REPORT

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Potential economic impact of a Crawford Master Class

Soil borne pathogens and cereal cyst nematode

Prepared for the ATSE Crawford Fund

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1 Introduction

Background

In May 2005, 21 Chinese plant pathologists attended a Crawford Fund Master Class (MC) on soil borne pathogens of wheat. The MC took place over 12 days at the Henan Agricultural University.

The idea for a Chinese based MC emerged from a similar 2003 MC in Turkey where, unfortunately, Chinese participants were unable to attend[1]. Given China is one of the world's largest producers of wheat and 'is relatively poorly trained in relation to soil borne diseases'[2], such a MC was considered to be an important activity for the Crawford Fund to be involved in.

The MC is broadly considered to have been very successful, having led to a number of spin-offs in terms of prospective research areas, development of networks and an increase in resources devoted to soil pathogen issues.

This report

The MC has been reviewed in some detail by Ferrar and Ryder (2005), Riley et al (2009), and Nicol et al (2009).

This report complements these other reviews by examining the ways in which the MC has had an economic impact and by providing an order of magnitude of the potential economic impact. While such economic impact analysis must be seen as speculative, the exercise nevertheless leads to a broad indication of the importance of this particular MC.

In particular, we adopt the broad analytical framework for considering the impact of capacity building projects set out in Davis et al (2008) and Gordon and Chadwick (2007). This report examines participants' perceptions of how the training has contributed to research outcomes as well as considering potential economic benefits

[1] This was a consequence of travel restrictions introduced because of the SARS outbreak in China.

[2] Ferrar and Ryder (2005), p. 3.

through outcomes related to a better understanding of one particular pathogen (the cereal cyst nematode).

Section 2 examines the broad pathways by which the MC affects research outcomes by basing the discussion around participant survey findings.

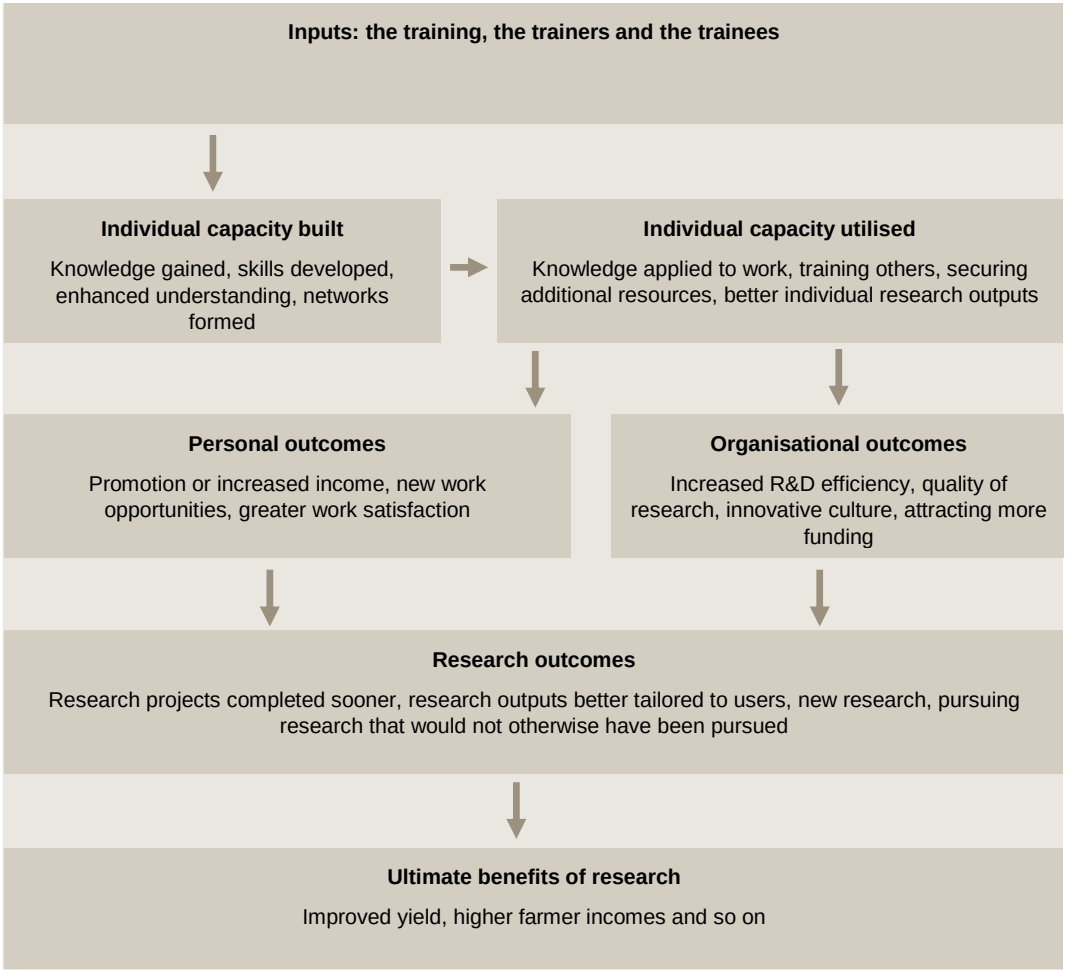
Section 3 examines the potential economic impact of the MC by considering its contribution to the potential benefits that may emerge from control of the cereal cyst nematode in wheat.

Section 4 concludes.

2 *The Master Class pathways of impact*

Capacity building projects, such as MC training provided by the Crawford Fund, generate economic outcomes through a number of pathways. These are illustrated in chart 2.1.

2.1 **Pathways for impact of a Master Class**



A number of key points emerge from this framework. First, the value of the training ultimately depends on the value of the research that is facilitated or enhanced by the training. Second, the impacts proceed from an individual level through to an organisational level. For there to be any impact, outcomes must emerge at an individual level (for the individual to be able to utilise the capacity developed in the

MC) and at and organisation level — the organisation must be able to take advantage of the improved individual capacities. Third, research outcomes must be changed in some way by the training, perhaps by becoming more efficient or less costly, or perhaps by leading to new research areas.

One way of assessing the impact of the MC on these various pathways is to directly ask participants their perceptions of various aspects of the MC, as well as their views of initial outcomes.

As part of the evaluation of the impact of the MC, Riley et al (2009) undertook a survey of MC participants. The questions for this survey were based on the template set out in Davis et al (2008). The questions are phrased as a proposition, which respondents are asked to score as 'strongly disagree', 'disagree', 'neutral', 'agree' or 'strongly agree'. Survey responses were obtained by 16 participants[3].

This survey is very qualitative in nature. With essentially a 5 point scoring system, the results provide an indicative picture of respondents' views rather than a finely grained one. Further, the responses are the subjective perceptions of the respondents. Within the resources available for this review it has not been possible to objectively verify respondents' observations — through discussions with peers or employers, for example, who did not attend the MC, but may be in a position to observe its impacts.

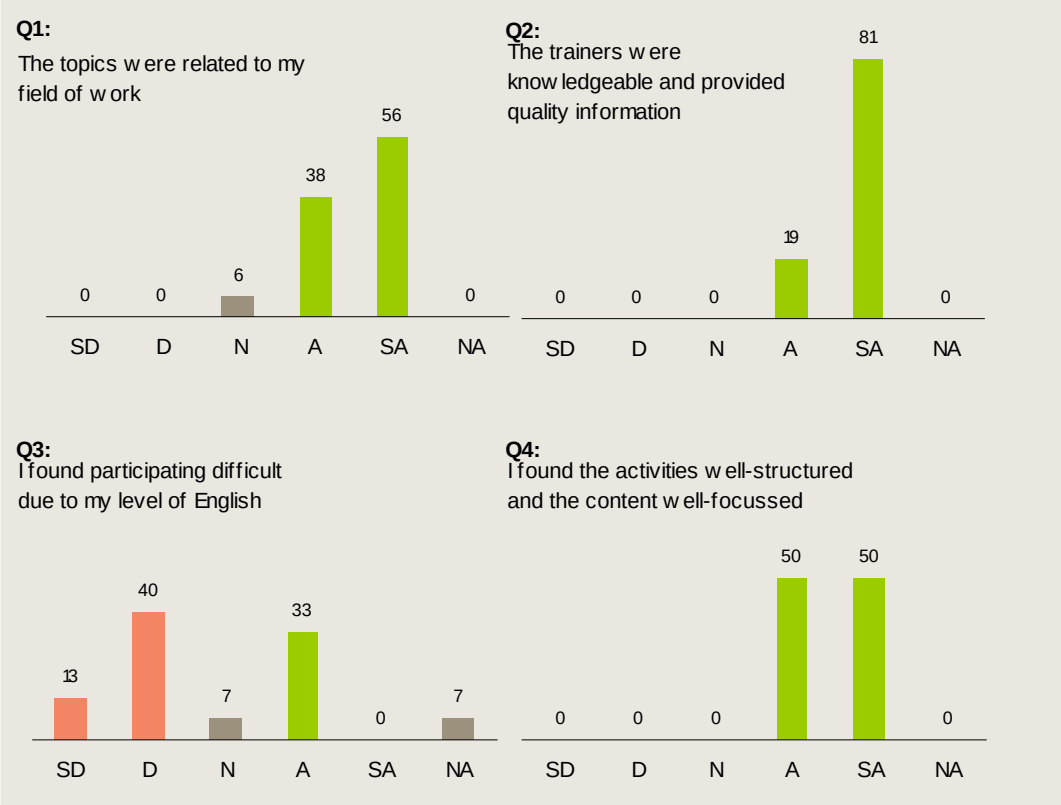
Inputs: the training and the trained

The MC delivered training to 21 individuals, most of whom were Professors or Associate Professors (15), with the remainder either lecturers or agricultural agents.

As chart 2.2 indicates, most responding participants agreed that the training was relevant to their field of work, that the trainers were knowledgeable and provided quality information, and that the activities were well-structured and well-focused. There is some indication that instruction in English was a challenge to around a third of participants, however given the responses to subsequent questions, this does not appear to have been a major constraint.

[3] This is a good response rate, and was obtained through individual follow up. It should be noted that the survey was undertaken by a team closely involved in the MC (as presenters and part-organisers).

2.2 **Relevance and quality related survey questions** Percent of total responses



Note: SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree; NA = not applicable

Data source: Survey results reported in Riley et al 2009.

Individual capacity built

The pathways by which capacity building leads to economic benefits starts with individual capacity building, which includes increased knowledge and awareness of particular issues, as well as improved contacts and networks. Individual capacity is, of course, central to the ability of the research system to identify and solve problems and constraints within the agricultural production systems.

The MC built individual capacity first, through direct training (which in the case of the MC is done using an interactive style of teaching); second, through practical work (laboratory exercises and field visits); third, through exposure to national and international experts; and finally through the opportunity to develop and pursue networks with other participants or trainers.

As chart 2.3 indicates, most respondents considered that the MC allowed them to increase individual capacity — at least 90 per cent of respondents agreed or strongly agreed with the survey propositions relating to capacity to conduct research, laboratory and technical skills, managements skills, general principles and new ways to approach work problems.

The exception to this general pattern is the question relating to improved ways of communicating within networks. In this case, just over half of respondents agreed with the proposition, around a quarter were neutral, and 6 per cent disagreed.

2.3 **Questions related to individual capacity built** Percent of total responses

Note: SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree; NA = not applicable

Data source: Survey results reported in Riley et al 2009.

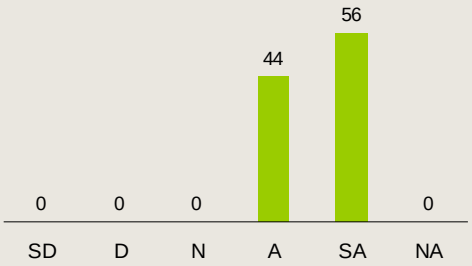
Individual capacity used

The next stage in the pathway of benefits from the MC is in the actual use of the capacity by individuals receiving the training. Individual improved capacity can only ultimately have an impact if it can be expressed in the daily responsibilities and working lives of those individuals. While this may depend to some extent on the institutions within which the individuals must operate, the MC process can contribute to this by appropriately selecting the individuals to receive the training.

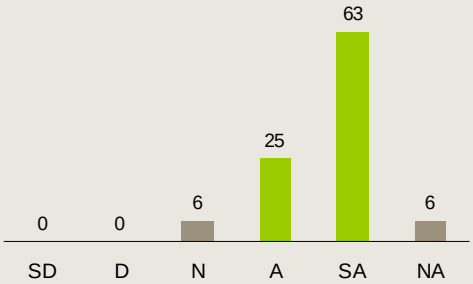
As chart 2.4 indicates, most respondents agreed that they have continued to use the knowledge gained from the MC and have increased their collaboration and obtained additional resources for their research. Importantly, over 80 per cent suggested that they have trained others in the skills learned in the MC.

2.4 **Questions related to capacity utilised** Percent of total responses

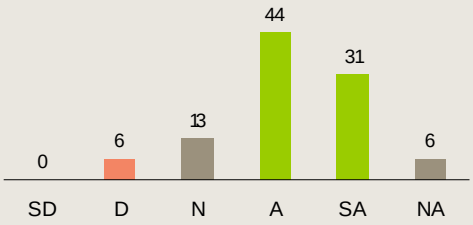
Q11:
I was able to apply the knowledge gained to my work



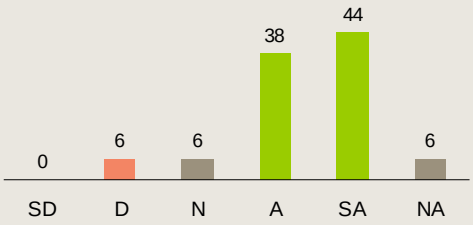
Q12:
I continue to use the knowledge gained



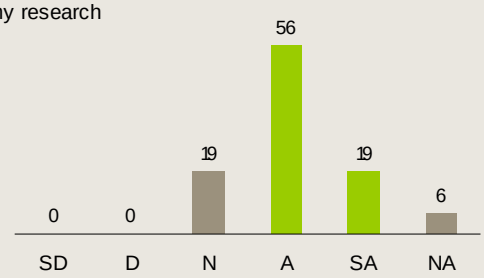
Q13:
I increased my professional collaboration with organisations both nationally and internationally



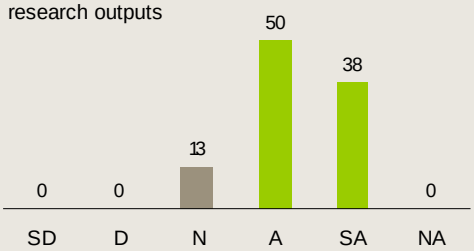
Q14:
I have trained others in the skills I learned



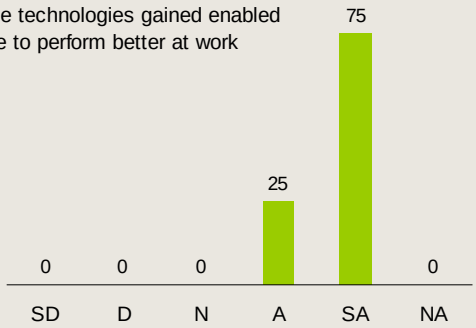
Q15:
I was able to secure additonal resources to expand or enhance my research



Q16:
The networks made have enabled me to produce better research outputs



Q17:
The technologies gained enabled me to perform better at work



Note: SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree; NA = not applicable

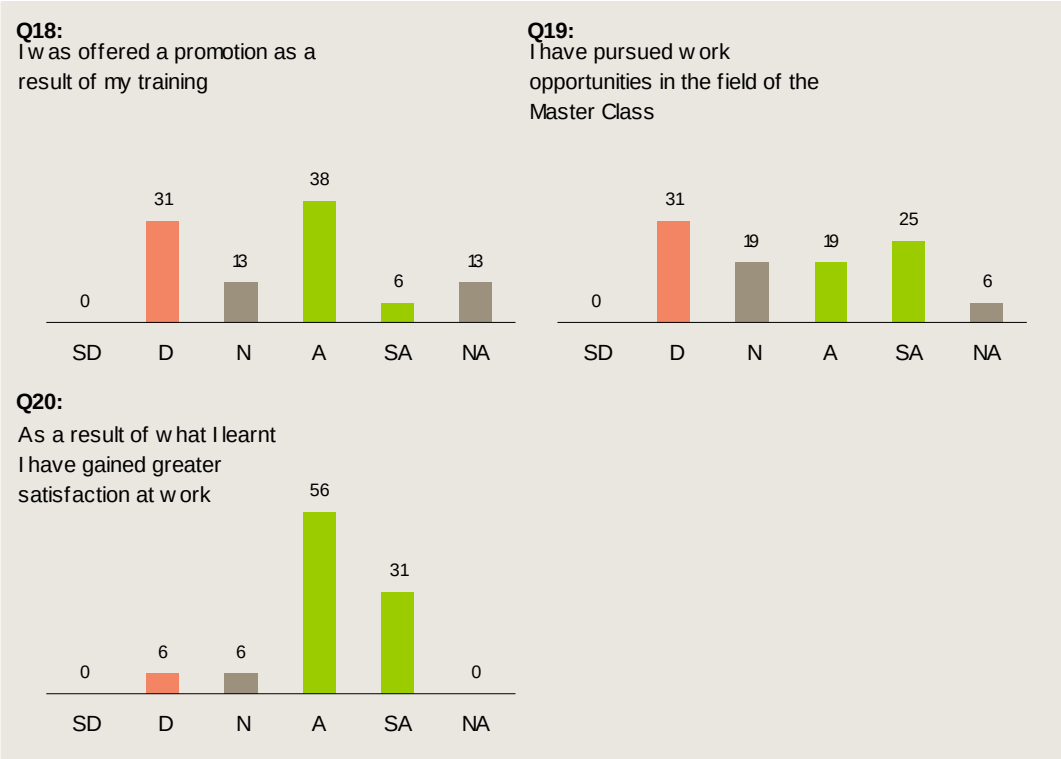
Data source: Survey results reported in Riley et al 2009.

Personal outcomes

In principle, some of the benefits from MC-style training may emerge as increased returns (higher income, better work opportunities or increased work satisfaction) to individuals trained. Responses to these questions are set out in chart 2.5. Individual promotion and individual pursuit of work opportunities were not an outcome for just under a third of respondents, although around 40 per cent appear to have been offered a promotion and just under half have pursued opportunities in the field of the MC.

Nearly 90 per cent consider that they have increased work satisfaction as a consequence of the MC.

2.5 **Questions related to personal outcomes** Percent of total responses



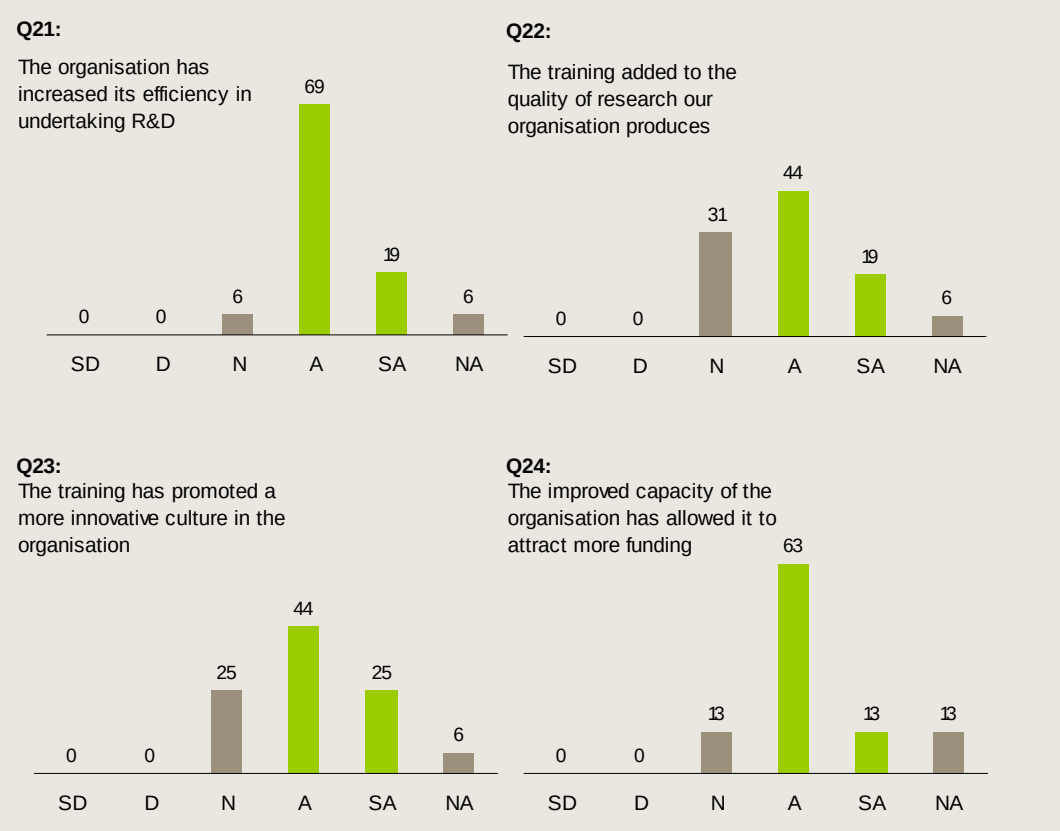
Note: SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree; NA = not applicable
Data source: Survey results reported in Riley et al 2009.

Organisational outcomes

Capacity building is also likely to have benefits at an organisational level by creating increased efficiency, improved innovation and increased research quality as participants apply their knew knowledge within the organisation. This part of the pathway is, of course, crucial to ultimately getting returns from the MC that can ultimately covert to outcomes for agricultural production.

As chart 2.6 indicates, most participants were very positive about these outcomes for their organizations. Almost 90 per cent considered that their organisational effectiveness has increased, while just over 60 per cent considered that the quality of the research had increased.

2.6 **Questions related to organisational outcomes** Percent of total responses



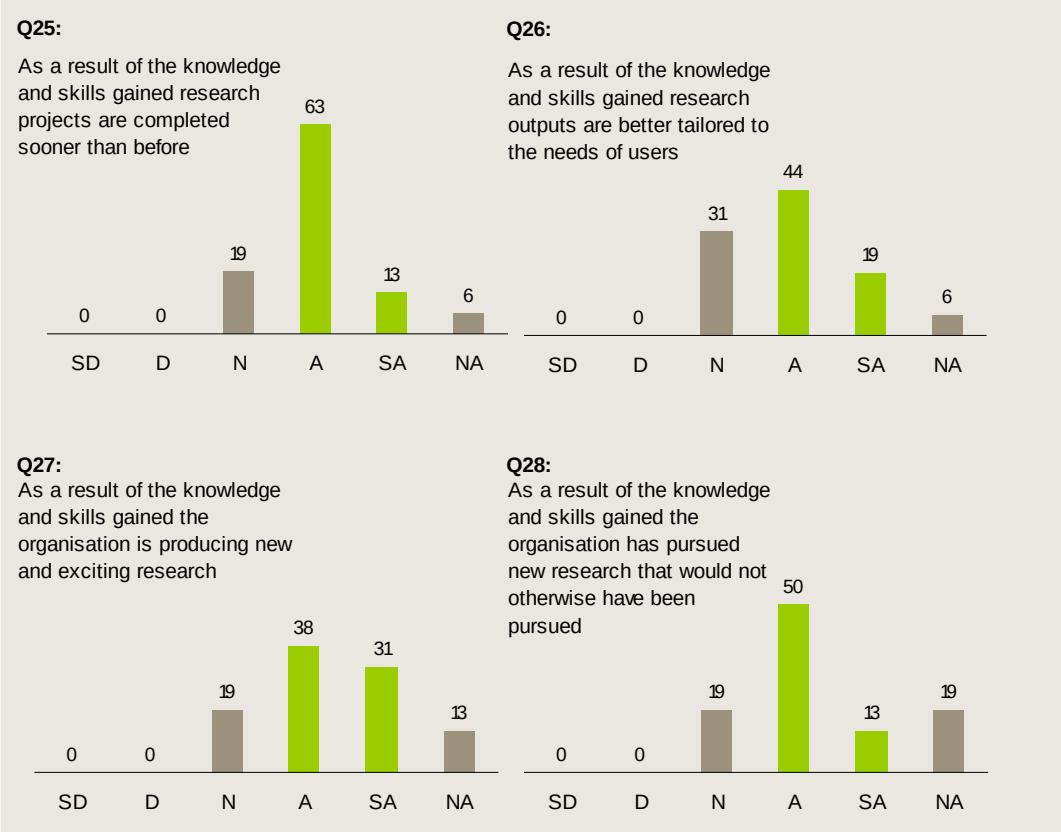
Note: SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree; NA = not applicable
Data source: Survey results reported in Riley et al 2009.

Research outcomes

The next impact pathway is through improved research outcomes arising either because of improved individual or organisational capacity. Participants views of research outcomes were again very positive (chart 2.7).

Of particular interest is that 63 per cent of respondents considered that as a consequence of the MC, the organisation pursued research that it would not otherwise have pursued. This particular outcome is considered in more detail below.

2.7 **Questions related to research outcomes** Percent of total responses



Note: SD = strongly disagree; D = disagree; N = neutral; A = agree; SA = strongly agree; NA = not applicable
Data source: Survey results reported in Riley et al 2009.

Some specific outcomes for evaluation

While the Soil Born Pathogens MC was designed to cover a range of specific pathogens of wheat, one of the major lines of impact of the MC has turned out to be the flow on implications of field trips undertaken during the MC. In the words of a recent review:

> Although a wide spectrum of wheat pathogens were considered, one highly significant aspect of this Master Class was its role in the recognition of cereal cyst nematode (CCN, *Heterodera avenae*) as a prevalent and potentially damaging pest in winter wheat on the Huang Huai flood plain (Zhengzhou where the Master Class was held is central to this area). (Riley et al 2009, p. 3).

Field trips were undertaken as part of the MC, and during these trips CCN was found to be more common than expected, with some evidence that CCN was an important pathogen affecting wheat growth. Subsequent surveys as part of the MC, confirmed these initial findings.

At the time of the MC, CCN was not considered an important pathogen of wheat in China. The findings within the MC, however, appear to have changed this perception significantly.

As documented in Riley et al (2009) following the MC a new series of research projects and research networks have been established in order to examine the CCN problem in considerably more detail. Riley et al consider that this increased focus is a direct consequence of the MC. In the following section, we will use this proposition as a means of providing an indicative valuation of the MC.

It is interesting to note that the flexible format of the MC contributed significantly to the flow on benefits from initially discovering CCN in the field trips. The initial discoveries of CCN led to restructuring of the MC program so that more field tests could be undertaken. Further, the careful selection of the participants meant that they realised the significance of the findings and part of the final week of the MC was spent planning a national program for Chinese research on CCN[4].

[4] Ferrar (2009).

3 Potential economic benefits of the MC

Approach

To provide indicative estimates of the value of the MC, we focus on the benefits that may arise through control of CCN in China.

CCN is clearly a threat to wheat productivity. Research into the problem continues, as does research into remedies. The current view appears to be that crop rotation and the use of resistant varieties will be the major tools for dealing with the pest. The use of resistant varieties in China is complicated by the fact that there is more than one type of pathogen involved.

Given that research into the problem continues (through a variety of funding sources), it is obviously difficult to estimate the economic benefits of managing CCN. The expectation at the moment is that the CCN damage is above economic thresholds, so that management will generate net benefits. The ultimate magnitude of benefits depends on yield losses actually avoided and the costs of the control measures. It is possible, however, to provide a broad indication of the magnitude of benefits that might be expected. From this, it is possible to assess the contribution of the MC to achieving these benefits.

Attribution

A key economic role of the MC has been in the provision of information and in the impetus to pursue a particular research program (which on the conservative estimates presented below appears likely to be very valuable). The value of the MC is its contribution to the value of the research program that ultimately emerges once the research leads to practical measures that can be adopted by farmers.

Clearly, the entire value of CCN control cannot be attributed to the MC — much additional value is yet to be added through subsequent research and extension work. But without the MC, understanding of the scope and significance of the issue may have been significantly delayed.

Research, training and technical improvements are all part of a chain of development that leads to ultimate economic benefits. These different points in the chain are clearly interdependent, and separating the marginal contribution of any one point is clearly problematic.

Here we adopt a common assumption (see, for example, Gordon and Chadwick 2007) of noting that the MC seems to have sped up interest in CCN in China. In that sense, the ultimate potential benefit of control of CCN will be realised sooner than otherwise. We use this approach as a means of obtaining a broad order of magnitude of expected benefits to the MC.

This estimate of benefits will clearly not have the rigor that might be required for due diligence in an investment portfolio, but nevertheless it provides an important indication that strategies such as the provision of Master Classes are capable of generating significant returns.

The benefits of a notional CCN control program

In line with standard evaluation practices (Alston et al 1998, Davis et al 2008), the benefits of a control program can be measured by calculating the present value (that is, the value today of a future stream) of the economic surplus generated by the control of CCN. For the analysis here, we use an open economy approach to generating the economic surplus for what is effectively a shift forward in the supply curve of wheat[5].

The expected benefits of control of CCN calculated in this way depend on:

- the probability of success in developing an economically viable control program;
- the magnitude of the yield increase (that is, yield loss avoided) achieved by the control;
- the increase in costs (for example, seed costs) required to achieve the yield increase;
- the extent of the crop that is subject to CCN losses;
- the adoption profile of the control technologies, including the maximum adoption rate and the time to achieving this maximum adoption;
- the producer price of wheat; and
- the discount rate using in putting future benefits in present value terms.

Table 3.1 sets out the assumption for each of these variables that are made here.

[5] The formulas used for the calculation are as set out in Appendix 5.1 of Alston et al (1998).

3.1 Key assumptions

Variable	*Assumption*
Probability of success	**70 per cent**, based on typical values used in impact assessments.
Yield increase (yield loss avoided)	**15 per cent**. Based on average 25 per cent yield reduction in Henan (Peng et al 2008 report 10 to 40 per cent in Henan) and 10 per cent in other regions (Peng et al 2008 report 0.4 to 17 per cent in Hebei). The weighted average is approximately 15 per cent. Note that yield loses reported in other countries are a similar order of magnitude (15 to 20 per cent in Pakistan, 20 to 50 per cent in Australia and 15 to 40 per cent in the US — see Nicol 2002 and Smiley et al 2007).
Increase in costs	**10 per cent**, designed to capture the effect of increased seed costs (for resistant varieties) or the effect of crop rotations. This is a broad estimate only. Note that the assumption of cost increase is constrained by the assumption that control is economic.
Extent of crop covered	**2.7 per cent of production in 11 regions** where CCN has been detected. Based on Riley et al (2009) for percent of production affected and on Peng et al (2008) for provinces covered. Data from the China Statistical Yearbook suggests this corresponds to approximately 70Mt
Adoption profile	Based on S-curve (logistic function) with **maximum adoption of 90 per cent** and **half of full adoption achieved after 11 years**. This is adjusted to simulate the impact of the Master Class.
Producer price of wheat	**US$220 per tonne**. Based on FAO data and converted to A$275 for reporting.
Discount rate	**5 per cent**, based on a typical values used in impact assessments

Source: CIE estimates

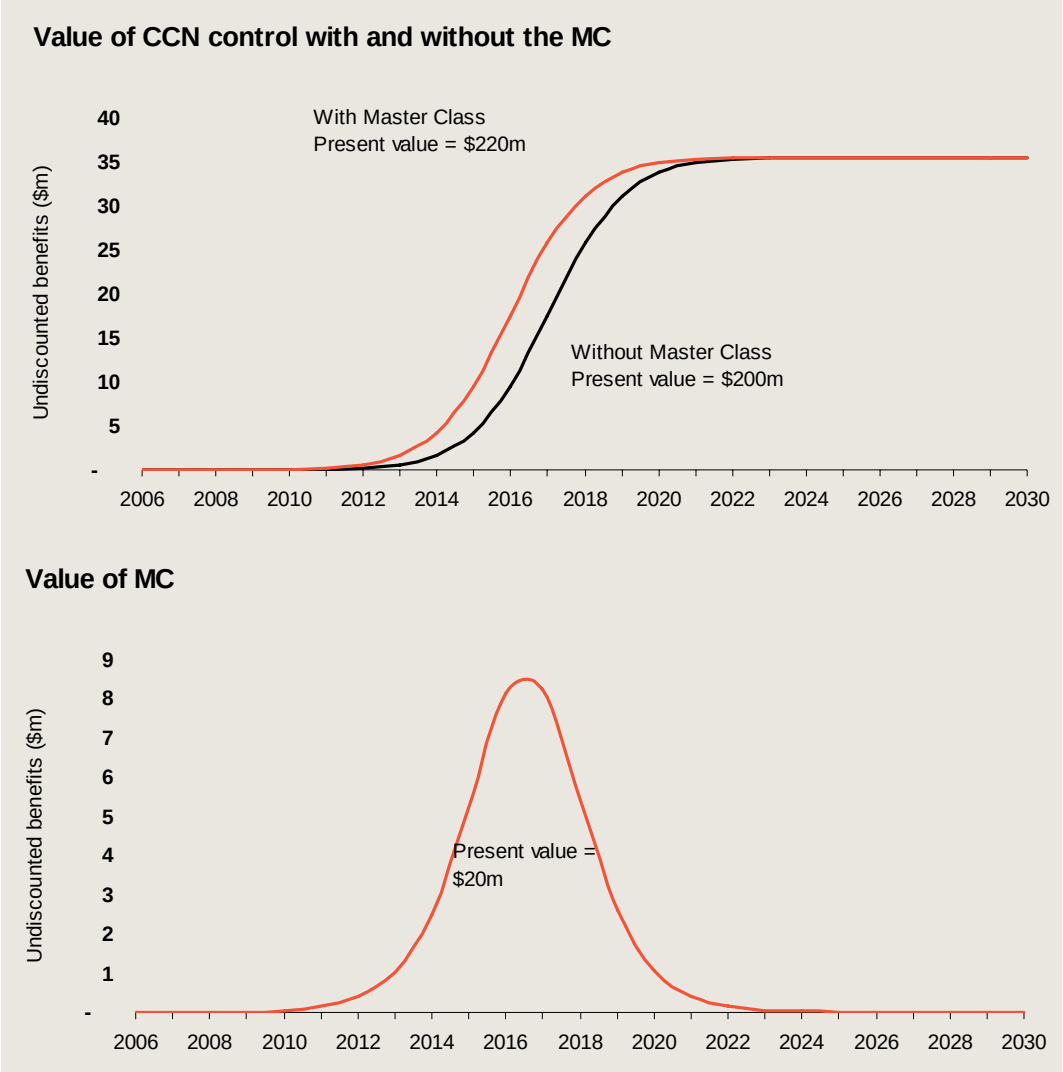
Using these assumptions, a notional CCN control program generates a present value of benefits of around $200 million. These assumptions, particularly the adoption rate in early years, are conservative.

Benefits of the Master Class

Assuming that the benefits from the MC emerge by bringing the time profile of benefits forward, then for a given yield improvement and probability of success, the benefits of the MC depend on the number of years that the benefits are brought forward.

To be conservative, we assume that these benefits are brought forward by one year. Chart 3.2 illustrates the implications of this in terms of the flow of benefits from CCN control with and without the master class (the top panel) and in terms of the flow of benefits from the MC itself (annual benefits being the difference, shown in the bottom panel.

3.2 Indicative benefits from the Master Class



Data source: CIE estimates

The present value of the benefits of the MC estimated in this way — under the assumptions set out above — is $20 million.

Clearly the actual magnitude of these benefits depends on a number of assumptions, but significant benefits emerge for a wide variety of assumptions. For example:

- if the ultimate CCN control adoption rate is as low as 20 per cent, the benefits of the MC are $4 million;
- if the yield improvement (yield loss avoided) is halved (set at 7.5 per cent, with a proportionate reduction in the change in costs), the benefits of the MC are $9 million.

Even at the lower end, these benefits are very large relative to the direct and indirect expenditure associated with the MC[6].

Benefits to Australia

The benefits quantified above accrue to producers and consumers within China. While more indirect, there are benefits to Australia that arise from the MC. CCN is a significant problem across eastern Australia and is detected in the Northern and Central regions of Western Australia (Wherret and Vanstone 2009).

From a research perspective, the new knowledge gained in understanding more of the of the genetic variety and distribution of CCN, as well as potential knowledge of additional wheat varieties that are resistant to CCN, may prove to be of value to Australian researchers in the future.

From a training perspective, the informal contacts made during the MC will also benefit Australian scientists by increasing the pool of plant pathologist they are able to correspond and communicate with. This will, of course, be an important factor in delivering the potential research benefits noted above.

The control of CCN (facilitated by the MC) is likely to lead to an increase in Chinese wheat production. In some senses, this may be viewed as direct competition with Australian production, potentially lowering Australian wheat export receipts. This is, however, quite a narrow perspective. A consequence of improved Chinese wheat productivity is an increase in Chinese income. Having more wealthy trading partners is unambiguously beneficial to the Australian economy — although the magnitude of this benefit is very difficult to estimate.

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[6] The Crawford Fund spent around $70 000 on the MC. There were, however, a number of other sources of funding and it is, of course, appropriate to include the opportunity cost of the participants themselves. Assuming that other agencies contributed about the same as the Crawford Fund, and including opportunity costs of participants, the total cost of the MC was probably around $200 000.

4 Conclusions

There are a number of pieces of evidence and analysis that suggest the MC on soil borne pathogens has had a major and important impact.

First, the MC covered a number of internationally recognized crop production issues some of which — in particular the cereal cyst nematode — were not previously as recognised as problems in China.

Second, the MC brought together leading international and national expertise on soil borne pathogens and combined these with well-selected participants. This provided a major opportunity of leading expertise to be distributed more widely in China.

Third, reviews to the MC to date have all been positive and in recent survey responses from 16 of the 21 participants, the respondents themselves rated the MC very highly in terms of the training and its benefits at the individual, organisational and research levels.

Finally, there is strong evidence to suggest that the MC directly lead to increased awareness of a very high prevalence and economic impact of the cereal cyst nematode in wheat production in China. The MC has directly lead to increased research effort on this issue, which has the potential to increase wheat yields in China.

Indeed, conservative estimates indicate that controlling CCN in China will lead to significant economic benefits over time. The MC can reasonably claim a share of these benefits. Assuming that the MC has lead to bringing these benefits forward by only one year yields estimates of the benefits of the MC of around $20 million. This is a very high return for the relatively low outlay.

While the magnitude of this estimate should be treated as indicative, it does illustrate the potential leverage than can arise from capacity building activities within a research chain. In the case of the MC, this leverage arose as a consequence of the flexible structure of the program and as a consequence of the very careful selection of participants.

While they are more indirect, the MC is also likely to have lead to benefits to Australia: through increased knowledge and research networks, but also through the benefits that inevitably result from increased income of a trading partner.

References

Alston J, Norton G and Pardey P 1998 *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*, CAB International and International Centre for National Agricultural Research.

Davis J, Gordon J, Pearce D and Templeton D 2008 *Guidelines for assessing the impact of ACIAR's research activities*. ACIAR Impact Assessment Series Report No. 58.

Ferrar P 2009, personal communication, 1 September.

Ferrar P and Ryder M 2005 *Report on International Master Class on Soil Borne Pathogens of Wheat* The Crawford Fund, August. Accessed August 2009, http://www.crawfordfund.org/training/pdf/soilborne.pdf.

Gordon J and Chadwick K 2007 *Impact assessment of capacity building and training: assessment framework and two case studies*. ACIAR Impact Assessment Series Report No. 44, February.

Nicol JM 2002 *Important Nematode Pests* in Curtis B, Rajaram S, and Macpherson H (eds) *Bread Wheat Improvement and Production*, FAO Plant Production and Protection Series No. 30. Accessed August 2009, http://www.fao.org/DOCREP/006/Y4011E/y4011e00.htm#Contents.

Nicol JM, Burgess LW, Riley IT, Wallwork H 2009 *The ATSE Crawford International Master Class series on soil borne pathogens of wheat*. In *Proceedings of the Rovira Rhizosphere Symposium - Celebrating 50 years of Rhizosphere research*. (Eds VVSR Gupta, M Ryder, J Radcliffe) (The ATSE Crawford Fund, Melbourne, Australia) [in press].

Peng DL, Nicol JM, Ou SQ, Zhang D, Chen SL, Riley IT, Waeyenberge L. Moens M. 2008 *Cereal cyst nematodes: a threat and challenge to food safety in China*. Fifth International Congress of Nematology, 13-18 July 2008, Brisbane, Australia, p. 169.

Riley I, Honglian L, and Wenhua T 2009 *Impact of international training on soil borne pathogens of wheat in China, with special consideration of cereal cyst nematode (Heterodera avenae)* Report to the ATSE Crawford Fund, July.

Smiley R, Sheedy J, Pinkerton J, Easley S, Thompson A and Yan G 2007 *Cereal Cyst Nematode: Distribution, Yield Reduction and Crop Management Strategies* in Oregon State University Agricultural Experimental Station *2007 Dryland Agriculture Research Annual Report*. Accessed August 2009, http://extension.oregonstate.edu/catalog/html/sr/sr1074-e/.

Wherret A, Vanstone V 2009 *Cereal Cyst Nematode*, available at www.soilquality.org.au/documents/9/original/Biol_-_Cereal_Cyst_Nematode_web.pdf. Accessed September 2009.