SOIL MOISTURE GROUPS FOR SUGARCANE MANAGEMENT

By

J.S. TORRES and J.R. CRUZ

Colombian Sugarcane Research Center, Cenicaña
jtorres@cenicana.org

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Abstract

CANE YIELD in Colombia is normally lower after wet years due to increased damage associated with harvest and the difficulty of post-harvest cultivation. The magnitude of the problem is impacted on by soil characteristics. To identify fields or areas requiring emphasis on irrigation or drainage and for the development of agronomic management packages, soil moisture management groups have been developed. The definition of soil moisture management groups is based on the annual balance between precipitation at 75% frequency level and soil permeability. The precipitation records from the sugarcane automatic weather network and the information from a recent detailed study of the soils of the Cauca River Valley of Colombia have been combined using the geographical information system to generate the spatial distribution of the soil moisture groups. Five groups were defined on the basis of the expected annual excess or deficit of water for sugarcane: A first group with a water deficit, a second group with an excess of water ranging from 0 to 200 mm/year, a third group with an excess of 200 to 400 mm/year, a fourth group with an excess of 400 to 600 mm/year and a fifth group with an excess of water greater than 600 mm/year. These moisture groups have been used as a backbone for the agro-ecological zoning system of the sugarcane in the Cauca Valley of Colombia. The Colombian sugar industry is committed to use a site specific agriculture approach based on the combination of the production factors on each cane field.

Introduction

The productivity of the Colombian sugar industry largely depends upon climatic conditions prevalent during crop establishment, harvesting and the first stage of ratoon crop development. Murrell and Childs (2000) indicated that it is necessary to identify the factors limiting production that can be controlled.

Critical values according to predominant environmental conditions should also be set. In wet years, those areas with heavy soils and low infiltration capacity are prone to water logging and cultural practices can not be executed on time; therefore, the expected cane yield is low.

Excessive moisture produces anaerobic conditions in the soil, reduced root respiration, demineralisation of nitrogen and poor crop growth affecting adversely the final cane and sugar yield. In flooded terrain or with high water table, the number of working days for land preparation or ratooning practices is reduced. If a crop is not established in time, it may result in a crop with increased production costs and reduced yield

Experiments conducted by Cenicaña (1991) using percolating type lysimeters depicted a yield reduction of 35 t/ha when the static water table was maintained at 70 cm below the soil surface. If soil moisture excess occurs during land preparation, planting or harvesting, all these practices should be delayed; otherwise soil compaction, stool damage and poor cane germination/regrowth are expected, increasing production cost if replanting is necessary.

A macro analysis of cane and sugar production in the Cauca River Valley (Cenicaña, 1996) for the period 1991 to 1995 showed that cane production in most of the sugar mills in the years 1994 and 1995 were negatively affected by high precipitations that occurred during the three first months of crop development, or by the rainfall events during the last month of the previous crop cycle. When rainfall events happened during the first stage of crop development, fertilisation and/or ratooning tasks could not be executed on time or efficiently. Intensive rainfall events during the harvest of the previous crop resulted in excessive soil moisture that hampered the traffic of the harvesting machinery, inducing soil compaction and cane stool damage.

According to commercial production data from the Cauca River Valley in Colombia, it is clear that dry years are ideal for cane and sugar production. This is a result of both the availability and adequacy of the existing irrigation infrastructure, and the opportunity for more efficient and timely execution of cultural practices under dry conditions.

Harvesting in wet conditions usually results in fields affected by direct stool damage, soil compaction and surface deformation. In some cases, field damage is so serious that remedial cultivation is in order to maintain crop productivity, but persistent rainfall events cause postponement of the remedial practices, resulting in idle or 'forced fallow' fields.

Weather conditions which make it difficult to execute cultural practices or harvesting due to excessive soil moisture have become more common, especially with the increasing presence of the El Niño phenomenon. It is therefore necessary to adopt strategies for optimum management of the cane fields under these conditions.

This study was undertaken to group the soils of the Cauca River Valley according to their ability to transmit water after a heavy rainfall event, and subsequently generate management guidelines to decrease the impact of excessive soil moisture on cane production.

Methodology

Field observations of the interaction between soil permeability and rainfall demonstrated that a very permeable soil will dry out quite rapidly after a heavy rainfall event, due to the high water transmitting or infiltration capacity. This characteristic allows the execution of cultural practices, or entry to the field with harvesting machinery a few hours after the rainfall. On the other hand, low permeability soils will remain wet after a light rainfall event, and there is a possibility of surface flooding after intense rainfall.

Initially, the reasoning used to develop soil moisture groups was based on the balance between the expected annual rainfall at 75% probability level, and the total annual evapo-transpiration (ET) calculated using boom stage values.

The amount of annual deficit or excess of water was established and compared with the permeability of the soil according to the matrix presented in Table 1. Six regions were demarcated within the matrix that correspond to six soil moisture groups identified as H0, H1, H2, H3, H4 and H5.

Table 1—Definition of soil moisture group regions based on the interaction between water excesses and soil permeability.

Water excess	(mm/year)		Soil permeability (m/day)	
		Low (< 0.5)	Medium (0.5–1.0)	high (>1.5)
Very high	(> 600)	H5	H5	H4
High	(400–600)	H4	H3	H3
Medium	(200–400)	H3	H2	H2
Low	0–200)	H2	HI	H1
Deficit	(< 0)	H1	HO	HO

Field inspections of the prevailing soil moisture conditions at 84 observation sites distributed along and across the Cauca River Valley indicated the necessity to include other parameters. The parameters selected modified the impact of soil moisture on plant growth, and included: land slope, depth to the water table, soil colour and the presence of artificial drainage installations.

In order to adjust the soil moisture groups according to prevalent local conditions of the cane fields, a logic-based process was developed to adjust the group number according to the severity of the drainage problem induced by each individual factor. A computer program was then developed. This program is available on Cenicaña´s web site (www.cenicana.org) and is used to verify or adjust the predominant soil moisture groups based on site specific conditions.

The main purpose of the soil grouping strategy is to generate basic guidelines to mitigate the impact of soil moisture on crop production. The most basic recommendations compiled for each soil moisture group are:

H0: Water deficit group

This group includes zones where there is water deficit and the permeability of the soil ranges from medium to high. It is very likely that salts accumulate in the soil profile, making it necessary to avoid the presence of high water tables. Artificial drainage installation could be required for saline or sodic soil reclamation. Irrigation is essential and a salt leaching fraction should be applied to avoid soil salinity build up.

H1: Adequate water supply group

This group consists of those areas where the annual water excess is less than 200 mm/year. Rainfall is sufficient to supply the crop water demand and the soils have medium to high permeability.

Rainfall distribution is not uniform and it is possible to observe some water ponding due to the flat slope of the terrain when the soils have low permeability. Precision land levelling and a minimum hilling up (<10 cm) to facilitate surface water runoff at the bottom of the rows during the rainy periods are advised.

H2: Low excess water group

The level of excess soil moisture ranges between 200 and 400 mm/year in soils which have medium to high permeability, as well as soils with low permeability with lower soil moisture excess (<200 mm/year). It is necessary to provide adequate field conditions such as precision land levelling, medium hilling up (10 to 15 cm), and adequate infrastructure for drainage.

H3: Medium excess water group

This group covers areas with water excess ranging between 400 to 600 mm/year and soil with medium to high permeability. Soils with low permeability but lower soil moisture excess (200 to 400 mm/year) were also included.

This group requires more intensive work for excess water removal, including land levelling, deep open canal collectors, removal of run off water, if possible, excess water tolerant varieties, application of an extra amount of nitrogen, high hilling up (15 to 20 cm).

H4: High excess water group

This group covers areas with water excess above 400 mm/year, with soils of low or high permeability, clay soils and predominance of flat slopes. The furrow length should be less than 120 m, drainage tubing installations combined with the presence of mole drains, open and deep drainage collectors and drainage pumping stations at places where gravity outlets are not available.

High hilling up is considered essential, top of row planting, varieties tolerant to excess water, application of extra nitrogen and harvesting in dry periods.

H5: Very high excess water group

Areas with water excess above 600 mm/year with flat terrain and clay soils with low to medium permeability. In this group, precision land levelling is a must and furrows should be shorter than 100 m. Drainage tubing installations combined with the presence of mole drains, open and deep drainage collectors and drainage pumping stations at places where gravity outlets are not available are also necessary. High hilling up is considered essential, along with top of row planting. Varieties tolerant to excess water and the application of extra nitrogen is recommended. Manual harvesting during dry periods is recommended.

Results and discussion

The information of the soil moisture groups for the Cauca River Valley region was fed into the Geographic Information System (GIS) to obtain maps depicting the spatial distribution and area covered by each soil moisture group (Figure 1).

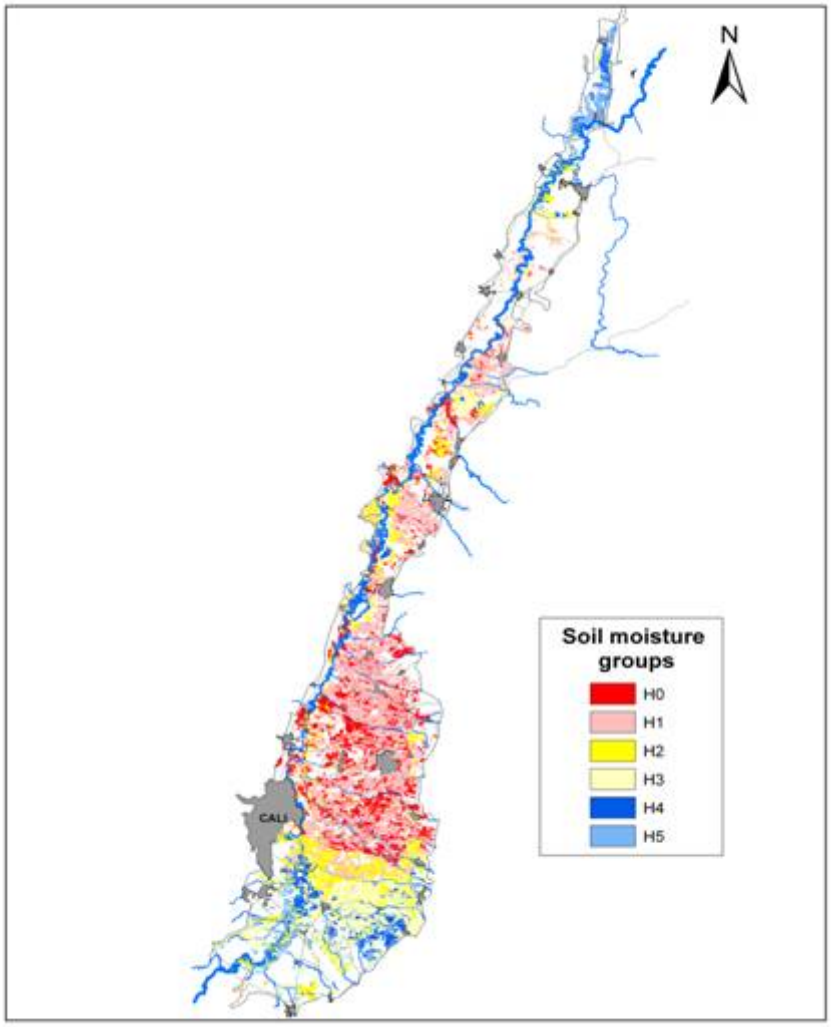

Fig. 1—Spatial distribution of the soil moisture groups in the Cauca River Valley of Colombia.

Most of the cultivated area within the sugarcane zone belongs to the moisture groups H0 and H1. This can be considered as a dry zone amounting to 119 025 ha, (58%) of the total of 203 778 ha of land currently planted in the valley. While all the sugar estates have cultivated areas in the dry zone, the agricultural lands of Manuelita, Providencia and Mayaguez sugar estates, which are located in the south central part of the valley, are predominantly in the H0 and H1 groups.

In these areas, in dry years, it is necessary to apply up to six or seven irrigation events per crop cycle of 13 months.

The areas of the soil moisture groups H2 and H3 can be considered a semidry zone. Most of the cane area belongs to Cauca, Cabaña, Castilla and Riopaila sugar estates in this zone, and the total area adds up to 64 300 ha, which is 32% of.the total agricultural area. In this zone, there is an annual water excess ranging between 200 to 400 mm of water in the low and medium permeability soils or with a water excess of 600 mm/year in areas with high permeability soils. This semidry zone requires the installation of more artificial drainage infrastructure.

The wettest zone of the valley (H4 and H5 groups) is concentrated in the northern and southern extremes of the Cauca River Valley covering an area of 19 410 ha (10% of the total area); however, this comprises a significant portion of Risaralda, Castilla, Cabaña and Cauca sugar estates. In the wet zone, the annual water excess is above 600 mm/year.

Planting, cultivation and harvesting of the cane is difficult due to high precipitation which in general is above 2000 mm/year. In this region, it is necessary to emphasise drainage development, precision land levelling and a short furrow length. Cane and sugar yields in this area are in general low due to the negative effects of the excess moisture on crop growth and maturity, and the interference with the execution of good cultural practices.

Conclusions

The soil moisture groups presented herein have become an important tool for crop management, selection of experiment sites, identification of the best niches for the new cane varieties, generation of site specific agronomic management packages and, combined with Cenicaña's soil management groups, have resulted in the agro-ecological zoning system for the sugarcane in the Cauca River Valley of Colombia.

The agro-ecological zones developed by Cenicaña (Carbonell *et al.*, 2001), were presented to the sugar cane industry in 2001 and it has been well accepted by the sugar estates, and individual cane growers; it is a primary input tool for research purposes and for crop management.

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GROUPEMENTS D'HUMIDITE DU SOL POUR LA GESTION DE LA CANNE

Par

J.S. TORRES et J.R. CRUZ

Centre de Recherches Colombien de la Canne à Sucre, Cenicaña
jtorres@cenicana.org

MOTS CLES: Sol, Humidité, Drainage, Perméabilité, Gestion de la Cane.

Résumé

LE RENDEMENT canne en Colombie est normalement plus bas après les années humides suite à l'augmentation des dégâts associés à la récolte and les difficultés des opérations poste-récolte. Les caractéristiques du sol ont un effet sur l'importance du problème. Des groupements de gestion de l'humidité du sol ont été constitués afin d'identifier les champs ou zones nécessitant une emphase sur l'irrigation ou le drainage et pour le développement de packages de gestion agronomique. La définition des groupements de gestion de l'humidité du sol est basée sur la balance annuelle entre les pluies à 75% de niveau de fréquence et la perméabilité du sol. Les relevés de pluie provenant du réseau climatique automatique de la canne à sucre et l'information provenant d'une récente étude détaillée des sols de la vallée de la rivière Cauca de Colombie ont été combinés avec un système d'information géographique pour générer la distribution spatiale des groupements d'humidité. Six groupements ont été définis sur la base de l'excédent ou déficit hydrique annuels attendus pour la canne à sucre : un premier groupement avec un déficit, un second avec un excédent d'eau entre 0 et 200 mm/an, un troisième avec un excédent d'eau entre 200 et 400 mm/an, un quatrième avec un excédent d'eau entre 400 et 600 mm/an et un cinquième avec un excédent d'eau supérieur à 600 mm/an. Ces groupements d'humidité furent utilisés comme ossature pour le zonage du système agro-écologique dans la vallée de Cauca en Colombie. L'industrie sucrière Colombienne est commise à utiliser une approche spécifique de site, basée sur la combinaison des facteurs de production de chaque champ de canne.

GRUPOS DE HUMEDAD PARA EL MANEJO DE LA CAÑA DE AZÚCAR

Por

J.S. TORRES y J.R. CRUZ

Centro de Investigación de la Caña de Azúcar de Colombia, Cenicaña
jrcruz@cenicana.org

PALABRAS CLAVE: Suelo, Humedad, Drenaje, Permeabilidad, Manejo de la Caña.

Resumen

EN GENERAL, la producción de caña en Colombia disminuye en los años de mayor precipitación debido a los daños asociados con la cosecha y la dificultad para realizar labores de cultivo después de la cosecha. La magnitud del problema se agudiza de acuerdo con las características del suelo. Para identificar los campos o áreas que requieren énfasis en riego o drenaje y para definir paquetes de manejo agronómico específico por sitio, se desarrollaron los grupos de humedad del suelo, cuya definición se basa en el balance entre la precipitación anual calculada con el 75% de probabilidad y la permeabilidad del suelo. Los registros de precipitación de la red meteorológica automática de la caña de azúcar y la información extractada del reciente estudio detallado de suelos del valle del río Cauca en Colombia se han combinado utilizando el sistema de información geográfico para generar la distribución espacial de los grupos de la humedad del suelo. Se definieron seis grupos de humedad sobre la base del exceso o déficit de humedad anual esperado para la caña de azúcar: El primer grupo de humedad es el que presenta algún déficit de agua para el cultivo de la caña, en el segundo grupo ocurren unos excesos de agua que van desde 0 hasta 200 mm/año, en el tercer grupo los excesos oscilan entre 200 a 400 mm/año, en el cuarto grupo los excesos son de 400 a 600 mm/año y en el quinto grupo los excesos de agua superan los 600 mm/año. Estos grupos de humedad han sido utilizados como base para definir el sistema de zonificación agro-ecológica de la caña de azúcar en el Valle geográfico de río Cauca, Colombia. La agroindustria de la caña en Colombia se ha comprometido a utilizar el enfoque de agricultura específica por sitio basada en la combinación de los factores de producción que intervienen en cada campo sembrado en caña.