An evaluation of the Triticeae Coordinated Agricultural Project (TCAP)

Comparisons of the graduate student, TCAP PI, and MSI PI survey results by year

Prepared by:

Mao Thao, BS, BA

Abdi M. Warfa, MS, PhD Candidate

Frances Lawrenz, PhD

Eric Moore, PhD Candidate

August 2012

Minneapolis, MN

Table of contents

List of tables and figures

Introduction

The Triticeae Coordinated Agricultural Project (TCAP), funded by the United States Department of Agriculture (USDA), is an effort to improve the quality of wheat and barley breeding and increase the number of plant breeders, especially from racially and ethnically diverse backgrounds. TCAP's educational component consists of providing education and research opportunities for graduate students in plant breeding programs and partnering with faculty from minority serving institutions (MSIs) to promote the plant breeding field.

An evaluation with multiple components is being conducted to assess the progress of TCAP. One of the evaluation components is a yearly survey to assess graduate students' perceptions of plant breeding education, perceptions of TCAP programming, and collaborative relationships and networks over time. This report provides a comparison of the separate graduate student survey, MSI PI survey, and TCAP PI survey by year.

Methods

The evaluation team worked collaboratively with members of the TCAP educational committee to develop three surveys in 2011: the graduate student survey, the TCAP PI survey, and the MSI PI survey. They also worked collaboratively to revise all three surveys in 2012. The surveys were administered online assessed perceptions of plant breeding education, interest and motivation in the plant breeding field, perceptions of the TCAP educational programming, and collaborative networks with other students, faculty, and researchers within and outside of the TCAP.

Given the small sample sizes of graduate students, crosstabs by year with chi-square significance testing was completed, but it should be interpreted with caution. Items that resulted in statistically significant differences are reported; however, some cells in the crosstabs have low counts. Matched analyses or more advanced statistical analyses were not completed given the number of students who completed the survey in both 2011 and 2012 (n = 8). A total of 123 chi-square tests were run, including chi-square tests of the five demographics by year and 118 survey items by year. However, with such small samples, it is important to note that the chi-square tests are not reliable.

No significance testing between years was completed for the MSI PI survey results due to the small number of MSI PIs involved in the TCAP; however, some large differences between years are highlighted. Additionally, demographics between years are not reported as it may breach confidentiality of responses and identify non-respondents.

Analyses for TCAP PI survey results

Similar to the graduate student survey comparison analysis, crosstabs by year with chi-square significance testing was completed for the TCAP PI data. Percentile changes in 2012 vs. 2011 is reported in Table 4 - 8, along with chi-square and p-values.

There were 29 respondents for the 2012 survey and 42 respondents for the 2011. Demographic analysis suggested there was no statistical differences between the respondents in 2011 and 2012 (Table 4, $p > 0.05$ on all the demographic items listed). However, given the differences between the

number of participants in each year, we were concerned about the possibility of response bias in the survey data. In order to avoid response bias, we analyzed only responses from the same participants (matched analysis). 4 of the 29 respondents in 2012 were new PIs who did not participate in the 2011 survey. As such, their responses were not included in the comparison analysis. These resulted 25 "matched sample" for both years. The PIs in the matched sample were mainly male (96%), of not Hispanic origin (91%), and mainly white (77-78%). PIs of Asian background roughly made up 20% of the sample.

Methods for cross-comparison study of TCAP PI-student survey results

Student confidence in knowledge areas and skill sets in plant breeding highly valued by TCAP PIs in the 2012 surveys were compared. Similarly, students' and PIs' perceptions about educational processes—the importance of certain processes in educating graduate students and the nature of their collaborative networking with others that PIs and students reported - were compared. These were items that could be compared based on the nature of the PI and student surveys. The results of these cross-comparisons are shown in Tables 10 - 13.

Comparison of the graduate student survey results by year

Summarized by Mao Thao, BS, BA

There were not any significant differences in demographics by year among graduate students. However, students completing this year's survey seemed to be more diverse in terms of race and citizenship. This year, there were more students who identified as Asian – 8/13 (62%) compared to 2/10 (20%) of students from last year. Additionally, there were more students who reported not having U.S. citizenship than last year – 9/15 (65%) compared to 3/12 (25%) respectively (Table 1).

The following items resulted in significant differences between years (Table 2):

- More students in 2012 reported participating in problem solving than students in 2011, 96% compared to 67% respectively.
- Students in 2012 reported communicating more frequently with students at and outside of their institution than students in 2011. However, students in 2011 reported more frequent interaction with students from MSIs, researchers outside of the U.S., and from businesses and/or private companies.

Comparisons of the MSI PI survey results by year

Summarized by Mao Thao, BS, BA

- After about a year and half into the program, MSI PIs have strengthened their relationship with TCAP institutions. At the baseline survey, only one of eight MSI PIs felt their relationship with TCAP institutions were "very strong", while in this year's survey all six MSI PIs who completed the survey reported similarly.

- Perceptions on the value of plant breeding skills may have decreased slightly. Six of seven MSI PIs felt making marker assisted selections was "very" valuable at baseline, while only two of six felt the item was "very" valuable this year. Additionally, more MSI PIs (3/7) felt utilizing single nucleotide polymorphisms or genotype by sequencing was "very" valuable at baseline, while in this year's survey – only one of six reported similarly.
- MSI PI increased their interaction with other students at their institution. This year, four of five PIs reported interacting with other students at their institution either "Once a week or less" or "More than once a week". In 2011, only one of seven MSI PIs reported the same.

Comparisons of the TCAP PI survey results by year

Summarized by Abdi Warfa, MS, PhD Candidate

The PI survey yearly comparison is divided into subsections that pertain to specific areas. The highlights of the comparison follows

Comparison of TCAP PIs' views of the importance of the TCAP education components

One of the survey items in years 2011 and 2012 solicited TCAP PI's views of the importance of several TCAP education components. Of 17 items that were similar both years in the survey, 7 items showed changes of more than 5 percentile points among the same 25 faculty members (Figure 1) while 10 items showed changes of 4% or less. Table 5 shows the net change (Δ) from 2011 to 2012 as well as statistical analysis of whether the observed changes were significant (chi-squared statistic).

- 84% of the 25 PIs viewed faculty mentoring of graduate students to be extremely important in 2012 vs. 64% who did so in 2011, an increase of twenty percentile points (20%).
- There was an increase of 12% in the number of PIs who viewed inquiry-based learning approaches to be important in 2012 when compared to 2011 (Table 5). Similarly, 8% more PIs viewed group interactions at the Plant and Animal Genome (PAG) meeting to be important in 2012 vs. 2011 (32% vs. 24%, respectfully).
- Four items showed decrease in the percentage of TCAP PIs who viewed them to be important in year 2011 vs. 2012, respectively (Figure 1): graduate student mentoring of undergraduates (16% vs. 28%, Δ = - 12%), developing relationships with MSI faculty (4% vs. 16%, Δ = - 12%), skill workshops (45% vs. 25%, Δ = - 15%), and recruiting more American-born underrepresented minorities to plant breeding programs (32% vs. 16%, Δ = - 16%).
- A significant test was performed to determine whether the percent increases or decreases in 2012 were statistically different from those of the baseline data collected in year-2011. None of the observed changes were statistically significant at the .05 critical alpha level (Table 5).

Comparison of TCAP PIs' relationship and collaborations with MSI institutions and faculty

- There was a 6% decrease in 2012 in the percent of PIs who reported having "no strong relationship" with MSI institutions (Table 6) when compared to the data in 2011. This decrease was not statistically significant at the $p = 0.05$ alpha level.
- Collaborative relationship between TCAP PIs and non-TCAP MSI faculty has not changed in 2012 when compared to 2011, with the majority of TCAP PIs reporting having no collaborative relationship "at all" with non-TCAP MSIs in both years (72% and 76% respectively).

Comparison in knowledge, skill areas, and processes viewed to be valuable for graduating MS and PhD students

- In 2012, there was an increase of 12% in the number of PIs who viewed "factors in crop plants that impact productivity" to be very valuable knowledge area, and 8% increase in the number who viewed "genetics" to be very valuable (Table 7). These percent increases were not statistically significant ($p > 0.05$). In terms of skill sets, there was a 20% increase in the number of PIs who viewed "communication your scientific ideas" as very valuable skill while 8% more PIs viewed "manage data" and "make phenotypic selection" to be very valuable (Table 8).
- Two knowledge areas, experimental design and data management, showed 8% decrease in terms of the number of PIs who viewed them to be very valuable while three items (causes and resistance to biotic stress, causes and resistance to abiotic stress, and selection theory and techniques) showed a decrease of 16%. Only the change in the selection theory and techniques was statistically significant ($\chi^2 = 6.658$, $p < 0.05$, Table 7).
- It is worth noting that while there was and 8% increase in 2012 in the number of PIs who believed "manage data" to be valuable skill set for graduating MS and PhD students, the was a decrease of exactly 8% in the number of PIs who viewed "data management" as an important knowledge area for educating MS and PhD students (Tables 7 and 8). There was a decrease in the number of PIs who viewed "designing experiments" to be a valuable skill set and important knowledge area (12% and 8% decrease respectfully).
- The percentage of PIs who viewed "consider alternative hypothesis" to be very valuable skill similarly decreased by 16%.
- When asked about the importance of certain processes for educating graduate students, there appears to be an increase of 16% in the number of PIs who viewed "one-on-one mentoring" to be very important, and 8% increase in the number who viewed "field experience," "laboratory experience," and "presenting results" as very important (Table 8). The decreases were in; independent development of hypotheses ($\Delta = -12\%$), and the independent development of research designs ($\Delta = -8\%$, Table 8). These changes were not statistically significant.

Comparison of networking and social interactions

Items asking TCAP PI about how often they interact with certain people and what those interactions were about appeared to remain similar in both years or result small sample differences to carry out meaningful analysis, thus, such analysis has not been carried out

2012 TCAP PI-student cross-comparisons study

Summarized by Abdi M. Warfa

We compared student confidence in knowledge areas and skill sets in plant breeding highly valued by TCAP PIs in the 2012 surveys. Similarly, we compared students' and PIs' perceptions about educational processes—the importance of certain processes in educating graduate students and the nature of their collaborative networking with others that PIs and students reported. These were items that could be compared based on the nature of the PI and student surveys.

Student confidence in plant breeding knowledge areas valued by PIs

Students appear to have less confidence in most areas that PIs consider to be very valuable knowledge areas for graduating MS or PhD students in plant breeding. It also appears that certain areas students report having confidence in are considered by the PIs to be less valuable. These findings are summarized in Table 10, which shows percentage of surveyed PIs who consider given knowledge areas in plant breeding very valuable and the percentage of students who report being moderately confident or very confident in those areas.

- On average, 74% of the students report being moderately confident or very confident in experimental design, genetics, and plant breeding strategies while, on average, 93% of the PIs report this to be very valuable knowledge areas, a difference of about 20 percentile points between the two variables (Table 10). Similarly, only 54% of the students report being moderately or very confident in selection theories and techniques while about 80% of the PIs consider this to be a very valuable knowledge area.
- Reversing the trend of students showing low confidence in areas highly valued by the PIs, an average of 64% of the students reported feeling moderately or very confident in "causes and resistance of biotic and abiotic" while only 34% of the PIs, on average, considered this to be very valuable knowledge areas in plant breeding. Similarly, 76% of the students report being moderately or very confident in factors in crop plants that impact productivity while only 54% of the PIs consider this to be a very valuable knowledge area, a difference of 22 percentile points.

Student confidence in skill sets in plant breeding valued by PIs

Table 11 shows skill sets in plant breeding highly valued by PIs and student confidence in those skill sets. The data seems to suggest that students are less confident in most skill sets highly valued by the PIs.

- There was mostly an agreement between skills sets that students felt moderately or very confident in and how highly those skill sets were valued by TCAP PIs. For instance, 93% of the PIs reported "define and solve problems" and "observing and interpreting results" to be the most valuable skill set and 84% of the students reported being moderately or very confident in those skill sets. Similarly, an average of 82% of the PIs reported "work cooperatively," "design experiments," "manage data," and "communicate your scientific ideas" to be valuable skill sets while roughly the same percent of students (82%) reported being moderate or very confidents in those skill sets.
- Student confidence in several skill sets highly valued by the PIs tended to be lower. For instance, 86% of the PIs reported "make wide genome selection" to be very valuable skill set while only 39% of the students reported being moderately or very confident in this skill set. Similarly, 71% of the PIs reported "networking" to be valuable skill while only 33% of the students reported being moderately or very confident in networking.
- Reversing the trend, there were several skill sets in which student confidence was moderate or very high while these skills were less valued by the PIs. For instance, 66% of the students reported being moderately or very confident in single nucleotide polymorphism (SNPs) and genotype by

sequencing (GNS) while this skill was valued by only 43% of the PIs. Similarly, while only 29% of the PIs reported "molecular techniques" to be valuable, almost 80% of the students report being moderately or very confident in this skill set.

- **Students' and PIs' perceptions of educational processes**

One item in the surveys asked both students and PIs about the importance of TCAP educational components that are valuable for educating graduate students.

- The highest number of PIs reported one-on-one mentoring to be the most important process (26/28 or 93%) for educating graduate students (Table 12) while only 65% of the students reported similar response. The highest number of students (19/25 or 76%), on the other hand, reported field experience to be extremely important process for educating graduate students and 71% of the PIs (the third highest PI response) similarly viewed field experience to be extremely important process for educating graduate students.
- There were some disagreements between educational processes students viewed to be extremely important and PIs views on those processes. For instance, while 72% of the students reported "laboratory experience" to be important processes for educating graduate students, only 43% of the PIs thought this to be extremely important, a difference of 29 percentile points. Similarly, students viewed "exposure to diverse research methods," "exposure to plant breeding strategies from diverse ethnic backgrounds," and teaching methods" to be more important than did faculty (68% vs. 46%, 32% vs. 11%, and 29% vs. 7% respectively).

- **Students' and PIs' views of collaborative networking with other**

The surveys asked both PIs and students how often they interacted with certain types of people (Table 13).

- Most PIs (79%) reported interacting with their advisees while 55% of the students reported interacting with their advisors (Table 13). Interestingly, when asked what the most prevalent topic of the interaction was about, 72% of the PIs reported the interactions to have been about either trouble shooting research (48%) or interpreting research results (24%). This is in contrast to 47% of students who indicated the interactions to have been about trouble shooting research (21%) or interpreting research results (26%).
- The lowest numbers of "more than once a week" interactions reported by TCAP PIs were with researchers from business and/or private companies (3% or 1/29 PIs) and with researchers from MSI institutions (4%), researchers at their own institution (4%), and TCAP researchers at other institutions (4%). TCAP students have not interacted with researchers from MSI institutions, business/industry, and TCAP researchers at other institutions more than once a week. However, the students do report interacting with researchers at their own institution more than the TCAP PIs reported (29% vs. 4%, Table 13)

Issues to consider for graduate and MSI surveys

The following are some issues for consideration based on the comparison of the survey results by year:

- Matched analyses were not completed for the graduate student survey results due to the small number of students who completed both the 2011 and 2012 survey. For future analyses of survey data by year, strategies to increase the response rate of graduate students should be considered such as incentives.
- While there were some noticeable differences in the data between years, it is important to understand that the significance tests and interpretation of differences are flawed due to the small,

unmatched sample. The TCAP educational committee should take note of the differences; however, interpreting the differences within its limits should carefully be considered before implementing any programming changes.

- This year, graduate students seem to have more frequent interaction with other students both at their institution and outside of their institution than students from last year, with the exception of students from MSIs. Perhaps, many students are new to the TCAP and have not had the opportunity to interact with MSI students or their institution may not have an MSI partner. As MSI collaborations are a key component of the educational portion of TCAP, it is important to consider strategies to provide students with opportunities to interact and network with MSI students.
- Fewer students interacted with researchers outside of the U.S. and from businesses and/or private companies in 2012 than in 2011. It is unclear why this is without additional background characteristics of students, however, if it is a priority – strategies for promoting and increasing the interaction between students and these researchers should be considered.
- Relationships between MSI PIs and TCAP PIs appear to have strengthened between years. It is important for the TCAP to continue to support these relationships and collaborations.

Issues to consider for the TCAP PI surveys

The following are some issues for consideration based on the comparison of the survey results by year:

- The year-to-year comparison showed certain areas in which there was a positive change and areas that resulted change in the other direction. For instance, faculty mentoring of graduate students appears to be an important knowledge areas, a process important for educating graduate students, and an area the TCAP PIs viewed is an extremely important component of the TCAP education. Areas that resulted changes in faculty views should be analyzed carefully and further actions considered.
- While none of the changes observed in comparing the TCAP PI survey of 2012 and 2011 were statistically significant, there may be practical importance in considering the data. For instance, relationships and collaborations between MSI and TCAP PIs appears to be weak, the value associated with developing relationships with underrepresented minority groups and their recruitment appears to have decreased in 2012 when compared to 2012. While statistically not significant changes, their practical importance should be carefully analyzed.

Issues to consider for the TCAP PI-student cross-comparison study

The 2012 TCAP PI-student cross-comparison study highlighted areas of agreement and disagreement between TCAP PIs and TCAP students with respect to knowledge areas and skill sets highly valued by the PIs and student confidence in those areas. The report also highlighted educational processes that both TCAP faculty and students considered to be extremely important and the nature of their collaborative networking with others.

- Data from the survey indicated that most students seemed to have less confidence in most areas that PIs consider to be very valuable knowledge areas or skill sets for graduating MS or PhD students in plant breeding. The disconnect between the knowledge/skill sets PIs consider very valuable and student confidence in those areas perhaps suggesting the need to align knowledge areas valued by educators and the teaching of those areas to students.

- While there were an overall agreement between the students and the PIs about the importance of processes needed to educate graduate students, there were also striking differences in the students' and PIs' perceptions of some of those processes. For instance, there was almost 30 percentile difference between the PIs and students with respect to the importance of laboratory experiences in educating graduate students, with 72% of students viewing this as an extremely important while only 43% of the PIs thought so. This suggests the need to align students perceptions of what is important for their education and PIs views of what is needed to educate graduate students in plant breeding programs.
- Interactions with MSI institutions and students from MSI institutions appears to be weak. This is an area that, if important to the program, should be considered for improvement by creating strategies that foster collaborative networking with MSI institutions.

Table 1: Comparison of student demographics by year.

Demographics[a]	2011		2012	
	n	%	n	%
What is your sex?				
Male	6/11	50%	9/16	56%
Female	5/11	50%	7/16	44%
Age[b]				
18 to 20 years old	—	—	1/15	7%
21 to 23 years old	1/8	13%	2/15	13%
24 to 26 years old	5/8	63%	4/15	27%
27 to 29 years old	2/8	25%	4/15	27%
30 to 32 years old	—	—	2/15	13%
33 years old or older	—	—	2/15	13%
Are you of Spanish, Hispanic, or Latino/Latina origin?				
Yes	—	—	—	—
No	11/11	100%	12/12	100%
Race				
American Indian or Alaskan Native	—	—	—	—
Asian	2/10	20%	8/13	62%
Black or African American	—	—	—	—
Native Hawaiian or Pacific Islander	—	—	—	—
White	8/10	80%	5/13	38%
Mixed race	—	—	—	—
Are you a U.S. citizen?				
Yes	9/12	75%	6/15	40%
No	3/12	25%	9/15	60%

[a] Chi-square significant tests were completed for all five demographics by year; however, none of the tests resulted in significant findings.

[b] Age categories were revised to be smaller increments in the 2012 survey. The age data shown here is from the eight students who completed both the baseline survey in 2011 and this year's 2012 survey.

Table 2: Graduate student trends by year[a].

Survey items	2011	2012
How often do you participate in the following activities?	*"Moderately" or "Very"*	
Problem solving*	8/12 (67%)	24/25 (96%)
How often do you interact with the following types of people?		
Other undergraduates at my institution* (Besides mentee)		
Never	7/9 (78%)	2/16 (13%)
Once a year or less	1/9 (11%)	3/16 (19%)
Once very three months or less	1/9 (11%)	2/16 (13%)
Once a month or less	0/9 (0%)	3/16 (19%)
Once a week or less	0/9 (0%)	1/16 (6%)
More than once a week	0/9 (0%)	5/16 (31%)
Students in my lab**		
Never	3/10 (30%)	3/22 (14%)
Once a year or less	4/10 (40%)	0/22 (0%)
Once very three months or less	1/10 (10%)	0/22 (0%)
Once a month or less	1/10 (10%)	0/22 (0%)
Once a week or less	1/10 (10%)	2/22 (9%)
More than once a week	0/10 (0%)	17/22 (77%)
Other graduate students at my institution***		
Never	6/10 (60%)	2/19 (11%)
Once a year or less	4/10 (40%)	0/19 (0%)
Once very three months or less	0/10 (0%)	0/19 (0%)
Once a month or less	0/10 (0%)	3/19 (16%)
Once a week or less	0/10 (0%)	3/19 (16%)
More than once a week	0/10 (0%)	11/19 (58%)
Students from other institutions in the US*		
Never	4/10 (40%)	6/21 (29%)
Once a year or less	4/10 (40%)	1/21 (5%)
Once very three months or less	2/10 (20%)	4/21 (19%)
Once a month or less	0/10 (0%)	7/21 (33%)
Once a week or less	0/10 (0%)	3/21 (14%)
More than once a week	0/10 (0%)	0/21 (0%)
Students from minority serving institutions (MSIs)*		
Never	2/8 (25%)	14/16 (88%)
Once a year or less	0/8 (0%)	1/16 (6%)
Once very three months or less	1/8 (13%)	0/16 (0%)
Once a month or less	1/8 (13%)	0/16 (0%)
Once a week or less	2/8 (25%)	0/16 (0%)
More than once a week	2/8 (25%)	0/16 (0%)
Researchers outside of the US***		
Never	0/11 (0%)	9/19 (47%)
Once a year or less	0/11 (0%)	4/19 (21%)
Once very three months or less	0/11 (0%)	3/19 (16%)
Once a month or less	0/11 (0%)	2/19 (11%)
Once a week or less	5/11 (46%)	0/19 (0%)
More than once a week	6/11 (55%)	1/19 (5%)
Researchers from business and/or private companies*		
Never	0/11 (0%)	8/19 (42%)
Once a year or less	0/11 (0%)	2/19 (11%)
Once very three months or less	2/11 (18%)	3/19 (16%)
Once a month or less	4/11 (36%)	5/19 (26%)
Once a week or less	3/11 (27%)	1/19 (5%)
More than once a week	2/11 (18%)	0/19 (0%)

[a] A total of 123 chi-square tests were completed to examine differences by year. All data and chi-square significance test results should be interpreted with caution due to the low sample size and low cell counts. *$p < .05$, **$p < .01$, ***$p < .001$

Table 3: MSI PI trends by year[a].

Survey items	2011	2012
	"Very strong"	
How strong do you feel your relationships are with TCAP institutions?	1/8	6/6
How valuable are the following skills for a graduating MS or PhD student in plant breeding?	*"Very"*	
Make marker assisted selections	6/7	2/6
Utilize single nucleotide polymorphisms or genotype by sequencing	3/7	1/6
How often do you interact with the following types of people?	*"Once a week or less" or "More than once a week"*	
Other students at my institution (Besides advisee)	1/7	4/5

[a] Significance testing was not completed on these items.

Table 4. Demographics by year

	2011		2012	
Demographics	**n**	**%**	**n**	**%**
What is your sex?				
Male	35/39	90%	27/28	96%
Female	4/39	10%	1/28	4%
Are you of Spanish, Hispanic, or Latino/Latina origin?				
Yes	4/37	11%	1/27	4%
No	33/37	89%	25/27	93%
Race				
American Indian or Alaskan Native	2/37	5%	—	—
Asian	6/37	16%	4/27	15%
Black or African American	—	—	—	—
Native Hawaiian or Pacific Islander	—	—	—	—
White	28/37	76%	22/27	81%
Mixed race	1/37	3%	1/27	4%

[a] Differences in age between years is not reported due to revisions to the age categories in the 2012 survey. However, most PIs (about 75%) were between the ages of 40 and 59 years in both 2011 and 2012.

Table 5. Trends by year in components of TCAP education viewed to be "extremely important" by TCAP PIs (data is arranged in descending order with respect to observed net change)

Components of TCAP education viewed as "extremely important" by TCAP PIs	2011		2012		Δ	χ^2	*p*-value*
	n	%	n	%			
Faculty mentoring of graduate students	16/25	64%	21/25	84%	20%	3.516	0.06
Inquiry-based learning approaches**	3/25	12%	6/25	24%	12%	2.367	0.12
Group interactions at PAG meeting	6/25	24%	8/25	32%	8%	0.493	0.48
International travel/workshop	1/25	4%	1/25	4%	0%	—	—
Collaboration between MSI and TCAP students	1/25	4%	1/25	4%	0%	—	—
Understanding challenges to recruiting URMs	5/25	20%	5/25	20%	0%	—	—
Teaching/learning tools	8/25	32%	7/25	28%	-4%	—	—
Research	19/25	76%	18/25	72%	-4%	—	—
Online course(PBTN network)	9/25	36%	8/25	32%	-4%	—	—
Interaction with plant breeders at other inst.	10/25	40%	9/25	36%	-4%	—	—
Participation at NAPB meeting	2/25	8%	1/25	4%	-4%	—	—
Plant breeding educational film	2/25	8%	1/25	4%	-4%	—	—
Increasing number of URM groups in plant breeding	5/25	20%	4/25	16%	-4%	—	—
Graduate student mentoring of undergrads	7/25	28%	4/25	16%	-12%	1.240	0.26
Relationship development with MSI faculty**	4/25	16%	1/25	4%	-12%	1.860	0.17
Skill workshops	10/25	40%	6/24	24%	-15%	2.042	0.15
Recruiting more American-born, underrepresented groups to plant breeding programs	8/25	32%	4/25	16%	-16%	2.252	0.13

**The null hypothesis tested here is that percent changes observed in 2012 are the same as those of the 2011 baseline data; the alternative hypothesis is that the percentages have changed. A p-value ≤ 0.05 suggests significant test. However, caution should be exercised as some of the cell counts are too small to make any meaningful conclusions about the data.*

*** Caution should be used when interpreting the findings on these items due to the low cell count in either the 2011 or 2012 data.*

Table 6. Trends in TCAP PI-MSI relations and collaborations by year

	2011		2012		Δ	χ^2	*p*-value*
	n	%	n	%			
Strength of TCAP PIs relationships with MSI institutions (number and percents are for those reporting having "no strong relationship at all" with MSI institutions	12/24	50%	11/25	44%	- 6%	0.018	0.89
PIs' collaboration with non-TCAP MSI faculty (number and percents are for those reporting not collaborating "at all" with non-TCAP MSIs)	19/25	76%	18/25	72%	- 4%	—	—

Table 7. Trends by year in listed knowledge areas viewed to be "very" valuable by TCAP PIs (data is arranged in descending order with respect to observed net change)

	2011		2012		Δ	χ^2	*p*-value
	n	%	n	%			
Factors in crop plants that impact productivity	12/25	48%	15/25	60%	12%	1.002	0.32
Genetics (Mendelian, quantitative, population and molecular)	22/25	88%	24/25	96%	8%	0.852	0.36
Methods for breeding in selfing and outcrossing systems	17/25	68%	17/25	68%	—	—	—
Teaching strategies (inquiry-based learning approaches)	4/24	17%	4/25	16%	- 1%	—	—
Plant breeding strategies (e.g., traditional, molecular, physiological)	24/25	96%	23/25	92%	- 4%	—	—
Experimental design	24/25	96%	22/25	88%	- 8%	2.344	0.13
Data management (collection, analysis, databases)	24/25	96%	22/25	88%	- 8%	1.988	0.16
Causes and resistance to abiotic stress	11/25	44%	7/25	28%	- 16%	1.963	0.16
Causes and resistance to boitic stress	13/25	52%	9/25	36%	- 16%	1.963	0.16
Selection theory and techniques	**23/25**	**92%**	**19/25**	**76%**	**- 16%**	**6.658**	**0.01***

**This item is statistically significant at p < 0.05 level.*

Table 8. Trends by year in listed skill areas viewed to be "very" valuable by TCAP PIs

	2011		2012		Δ	χ^2	*p*-value
	n	%	n	%			
Utilize single nucleotide polymorphisms (SNPs) or genotype by sequencing (GBS)[a,b]	3/25	12%	22/25	88%	76%	129.64	0.000
Communicate your scientific ideas	16/25	64%	21/25	84%	20%	3.517	0.06
Make marker assisted selections	10/25	40%	13/25	52%	12%	1.041	0.31
Manage data	18/25`	72%	20/25	80%	8%	0.446	0.50
Make phenotypic selections	19/25	76%	21/25	84%	8%	0.493	0.48
Work cooperatively	20/25	80%	20/25	80%	—	—	—
Define and solve problems	23/25	92%	23/25	92%	—	—	—
Molecular techniques==9	6/25	24%	6/25	24%	—	—	—
Identify new alleles to use for improvement	8/25	32%	8/25	32%	—	—	—
Observe and interpret results	24/25	96%	23/25	92%	-4%	—	—
Statistical analysis	18/25	72%	17/25	68%	-4%	—	—
Make genome wide selections	8/25	32%	7/25	28%	-4%	—	—
Design experiments	23/25	92%	20/25	80%	-12%	3.397	0.06
Consider alternative hypothesis	18/25	72%	14/25	56%	-16%	2.431	0.12
Choose parents and make crosses[b]	21/25	84%	10/25	40%	-44%	32.81	0.00

[a] observed change on this item is high but chi-square statistics could not be calculated because of the low count in the 2011 cell

[b] These two items appear to be outliers. Care should be taken in interpreting what the data suggests

Table 9. Trends by year in the process of graduating students [only items reported to be "very valuable" by PIs reported]

	2011		**2012**		**Δ**	**χ^2**	***p*-value**
	n	**%**	**n**	**%**			
One-on-one mentoring	19/25	76%	23/25	92%	16%	2.686	0.10
Field experience	17/25	68%	19/25	76%	8%	0.4136	0.52
Laboratory experience	9/25	36%	11/25	44%	8%	0.3906	0.53
Experience presenting results (meetings, papers)	17/25	68%	19/25	76%	8%	0.4136	0.52
Independent development of research designs	15/25	60%	13/25	52%	- 8%	0.375	0.54
Collaboration with faculty other than the advisor	12/25	48%	7/25	28%	-20%	1.042	0.31

Table 10
PIs' views of the value of knowledge areas and student confidence in those areas. Data is sorted in descending order by the percentage of PIs.

Knowledge Areas	% of PIs' who indicate areas to be "very valuable"		% of Students who feel "moderately" or "very" confident in areas	
	n		%	n
Genetics (mendelian, quantitative, population and molecular)	27/28	96%	18/24	75%
Plant breeding strategies (e.g. traditional, molecular, physiological)	26/28	93%	17/24	71%
Experimental design	25/28	89%	17/24	76%
Data management (collection, analysis, database)	24/28	86%	22/25	88%
Selection theory and techniques	22/28	79%	13/24	54%
Methods for breeding in selfing and outcrossing systems	19/28	68%	16/23	70%
Factors in crop plants that impact productivity	15/28	54%	19/25	76%
Causes of and resistance to biotic stress	11/28	39%	17/25	68%
Causes of and resistance to abiotic stress	8/28	29%	15/25	60%
Teaching strategies (Inquiry-based learning approaches)	5/28	19%	7/21	33%

Table 11
PIs' views of the value of skill sets in plant breeding and student confidence in those areas. Data is sorted in descending order by the percent of PIs.

Skill set areas in plant breeding	% of PIs' who indicate skill set to be "very valuable"		% of Students who feel "moderately" or "very" confident in skill set	
	n	%	n	%
Define and solve problems	26/28	93%	21/25	84%
Observe and interpret results	26/28	93%	21/25	84%
Make genome wide selections	24/28	86%	9/23	39%
Work cooperatively	23/28	82%	21/24	87%
Design experiments	23/28	82%	18/25	72%
Manage data	23/28	82%	22/25	88%
Communicate your scientific ideas	23/28	82%	20/25	80%
Networking skills	20/28	71%	8/23	35%
Resource Management skills	20/28	71%	19/25	83%
Statistical analysis	19/28	67%	19/25	75%
Choose parents and make crosses	18/28	64%	13/24	58%
Consider alternative hypotheses	16/28	57%	22/25	33%
Make phenotypic selections	15/28	54%	16/25	25%
single nucleotide polymorphisms (SNPs) or genotype by sequencing (GBS)	12/28	43%	10/24	66%

Identify new alleles to use for improvement	10/28	36%	14/24	41%
Molecular techniques	8/28	29%	19/24	79%
Make marker assisted selections	8/28	29%	14/23	61%

Table 12. TCAP Students' and PIs' perceptions of educational processes. Data is sorted in descending order by the percent of PIs.

How important do you believe the following are in the process of educating graduate students?	% of PIs' who consider item to be "extremely important"		% of Students who indicate item to be "extremely important"	
	n	**%**	**n**	**%**
One-on-one mentoring	26/28	93%	9/25	65%
Experience presenting results (meetings, papers)	21/28	75%	15/25	67%
Field experience	20/28	71%	19/25	76%
Independent development of research designs	13/28	46%	13/25	52%
Exposure to diverse research methods and tools	13/28	46%	17/25	68%
Collaboration with other graduate students in this institution (in this lab or other labs)	12/28	43%	11/25	44%
Independent development of hypotheses	12/28	43%	13/25	52%
Laboratory experience	12/28	43%	18/25	72%
Collaboration with faculty other than the advisor	8/28	29%	10/25	40%
Experience writing grants	8/28	29%	10/25	40%
Exposure to plant breeding students from different ethnic backgrounds	3/28	11%	8/25	32%
Collaboration with graduate students from OTHER institutions	2/28	7%	5/25	20%
Teaching experience	2/28	7%	7/25	29%

Table 13
Item list for collaborative networking questionnaires for both PIs and students. List is ordered from most to the least interactions reported by both PIs and students, respectively.

How often have you interacted with the following types of people?	Interactions of more than once a week			
	PIs		Students	
	n	%	n	%
My advisee/my advisor	22/28	79%	12/21	55%
Other researchers at U.S. institutions (not TCAP or MSI researchers)	21/28	75%	1/18	6%
Other students at my institution	8/29	28%	11/19	58%
Other researchers outside of the U.S.	5/28	18%		
TCAP students from other institutions	3/29	10%	1/19	5%
Students from minority serving institutions (MSIs)	2/29	7%	1/16	6%
Researchers at my institution	1/27	4%	6/21	29%
TCAP researchers at other institutions	1/27	4%	—	—
Researchers at MSIs	1/27	4%	—	—
Researchers from businesses and/or private companies	1/29	3%	—	—
Non-TCAP students from non-MSIs in the U.S.	—	—	—	—
Non-TCAP students from institutions outside the U.S.	—	—	—	—

Figure 1.

Percent changes in TCAP PIs' view of "how important" a component of TCAP education is from year 2011 to 2012. Percentages indicate increase/decrease in the percent of 25 PIs who viewed an item to be "extremely important". Only items resulting a change of more than 5% were considered for analysis.