SUGARCANE SMUT AFTER THREE YEARS: A POLICY RETROSPECTIVE

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Abstract

THE DETECTION of sugarcane smut disease (*Ustilago scitaminea*) in the Bundaberg-Childers region of eastern Australia in 2006 triggered a comprehensive and united response from BSES Limited, Queensland Government and CANEGROWERS. The response to sugarcane smut in the Bundaberg-Childers area was the first test for the Emergency Plant Pest Response Deed, an agreement between Australian governments and plant industries to facilitate a response to a plant pest incursion. As part of this response and the subsequent inquiry, economic models of the likely pattern of spread and cost of the smut epidemic were prepared. This paper reviews the predictions of those models in the light of the subsequent three years' experience. It examines reasons for divergence from the modelled outcomes, some of which were good approximations of actual experience.

Introduction

Sugarcane smut disease (smut, *Ustilago scitaminea*) was first detected in Western Australia in 1998, hard on the heels of the completion of an industry contingency plan that anticipated its eventual arrival (Croft and Magarey, 1997). Eradication was deemed impossible, and the Ord cane industry commenced a switch to resistant varieties. Despite quarantine measures to protect the major eastern industry, sugarcane cane smut was identified on the east coast near the Queensland town of Childers on 9 June 2006 (Croft *et al*., 2008).

Given the record of the calamitous impact of smut on sugarcane industries worldwide, the industry expected the worst. Under such circumstances, a strong partnership between the Queensland Government, BSES Limited and the industry through CANEGROWERS was imperative.

This paper reviews the 2006 estimates of likely impact on the industry and the background considerations on which these were based. With three years' data on the spread of the pest and yields now available for some canegrowing regions, it is possible to look back and compare the actual and expected outcomes of smut on the sugarcane industry.

From incursion to established disease: Policy responses in Queensland

The detection of sugarcane smut in the Bundaberg-Childers region of eastern Australia in 2006 triggered a comprehensive and united response from BSES, Queensland Government and CANEGROWERS.

The response to sugarcane smut in the Bundaberg-Childers area was the first test for the Emergency Plant Pest Response Deed (EPPRD), the agreement between State and Federal Governments and plant industry stakeholders to facilitate a response to a plant pest incursion.

The response was facilitated by the template provided by the EPPRD, by industry's preparedness in development of its own biosecurity plan, by activities of BSES to have resistant varieties and pathology and diagnostic expertise available, and by the expertise and significant resources of QDPI&F in dealing with the logistic, legislative and practical tasks of mounting a significant response.

Areas covered in the response were: quarantine of the affected area quarantine and movement controls surveillance and tracing disposal of affected material removal of infested cane.

In addition to managing the initial response and delimitation phase, the lead agency, QDPI&F, was also responsible for development of a response plan that would set out the proposed long-term response activities and demonstrate that the disease was capable of being eliminated or contained and that the response was economically justified.

The response plan was costed and the outcomes subjected to a rigorous economic analysis of the net benefit compared to the cost (benefit-cost analysis). Important elements were the costs of the activities detailed above and the owner reimbursement costs for activities required under the response plan. These included:

- value of the crop destroyed
- cost of crop destruction
- costs of activities required under the response plan such as extra cleaning and transport costs, the cost of burning cane before harvest and so on
- costs of crop replanting, discounted to take account of the normal ratoon cycle
- net loss of profit from fallow.

In order to estimate the benefit of the response, assumptions were made on the likely date of entry of the disease into other regions with and without the response. Removal of susceptible varieties in other regions was assumed in both cases. Estimates of losses as the disease progressed in each region were also made–these were generally based on an assumed loss of 6% yield for each 10% of a crop infested (Croft *et al.*, 2008).

Despite the fact that the National Management Group of government and industry stakeholders determined in August 2006 that the disease could not be contained and therefore did not come under the scope of the EPPRD, the cost-benefit analysis carried out had ongoing impacts. It facilitated the announcement by the Queensland Government of $15.6 M over four years to fight the disease and led to the announcement of an inquiry into the potential economic impact of the disease and the best way to deal with it (Antony, 2008).

This occurred after the disease was discovered in Mackay and thus shown to be endemic and to have spread beyond the containment stage. The purpose of the study, led by Dr David Watson, the former State treasurer, was to establish the expected economic impact and to identify measures to facilitate economic recovery (Watson, 2007).

The enquiry soon focussed on the question of how long the industry was willing to live with susceptible crops and whether there were ways or justification for accelerating the replacement of susceptible canes with resistant varieties.

An immediate move into resistant varieties had potentially large opportunity costs. Northern cane regions had a suite of approved resistant varieties yielding as well as susceptible ones.

However, further south, susceptible varieties held a yield advantage over resistant canes and this favoured the retention of susceptible varieties for planting. Given that smut was progressively spreading, the optimal year of replacement was when the initial yield advantage of susceptible varieties was eliminated by smut losses.

Still, a general rule could not be established as smut was not uniformly established and growers' expectations were not identical regarding further spread, yield differentials and the acceptable risk.

In order to assist this inquiry, Antony (2007) prepared an industry-wide model of replanting for four major Plant Quarantine Areas (PQAs) that accounted for 66% of Queensland's 2005 cane crop.

The model totalled areas planted to susceptible and resistant varieties in plant and ratoon crops between 2003 and 2006. Replanting simulations between 2007 and 2014 were driven by a simple rule that favoured:

(a) susceptible varieties for the notional base case of no smut; and

(b) resistant varieties for the smut-infested actual scenario.

A technology constraint prescribed the proportion of area physically able to be replanted. With a six-year crop cycle (fallow, plant crop and four ratoons), normally one-sixth of the cane is replaced every year. Even if farmers wanted to transition faster to resistant varieties, machinery capacity restrictions limit region-wide replacement to around a quarter of the area. Region-specific data and forecasts on the status, spread and impact of smut on yield and CCS were supplied by BSES. Epidemiological data from Isis-Bundaberg improved industry confidence in the BSES forecasts. Nevertheless, to account for uncertainty, two smut-impact scenarios were developed, based on 'optimistic' and 'pessimistic' forecasts about smut severity.

Tables 1 and 2 show the parameters forecasted for PQA4 (comprising Mackay, Plane Creek and Proserpine) and PQA5 (Isis and Bundaberg). Figure 1 charts the historic and modelled cane crops in the four PQAs. In both the tables and the graph, years 2003–06 contain observed data, while 2007–14 are forecasted.

Table 1—Forecasted parameters of smut impact in PQA4–2007 assessment.

Year	Yield margin best S over R[a] (%)	Smut-free cane yield (t/ha)		Smut-free CCS		Smut yield loss in affected S stands[b] (%)		Smut CCS loss in affected S stands[b] (%)		Smut Spread (% of region affected)	
		S	R	S	R	Opt	Pess	Opt	Pess	Opt	Pess
2003		72.5	63.4	13.8	14.2	0	0	0	0	0	0
2004		84.0	78.4	14.2	14.8	0	0	0	0	0	0
2005		94.3	86.1	13.8	13.7	0	0	0	0	0	0
2006		94.5	85.0	14.0	13.5	2	2	0	0	0	0
2007	11	94.5	85.0	14.0	13.5	5	5	0	0	0	0
2008	11	94.5	85.0	14.0	13.5	10	15	0	0	1	1
2009	11	94.5	85.0	14.0	13.5	20	30	0	1	5	10
2010	11	94.5	85.0	14.0	13.5	25	50	1	2	10	30
2011	5	94.5	90.0	14.0	13.5	30	50	2	4	30	80
2012	5	94.5	90.0	14.0	13.5	40	50	3	5	60	100
2013	5	94.5	90.0	14.0	13.5	60	60	5	5	100	100
2014	5	94.5	90.0	14.0	13.5	60	60	5	5	100	100

Source: Antony (2007)
S = susceptible varieties, R=resistant varieties Opt= optimistic, Pess= pessimistic
[a] The yield margin of the best susceptible varieties over the best resistant ones
[b] Note that smut was assumed to have no yield or CCS impact on resistant varieties

The last year of historic data in the model was 2006, and from 2007 the crop estimate is the product of the modelled replanting strategies under a notional base case of no smut, and smut scenarios with either optimistic or pessimistic impact assumptions.

The upturn in 2012 (Figure 1) is due to the complete replacement of susceptible crops and a temporary drop in fallow area.

The impact of the scenarios was measured as net present values of the 2007–2014 period in terms of total sugar income and farm gross margin at the regional levels.

Table 2—Forecasted parameters of smut impact in PQA5–2007 assessment.

Year	Yield margin best S over R[a] (%)	Smut-free cane yield (t/ha)		Smut-free CCS		Smut yield loss in affected S stands[b] (%)		Smut CCS loss in affected S stands[b] (%)		Smut spread (% of region affected)	
		S	R	S	R	Opt	Pess	Opt	Pess	Opt	Pess
2003		77.0	75.5	14.2	14.1	0	0	0	0	0	0
2004		90.6	92.3	14.3	14.5	0	0	0	0	0	0
2005		86.8	83.0	13.3	13.3	2	2	0	0	0	0
2006		95.9	84.6	13.4	13.1	5	5	0	0	0	0
2007	15	100	85	13.4	13.1	10	15	0	0	1	1
2008	15	100	85	13.4	13.1	20	30	0	1	5	10
2009	15	100	85	13.4	13.1	25	50	1	2	10	30
2010	10	100	90	13.4	13.1	30	50	2	4	30	80
2011	10	100	90	13.4	13.1	40	50	3	5	60	100
2012	10	100	90	13.4	13.1	60	60	5	5	100	100
2013	10	100	90	13.4	13.1	60	60	5	5	100	100
2014	10	100	90	13.4	13.1	60	60	5	5	100	100

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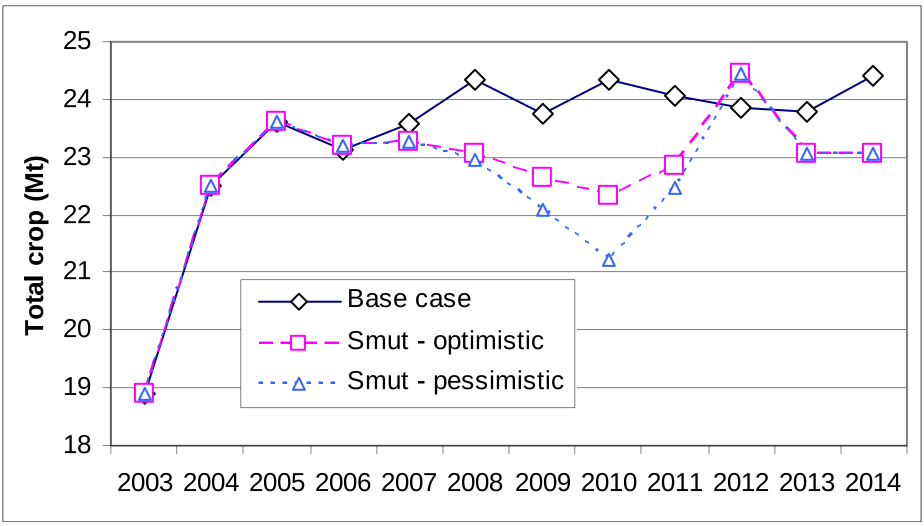

Fig. 1—Modelled impacts of smut under alternative scenarios for Queensland PQAs 2 to 5.

Model runs confirmed that the industry was going to be worse-off owing to smut, but revealed that the likely extent of impact would not be as great as some earlier calculations had suggested.

While there were costs in ploughing out crops and replanting early, there were positive effects on cash flows from earlier access to higher revenue from plant and early ratoon crops that improved the calculated net present value.

Table 3 shows the results of calculations for optimistic and pessimistic assumptions about the future severity of smut against the no-smut base case.

Table 3—Forecasted 2007–2014 smut impacts (%) on Queensland sugar regions–2007assessment.

Region	Sugar value		Farm gross margins	
	Optimistic	*Pessimistic*	*Optimistic*	*Pessimistic*
Herbert (PQA2)	–2	–5	–6	–13
Burdekin (PQA3)	–1	–2	–3	–4
Mackay, Plane Creek & Proserpine (PQA4)	–8	–8	–27	–29
Isis-Bundaberg (PQA5)	–10	–11	–29	–32

As large as these impacts are in some regions, they fall within the range of external influences that the industry regularly experiences; even a 10% drop in the sugar price would have a larger effect. The policy option of enforcing a faster rate of replanting was tested by raising the replanting proportion from the regular 17% to 25%.

All financial returns in all regions were marginally worse under this option, primarily owing to the higher unproductive fallow area. While northern regions had an adequate supply of resistant varieties for most agro-climatic niches, the choice was much more limited in the south.

Moreover, there was a physical shortage of resistant planting material for Isis-Bundaberg for autumn 2007 plant crops. Hence, the industry requested approval for the limited planting of susceptible varieties at that time.

A model run providing for 2000 ha of susceptible plantings indicated positive financial results under optimistic smut severity, and a small potential negative outcome should the pessimistic forecast eventuate.

While on balance there were small but positive probabilities for 2007, the outcome for a similar small susceptible planting was unequivocally negative from 2008.

The findings of the Watson inquiry were accepted by both the Queensland Government and industry stakeholders. It was agreed that there was no advantage in forcing a faster replacement of susceptible crops than the regular crop cycle. Neither was there a useful way of improving the industry's smut response in the short term even with large financial inputs. Instead, the best assistance the Government could provide was by resourcing the accelerated release of new resistant varieties by BSES.

Was the policy response right?

Three years' data are now available on the total Queensland sugarcane crop since the smut outbreak in 2006. Detailed crop data were obtained on areas, yields and varieties in the Mackay region (part of PQA4), as well as for those in Bundaberg (part of PQA5). So, it is now possible to start assessing the accuracy of the 2007 forecasts. Figure 2 shows the volume index for Queensland's sugarcane crop for the period 2003–09, for comparison with Figure 1.

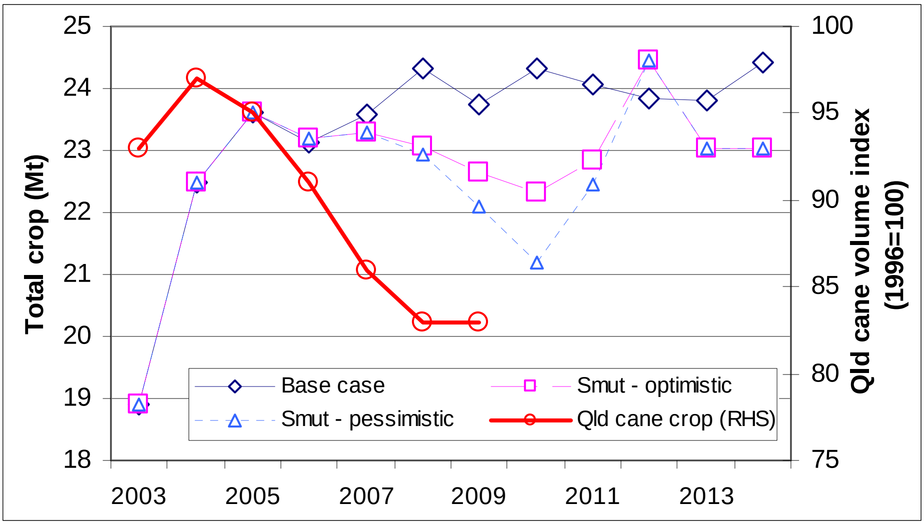

Fig. 2—Volume index of Queensland sugarcane production Source: DEEDI (2009).

There are differences in the historical data between the Queensland total and the four PQAs modelled. The crop peaks in 2005 for the four PQAs, but in 2004 for Queensland.

This is partly due to permanent production drops outside the four PQAs, particularly the closure of the Nambour mill in 2004, and also to drought influencing crops a year earlier in the smaller southern regions.

Figures 1 and 2 both show a 2006 decline, but the original forecast assumed a levelling-out after 2006.

Unanticipated effects other than smut have reduced the sugarcane crop in the period between 2007 and 2009 in Queensland, including drought, loss of land to forestry, reductions in input use due to high prices and low returns and long crushing seasons.

Sugarcane yields reflect the same pattern (see Figure 3 for Mackay and Figure 4 for Bundaberg).

Fig. 3—Modelled and actual sugarcane yields for smut-susceptible and resistant varieties in Mackay[1].

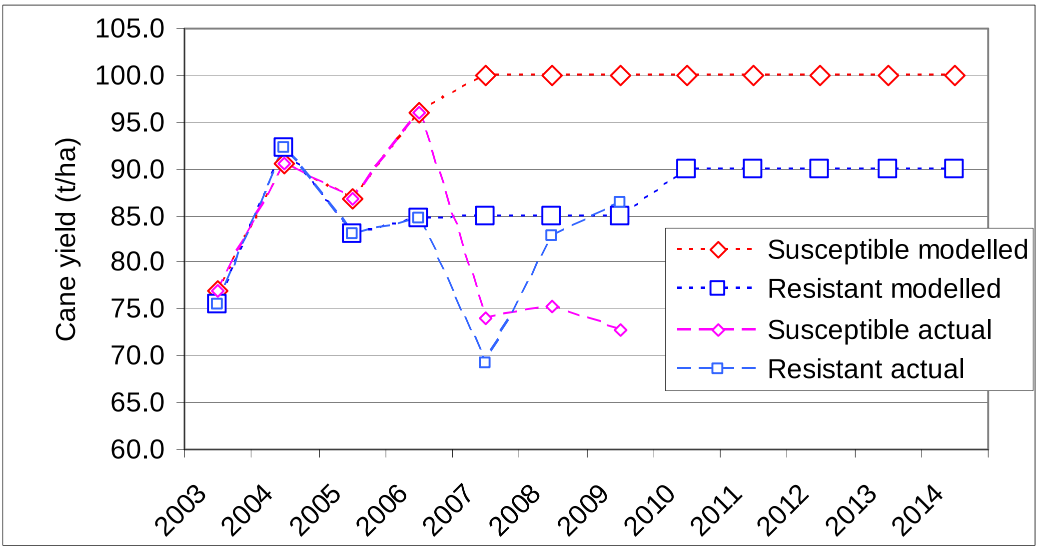

Fig. 4—Modelled and actual sugarcane yields for smut-susceptible and resistant varieties in Bundaberg[2].

Yields of both smut-susceptible and resistant cultivars were expected to remain near their 2006 levels for a few years–but in fact dropped precipitously in both Mackay and Bundaberg (Figures 3 and 4, respectively). What turned out better

[1] Note some inconsistency in the data sets. Modelled data are for PQA4 for all years. Actual data are for PQA4 for 2003–06, but only Mackay for 2007–09

[2] Modelled data are for PQA5 for all years. Actual data are for PQA5 for 2003–06, but only Bundaberg for 2007–09

than expected in both regions was the generally stronger yield performance of resistant (versus susceptible) varieties Though the yields of both susceptible and resistant varieties decreased post-2006 (for a range of reasons), the yield of resistant varieties was relatively higher compared to the susceptibles. Data from individual mill areas (not cited here) suggests some resistant varieties such as Q208 are continuing to yield very well relative to the susceptible canes it is replacing. Change in the proportion of resistant and susceptible crops was a major assumption in the modelling. Figures 5 to 8 illustrate this change for Mackay and Bundaberg.

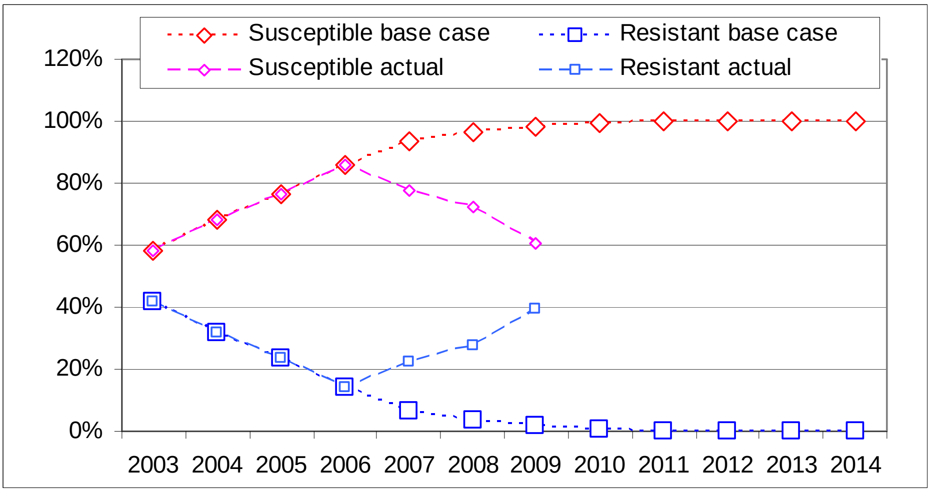

Fig. 5—Modelled base-case and actual stand compositions in Mackay[3].

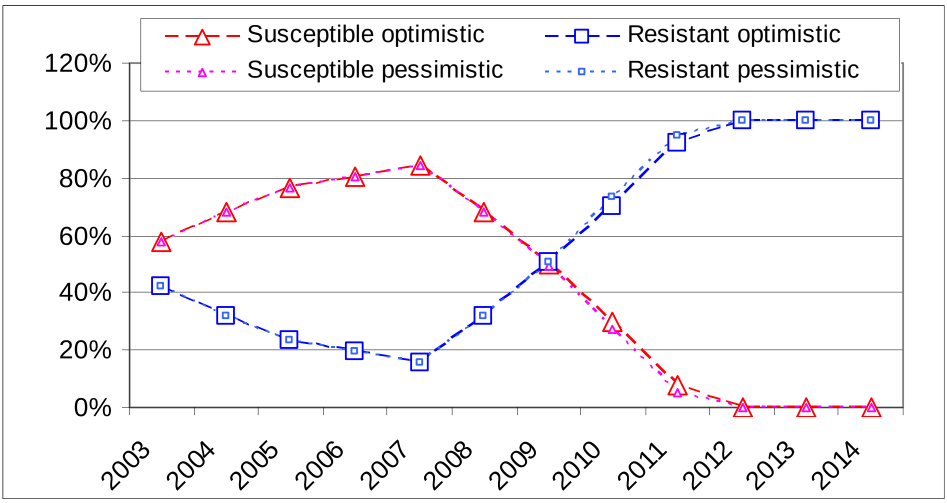

Fig. 6—Modelled smut-influenced crop compositions in Mackay[4].

[3] Note some inconsistency in the data sets. Modelled data are for PQA4 for all years. Actual data are for PQA4 for 2003–06, but only Mackay for 2007–09

[4] Modelled data are for PQA4 for all years. Actual data are for PQA4 for 2003–06, but only Mackay for 2007–09

Without smut, susceptible varieties were expected to be planted to the whole region by 2010 (Fig. 5). With smut, the area under resistant varieties was expected to reach 50% in 2009, but this has not yet occurred in Mackay (Figures 5 and 6).

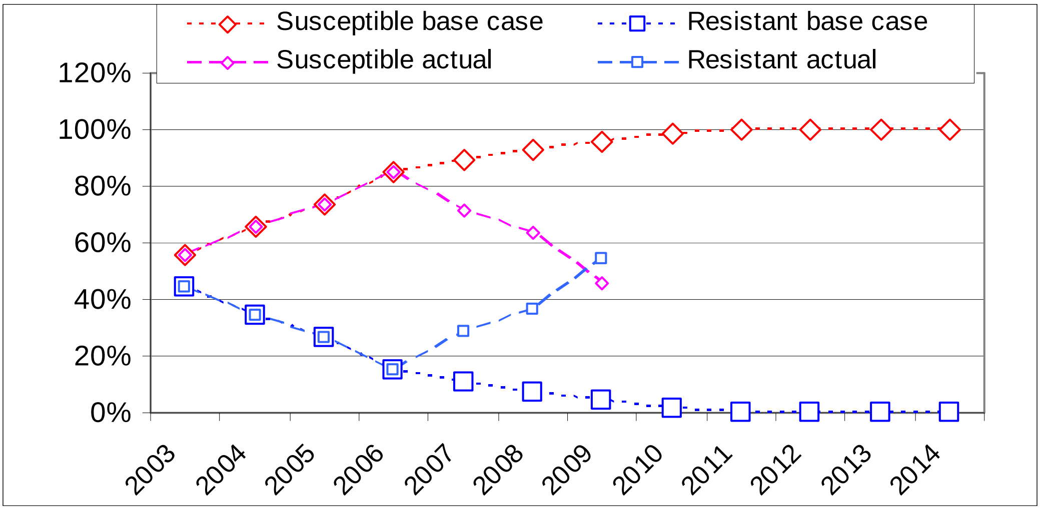

Fig. 7—Modelled base-case and actual crop compositions in Bundaberg[5].

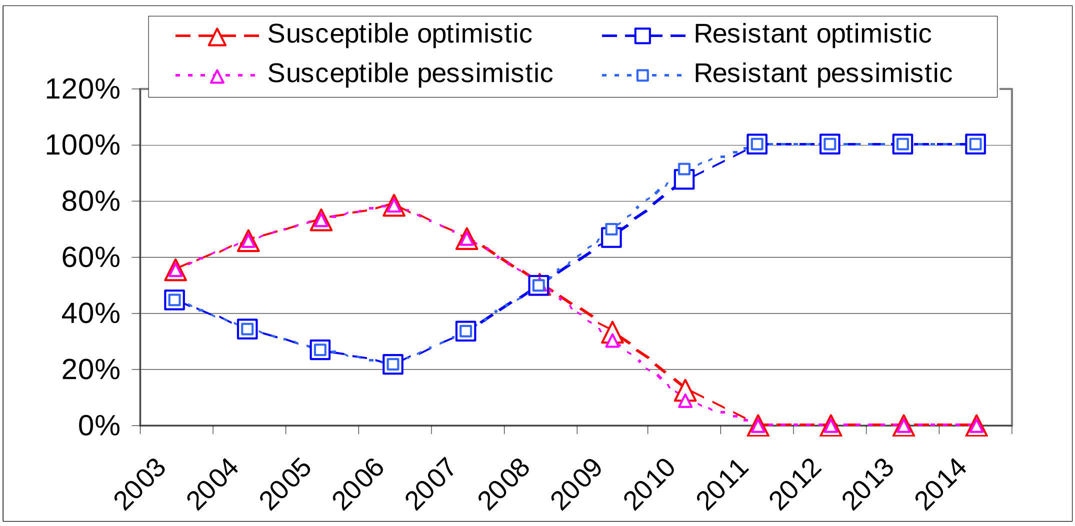

Fig. 8—Modelled smut-influenced crop compositions in Bundaberg[6].

The replacement of susceptible crop with resistant varieties in Bundaberg is near that anticipated in the modelling (Figures 7 and 8).

[5] Modelled data are for PQA5 for all years. Actual data are for PQA5 for 2003–06, but only Bundaberg for 2007–09

[6] Modelled data are for PQA5 for all years. Actual data are for PQA5 for 2003–06, but only Bundaberg for 2007–09

Discussion

The policies put in place by the response partners (QPI&F, BSES and CANEGROWERS) to deal with sugarcane smut in 2007 have so far been vindicated. The sugarcane industry is progressively transitioning to resistant varieties utilising the accelerated release of resistant varieties by BSES.

Other climatic and economic influences have so far caused yields to vary much more than has smut. The industry has therefore managed to alleviate in good measure the effects of a very serious disease that has affected industries all around the world. Several things are worthy of note.

Firstly, smut has spread faster within each region than anticipated under both optimistic and pessimistic protocols. Tables 1 and 2 predict the expected percentage of the areas likely to be smut-infested each year. Particularly for PQA4, but also PQA5, these areas have been exceeded and the disease is likely to have spread to all farms within these areas by mid-2009 (Magarey *et al*., 2009, 2010a).

Secondly, the yield losses to smut are probably close to predictions, particularly the pessimistic scenario. In the Mackay (PQA4) area, the magnitude of losses in susceptible 2010 crops will be significant and substantial. Years 2010 and 2011 will be crunch years regarding direct smut-induced yield losses (Magarey *et al*., 2010b).

With the current transition to resistant varieties, the losses will ease in 2012 as the area of susceptible crops drops to a much lower proportion of the total crop (Magarey *et al*., 2010b). It is quite clear that sugarcane smut has the potential to cause major crop losses.

Many of those farmers who have been unable or unwilling to transition from susceptible to resistant varieties in the first-infested PQAs are now caught between a ‘rock and a hard place’ with high smut severity developing in their crops and too little time to now transition to resistant varieties.

It is in these situations that smut will have its greatest effect on financial returns (Magarey *et al*., 2010b). The regulations and policies adopted early on in the smut epidemic have minimised the occurrence of these circumstances and saved the industry many millions of dollars.

Big factors in the success of the implemented smut strategy have been:

- The higher than anticipated yield of resistant varieties.
- The widespread planting of the resistant Q200$^{\Phi}$, KQ228$^{\Phi}$ and particularly Q208$^{\Phi}$, and their excellent performance in many districts has minimised the adverse influence creating by terminating crops of previously high-yielding susceptible crops.
- A second factor has been the rapid multiplication of planting material. The quantities of resistant varieties available for planting have been expedited by industry cooperation in the release of available planting

material from one district and the coordinated inspection, transport and re-propagation of this material in other districts.

- Lastly, acceleration of the BSES breeding program has led to the release of high-yielding resistant varieties, with more in the pipeline.

The situation regarding smut is still unfolding and it is worth considering undertaking another detailed analysis as outlined above in 2013, as this will provide an even better reflection on the accuracy of 2006 predictions and the policy decisions made at that time.

Acknowledgements

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