REVIEW OF PRODUCTIVITY TRENDS IN THE HERBERT SUGARCANE GROWING REGION

By

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KEYWORDS: Seasonal Conditions, Water Management, Varieties, Rainfall, Harvesting.

Abstract

CONCERNS ABOUT decreasing productivity in recent years in the Herbert cane growing region prompted the Herbert Cane Productivity Services Limited (HCPSL) to commission a review of the production system in an attempt to identify issues that have likely influenced productivity. The review encompassed the collation and analysis of productivity data held by HCPSL, interpretation of the analyses and interviews with growers. In general the outcomes indicated that water management (seasonal conditions, drainage, waterlogging), various aspects of harvesting (groups too big, harvesting too fast, not enough adjustment for seasonal conditions/geographic harvesting, cane loss and season length (the harvest season being too long) were the main factors influencing productivity in the Herbert. The review showed that productivity was strongly linked to seasonal conditions with high rainfall in November, in particular, having an adverse effect on crop productivity the next year. This is likely due, at least in part, to radiation limitation, waterlogging, and nutrient loss under the wet conditions. However, the combination of high rainfall in November and harvesting with heavy machinery under wet conditions is also likely to be having a significant adverse effect on productivity the next season, through either direct effects on the ratoons and/or limiting the opportunity for field maintenance between cycles. Of the 23 years since 1989 harvesting has continued into November and/or December in 21 and 19 of those years for Victoria and Macknade mills, respectively. It is suggested that if the harvest season is completed by the end of October the adverse effects on productivity the following year are likely to be substantially reduced. Suggestions are made as to how this may be achieved. Contrary to popular opinion there is no clear evidence that varieties are involved in the season to season variation in yield.

Introduction

Since 1990 the average cane and sugar yields for the Herbert region are of the order of 80 and 11 t/ha, respectively. However, in recent years, yields have generally been below these averages, particularly in the 2011 season when only 2.9 M tonnes of cane were harvested from 52 000 ha at cane and sugar yields of 56 and 7t/ha, respectively.

In addition, the cane yields for 2009 (76 t/ha), 2010 (83 t/ha) and 2012 (72 t/ha) have been average or below average. These recent yields have raised concerns in the Herbert industry that there may be an overall trend towards reduced productivity.

Numerous suggestions have been put forward as to the cause of lower productivity. In general, growers in the Herbert believe that poorly adapted varieties introduced to provide smut tolerance/resistance are a major reason. However, no critical analysis of the available data held by the Herbert Cane Productivity Services Ltd (HCPSL) has been carried out.

This encouraged HCPSL to commission a review of the available data to try and identify the reasons for lower productivity. The review was carried out between January and April 2013 by Agritrop Consulting with the assistance of staff from the HCPSL.

Methods

Background

In carrying out any review of productivity there are three basic areas that should always be considered: genotype, environment and management, as productivity is determined by the combination of all three.

Thus, in approaching this review it was decided to assess the productivity issues under those three broad headings:

- Impact of varieties
- Impact of seasonal conditions (environment)
- Impact of crop management.

In addition, a grower survey was included as part of the review to gauge what the growers thought were the most important factors controlling productivity.

HCPSL Organisation of the Herbert Region

The Herbert Region is fortunate in that the HCPSL has a large amount of data on productivity issues. Unfortunately, much of these data have not been subjected to critical analyses so a major task in the early part of the review was to access the data, convert it to a format suitable for statistical analyses and carry out the analyses. This was a time consuming exercise and detracted somewhat from a more in depth coverage of the main issues.

The HCPSL has divided the Herbert region into a number of districts and further into sub-districts. The districts and sub-districts tend to reflect different climatic zones to some extent and thus have special attributes that need to be considered independently in any review. Thus it was decided that both districts and sub-districts needed to be considered in this review and not simply the region as a whole.

There are six districts: Ingham Line, Central Herbert, Abergowrie, Lower Herbert, Stone River and Wet Belt. Each district is divided into a number of sub-districts as detailed below and shown in Figure 1:

- Ingham Line: Coolbie Rollingstone, Bambaroo East, Bambaroo West, Yuruga, Helens Hill.
- Central Herbert: Blackrock, Toobanna, Hamleigh, Fairford Trebonne, Victoria Estate.
- Wet Belt: Tara Seymour, Hawkins Creek, Lannercost, Lannercost Extension.
- Lower Herbert: Macknade, Halifax Fourmile, Cordelia, Forresthome, Sunnybank, Ripple Creek.
- Abergowrie: Long Pocket Elphinstone, Leach, Garrawalt.
- Stone River: Lower Stone, Mid Stone, Upper Stone.

In sections of the review, issues are discussed at regional level, district level or sub-district level depending on what level is the most appropriate for the particular issue.

Grower perspective

In order to obtain the growers perspective, 20 growers were interviewed individually, with at least three from each district, in a structured interview at the HCPSL offices.

In the interview, each grower was asked the same questions and each was given the opportunity to comment on the importance of different issues. Interviews lasted between 30 minutes and 1 hour. Growers were asked to rate from 1 to 5 (with a 1 rating being of least importance) the importance of a number of factors for the district as a whole and their particular operation. Growers were also given the opportunity to raise additional points issues not covered in the interviews. The data were collated and are summarised in the results section.

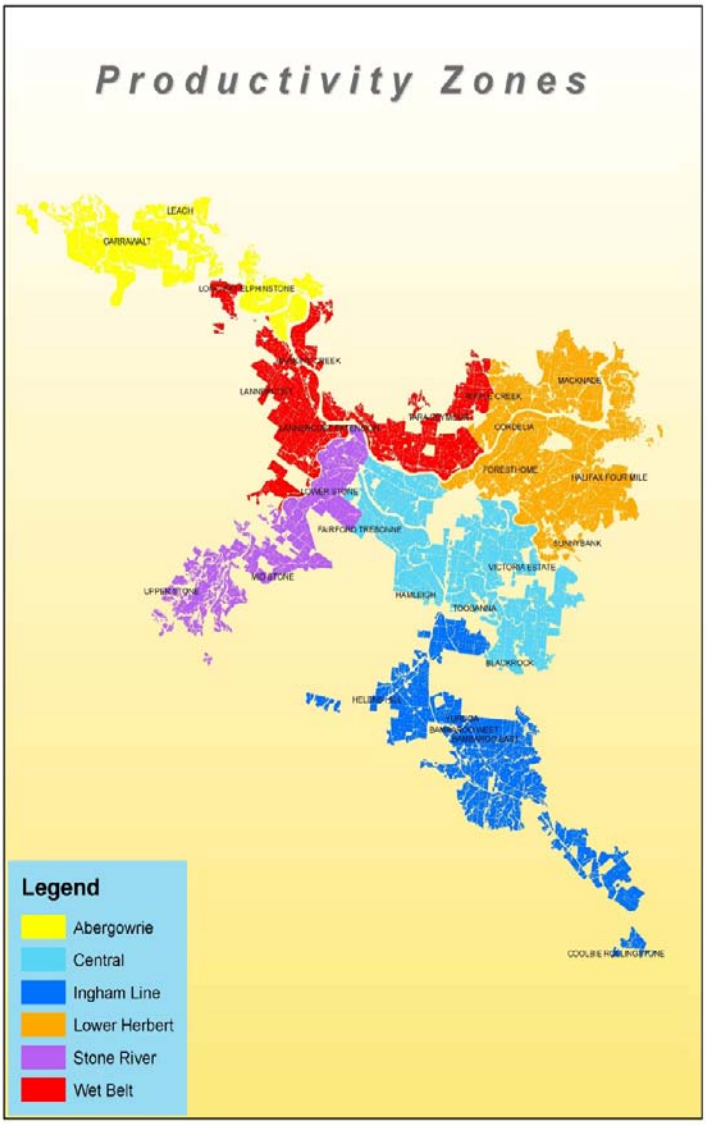

Fig. 1—Districts and Sub-districts in the Herbert sugarcane productivity region.

Varieties

There is a general perception in the industry that new varieties will overcome most problems in the production system. Currently, there is concern in the Herbert that the replacement varieties for Q174 (removed due to smut) are not as productive, robust, and do not ratoon very well. However, there is little objective data available to realistically assess the relative performance of the pre and post smut varieties. Some attempts at comparisons are made here with the limited data available.

Seasonal conditions

Recent studies in the Mackay region have clearly indicated that variations in crop yield between seasons can be closely associated with seasonal conditions (Salter and Schroeder, 2012).

They demonstrated effects of both drought stress, extended wet periods and the timing of both in the crop cycle. In this review a major effort has been put into understanding the implications of varying seasonal conditions on productivity in terms of the Herbert as a whole, the various districts and sub-districts and the importance of the timing of particular seasonal conditions. To carry out these analyses the district and sub-district rainfall data for all the years from 1994 to 2011 (17 years) was collated and linear regression analyses were used to relate cane yield, CCS and sugar yield to seasonal rainfall. We did not use data from earlier than 1994 as rainfall data were not available for all the sub-districts for years prior to 1994. The rainfall data on a sub-district basis was provided by M. Torrisi (pers. comm.), a Bureau of Meteorology employee. Where more than one registration gauge was available for a sub-district the data was meaned. District data is the mean of sub-district data.

The approach we used was to first convert the available annual rainfall data (January to December) to seasonal rainfall (July to June) data, as seasonal rainfall mirrors the crop growing period more closely than annual rainfall. Seasonal rainfall data were then related to productivity indices for the previous year i.e. the cane yield, CCS and sugar yield for 1995 were regressed against the rainfall data for 1994–1995 and so on for progressive seasons. Analyses were carried out at regional, district and sub-district levels. In this paper we report the more significant seasonal effects.

Crop management

There is a whole range of factors that can come under the category of crop management. For this review, harvesting and season length were the major factors considered. Issues such as nutrition, disease, row spacing, weed control, flat vs mound planting and clean seed have also been assessed but have been found to be of relatively minor importance in their influence on the variation in seasonal productivity. This conclusion was reached after assessing relevant data held by HCPSL.

Results and discussion

Grower perspective

Growers generally regarded varieties as the most important factor limiting yields, with the smut tolerant varieties being less robust, producing fewer and poorer yielding ratoons. Numerous growers commented that where they could once grow 4–5 ratoons they were now limited to 2–3.

Other important factors highlighted by growers included water management (wet seasonal conditions, drainage, waterlogging), various aspects of harvesting (groups too big, harvesting too fast, not enough adjustment for seasonal conditions/geographic harvesting) and season length (the harvest season being too long). Planting is also becoming a substantial issue with more growers being dependent on contractors for planting and this was having an adverse effect on timeliness of operations. Many growers were accepting of a more staggered start and finish to the harvest season in different areas providing equity could be maintained.

Another important issue that was raised with growers was whether reef regulations were a major negative issue with regard to their farming operations. Most growers believed that the regulations weren't a major impediment, except that they increased paper work. Those that did raise concerns mainly focussed on the loss of diuron as a herbicide.

Varieties

Similar suites of varieties produced overall regional cane yields of 76, 83, 56 and 72 t/ha in 2009, 2010, 2011 and 2012, respectively, clearly indicating that either environment or management were the major contributors to yield variation between those seasons. Further, the cane and sugar yields across the Herbert in 1996, when Q124 was the main variety, were 98 and 13 t/ha while the equivalent figures in 2005 with a suite of varieties (Q174, Q157, Q158) were 97 and 13 t/ha. Thus with a cursory glance one could say that there had been no improvement in productivity due to varieties in 10 years. We all know that this is not the case as numerous studies have demonstrated productivity gains associated with varietal improvement over time (Cox *et al*., 2005) and of course disease resistance (orange rust, smut) has been a major achievement of the breeding program.

In their review of productivity on the Wet Tropical Coast, Wilson and Leslie (1997) were able to demonstrate varietal improvement in tonnes of cane per hectare over time by using Q57 (a long-term variety) as a base line and comparing productivity of new varieties with Q57. Unfortunately the same could not be done in the Herbert because there was no long-term variety to use as a base line over the study period.

Two very productive varieties, Q124 and Q174, have been taken out of the system by orange rust (Q124 in 2000) and smut (Q174 in 2006). Consequently, it is almost impossible to systematically gauge the impact of varieties. We have attempted some comparisons between Q174 (pre-smut) and Q200 (post-smut) with limited data (Table 1). Both of these varieties have commanded substantial areas at different times.

Table1—Average cane yield, CCS and sugar yield for varieties Q174 and Q200 grown in the Herbert area between 2004 and 2009.

	PC	R1	R2	R3	R4	R5	R6
Q174							
Cane yield (t/ha)	101	98	92	87	83	78	83
CCS (%)	14.90	13.56	13.30	13.39	13.46	13.23	13.10
Sugar yield (t/ha)	14.20	13.19	12.25	11.60	11.10	10.30	10.81
Q200							
Cane yield	102	95	87	79	81	83	93
CCS (%)	14.89	14.51	14.40	14.54	14.33	14.55	14.64
Sugar yield (t/ha)	15.22	13.68	12.52	11.50	11.51	12.14	13.68

On the basis of these limited data there appears little difference in productivity between pre (Q174) and post smut (Q200) varieties.

Further, from the perspective of disease resistance/tolerance the newer varieties appear better adapted than earlier varieties, except for the fungal disease *Pachymetra chaunoriza* (Table 2).

Table 2—Disease ratings** of varieties grown in the Herbert in 2005 (pre-smut) and 2012.

Disease	2005	2012
Smut	83% (susceptible)	(42% susceptible)
Pachymetra	45% (intermediate/resistant)	80% (intermediate/resistant)
Leaf scald	75% (resistant)	94% (resistant)
Chlorotic streak	53% (resistant)	62% (resistant)
Ratoon stunting disease	26% (resistant)	76% (resistant)

** Data from HCPSL survey.

Overall, on the basis of the productivity data available it is very difficult to attribute the large variation in seasonal productivity to varieties.

Seasonal conditions

Regional

The average annual cane yield, CCS and sugar yield data for the region for each season between 1995 and 2011 were regressed against the seasonal rainfall data between 1995 and 2011. Across the region rainfall accounted for 21% of the variation in cane yield, 4% of the variation in CCS and 27% of the variation in sugar yield.

The regressions were highly significant ($p<0.001$) and clearly showed a strong negative relationship between each of the parameters and seasonal rainfall. Basically the higher the rainfall the lower the cane and sugar yield with the latter being mainly due to the influence of seasonal conditions on cane yield as the effect on CCS was relatively small. Thus the presentation of further results will largely be restricted to cane yield with CCS and sugar yield only reported for specific situations.

Individual districts

The next step was to run regression analyses for each of the districts. Data for the percentage of variation accounted for by seasonal rainfall are shown in Table 3.

Clearly there are differences among the districts. First, the Ingham Line is not as sensitive to seasonal conditions in terms of excess rainfall and in fact, although the data are not presented, the Ingham Line suffers as much from low rainfall seasons as it does from high rainfall seasons. This suggests that it should possibly be treated separately to the other districts.

The other interesting point is the relatively low variation in cane yield and high variation in CCS that rainfall accounts for in the Wet Belt district. This is different to all other districts (Table 3).

The combination of low relative variation in cane yield yet high relative variation in CCS accounted for by seasonal conditions brings the variation in sugar yield accounted for by seasonal conditions up to 45.8%, similar to Central Herbert where CCS appears less important. The reason for the different response in the Wet Belt may be associated with wet/overcast conditions during April to June when CCS is being determined (Table 4). This issue was not taken any further.

Table 3—Percent of variation in cane yield, CCS, and sugar yield accounted for by seasonal rainfall for each district within the Herbert region.

District	Cane yield	CCS	Sugar yield
Ingham Line	2.9 (ns)	4.0 (ns)	3.4 (ns)
Central Herbert	40.5 (p<0.001)	0.6 (ns)	45.8 (p<0.001)
Lower Herbert	37.5 (p<0.001	1.5 (ns)	42.6 (p<0.001)
Wet Belt	15.6 (p<0.001)	12.2 (p=0.002)	45.8 (p<0.001)
Abergowrie	21.7 (p<0.001)	1.3 (ns)	34.7 (p<0.001)
Stone River	21.7 (p<0.001)	2.7 (ns)	30.4 (p<0.001)

As there were large differences between the Ingham Line and the other districts the analysis was run again without the data for the Ingham Line. The percent variation in cane yield, CCS and sugar yield accounted for by seasonal rainfall increased for cane yield (21 to 29%) and sugar yield (27 to 35%) while CCS was only slightly affected (4 to 4.6%).

Groups of months

Given the very strong overall effect of seasonal conditions on cane and sugar yield it was decided to analyse the data for different periods in a year. Data were organised on the basis of four different periods viz. July–September, October–December, January–March and April–June. The Ingham Line data have been excluded from these analyses given the general non-conformity with the other districts. The results of these analyses are presented in Table 4.

Table 4—Percent of variation in cane yield, CCS, and sugar yield in the Herbert region accounted for by seasonal rainfall in the periods July–September, October–December, January–March, and April–June. Ingham line data excluded.

Month	Cane yield	CCS	Sugar yield
July–September	4.4 (p<0.001)	2.6 (p<0.001)	6.6 (p<0.001)
October–December	41.4 (p<0.001)	2.7 (p<0.001)	46.5 (p<0.001)
January–March	23.1 (p<0.001)	Nil (p<0.001)	23.8 (p<0.001)
April–June	Nil (p<0.03)	19 (p<0.001)	6.8 (p<0.001)

Rainfall, particularly in the October–December, but also the January–March periods is having a major negative effect on cane and sugar yield in the next harvest season (Table 4). On the other hand, the April to June rainfall is having no effect on cane yield but a substantial effect on CCS.

Individual months

The large effect of October– December rainfall on the crop the following year was narrowed down further by analysing the data for individual months during that period. The results are presented in Table 5.

Table 5—Percent of variation in cane yield, CCS, and sugar yield in the Herbert region accounted for by seasonal rainfall in the months of October, November and December. Ingham Line data excluded.

Month	Cane yield	CCS	Sugar yield
October	8.7 (p<0.001)	1.0 (ns)	9.8 (p<0.001)
November	43.4 (p<0.001)	Nil (ns)	41.4 (p<0.001)
December	21.9 (p<0.001)	10.45 (p<0.001)	32.0 (p<0.001)

Clearly it is the rainfall in November that is having a major effect on productivity the next year (Table 5 and Figure 2) while rainfall in October is having a relatively small effect. We are somewhat at a loss to explain the rainfall/CCS relationship (10.45%) for December.

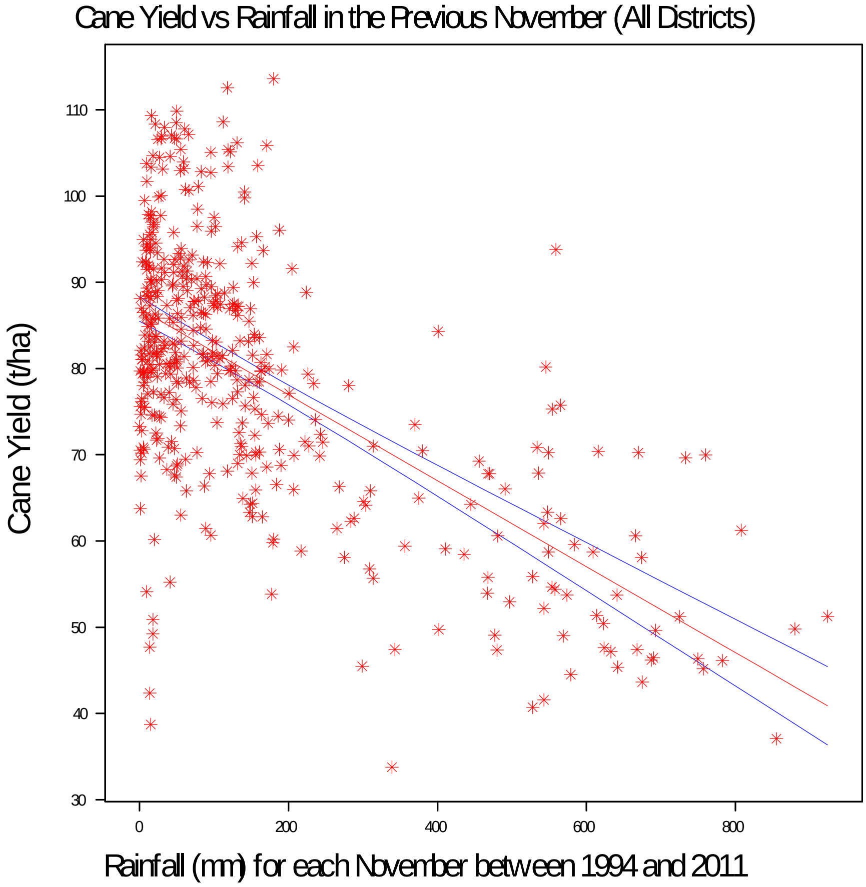

Fig.2—Effect of November rainfall on cane yield in the following season across the Herbert Region.

November rainfall and yield parameters for each sub-district

Given the very significant influence that November rainfall has had on cane and sugar yield across the region in the following year, and differences demonstrated between districts, it was decided to run regression analyses to estimate the effect of November rainfall on cane yield the next year for each of the sub-districts within the Herbert region. The results are presented in Table 6.

These data reveal that wet Novembers are having a major effect on the potential yield in most sub-districts, the exceptions being the Coolbie Rollingstone, Bambaroo East and West sub-districts of the Ingham Line, Upper Stone and for some unknown reason the Blackrock sub-district of the Central Herbert.

Crop management

Harvesting

In recent times the importance of harvester fan speed, ground speed and pour rate have emerged as important factors in cane loss and harvester damage (Sandell and Agnew, 2002). Further, general comments from growers indicated that harvesting is a major issue in the productivity equation and is becoming more significant each year. Many growers and professionals believe that the reduction in the number of harvesting groups is putting too much pressure on remaining groups that are having to take on bigger contracts. This is resulting in faster harvesting, greater cane loss, and reduced opportunity to stop harvesting under adverse conditions. These constraints were in turn having an adverse effect on ratoons. This effect on ratoons begs the question as to whether the current varieties are as poor ratooners as is being claimed and/or whether increased harvesting damage is a major contributor to poor ratooning.

Table 6—Effect of November rainfall on the variation in cane yield for each sub-district in the Herbert region.

District/sub-district	% Variation accounted	Level of significance
INGHAM LINE		
Coolbie Rollingstone	8.0	ns
Bambaroo East	15.9	ns
Bambaroo West	13.8	ns
Yuruga	23.6	P=0.02
Helens Hill	25.5	P=0.02
CENTRAL HERBERT		
Toobanna	56.9	P<0.001
Blackrock	18.5	ns
Hamleigh	54.5	P<0.001
Fairford Trebonne	53.7	P<0.001
Victoria	55.5	P<0.001
LOWER HERBERT		
Ripple Creek	57.3	P<0.001
Macknade	52.1	P<0.001
Halifax Fourmile	48.7	P<0.001
Cordelia	51.7	P<0.001
Forresthome	60.3	P<0.001
Sunnybank	53.9	P<0.001
WET BELT		
Tara Seymour	20.0	P=0.04
Hawkins Creek	54.4	P<0.001
Lannercost	61.6	P<0.001
ABERGOWRIE		
Garrawalt	35.4	P=0.005
Leach	46.8	P=0.001
Long Pocket Elphinstone	35.3	P=0.005
STONE RIVER		
Lower Stone	55.6	P<0.001
Mid Stone	35.7	P=0.005
Upper stone	nil	ns

Available data on harvester pour rates in 2009 and their effect on the crop in 2010 was investigated for more than 10 000 blocks (Figure 3). The data can be questioned due to some of the calculations that were required for some of the parameters that went into the analysis. However, there were certainly indications that pour rates are important. These data demonstrated that 14% of the variation in cane yield in 2010 could be attributed to pour rate in 2009. Basically, the higher the pour rate in 2009 the greater the yield was reduced in 2010.

Season length

The length of the harvest season (too long) is an issue upon which almost every sector of the industry agrees, yet the sectors do not seem to be able to agree on how to overcome the problem, unless the mills increase their milling capacity to facilitate harvesting the crop in a shorter time period, which is most unlikely.

In the absence of increased milling capacity the harvest will not be able to be shortened. However, it may be able to be adjusted to provide a better overall result for all parties. Our data clearly indicate that high rainfall in November and to a lesser extent December, has an adverse effect on productivity the next year.

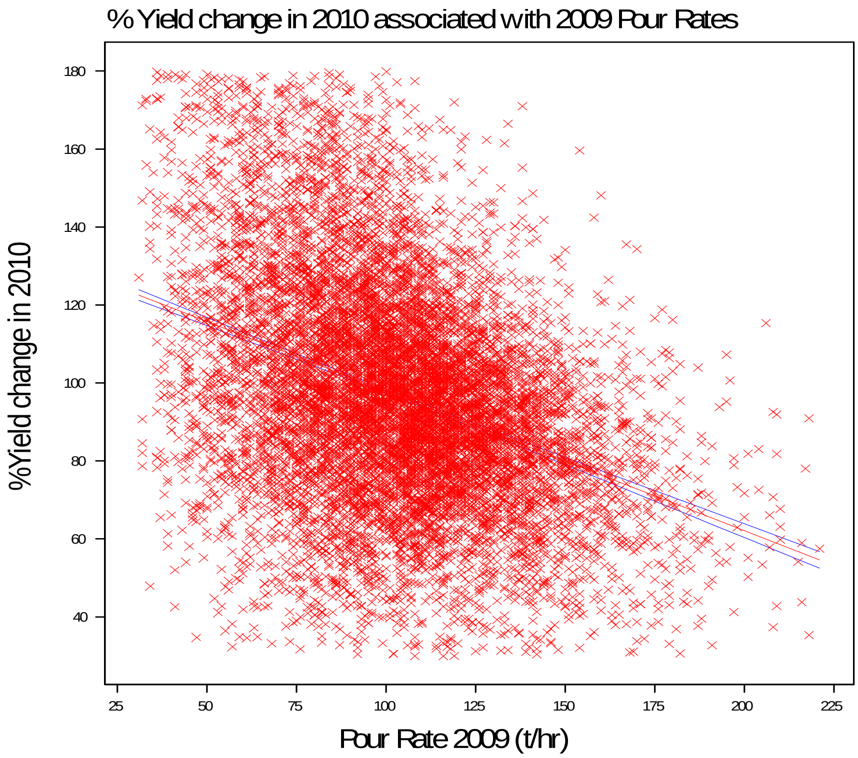

Fig. 3—Percent change in yield in 2010 associated with pour rate in 2009. On Y-axis 100% means harvesting pour rate in 2009 had no effect on yield in 2010.

This may be due, in part, to harvester damage under wet soil conditions in November and December adversely affecting ratoon establishment. In addition, radiation limitation, waterlogging and nutrient loss associated with these wet conditions are also likely to be adversely affecting crop growth.

Further, in situations where the last ratoon in a cycle has been harvested in November, wet conditions may well impede paddock maintenance such as drainage renovation, laser levelling, land preparation and the establishment of break crops. These factors may well have an impact on the establishment of the next crop cycle.

Although the actual data are not available, it is unlikely that wet weather in November *per se* is as much the problem as the combination of wet weather, reduced solar radiation, waterlogging, nutrient loss and the traffic of heavy (harvesting) machinery.

In fact, when the harvest season in the Herbert is considered on an annual basis in the 23 years since 1989 it has extended into November and/or December in 21 and 19 years for the Victoria and Macknade Mills, respectively.

That is, heavy machinery is passing over wet ground in November and December in the majority of years. Conversely, October rainfall is having a relatively minor effect on productivity the next year (9% of yield variation accounted–Table 5).

This clearly suggests that with the majority of seasons, yields the following year are unlikely to be compromised to the same extent if harvesting was completed by the end of October.

However, within the overall rainfall analyses there are more significant relationships for various districts and sub-districts (> 60% accounted with November rainfall for Lannercost and Foresthome but only 8% for Coolbie Rollingstone and 16% for Bambaroo East–Table 6).

These variations in the adverse effects of seasonal conditions in November across the Herbert suggest that there is opportunity to stagger harvesting to target the drier areas (e.g. Ingham Line and Upper Stone) during the wetter periods of the harvest season and the wetter areas (e.g. Wet Belt, Lower Herbert) during the drier periods of the season. Similar conclusions were drawn from studies into optimising harvest dates (Higgins *et al.*, 1998) and alternative cane supply arrangements (Higgins and Muchow 2003).

General discussion and implications

This analysis has not been exhaustive and there are no doubt many other issues that may be having an effect on the season to season variation in productivity. However, it is believed that the major issues have been identified and that the suggestions made will allow the effects to be at least moderated.

In order to complete the harvest by the end of October it will be necessary (with current milling capacity) to commence earlier than mid-June (current starting time) to harvest the crop in time. Thus commencement of the crushing season in May is likely to be necessary. Such a strategy raises concerns with regard to an adverse effect on CCS. However, recent data of Di Bella *et al.* (2008) indicates that the effects on CCS in May from previous early, mid-season and late harvests are likely to be minimal. In addition to this minimal effect on CCS, there appear to be many advantages in terms of long-term productivity.

There is a real need to recognise that we are not dealing with an annual crop and management one year will affect productivity in ensuing years as shown in a number of studies on season length in the Herbert Region (McDonald *et al.,* 1999; McDonald and Wood, 2001; Di Bella *et al.,* 2008). All of these studies showed that late harvesting (November/December) had a major negative effect on cane yield in the following ratoon and can result in reducing the number of ratoons in a cycle. The current analysis supports the results of these previous studies.

Commencement of the harvest season earlier (late May) and finishing by the end of October is likely to provide a range of other advantages at the end of the season such as time to address drainage issues, laser levelling of blocks and the establishment of legume breaks. No doubt there will be situations when harvesting in May will present difficulties because of wet conditions in extended wet seasons. However, this is not seen as a major problem if late ratoons and plough-out crops are harvested first in such years.

With the exception of the growers concerns about the deficiencies in current varieties there is general agreement between the growers and technologists regarding the major factors influencing productivity. These come down to water management (seasonal conditions, drainage, water-logging), various aspects of harvesting (groups too big, harvesting too fast, not enough adjustment for seasonal conditions/ geographic harvesting, cane loss) and season length (the harvest season being too long). We have attempted to address these issues and suggest possible solutions below.

There is little evidence to show that varieties are having an impact on seasonal production trends. However, there is some circumstantial evidence that the newer varieties (post- smut) are not as productive as the pre-smut varieties and are poorer ratooners. This needs to be fully explored. It is possible that the changes to larger harvesting groups and increased pour rates may, at least in part, be also contributing to poor ratoonability.

There is no doubt that many managerial issues will impact on crop yield. Issues such as weed control, pests, diseases, the aging grower population etc. are all likely to be of some significance. However, these issues are unlikely to have a major influence on season to season variability.

The approach taken in this study has been to tackle what was seen as the major over-riding issues of managing for the climate, season length and its start and finish time, and harvesting loss and damage. It is believed that productivity will remain highly variable from season to season until these issues are addressed as the benefits of other agronomic and genetic initiatives will continue to be overwhelmed by seasonal issues.

Certainly the season length and early start to the harvesting season that is being suggested is likely to have political and harvesting equity considerations and will no doubt not sit well with some in the industry. However, it is strongly believed that long-term productivity will not improve unless these issues are addressed. It was our role to review the reasons for poor productivity in the Herbert in recent years. We believe we have done that and identified the major issues that need to be addressed. However, if they are to be properly addressed the adoption of a co-operative approach on the part of growers and millers will be essential. That is the immediate challenge.

Acknowledgments

The Sugar Research and Development Corporation for funding the review through the Herbert Water Quality Project being carried out by Terrain Natural Resource Management. We would also like to acknowledge the assistance provided by the 20 growers who participated in the survey. Further, helpful comments on the manuscript were provided by Dr. Barry Salter.

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