Hidden value of CGIAR training programs for national research capacity

A case study of CIMMYT's impact on China's wheat R&D productivity

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WHEAT (http://wheat.org) is a CGIAR Research Program launched in 2012 and led by the International Maize and Wheat Improvement Center (CIMMYT). Coupling advanced science with field-level research and extension in lower- and middle-income countries, WHEAT works to raise wheat productivity, production and affordable availability for 2.5 billion resource-poor consumers who depend on the crop as a staple food. Partners include the Australian Centre for International Agricultural Research (ACIAR), the British Biotechnology and Biological Sciences Research Council (BBSRC), the International Center for Agricultural Research in the Dry Areas (ICARDA), the Indian Council of Agricultural Research (ICAR), and a community of more than 200 public and private organizations worldwide, among them national governments, companies, international centers, regional and local agencies and farmers. Funding for WHEAT comes from CGIAR and generous donors including national governments, foundations, development banks and other public and private agencies.

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Executive summary

Most studies on agricultural R&D expenditure have focused on its impact on agricultural productivity rather than on human research capacity. Impact assessments of CGIAR training have been qualitative and indicative and based mainly on the perceptions of selected trainees. More quantitative analyses are needed to identify CGIAR impacts on national agricultural research systems (NARS) capacity.

This study assesses the impact of CGIAR training programs on NARS research capacity using CIMMYT's wheat training program as a case study. We conducted both descriptive and quantitative econometric analyses on the academic performance of a group of trainees before and after training. We also compared the academic performance of the trainees to that of average scientists at each trainee's institute. Moreover, based on an opinion survey, we gained insights on how the training may have impacted the trainees' research capacity.

In general, our survey shows that CIMMYT has provided a large and increasing number of training opportunities for Chinese scholars in the past four decades. Visiting scientist fellowships and training courses have been the traditional and major means of providing wheat training. In addition, postgraduate and postdoctoral fellowships have been increasing since the early 1990s. The trainees tend to be younger and also include a growing number of female participants and more participants from universities.

Impact assessment was conducted based on five major indicators of research capacity. They include the ability to obtain research funding and five indicators of academic performance, including number of publications in domestic (in Chinese) and international journals, patents obtained, science and technology (S&T) awards, and wheat varieties bred. The results show that CIMMYT training programs have improved the trainees' academic performance and their ability to obtain research funding. The graduate and postdoctoral training program and the visiting scientist program had significant impact on the trainees' academic performance, as evidenced by their ability to publish more papers in both Chinese and international journals, their capacity to obtain more patents, and their overall contribution to wheat science and technology measured by the number of S&T awards given by the government. However, no significant impact of the regular training course on the trainees' academic performance was found in this study.

The findings on the impact of training are largely supported by the results of the trainees' opinion survey. The majority of trainees highly appreciated how CIMMYT's training influenced their careers. Most of them claimed that the training helped them acquire new scientific knowledge and technology, improve their research and work experiences, access more germplasm resources, and develop a good research network. They believe that the training programs have significantly contributed to China's wheat technological changes and that CIMMYT could play a more important role by expanding its training program and collaborative work in China in the future.

The findings of this study do have several policy implications. First, the most direct implication is that CIMMYT should continue to enhance its training program and prioritize its efforts in the graduate program, postdoctoral fellowships and the visiting scientist program. Second, while the results of this study are for CIMMYT's wheat training in China only, we recommend that all or most CGIAR centers should seriously consider making their training programs a top priority. Of course, rigorous impact analyses of different types of training programs should be conducted. Third, as a significant beneficiary of CIMMYT's wheat training program, China may need to revisit its current R&D investment priorities. Investing in the

CG's training program to improve its domestic research capacity could be a good option. Last but not least, despite the significant increase in funding to support CGIAR research programs in recent years, resources allocated to the training programs has not been promising. The significant hidden value and impact of CIMMYT's training program on the trainees' academic performance in China should have important implications for major international donors who are interested in increasing the CGIAR's impacts through its unique role in improving NARS research capacity.

1. Introduction

China's ability to feed its growing population with rising income has been impressive. From 1978 to 2013, China's agricultural GDP grew at an average annual rate of 4.26%, a pace 4.23 times higher than its population growth rate (NBSC, 2013), indicating a substantial increase in per capita domestic food supply in the past 35 years. Although this rapid growth in income also significantly increased overall food demand, China became a net food exporter by the late 2000s (Yang et al., 2012).

While China's agricultural success over more than three decades has come from several major driving forces, agricultural technology change has been a primary source of agricultural growth. Although growth in agricultural production was largely due to the de-collectivization of collectively owned land to individual households in the early reform period (1979-1984) (Lin, 1992), the empirical literature shows that technological change has been the main driver of productivity growth since the mid-1980s (Huang and Rozelle, 1996; Fan and Pardey, 1997; Jin et al., 2002).

Technological change depends heavily on agricultural research and development (R&D). China's agricultural R&D is unique in many ways. It is a large public system. Its research staff increased from about 22,000 in 1979 to a peak of 102,000 in 1985 (Huang and Hu, 2008) and remained at about 95,000 from 2005 to 2010 (Huang et al., 2012). More than 65% of scientists work in the crop sector, mostly rice, wheat, and maize (Huang and Rozelle, 2014). Both China's agricultural R&D investment and research capacity have grown significantly since the late 1990s.

Previous studies have focused on agricultural R&D expenditure and its impact on agricultural productivity (Jin et al., 2002; Fan and Pardey, 1997), but few have focused on human research capacity. To our knowledge, no study has addressed the impact of improved human research capacity on research productivity. In China, improved human research capital is the result of both domestic and international training (He et al., 2003; Yuan, 2011; Zhao and Li, 2010). Many Chinese scholars returning from overseas (or haigui) have achieved prominent positions and led Chinese R&D in several fields (Miao, 2003).

Among agricultural scholars returning from overseas, those trained at the Consultative Group on International Agricultural Research (or CGIAR) are both unique and numerous. Thousands of Chinese scholars, particularly young ones, have participated in CGIAR training programs since the early 1960s, particularly the training programs offered by the International Maize and Wheat Improvement Center (CIMMYT) (Swanson, 1975; Cooksy and Arellano, 2006) and the International Rice Research Institute (IRRI) (Molina et al., 2012).

Several previous studies have attempted to document the likely impacts of CGIAR training programs and identify what needs to improve in the training programs in the future. For instance, Villareal and Toro (1993) documented the impact and needs of CIMMYT's training courses. Cooksy and Arellano (2006) examined the impacts of CIMMYT's formal training activities based on a survey of former trainees, NARS research leaders and CIMMYT scientists. Molina et al. (2012) documented the trends and achievements of both M.Sc./Ph.D. programs and nondegree training programs at IRRI, and evaluated their benefits based on case studies. However, these impact evaluations were mainly qualitative and indicative, with many discussions of benefits and impacts based on the perceptions of the selected individuals. More quantitative analysis is needed to identify the actual impact on NARS research capacity.

The overall goal of this study is to quantitatively assess the impact of CGIAR training programs on NARS human research capacity using CIMMYT's wheat training program as a case study. Wheat, China's second-largest food crop after rice, recorded the highest growth in yield among all grain crops (i.e., rice, wheat, maize, and soybeans) in the past three decades (NSBC, 2013). A recent study showed that CIMMYT germplasm has contributed significantly to wheat total factor productivity in China (Huang et al., 2014). However, CIMMYT's contribution to China's wheat production may include far more than the impact of its germplasm. Human capacity building is thus an area worth analyzing.

To achieve the above goal, this study has the following three objectives: (1) to document the types and trends of CIMMYT training programs attended by Chinese scholars; (2) to identify the impact of CIMMYT training on the human capital and productivity of the trainees through a quantitative analysis; and (3) to gain more insight into the benefits obtained by the trainees and identify what they need from the CIMMYT training program.

The report is organized as follows. Data and sampling designs are presented in section 2. Section 3 provides a brief overview of CIMMYT wheat training programs. Descriptive analyses of the impacts of the training program are presented in section 4, and quantitative impact assessment modeling is developed and quantitative impacts are evaluated in section 5. To understand the likely impact mechanisms, section 6 presents the trainees' views on the major benefits they obtained from the training. The last section describes several of the study's policy implications.

2. Data and sampling designs

This study uses four datasets. The first dataset includes information on all Chinese scholars who have participated in CIMMYT's wheat training programs (Dataset 1). The second dataset includes the individual academic performances of the trainees who participated in CIMMYT's wheat training programs lasting more than two months (Dataset 2). The third dataset is from a survey on the trainees' average performance at the institutes where they work (Dataset 3). The fourth dataset includes trainees' views on CIMMYT training programs (Dataset 4).

Dataset 1 includes basic information (e.g., gender, type and duration of training, and the originating institution or affiliation) about all the participants. The data was obtained from CIMMYT's China Office. Significant efforts were made to identify each participant's information,[1] and 350 Chinese scholars were confirmed to have participated in CIMMYT wheat training programs from 1977 to 2012, totaling 417 training events, with some candidates participating in training multiple times (Table 1).

Dataset 2 comprises the academic performance of CIMMYT's wheat training participants who completed at least two months' training before the end of 2010. It is used to analyze the impact of the training program on the trainees' academic performance. The data were obtained from a survey conducted through the regular mail followed by

Table 1. A summary of all participants at the time training started.

	Total	By starting period			
		1970-1979	1980-1989	1990-1999	2000-2012
	(1)	(2)	(3)	(4)	(5)
Number of participants[a]	350	5	67	109	191
Total training events	417	6	71	128	212
By gender					
Male	314	6	60	110	138
Female	103	0	11	18	74
By duration					
< 2 months	270	6	44	78	142
[2 months, 1 year)	95	0	25	44	26
[1 year, 2 years)	15	0	2	3	10
≥2 years	37	0	0	3	34
By affiliation of origin					
Institute	294	0	58	110	126
University or college	66	0	3	9	54
Government agency	29	1	0	7	21
Other[b]	28	5	10	2	11

Source: CIMMYT's China Office & Training Office.

[a] Some trainees visited CIMMYT more than once, with each training starting in different periods (e.g., during1990s and 2000s). Therefore, for the number of participants, (2) + (3) + (4) + (5) ≥ (1).

[b] Includes participants from companies and those for whom we couldn't obtain any information.

Detailed data by year are presented in Appendix Table 3.

[1] CIMMYT's Global Wheat Program, Genetic Resources Program, Global Maize Program, Socioeconomic Program, Applied Biotechnology Program, and Global Conservation Agriculture Program offer training programs. We limited our sample to trainees who participated in the wheat training program and other programs related to wheat. As the names of all the participants were recorded in Chinese Pinyin and as the type of training was not indicated for some participants, we spent much time identifying whether each person was involved in training programs related to wheat.

intensive phone and personal communications. In this dataset, we excluded participants who received less than two months training for the following reasons. First, the participants who received less than two months training (from 2 to 59 days) are very diverse, including scholars, administrative officials at research institutes or universities, company managers and government officials. Given that this study focuses on the impacts of training on academic performance, this requires sampling trainees mainly from research institutes and universities. Second, the impact of such short training (less than 2 months) on academic performance (see below) would be difficult to identify. As Dataset 2 is designed to be used for impact assessment, we also excluded recent participants who did not finish their training before the end of 2010. Based on these sample design criteria, we reduced the survey sample (or scholars) from 350 to 116 (Appendix Table 1). However, 43 of the 116 trainees could not be reached because two had died and contact details for the other 41 were not available (Appendix Table 1). In the end, we conducted the survey on the remaining 73 participants and obtained 67 valid questionnaires (6 of the 74 participants did not return their questionnaires; see Appendix Table 1). To check whether the selection was biased, we compared the characteristics of 67 respondents and the 49 (43+6) that were missing. The results presented in Appendix Table 2 show that there are no systematic differences between these two groups of participants, suggesting that the 67 respondents are largely representative of all 116 trainees.

In Dataset 2, besides individual characteristics, academic performance includes five major indicators: (1) research projects; (2) publications; (3) patents obtained; (4) science and technology (S&T) awards received; and (5) wheat varieties bred. Data on research projects include the number and funding of research projects led or engaged in by each of the 67 trainees in 2012. For all other performance indicators, data cover the period since the respondent started his/her first job.[2] Publications include only papers published in domestic journals (in Chinese) included in the CNKI (one of the most complete records of Chinese publications), and journals listed in the Science Citation Index (SCI) found on the Web of Science. The patents were obtained from the Patent Information Search and Query System of the State Intellectual Property Office of the PRC. The S&T awards include only the top three types of awards given by the government.[3] Our survey also includes information on wheat varieties bred and released (for short, wheat varieties thereafter) by each respondent in each year.

Dataset 3 includes basic information and performance indicators for the institutions where the trainees identified in Dataset 2 have been working. This dataset is used to compare the average performance (per scientist) of the institute with that of the trainee(s) from the institute. Currently, the 67 respondents (or trainees) included in Dataset 2 belong to 37 institutes. After excluding those trainees who changed their affiliation during the studied period and those whose affiliations lacked data or who failed to provide their institution's performance data, Dataset 3 ended up with 47 trainees and their 18 affiliations for the period 2000-2012.[4] As in Dataset 2, data on the institutes' performance also include: (1) research projects; (2) publications; (3) patents obtained; (4) science and technology (S&T) awards received; and (5) wheat varieties bred. Sources of data and survey methods are the same as those discussed in Dataset 2.

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[2] For respondents who participated in CIMMYT M.Sc. and Ph.D. degree training programs and had not begun a formal job before the program, the beginning year was set as the year when the trainee's academic performance was first recorded. For respondents who were not conducting research work when they were surveyed (e.g., being retired, doing administrative work, or working for a company), the ending year was set as the year when he/she stopped his/her research work.

[3] Specifically, they include the top three types of national S&T awards (i.e., State Natural Science Award, State Technological Invention Award, State Scientific and Technological Progress Award) and provincial and ministerial S&T awards (i.e., Natural Science Award, Technological Invention Award, Scientific and Technological Progress Award, Science and Technology Achievement Award, and other S&T awards).

[4] Of the 18 institutes, 11 institutions have data from 2000 to 2012), one has data from 2002 to 2012, another has data from 2003 to 2012, 3 institutes have data from 2005 to 2012, one has data from 2008 to 2012, and one has data from 2009 to 2012.

Dataset 4 includes trainees' views on the value of CIMMYT's training programs. The data were collected through an opinion survey covering two sub-samples. The first sub-sample (Group 1) includes the 67 trainees in Dataset 2. The second sub-sample (Group 2) is designed to cover the trainees who were excluded from Group 1, which includes only those with more than 2 months training completed before the end of 2010. Therefore, Group 2 includes trainees with less than 2 months of training (16 samples randomly selected) and trainees who completed their training after 2010 (14 samples randomly selected).[5] When the final 30 questionnaires were collected, the full sample totaled 97 (67+30) for Dataset 4.

[5] While the trainees were randomly selected, they are from a list of scholars who have been keeping in touch with CIMMYT's Beijing Office. One could argue that this sample includes trainees who have maintained close contact with CIMMYT.

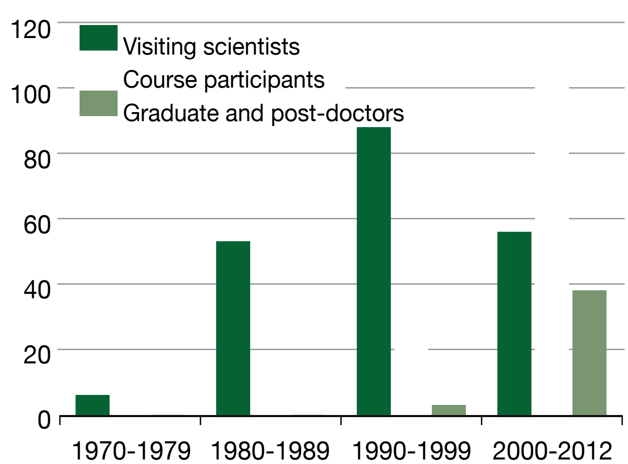
3. Overview of CIMMYT wheat training programs

Although CIMMYT offers various training programs, we limited our study to training programs related to wheat (see footnote 1). The following is a brief introduction to CIMMYT wheat training programs based on Datasets 1 and 2. Detailed data are presented in Appendix Table 3.

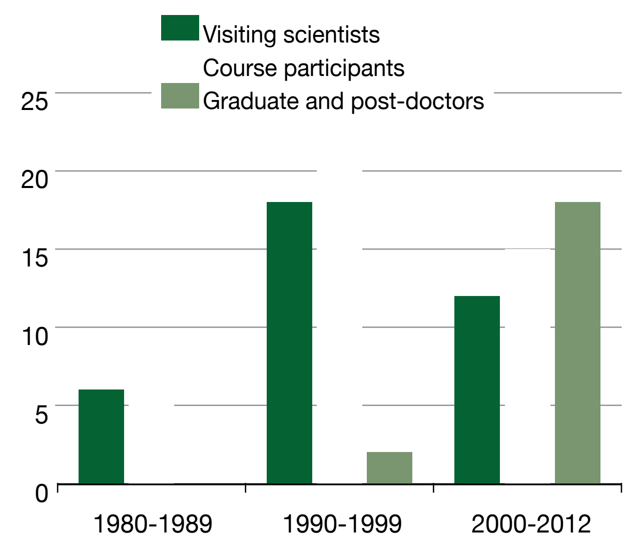
Over time, the total number of Chinese trainees has risen significantly (Table 1). For example, while only 5 Chinese scholars participated in CIMMYT's wheat training programs in 1970-1979, that number rose to 67 in 1980-1989, 109 in 1990-1999, and 191 in 2000-2012 (row 1, Table 1). For the entire 1970-2012 period, 350 scholars participated in 417 training events. For participants with more than 2 months of training, the major increase occurred in the 1990s (rows 1 and 2, Table 2).

Chinese scholars participated in a range of training and visiting programs (Figure 1). They can be broadly categorized into three types: visiting scientists, short-course participants, and graduate and postdoctoral fellows. The first visiting wheat scientist came to CIMMYT in 1977. Since then, 170 wheat scholars from China had participated in 203 visiting scientist appointments (Figure 1 and Appendix 3). Wheat training courses for Chinese scholars started in the early 1980s. By 2012, Chinese scholars had participated in 173 training courses (Appendix Table 3). Training activities for visiting scientists and short-course trainees lasted from two days to two years. Before 2000, most training participants were visiting scientists, but short-course participants have predominated since then (Figure 1). While the first Chinese graduate conducted his Ph.D. thesis research on wheat at CIMMYT in 1991, this did not occur again until CIMMYT established its China Office in 1997. There have been many graduate training opportunities for Chinese students since 2000 (Figure 1). Interestingly, they have been provided mostly by CIMMYT's China Office. Postdoctoral positions are not common. Only four wheat scholars in our sample are in this category. Because postdoctoral and graduate programs have similar training duration and only a few postdoctoral fellows, we put them together as one group: graduates and postdoctorates.

CIMMYT wheat training programs started including more women and young researchers from universities and colleges. As shown in Table 1, although the overall training programs were male-dominated during the entire 1970-2012 period (75% or 314/417, column 1), the share of female participants increased from 0% in 1970-1979 to about 15% in 1980-1990, and 35% (74/212) in 2000-2012 (rows 2 and 4, Table 1). A similar rising



Source: CIMMYT's China Office & Training Office.
Figure 1. Number of participants by program (350), 1970-2012



Source: Authors' survey.
Figure 2. Number of participants by program (67 trainees), 1980-2012

trend in female participation has also occurred for trainees with more than 2 months training (row 4, Table 2). Moreover, since the 1990s, most trainees have been young scholars under the age of 40, and have tended to be even younger in the 2000s (Table 2). Meanwhile, the share of trainees from universities and colleges rose significantly in the 2000s, indicating an intense collaboration between CIMMYT and China (Tables 1 and 2). In addition, in recent years, training has tended to involve more scholars from graduate programs and more junior scholars (e.g., the position of associate professor or lower) (Table 2).

Looking at the current status of the trainees we surveyed, many participants have become mainstays of China's wheat research program and most have been promoted to higher positions. For example, Jianjun Liu, a visiting scientist in the early 2000s, is now one of China's best-known wheat breeders at the Shandong Academy of Agricultural Sciences. Yuejian Li, a course participant in the late 1980s, has been president of the Sichuan Academy of Agricultural Sciences. Zhonghu He, the first Chinese postdoctorate at CIMMYT, has been a leading scientist, director of the National Wheat Improvement Center and head of CIMMYT's China Office. Table 3 presents general information such as affiliation, education, title, major work, and field of specialization on the 67 respondents in 2012. At that time, the majority were still conducting scientific research on wheat at research institutes, universities or colleges. Compared to the share of Ph.Ds. (16%, 16/101, see Table 2) and professors (16%, 16/101, see Table 2) at the time they attended training, 54% (36/67) of them had obtained a Ph.D. degree and 63% (42/67) had become professors by the end of 2012 (Table 3).

Table 2. Characteristics of participants with more than two months training, at the time training started.

		By starting period		
	Total (1)	1980-1989 (2)	1990-1999 (3)	2000-2012 (4)
Number of participants[a]	67	10	32	37
Total training events	101	12	43	45
By gender				
Male	77	12	36	29
Female	23	0	7	16
By age				
≤ 30	29	4	8	17
31-40	51	1	29	21
41-50	11	5	2	4
≥ 51	9	2	4	3
By affiliation				
Institute	85	11	40	34
University or college	15	1	3	11
By degree				
Ph.D.	16	0	7	9
M.Sc.	46	3	18	25
Other[b]	38	9	18	11
By academic title				
Professor	16	0	7	9
Associate professor	29	2	11	16
Other[c]	56	10	26	20

Source: Authors' survey.

[a] Some trainees visited CIMMYT more than once, with each training starting at different periods (e.g., during1990s and 2000s). Therefore, for the number of participants, (2) + (3) + (4) ≥ (1).

[b] Includes bachelor degree or no degree.

[c] Includes advanced agronomist, lecturer, assistant professor, and no title.

Table 3. The current (2012) characteristics of participants with more than two months of training.

		By type of training[a]		
	Total (1)	Visiting scientists (2)	Short-course participants (3)	Graduates and postdoctorates (4)
Number of participants	67	23	39	19
By affiliation				
Institute	55	19	35	13
University or college	11	3	3	6
Company	1	1	1	0
By degree				
Ph.D.	36	11	19	15
M.Sc.	22	7	13	4
Other[b]	9	5	7	0
By title in the faculty				
Professor	42	20	27	7
Associate professor	15	2	10	5
Other[c]	10	1	2	7
By major work				
Scientific research	53	17	32	15
Teaching	4	0	2	2
Other[d]	10	6	5	2
By field of specification				
Wheat breeding	38	12	22	13
Wheat cultivation	2	2	1	0
Wheat germplasm resources	7	2	5	1
Non-wheat crops research	9	0	6	3
Crop model	1	1	0	0
Other[d]	10	6	5	2

Source: Authors' survey.

[a] Some scholars attended more than one type of CIMMYT training program (e.g., visiting scientist training and short courses). Therefore, (2) + (3) + (4) ≥ (1) for the number of respondents.

[b] Includes bachelor degree or no degree.

[c] Includes senior agronomist, lecturer, assistant professor, and those without title.

[d] Includes administrative staff, retiree, and graduate, etc.

4. Descriptive analysis of the impacts of CIMMYT wheat training programs

This section presents the outcomes for the 67 respondents based on Datasets 2 and 3. Descriptive statistics are used to provide likely evidence of the impact of training on trainees' academic performance, their ability to obtain research funding, papers published in Chinese journals and SCI-listed journals, patents obtained, major government S&T awards received, and number of wheat varieties bred. To gain more insight on the impacts of different training programs, we further analyzed data by type of training program attended.[6]

On the ability to obtain research funding, we compared the number and budget of the respondents' research projects with the average figures per scientist at their institutions in 2012. Results in Table 4 clearly show that the ability of the trainees to obtain research funding is significantly higher than the average level of scientists at their institutions (research institutes and colleges). On average, each of the 67 led or participated in 5.8 projects with a total budget of 1.727 million RMB (or about USD 274,000) in 2012, while their institutes' average number of projects per scientist was only 1.3 with a total budget of 0.5 million RMB.[7] Those who were once visiting scientists at CIMMYT enjoyed the highest funding (2.171 million RMB), especially when they were the project PIs (Table 4). As for the scientists who once took a short course at CIMMYT, although both the total funding and the budgets of their PI projects were lower than those of the visiting scientists, the numbers were still much higher than the average at their institutes. Among the three types of trainees, graduate and postdoctoral scholars had the lowest project numbers and budgets, perhaps due to the academic status of the participants, who tend to be associate professors, lecturers, or lower (Table 3). However, their ability to obtain research funding as project PIs was still much higher than the average level at their institutes.

With data for consecutive years, we can compare the trainees' academic performance before and after their training. Table 5 reports the respondents' (or trainees') annual performance in terms of total number of publications, patents obtained, S&T awards received, and wheat varieties bred (as the PI) for all trainees before and after training. Overall, Table 5 shows that the respondents performed better on most of the above four indicators after participating in CIMMYT's training programs. For example, they published 139 Chinese journal

Table 4. Number of projects and research funding (thousand RMB) per scientist for the respondents and their institutions in 2012.

		The trainees by type			
	Average	Visiting scientists	Short-course participants	Graduates and postdoctorates	Averages at their institutions
Number of projects	5.8	4.0	7.0	4.6	1.3
Funding	1727	2171	1865	1169	533
As project PI:					
Number of projects	2.3	1.8	2.7	1.7	0.7
Funding	1336	1903	1331	956	314
As project member:					
Number of projects	3.5	2.2	4.3	2.9	0.6
Funding[a]	391	268	534	213	219

Source: Authors' survey.

[a] Includes only the funds managed by the respondent. The exchange rate was 6.31RMB/USD in 2012.

[6] If a trainee participated in more than one training program, he/she is grouped into the one with the longest training time.

[7] Note: the number and budget of research projects in 2012 may include some budgets to be expensed in the following year.

articles one year after training ($P_{[t+1]}$), which was higher than what they published one year before training (103, $P_{[t-1]}$) or two years before training (124, $P_{[t-3, t-2]}$). The annual number of papers published in Chinese journals rose to 147 in the second and third years after training ($P_{[t+2, t+3]}$). A similar rising trend in research output was also observed for papers published in SCI-listed journals, number of patents obtained and S&T awards received, as well as wheat varieties bred (rows 2-5, Table 5). The last column in Table 5 reports annual output in the period from the first year after training until 2012, which provides further evidence of the impacts of CIMMYT's training programs.

When looking at respondents' academic performance by type of training, it is clear that their performance differs. For visiting scientists, in the year after training, significant improvement in their performance was observed mainly in the number of papers published Chinese journals and the number of wheat varieties bred (rows 6 and 10, Table 5). For the short courses, while there was a rise in the number of S&T awards after the training program, no obvious trend is observed for the other indicators (row 14, Table 5). It seems that trainees who participated in graduate and postdoctoral programs benefited the most, especially in articles published in SCI-listed journals. The total number of SCI-listed journal articles increased significantly after training (row 17, Table 5). This may be because training programs for graduate and postdoctoral scholars lasted much longer than those for visiting scientists and short-course participants. Nevertheless, from the training year to 2012, the annual total number in all four indicators increased regardless of the type of training (column 5, Table 5).

The comparison between the trainees' performance and the average levels at their institutions after 1999 also shows that participants may benefit from CIMMYT's training programs.

Table 5. Total number of trainees per year: major performance indicators before and after training.

	$P_{[t-3, t-2]}$	$P_{[t-1]}$	$P_{[t+1]}$	$P_{[t+2, t+3]}$	$P_{[t+1, 2012]}$
All respondents					
Chinese journal articles	124	103	139	147	210
SCI-listed journal articles	5	14	25	21	45
Patents	0	0	5	5	12
S&T awards	3	5	6	9	12
Wheat varieties	1	2	4	7	9
Visiting scientists					
Chinese journal articles	13	24	32	38	45
SCI-listed journal articles	0	0	0	0	3
Patents	0	0	0	1	2
S&T awards	0	1	1	2	2
Wheat varieties	1	0	1	4	3
Short-course participants					
Chinese journal articles	78	54	64	67	106
SCI-listed journal articles	3	5	8	4	12
Patents	0	0	0	1	3
S&T awards	2	3	4	6	7
Wheat varieties	0	1	3	1	4
Graduates and postdoctorates					
Chinese journal articles	33	25	43	42	59
SCI-listed journal articles	2	9	17	17	30
Patents	0	0	5	4	7
S&T awards	1	1	1	2	2
Wheat varieties	0	1	0	2	2

Source: Authors' survey.
Note: t indicates the year when participants finished CIMMYT's training programs. The number of participants is 67.

As shown in Table 6, in 2000 and 2005, for those who once were visiting scientists, the number per person of Chinese journal articles published and wheat varieties bred as the PI was significantly higher than the average level at their institutions (rows 2, 6, 8 and 12). At the same time, short-course participants published more Chinese journal articles and received more S&T awards per person than the institutional average (rows 2, 5, 8 and 11, Table 6). However, in 2010, SCI-listed journal articles increased significantly for those who once participated in CIMMYT's visiting scientist programs and short training courses: the numbers per person were 1.1 and 0.5, respectively, while the average at their institutions was only 0.1 (row 14, Table 6). Graduate and postdoctoral program participants were best in articles published both in Chinese journals and SCI-listed journals, compared to the average levels at their institutes (columns 4 and 5, Table 6).

Table 6. Average performance indicators per person for the trainees and their institutions in 2000, 2005, and 2010.

	The trainees by type				
	Total or average	Visiting scientists	Short-course participants	Graduates and post-doctorates	Average at their institutions
			In the year 2000		
Number of trainees or institutes	33	8	24	1	11
Chinese journal articles	2.2	2.9	1.9	3.0	0.5
SCI-listed journal articles	0.0	0.0	0.0	0.0	0.0
Patents	0.0	0.0	0.0	0.0	0.0
S&T awards	0.1	0.0	0.1	0.0	0.0
Wheat varieties	0.2	0.4	0.0	1.0	0.1
			In the year 2005		
Number of trainees or institutes	43	10	29	4	16
Chinese journal articles	3.4	3.7	3.0	5.8	0.7
SCI-listed journal articles	0.0	0.0	0.0	0.5	0.0
Patents	0.0	0.0	0.0	0.0	0.0
S&T awards	0.1	0.0	0.2	0.0	0.0
Wheat varieties	0.1	0.2	0.1	0.0	0.1
			In the year 2010		
Number of trainees or institutes[a]	56	10	32	14	18
Chinese journal articles	3.8	4.1	3.9	3.4	0.9
SCI-listed journal articles	1.1	1.1	0.5	2.5	0.1
Patents	0.1	0.1	0.1	0.1	0.0
S&T awards	0.3	0.2	0.5	0.0	0.0
Wheat varieties	0.1	0.0	0.1	0.1	0.1

Source: Authors' survey.

[a] Although all 67 respondents had been trained by the end of 2010, 5 of them had stopped their scientific career in 2010 (e.g., retired, turned to administrative work or left to work in a company); another 6 finished CIMMYT training in 2010 but were not included in this table.

5. Modeling the impacts of CIMMYT's wheat training programs

5.1 Model specifications

As shown in the previous section, trainees' academic performance varied by type of participant. Since there are several factors that may simultaneously affect trainees' academic performance, we utilized two multivariate models that seek to isolate the impacts of CIMMYT training from other factors.

Model for identifying differences in performance before and after training

To quantitatively examine the impact of CIMMYT's wheat training programs on the academic performance of Chinese trainees, we used the following multivariate regression model based on Dataset 2:

$$P_{ijt} = a + b \bullet Visit_{it} + c \bullet Course_{it} + d \bullet Graduate_{it} + \phi \bullet X + \varepsilon_{it} \quad (1)$$

where the dependent variable P_{ijt} is a set of academic performance indicators, measured by the number of Chinese journal articles (j=1), number of SCI-listed journal articles (j=2), number of patents obtained (j=3), number of S&T awards received (j=4), number of wheat varieties bred as the PI (j=5) for the i^{th} respondent in the t^{th} year. As the key independent variables of interest on the right-hand side of equation (1), $Visit_{it}$, $Course_{it}$ and $Graduate_{it}$ refer to visiting scientists, short-course participants, and graduate and postdoctoral scholars, respectively, as discussed in the previous section. They are binary variables and equal to 1 if the time is after training; otherwise they are equal to 0. The bases for comparison are the respondents themselves in the years before their training or the year they just finished their training. Besides the above variables, in equation (1) we also include a set of variables (X) that may have significant effects on the trainees' academic performance. These include the academic title with two dummy variables for Professor and Associate professor, a dummy variable for received Ph.D., a female dummy variable, and two time period dummies (dummy variables for 1990s and 20002). The term ε_{it} is the idiosyncratic error term. Marginal effects to be estimated include b, c, d and ϕ.

To have a more balanced set of observations before and after training, data used in the regression are limited to a maximum of six years before the end of the training year (including the year in training) and a maximum of six years after training for each trainee. Respondents with a total of fewer than five years of observations are excluded. Finally, an almost balanced longitudinal dataset is created, which consists of 64 respondents[8] and 694 observations. A summary of the statistics of all dependent and independent variables used in the regression is presented in Table 7.

Model for identifying differences in performance between the trainees and the average at their institutions

To quantitatively examine the impact of CIMMYT's wheat training programs, we developed a model that, in addition to analyzing indicators before and after training, also identifies the difference in the academic performance of the trainees and the average performance of scientists at their

Table 7. Descriptive statistics of all variables used in the regression analysis in equation (1).

	Mean	Std. Dev.
Chinese journal articles	2.09	2.78
SCI-listed journal articles	0.22	0.83
Patents	0.04	0.35
S&T awards	0.11	0.34
Wheat varieties	0.05	0.26
Visiting Scientist (Yes=1; No=0)	0.11	0.31
Short-course participant (Yes=1; No=0)	0.29	0.45
Graduate and postdoctorate (Yes=1; No=0)	0.10	0.29
Professor (Yes=1; No=0)	0.15	0.36
Associate professor (Yes=1; No=0)	0.29	0.45
Ph.D. (Yes=1; No=0)	0.21	0.41
Female (Yes=1; No=0)	0.24	0.43
Dummy for 1990s (Yes=1; No=0)	0.40	0.49
Dummy for 2000s (Yes=1; No=0)	0.42	0.49

Source: Authors' survey.

[8] Another three respondents had just finished their graduate program in 2009 or 2010 and they had no job experience before the training.

corresponding institutions using Datasets 2 and 3. To largely avoid the effect of unobserved factors (which may influence training opportunities), we specify the following difference model:

$$\Delta P_{ijt} = a + b \bullet Visit_{it} + c \bullet Course_{it} + d \bullet Graduate_{it} + \phi \bullet \Delta X + \varepsilon_{it}$$

(2)

where the dependent variable ΔP_{ijt} measures the difference in performance between the i^{th} respondent (or trainee) and the average at his/her institution in the t^{th} year. The five performance indicators are the same as those in discussed in equation (1). The key variables $Visit_{it}$, $Course_{it}$, and $Graduate_{it}$ also have the same definitions as those in equation (1). ΔX denotes the differences in other control variables, including the ratio of professors and associate professors to total scientists.[9] Similarly, the term ε_{it} is the idiosyncratic error term, while b, c, d and ϕ denote the marginal effects to be estimated.

As Dataset 3 refers to the years from 2000 to 2012, for each trainee, we consider only the observations between 2000 and 2012 from Dataset 2. Finally, a dataset that includes new longitudinal data is constructed, involving 512 observations. A summary of the statistics of all dependent and independent variables in this new dataset is given in Table 8. A summary of Dataset 3 is provided in Appendix Table 4. Equation (2) is estimated using OLS.

9 In case of the trainees, it is either 1 or 0; in case of the institutions, it is a continuous variable ranging from 0 to 1. The variable is the difference between the trainee and the average at his/her institution.

5.2 Estimation results

Equation (1) is first estimated using ordinary least squares (OLS). The results are presented in Appendix Table 5. However, some unobserved but time-constant factors may also have an effect on the trainees' performance; therefore, to account for both unobserved factors and heterogeneity that does not vary over time, we further estimated equation (1) using the individual fixed effect (FE) model and present the results in Table 9.

In general, the statistical significance of the key variables in both the OLS and FE estimations is robust and most are consistent. The regression results are also largely consistent with the descriptive analysis presented in the previous section, though here we are able to identify those impacts that are statistically significantly. In the following discussions, we focus on the results from the FE model (Table 9).

The regression results show that, after controlling for the impacts of observed and unobserved non-time-varying factors of individual trainees, CIMMYT's graduate and postdoctoral programs have the most significant impacts on the trainees' academic performance. All the coefficients for graduate and postdoctoral trainees have positive signs and are statistically significant for four of five performance indicators (row 3, Table 9). For example, the estimated coefficient for the variable of graduates is 1.02 and statistically significant at 5% in the equations of Chinese journal articles (column 1), which suggests that the training increased research productivity by about 1 Chinese journal article annually. A similar impact (0.94 with

Table 8. Descriptive statistics of all variables used in the regression analysis in equation (2).

	Mean	Std. Dev.
Performance difference in the number of Chinese journal articles	3.32	4.07
Performance difference in the number of SCI-listed journal articles	0.59	1.60
Performance difference in the number of patents obtained	0.18	0.70
Performance difference in the number of S&T awards received	0.21	0.47
Performance difference in the number of wheat varieties bred	0.06	0.40
Visiting scientist (Yes=1; No=0)	0.10	0.30
Short-course participant (Yes=1; No=0)	0.54	0.50
Graduate and postdoctorate (Yes=1; No=0)	0.13	0.34
Difference in the share of professors	0.30	0.49
Difference in the share of associate professors	-0.03	0.47

Source: Authors' survey.

1% statistically significant) is found on publishing articles in SCI-listed journals (column 2). The results further show that participation in graduate and postdoctoral programs also increased the number of patents obtained (0.34, column 3) and the S&T awards given by government (0.13, column 4). The impacts are not only statistically significant but also of great magnitude.

The modeling results also show that CIMMYT's visiting scientist program had positive and statistically significant impacts on the trainees' academic performance in terms of publishing papers in Chinese journals and the number of wheat varieties bred (row 1, Table 9). The estimated coefficient for the visiting scientist variable is 0.89, statistically significant at the 5% level (column 1), indicating that the visiting scientist program increased trainees' publications by nearly one paper annually. Moreover, the number of wheat varieties developed by the trainees participating in the visiting scientist program also increased by 0.13 (not statistically significant at 1%) annually (column 5). On the other hand, we did not find that the visiting scientist program had a significant impact on publishing papers in SCI-listed journals, the number of patents and the number of S&T awards.

Largely consistent with the descriptive analysis, the regression results did not find that the short training course had a significant impact on the five academic performance indicators. As shown in Table 9 and Appendix Table 5, none of the coefficients for short-course participants are statistically significant (Row 2). While we were not able to determine the reasons for the ineffectiveness of the training course on the trainees' five academic performance indicators, several likely reasons are provided. First, the short training course includes more diversified training activities than the other training programs. Moreover, some short training courses do not focus on improving research capacity but on wheat production, farm management and other activities that are not examined in this study. Second, in general, the short training course does not last very long, particularly compared to the graduate

Table 9. Estimated results of major performance indicators before and after participating in the training program, fixed-effect model.

	Chinese journal articles (1)	SCI-listed articles (2)	Patents (3)	S&T awards (4)	Wheat varieties (5)
Visiting Scientist	0.89**	-0.03	0.03	0.06	0.13***
(Yes=1; No=0)	(2.24) [a]	(0.28)	(0.52)	(0.95)	(3.22)
Short-course participant	-0.07	0.05	0.01	0.03	0.02
(Yes=1; No=0)	(0.23)	(0.65)	(0.24)	(0.68)	(0.73)
Graduate and postdoctorate	1.02**	0.94***	0.34***	0.13*	0.06
(Yes=1; No=0)	(2.24)	(7.56)	(5.04)	(1.96)	(1.29)
Professor	0.49	0.23*	0.00	0.02	-0.02
(Yes=1; No=0)	(1.07)	(1.83)	(0.06)	(0.30)	(0.49)
Associate professor	1.00***	0.03	0.03	0.06	0.05*
(Yes=1; No=0)	(3.50)	(0.33)	(0.78)	(1.45)	(1.72)
Ph.D.	0.78*	0.09	0.10	-0.10	0.00
(Yes=1; No=0)	(1.85)	(0.77)	(1.61)	(1.61)	(0.06)
Dummy for 1990s	0.13	-0.08	-0.02	0.03	-0.03
(Yes=1; No=0)	(0.35)	(0.78)	(0.29)	(0.63)	(0.72)
Dummy for 2000s	0.70	-0.16	-0.04	0.04	0.02
(Yes=1; No=0)	(1.25)	(1.05)	(0.52)	(0.50)	(0.38)
Constant	1.05***	0.16*	-0.00	0.05	0.02
	(3.20)	(1.78)	(0.01)	(1.11)	(0.50)
R^2	0.093	0.156	0.081	0.019	0.042

Source: Authors' survey.

[a] The figures in parentheses are absolute t ratios of estimates. ***, ** and * represent statistically significant at 1%, 5% and 10%, respectively. The total sample used in the regression was 694.

and postdoctoral programs. Third, it could also be that some short courses may not be well-designed for the trainees. In any case, the reason(s) for the insignificant effect of the short training course should be further studied in the future.

Several control variables also had a statistically significant effect on academic performance. For instance, compared with those holding a title lower than associate professor, a full professor published more papers in SCI-listed journals (row 4, column 2, Table 9); while associate respondents published more Chinese journal articles and developed more wheat varieties (row 5). Furthermore, the number of papers published in Chinese journals was higher for those with a Ph.D. than those without one (row 6). Interestingly, compared to the men, women performed better in publishing papers in SCI-listed journals but developed fewer wheat varieties (row 7, Appendix Table 5).

The estimated results for equation (2) based on both the trainees and their institutes are also striking, and the signs of the estimated coefficients for the variables of interest and for the control variables (Table 10) are almost consistent with the fixed-effect estimators using individual trainee's data (Table 9). For example, the regression results of equation (2) further confirm that both the graduate and postdoctoral program and the visiting scientist program had significantly positive impact on several academic performances. The graduate and postdoctoral program raised research productivity in terms of publishing papers in both Chinese journals and SCI-listed journals, as well as the number of patents obtained (row 3, Table 10). The visiting scientist program increased academic performance in terms of publishing more papers in Chinese journals and patenting more inventions (row 1, Table 10).

Table 10. Estimated results of the differences in performance between trainees and the averages at their institutions, 2000-2012, OLS model.

	Difference in performance				
	Chinese journal articles (1)	SCI-listed journal articles (2)	Patent (3)	S&T awards (4)	Wheat varieties (5)
Visiting Scientist	1.85**	0.21	0.29**	-0.00	0.06
(Yes=1; No=0)	(2.44) [a]	(0.78)	(2.25)	(0.03)	(0.76)
Short-course participant	-0.03	-0.27	0.07	-0.04	0.04
(Yes=1; No=0)	(0.06)	(1.39)	(0.76)	(0.59)	(0.83)
Graduate and postdoctorate	1.29*	1.77***	0.53***	-0.10	0.00
(Yes=1; No=0)	(1.96)	(7.44)	(4.77)	(1.26)	(0.02)
Difference in the share of professors	0.92	0.30	0.11	0.12*	0.25***
	(1.59)	(1.41)	(1.08)	(1.81)	(4.33)
Difference in the share of	0.07	0.07	0.01	0.07	0.14***
associate professors	(0.14)	(0.35)	(0.13)	(1.02)	(2.62)
Constant	2.69***	0.37***	0.01	0.21***	-0.04
	(6.85)	(2.62)	(0.08)	(4.66)	(0.93)
R^2	0.047	0.195	0.076	0.011	0.064

Source: Authors' survey.

[a] The figures in parentheses are absolute t ratios of estimates. ***, ** and * indicate statistically significant at 1%, 5% and 10%, respectively. The total sample used in the regression was 512.

6. Trainees' views on CIMMYT's training programs

The above quantitative analysis shows that CIMMYT's training programs have improved the research capacity of Chinese scholars, as measured by several of the five major academic performance indicators. This section provides information to better understand the above finding through a subjective evaluation based on the trainees' opinion survey. As discussed in the data and sampling design section (Dataset 4), we have 2 groups of respondents: 67 scholars examined in the previous sections (Group 1) and 30 new respondents (Group 2). The latter group includes those with less than 2 months training and those who completed their training after the end of 2010. Of course, it should be noted that respondents in this kind of opinion survey may tend to more positively appraise the training they had. Nonetheless, the results of this survey are striking.

Table 11. Trainees' views of the usefulness of CIMMYT training programs for their careers (%), Group 1.

	Highly useful	Useful
Visiting scientist	53	47
Short training courses	68	32
Graduates and postdocs	81	19

Source: Authors' survey.
Note: There were three possible answers: highly useful, useful, and not very useful. However, no one selected "not very useful."

Table 11 reports the views expressed by the 67 respondents on the effect the wheat training programs had on their careers. Surprisingly, none of the respondents considered the training useless, and most rated it as "highly useful" regardless of the type of training program. For example, 53% of the visiting scientists and 68% of the short-course participants appraised their training opportunities highly (Table 11). The highest evaluation was given by participants in the graduate and post-doctoral program, since 81% of them rated it as highly valuable to their careers.

When asked about the contribution of the training programs to China's wheat technological progress, the responses were also very positive (Table 12). For example, most respondents considered that CIMMYT's training programs have played a very important (57%) or an important (38%) role in improving China's wheat technology. Similar results were found for respondents in both Groups (Table 12).

More specific questions on the impacts of the training on the trainees' personal work revealed that they occurred in several dimensions. Table 12 shows that as many as 89% of the respondents claimed that the training helped them obtain new scientific knowledge and technology, particularly in the areas of conservation agriculture, quality

Table 12. Trainees' views on the contributions of CIMMYT training programs.

	Group 1	Group 2	Total
Role in China's wheat technological progress:			
Very important	55	60	57
Important	37	40	38
Not very important	1	0	1
No answer	6	0	4
Contribution to the trainee's personal work:			
Obtained new knowledge and technology	84	100	89
Improved research and other work capacity	84	93	87
Obtained new wheat germplasm resources	60	83	67
Expanded research network	58	93	69
Other[a]	6	3	5

Source: Authors' survey.
[a] This includes: stimulated his/her enthusiasm for agricultural technology, got a job related to CIMMYT, etc.

testing of varieties and shuttle breeding. A similarly high percentage (87%) of respondents indicated that their research and other work capabilities improved after their training (Table 12), especially wheat variety breeding, reading and writing more papers in English and broadening of their research horizons. Meanwhile, 67% of respondents indicated they had obtained more wheat germplasm resources from CIMMYT, which helped them breed new varieties with improved yield potential, disease resistance and better quality. Moreover, 69% emphasized that the training helped them expand their network to include scientists from CIMMYT and the rest of world.

While there were some differences in the responses from Groups 1 and 2, particularly regarding their access to CIMMYT germplasm and expanding their networks, the story is similar. The relatively higher appraisal from Group 2 may be due to the fact that those respondents were selected from the list of trainees who currently are in contact with CIMMYT's Beijing Office (see the introduction to Dataset 4 in the previous section) and therefore may have worked more closely with CIMMYT.

The respondents were also asked to provide their suggestions for future CIMMYT training programs and collaborative efforts. Regarding training, three major suggestions were: (1) extend the duration of the training programs, particularly by giving young scholars more opportunities to participate in graduate and postdoctoral programs, which is consistent with our findings on impact assessment; (2) include more participants from local research institutes/universities in major wheat producing areas; and (3) send more CIMMYT scientists to China to conduct technical training courses. On future collaboration, strengthening germplasm resource exchanges and collaborative efforts on bioinformatics, molecular biology, wide hybridization, shuttle breeding, disease resistance and stress tolerance breeding, and conservation tillage are the major areas highly suggested by the respondents.

7. Conclusions

CIMMYT has provided an increasing number of training opportunities for Chinese scholars in the past four decades. The visiting scientist program and short training course were the major wheat training programs, although graduate fellowships and postdoctoral positions have increased since the early 1990s. Survey data also show that the trainees now tend to be younger and more inclusive, including a growing number of female participants and participants from universities, although most are still male and scholars from research institutes.

Descriptive statistics on academic performance show that, in general, the trainees performed better after training. On average, the trainees' annual total numbers of publications, patents, S&T awards, and wheat varieties were higher in the post-training period than the pre-training period. Meantime, the trainees' ability to obtain research projects and funding was also higher than the average level of all scientists at their institutions.

The quantitative study based on econometric analysis provides empirical evidence of the specific impacts of different training programs on the trainees' academic performance. The results consistently reveal significant impacts of the graduate or post-doctoral training program and the visiting scientist program. Positive impacts were revealed by four of the five major academic performance indicators, including trainees' ability to publish more papers in both Chinese and international journals, their capacity to obtain patents, and their overall contribution to wheat science and technology as reflected by the number of S&T awards given by government. As for the visiting scientist program, its major impacts have been on improving research capacity in terms of generating more wheat varieties, publications, and patenting inventions. However, this study did not find that the short training course had significant impact on the trainees' academic performance.

The empirical findings on the impact of training are largely supported by the results of the trainees' opinion survey. The majority of trainees highly appreciated the effect CIMMYT training had on their careers. Most of them claimed that the training helped them obtain new scientific knowledge and technology, improve their research and work experiences, access more germplasm resources and develop a better research network. Moreover, most of the respondents also believe that the training programs have largely contributed to wheat technological changes in China. They suggest that CIMMYT can play a more important role by expanding its training programs and conducting more collaborative work in China in the future.

Admittedly, this study is the first attempt to quantitatively assess the impact of CIMMYT's training programs on Chinese scholars' research capacity based on a few limited academic performance indicators. The impacts of the training programs may be much greater than what was revealed by these performance indicators. However, the findings of this study do have several policy implications.

The most direct implication is that CIMMYT should continue to enhance its training program. There is also a need to revisit the priorities of different training programs. This study shows that the graduate program, postdoctoral fellowship and visiting scientist program have had significant impacts on the trainees' research capacity and should therefore be prioritized. Second, while the results of this study are from China and for wheat only, we believe that making training programs a top priority at most CGIAR centers is also likely to increase the CG's role in building NARS research capacity. Of course, more impact assessments should be conducted before making this the policy at all CGIAR centers. Third, as a significant beneficiary of CIMMYT's wheat training program, China may need to revisit its current R&D investment priorities. Investing in CGIAR training programs to improve its domestic research capacity could be a good option. Last but not least, previous studies have focused mainly on the impacts of research programs at CGIAR centers on poverty, food security and sustainable agriculture in developing countries, and the positive impact revealed by these studies has generated significant funding to support the CGIAR's research programs. However, resource allocation to training programs at CGIAR centers has not been promising. Many donors do not consider training an investment priority. The significant hidden value of CIMMYT's training programs for Chinese trainees' academic performance revealed by this study should have important implications for major international donors who are interested in improving NARS research capacity.

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Appendix Tables

Appendix Table 1. Summary of samples in the individual survey (obs.), Dataset 2.

	Sample size
Sample: > 2 months training completed by end of 2010	116
Sample not able to reach	43
Dead	2
Working abroad for many years	17
Changed work place and no contact details	18
Retired for many years and no contact details	6
Sample conducted survey	73
Sample received responses	67

Source: Authors' survey.

Appendix Table 2. Characteristics of samples by respondents and missing ones.

	Total samples	Respondents	Missing
Number of participants	116	67	49
By gender (%)			
Male	72	78	65
Female	28	22	35
By affiliation (%)			
Institution	84	84	86
University	16	16	14
By duration (%) [a]			
< 2 months	17	22	10
[2 months, 1 year)	69	67	71
[1 year, 2 years)	8	6	10
≥2 years	23	27	18
By type of participant (%)[a]			
Visiting scientist	31	33	29
Short-course participant	56	58	53
Graduates and postdocs	25	27	22

Source: Authors' survey.

[a] Because some participants took part in programs more than once in different periods with the same or different type of participant, the aggregate of the percentages may be more than 100.

Appendix Table 3. Summary of wheat training programs offered to Chinese scholars, 1977 to 2012.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total																		
Number of participants	5	0	1	2	0	3	17	10	6	6	8	9	10	11	12	14	6	11
By gender																		
Male	5	0	1	1	0	2	16	10	6	6	4	7	8	10	10	12	4	9
Female	0	0	0	1	0	1	1	0	0	0	4	2	2	1	2	2	2	2
By affiliation of origin																		
Institute	0	0	0	1	0	3	11	7	6	4	8	9	9	10	12	14	6	11
University or college	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0
Government agency	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other[a]	4	0	1	0	0	0	6	3	0	1	0	0	0	0	0	0	0	0
Visiting scientist																		
Number of participants	5	0	1	2	0	3	17	9	3	6	3	4	6	7	5	10	3	9
By gender																		
Male	5	0	1	1	0	2	16	9	3	6	2	4	5	6	5	8	3	8
Female	0	0	0	1	0	1	1	0	0	0	1	0	1	1	0	2	0	1
Short courses																		
Number of participants	0	0	0	0	0	0	0	1	3	0	5	5	4	3	6	4	3	2
By gender																		
Male	0	0	0	0	0	0	0	1	3	0	2	3	3	3	4	4	1	1
Female	0	0	0	0	0	0	0	0	0	0	3	2	1	0	2	0	2	1
Graduate and postdoc																		
Number of participants	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
By gender																		
Male	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Female	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Authors' survey.

[a] Some institutions were broken up or merged during 2000-2012; information before the year they divided or merged could not be obtained. Other institutes failed to collect complete information for the early 2000s.

Appendix Table 3 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total																		
Number of participants	13	11	13	7	30	14	18	19	6	7	69	23	10	10	7	4	15	10
By gender																		
Male	11	9	11	6	28	13	18	16	4	5	35	15	5	5	5	0	11	6
Female	2	2	2	1	2	1	0	3	2	2	34	8	5	5	2	4	4	4
By affiliation of origin																		
Institute	9	9	11	6	22	10	11	14	3	4	32	9	6	6	5	3	13	10
University or college	4	2	2	0	0	1	1	4	3	3	16	13	4	4	2	1	2	0
Government agency	0	0	0	0	7	3	5	1	0	0	11	1	0	0	0	0	0	0
Other[a]	0	0	0	1	1	0	1	0	0	0	10	0	0	0	0	0	0	0
Visiting scientist																		
Number of participants	7	7	10	3	27	9	13	14	3	3	1	0	2	1	0	2	6	2
By gender																		
Male	7	6	10	3	25	9	13	13	2	3	0	0	1	1	0	0	6	1
Female	0	1	0	0	2	0	0	1	1	0	1	0	1	0	0	2	0	1
Short courses																		
Number of participants	6	4	3	4	2	3	4	5	0	0	66	18	1	2	5	1	8	5
By gender																		
Male	4	3	1	3	2	2	4	3	0	0	33	12	1	2	4	0	5	3
Female	2	1	2	1	0	1	0	2	0	0	33	6	0	0	1	1	3	2
Graduate and postdoc																		
Number of participants	0	0	0	0	1	2	1	0	3	4	2	5	7	7	2	1	1	3
By gender																		
Male	0	0	0	0	1	2	1	0	2	2	2	3	3	2	1	0	0	2
Female	0	0	0	0	0	0	0	0	1	2	0	2	4	5	1	1	1	1

Source: Authors' survey.

[a] Some institutions were broken up or merged during 2000-2012; information before the year they divided or merged could not be obtained. Other institutes failed to collect complete information for the early 2000s.

Appendix Table 4. Major performance indicators per scientist for the respondents' institutions from 2000 to 2012.

	Number of valid samples[a]	Chinese journal articles	SCI-listed journal articles	Patents	S&T awards	Wheat varieties
2000	11	0.498	0.003	0.003	0.014	0.055
2001	11	0.463	0.001	0.003	0.022	0.043
2002	12	0.425	0.005	0.001	0.014	0.052
2003	13	0.455	0.004	0.003	0.023	0.084
2004	13	0.496	0.006	0.007	0.021	0.102
2005	16	0.748	0.021	0.009	0.022	0.059
2006	16	0.959	0.036	0.017	0.026	0.093
2007	16	1.072	0.043	0.011	0.033	0.085
2008	17	1.014	0.049	0.019	0.021	0.059
2009	18	1.116	0.048	0.023	0.027	0.071
2010	18	0.941	0.065	0.025	0.042	0.070
2011	18	0.792	0.098	0.059	0.037	0.064
2012	18	0.763	0.097	0.067	0.019	0.066

Source: Authors' survey.

[a] Some institutions were separated or merged during 2000-2012; information before the year they divided or merged could not be obtained. Others failed to collect complete information for the early 2000s.

Appendix Table 5. Estimated results of major performance indicators before and after participating in a training program, OLS model.

	Chinese journal articles (1)	SCI-listed articles (2)	Patents (3)	S&T awards (4)	Wheat varieties (5)
Visiting Scientist	0.52	-0.14	0.04	0.04	0.14***
(Yes=1; No=0)	(1.53)[a]	(1.51)	(0.89)	(0.94)	(4.02)
Short-course participant	0.15	0.02	0.03	-0.00	0.01
(Yes=1; No=0)	(0.60)	(0.25)	(0.79)	(0.03)	(0.24)
Graduate and postdoctorate	-0.12	0.77***	0.34***	-0.02	0.02
(Yes=1; No=0)	(0.31)	(6.73)	(6.43)	(0.47)	(0.39)
Professor	0.26	-0.08	-0.04	0.06	0.07**
(Yes=1; No=0)	(0.74)	(0.82)	(0.87)	(1.39)	(2.03)
Associate professor	0.70***	-0.03	-0.02	0.08**	0.06***
(Yes=1; No=0)	(2.93)	(0.50)	(0.68)	(2.40)	(2.60)
Ph.D.	1.36***	0.50***	0.05	-0.02	-0.04
(Yes=1; No=0)	(4.22)	(5.48)	(1.30)	(0.39)	(1.27)
Female	0.10	0.14**	-0.02	0.04	-0.07***
(Yes=1; No=0)	(0.43)	(2.02)	(0.67)	(1.34)	(2.76)
Dummy for 1990s	0.63**	-0.07	0.00	0.05	-0.05*
(Yes=1; No=0)	(2.14)	(0.87)	(0.01)	(1.34)	(1.82)
Dummy for 2000s	1.83***	0.16*	0.03	0.13***	0.01
(Yes=1; No=0)	(5.71)	(1.76)	(0.61)	(3.04)	(0.20)
Constant	0.43*	0.01	-0.00	-0.00	0.05**
	(1.82)	(0.09)	(0.15)	(0.15)	(2.10)
R^2	0.185	0.265	0.103	0.047	0.070

Source: Authors' survey.

[a] The figures in parentheses are absolute t ratios of estimates. ***, ** and * indicate statistically significant at 1%, 5% and 10%, respectively. The total sample used in the regression is 694.

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