates of breeding values of parental genotypes are required. The breeding value (BV) of a genotype refers to the value of the genes the genotype can transmit to its progenies during crossing. Breeding values of a genotype can be estimated using cane yield data of progenies produced by the genotype when crossed to other genotypes. The objective of this study was to demonstrate the estimation of BV in sugarcane breeding using Statistical Analysis System (SAS) linear mixed models procedure. Data were collected from Stage 1 trials established in 2012 at the Empangeni Research Station of the South African Sugarcane Research Institute (SASRI). Seedlings were germinated in the glasshouse at SASRI's Mount Edgecombe research station in Durban from 199 crosses made from 69 females and 46 males. Seedlings were transplanted to airbricks and left to grow for 10 months until they produced at least 1 m long stalks. The design used in the bricks was a randomised complete block with three replicates and the design was carried forward to field planting. At 10 months age, the stalks from each seedling were harvested and planted in 1 m long plots in a tramline with adjacent rows spaced 1.2-m apart and 2.4-m between tramlines in a serpentine fashion. Data for stalk number, stalk height and stalk diameter per genotype for the first 20 genotypes in a plot of a cross were recorded at 12 months crop age. Cane yield (CY) of a genotype was estimated as the product of stalk number, height and diameter using established formula. The CY data was analysed using SAS mixed models, with the COVTEST option, to determine BVs for parental genotypes using Best Linear Unbiased Prediction (BLUP). The highly significant female genetic variance (σ^2=2.97±0.70, P<0.0001) suggested variability of female genetic contribution to progenies' CY potential. Males had significant genetic variance (σ^2=1.25±0.53, P=0.009) indicating male genetic contribution to progeny CY. Females contributed larger variability among progeny cane yield. Female parents 01U0546, 03U0757, 05T0740, 79F0779, 93E0888, 97E0474, 99T2609 and WI8508 had significantly (P<0.05) higher BVs for cane yield. Male parents 93W1588, B74713, N53 and WI8508 had significantly (P<0.05) higher BVs for cane yield. The results further confirmed higher genetic contribution of females to CY of progenies compared to males and that 12% females and 9% of males had significant breeding values. The analysis is suitable for unbalanced data and can be combined across trials in similar environments. Estimates of breeding values are helpful in guiding parent selection in sugarcane breeding at SASRI.

Keywords: Parent evaluation, Additive genes, Genetic variance

HOW TO MAKE THE BEST SUGARCANE CROSSINGS MANAGING THE FLOWERING TIME

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Parental clone improvement is an essential component in commercial breeding programmes. Its importance has been fully realised in the CTC Sugarcane Breeding Programme. The breeding values (BV) for TCH (tonnes cane per hectare) and sucrose content (SC) are estimated from progeny performance data and used to select the best parents and to plan all the superior predicted cross combinations. Every year about 1140 bi-parental combinations are planned in advance, comprising 190 crosses for three specific agro-climatic regions and two harvest periods (late and early). All crossings are done at the Camamu/BA research station. The crossing station is located at an altitude of 125 m, at latitude of 13°55'S and longitude of 39°08'W. The annual average temperature is 24.5°C and the precipitation of 2100 mm. These conditions are favorable for optimum crop development and flowering of most genotypes. The flowering period begins at the end of April and is over by the end of June. The flowering peak occurs in the middle of May. Among the parents used in the planned crosses, some of them can flower at the beginning of the crossing period, others in the middle and some of them at the end. Therefore, it is extremely important to have a good management of flowering and flower synchronization and make the desired combinations between the best parents. The early flowering genotypes are planned for use at distinct periods. As a result, some early flowering parents are subjected to the delay of flowering treatment, using lights to promote changes in the length of the nights. For the genotypes that are more responsive to long nights or that are not induced, photoperiodic facilities with controlled light are used in order to induce flowering using dark chambers. The success of these flower synchronisation strategies is a function of flowering date, early or late, and flowering intensity. As early-flowering genotypes flower intensely, the strategy is to plant in different seasons and areas to increase the window of flowering. For late-flowering genotypes that flower less intensely, the strategy is to plant early, in different areas, where there is higher sunlight intensity and in multiple plots. With all these strategies the CTC crossing stations are achieving 98% of the planned elite crossings and the main emphasis of the program is to use the best parents that have higher probability of producing elite genotypes.

Keywords: Flowering, Crossing, Synchronisation, Breeding value

EVALUATION OF EXTENT OF FLOWERING AND ISLAND PITHINESS IN COMMERCIAL PARENT VARIETIES IN MAURITIUS

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New sugarcane varieties, that suit the needs of the Mauritian sugarcane industry, are produced through breeding (and selection) which predominately rely on the flowering ability of potential parent genotypes. In Mauritius, breeders rely on natural flowering of parent varieties for carrying out hybridization. Flowering intensity and extent of pith development are important criteria at stage 4 (2x5 m, in three replicates) and the final selection stages of the variety development programme. Flowering which is an undesirable characteristic among growers makes it a key criterion in the process of selection in the variety development programme. High flowering commercial varieties, if not harvested in time, tend to develop island pithiness in the upper portion of the stalk leading to cane yield losses. The objective of the study was to evaluate the flowering ability of the current parent varieties and to use the displacement method through accurate measurements of volume and mass of flowered and vegetative stalks, of the same age, to assess yield loss due to pithiness. A replicated trial was laid out at Belle Rive, in an F soil (Humic Ferruginous Latosol), in the superhumid zone of the island, involving four commercial parent varieties namely M 387/85, M 1394/86, M 1400/86 and M 703/89 in order to assess the effect of flowering on cane yield loss due to pithiness, in two ratoon crops. A split plot design was used with light treatment as main plot and varieties as sub plot. Each test variety was planted on 6 rows x 12 m, in three replicates. The night break treatment, to inhibit flowering, consisted of two white spot lights of 100 W at both extremities of the two middle rows, for 3 h from 19h00 to 22h00, during 4 consecutive weeks, at the induction phase at the age of 7 months. Results averaged over two crop cycles gave a flowering intensity of 19% in M 1394/86, 35% in M 1400/86, 65% in M 387/85 and 88% in M 703/89. The extent of pith development in the upper portion of the flowered stalks was 3, 4, 7 and 9 internodes in M 387/85, M 1400/86, M 703/89 and M 1394/86 respectively. The resulting cane yield loss due to pith development amounted to 1.1% in M 1394/86, 1.3% in M 387/85, 1.6% in M 1400/86, and 4.8% in M 703/89. In all cases of comparison, there were no significant correlations between the three parameters: pithiness and yield loss (0.22^{ns}), flowering intensity and pithiness (-0.27^{ns}) and flowering intensity and cane yield loss (0.80^{ns}). The correlation between flowering intensity and cane yield loss was not significant but the correlation between the combined effect of flowering and extent of pithiness against cane yield loss was significant. Given that cane yield loss is higher in varieties that have high flowering intensity combined with high extent of pith development, therefore parent varieties with high flowering intensity but low pith development can be used in crosses.

Keywords: Parent varieties, Flowering, Pithiness, Yield loss

TOTAL ANTIOXIDANT ACTIVITY IN EARLY GENERATION AND COMMERCIAL SUGARCANE GENOTYPES IN LOUISIANA'S SUGARCANE VARIETY DEVELOPMENT PROGRAM

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Sugarcane genotypes from Louisiana's commercial variety development and germplasm enhancement programmes were evaluated for total antioxidant activity using 2,2-diphenyl-1-picrylhydrazyl (DPPH) of sugarcane juice collected at harvest. Commercial genotypes were collected from multi-location replicated experiments, while enhanced germplasm was collected from a single location. The average range in activity of the commercial genotypes was 13-26 ug/ul Trolox equivalents while that of the early-generation genotypes ranged from 9 to32 ug/ul Trolox equivalents. While significant differences in activity were seen between genotypes and locations, no significant location by genotype interaction was detected. The relationship of antioxidant activity with important economic traits of sugarcane were evaluated. Antioxidant activity was positively correlated with fibre content, stalk number and colour.

Keywords: Antioxidant, Multi-location, Fibre content, Sugarcane, Variety

VEGETATION INDEX AS A PARAMETER FOR IDENTIFYING SPATIAL VARIABILITY ZONES IN EARLY STAGE SELECTION TRIALS

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Experimental trials may be assumed by breeders as being uniform such that significant differences observed between treatments are exclusively due to genetic effects. This is theoretically possible if spatial variability is effectively accounted for and partitioned in analyses via incomplete, complete blocking or by row-and-column designs. This may be especially important in the early stages of selection where large areas are involved. However, blocking does not always ensure control of spatial variation. Inappropriate blocking may even inflate the estimated experimental error variance, thus reducing heritability values. Spatial variability can be measured through either a priori or posteriori approach. A priori methods of quantifying spatial variability are based on identifying existing trends within a field and may then be accounted for using appropriate experimental designs. Vegetation indices, such as the normalized difference vegetation index (NDVI), obtained via reflectance measurements at the red and near-infrared (NIR) wavelengths, have been successfully used for a priori mapping field variability. A rotation crop (_Crotalaria juncea L._) was considered for a priori mapping field variability for a Progeny Assessment Trial (PAT), which is the first selection stage of the Sugarcane Breeding Program of the Inter-University Network for the Sugar and Ethanol Development Sector (RIDESA) from the Federal University of Sao Carlos (UFSCar), Brazil. About 300 families were tested for cane yield in an area of 6.5 ha. The NDVI was calculated using the rotation crop spectral reflectance from an aerial platform using a multispectral camera. Following the imagery post-processing, if spatial variability was identified, correlated traits were considered and then used as covariates in the statistical genetic modeling, aiming an increase in the selection accuracy. The NDVI was able to subdivide the experimental area into three different zones of spatial variability varying from low to high yield potential. Adjusting the statistical genetic model, it was possible to identify different estimates of genetic values among the families, an expected result since the within-field variability could be handled efficiently. Therefore, an increase in the heritability of the trait under selection could be observed. The results suggest that vegetation index should be considered at early breeding trials, aiming to enhance the selection accuracy, one of the ways to accelerate the genetic gain within a breeding program. Even more promising results could be obtained using additional and complementary remotely sensed measurements such as soil electrical conductivity.

Keywords: NDVI, Remote sensing, Site variability, Selection accuracy

EVALUATION OF CROSSING COMBINATION FOR IMPROVEMENT OF RATOON YIELD IN TANEGASHIMA ISLAND, JAPAN

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Improvement of ratoon yield is one of the most important breeding objectives in Japanese sugarcane breeding programmes. In the present study, ratoon yield of progenies derived from selected crossing combinations was evaluated in order to identify the important traits for improvement in Tanegashima island and the required characteristics of parents. Cane yield and brix of 20 progenies in the seedling stage (plant cane crop) was examined. Each progeny was composed 60 seedlings (30 seedlings/plot in two 2 replicates) and planted at the Sugarcane Breeding Site of KARC/NARO on Tanegashima island in April 2015. Cane yield of each seedling was estimated from stalk number, stalk diameter and stalk height measured in October, and brix was measured with a hand refractometer in December. Brix yield of each seedling was calculated by multiplying the estimated cane yield by brix. Ten progenies, including the top 3 and bottom 3, based on average brix yield, were selected. From each progeny 15 clones were randomly selected and planted in February 2016 in a completely randomized design with no replication. The planting density was 6.1 plants/m^2 (1 row, 1.5 m long and 1.1 m wide). All clones were evaluated based on standard practice for 2 years (plant cane and first ratoon crops), and cane yield, brix and brix yield in each year were recorded. Although progeny-averaged cane yield and brix yield showed positive correlation between the seedling stage and the clonal plant year, there was no correlation between the seedlings stage and the clonal ratoon year. Among the examined progenies, the progenies which had interspecific F1 hybrid or BC1 clones as one of the parents showed relatively higher stalk number and higher cane yield in the ratoon crop. These results suggested that the progeny test only in the seedling stage might be less effective in improving ratoon yield, and that enhancement of tillering capacity with the use of interspecific crossing would contribute to improve ratoon yield in Tanegashima island.

Keywords: Interspecific crossing, Progeny test, Ratoon yield, Stalk number

BO8

CREATION OF GENETIC VARIATION AND SELECTION FOR DROUGHT TOLERANCE IN SUGARCANE

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Drought is a serious problem for sugarcane production in Thailand. It impacts negatively through the reduction in quantity and quality of sugarcane. To cope with the drought problem, interspecific hybrids between sugarcane cultivars and wild cane (*Saccharum spontaneum*) were developed. A total of 5213 interspecific hybrids were developed from 6 crosses. Out of the total, 235 hybrids from Uthong1 x *S. spontaneum*, Uthong1 x Biotech1 and TBy26-1255 x KUS0707 were prepared for *in vitro* induced mutation. After *in vitro* culture, two hybrid plants from crossing between Uthong1 and Biotech1 (UB2 and 7 UB7) and a hybrid from crossing between TBy26-1255 and KUS0707 (TByk3) were grown on culture media. The three hybrids were selected for multiplication and induced mutation. After 6 months of multiplication process, a total of 2,791 hybrid plants were available for mutation induction by gamma radiation and Ethyl-methanesulfonate (EMS). The 2296 hybrids were treated with 5 doses of gamma irradiation (0 ,15 ,20 ,25 and 30 Gy) and the 495 samples were applied with 10 mM of EMS for 4 hours. Results of the *in vitro* evaluation in M3 population for water deficit tolerance showed that 82.7% of the mutants survived on the selected media. Moreover, 14 mutant hybrids for water shortage tolerance showed good performance on the selective media. On the other hand, 5000 sugarcane hybrids were screened for drought tolerance under both greenhouse and field conditions. Under greenhouse conditions, drought was set up by decreasing available soil moisture (DASM) around 5-6% over three drying cycles. Out of the total, 721)14.4%(hybrids were identified as water-stress tolerant based on leaf symptoms. The selected hybrids were transplanted in Loburi province for drought evaluation. After two cycles of extreme drought, a total of 476 hybrids survived while sugarcane cultivars used as female parent did not. Out of 476, only 3 interspecific hybrids presented stalk height and stalk number per clump greater than the set selection criteria. The number of selected hybrids from *in vitro* evaluation and field evaluation amounted to 17 clones. The total number of selected hybrids can be used in sugarcane breeding programmes for drought tolerance.

Keywords: Interspecific hybrids, Mutation, Gamma ray, EMS, Drought tolerance

BREEDING FOR HIGHER TOTAL CANE BIOMASS FOR MARGINAL ENVIRONMENTS AND FOR YEAR-ROUND HARVEST IN MAURITIUS

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In view of the enormous challenges facing the Mauritian sugarcane industry, research on high biomass varieties started in the last decade. In 2014, a highly selected population of 12 genotypes, including three commercial varieties, were implemented in two sub-optimal environments (dry rainfed and super-humid) for harvest in two contrasting periods (June and December). In each environment, consisting of two trials with 2 x 10 m plots in three replicates, data were collected on 8-, 10- and 12-month old crops over a plant cane and first ratoon in order to estimate yield potential of each variety. The following characters were measured: cane quality (sucrose content, fibre content and juice purity), morphology (stalk diameter, height, cane density per unit area, growth habit and flowering) and aboveground biomass parameters (cane yield, sugar yield, fibre yield, sugarcane field residues consisting of cane tops, green and clinging dry leaves) yield and total biomass yield, on both fresh and dry weights basis. Cane yield of each plot was recorded at 12-month age. Biomass yields in 8- and 10-month old crops were estimated using stalk number per unit area, stalk diameter, stalk height and field residues weight. A split-split-plot model was adopted where location was assigned as whole plot, variety as sub-plot and sampling date as sub-sub-plot. There were significant differences between varieties for all the biomass characters at the first ratoon crop at both locations. Above ground biomass yield, on a fresh weight basis ranged from 93.3 to 131.2 t ha^{-1}, at 12-month age across four trials, compared to 108 - 119 t ha^{-1} for the three commercial varieties. The cane quality traits, particularly sucrose level, showed high GxE interaction across harvest period while the yield parameters showed significant interaction across locations. The commercial type varieties were highest biomass yielders in the dry area, producing 20% more biomass compared to the high fibre genotypes. In contrast, some high fibre varieties were highest biomass yielders in the super-humid zone. In the dry zone, in June and December respectively, total dry biomass production (t ha^{-1}) was as follows: M 1334/84 (60 and 43), M 196/07 (51 and 50) and WI 81456 (42 and 45) compared to an average of 51 and 38, for the three commercial varieties. In the super-humid zone, WI 81456 was the highest dry biomass yielder producing 41 and 37 t ha^{-1} of dry biomass while the commercial varieties averaged 29 and 22 t ha^{-1} in the June and December, respectively. In the dry zone, M 1334/84 represented a good candidate for increasing the total biomass without jeopardizing sugar yield. The high fibre type biomass varieties are characterized by numerous tall stalks of thin diameter that were lighter than those of the commercial varieties. They were also highly vigorous during the vegetative phase that ascertained that they could be harvested at younger crop age and outside the harvest season. Weight estimates at 8-month old crops indicated the potential of exploiting different varieties for biomass production under sub-optimal environments with three harvests in two years, instead of the usual 12 months harvest.

Keywords: Bioenergy, Sub-optimal environment, Interaction, Biomass yield

OPTIMIZING GENOMIC SELECTION IN SUGARCANE FOR PHENOTYPING COST AND SELECTION ACCURACY

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Genomic selection is a promising technology for accelerating the genetic improvement of sugarcane because phenotypic evaluation of economic traits is time consuming especially when evaluating phenotypic values in ratoon crops. In this study, the accuracy of genomic prediction for selecting ratoon crops was evaluated based on the phenotypic data of plant cane as well as genome-wide marker data. As the cost for phenotyping plant cane seems to have a trade-off relationship with selection accuracy, an attempt was made to optimize the genomic prediction for phenotyping cost and selection accuracy. In this study, phenotype data and marker genotype data of 189 F_1 lines of sugarcane (*Saccharum* spp. hybrid) and parents NiF8 and Ni9 were analysed. The phenotypic data of F_1 lines was collected at three locations, Tanegashima (in 2009-2010), Tokunoshima and Ishigakijima (in 2010-2011) in plant cane and ratoon crops. Sugar yield in ratoon crops was taken as a target trait, and stalk number, stalk height, stalk diameter and brix (top and bottom) of plant cane for predictors. The F_1 lines were genotyped with 5,389 SNPs. As 12 traits were used as covariates, there were 2^{12} possible combinations of traits included in the model. To find the optimal combinations of traits, the accuracy of genomic prediction with brute force searching and Bayesian optimization was evaluated. Stalk number and height at the harvesting of the plant cane crops were particularly important for accurate prediction. The Bayesian optimization is an efficient way to find optimal combinations of traits as predictors. With the optimization method proposed in this study, genomic selection of sugar production can be accurate even under the reduction of phenotyping cost.

Keywords: Genomic prediction, Phenotyping cost, Bayesian optimization

USE OF GENOMIC SELECTION TO SPEED UP GAINS IN SUGARCANE BREEDING

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Traditional sugarcane breeding methods have limitations which are well known to most breeders: most phenotypic data is time consuming and expensive to obtain, and because of variation due to experimental error, inter-plot competition, and GE interactions, may be poorly predictive of genetic values. Further, and most importantly for sugarcane, low narrow sense heritability of key traits cane yield and sugar content, coupled with a long generation interval, contributes to very slow longer-term rates of genetic gain compared with other crops. Some recent data from experiments in Australia will be shown to illustrate low narrow sense heritability and highlight this issue. Development of high throughput SNP marker technologies in the past decade and concurrent developments in statistical analysis of data sets with very large numbers of DNA markers has led to approaches called "genomic selection". These are being progressively applied in commercial breeding in animals and some crops for fast and accurate prediction of breeding values in potential parents. These methods, facilitated by relatively low cost and high throughput SNP marker platforms, are expected to be progressively incorporated into commercial breeding programs. Genomic selection has already had a large impact in some commercial animal breeding programs, and is being adopted in some major crop breeding programs. Sugarcane breeding programs present special opportunities which would appear to be ready-made for some applications of genomic selection. In particular, it seems that genomic selection could speed up rates of genetic gain in sugarcane breeding through more accurate and concurrent prediction of breeding value for major traits such as cane yield, sugar content and disease resistance, combined with rapid marker assisted recurrent breeding cycles. Data from recent experiments in Australia will be used to illustrate this. Several potential breeding schemes to take advantage of genomic selection in sugarcane breeding programs will be discussed. The value of genomic selection for predicting total genetic value in sugarcane will likely benefit greatly from development of statistical models which can predict non-additive genetic effects better than those currently available. Genomic selection should also have potential to improve introgression of wild germplasm and approaches for this purpose will also be briefly described.

Keywords: DNA markers, Narrow sense Heritability, Breeding values

UTILIZING WILD GERMPLASM IN SUGARCANE BREEDING – PROGRESS AND PROSPECTS

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Sugarcane breeders have a long experience of using wild germplasm. The introgression of *Saccharum spontaneum* into the original sugarcane clones of *S. officinarum* in the early 1900s remains historically one of the most successful examples of utilizing wild germplasm in any crop species. Later, from the 1960's there were further enormous efforts in several countries to introgress other wild clones in order to sustain ongoing gains in sugarcane improvement. There remains interest and effort in introgression breeding in sugarcane in many countries. Some important successes have been achieved in sugarcane introgression breeding efforts initiated since the 1960's. In Australia, the most successful example is the development of numerous important cultivars from the wild *S. spontaneum* clone 'Mandalay'. However, a great amount of introgression breeding has also been conducted (in Australia and other countries) which up to now has been unsuccessful in terms of cultivar delivery. Most effort has been devoted to using *S. spontaneum*. More recently emphasis has been laid on the use of *Erianthus arundinaceus*. Some promising clones derived from *Erianthus* in third or fourth backcross generations have been developed in some countries (e.g. India, China, Australia), but perhaps the results have not been as successful as hoped or expected by some. Overall, the results of introgression breeding in the last 50 years in terms of commercial cultivars generated remain very mixed – some successes but some not. The basic overall difficulty and key challenge associated with introgression breeding in sugarcane is the same as in other crops. This is that the basic germplasm brings with undesirable traits and QTL (especially for low sugar content in the case of sugarcane) which need to be eliminated via repeated cycles of crossing back to the highly bred and commercially superior parental material. At the same time as this backcrossing occurs, desirable traits and genes from the wild donor may be progressively diluted or lost with successive generations. In this paper, based on past experience and available knowledge, some opinions and recommendations are given on best approaches to use wild germplasm in sugarcane breeding in future. Some key points include: (i) That there would appear to be a compelling case for using the emerging genomic selection technologies to assist introgression breeding in future. In theory this should be very effective at addressing past problems. Specific and practical approaches that may be effective in sugarcane are suggested. This includes doing QTL mapping in appropriately segregating backcross generations in order to identify both favourable and unfavourable alleles derived from the wild germplasm clones, which can then be effectively selected for and against using markers. Some example data is indicated which illustrates this approach. (ii) It is possible that much greater progress could be made through a coordinated international network involving sharing data, results, and germplasm for mutual benefit, rather than smaller independent efforts. Some suggestions on how this could develop are suggested.

Keywords: *Saccharum spontaneum, Erianthus*, Introgression breeding, Genomic selection

CHARACTERISTICS OF INTERGENERIC HYBRIDS BETWEEN *SACCHARUM* SPP. HYBRID AND *ERIANTHUS ARUNDINACEUS*

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Erianthus arundinaceus shows potential as a breeding material with *Saccharum* spp. hybrids. However, little is known about the cytogenetic and agronomic characteristics and relationships of intergeneric hybrids between these two genera. In Japan, 43 intergeneric hybrids were identified from analyses of 5S rDNA markers and morphological traits. The nuclear DNA content and 5S rDNA sites of intergeneric hybrids showed intra-clonal variation. The somatic chromosome numbers from the *Saccharum* spp. hybrid (2n = 110) and *E. arundinaceus* (2n = 60) in the intergeneric hybrids suggested n + n parental chromosome transmission with varying degrees of *E. arundinaceus* chromosome elimination. On comparing with both parents, most intergeneric hybrids showed hybrid weakness in agronomic traits such as dry matter and cane yield (36% and 28% of female sugarcane, respectively). Average values for millable stalk length, stalk diameter, and single-stalk weight were smaller than the mid-parent values, although the average value for stalk number was higher than that of the female *Saccharum* spp. hybrid. The average juice Brix (14.1%) and sucrose content (8.5%) of the intergeneric hybrids were lower than the female sugarcane (18.8% and 17.8%, respectively) but its fibre content (16.7%) was higher than the female sugarcane (10.2%). The hybrids showed wide variation in quality-related traits, thus allowing selection of those showing a relatively high sugar content, low fibre content, and low reducing sugar content for backcrossing. A significant positive correlation (0.78 – 0.67) was observed between the number of *E. arundinaceus* chromosomes and the dry matter yield, number of stalks per stool, millable stalk weight, single-stalk weight, and stalk length. However, an increase in the number of *E. arundinaceus* chromosomes was not correlated with stalk diameter, number of internodes, juice Brix, and fibre content. The root system of a promising hybrid was bigger and deeper than typical female sugarcane. These findings could be utilized to enhance the use of *E. arundinaceus* as a breeding material with *Saccharum* spp. hybrids.

Keywords: Agronomic traits, *Erianthus*, GISH, Intergeneric hybrid, Sugarcane

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WEB-BASED PEDIGREE DATABASE FOR SUGARCANE BREEDING

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A sugarcane pedigree database for breeders was developed by the Kyushu Okinawa Agricultural Research Center (KOARC). Pedigree information is important for crossing and selection. A sugarcane pedigree database was designed which can be used by browser like 'IE' and 'Safari' using PHP and MySQL. PHP is a widely-used open source scripting language that is suited for web development. MySQL is the most popular open source database. Web server supporting PHP and MySQL is required to run this system. However, for breeders it is easy to use this web-based application which can provide pedigree information anywhere, at any time. At present, the database has almost 3000 sugarcane accessions which are utilised in Japan including their respective parents. The main characteristics of this system are as follows: (a) Pedigree; male and female information between 3 to 8 generations: if there are same lines in the pedigree chart, they are filled with the same colour and the number of coloured lines indicate similarity with coefficient of inbreeding, (b) sibling; not only both parents are the same, but also one parent is the same, (c) offspring; results of crossing if it is successful. (4) reverse pedigree; offspring information with generations. In this system, the data on male and female parents is indispensable. Optionally, it contains stalk thickness and height, sugar content, maturity, reaction to smut disease and species name (*officinarum*' or '*spontaneum)*. The database can be managed in two ways: (1) editing data by accessing the database using MySQL directly. However, it will need technical skill. (2) using 'Pedigree Publisher' or 'Pedigree Explore' by ©Breedmate. This software is as user-friendly as Microsoft Excel and involves the export of data to this system. At present, advances in breeding technology bring widespread variation in crossing. Furthermore, the use of interspecific and intergeneric hybridization is on the rise. Therefore, breeders need to manage these complicated pedigree data. This system is useful to share and to manage pedigree data. Current data is based on useful agronomic trait, but marker data linked with pedigree information widen the scope for use of the database.

Keywords: Database, Pedigree, Network, Web

DEVELOPMENT OF MOBILE APPLICATION FOR SEARCHING THAI COMMERCIAL CANE VARIETIES

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A large number of commercial cane varieties are grown in Thailand and it is difficult to identify all of them by observation. A basic tool for cane identification was developed to assist technologists and those who are interested in sugarcane but lacking the skill and experiences to better understand about Thai cane varieties. This research aimed to develop an application on mobile phone under Android operational system widely used nowadays. The "Cane Variety Search" application can identify and show the varietal names quite rapidly. It linked information of cane varieties from the database of Thailand Sugarcane Breeding Center and identification was based on external characteristics including presence of hairs, type of auricle, degree of waxiness, internodes shape, stalks number, growth habit, stalk colour, number of rows of root primordial, bud tip and bud base, respectively. Pictures of these 10 external characteristics could be viewed from the menu with detailed explanation before sorting out by each characteristic in order until being able to tell what the observed commercial cane variety was. The "Cane Variety Search" application was tested on 100 samples and it could identify the Thai commercial cane varieties with an accuracy of more than 95%. The application was used in the training programmes and during the field visit at Thailand Sugarcane Breeding Center. Satisfaction level of 96.56% was rated by 50 users, indicating very good potential for use.

Keywords: Database, External characteristics, Sorting

SELECTION FOR BROWN RUST SUGARCANE RESISTANT VARIETIES USING SEEDLINGS FROM FUZZ

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Sugar cane brown rust (*Puccinia melanocephala* H. & P. Sydow), is a disease of economic importance in several countries of the Americas. In Ecuador, an increase in severity and incidence in the introduced varieties CR74 250 and CC85-92 along with a higher percentage of susceptible clones at the initial stages of selection has been observed since the 2013 crop cycle. In 2015 three groups of seedlings from 12 crosses at 76, 67 and 62 days after planting (dap) were evaluated on growing terraces simulating natural infection conditions. The seedlings were planted along with cane bud plants of two ages of 77 and 108 dap susceptible varieties/clones (B43-62, EC06-781 and EC11-1766). The reaction of the different progenies was evaluated using a visual scale where 1 = healthy seedlings (degree 0), 2 = seedlings with small pustules without sporulation (reaction 1-5 grade) and 3 = seedlings with large pustules at sporulation (reaction 6-9 grade). The highest percentage of infected families were at 76 and 67 dap together with susceptible bud plants of 108 dap. Seedlings from crosses with at least one of the parents with the *Bru*1 gene, previously identified with molecular markers, showed the least number of infected seedlings. The same group of 12 crosses were evaluated in 2017 with seedlings of 76 dap along with plants from buds of 108 days of the susceptible varieties. The trend of severity and incidence observed in the families was similar as registered in 2015. Seedlings of each family were sandwiched between rows of three susceptible varieties (used as inoculum lines). Results showed that from 685 seedlings of 12 families rated as 1 (degree of reaction 0) on terraces, only six plants (0.88%) had pustules, indicating that evaluation of seedlings in terraces is efficient to identify seedlings that are brown rust-resistant and is being used routinely in the selection process at CINCAE.

Keywords: Evaluation, Disease, *Bru* 1 gene

EVALUATION OF DISEASE RESISTANCE IN SUGARCANE CROSSES IN CHINA

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The aim of this study was to understand the characteristics of disease resistance of sugarcane parents and hybrid combinations, and to provide guidance for the selection of parents and hybrid progeny. Major agronomic traits and observations on pokkah boeng smut and leaf diseases in the plant crop, and pokkah boeng in the ratoon crop, were made in seedlings from 146 crosses. Correlation analysis, variance and combining ability analysis were conducted. Diseases observed in the seedlings in the plant crop included smut, red rot, ring spot, brown streak, purple spot and yellow spot diseases. Incidence of pokkah boeng in ratoon sugarcane was significantly higher than that in the plant crop. Correlation analysis showed that smut disease affected sugarcane yield in the plant crop. A highly significant ($P<0.01$) negative correlation was observed between incidence of pokkah boeng and leaf disease. Highly significant variation in incidence of pokkah boeng and incidence of leaf diseases among crosses was observed. The traits contained low broad sense heritability. Both additive and non-additive effects were important for incidence of pokkah boeng, but only additive effects were found for mean incidence of leaf disease and selection rate for leaf diseases. In the top 20 parents, leaf disease index had the highest breeding value, followed by pokkah boeng index, and leaf disease selectable rate had low breeding value. The results indicate that resistance to smut and pokkah boeng should not be evaluated in the plant crop.

Keywords: Disease resistance, Pokkah boeng, Smut, Heritability

HOW TO IMPROVE SELECTION DECISIONS IN THE FIRST REPLICATED YIELD TRIAL (RYT) OF SUGARCANE SELECTION PROGRAMS ?

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In the context of opportunities of revenue diversification from sugarcane, cane biomass remains the primary criteria of selection considered in variety development programs (VDPs). Measurements of cane yield (CY) is performed in replicated yield trials (RYTs) which usually start from the middle term of VDPs. Prediction of the genotypic value of candidate varieties (BLUP) for their cane yield is sought after as accurate as possible. In particular, confidence level in selection decision taken in the first RYT stage is crucial to expect for highest genetic gains for CY at the end of selection programs. Before RYTs, most of the initial genotype candidates are discarded in non-replicated stages due to insufficient performance for some traits showing good heritability. However, the first RYT can still contain a relatively large number of candidates, reaching about one to several hundred candidates (depending on programs). In some fields with a hilly topography a full replicate might involve risks of spatial heterogeneity due to possible differences in soil fertility, depth or humidity. Multidimensional regression spline methods represent a potentially attractive option to correct for potentially complex spatial heterogeneities. Such methods can be implemented in the framework of mixed linear models (REML algorithm). The study aimed to assess the potential of multidimensional regression spline (MRS) methods to improve selection decision in the first RYT stage of eRcane program. The MRS methods were applied to four variety trial series of 120 to 138 candidates. These candidates were tested for CY on $15m^2$ plots in a first RYT stage in a randomized complete block design (RCBD) in two replicates. In each series, the 30 elite candidates were advanced to the second RYT stage in a RCBD in three replicates on $45m^2$ plots. Compared to the conventional RCBD model, MRS methods allowed a reduction of the residual coefficient of variation of CY in the first RYT stage (0.65% to 4.36%), depending on series considered. Correlation between the first and second RYT stages for CY was improved (3% to 10%) when considering variety BLUPs inferred in the first RYT from MRS data modeling. The set of the highest 30 candidates for CY in the first RYT stage differed from 2 to 10 genotypes when comparing BLUPs inferred from RCBD and MRS models. These four case studies illustrate opportunities of improved trial precision and selection decision provided by data modelling of CY using MRS approaches.

Keywords: Replicated yield trial, Spatial heterogeneity, Multidimensional regression spline

HIGH-THROUGHPUT UAV PLATFORM FOR EARLY STAGE SELECTION IN SUGARCANE CLONAL ASSESSMENT TRIALS

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A clonal assessment trial (CAT) was established at Burdekin region of Australia in 2016. A total of 2108 clones selected from a progeny assessment trial in 2015 were tested in 6 m single row plot in two replicates. A high-throughput aerial imaging system was developed to capture various biological indices (BI) during crop growth using a multispectral sensor attached to a drone (M100 DJI). Drone-based BI were validated with ground truth data, obtained from a subset of clones of 60 within the CAT. The target BI were: canopy height, canopy cover, and spectral reflectance indices, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge (NDRE). Canopy height was derived from the visual images after constructing a Digital Surface Model (DSM). DSM is an elevation model, which captures the height of surfaces above the terrain. Canopy cover is estimated from the visual images as the number of vegetation (green) pixels per plot relative to the number of soil pixels. Vegetation indices NDVI and NDRE are derived from multispectral images. Multispectral camera captures five images at wavelengths 475 nm, 560 nm, 668 nm, 717 nm and 840 nm, which corresponds to Blue, Green, Red, Red Edge and Near IR regions in the electromagnetic spectrum respectively. Crop attributes in the early stage of CAT selection were derived from the BI with a high degree of prediction. The ground truth data and the drone-based BI had high phenotypic and genetic correlations. Ground cover estimation is an indirect prediction of radiation use efficiency of clones and directly related to biomass production. Stalk number was moderately correlated (r^2=0.61) with ground cover and the digital surface model (DSM) was correlated (r^2= 0.58) with plant height. The estimated NDRE had the highest correlation with the biomass measured at 6 months age. An alternate selection index was developed with the BI in addition to the conventional selection index estimated from cane yield (TCH), commercial cane sugar (CCS) and fibre content. Two different populations were selected based on two selection methods. There was a strong correlation ($r^2 = 0.78$) between rankings of clones selected from two methods in the CAT population. Nevertheless, the correlation between rankings of the top 10% clones from the two selection methods was weak, as only 75% of the clones were common between two methods. This suggests that the selection would be different if the early stage (before onset of single-row competition effects) crop attributes (BI) are incorporated to the current conventional selection model. Further experiments are being conducted to test the hypothesis that the genetic correlation between CAT and standalone trials (FAT) would be higher if early-stage crop growth attributes measured before the onset of competition effects are incorporated to the selection model.

Keywords: Sugarcane, Phenomics platform, Biological indices, Selection index, Drone

INVESTIGATION OF GENOTYPE BY ENVIRONMENT INTERACTIONS IN LOUISIANA BREEDING, USA

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Sugarcane breeding efforts for the Louisiana industry in the USA is complicated by genotype by environment (G x E) interactions. Sugarcane is cultivated under a wide range of conditions including different soil types and cultural management practices. To help address G x E interactions, the breeding programs servicing the industry evaluate varieties on cooperator managed fields throughout Louisiana to provide data for selection. However, these evaluations are limited by labor and resources. Identifying consistent patterns of GE interactions may provide guidance for rationalizing choice of environments for evaluation and selection. Statistical methods including GGE bi-plots are available to help evaluate G x E interactions and identify patterns. Based on analyses from graphical GGE bi-plot patterns and statistical analyses, our results indicated that yield variability was strongly dependent on crop, year, and variety. Consistent regional or soil related patterns were not observed. However, there were significant differences among locations for yield discrimination. Yield stability in the large plot trials differed significantly among genotypes. The results indicated the most stable cultivars and discriminating locations but ideal macro environments in Louisiana varied by ratoon and year.

Keywords: CCS, GxE, Biplots, Sugarcane,

MULTI-LOCAL SELECTION OF SUGARCANE ANALYZED WITH GGE BIPLOTS: OVERVIEW OF RESULTS AT A GLANCE AND SCOPE OF LESSONS

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Multi-environment trials (METs) represent the final stage of breeding programs prior to the commercial release of new varieties. Optimized analysis of METs impact genetic gains subsequently delivered to cane growers. The information provided by METs can be large and therefore complex to analyze and interpret when considering many environments of selection. An overview and a comprehensive interpretation of METs can be laborious on the sole basis of many tables of summary data and quantitative analyses of yield components. A complementary approach to interpreting many tables of figures can be obtained using "_Genotype main effect plus Genotype-by-Environment_" (GGE) analysis. The two-way data table of adjusted genotype means x locations is first standardized by environment. The resulting "standardized GGE matrix" of _genotype main effect_ (G) and _genotype x environment_ interaction (GE) is then subjected to a singular value partitioning between the genotype and environment eigenvectors. Genotypes and environments are represented on biplots defined by axes representing the most significant principal components (PCs). In order to assess effectiveness of GGE biplots to analyze sugarcane METs of Réunion Island, GGE analysis was performed on 21 sugarcane varieties tested in the MET network of eRcane that consists of seven sites of selection. These sites cover a wide range of ecologies of production representative of the main sugarcane growing areas of the industry. Varieties were assessed during two crop-cycles for tonne cane per hectare (TCH), estimable recoverable sugar (ERS), fiber content (FIB) and an economic index (EI). A biplot represented by both PC1 and PC2 : (i) adequately approximated the total GGE variation of TCH (76.52%) and ERS (71.55%) data, (ii) represented very accurately the GGE data of FIB (90.23%) and (iii) represented less efficiently the GGE data of EI (63.41%). Such two-dimensional GGE biplots of genotypes and locations permitted to visualize at a glance: (i) congruent scatterings of genotypes on trait biplots for traits linked by significant positive (TCH and EI) or negative (TCH and ERS) correlations; (ii) a succinct summary of interrelationships among environments; (iii) best performing candidates and reliable rankings of genotypes in each environment; and (iv) the ranking of mean performance and stability of genotypes across environments. This GGE biplots graphical statistical tool permits to grasp a large scope of lessons relative to multi-local selection in the particular context of eRcane programme and provide a useful tool to rapidly assist decision-making at the time of selection.

Keywords: Multi-environment trials (METs), Genotype main effect plus Genotype-by-Environment (GGE) biplot

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GENETIC VARIABILITY OF YIELD TRAITS IN DIVERSE SUGARCANE ECOLOGIES OF SELECTION IN RÉUNION ISLAND

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eRcane currently operates in Réunion several decentralized concurrent sub-selection programmes located in the major areas under cane differing in their agro-climatic conditions. Each year about 100,000 new seedlings are dispatched among the different sub-programs which receive mainly the same families. This early decentralized scheme of selection corresponds to a selection strategy for local adaptation with the objective of increased genetic gains in each environment. Seedlings enter into the same 14-years selection scheme across all sub-programs: two non-replicated stages followed by three replicated yield trials (RYT) stages dedicated to the evaluation of cane yield (CY), estimable recoverable sugar (ERS) and an economic index (EI). The selection scheme is strictly the same across all sub-programmes (trial designs, rate of selection between stages, selection criteria and procedures). A database of 10 years trial was used in order to compare the genetic variability of agronomic traits of interest (CY, ERS and EI) in the second RYT between four regional sub-programmes. Two selection sites are located in the wet windward coast (La Mare: LM and Saint-Benoit: SB) of the island and two others in the dry leeward coast (Vue-Belle: VB and Etang-Salé: ES). The objective of this retrospective study was to compare the effect of selection pressure exerted on genotypes by the different agro-climatic environments of the selection sites. Mean genetic coefficient of variation (GCV%) across the ten series and range [min-max] of variety performances for CY distinguished clearly SB and VB sites from LM and ES sites: (i) mean GCV% for CY was higher at SB (15.5%) and VB (15.8%) compared to LM (13.7%) and ES (11.3%); (ii) congruently, the [min-max] range of CY performance of candidates was wider and better centered on the standard cultivar at SB ([45%-152%]) and VB ([35%-173%]) compared to LM ([42%-123%]) and ES ([50%-116%]). These results reflect higher chances of identifying new cultivars in SB and VB in the subsequent final RYT and in semi-commercial tests before release. These larger genetic variabilities of CY in SB and VB compared to LM and ES could be related to agro-climatic differences between selection sites. As opposed to SB and VB, LM and ES are under irrigation. Moreover, LM, SB and ES are at a low altitude synonymous with high temperatures favorable for cane growth. On the contrary, the high altitude of VB site (700 m) implies a seasonal thermal stress (from April to September) less favorable for plant growth. SB has a very stony soil and a relatively fine layer of topsoil (0.25 m) which dries more quickly due to a smaller water reserve. On the contrary LM, VB and ES are not stony and have deeper topsoil layers (>0.50-1.00 m). All these agro-climatic comparisons show that the most favorable environments for cane growth (LM and ES) tend to buffer the differences between candidates for their yield potential. Conversely, in less favorable environments due to water stress (VB, SB) and/or soil characteristics (SB), identification of true superior varieties in cane yield seems easier.

Keywords: Local adaptation, Genetic variabilities, Yield components

STUDYING THREE-WAY INTERACTION UNDER GENERALIZED SITES REGRESSION MODEL IN SUGARCANE FINAL ASSESSMENT TRIALS

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Final assessment trials are essential part of sugarcane breeding programs. They are characterized as a pool of experiments carried out over different agronomic and/or locations for testing several promising genotypes. At this stage, genotype by environment interaction emerges as a potential source of variation challenging the decision-making process. However, for sugarcane yield trials interaction between genotypes and harvests is an important issue, resulting in a three-way (genotype, location and harvests) interaction problem. Most studies consider only two-way interaction, considering as environment a combination between harvest and location, which is not the real situation once two factors are merged in a single one. On the other hand, methodology that generalizes the site regression (SREG) approach for dealing with three-way interaction is available. In this context, the objective of this study was to investigate the interaction between genotype, location and harvest for identifying stable and location-harvest specific genotypes. A breeding population derived from UFSCar (Federal University of São Carlos, Brazil) integrant of RIDESA (Sugarcane Breeding Program of the Inter-University Network for the Sugar and Ethanol Development Sector) composed by 21 genotypes and four checks were considered; cane yield (TCH) data from six different locations in São Paulo state along three harvesting periods were studied. The methodology of data analysis can be summarized by the following steps: scaling of phenotypic values; arranging dataset in a three-way array; usage of *Tucker3* approach to perform several array compositions in function of the number of parameters for genotype, location and harvest; selection of the best *Tucker3* model and identification of the joint plot for dataset interpretation. In summary, for this dataset the *Tucker3* best model contained three linear combination to explain genotypic variation, two for locations and two for harvests. The first component for location was an average of all levels once they show same signal and the second component was contrast clustering in two groups. The same pattern was observed for harvest. The first component of the joint plot explained 78% of the three-way interaction, and the second explained 16,39%. In the first joint plot, there are three groups along the x-axis. RB 935744, RB 867515 were located on the left side, the same as RB985476 which was recently released for commercial exploitation. The nearest genotype from origin was SP 81-3250 followed by nine other genotypes; RB72454 was on the right side. In the second component, genotypes were sparse indicating more difficulties to identifying stable genotypes and finally, one may infer two different cluster of genotypes.

Keywords: MET, Tucker3, Joint plot, SVD, RB varieties

METHODOLOGY FOR SELECTING SUGARCANE CLONES FOR DRY ENVIRONMENTS

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Selection of sugarcane clones for very dry environments is often difficult because of highly variable rainfall creating variable growing conditions, and high experimental error variance when soil texture under field trials is not highly uniform. If measurements made in clones under relatively non-stress conditions could also be used to predict their relative yield in dry environments it could greatly improve effectiveness of selection. This could be particularly useful for early stage selection trials in breeding programs where clones are usually evaluated at a single site. Based on theoretical considerations it was hypothesised that yield measured under a well-watered environment combined with measurement of transpiration efficiency (yield per water lost by the plant) in the same environment could provide an optimal selection index for choosing clones adapted to different levels of water stress. Clones combining relatively high yield under well-watered environments coupled with high transpiration efficiency would on average perform relatively well under dry environments. To test this approach, field experiments were conducted using 31 sugarcane genotypes under rain-fed and irrigated treatments across multiple sites and years in Yunnan province, South China. As expected, irrigation greatly increased cane yield confirming the large limitation in yield due to water stress under the rainfed treatments. However, for cane yield genotype × water treatment interactions were relatively small relative to genotype main effects, except when water stress was severe. It was found that a combination of high yield and low leaf conductance or high leaf temperature (both of which may be related to reduced rates of water use) of different clones, all measured under non-stress conditions, was predictive of their relative yield in the limited water treatments. The prediction accuracies for the combination of traits was better than either yield or leaf based measurements alone. These results are supportive of a potentially valuable role for this combination of measurements in optimal selection indices in early stages of selection in sugarcane breeding programs. High sampling and error variances and high labour requirements associated with measuring conductance or leaf temperature using traditional methods are a limitation to practical application of this approach in large scale selection trials. However, these may be overcome through emerging technologies enabling related measurements through aerial imaging. Water use may be estimated cheaply in large scale selection trials in breeding programmes through remotely sensed canopy temperature and this could be used in estimating transpiration efficiency. Development and testing of these approaches is recommended to develop better selection methods in early stage selection trials in breeding programmes.

Keywords: Drought, Water use efficiency, Selection index, Canopy temperature, Phenomics

BO25

SCREENING OF ELITE SUGARCANE GERMPLASM FOR DEVELOPING HIGH SUGAR VARIETIES IN SOUTH INDIA

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Sugarcane (_Saccharum_ spp. hybrids) accounts for nearly 80% of the production of white sugar and value-added by-products and is the principal crop entailing sustenance to farmers in many parts of the world. It is imperative to develop high sugar content varieties in order to sustain the profitability of the industry in the current context of global surplus and in increasing the livelihood of farmers. Sugarcane variety development is expensive and time consuming due to its cytogenetic complexities and long breeding cycles of 13 to 15 years. Narrow genetic base of the cultivars used in breeding as donors has limited the potential in hybridization and successful release of a high sugar variety. Use of high sugar parental lines in crossing by evaluation and exploitation of natural population present among the domestic cultivars will accelerate the development of high sugar varieties coupled with introgression of other desirable genes from other genera through wide hybridization. A total of 1314 sugarcane germplasm which include commercial clones, _S. officinarum_ clones, Parry India clones, intergeneric and interspecific hybrids and a significant number of _Saccharum_ complex are currently maintained and every year new germplasm is included in the germplasm collection at Bangalore. A total of 419 sugarcane genotypes (254 commercial clones, 24 Parry India Hybrids (PIH), 141 pre-commercial clones) were analyzed for brix % (HR brix) and flowering pattern simultaneously during the season 2017-2018. Eighty five (85) genotypes recorded brix% of above 22. Among that 5, 11, 27 male fertile and 6, 17, 19 female genotypes were categorized as early, late and high flowering types respectively. HR brix% ranged from 12 (PIH 01-3180) to 25.96 (Co 11015) with a mean of 20.25%. Four hundred and seventy four (474) crosses were performed during the crossing season of 2017-2018 which included 9 intergeneric crosses involving _Erianthus_ as one of the parent and 300 crosses were carried out in peak season (November 2nd week to December 2nd week, 2017). Among these, 110 crosses were effected using pre-determined high sugar genotypes (above 22%) and only 26 crosses were made using the low or medium sugar genotypes (below 17%). A total of 44 904 seedlings were produced in 2017-2018 crossing season and among them 21738 seedlings were from 26 high sugar female parents. One thousand seven hundred and seventy six (1776) seedlings were produced from commercial high sugar varieties X _Erianthus spp_ and 108 seedlings from _S. officinarum_ x _Erianthus spp_. The current breeding program of EID Parry is being redefined to focus on the evaluation of compatibility and use of high sugar varieties as female parents coupled with broad genetic base in order to confer desired traits such as drought tolerance and to produce high sugar short duration varieties, which is the topmost priority for the very sustenance of the industry especially in southern India.

Keywords: _Saccharum, Erianthus_, Germplasm, Brix %, Crosses

BO26

EVALUATION OF CULTIVAR PERFORMANCE OF SUGARCANE IN THE TEMPERATE AREA IN JAPAN

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Sugarcane is cultivated on 14 small islands in "Nansei Arcs" belonging to subtropical climate in Japan, and raw sugar is produced at 16 mills. Cultivars have also been bred in this area; more than 30 had been released. The objective of this study was to select suitable cultivars for temperate areas and to identify the cultivar characteristics in different environments. Cultivation tests at Higashi Mikawa (34 ° 48 'N, 137 ° 22' E) as temperate area and Okinawa Island (26 ° 15 'N, 127 ° 46' E) have been conducted since 2013 using ten cultivars which were widely cultivated. Average annual temperatures of Higashi Mikawa, Tanegashima and Naha (Okinawa Island) are 16.1° C, 19.6° C and 23.1°C respectively. The yield and growth characteristics, Pol in cane (PIC) were measured. "Black sugar" was produced as one of evaluation methods. Germination rate varied depending on cultivar. The yields were almost the same as that of NiF8 (Control), and not less than yield of the Nansei Islands. NiTn18 was very good, followed by Ni27, Ni30 and Ni22. The values of PIC of Kurokaido and NiN24 were high, followed by Ni15, Ni22 and Ni27. The PIC reached a peak of 12.2% -16.1% (compared to 13.1% -17.0% in ratoon crop) from November to December, and then declined. Although the emergence rate varied among cultivars, in the ratoon crop, both the yield and PIC of all cultivars were better than those in the spring plant cane. There were no cultivars with both high PIC and high yield, and weak negative correlation was observed. Growth was vigorous during the short term from mid-July to mid-September, and the temporary stem length drew the logistic curve. If harvesting was done from end-November to mid-December, the damage by frost and low temperature was not that severe, making it possible to secure seedlings. Varieties Ni15, NiTn18, NiF8 need to be harvested early, especially Ni15 which is damaged by light frost. The most appropriate planting period of NiF8, NiTn18, Ni22, Kurokaido and Ni30 were from end-March to mid-April, and that of Ni15, Ni17, NiN24, NiH25 and Ni27 were from mid-April to early-May. Growth and sugar content after September were affected by low temperature, especially minimum temperature. It is concluded that the evaluation of cultivars in the different environments is quite effective in identifying the desirable characteristics such as robustness.

Keywords: Evaluation, Cultivar performance, Temperate, Low temperature

BO27

PERFORMANCE OF SELECTED PHIL 2009 SERIES OF SUGARCANE VARIETIES IN FOUR MILL DISTRICTS IN LUZON

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Varietal response in terms of productivity is largely determined by soil factor, climatic conditions and cultural practices in the locality. Thus, yield performance and other agronomic responses of sugarcane varieties may vary from location to location according to adaptability. In Luzon and Mindanao the mill districts differ in their agro-climatic conditions. Ten promising Phil 2009 series sugarcane varieties and two check varieties in each location were evaluated in four mill districts in Luzon. Phil was used as the national check while Phil 75-44 was used as the local check in Pampanga and Balayan and Phil 66-07 in Pensumil and Carsumco. The varieties were planted in 6 rows x 9 m plots in RCBD to evaluate their yield performance in the plant cane only. This test aims to evaluate and identify promising varieties for adaptation in the different mill districts in Luzon having distinct agro-climatic conditions based on their yield performance and resistance to smut and downy mildew which are the two major diseases in Luzon. Among the test varieties, Phil 2009-1867 showed the best yield performance against all the check varieties. In terms of yield (TCH), it was comparable to the two check varieties Phil 8013 and Phil 75-44 in Pampanga and Phil 8013 and Phil 66-07 in Carsumco. In Balayan and Pensumil it was comparable only to Phil 8013 and Phil 66-07, respectively. It gave significantly higher sucrose content and sugar yield compared to Phil 75-44 in Pampanga and to Phil 66-07 in Pensumil. It was comparable in sugar yield to the two check varieties in Balayan and Pensumil and in three mill districts. Phil 2009-1867 has a potential yield of 178.52 TCH. It is very highly resistant to both smut and downy mildew and did not flower in the four mill districts.

Keywords: Productivity, Agro-climatic condition, Resistance, Gain-even-loss, Varieties

LONG-TERM EVALUATION OF THE PRODUCTIVITY OF SUGARCANE CULTIVARS IN THE DAITOH ISLANDS, OKINAWA

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In Japan, several superior sugarcane cultivars have been released from breeding programs. However, following release, the subsequent yield performance of these cultivars has not been evaluated systematically despite the need to assess the effective use of these cultivars and the cost-benefit analysis of sugarcane breeding programmes. There are two data resources available for the long-term evaluation of varietal productivity, namely the productivity relative to that of a standard (reference) cultivar in trials and mill data that contain information on the cultivar, cane productivity and area harvested. Precise data from harvested fields have been collected on-site by sugar mill in the Daitoh Islands since 1980s using GPS and GIS techniques. Using loading records of the cane harvested from each harvested area, precise evaluation of cane yield is possible. The present study attempted to evaluate the long-term performances of individual sugarcane cultivars using such factory data (1989–2017), particularly in ratoon crops, the dominant sugarcane cultivation practice in the Daitoh Islands and having continuous data in over 5 years for many cultivars introduced into this district. Cultivar F 161 has been the dominant cultivar for a long period in this area, and yield from this cultivar has shown a similar trend to the total average yield in these islands. This cultivar also exhibited the highest yield in the recent high-yield production year, 2016/2017, which suggested its potential for high yields, with no signs of cultivar deterioration. To minimize the effects of climate change and/or social background of the grower on the cultivar yield evaluation, the yield of each variety relative to that of F 161 as the standard cultivar was analyzed. A relative yield in excess of 1.0, relative to F 161, was been identified for several cultivars introduced since 2009, which indicated that recent breeding efforts were effective for ratoon cropping. Long-term cultivar records could also be useful in monitoring cultivar deterioration and breeding achievement.

Keywords: Breeding achievement, Cost-beneficial breeding, Existing varieties, Sugar mill data, GIS, GPS, Varietal deterioration

RAPID ADOPTION OF NEW VARIETIES THROUGH POST-RELEASE TRIALS IN ECUADOR

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The Breeding Program of the Ecuadorian Sugarcane Research Center began its activities in 1997 releasing the first variety ECU-01 in 2007. A continuous breeding and clonal selection process has allowed the release of seven additional varieties up to 2017. Rapid adoption of new varieties is needed in order to improve crop production under local conditions. Therefore, in 2012 the newly released varieties were evaluated in post-release trials. These trials were planted in the three largest sugar mills: COAZÚCAR, San Carlos and Valdez, and comprised commercial or most widely cultivated varieties, in different soil types and at different harvest periods in large plots of six rows of minimum of 150 m long with three replications. The data collected allowed to draw maturation curves and calculate cane and sugar production in the cane plant and first ratoon crops. Most of the evaluation and field observations were carried out with the field managers and technicians of the sugar mills. This active participation of the sugar mills technicians had produced valuable suggestions that will be helpful for effective selection of clones and will become part of the process for a rapid variety adoption. In addition, these trials facilitated the determination of specific adaptation to soil types and suitability to harvest periods allowing precision agriculture for variety management. The adoption of the CINCAE varieties at the sugar mills has been a rapid process. Until the 2017 harvesting season the planted area of CINCAE varieties, ECU-01, EC-02, EC-03, EC-04 and EC-05 increased up to 50%.

Keywords: Post-release trials, Adoption, Breeding

IDENTIFYING BREEDING GROUPS TO SELECT SUGARCANE GENOTYPES ACCORDING TO SUCROSE ACCUMULATION CURVES

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Sucrose accumulation curves represent the maturity profile of sugarcane, which is considered a character of interest for the selection of genotypes in breeding programs. However, variations due to the environment (E) and interaction between genotype (G) and environment (G×E) may be confused with the effect of genotype and hinder the selection process of promising clones. The objective of this study was to identify a group of accumulation curves with high intragroup genotypic variability in the sucrose accumulation process. This breeding group could be used to select genotypes according to their maturity profile. A protocol is presented whereby the following statistical tools are integrated: (a) classification of accumulation curves according to parameters associated with the beginning of the maturity process, the sucrose accumulation rate, and the time elapsed until the accumulation rate decreases, (b) estimation of the genotypic contribution to intragroup variability of each accumulation curve parameter, and (c) identification of the group of accumulation curves to be considered as a breeding group. The novelty of the work lies in the sequence logic of analytic steps to identify curves useful to select genotypes according to their maturity profile. The protocol involves estimating parameters of nonlinear models for fitting maturity curves of several genotypes in multi-environment trials, clustering of curves according to the adjusted parameters, and estimation of variability due to G, E, and G×E within each cluster of curves. Its implementation is illustrated using 175 sucrose accumulation curves of nine sugarcane varieties evaluated in different crop cycles (first and second ratoon) and several environments (7 to 50 for each variety) of Tucumán, Argentina. The proposed protocol allows clustering of sucrose accumulation curves that exhibit a high genotypic contribution to variability of their parameters, thus facilitating the selection of genotypes.

Keywords: Accumulation curves, Nonlinear models, Cluster analysis, Variance components.

EVALUATION OF THE PHENOTYPIC DIVERSITY FOR TRAITS RELATED TO PLANT GROWTH AND SUGAR CONTENT IN A SUGARCANE GERMPLASM COLLECTION

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A germplasm with strong genetic and phenotypic diversity is a key tool for sugarcane breeding programmes as it provides breeders with valuable resources for the development of new varieties. The objective of this study was to perform a complete phenotypic evaluation of a sugarcane germplasm collection with accessions originating from different countries using phenotypic traits related to plant growth and sugar content. Six quantitative traits were recorded on 250 accessions located at Chaiyaphum, Thailand: stalk height, stalk diameter, number of millable stalks, cane yield, sugar content (%CCS) and fibre content (%fibre) on plant cane 12 months after planting (MAP) during the season 2016/2017. The accessions, which were planted in single row of 5-m length space 1.65 m apart, were evaluated in an augmented design by using KK3 as the standard variety. Statistical analyses reveal a strong variance for all traits e.g. stalk diameter (range:15 to 37 mm), %CCS (range: 5.90 to 16.23) and % fibre (range:10.27 to 21.37). Accessions with the highest cane yield, % CCS and % fibre originated from Thailand, China and Barbados, respectively. For each accession, phenotypic performances were compared to the most popular variety cultivated in Thailand (KK3). Overall, 56, 38 and 116 accessions performed better than KK3 with respect to cane yield, %CCS and fibre content, respectively. However, only two accessions displayed overall better performances compared to KK3: Mossman (Australia) and M336 (USA). According to the hierarchical clustering analysis, the diversity of sugarcane germplasm was categorized into 6 groups based on cane yield and %CCS, as follows (1) lower cane yield, (2) lower CCS, (3) high cane yield and high CCS, (4) high cane yield and low CCS, (5) low cane yield and high CCS, and (6) low cane yield and low CCS. The two smallest clusters, as lower cane yield (N50-211, LF70-7143 and PT52-227) and lower %CCS (MPT04-303, MPT08-50 and ROC23), contained only three accessions each. This study provides valuable data to sugarcane breeders in Thailand for the judicious use of accessions.

Keywords: Phenotypic traits, Sugarcane germplasm, Cane yield, %CCS

THAI SUGARCANE PROMISING CLONE KK07-250

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KK07-250 is a self- pollinated progeny of Khon Kaen 1. The pollination was conducted in 2007 at Khon Kaen Field Crops Research Center in the northeast of Thailand. The first and second selections, and the preliminary yield trial stages were carried out in 2008-2012 at Khon Kaen Field Crops Research Center. The objectives were to select for high yield and good ratooning ability compared to Khon Kaen 3 which is the most popular sugarcane cultivar in Thailand, occupying 80% of land area. The standard yield trial was conducted in 2013-2014 at Khon Kaen Field Crops Research Center and Burirum Sugar Mill Limited. In 2015-2016, the farm trials were conducted at 5 locations, Kalasin and Mukdahan province (northeast region), Kanchanaburi province (central region), Uttaradit province (north region) and Rayong province (east region). The results confirmed the good performance at the preliminary and standard yield trial stages and that KK07-250 had yield and ratooning ability comparable to that of Khon Kaen 3. In the plant cane crop, average sugar yield, average cane yield and average commercial cane sugar of KK07-250 were 13.2 t/ha, 104 t/ha and 12.34%, respectively and Khon Kaen 3 were 12.4 t/ha, 99 t/ha and 12.69 %, respectively. In the ratoon crop, average sugar yield, average cane yield and average commercial cane sugar of KK07-250 were 10.9 t/ha, 76 t/ha and 14.34 %, respectively and Khon Kaen 3 were 11.5 t/ha, 76 t/ha and 15.32 %, respectively. Therefore, KK07-250 could contribute in reducing the area under cultivation with Khon Kaen 3.

Keywords: Promising clone, High yield, Ratooning ability, Khon Kaen Field Crops Research Centre

AGRONOMIC TRAITS AND ROOT DISTRIBUTION OF INTERGENERIC F$_1$ AND BC$_1$ HYBRIDS BETWEEN *SACCHARUM* SPP. HYBRID AND THAI *ERIANTHUS ARUNDINACEUS* IN NORTH-EAST THAILAND

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Erianthus germplasm in Thailand is considered to be a promising breeding material to improve sugarcane productivity and drought tolerance. Khon Kaen Field Crops Research Center (KKFCRC) and the Japan International Research Center for Agricultural Sciences (JIRCAS) have implemented a collaborative research project to utilize *Erianthus* germplasm in sugarcane breeding. Intergeneric F$_1$ hybrids have been developed between Thai sugarcane varieties (*Saccharum* spp. hybrid) and *E. arundinaceus* by using a DNA marker (5S rDNA) selection technique and BC$_1$ hybrids between the hybrids and sugarcane varieties have been generated. Four intergeneric F$_1$ hybrids and 32 BC$_1$ hybrids were evaluated alongside commercial sugarcane varieties KK3 and K88-92 and the interspecific hybrids TPJ04-768 and TPJ03-452 as standards. They were planted at KKFCRC, on a sandy loam, under rainfed conditions, in October 2016, and harvested in December 2017. The plot size was 2 x 3-m rows, spaced 1.4 m apart, with three replicates in randomized complete block design. The root distribution of the hybrids was evaluated with a soil-core sampler after harvesting. Intergeneric F$_1$ hybrids had a lower cane yield (5.3kg/m^2), sugar content (6.0%) and CCS yield (1.1kg/m^2) but a higher fibre content (16.6%) and fibre yield (8.7kg/m^2) than the standard varieties KK3 (6.7 kg/m^2, 16.1%, 11.4%, 10.8% and 7.3kg/m^2, for cane yield, sugar content, CCS, fibre content and fibre yield, respectively). The average cane yield of BC$_1$ hybrids (6.8 kg/m^2) was higher than that of F$_1$ hybrids and some hybrids had higher cane yield than the standard varieties. Although sugar content of BC$_1$ was higher (8.2%) than that of F$_1$, it was still lower than that of the standard varieties, and further backcrossing would be necessary before using them for sugar production. In the shallow soil layer (0 to 30 cm), there was no difference in root weight between the standard varieties and the intergeneric F$_1$ and BC$_1$ hybrids. However, the root weight of intergeneric hybrids was higher than that of KK3 in the deeper soil layers (30 to 60 cm and 60 to 90 cm). Intergeneric BC$_1$ hybrids need further improvement in sugar content, and they offer promise as new breeding materials for sugarcane improvement because of their high biomass productivity and deep root distribution.

Keywords: Sugarcane, *Erianthus*, Intergeneric hybrid, Agronomic trait, Root

BREEDING NEW RESILIENT AND HIGH YIELDING SUGARCANE CULTIVARS FOR STRESS ENVIRONMENTS IN BRAZIL

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The sugarcane breeding program of the Inter-University Network for the Sugar and Ethanol Development Sector (RIDESA) from the Federal University of Alagoas (UFAL), Brazil, employs the strategy of breeding RB (Republic of Brazil) cultivars of high sugar yield that confer resilience to long periods of marked water deficit. This study aimed at presenting the results obtained in the improvement of sugarcane cultivars for stress environments. Crosses were carried out in 2004 at the *Serra do Ouro* Flowering and Crossing Station (09º13'S, 35º50'W; 450 m) using the RB 72910 as female parent (clone with high rusticity, high number of stalks per clump and low sugar content), combined with several high sugar content male-fertile parents. In the same year, 8,135 seedlings were distributed to several stress environments in Alagoas State, Brazil, characterized by a marked water deficit. Visual mass selection was applied at 10 months of age based on the number of stalks, plant health and soluble solid content, compared to a widely grown, high sugar yielding, commercial standard cultivar RB 92579, that occupied 37% of the northeast growing area in 2017. All selected clones were submitted to rigorous evaluation at the clonal and final assessment trials, under environmental stress conditions. Selection was based on cane yield (TCH), dry matter yield (DMYH) and sugar yield (TSH) per hectare. Data was obtained in six successive harvests, of which four stood out due to the high-water deficit observed, varying from 600 mm to 800 mm. Among the selected genotypes, RB 0442 performed much better than RB 92579: TCH (107.7 vs. 77.5; an increase of 39.0%); DMYH (29.0 vs. 22.0, an increase of 31.8%); TSH (13.2 vs. 11.3, a gain of 16.8%). Despite the high resilience to water deficit and the high sugar content of this clone, less total recoverable sugar per ton of cane - TRS was obtained for RB 0442 (122.2 vs. 144.0, a reduction of 15.1% compared to RB 92579). However, RB0442 had 5% fibre content higher than RB 92579, which represents an advantage for the electricity cogeneration. These results motivated some growers and mills from Alagoas State to cultivate RB 0442 on a commercial scale. An additional 2,500 ha of RB 0442 are expected to be planted later in 2018. On the other hand, RIDESA/UFAL will release this clone for commercial exploitation, confident that it will occupy an important area under rainfed conditions, aiming at a greater tolerance to water shortage.

Keywords: Genetic improvement, Selection strategies, Resilience, Water deficit

SEED CHARACTERIZATION AND PRESERVATION FOR FUZZ EXCHANGE

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Sugarcane fuzz preservation to use either for future planting to initiate stage I of selection or germplasm exchange is one of the priorities in the Ecuadorian Sugarcane Breeding Programme. This study had the following objectives: (1) characterize morphologically true seed from 20 crosses, 2) establish the loss of viability of the fuzz stored at - 20°C from 1 to 11 years, and 3) determine the effect of Carboxin + Captan application on seed viability and presence of fungi during 12 months of storage. For objectives 1 and 2, seed length, diameter, weight and germination were measured, the last one by two methods: counting 100 seeds (%) and weighing 0.5 g of fuzz (seed) of 20 families. For objective 3, Carboxin + Captan were applied to fuzz collected in 2012 and 2013 and stored during one year. Samples of five seeds (treated and untreated) with six replications were placed in solid agar-water solution monthly, in order to observe fungal growth at 24 and 48 hours. Sugarcane seeds showed 3.97 mm length, 0.89 mm diameter, and 100 seeds had 59.4 mg weight, the average germination rate was low (42%). The two germination methods evaluated (100 seeds and 0.5 g fuzz) were positively correlated with r = 0.74. The seed stored at -20 °C in aluminum-plastic bags showed a reduction in viability of 4.3% per year. Seeds with Carboxin + Captan fungicide applications showed no reduction in viability until ninth month. There was no colony growth on seed with fungicide application after 24 hours of growth chamber storage, whereas in the seed without treatment colonies growth were registered. This evaluation showed that fuzz can be treated with fungicide to prevent fungal diseases and could benefit from a more dynamic fuzz exchange between sugarcane research centers.

Keywords: Sugarcane seeds, Fuzz, Characterization, Germplasm exchange

EFFECT OF HIGH TEMPERATURES ON FLOWERING AND TRUE SEED GERMINATION IN SUGAR CANE

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The Sugarcane Breeding Program (SCBP) of Estación Experimental Agro-industrial Obispo Colombres (Tucumán, Argentina) applies artificial photoperiodic treatments to induce the flowering of their parents through the use of light-tight chambers. In this programme, flowering percentage and germination rate of the true seed are indicators of the performance of the crossing stage. Between 2012 and 2014 there was a significant decrease in both indicators (germination rate in 2012 and 2013 seasons and flowering percentage in 2014), compared to those obtained in the period 2000-2011. This reduction coincided with an increase in the number of hours with temperatures higher than 32ºC recorded during the time of photoperiodic treatments (November to February) and emergence of the first inflorescences and crosses (March). For these reasons, correlation analysis involving flowering percentage, germination rate and the number of hours with temperatures above 32ºC, in different time intervals, was performed from the information collected by the SCBP during the past 15 years. Highly significant negative associations were observed between the number of hours higher than 32ºC and flowering percentage ($r = -0.75**$) and germination rate ($r = -0.88**$). These results would explain, in part, the drop observed for these two indicators between 2012 and 2014, as 56% of the variability of the flowering percentage and the 77% of the germination power were associated by a linear relationship with the occurrence of high temperatures.

Keywords: Photoperiodic treatments, Flowering percentage, Germination rate, High temperatures

PRESENCE OF A RESISTANCE GENE TO BROWN RUST (BRU1) IN BRAZILIAN VARIETIES AND SUGARCANE CLONES

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Sugarcane (*Saccharum* spp. L.) is one of the main crops in the world. Several factors may limit crop productivity of sugarcane, among them the occurrence of diseases. Brown rust, caused by the fungus *Puccinia melanocephala,* is one important disease for sugarcane and may cause losses of up to 50% in susceptible varieties. The selection and use of resistant cultivars to brown rust is the most effective method of control. A larger effect gene, Bru1, has already been identified as responsible for resistance to brown rust and two molecular markers (R12H16 and 9O20-F4) have previously been reported as strongly associated with this gene. The objective of this study was to identify the presence of the Bru1 gene in the varieties most planted in Brazil and some of interest in the UFPR/RIDESA Breeding Program. To this end, 24 varieties (CTC, SP and RB) were used, among which 14 developed by RIDESA, which are among the most planted in Brazil. Variety R570 was used as the positive control (Bru1 positive) and variety NA56-79 as the susceptible control (Bru1negative). The DNA of the 24 varieties was extracted followed by amplification with the molecular markers R12H16 and 9O20-F4. The association of the presence of the Bru1 gene and the resistance to brown rust was based on bibliographical information, regarding the resistance/susceptibility of the disease in the varieties under study. The presence of Bru1 was detected in 20 out of the 24 varieties analyzed (83.4%). The association of the Bru1 gene with brown rust resistance in the varieties under study was 100%. It can be concluded that the R12H16 and 9O20-F4 markers are highly efficient in predicting resistance to brown rust, and that the Bru1 resistance gene is probably the main source of resistance to brown rust in Brazil.

Keywords: Bru1; *Puccinia melanocephala*; *Saccharum* spp.; Selection based on molecular markers, R12H16, 9020-F4.

NITROGEN USE EFFICIENCY – A TOOL FOR SCREENING DROUGHT TOLERANT SUGARCANE VARIETIES AT EARLY GROWTH STAGE

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The aim of the study was to evaluate nitrogen use efficiency and drought tolerant ability of different sugarcane varieties under glasshouse conditions. A split-plot design was used with 5 replicates: two water regimes (well-watered and water stress for 60 days from 60 days after transplanting respectively) as main-plot treatment and varieties as sub-plot (NiF3, Ni9, Ni17, Ni21, and Ni22). The following data was collected: potential photosynthetic rate (A_{max}), plant height (PH), leaf area (LA); dry weight traits (DWs) including partial and total DW, nitrogen traits specific leaf nitrogen content (NL), total nitrogen content (TN) and total nitrogen uptake (TNU); nitrogen use efficiency traits (NUEs) including photosynthetic NUE, nitrogen utilization efficiency and biomass NUE; drought-tolerant index (DTI). The results showed that drought stress reduces A_{max}, PH, LA, DWs, TN and NUEs of varieties. Significant differences were found among varieties for PH, LA, DWs, NL, TN, NUEs and DTI. Significant positive correlations among NUEs and DTI suggest that sugarcane varieties with higher NUEs are more tolerant to drought stress. NiF3 and Ni17 were 2 types of drought-tolerant varieties which maintain stalk and leaf growth under stress conditions, respectively. On account of larger contributions, DTIs for above ground and stalk DW could be used as important DTIs to evaluate drought tolerant ability in sugarcane.

Keywords: Early growth stage, Nitrogen use efficiency, Sugarcane, Water stress.

SELECTION OF ENERGY CANE CLONES BY LOGISTIC MODEL

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The selection process of cane energy clones is considered to be subjective, especially in the first selection stages (T1 (one plant) and T2 (single plots with two rows of 5.0 m)). The reduced availability of planting material in the second selection phase does not allow the use of repetition, leading to reduced experimental precision. Logistic regression analysis is a technique that may aid breeding programmes in the selection of clones. The objective of this study was to identify the most important agronomic traits at the clonal selection process in the second test phase and to evaluate the efficiency of the logistic model in predicting the number of energy cane genotypes to be selected. Evaluations were carried out on 220 clones in the second selection phase in the first ratoon. The plots were constituted of two rows of 5.0 m spaced 1.4 m apart. Stalk number, stalk diameter and height, stalk weight, apparent sucrose content and fiber content were assessed. Grades ranging from 1 to 5 were assigned for ease of trashing, stalk diameter, stalk number, stalk height, lateral sprouting, growth habit, flowering, pith, general grade and diseases (smut, brown rust and orange rust). The data was then submitted to binary logistic regression analysis. Stalk number was an important feature for the selection of energy cane clones, genotypes with a higher grade had 4.4 times more chance of being selected, as well as genotypes that obtained a lower grade for smut had a greater chance of being selected. Thirty-eight clones were selected using mass selection method in T2, whilst the logistic regression models enabled the selection of 42 and 22 clones, respectively. The predictive capacity of the models, qualitative and quantitative were 94% and 87%, respectively. The use of a qualitative model proved to be efficient in predicting the number of genotypes to be selected and could be used as a selection strategy.

Keywords: *Saccharum*, Biomass, Smut

ASSOCIATION OF PHYSIOLOGICAL RESPONSES AND ROOT DISTRIBUTION PATTERNS TO RATOONING ABILITY AND YIELD OF THE 2ND RATOON CROP IN ELITE SUGARCANE CLONES

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Ratooning ability is the one of the factors limiting the production of sugarcane (*Saccharum officinarum* L). Ratoon keeping is playing an important role in sugarcane production to save cost and increase profit. The understandings of the association of physiological parameters such as above ground and root distribution patterns to maintain higher ratooning ability could improve the efficiency of sugarcane production. The objective of this study was to determine physiological responses and root distribution patterns in yield of the 2nd ratoon and their relationships. The experiment was conducted in a randomized complete block design with four replicates in order to evaluate ratooning ability and yield at the 2nd ratoon crop, during the growing season of 2016 to 2017. Data was recorded on ratooning ability, expressed as percentage of regrowth of ratoon at 60 days after harvest (DAH), physiological traits (SPAD (soil plant analytical development) chlorophyll meter reading, chlorophyll fluorescence, relative water content, specific leaf area and stomatal conductance) at 90, 180 and 270 DAH, and root sampling by auger method were taken for analysing the root length density (RLD) (at 90 and 270 DAH) by Winrhizo program (Winrhizo Pro (s) V. 2004a, Regent Instruments, Inc.), and yield at 360 DAH. There were highly significant differences between sugarcane genotypes for root distribution, yield and ratooning ability. Root distribution patterns were classified into three groups based on the RLD in the upper and lower soil layers. Variety KKU99-02 had high RLD in the upper and lower soil layers, that affected yield and ratooning ability compared to the other genotypes. Moreover, physiological responses such as chlorophyll fluorescence, relative water content and stomatal conductance contributed to high yield and ratooning ability. This information will be useful in explaining association between ratooning ability and root distribution patterns (r = 0.30 – 0.50, P=0.05) for recommendation of the surrogate traits for improving sugarcane genotypes in breeding programs.

Keywords: Root length density, Ratoon crop, *Saccharum* spp, Varietal selection

BP10

PHYSIOLOGICAL TRAITS RELATED TO HIGH SUGAR YIELD OF 40 SUGARCANE GENOTYPES GROWN UNDER RAINFED CONDITION

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Physiological traits related to maintaining high sugar yield under drought stress are playing an importance role to understand and use for breeding programs to improve high sugar yield. The objective of this study was to determine sugar yield and physiological traits of 40 sugarcane genotypes under rainfed condition. The experiment was conducted during the period December 2015 to December 2016 at the Faculty of Agriculture, Khon Kaen University. A Randomized Complete Block Design was used with three replicates. The 40 genotypes were grown in plots comprising 4 rows x 8-m long and spaced 1.5 m apart. The physiological traits, (chlorophyll fluorescence (Fv/Fm), SPAD (soil plant analytical development) chlorophyll meter reading (SCMR), relative water content (RWC)) were measured at 3 months (drought stress period) and 6 months (recovery period). At harvest (12 months after planting) sugar yield was recorded. The results indicated that genotypes MPT02-458, TBy28-0348, Kps01-12 and UT07-317 had the highest sugar yield, associated with high relative water content and SPAD chlorophyll meter readings at both 3 and 6 months. Genotype TBy28-1211 had high SCMR at 3 and 6 months. It is concluded that physiological traits such as Fv/Fm and SCMR could be used to screen varieties with improved sugar yield in breeding programs under rainfed conditions.

Keywords: Sugarcane breeding, Photosynthesis efficiency, Relative water content, Chlorophyll index

ASSOCIATION OF THE PHYSIOLOGICAL RESPONSES ON YIELD AND AGRONOMIC TRAITS OF 19 SUGARCANE GENOTYPES GROWN UNDER RAINFED CONDITION

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The information on the physiological traits associated to yield is important in understanding plant responses under stress conditions. The aim of this study was to determine the physiological and agronomic characteristics and their associations with 19 sugarcane varieties grown under rainfed condition. The field experiment was conducted during the period February 2014 to January 2015 at the Faculty of Agriculture, Khon Kaen University, Thailand. A Randomized Complete Block Design with three replicates was used. The 19 sugarcane genotypes were grown in plots of 4 rows x 6-m at a spacing of 1.5 x 0.5 m. At 6 months after planting, the physiological traits (chlorophyll fluorescence; Fv/Fm), SPAD chlorophyll meter reading (SCMR), stomatal conductance) were measured. At harvest (12 months after planting), the following agronomic traits were recorded: cane yield, brix value, millable cane/unit area, stalk diameter and stalk length. KK3 had superior agronomic traits such as cane yield, stalk diameter, stalk length and was also associated with physiological traits such as high photosynthesis efficiency and stomatal conductance. The following genotypes had similar cane yield to KK3: KK07-037, MP-458, CSB07-79, K88-92, UT84-12, KKU99-01 and TBy28-0941. The genotypes Q229 and UT84-13 had high brix values.

Keywords: Cane yield, Chlorophyll index, Photosynthesis efficiency, Stomatal conductance, Sugarcane breeding

LEAF ANATOMICAL TRAITS OF SUGARCANE F₁ HYBRID DERIVED FROM PARENTS HAVING DIFFERENT GENETIC BACKGROUNDS

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Water deficit severely reduces sugarcane yield. Drought tolerant genotypes might be able to mitigate this obstacle. Current commercial cane cultivars are developed from parents with narrow genetic base. Cultivars with improved drought tolerance might be achieved through intergeneric crossing. However, the knowledge of genetic distribution and diversity for anatomical traits in sugarcane is not clear. The objective of this study was to investigate on the distribution and diversity of anatomical traits in an F₁ hybrid population derived from parents having different genetic backgrounds. Twenty-four sugarcane clones were derived from female parent KK07-599 (*Saccharum officinarum* L.) and male parent S98-272 (*Saccharum spontaneum* L.). Free hand transverse section was done at the lamina position and stained with 1% (w/v) Safranin O before transformed to permanent slide using DePeX. Anatomical characters were observed using light microscope. The size of the major vascular bundle, leaf thickness and stomata crypt depth were measured for the F₁ progeny and the two parents. The results showed that major vascular bundle size, leaf thickness and stomatal crypt depth of F₁ hybrids were 20.8%, 12.5% and 16.7%, respectively, higher than mid-parent values. Moreover, there was different distribution of anatomical traits. Distribution in major vascular bundle size of F1 hybrids lied within the parental range, with the female parent having the highest and male parent the lowest values. For leaf thickness, the female parent had the highest value, 91.7% of F₁ hybrids had values within the parental range and 8.3% of the F₁ clones had values lower than that of the male parent. The male parent clone had increased stomatal crypt depth compared to the female parent, 8.3% of F₁ hybrids had increased stomatal crypt depth than the male parent, 75.0% had lower values than the female parent. This information provided an understanding of the distribution of anatomical traits in F₁ hybrids derived from a cross between *S. officinarum* and *S. spontaneum*.

Keywords: Water deficit, F₁ hybrid, Vascular bundle, Leaf thickness, Stomatal crypt