REVIEW OF PRODUCTIVITY TRENDS IN THE HERBERT SUGARCANE GROWING REGION

Dr. A.L. Garside

Adjunct Crop Scientist
Tropical Crop Science Unit
School of Marine and Tropical Biology
James Cook University
Townsville
and
Agritrop Consulting

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Summary and recommendations

This review was initiated by the Herbert Cane Productivity Services (HCPSL) limited in order to identify the major reasons for highly variable productivity in recent years. 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 clearly indicated that 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) were the main factors influencing productivity in the Herbert. Suggestions are made as to how these issues may be addressed. Although it is acknowledged that varieties are an important part of any production system it is demonstrated that their influence on the large season to season variability in productivity is relatively minor.

The following recommendations are made:

Recommendation 1: The large amount of variety performance data on different soil types in different seasons held by HCPSL warrants collation and analysis in order to objectively assess whether different varieties are suited to different soil types and regions.

Recommendation 2: The importance of seasonal conditions in November as they affect the subsequent crop needs to be fully appreciated and strategies adopted to minimise their impact.

Recommendation 3: The difference in climatic regimes between the Ingham Line area (and Upper Stone) and other areas needs to be recognised and if necessary different production strategies put in place.

Recommendation 4: The most suitable varieties for Ingham Line may well be different to those for other areas and this should be taken into account within the variety evaluation program

Recommendation 5: Emphasis should be placed on the development of mound planting for the wetter areas.

Recommendation 6: The analysis of harvesting losses in the current crop and harvesting practices on the productivity of the next crop needs to be continued and expanded. It is a critical area of investigation.

Recommendation 7: The harvest season should be adjusted to aim for the crushing to finish by the end of October with the current practice of setting a starting date to be replaced by setting a finishing date. This recommendation will obviously require an earlier starting date and probably staggered harvesting based on geographical and equity considerations but should not be dismissed out of hand.

Introduction

The more recent long-term (since 1990) average cane and sugar yields for the Herbert region are of the order of 80 and 10.97 t/ha, respectively. 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 7.19 t/ha, respectively. Many theories have been put forward as to the cause of these recent poor yields but no critical analyses of the possible causes have been carried out. The lack of critical analyses encouraged the Herbert Cane Productivity Services Limited (HCPSL) to approach the Sugar Research and Development Corporation for funding to commission a review in order to ascertain the causes of below average yields and to recommend strategies that may overcome poor productivity in future.

The review was carried out between January and April 2013 by Agritrop Consulting with the assistance of staff from the HCPSL. It was funded by the Sugar Research and Development Corporation (SRDC) as part of the Herbert Water Quality Project being carried out by Terrain Natural Resource Management. The Terms of Reference are detailed in Appendix 1.

Background

In approaching any review of productivity there are three basic areas that should always be addressed: genotype, environment and management.

Productivity = genotype x environment x management.

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

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

A grower survey was included as part of the review to gauge what the growers thought were the most important factors controlling productivity. Details of the grower survey format and results are provided in Appendix 2.

HCPSL Organisation of the Herbert Region

The Herbert Region is fortunate in that it has a large amount of data on productivity issues. Unfortunately, much of this data has not been subjected to statistical 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 very time consuming exercise and detracted somewhat from a more in depth coverage of the main issues.

For the purposes of managing the Herbert Region the HCPSL has divided the region into a number of districts and further into sub-districts. The 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 I decided that I needed to consider districts and sub-districts in this review and not simply the region as a whole.

There are six districts - Ingham line, Central Herbert, Abergowrie, Lower Herbert, Stone River, Wet Belt each having a number of sub-districts. The sub-districts are:

- 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, Forrest Home, 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 on what the deficiencies were in the sugarcane cropping system we interviewed 20 growers 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 how they saw fit. Interviews lasted between 30 minutes to 1 hour. Growers were asked to rate from 1 to 5 (with a 1 rating being of least importance) the importance of each particular factor listed in Question 1 for the district as a whole. In Question 2 each was asked about specific issues relevant to their own operation.

A copy of the interview form with averaged results is attached as Appendix 3.

We have summarised the responses in order to try and identify the major issues from a growers perspective. In effect, with the exception of varieties, the growers and technologists generally agreed on 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) 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 operation. 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.

THE IMPACT OF VARIETIES

It is generally perceived by the industry that new varieties will overcome most problems in the production system. This is simply not true although genetic improvement is an important issue in any production system and must be maintained. However, it is most unlikely that varietal deficiencies are likely to be the cause of major variations in yield from season to season in the Herbert. Thus, I have not focussed heavily on varieties in this review as I do not believe they are having a major impact on overall productivity trends. For example, a similar suite of varieties produced overall regional cane yields of 76, 83, 55 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 12.96 t/ha while the equivalent figures in 2005 with a suite of varieties (Q174, Q157, Q158) were 97 and 12.76 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 know this not to be the case as resistance to diseases such as pachymetra, orange rust, and smut have been major achievements of the variety development program. Further, numerous studies have demonstrated productivity improvements associated with varietal improvement over time (Cox et al., 2005). However, as stated in the background to this review, varieties are only one component of the production system - management and environment are the other components. The industry needs to stop seeing varieties as "silver bullets" and recognise that environmental conditions and the management of those varieties have important implications for their productivity.

The Herbert has been unfortunate in that two very good varieties Q124 and Q174 have been taken out of the system by orange rust (Q124 in 2000) and smut (Q174 in 2006). These were both very productive varieties. At present there is general concern within the industry that the replacement varieties for Q174 are not as robust, productive and do not ratoon very well. Growers have advised us that the number of ratoons they can now expect to grow is down to 2 - 3 from 4 - 6. It seems likely that this general observation regarding the new varieties has some merit as the removal of varieties to counteract a disease (orange rust, smut) may have an adverse effect on other positive virtues of the variety that has been removed. However, there has been no objective assessment to confirm or otherwise whether the new varieties are poorer performers or not. Further, there are little data available to carry out such an assessment.

Any objective assessment would require a base line variety that has been grown in substantial areas during the pre (before 2006) and post smut (after 2006) periods. Such a variety does not exist. However, some tentative comparisons can be made between Q174 and Q200 (which in 2011 commanded 38% of the Herbert crop). These two varieties were both grown in reasonable areas between 2004 and 2009. Average cane yield, CCS and sugar yield for the two varieties between 2004 and 2009 are provided in Table 1.

Table1. Average Cane yield , CCS and Sugar yield for varieties Q174 and Q200 grown in the Herbert Area between 2004 and 2009.

Q174	PC	R1	R2	R3	R4	R5	R6
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	15.22	13.68	12.52	11.50	11.51	12.14	13.68

The data in Table 1 indicates little difference in the productivity between Q174 and Q200 with this limited data set. However, it is very limited data and not really suitable for drawing constructive conclusions.

There is a lot of data available in the Herbert on the performance of varieties on different soils in different seasons from which "ad hoc" statements on varietal suitability are made. Unfortunately, there appears to have been no formal analyses of these data. Such analyses is outside the scope of this review but should be done as it may well lead to the identification of the suitability of different varieties for different regions, different soil types and different seasonal conditions.

Recommendation 1: The large amount of variety performance data on different soil types in different seasons held by HCPSL warrants collation and analysis in order to objectively assess whether different varieties are suited to different soil types and regions.

THE IMPACT OF SEASONAL CONDITIONS

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 within the Herbert and the importance of the timing of particular seasonal conditions. To carry out these analyses I used the district and sub-district rainfall data for all the years from 1994 to 2012 (17 years) and carried out regression analyses to relate cane yield, CCS and sugar yield to seasonal rainfall. I did not go further back than 1995 as rainfall data was not available for all the sub-districts for years prior to 1995.

The approach I took was to first convert the available annual rainfall data (January to December) to seasonal rainfall (July to June), as seasonal rainfall data would have more effect on crop growth and yield. Seasonal rainfall data were then related to yield for the latter year *i.e*. the cane yield, CCS and sugar yield for 1995 was regressed against the rainfall data for 1994 - 1995 and so on for progressive seasons.

Overall for the Herbert

All the cane yield, CCS and sugar yield data were regressed against all the seasonal rainfall data between 1995 and 2012. The regression equations are shown in Appendix 3. Basically the analyses showed that seasonal conditions could account for 21% of the variation in cane yield, 4% of the variation in CCS and 27% of the variation in sugar yield. The regression was highly significant ($p<0.001$). Graphs of the relationships are shown below in Figures 1 (Cane yield), 2 (CCS) and 3 (Sugar Yield).

The very important point to note in this analysis, and for all other analyses involving rainfall covered in this report, is that **the higher the rainfall the lower the yield (cane or sugar)**. Whether this effect is due to rainfall *per se* or issues such as cloud cover limiting radiation, crop water logging, and stool damage and compaction associated with trafficking wet fields is problematical. The data are not available to take the analysis further and incorporate these factors. CCS is only marginally affected by seasonal conditions. This may sound strange but in this instance we are talking about season to season variation in CCS not within season variation which we know is dependent on the timing of particular seasonal conditions.

Given the CCS response I have not dealt with CCS any further in this report except for one instance where seasonal rainfall has had an effect on CCS. Likewise I have largely discussed the outcomes in terms of cane yield and not sugar yield as trends for both were similar.

Figure 1- Effect of seasonal rainfall on cane yield across the Herbert Region

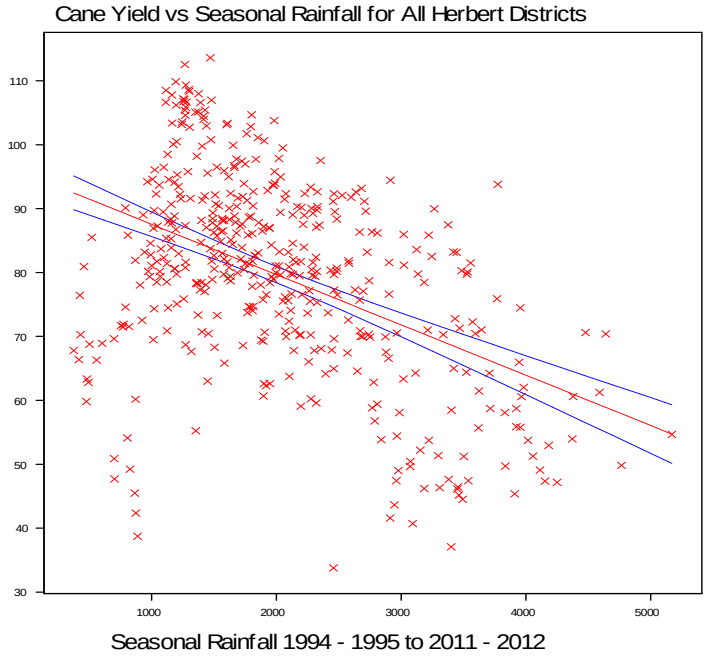


Figure 2 - Effect of seasonal rainfall on CCS across the Herbert Region

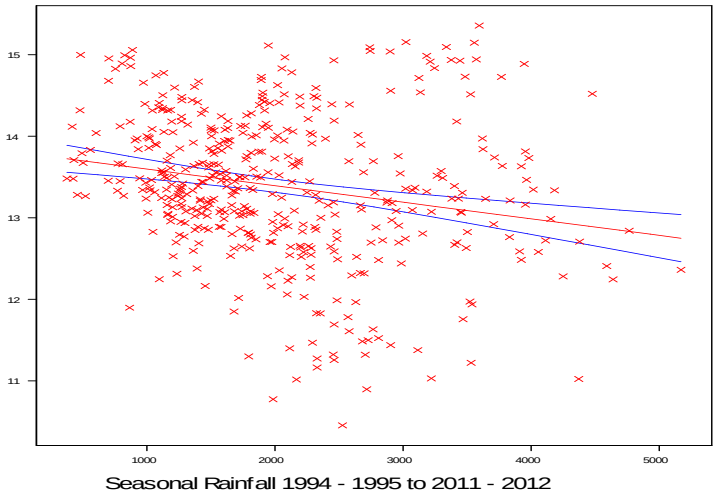
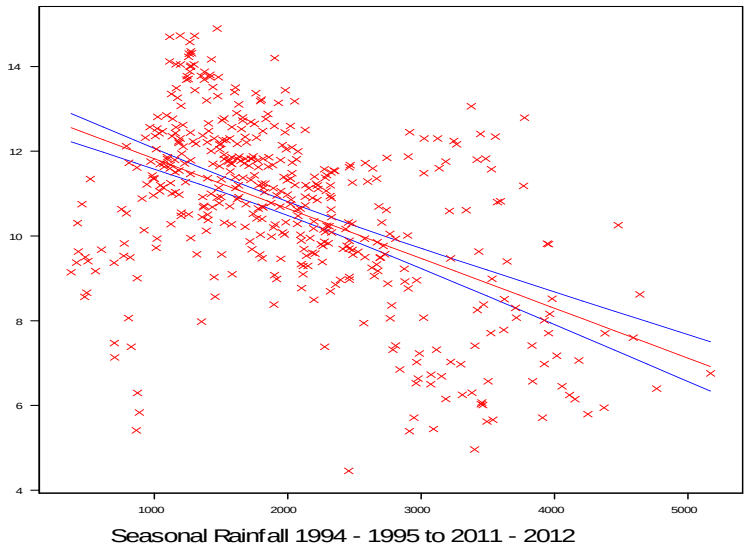


Figure 3 - Effect of seasonal rainfall on sugar yield across the Herbert Region



Analysis for 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 conditions are shown in Table 2 below.

Table 2 - Percent of variation in cane yield, CCS, and sugar yield for each district within the Herbert region accounted for by seasonal rainfall.

District	Cane Yield	CCS	Sugar Yield
Ingham Line	2.9	4.0	3.4
Central Herbert	40.5	0.6	45.8
Lower Herbert	37.5	1.5	42.6
Wet Belt	15.6	12.2	45.8
Abergowrie	21.7	1.3	34.7
Stone River	21.7	2.7	30.4

Clearly there is a difference between the districts. First, the Ingham Line is not as sensitive to seasonal conditions in terms of excess rainfall. In fact, although I have not presented the data, 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 in terms of the production system. For example measures to avoid water logging are not likely to be as important as for other areas.

The other interesting aspect is the relatively low variation in cane yield (%) and high variation in CCS (%) that rainfall accounts for in the wet belt. This is different to all other districts (Table 2). The combination of low % cane yield yet high % CCS accounted for by seasonal conditions brings the sugar yield % accounted for up to 45.8% similar to Central Herbert where CCS is of less importance. The reason for the different response in the Wet Belt is probably associated with wet/overcast conditions during April to June when CCS is being determined (see Table 3 below). I have not taken this issue any further in these analyses.

As there were large differences between the Ingham line and the other districts I ran the analysis 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 virtually unaffected (4 - 4.6%).

Analysis of Groups of Months

Given the very strong overall effect of seasonal conditions on cane and sugar yield I then analysed for different periods in a year. Data were organised on the basis of four different periods *viz.* July - September, October - December, January - March, April - June. The Ingham Line data have been excluded from these analyses given the general non-conformity with the other districts. Data is presented in Table 3

Table 3 - - 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.

District	Cane Yield	CCS	Sugar Yield
July - September	4.4	2.6	6.6
October - December	41.4	2.7	46.5
January - March	23.1	nil	23.8
April - June	nil	19	6.8

From Table 3 it is obvious that rainfall in the October - December and January - March periods is having a major effect on both cane and sugar yield in the following year, particularly that in the October - December period. On the other hand, the April to June rainfall is having no effect on cane yield but a substantial effect on CCS.

Analysis of Individual Months

I then decided that the big effect of October - December rainfall on the crop the following year may be able to be narrowed down further and so I analysed for individual months within that period. Data 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 months of October, November and December. Ingham line data excluded.

District	Cane Yield	CCS	Sugar Yield
October	8.7	1.0	9.8
November	43.4	nil	41.4
December	21.9	10.45	32.0

Clearly it is the rainfall in November which is a major issue followed by that in December (Table 4). Rainfall in October is having only a small effect on the productivity in the following year. I am somewhat at a loss to explain the rainfall/CCS relationship (10.45%) for December.

As indicated above whether rainfall *per se* or other related factors such as cloud cover, poor drainage, and/or stool damage from the traffic of heavy machinery are the major problems is not known. However, enough of the harvest season extends into November to indicate that crop damage through heavy machinery is likely to be a substantial problem. Of the 23 years since 1989, the crushing has extended into November and/or December in 21 and 19 years for Victoria and Macknade mills, respectively.

On the basis of the data presented in Table 4 there is a strong case to indicate that if the season finished by the end of October the very adverse effects of wet Novembers may be largely avoided.

I will return to this issue in the discussion at the end of the review.

Analysis of November rainfall and yield parameters for each sub-district

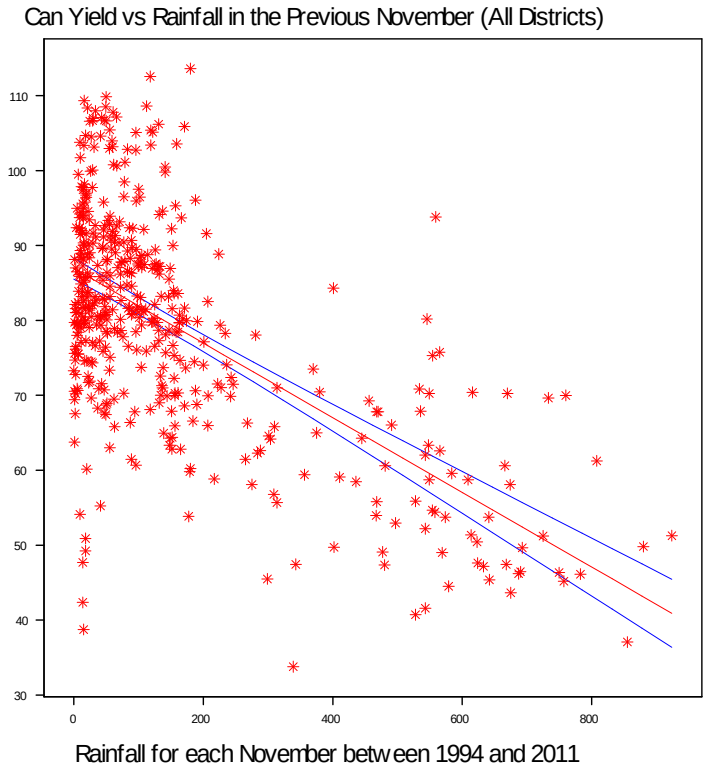
Given the very significant influence that November rainfall has had on cane and sugar yield the following year it was decided to run regression analyses to estimate the effect of November rainfall on cane yield the next year for each of the sub-districts within the Herbert region. These data are shown in Table 5 and Figure 4.

Table 5 - Percent of variation in cane yield and level of significance of the response for each sub-district in the Herbert region as affected by November rainfall.

INGHAM LINE	% Variation Accounted (R^2)	Level of Significance
Coolbie Rollingstone	8.0	nsd
Bambaroo East	15.9	nsd
Bambaroo West	13.8	nsd
Yuruga	23.6	P=0.02
Helens Hill	25.5	P=0.02
CENTRAL HERBERT		
Toobannna	56.9	P<0.001
Blackrock	18.5	nsd
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	nsd

These data reveal that wet Novembers are having a major effect on the potential yield in most areas, such as the Central (with the exception of Blackrock) and Lower Herbert, the Wet Belt, Abergowrie and the Lower and Mid-Stone. The November rainfall is having minimal effects on the Ingham line and Upper Stone.

Figure 4- Effect of November rainfall on cane yield in the following season across the Herbert Region.



Recommendation 2: The importance of seasonal conditions in November as they affect the subsequent crop needs to be fully appreciated and strategies adopted to minimise their impact.

Recommendation 3: The difference in climatic regimes between the Ingham Line area (and Upper Stone) and other areas needs to be recognised and if necessary different production strategies put in place.

Recommendation 4: The most suitable varieties for Ingham Line may well be different to those for other areas and this should be taken into account within the variety evaluation program.

IMPACT OF CROP MANAGEMENT

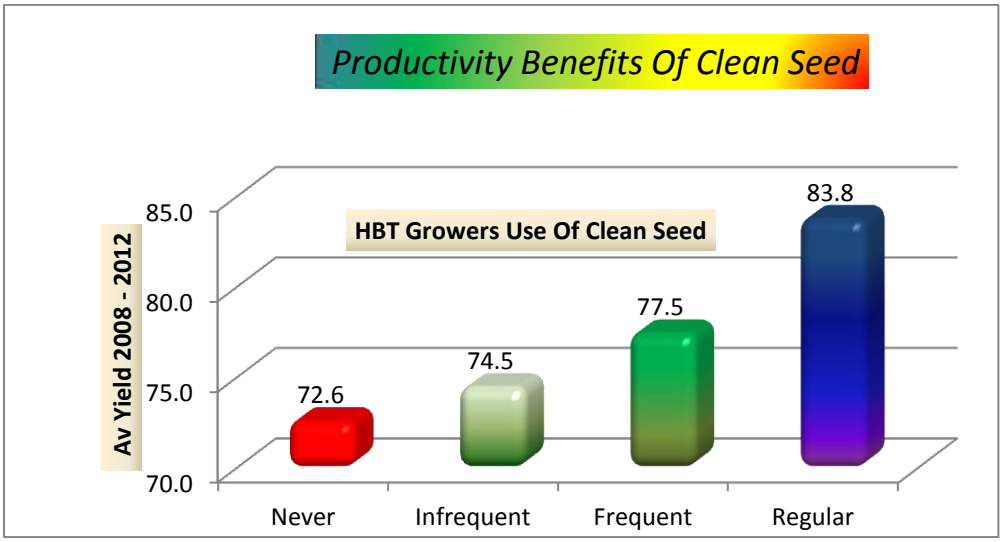
A whole range of factors that fit into the category of crop management can be gauged to be having an impact on crop productivity. Many of these factors can be controlled by the growers themselves and should be adopted. That the growers recognise this is evidenced by the response to Question 3 (Appendix3 - *why do some growers have consistently better productivity than others*). Nearly all growers mentioned attention to detail, timing of operations and good management. Some of the more important issues are addressed below.

Clean Seed

Recent work by the HCPSL has been able to show a relationship between cane yields and the utilisation of clean seed. Figure 1 below shows the average cane yield between 2008 - 2012 for growers who used clean seed cane to varying degrees. It clearly demonstrates the importance of clean

seed. These data become extremely significant when it is realised that only 18% of growers frequently or regularly used clean seed.

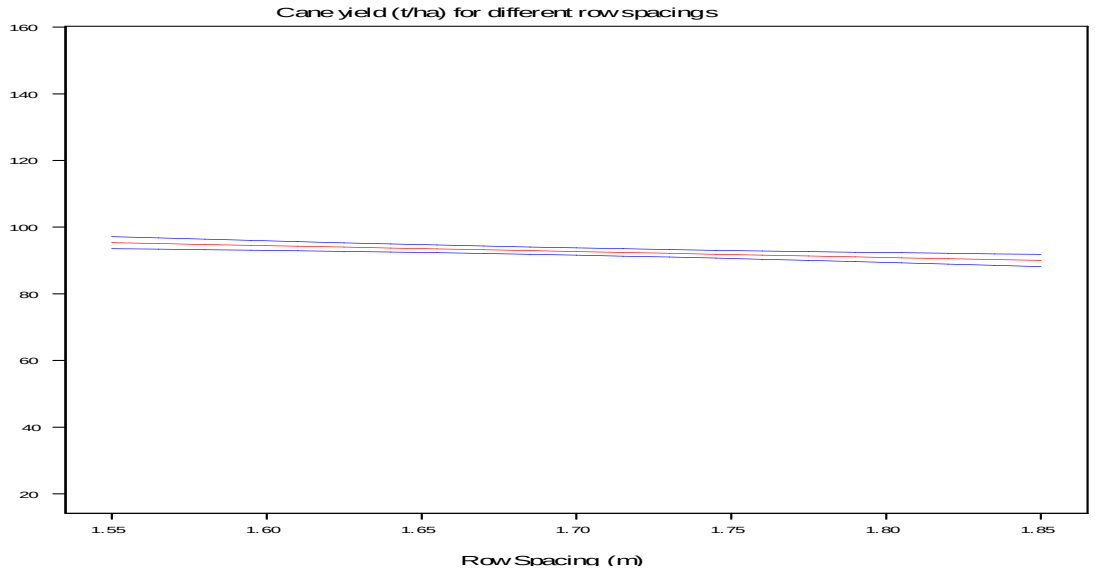
Figure 5- The effect of clean seed on cane yield



Row spacing

HCPSL has collected some data on row spacing and its effect on yield in recent years. Row spacings ranging from 1.55 to 1.85 have been used across the region. Regression analysis showed that there was little difference in yield across the range of row spacings with the overall cane yields ranging from 95 t/ha in 1.55 m rows to 90 t/ha in 1.85 m rows (Figure 5). Whether these data will change once guidance and controlled traffic are adopted more widely is yet to be tested. The real benefits of wider rows are only likely to be realised with controlled traffic and guidance. However it is important to note that even with these data the effect of row spacing is minimal.

Figure 6 - Response in cane yield to different row spacing in commercial crops in the Herbert



Mound vs Flat Planting

The importance of poor drainage and water logging in many parts of the region suggests that these factors may be mitigated by mound planting. Only limited data have been collected to date but there are certainly indications that mound planting can be successful. Data available from 15 growers over four years where mound and conventional planting have been compared shows increases with mounds in 11 cases, decreases in 3 cases and no change in one case.

Recommendation 5: Emphasis should be placed on the development of mound planting for the wetter areas.

Diseases

The focus on smut resistance in recent years certainly appears to be paying off with a change from 83% susceptible varieties in 2005 to 58% resistant varieties in 2012. However it also appears that the resistance/tolerance to a range of other diseases has also been improved during that time. The only negative has been for *Pachymetra chaunorhiza* with the rating of available varieties changing from 45% intermediate to resistant to 80% intermediate. Details are provided in Table 6.

Table 6 - Disease ratings of varieties grown in the Herbert in 2005 and 2012.

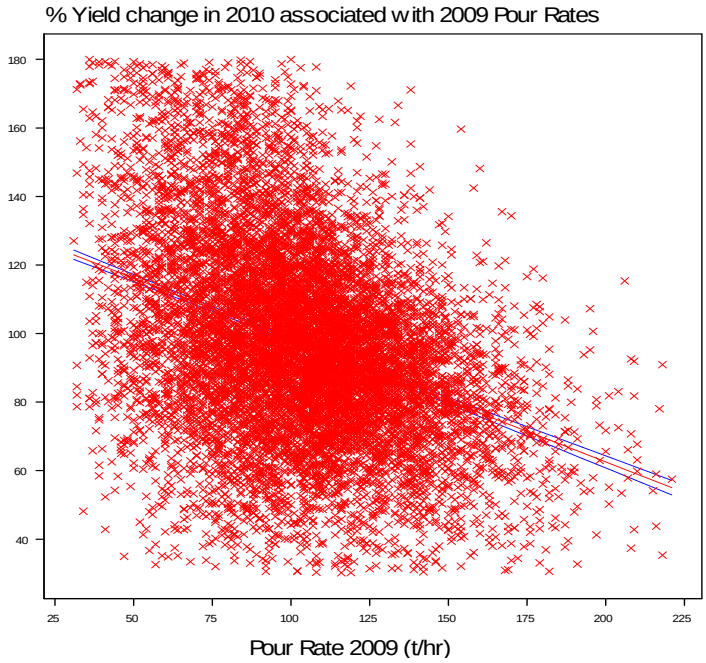
Disease	2005	2012
Smut	83% (susceptible)	58% (resistant)
Pachymetra	45% (intermediate/resistant)	80% (intermediate)
Leaf Scald	75% (resistant)	94% (resistant)
Chlorotic streak	53% (resistant)	62% (resistant)
Ratoon Stunting Disease	26% (resistant)	76% (resistant)

Harvesting

General comments from growers suggested that harvesting is a major issue 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 flexibility 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 poor ratooners and/or whether harvesting damage is contributing to poor ratooning.

We investigated available data on harvester pour rates in 2009 and their effect on the crop in 2010 for in excess of 10,000 blocks (Figure 7). The data can be questioned due to some of the calculations that were required for some of the parameters that went into the analysis (calculations and equations are shown in Appendix 4). 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 more yield was reduced in 2010. We suspect that relating pour rate to yield the following year will become more important in the future as technology allows us to better collect the necessary data. These type of analyses need to be continued. It is necessary to be able to put figures onto what many people believe is a substantial source of cane and sugar loss.

Figure 7 - % change in yield in 2010 associated with pour rate in 2009



Recommendation 6: The analysis of harvesting losses in the current crop and harvesting practices on the productivity of the next crop needs to be continued and expanded. It is a critical area of investigation.

Season Length

The length (too long) of the harvest season is an issue upon which almost every sector of the industry agrees, yet no one seems to be able to agree on how to overcome the problem, given that millers are not likely to increase their milling capacity. 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. This was alluded to above in the section on seasonal conditions and will be expanded further here.

As previously stated a major problem with the length of the harvesting season is that it often extends late into November and December when wet weather can have a major impact (43% of overall yield variation accounted - Table 3 above). In fact, although we don't have the data to prove it, it is unlikely that wet weather in November *per se* is as much the issue as the combination of wet weather, reduced solar radiation, water logging and the traffic of heavy machinery. However, as shown above, enough of the harvest season extends into November to indicate that crop damage through heavy machinery is likely to be a substantial problem. Conversely, the rainfall in October is having only a small effect (9% of yield variation accounted - Table 3 above) which leads one to suggest that the completion of the harvest by the end of October is likely to have a positive effect on productivity. Of course within these 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 4). These differences should be able to utilised to develop a more geographically based staggered harvesting strategy.

The variation in the adverse effects of wet conditions across the Herbert suggests that there is opportunity to stagger harvest to target the drier areas (e.g. Ingham Line and Upper Stone) during the wetter times of the year and the wetter areas (e.g. Wet Belt, Lower Herbert) during the drier periods of the season.

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.

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.

Commencement of the harvest season earlier (late May) and finishing by the end of October is likely to provide a range of other advantages such as time to address drainage issues, laser levelling of blocks, legume break establishment and in the event of severe harvesting damage an opportunity to re-plant.

No doubt there will certainly be situations when harvesting in May will present difficulties because of wet conditions in late wet seasons. However, I do not see this as such a major problems if late ratoons and plough-out crops are harvested first.

Recommendation 7: The harvest season should be adjusted to aim for the crushing to finish by the end of October with the current practice of setting a starting date to be replaced by setting a finishing date.

This recommendation will obviously require an earlier starting date and probably staggered harvesting based on geographical and equity considerations but should not be dismissed out of hand.

DISCUSSION AND IMPLICATIONS

With the exception of the growers concerns about the importance of varieties in the sugar cane production system in the Herbert, there is general agreement between the growers and the 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). I have attempted to address these issues and suggest solutions in the body of this report and in the recommendations. Whether my suggested solutions are acceptable to the sugar industry in the Herbert is up to the industry. I can only report on the analyses that I have carried out.

I don't believe that varieties have had a major impact on overall production trends. However, there is certainly 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 are no doubt many managerial issues that will impact on crop yield. Issues such as nutrition, weed control, pests, the aging grower population *etc.* are all likely to be of some significance. However, my approach has been to tackle what I see as the major over-riding issues of managing for the climate, season length and it's start and finish time, and harvesting loss and damage. To my mind 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 these issues.

Certainly the season length and early start to the harvesting season that I have recommended are likely to have political and equity considerations and will no doubt not sit well with some in the industry. However, I strongly believe that long-term productivity will not improve unless these issues are

addressed. It was my role to objectively review the reasons for poor productivity in the Herbert in recent years. I believe I have done exactly that and identified the major issues that need to be addressed. It is the industry's role to address these issues. 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:

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The views expressed in this document are the personal views of the author.

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APPENDIX 1

External consultancy to the Herbert Cane Industry by Dr. A. Garside to

Review the Herbert's Long Term Productivity Drivers and the impact of Government Regulations.

Proponent group: Herbert Cane Productivity Services Limited

Project manager: Lawrence Di Bella (HCPSL- Manager)

Cross linkage project: The Herbert Water Quality Project

Scope of work:

The consultancy will review all aspects associated with the long term productivity and sustainability of the Herbert cane industry. The consultancy will undertake the following activities:

Part 1 of consultancy- Review

1. Review historical data influencing productivity trends overtime, with linkages created to key productivity issues (if present).
2. Review existing farming, milling and harvesting practices that my influence productivity.
3. Undertake an assessment of potential impacts government regulations may have on the industry.
4. Review Herbert and other available data concerning environment impact from sugarcane product.
5. Review other data that may influence productivity and sustainability of the Herbert industry, both internal and external issues.

Part 2 of consultancy- Opportunities for industry to ensure its long term sustainability

1. Opportunities that have the potential to ensure the long term sustainability.
2. Possible methods to mitigate any negative impacts from government regulation.
3. Propose methods that may address any potential environmental impacts from sugarcane production
4. Develop a matrix for industry to work upon to increase industry productivity.

Reporting-

The consultancy will:

- Produce a report for industry with consultancy findings.
- Undertake an oral presentation to the industry of findings.
- A project final report will be submitted to SRDC highlighting the outcomes of the consultancy.

Milestone reporting:

Milestone 1. Signing of project variation- $10,000 (June 2012)

Milestone 2. Final report- $5,000

APPENDIX 2

In order to obtain the growers perspective on what the deficiencies were in the sugarcane cropping system we interviewed 20 growers 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 how they saw fit. Interviews lasted between 30 minutes to 1 hour. A copy of the interview form with averaged results is attached as Appendix 2.

Growers were asked to rate from 1 to 5 (with a 1 rating being of least importance) the importance of each particular factor listed in Question 1 for the district as a whole. In Question 2 each was asked about specific issues relevant to their own operation.

The scores for each factor for each grower in Question 1 were collated and an overall percentage of importance was calculated. In the table below the ratings of 4 and 5 have been combined as ratings at that those levels of a factor can designate it as very important.

Question 1- Rate on a 1 - 5 scale (1 being low and 5 being high) how important are the following in relation to significantly impacting on productivity across the district.

Importance of different factors as nominated by growers in influencing productivity in the Herbert. The data is presented as a combination of 4 and 5 ratings and are based on percentage of response.

Weather/Seasonal Conditions	95%
Varieties	100%
Time of Harvest	90%
Drainage	100%
Drought	70%
Crop Nutrition	95%
Nutrient Losses	55%
Impact of Harvesting	80%
Harvester Group Size	85%
Harvester operation and setting	85%
Season length	90% (season too long)
Compaction	80%
Pests	60%
Diseases	85%
Herbicides	30% (adequate available)
Weeds	90% (herbicides not being used properly)
Farming system	50% (indicates current system acceptable)
Poor soil health	90%
Lack of machinery when it is required	60% (Surprise -expected to be important)
Finances	95%

The big issues appear to be **water management** (seasonal conditions, drainage, water logging), **various aspects of harvesting**, (group size, crop damage from harvesting, harvester setting**) varieties**, **season length** and **crop nutrition.**

Question 2 - What do you believe are the three main issues that drive productivity on your farm.

Ranked on the basis of the number of replies received.

1. Current Varieties - not **robust, poor ratooning, poor root systems, poor adaptation to marginal soils and clay soils.**
2. Weather- too much rain
3. Poor drainage - flat clay soil areas.
4. Harvesting - group size, harvester speed, cane loss, base cutter damage, poor ratooning.
5. Season length - too long, should be finished by the end of October.
6. Timing of activities especially planting and weed control.
7. Financial issues - lack of funds, increasing production costs.
8. Access to machinery.
9. Grubs- control expensive and short term.
10. Nutrition - trace elements, acidification.

Overall the big issues seem to be similar to those identified in Question 1 - **water management, various aspects of harvesting** and **varieties.**

Question 3 - why do some growers have consistently better productivity than others

1. Timing, attention to detail, good management. Can all impact on drainage, plant establishment, replacing older ratoons.
2. Hygiene
3. Access to available finance to undertake fertilising and weed control.
4. Being able to manage harvest
5. Better soils
6. Older growers not as innovative.
7. Access to equipment.

Overall the big issue here is **good management, timing of operations and hygiene**

Question 4 - what activity/ies do you undertake on your farm to manage seasonal variation in productivity.

1. Drainage
2. Be flexible, especially with harvesting
3. Harvest geographically/schedule
4. Own the harvester
5. Maintain hygiene
6. Cut plough-out last
7. Plant as soon as possible.
8. Fertilise at appropriate time.
9. Variety selection
10. Utilise irrigation

As above the big issues once again appear to be associated with **good management (drainage, harvest flexibility, geographic harvesting, early planting etc.)**

Question 5 - Are there any activities that additional resources or funding could assist the industry to better drive productivity.

1. More better varieties (robustness)
2. Better access to approved seed cane.
3. Harvester research to minimise cane and sugar losses.
4. Access to mill mud (no equity at present).
5. Value adding to crop
6. soil research (nutrition, sodicity).

Varieties and harvesting again to the fore.

Question 6 - Do you think Reef Regulations (RR) have impacted on the ways you manage and farm

1. 25% indicated no impact.
2. 55% raised the concerns about the regulations regarding Diuron use.
3. 20% indicated that additional paperwork was a nuisance.
4. 25% indicated that RR had made them review their nutrient management program and believed that was a positive.

Overall RR doesn't seem to be having a major negative impact

Question 7 - Do you believe the following changes could influence productivity on your farm.

1. Mound planting - 60% yes, 15% no, 25% maybe.
2. Season length - 95% yes, 5% maybe (Most growers thought season length was too long and indicate they would be happy with staggered start and staggered finishes)
3. Matching row and wheel spacing - 80% yes, 20% no.
4. Improved varieties - 100% yes.
5. Better use of mil mud and ash - 100% yes. (All growers believed they would be beneficial but cost prohibitive. Some suggested should be allocated on a pro-rata basis in line with farm size).
6. Use of break crops - 50% yes, 20% no, 30% maybe. (Most growers saw benefits but worried about prolonged water logging and flooding.

Question 8 - Open for Comments

Variety related issues

- More money required for variety development
- New varieties since smut are not performing - low vigour, not robust
- Heavy flowering
- Poor ratooning
- Low yields
- Lack of appropriate varieties for marginal soils.
- Poor germination (Q208)
- Lack of crop cover (Q208)
- Shallow root systems.

Harvesting issues

- Speed of operation (too fast)
- Cane loss from extractors
- Damage to ratoons
- Poor attitude of harvesting sector
- Cost

- Equity - most growers did not believe that equity was working
- Big groups - no time to stop if field conditions are wet, lack of attention to detail, fatigue and WPHS concern.

Mill related issues

- Poor mill reliability
- Lack of mill support to manage harvest
- Shortage of bins due to accidents
- Wait too long for bins
- ETA of bins by mill will assist harvesting sector.
- Declining morale due to inefficiencies in bin deliveries.

Season length

- Season is too long
- After October the risk of ratoon failure or poor performance is significant.
- The majority of growers believed they would have no issues with a staggered start and staggered finish.
- Most growers indicated that the mill should start earlier than it currently does. However, some growers requested a lead -in phase for implementation and under writing for CCS losses.

Better access to approved seed.

Planting delays due to lack of contractors.

Ageing Industry

- Low morale with older growers
- Low productivity with older growers
- Reliance on contractors to do work

Financial issues;

Soil health and nutrition.

APPENDIX 3

REGRESSION EQUATIONS AND GRAPHS

Overall relationship between seasonal rainfall and yield parameters:

Cane yield vs seasonal rainfall	95.42 – 0.007872 *b* ($p<0.001$, $R^2 = 0.21$)	21%
CCS vs seasonal rainfall	13.80 – 0.0002031 *b* ($p<0.001$, $R^2 = 0.04$)	4%
Sugar yield vs seasonal rainfall	12.999 0 0.0011761 *b* ($p<0.001$, $R^2 = 0.27$)	27%

Individual Districts:

Ingham Line:

Cane Yield:	81.65 – 0.00339 *b* (nsd, $R^2 = 0.029$)	2.9%
CCS:	13.92 – 0.0000451 *b* (nsd, $R^2 = 0.04$)	4.0%
Sugar Yield:	13.92 – 0.0000451 *b* (nsd, $R^2 = 0.034$)	3.4%

Central Herbert:

Cane Yield:	109.92 – 0.1219 *b* ($p<0.001$, $R^2 = 0.405$)	40.5%
CCS:	13.679 – 0.000124 *b* (nsd, $R^2 = 0.006$)	0.6%
Sugar Yield:	13.92 – 0.0000451 *b* ($p<0.001$, $R^2 = 0.458$)	45.8%

Wet Belt:

Cane Yield:	87.95 – 0.00596 *b* ($p<0.001$, $R^2 = 0.156$)	15.6%
CCS:	13.849 – 0.000333 *b* ($p=0.002$, $R^2 = 0.122$)	12.2%
Sugar Yield:	12.03 – 0.001005 *b* ($p<0.001$, $R^2 = 0.458$)	45.8%

Stone River:

Cane Yield:	89.44 – 0.00708 *b* ($p<0.001$, $R^2 = 0.217$)	21.7%
CCS:	14.062 – 0.000218 *b* (nsd, $R^2 = 0.027$)	2.7%
Sugar Yield:	12.47 – 0.001115 *b* ($p<0.001$, $R^2 = 0.304$)	30.4%

Abergowrie:

Cane Yield:	96.92 – 0.00793 *b* ($p<0.001$, $R^2 = 0.217$)	21.7%
CCS:	13.435 – 0.000241 *b* (nsd, $R^2 = 0.013$)	1.3%
Sugar Yield:	12.89 – 0.001205 *b* ($p<0.001$, $R^2 = 0.347$)	34.7%

Lower Herbert:

Cane Yield:	106.00 – 0.01112 *b* ($p<0.001$, $R^2 = 0.375$)	37.5%
CCS:	13.517 – 0.0001267 *b* (nsd, $R^2 = 0.015$)	1.5%
Sugar Yield:	14.188 – 0.001551 *b* ($p<0.001$, $R^2 = 0.426$)	42.6%

Ingham Line data responding differently to the other districts – rainfall negligible in accounting for variations in cane and sugar yield.

For all other districts seasonal rainfall accounts for 30 – 45% of variation in sugar yield. Yields lower in higher rainfall seasons.

No relationship between seasonal rainfall and CCS except for Wet Belt.

Overall relationship between seasonal rainfall and yield parameters WO Ingham Line Data:

Cane yield	99.35 – 0.009135 *b* ($p<0.001$, $R^2 = 0.286$)	28.6% (vs 21%)
CCS	13.718 – 0.0002122 *b* ($p<0.001$, $R^2 = 0.04$)	4.6%
Sugar yield	13.467 - 0.0013528 *b* ($p<0.001$, $R^2 = 0.35$)	35% (vs 27%)

OCTOBER, NOVEMBER, DECEMBER RAINFALL

Relationship between Oct, Nov, Dec Rainfall and Yield Parameters (Ingham Line Included).

Cane yield	90.665 – 0.02684 *b* ($p<0.001$, $R^2 = 0.34$)	34%
CCS	13.5654 – 0.000405 *b* ($p<0.001$, $R^2 = 0.04$)	2.2%
Sugar yield	12.371 - 0.004161 *b* ($p<0.001$, $R^2 = 0.465$)	39.7%

Relationship between Oct, Nov, Dec Rainfall and Yield Parameters (Ingham Line Not Included).

Cane yield	92.415 – 0.02938 *b* ($p<0.001$, $R^2 = 0.414$)	41.4%
CCS	13.718 – 0.0002122 *b* ($p<0.001$, $R^2 = 0.04$)	2.7%
Sugar yield	12.371 - 0.004161 *b* ($p<0.001$, $R^2 = 0.465$)	46.5%

JANUARY, FEBRUARY, MARCH RAINFALL

Relationship between Jan, Feb, March Rainfall and Yield Parameters (Ingham Line Included).

Cane Yield:	93.86 – 0.01130 *b* ($p<0.001$, $R^2 = 0.172$)	17.2%
CCS	13.39 – 0.0000074 *b* ($p<0.001$, R^2 = nil)	nil
Sugar yield	12.483 - 0.001471 *b* ($p<0.001$, $R^2 = 0.167$)	16.7%

Relationship between Jan, Feb, March Rainfall and Yield Parameters (Ingham Line Not Included).

Cane Yield:	98.15 – 0.01416 *b* ($p<0.001$, $R^2 = 0.23$)	23.1%
CCS	13.405 – 0.0001078 *b* ($p<0.001$, R^2 = nil)	nil
Sugar yield	13.064 - 0.001922 *b* ($p<0.001$, $R^2 = 0.23$)	23.8%

APRIL, MAY, JUNE

Relationship between April, May, June Rainfall and Yield Parameters (WO Ingham Line).

Cane Yield:	84.1 – 0.01013 *b* ($p<0.03$, $R^2 = 0.0$)	nil
CCS	14.02 – 0.002252 *b* ($p<0.001$, $R^2 = 0.019$)	19%
Sugar yield	11.751 - 0.003154 *b* ($p<0.001$, $R^2 = 0.068$)	6.8%

DECEMBER ONLY (WO Ingham Line)

Cane yield:	89.46 - 0.04633 b ($p<0.001$, R^2 =0.219)	21.9%
CCS	13.6459 - 0.001809 b ($p<0.001$, R^2 =0.1045)	10.45%

Sugar yield	12.132 - 0.007470 b ($p<0.001$, $R^2=0.32$)	32.00%

NOVEMBER ONLY (WO Ingham Line)

Cane yield:	88.169 - 0.05339 b ($p<0.001$, $R^2=0.434$)	43.4%
CCS	13.2870 - 0.000008 b 9 (nsd, nil)	nil
Sugar yield	11.677 - 0.06947 *b* ($p<0.001$, $R^2 = 0.414$)	41.4%

OCTOBER ONLY (WO Ingham Line)

Cane yield:	85.2 - 0.0740 b ($p<0.001$, $R^2=0.087$)	8.7%
CCS	13.3953 - 0.001625 b (nsd, $R^2=0.001$)	1%
Sugar yield	11.352 - 0.01053 *b* ($p<0.001$, $R^2 = 0.098$)	9.8%

APPENDIX 4

POUR RATE CALCULATION

GPS can tell speed of harvester in the block.

Block yield is recorded.

Common row width in Herbert is 1.65 m.

For every km travelled 1650 sq m or 0.1650 ha is covered

If speed 10.38 km/hr in 1 hr we cover 17,127 or 1.7127 ha

If yield is 60 t/ha then pour rate is 60 x 1.7127 = 103 t/hr

Regression Equation:

Cane Yield = 134.057 - 0.35763 x pour rate (R^2 = 0.14, $p<0.001$)