Horticulture Australia Limited

Final Report

Banana harvest forecasting project

Project FR01030 (March 2002 to August 2004)

S.J. Lindsay
Department of Primary Industries and Fisheries, Queensland

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HA Ltd Project Number	FR 01030 Banana crop forecasting project
Project Leader	Stewart Lindsay, Department of Primary Industries and Fisheries, Queensland
Contact Details	Centre for Wet Tropics Agriculture, PO Box 20, South Johnstone. Qld. 4859 Ph (07) 40641130 Fax (07) 40642249 E-mail: stewart.lindsay@dpi.qld.gov.au
Key Project Personnel	Mr S. Mulo (DPI&F), Mr P. Leahy (producer) Mr J. Daniells (DPI&F), Mr Z. Murad (formerly DPI&F), Mr R. Parker (formerly DPI&F)
Purpose	To develop a system to allow the prediction of fruit production levels throughout the year three months in advance, and that could provide the industry with overall production figures three months in advance.
Funding	This project was funded the Queensland Department of Primary Industries and Fisheries, Growcom Ltd and Horticulture Australia Ltd.

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Media Summary

This project was initiated to develop and implement a banana crop forecasting system for the north Queensland banana industry, the major Australian production region, to produce short-term rolling weekly forecasts of fruit volumes for the industry and supply chain members. The forecasting system developed by the project uses computer software and the internet to calculate individual plantation and industry-wide forecasts based on weekly bunch emergence figures.

An effective crop forecasting system produces information that allows better planning throughout the supply chain, such as:

- Opportunity for producers to improve budgeting and management of material and labour inputs.
- Opportunity for improved logistics management for the transport and packaging sectors.
- Opportunity for better timing of promotion and advertising by the industry, wholesalers and retailers.

The key outcomes for the project are:

- The client application software (CAS) has been developed and finalised, and is available to producers.
- An internet database for collating individual farm forecasts and producing an industry forecast is completed, and operating from an established domain name – www.bcfs.net.au
- Producers collectively representing 3000 hectares of production have the CAS currently installed on their computers.

The project has developed a crop forecasting system that is functional and effective, and should be regarded as a starting point from which a better system can be built. Issues that have been identified as areas for improvement are:

- The need to address the concerns of producers about the potential for unscrupulous use of the forecasting data by the wholesaling and retailing sectors.
- The need to improve the accuracy of forecasts in the current system, including changing from weekly to 4 weekly forecasts.
- The provision of resources for system improvement, user support and extension to increase adoption and implementation by producers.

Introduction

Forecasting future production volumes is not a new concept or practice in commercial banana practice. Many experienced producers already forecast future production for their own management needs. Major international banana production companies have used detailed, formal crop forecasting systems for 30 years to better organise freight logistics with charter shipping.

What is the Banana Crop Forecasting Project?
This project aimed to develop and implement a banana crop forecasting system for the major Australian production region to provide short-term rolling forecasts of fruit production for the industry and supply chain members. The crop forecasting system is based on computer software for individual banana producers and a purpose-built internet database to produce an industry-wide forecast.

How does the Banana Crop Forecasting System (BCFS) work?
Individual banana producers enter specific farm data based around weekly bunch emergence figures. The BCFS software loaded onto their personal computers then produces harvest forecasts for their farm.

The forecasts are made using historical data about the average time it takes from bunch emergence to bunch harvest for the different weeks of the year (BE-BH interval), and the typical spread of harvest for the bunches emerging in a single week. By entering farm data such as weekly bell injection figures, predicted box to bunch pack-out ratios and the percentage of field losses (bells injected that never make it to the packing shed), the BCFS software makes a forecast of future harvest volumes.

The BCFS also has an industry-wide forecasting capacity using a purpose-built internet site. The BCFS software has an upload function that gives individual producers the option to send their farm forecasts to a database at the internet site where the forecasts for all the contributing producers are added together to produce an industry crop forecast.

Under the terms of the project agreement, the BCFS software is available to any Queensland banana producer. For producers, access to the BCFS internet site is only available for those using the BCFS software. Access is organised by contacting the program administrator, and setting up a user name and password for the site.

Technology transfer strategy and methodology/activities

1. Developing a system to provide a reasonable banana production forecast

Banana crop forecasting systems

The Australian and Queensland banana industry organisations identified the requirements of the banana crop forecasting system as:

- To provide short-term rolling forecasts (12 – 20 weeks) of fruit production for the industry
- To provide short-term rolling forecasts (12 – 20 weeks) of fruit production for individual producers

Short-term production forecasting for banana plantations is routinely practised by the large international banana production companies. Their system is mainly based on historical records of the period between bunch covering and harvest for each week of bunch covering records. Regional or company forecasts are achieved by collating the individual plantation forecasts.

Other systems used are based on:

- A measurement of temperature and time, related to fruit development, called heat sums or heat units.
- Regular measurements of fruit diameter from a standardised plant development stage, extrapolating growth rates to indicate the time required to achieve the nominated diameter for harvest.

The crop forecasting system proposal and project methodology

Initially the project examined the 3 main options to see which of the systems best met the industry's requirements. A computerised system was envisaged as the best way to provide a system to growers, with client application software on the computers of individual producers to collect data and display individual forecasts. This software would also then provide the producer with the option of uploading the individual forecasts to a purpose-built internet database to collate and produce an overall industry forecast.

The proposed project methodology was:

- An awareness program to explain the proposed crop forecasting system and its uses.
- To collect useful farm data and records from collaborating producers for various districts for the 2 previous seasons.
- To develop the client application software, involving collaborating producers to check its functionality (how user-friendly it is) and logic (how it makes forecasts)
- After sufficient trialling and refinement, to provide the software and training for collaborating producers
- To raise awareness of the system in the broader industry through presentations at the 2003 National Banana Industry Congress and to

producer groups and associations, and via articles in industry publications.

- To develop a commercialisation agreement whereby the industry would assume management of software distribution and training, and potential commercialisation of industry forecast data

Developing the crop forecasting system software

To start the forecasting system as quickly as possible we chose to use the historical BE-BH model as our starting point. This system is best suited to computerisation, and its development is facilitated by the industry-wide practice of bell-injection. Bell-injection is a bunch pest control practice that visits newly emerging banana bunches on a weekly interval. Records of the number of new bunches emerging each week provide valuable data from which to forecast production.

However the BE-BH model has some major requirements for accurate forecasting. Production companies in the equatorial tropics have successful forecasting systems using this model because they have very accurate and extensive records of historical BE-BH intervals, and because they have more uniform climatic conditions. The high level of inherent variability in BE-BH intervals can be exacerbated significantly by climatic influences and management practices (Robinson and Human 1988). Production regions in the equatorial tropics run this model successfully because less seasonal variation leaves only natural variation as the main source of inaccuracy in forecasting.

To develop an effective crop forecasting system for the north Queensland production region, accurate records of BE-BH intervals for the previous 2 seasons were required. However, this data was not available from the majority of collaborators as they had not previously kept records relating their harvest times with their bell-injection records. Greater seasonal variability in north Queensland compared with the equatorial tropics also results in increased variability in BE-BH intervals for different seasons. Investigations into the use of temperature forecasting to help account for the seasonal variations were undertaken, and the results are described in a later section.

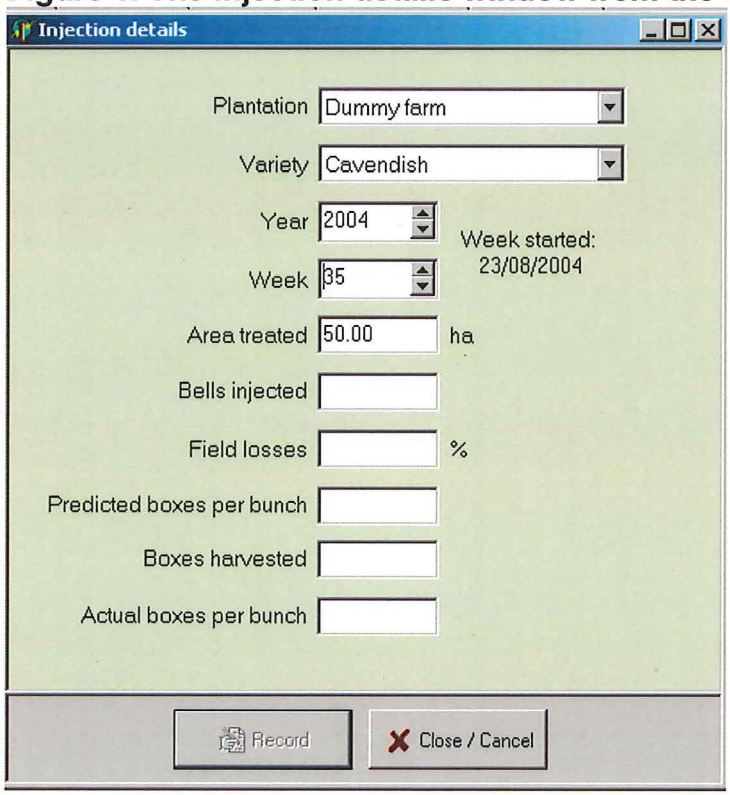
Development of the client application software (CAS) began in December 2002, and by April 2003 the software was sufficiently developed to begin trialling with key collaborating producers. The CAS uses "look-up" tables of BE-BH intervals for 13 sub-districts identified for the wet tropical coast and Atherton Tablelands. The "look-up" tables try to reflect the variation in BE-BH intervals for bunches emerging in the different weeks of the year, as well as the spread of harvest from each particular week of bunch emergence. For example, bunches emerging in the first week of the year (week 1) in the "Innisfail – south" district are assumed to start harvesting in week 12, with most bunches harvested in week 13, and the final harvest in week 14. The spread of harvest varies between 3 and 4 weeks depending on the time of year the fruit is expected to harvest.

To begin using the CAS a producer initially enters plantation details that identify their district (this tells the software which look-up table to use), variety and

production area. He/she then enters the following farm data on a weekly basis in the main data input window (Figure 1):

- Bells injected – the number of bells injected in the week indicated.
- Field losses – this figure represents the percentage of bells injected that don't make it to packing stage.
- Predicted boxes per bunch – the expected ratio of cartons packed from each bunch harvested for the bells injected in the week indicated.
- Current boxes per bunch – the actual ratio of cartons packed to bunches harvested in the week indicated.
- Boxes harvested – the number of boxes packed for the week indicated. This figure is used to compare the actual harvest figures with the predicted figures for the week indicated.

Figure 1. The injection details window from the CAS



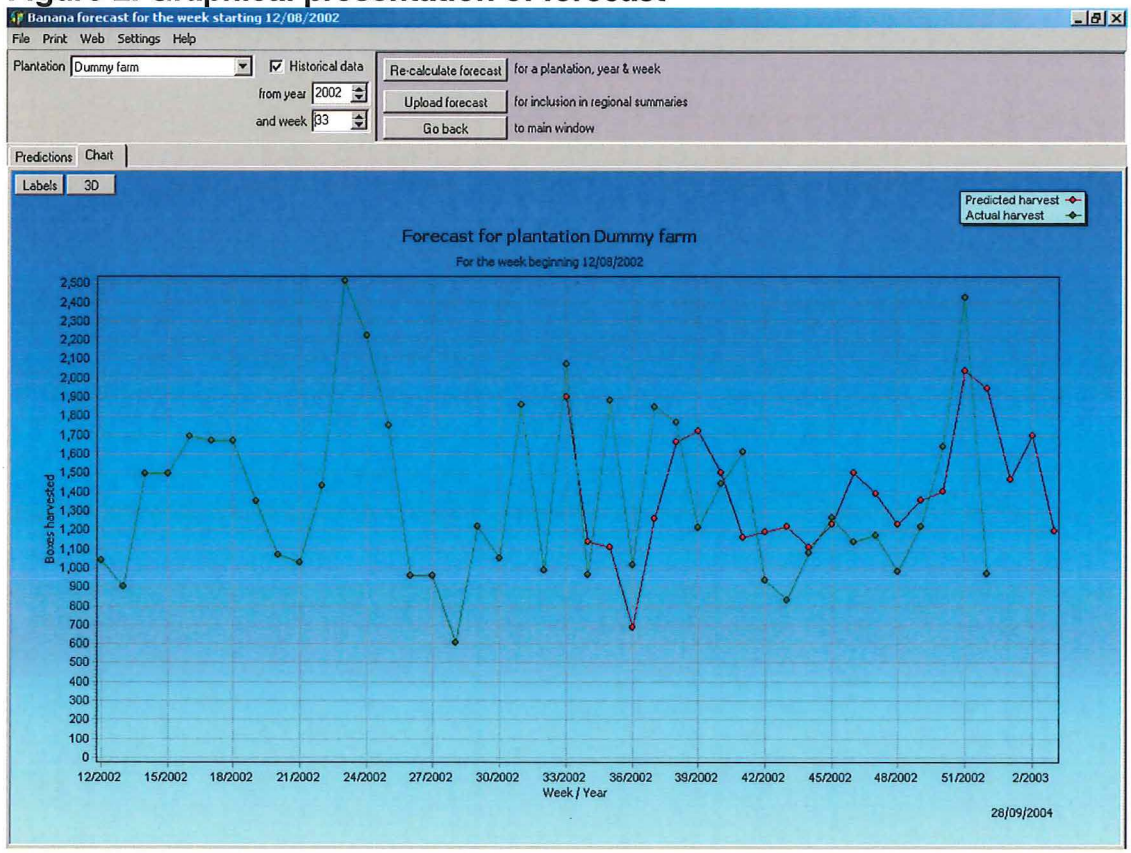
The software uses this data to calculate the forecast by:

(Bell injection from a week – field losses) X predicted box/bunch ratio

= the number of cartons expected

The forecast production is then allocated to future weeks of the year based on the "look-up" tables. The CAS presents the forecast in both table and graph formats, with the graph including both the forecast and actual harvest figures (Figure 2).

Figure 2. Graphical presentation of forecast



After the resignation of the initial project leader in April 2003, the key collaborators were revisited by the new project leader to confirm their continued participation in the project. In June 2003 the latest draft of the CAS was installed with each of the 13 key collaborators to trial and provide feedback on functionality and logic. By August 2003 there was sufficient feedback to suggest improvements were needed in both functionality and logic. Comments on the forecast accuracy indicated that changes were required in most of the "look-up" tables. Through September – October 2003 better BE-BH interval data was sought from collaborators to try and improve the forecast accuracy. The subsequent changes to the BE-BH interval and spread data improved the forecast accuracy, although major week-to-week variations (>20%) still occur.

The client application software was finalised in July 2004 with additional functionality changes and is now available to all banana producers.

The other major component to the BCFS is the industry-wide forecasting function using the internet. To achieve an indicative industry-wide forecast for north Queensland, the BCFS collates the uploaded forecasts of individual producers using an internet-based database.

Participation in the industry forecast is entirely voluntary, and a high level of participation, in terms of production area, is required for the forecast to be representative of the industry. Project collaborators and industry

representatives have identified participation by 30% of the production area as the minimum required for confidence.

The internet database software was developed under contract by Lance Conry of Rhino Software Pty Ltd. Several changes were identified by the key collaborators, in particular the addition of a printer-friendly option for the forecast graphs, and the addition of a regional forecast to the overall industry forecast graph. The internet database became functional in early November 2003 with the registered domain name of www.bcfs.net.au

Hosting of the industry forecast database was purchased for 12 months from 1 August 2003 from WebCentral Pty Ltd, a commercial internet provider.

Access to the industry forecast is managed through the allocation of user accounts protected by password. The project leader is currently responsible for allocating user accounts and other general site administration.

Data management and confidentiality

Ensuring the confidentiality of data of individual producers has been a key requirement of the project. Under the project guidelines, the data entered by individual producers remains their property, and is provided for the industry-wide forecast on the understanding that it may not be distributed or transmitted in any form to third parties. These conditions form part of an automatic disclaimer function that contributing producers must complete before uploading their forecast data. At the industry forecasting website, participating producers can only access their own data, and a regional and industry forecast.

Managing intellectual property and commercialisation

Distributing and supporting the software

The project developed a compiled software program (the CAS) for use on the computers of individual producers. This software is based in part on previous intellectual property (IP) in software development owned by DPI&F, and the ownership of the source code of the CAS is retained by DPI&F. Under the arrangements of the project a commercialisation agreement would be developed with Growcom Ltd to grant an exclusive and non-transferable licence to distribute the CAS to banana producers in Queensland, and to cover the management of continuing assistance to users.

Potential for commercialisation

The crop forecasting system generates information that is potentially valuable to members of the banana supply chain. The industry-wide forecast potentially holds some value to supply chain members. Forward knowledge of future supply volumes can assist logistics, promotions and budgeting provided the forecasts are sufficiently accurate.

Under the terms of the project Growcom Ltd would be granted non-exclusive and non-transferable rights to manage the stored and compiled data in the central database, and to manage and commercialise the industry forecasts generated by the Internet database

Commercialisation agreement
Since March 2004 the project parties have reviewed the intent of the commercialisation proposal. In August 2004 an agreement was arrived at for DPI&F to continue in the management and distribution of the CAS, and for Growcom Ltd, HAL and DPI&F to review the participation and potential for commercialisation for a 12 month period from September 2004.

2. Investigating the use of temperature monitoring to manage seasonal variations in banana production forecasting

While crop forecasting using historical BE-BH data is routinely used in major equatorial production regions, it has the potential for major variation between the forecast and actual harvests because of climatic variations. Forecast accuracy with this method is more consistent in the tropical production regions because temperatures are consistently in the optimum range for growth and development throughout the year, resulting in short and consistent BE-BH periods through the year (Robinson and Human 1989)

However, production areas with significant seasonal climatic variation face more difficulty in accurate forecasting using historical data. While the main Australian production region in north Queensland has less temperature variation than subtropical regions, it has greater seasonal variation than the tropical production regions of central America (Table 1.) The greater variation in the Australian production region is reflected in the greater seasonal BE-BH period variation. Daniells (1984) reports typical BE-BH of 100 – 150 days through the year in north Queensland, compared with 98 – 117 days for Honduras reported by Stover and Simmonds (1987).

Table 1. Comparison of climatic data in north Queensland and Costa Rican* banana production regions

		J	F	M	A	M	J	J	A	S	O	N	D
Guapiles, Costa Rica (10.13 N)	**Mean max (^{0}C)**	28	29	29	30	30	30	29	30	30	30	29	28
	Mean min (^{0}C)	19	19	19	20	21	21	21	21	21	20	20	20
	mm	289	215	196	260	403	439	499	418	349	440	511	512
Innisfail, Australia (17.53 S)	**Meanmax (^{0}C)**	31	31	30	28	26	25	24	25	27	28	30	31
	Mean min (^{0}C)	23	23	22	20	18	16	15	15	17	19	21	22
	mm	508	598	655	466	302	190	133	119	87	83	157	261

* Data from Stover and Simmonds (1987)

Investigations of the relationship between temperature and the BE-BH period was first reported by Hord and Spell (1962), where they found significant relationships between the length of the BE-BH and the mean daily temperature for the period. Ganry (1978) explored the relationship further in the French West Indies, investigating the concept of heat units, the effect of temperature over time on fruit development, as a way of indicating fruit maturity. His work was based on a heat unit model of the sum of daily mean temperatures above

a threshold of 14^{0}C, and identified 900 heat units as the accumulated heat sum for optimum fruit maturity for harvest.

The use of heat sums to determine harvest maturity has the potential to provide a crop forecasting method based on real-time monitoring of temperatures. The project team investigated this method as a way of accounting for the seasonal variations that contribute to the inaccuracies inherent in the current crop forecasting model.

To test for a relationship between heat sums and BE-BH period we examined data from a research trial conducted at the DPI&F South Johnstone Research Station in the early 1980's. Originally the project intended to measure temperatures in 5 different districts in north Queensland to determine if a temperature relationship existed. However, this proved to be unfeasible due to the lack of control over decisions about harvest criteria and timing and data collection on collaborating properties. The use of past research data was chosen as an alternative because accurate BE-BH data sets were available for a range of planting dates, as well as accurate climatic data for the period of the trial.

The original trial investigated the effects of 6 different planting times on crop phenological cycles and fruit quality. Each planting (21 Jan 1983, 18 Mar 1983, 10 Jun 1983, 4 Aug 1983, 27 Sep 1983, 1 Dec 1983) consisted of 3 replicates with 10 datum plants in each, and data for the plant crop (1983/84) and first ratoon (1984/85) was recorded. Tropical Cyclone Winifred subsequently destroyed the trial in 1986. Recorded temperatures from the meteorological recording station at the DPI&F South Johnstone Research Station were used to calculate the heat sums based on modified equations for different seasons outlined in Ganry (1978).

Initial regression analysis comparing heat sums to the corresponding BE-BH period for the plant and ratoon crops did not establish any significant relationship. Further investigation of the system used in the French West Indies revealed that their heat unit forecasting system aimed to identify appropriate harvest maturity to ensure sufficient fruit greenlife for transport to Europe by sea and distribution through the supply chain. Greenlife of banana fruit is defined as the period between harvest and the beginning of the climacteric rise, indicating ripening, and is an indicator of the degree of fruit immaturity at harvest (Peacock and Blake 1970).

This information identified that their system was designed to determine harvest maturity based on potential fruit greenlife rather than the degree of "fullness" that is commonly used in the Australian industry. The harvest criterion used in this trial was the achievement of 37mm diameter of an indicator fruit on the bunch, with no consideration of fruit greenlife. This objective measurement system, called the fruit grade, is quite well correlated with physiological age of fruit in regions where fruit growth is relatively consistent throughout the year ie. Equatorial tropics. However, in the more variable north Queensland climate bunches harvested in February at 37 mm will not be more than 14 weeks old

compared with bunches harvested at 37 mm in September that may be up to 20 weeks old, with a corresponding difference in fruit greenlife.

From this the project team postulated that the heat sum model might have a stronger correlation with fruit greenlife than with fruit grade. Using the greenlife data available from the original trial we identified a statistically significant relationship between accumulated heat sums and greenlife for some of the different planting times (Table 2).

Table 2. Actual and predicted green life (GL) of bunches after harvest, using linear regressions based on accumulated heat units (HU) and period between bunch emergence (E) and harvest (H).

Crop	Actual GL (days)		Predicting GL from accum. HU				Predicting GL from period E-H			
	Average	Range	R^2	Max.HU*	GL†	95% P.I.	R^2	Max. E-H**	GL†	95% P.I.
Jan	23.2	11-34	52%	2486	27.7	21-34	34%	12.9‡	29.3	21-38
Mar	24.6	20-33	75%	2811	24.6	21-28	57%	15.8	25.6	21-30
Jun	23.5	19-26	61%	2922	23.6	21-26	51%	16.9	23.8	21-27
Aug	19.6	8-27	57%	2674‡	28.5	21-36	65%	16.2‡	27.5	21-34
Sept	13.1	6-24	4%	***			1%	***		
Dec	29.7	22-40	7%	***			2%	***		
All±	22.2	6-40	52%	2520	30.2	21-39	42%	12.1‡	31.1	21-41

* The maximum heat unit accumulation so that 95% of bunches will have a minimum green life of 21 days
** The maximum no. of weeks from emergence until harvest so that 95% of bunches will have a minimum green life of 21 days
*** Prediction equation was not significant (P>0.05)
†The average predicted green life of bunches with these maximum HU or E-H values, together with 95% prediction intervals
‡ Extrapolated beyond the range observed for the data set
± Combining data from all crops for single prediction equations

The conclusion from the trial data analysis is that the heat sum model of crop forecasting used in the French West Indies does not appear to improve the accuracy of the current system using historical BE-BH data. The analysis does identify the poor relationship between fruit diameter and fruit maturity under north Queensland conditions, and possibly points to the need to refine the maturity indicators used to determine harvest. The inclusion of a heat sum measure for the fruit that hangs during the winter months and harvests in spring could help to overcome problems of mixed ripe fruit often experienced in the August/September/October period of the year.

Alternative ways of calculating the heat sum should also be considered. Diczbalis et al (1997) compared indirect heat sums (calculated using a daily mean temperature calculated from daily maximum and minimum temperatures) and direct heat sums (calculated using a daily mean temperature calculated from temperature measurements taken at 15 min intervals) as indicators of mango fruit maturity. His work reports a major improvement in the correlation coefficient using the direct heat sum (r^2=0.51) compared with the indirect heat sum (r^2=0.25). Direct measurement of heat sums may significantly improve the explanation of variation in fruit greenlife in bananas.

3. Communication and awareness of the forecasting system for banana producers

Because development of the system has been prolonged, widespread training for producers in the use of the system has not yet been required. The 13 key project collaborators all received on-site training in the installation and use of the CAS, and in accessing and using the BCFS website.

A plain English users' manual for both the CAS and the BCFS website has been developed and finalised, and is included in the CAS Help function in PDF format. This publication will significantly assist any future training activities for the BCFS.

Evaluation and measurement of outcomes – impact and adoption

Currently the participation levels are the main method of evaluation being conducted for this project. To the 31st August 2004, 13 banana producing businesses have been supplied with the CAS. This group collectively represent about 3000 ha of the approximately 11,000 ha under production in north Queensland, or 27% of the total area. While this has not grown beyond the initial group of collaborators, 3 additional businesses have made approaches to access the CAS since the end of the project.

Of these 13 businesses, 7 have been uploading their forecasts to the BCFS website, representing about 850 ha or 8% of the north Queensland production area. Problems with internet connections and suspicion about the use of the forecast information are reportedly the main reasons why the participation rate of the industry-wide forecasts (approx 30%) is currently low.

Discussion

Different forecasting system options

Initially the project considered 3 different ways of short-term crop forecasting, and chose to develop the BCFS on the BE-BH intervals model. This decision was taken because it meant a software-based system could be developed relatively quickly, and refinements made as required. The other methods considered were:

- Forecasts based on monitoring the rate of fruit growth (fruit diameter) on "sentinel" bunches – measurements of weekly or fortnightly diameter increases were trialled. This method forecasts the time to harvest by extrapolating growth rate to predict the time taken to achieve the nominated fruit diameter used to indicate harvest maturity. This method appeared quite accurate and incorporates climatic and management factors. However, it is exceedingly labour intensive, and hence impractical, if sentinel bunch measurements need to be done across a number of local districts on a regular basis. Additionally, it is not a method that is easily automated as a computer-based system. Discussions with international production companies indicated that Chiquita sometimes uses this method in Costa Rica to help refine its forecasts based on the BE-BH method (Romero pers. comm.).
- Forecasts based on the influence of temperature on the rate of fruit development – the concept of heat units to account for the influence of temperatures over time has been most developed by the banana industry in the French West Indies. This offers the opportunity to account for seasonal variations in BE-BH intervals due to temperature, especially if heat unit data can be extrapolated to predict time of harvest. Our analysis of past research data showed a stronger relationship between

heat units and fruit greenlife than between heat units and BE-BH intervals. However, the relationships were not strong enough to use as a prediction tool. The relationship between heat units and fruit development should be re-examined using direct measurement of temperatures (measuring temperature at 15 min intervals) rather than using daily maximum and minimums to calculate the heat units.

The BE-BH interval model used best suited the project requirements but it needs improved historical BE-BH data to improve the accuracy of the forecasts. Romero (pers. comm.) indicated that their crop forecasting system works on the same basis as the BCFS, but they use a 5 year rolling average figure for their BE-BH intervals based on collected farm records. In combination with their uniform climatic conditions, this allows them to achieve weekly forecasts within 10% of actual harvests.

Currently the BCFS forecasting is reflecting production trends well, but variations of >20% are still occurring for some weekly forecasts. The use of a rolling average for the BE-BH intervals would undoubtedly improve the forecasts. To try and reduce the week to week variation in the absence of more accurate BE-BH interval data, weekly forecast data was summed in 2 and 4 week blocks and compared to actual harvest data (Table 3). The 4 week summed figures reduced the variation of forecast from actual harvest, and offers an opportunity to reduce variation within the existing system

Table 3. Comparisons of % variation of weekly, and 2 weekly and 4 weekly summed forecasts from actual harvests for 3 farms for weeks 1 – 12 2003

Farms	Weeks												
Tully 1		1	2	3	4	5	6	7	8	9	10	11	12
	Wk	-10.6	-5.3	52.7	10.1	22.0	22.9	5.6	-5.5	7.8	-19.5	-0.3	-13.2
	2 wk		-8.5		26.0		-5.3		-0.8		-7.8		-7.7
	4 wk				6.2				-2.8				-7.7
Tully 2	Wk	50.6	115.2	75.5	24.0	30.4	6.3	-15.2	-48.2	76.0	45.1	84.7	N/A
	2 wk		79.6		45.8		16.1		-31.5		57.3		N/A
	4 wk				59.7				-7.9				N/A
Innisfail	Wk	-18.5	3.9	43.8	12.9	-31.0	20.0	55.2	20.6	-7.3	14.1	-29.5	13.2
	2 wk		-8.8		27.4		-12.3		35.6		1.5		-12.5
	4 wk				2.9				7.8				-5.1

Using a computer-based approach

Choosing to use a computer-based crop forecasting system was based on the ability to use the internet to collate individual forecasts into an industry forecast, and the efficiency of a database program to use farm data to produce the individual forecasts.

However, this approach has experienced some problems, especially:

- Software/system compatibility problems – for reasons that are not immediately obvious, some of the key collaborators had problems with getting the software to work properly. In at least one instance a large plantation was unable to successfully install the CAS. In a majority of cases the problems related to small computer networks (LAN's) used to network multiple computers within the office, and the administration privileges allocated to the users in the networks. This has stretched the capacity of the project leader's computer skills in attempting to overcome the problems.
- Poor internet connections – this appears to be an issue of infrastructure in rural and regional areas. Dropouts and very slow connection speeds make uploading forecasts and general use of the BCFS website very frustrating.
- Limited computer skills and knowledge – while most collaborators have some competence in using computers, this area has been a problem for some users and could potentially limit the involvement of a proportion of the industry. The production of the users' manual has helped to overcome most of the software specific issues, and a training module based on the manual can be quickly developed when needed to cover how the BCFS works, getting started, making a forecast, uploading to the website and backing up your data.

Communication and technology transfer methodology

The approach initially taken in the project assumed a high level of enthusiasm by banana producers for a crop forecasting system. As a result a technology transfer model of extension was mostly used, with a strong emphasis on information provision and industry awareness about the technology and processes. However, this initial approach did not meet our expectations for involvement, mainly because of a range of concerns from producers about crop forecasting. The concerns raised are:

- The system won't work – this was based on the negative experiences of some producers in using bell injection figures to forecast production.
- The system could work but it offers no real benefit – this came from comments that by the time bunch emergence has occurred there are no practical management options to avoid oversupply or take advantage of undersupply.
- The system is a good idea as long as only producers get the information – concern about the use of forecast data to depress produce prices was the main feedback from a large majority of producers. The scenario proposed was that predictions of oversupply would be used to depress prices prior to any actual increase in supply.

There were also a number of producers who saw great merit in an industry forecasting scheme, and dismissed concerns about misuse of data stating that market information already existed with major supply chain partners. Based on this feedback, and in consultation with the industry "project champion", the approach was changed to focus more on a participatory approach with key collaborators to address their concerns as well as to develop the software. This

process has worked better, allowing iterative development of the software and discussion of producers' concerns about the crop forecasting system.

While the use of the key collaborators group has been reasonably successful, and allowed large production areas to be covered with a small number of participants, it has been a very time-consuming process because of the "one-to-one" nature of the interaction. A large percentage of this time was spent trying to solve technical issues such as system/software compatibility problems, most of them requiring return visits.

The use of industry forums, such as the national banana industry congress and producer association meetings, as well as regional rural media outlets have served to increase awareness of the project generally among producers, but has not yet increased participation in the project beyond the key collaborators group.

Recommendations

Methods of crop forecasting

- To develop clear criteria for forecast accuracy so that the need for improvements can be assessed. This is required to start an assessment of current data from collaborators.
- Discussion with the industry partners about the practicality of emulating the Chiquita system of using BE-BH interval data based on a 5 year rolling average. This requires 2 main activities:
    - The input of producers about practical and realistic methods of BE-BH data capture.
    - Assessment of the CAS to determine if it can be modified to allow recording of BE-BH records and updating of "look-up" tables
- A reassessment of the production of weekly forecasts is required. Inherently high variability in BE-BH intervals, as well as significant influences from climatic and management variability, makes consistently accurate weekly forecasts very difficult to achieve. Poor historical BE-BH interval data makes it even more so. A more rigorous assessment and comparison of the accuracy and usefulness of 4 weekly summed forecasts with weekly forecasts needs to be made.
- Re-examine the relationship of heat units with BE-BH intervals, comparing the use of direct and indirect measurement of temperatures.

Industry support for the BCFS

- The success of the BCFS is tied to a high level of producer participation. During the course of the project it has become obvious that we cannot currently assume general support for the BCFS, because of a high level of producer suspicion about how the information will be used.
- Project partners and other key industry members need to make a decision about the BCFS. With current suspicions among producers about the use of the BCFS, and general attitudes about the future of the industry, the increase in participation required to make the system more functional will require extensive "one-to-one" approaches to potential participants. This is very slow and time-consuming, with each new producer requiring support (around 4-5 visits) before becoming self-sufficient. The project partners need to discuss what commitment and resources are available to continue this support, as the BCFS will fail if there is no continued effort due to a lack of system administration and loss of participants.

Extension methodology

- Increased participation is probably still best achieved with a "one-to-one" personal approach and sufficient resources need to be allocated to support this.
- Improvements in the BCFS are probably best achieved using a continuous improvement approach, working with the existing users to improve the system logic and functionality. For resource efficiency this is best done in a small group format but issues of data confidentiality need to be clearly managed for any group format to work effectively.

- Development and implementation of a training module for use of the BCFS will go a long way to reducing the requirement for on-going user support. Any need to improve general computer skills is best met by existing providers eg. TAFE or training consultants.

Acknowledgements

This project has benefited greatly by the contributions of the following people:

- Mr Patrick Leahy – industry project champion and collaborator
- The group of collaborating producers for providing feedback and advice
- Mr Shane Mulo – DPI&F horticulturist and software developer
- Mr Jeff Daniells – DPI&F horticulturist
- Mr Bob Mayer – DPI&F biometrician

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Richard Ross
Grower Services Manager
Growcom
PO Box 202
Fortitude Valley QLD 4006

Dear Richard

FRO1030 BANANA FORECASTING PROJECT

I am seeking your agreement in finalising the project, FR01030 "Banana Forecasting Project" that has an outstanding milestone covering the commercialisation of the system.

Since our meeting of the 21st July 2004, we have both had the chance to further explore the possibilities of the commercial future of the system. At this meeting we tabled for discussion a draft agreement where the DPI&F agreed to grant an exclusive, non-transferable license to Growcom to distribute the client software and a non-exclusive, non-transferable license to use the website for commercialisation purposes.

I feel it would be true to say that we have both found from our research since the meeting, the commercialisation targets as stated in the draft agreement discussed at that meeting would prove near impossible to achieve and certainly not in the timeframe stated.

Specifically these were:

Milestone 1 (by 31/8/2004):	Achieve 25% of the current production area (5,500 ha) utilising the client application software.
Milestone 2 (by 31/8/2004):	Achieve 10% of the current production area (5,500 ha) utilising the internet central database.
Milestone 3 (by 31/8/2005):	Achieve 40% of the current production area (5,500 ha) utilising the client application software.
Milestone 4 (by 31/8/2005):	Achieve 30% of the current production area (5,500 ha) utilising the internet central database.

Many factors have arisen since this project was first instigated and include the changed structure and staffing of QFVG/Growcom, staff arrangements within the DPI&F project team, funding arrangements within the banana industry and as stated in project Milestone Report #2:

"*Most of the growers eventually agreed to join the forecasting project (up to 25% of the growing area in north Queensland), despite a lot of reservations about the possible mis-use*

Gate 3, 80 Meiers Road

PO Box 631 Indooroopilly
Queensland 4068 Australia
Call Centre 13 25 23
Website www.dpi.qld.gov.au
ABN 78 342 684 030

of any eventual overall forecasts of production within the industry. Significantly, some larger growers, representing almost 10% of the industry were the most suspicious about possible abuses of forecasting information being in the public domain. Specifically the lowering of price received by growers before the forecasted supply had risen was mentioned as well as misinterpretation of forecasting information from only a minor percentage of growers (as the rest had yet to contribute to the scheme)."

As a way of finalising this project may I suggest without prejudice the following arrangements:

- Both the DPI&F and Growcom indicate to HAL that the project requirement in Milestone #3 to have "the software usage license finalised in written form and the IP arrangements for the licenses in place", have been written and are in place. However due to changed industry circumstances are not possible for either party to meet within a commercial reality framework of additional time or monetary investment. For all intents and purposes this should satisfy the requirements of Milestone #3.

- DPI&F submit a final project report to HAL. For all intents and purposes this should satisfy the requirements of Milestone #4 and complete the project.

- Both the DPI&F and Growcom indicate to HAL that we are committed to the outcomes of this project and agree until at least August 2005 to:

- DPI&F maintaining the website.

- DPI&F and Growcom to promote the concept of a banana forecasting system to the banana industry.

- DPI&F to supply a licensed copy of the client software and a user manual to interested growers in an attempt to promote the concept of a banana forecasting system to the banana industry.

- DPI&F, Horticulture Australia Limited and Growcom meet in March 2005 to consider commercialisation strategies for the system based upon our continued efforts in promoting the system to the banana industry.

- DPI&F, Horticulture Australia Limited and Growcom meet in August 2005 to consider commercialisation strategies for the system based upon our continued efforts in promoting the system to the banana industry. This meeting will fully explore the commercial realities of the system in the current banana industry climate.

    - If bringing the system to a fully commercial reality at this time is not possible, all parties without prejudice will agree to terminate any inferred licenses or agreements in respect to this matter.

    - If bringing the system to a fully commercial reality at this time is possible in some way, DPI&F, Horticulture Australia Limited and Growcom will negotiate license agreements to facilitate that outcome.

Please contact me to discuss any matter raised about finalising this project, as we are keen to finalise this project but continue to explore the commercial possibilities in partnership with Horticulture Australia and Growcom for this system.

Yours sincerely

Garry Fullelove
Acting Business Manager
Horticulture & Forestry Science
Department of **Primary Industries & Fisheries**

Phone 07 3896 9401 **Facsimile** 07 3896 9628
Mobile 0427 124 578
email garry.fullelove@dpi.qld.gov.au

Website www.dpi.qld.gov.au **Call Centre** 13 25 23

8 October 2004

Gary Fullelove
Acting Business Manager
Horticulture & Forestry Sciences
Department of Primary Industries and Fisheries
PO Box 631
Indooroopilly 4068

Dear Gary,

FR01030 BANANA FORCASTING PROJECT

Growcom wishes to support your proposal for the commercialisation of FR01030, the Banana Forecasting Project. As outlined in your letter of the 15 September 2004

Growcom will contact Horticulture Australia Limited informing them that the project requirement in milestone #3 to have "the software usage license finalised in written form and the IP arrangements for the licence in place", have been written and are in place. We will also inform them that due to changed industry circumstances it is not possible for either party to meet within a commercial reality framework of additional time or monetary investment.

I will contact you in the near future to formalise these arrangements.

Yours sincerely

Richard Ross
Industry Services Manager