

SOIL SODICITY AND PLANT AVAILABLE WATER CAPACITY MAPS USED TO PLAN SUGARCANE EXPANSION AND POTENTIAL IRRIGATION REQUIREMENTS IN CENTRAL QUEENSLAND

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Abstract

Knowledge of soil limitations and the land management methods used to overcome them are vital for successful agricultural pursuits. Soil mapping in the Gregory River area (30,100 ha), central Queensland has been used to assess potential sugarcane expansion. The study results indicate that 69% of the 10,810 ha of existing sugarcane is grown on sodic soils. Some 8890 ha in the Gregory River area are suitable for future sugarcane expansion. Of the suitable land, 5522 ha have subsoil ESP levels between 14 and 20. Some 5066 ha of potential sugarcane land were estimated to have a low PAWC of between 40 and 60 mm. Irrigation scheduling for the expansion area could use the estimated PAWC from the study. The crop tonnage for the expansion area was estimated using the Proserpine Sugar Mill average and also the relationship between crop size and sodicity. The estimated tonnage using the Mill average is 880,120 tonnes compared to 663,387 tonnes using the sugarcane - sodicity relationship, a reduction of 25%. The potential sugarcane crop would require about 92,957 ML/yr, or about 10.34 ML/ha/yr. This study has demonstrated the value of soil data, especially sodicity and PAWC for broad scale agricultural planning.

Additional Keywords: sodicity, soil mapping, irrigation requirements, sugarcane expansion.

Introduction

The Australian sugar mills produce approximately 40 million tonnes of sugarcane on over 420,000 ha (Holden, 2000). In the mid to late 1990's the sugarcane industry gradually expanded in Queensland on the back of relatively profitable years. During this boom time, the Proserpine sugarcane industry expanded into 4089 ha, an increase of 18%. In recent years sugarcane has not been as profitable, however this may change and the sugarcane industry needs to have the appropriate information for sugarcane expansion planning. One of these tools include soil data and land suitability assessments of potential sugarcane land.

Soil and land limitations are used to assess the suitability of land for sugarcane. Two soil limitations which can be used to assess potential irrigation requirements and yield are soil sodicity and the Plant Availability Water Capacity (PAWC). The PAWC of the soil is the field capacity minus the wilting point and is usually expressed in mm/m of soil. The soil attributes which influence the PAWC include soil depth, amount and type of clay, gravel and soil chemistry. The soil chemistry components which influence the rooting depth of plants and thus the amount of water which is available include quantity of free salt (salinity), exchangeable salt (sodicity), calcium : magnesium and the presence of toxic ions. In sufficient quantities, exchangeable sodium or sodicity can reduce the amount of water available to sugarcane roots and thus potentially impact on yield. Sodicity also destabilises soil structure which leads to reduced pore space, lower permeability and available water (Nelson, 2001).

Soils which have an Exchangeable Sodium Percentage (ESP) of more than six are described as sodic soils (Natraqualls, Soil survey Staff, 1992) and are found in most cane growing areas in Queensland. Some 32% of sugarcane in the Proserpine area is grown on sodic soils (Nelson, 2001). Approximately 35% of the Burdekin River Irrigation Area has been mapped as sodic soils (Donnollan, 1991). Soil sodicity is a major limitation to economic growth in caneland areas. Ham *et al* (1995) state that sodicity could be responsible for reducing the Sugarcane industry annual production by 500,000 tonnes which is a potential loss of \$22.5 m. This sodicity – yield relationship could be used to predict future crop sizes in sugarcane expansion areas.

The Gregory river area (30,100 ha) is located north of Proserpine in Central Queensland and is one of many areas in the region with potential for sugarcane expansion. This area has a rainfall range from 1100 in the north to 1700 mm in the south. The Gregory River area was chosen to highlight the usefulness of soil data, especially PAWC and sodicity to assess potential cropping land and determine irrigation requirements and sugarcane yield over large areas.

Methods

Soil data for the study were gathered from a land resource survey by Hardy (1998) at a scale of 1:50,000. Soil profile classes were used to group similar soil profiles and map soil properties. The soil data collected from the land resource survey were used as part of the land suitability assessment for sugarcane. The land suitability assessment followed the guidelines outlined in the Land Resources Branch Staff (1990). Seventeen soil and land limitations were used in the land suitability assessment. The classes used to express the suitability of each mapping unit for sugarcane were as follows;

- * Class 1 Suitable land with negligible limitations.
- * Class 2 Suitable land with minor limitations.
- * Class 3 Suitable land with moderate limitations.
- * Class 4 Marginal land - presently unsuitable with severe limitations.
- * Class 5 Unsuitable land with extreme limitations that preclude its use.

Sodicity and Plant Available Water Capacity (PAWC) were identified as potentially useful soil limitations that could be used in sugarcane expansion planning. Sodicity was calculated from subsoil samples collected from the land resource survey. Each soil profile class was allocated a subsoil sodicity class from the analysed samples. The sodicity classes were, ESP 0-6, ESP 7-14, ESP 15-20, ESP 21-30 and ESP 31-40.

The PAWC of the soils were determined by using the PAWCER computer program developed by Littleboy (1996). The PAWCER program uses the amount of clay, silt, fine sand, coarse sand and gravel and the 1/3 bar moisture content to determine field capacity and wilting point. The PAWCER then calculates the PAWC for each soil layer depending on the input data. The PAWC of the soil profile is simply determined by adding the PAWC values for each 10 cm soil increment to a given rooting depth. The rooting depth chosen depended upon the soil depth or a chemical limitation such as salinity or sodicity. The sodicity value of 20 was assumed to have a limiting affect on sugarcane roots and was chosen as a rooting depth. It should be noted that sugarcane may be able to extract small amounts of soil water where the sodicity level is 20 to 35. The amount of water which sugarcane can extract past an ESP of 20 is disregarded for this study as it is very small. Zund and McDougall (1997) found that the predicted PAWC using the PAWCER program was closely correlated to the available water measured in the field. Each soil was then allocated a PAWC class. The PAWC classes were those soils >125 mm, 100-125 mm, 75-100 mm, 60-75 mm, 40-60 mm and those less than 40mm.

The ACCESS database which contains the PAWC and sodicity data for each soil profile class were then imported into a GIS. The PAWC or sodicity field can then be selected in the GIS, colour coded and mapped.

The PAWC data will assist with the determination of the irrigation requirements for the potential sugarcane crop. According to Holden (1998), the annual crop water use for the Mackay area is 1490 mm/m/yr with an effective rainfall of 630 mm/m/yr. The irrigation requirement for sugarcane in the Mackay area is estimated by Holden (2000) to be 860 mm/m/yr. The annual crop water use in the Burdekin area is 1520 mm/m/yr with an effective rainfall figure of 450 mm/m/yr and an irrigation requirement of 1070 mm/m/yr. The crop water use for the Mackay area will be used to estimate the crop water use requirements for the Gregory River area. If the effective rainfall for the Mackay area is 38% of the total rainfall then this amount can be used to determine the effective rainfall for the Gregory River survey.

The sodicity – sugarcane yield relationship is used to estimate sugarcane yield across the study area. Spalding (1983) has indicated that subsoil sodicity reduces the profile PAWC and sugarcane yields. The study conducted by Spalding found that for every one ESP % increase in the soil corresponds to a loss of 1.5 tonnes of cane, while Nelson and Ham (2000) found the loss to be 2.1 t/ha. The use of the sodicity-yield relationship will be compared to the use of the Sugar Mill average for calculating yield. The average production of sugarcane in the Proserpine Mill area was 97.9 t/ha for the five years from 1995 to 1999 (Holden, 2000).

Results

The land resource survey covered 30,100 ha with 244 sites described and 51 soil profile classes identified. The survey identified that sugarcane is grown on 10,810 ha in the Gregory River survey area. Data derived from the sodicity map of the Gregory River survey suggest that approximately 7458 ha or 69% of sugarcane is grown on soils with low to moderate levels of subsoil sodicity.

The land suitability assessment calculated that 9,995 ha were suitable for future spray irrigated sugarcane expansion. If 10 % is subtracted from the land suitable for cane for infrastructure, then 8890 ha could be used to grow cane. There are approximately 2 719 ha with a subsoil ESP of 6 to 14 which are suitable for spray irrigated sugarcane expansion. There are a further 5 522 ha suitable for spray irrigated sugarcane expansion with subsoil ESP levels between 14 and 20. The remaining soils suitable for sugarcane expansion have low subsoil sodicity levels.

The PAWC of the potential sugarcane land was estimated using the PAWCER program. Table 3 shows the PAWC of the land suitable for sugarcane, and will be useful in irrigation scheduling.

Table 3. The PAWC of the soils in the expansion areas of Gregory river survey

PAWC Range	PAWC Class	Area (ha)
>125 mm	1	97
100-125	2	1374
75-100	3	856
60-75	4	2602
40-60	5	5066
<40	6	0
Total		9995

If we use the 97.9 t/ha to calculate the potential sugarcane production from the Gregory river expansion areas, some 880,120 tonnes of cane could be grown in an average year. With the Spalding sodicity-sugarcane productivity relationship we can recalculate the possible sugarcane production for the Gregory river area. The Gregory river study found 1754 ha are suitable for sugarcane with ESP levels less than 6, 2719 ha suitable and have subsoil sodicity levels of 6 to 4 and 5522 ha have an ESP of 14 to 20. If the experimentally derived correlation curve of ESP and yield described by Spalding is used with the modal value from the ESP classes, the yield for the Gregory River expansion area can be calculated.

$$Y = -1.538 \times \text{ESP} + 101.040$$

ESP class one (0-6), the value of 3 is used and the yield = $96.4 \times 1754 = 16,913 \text{ t}$

ESP class two (6 – 14), the value of 10 is used and the yield = $85.66 \times 2,719 = 232,909 \text{ t}$

ESP class three (14 – 20), the value of 17 is used and the yield = $74.89 \times 5522 = 413,565 \text{ t}$

The estimated cane production using the Spalding relationship between ESP and yield is 663,387 tonnes for the potential sugarcane land in the Gregory river area. This revised figure is approximately 25% less than the figure calculated using the Proserpine Sugar Mill cane yield average.

The irrigation requirements for the potential crop were calculated. If a conservative mean annual rainfall of 1200 mm/yr is chosen and the effective rainfall is $1200 \times 0.38 = 456 \text{ mm/m/yr}$. The amount of irrigation required for the Gregory river area is 1034 mm/m/yr. If we then calculate the amount of water required for the 8990 ha expansion:

$$1034 \text{ mm/m/yr} \times 10000 \text{ m}^2 = 10.34 \text{ MegaLitres per ha/yr}$$

$$8990 \text{ ha} \times 10.34 \text{ ML} = 92,957 \text{ ML required to supply the sugarcane expansion areas.}$$

The 10.34 ML /ha is similar to the irrigation requirement for sugarcane in the Burdekin where 10.9 ML/ha is used (Holden, 2000). The irrigation requirement for sugarcane in the Gregory river area is considered the minimum needed to grow the crop. The PAWC data is then used to maximise water use efficiency. The use of inappropriate irrigation practises would increase the 10.34 ML/ha/yr. The PAWC data for the area could be used for irrigation infrastructure planning and guide the application of irrigation water to the crop.

Discussion

Soil data collected from the Gregory River land resource survey enabled soil properties to be mapped and the suitability of sugarcane assessed. The study found that 10,810 ha is used to grow sugarcane, of which 69 % has low to moderate subsoil sodicity. The study identified a further 8996 ha suitable for sugarcane expansion. However, 60 % of potential sugarcane land has ESP levels between 14 and 20 in the first 10 cm of the subsoil. The moderately high sodicity reduces the PAWC of the soils.

With the ESP and PAWC data in digital format some productivity calculations can be made for the expansion areas. The estimation of sugarcane yield used the Proserpine Sugar Mill average and the sodicity – sugarcane yield relationship. The sodicity – yield relationship estimated a 25% smaller crop than that estimated using the Mill average. The estimated 663,387 t/yr production from the sodicity-yield relationship will vary depending on climate, disease and management inputs.

The annual crop water use of 1490 mm/m/yr and effective rainfall of 456 mm/m/yr were used to estimate the amount of irrigation required for the Gregory river area. The 1034 mm/m/yr of supplementary irrigation that would be required for the crop is approximately 10.34 MegaLitres per ha/yr or 92,957 ML/yr for the whole area. The PAWC data is vital to ensure water is used efficiently. Irrigation infrastructure planning for the area would greatly benefit from the PAWC data. This amount of irrigation water assumes that irrigation is applied to the crop when required and that there is minimal loss. The estimated quantity of water for the expansion area is almost 19% of the total storage capacity of Peter Faust dam west of Proserpine. Such a high water demand would need to be partly offset by the use of groundwater in the area. Consequently, before the expansion occurs in the Gregory river area, a comprehensive groundwater study is highly recommended.

This study has demonstrated the value of soil data in providing information that can be used in planning sugarcane expansion over large areas. Having the capability of mapping soil properties such as sodicity and PAWC is valuable in understanding the soil limitations present and also prioritising areas for expansion. It is likely that more stringent environmental conditions will be placed upon sugarcane expansion in the future. The land suitability data, together with the sodicity and PAWC information will assist the sugarcane industry in developing more efficient irrigation infrastructure and practises in expansion areas. The sugarcane industry has an increasing number of strategic tools at its disposal to more strategically plan sugarcane expansion. One of the most valuable of these tools is soil data and its interpretation to estimate crop irrigation requirements and yield.

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