A comparison of TCAP & non-TCAP graduate students

Summary of methods

As part of the evaluation of the TCAP, an annual online survey is administered to fully and partially funded TCAP graduate students each year. The survey assesses students' graduate educational experiences and is administered online by a member of the evaluation group. This year, a group of graduate students not funded by the TCAP were also surveyed to serve as a comparison group to the TCAP students. Non-TCAP students consisted of students who are members of the National Plant Breeding Association (NAPB). The survey was administered online using an anonymous link and sent through email by a member of the educational committee. The survey response rate for the TCAP students is 80% (32/40), while the response rate for the non-TCAP students is 42% (25/59).
Students were compared on their confidence in 10 plant breeding knowledge areas, confidence in 19 plant breeding skills, exposure level to 42 educational experiences, importance of 13 educational processes, perceptions of 5 interests and experiences in the plant breeding field, and networking experiences with 13 different groups. To examine proportional differences between groups, crosstabs with a chi-square test of homogeneity were performed for each item with group as the dependent variable in the columns and each item as the independent variable in the rows. Given the distribution of responses for items, response categories with low frequencies were removed from the analyses. Significance testing was not performed on the items relating to students' networking experiences as the distribution of responses for items varied across categories and there was not a consistent way to analyze all the items using the same response categories.
The Chi-square test of homogeneity tests whether proportions are equivalent across cells, where the null hypothesis is that the proportions are homogeneous across cells and the alternative hypothesis is that the proportions are NOT homogeneous across cells. Proportions across cells are significantly different if the null hypothesis is rejected; however, the Chi-square test does not indicate whether differences are between groups or across response categories of an item. A post-hoc test is needed to appropriately compare proportions between groups. Thus, pairwise Z-tests using the Dunn-Bonferroni method were completed when Chi-square test results were significant. The Z-tests help to determine whether proportions within a response category of an item are different between the two groups. It is important to note that given the small sample sizes of both groups, items resulting in significant chi-square tests results likely do not meet the assumption of having an expected cell count of at least 5 in all cells in the crosstab. Thus, results should be interpreted carefully. All analyses were completed using the IMB SPSS Version 22 software.

Findings

Students from both groups seemed to have similar demographics, except for age (Table 1). TCAP students were slightly older than non-TCAP students with almost half of the TCAP students (48%) being between 27 and 29 years of age, while about half of the non-TCAP students were between 24 and 26 years of age.

Table 1. Student demographics.

	NON-TCAP students		TCAP students	
Demographics	n	%	n	%
What is your sex?				
χ^2 (1, N = 53) = 0.290, p-value = 0.590	13	59%	16	52%
Male	9	41%	15	48%
Female	22	100%	31	100%
Total				
What is your age?[1]				
χ^2 (4, N = 53) = 9.921, p-value = 0.042				
21 to 23 years old	1_a	5%	1_a	3%
24 to 26 years old	10_a	46%	8_a	26%
27 to 29 years old	2_a	9%	15_b	48%
30 to 32 years old	6_a	27%	6_a	19%
33 years or older	3_a	14%	1_a	3%
Total	22	100%	31	100%
Are you of Spanish, Hispanic, or Latino origin?				
χ^2 (1, N = 52) = 0.944, p-value = 0.331				
Yes	4	19%	3	10%
No	17	81%	28	90%
Total	21	100%	31	100%
Please specify your race.[2]				
χ^2 (3, N = 51) = 1.572, p-value = 0.666				
Asian	5	24%	7	23%
Black or African American	1	5%	1	3%
White	14	67%	22	73%
Mixed Race	1	5%	0	0%
Total	21	100%	30	100%
Are you a U.S. citizen?				
χ^2 (1, N = 51) = 0.001, p-value = 0.982				
Yes	14	64%	19	63%
No	8	36%	11	37%
Total	22	100%	30	100%

[1] None of the students were younger than 21 years old.

[2] None of students identified as American Indian/Alaskan Native or Native Hawaiian/Pacific Islander.

Table 2. Comparison of students' confidence in plant breeding knowledge areas.

How confident do you feel in the following knowledge areas?	NON-TCAP students		TCAP students	
	n	%	n	%
Experimental design				
χ^2 (2, N = 56) = 0.228, p-value = 0.892				
Somewhat	4	16%	6	19%
Moderate	12	48%	13	42%
Very	9	36%	12	39%
Total	25	100%	31	100%
Data management (collection, analysis, and database)				
χ^2 (2, N = 57) = 2.199, p-value = 0.333				
Somewhat	5	20%	4	13%
Moderate	15	60%	16	50%
Very	5	20%	12	38%
Total	25	100%	32	100%
Causes of and resistance to abiotic stress				
χ^2 (2, N = 57) = 0.846, p-value = 0.655				
Somewhat	11	44%	11	34%
Moderate	8	32%	10	31%
Very	6	24%	11	34%
Total	25	100%	32	100%
Causes of and resistance to biotic stress				
χ^2 (2, N = 57) = 0.879, p-value = 0.644				
Somewhat	9	36%	8	25%
Moderate	10	40%	14	44%
Very	6	24%	10	31%
Total	25	100%	32	100%
Plant breeding strategies (e.g. traditional, molecular, and physiological)				
χ^2 (2, N = 57) = 5.232, p-value = 0.073				
Somewhat	4	16%	3	9%
Moderate	13	52%	9	28%
Very	8	32%	20	63%
Total	25	100%	32	100%
Genetics (e.g. mendelian, quantitative, population, and molecular)				
χ^2 (2, N = 56) = 10.233, p-value = 0.006				
Somewhat	2_a	8%	1_a	3%
Moderate	16_a	64%	8_b	26%
Very	7_a	28%	22_b	71%
Total	25	100%	31	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 2. Comparison of students' confidence in plant breeding knowledge areas *(continued…)*.

How confident do you feel in the following knowledge areas?	NON-TCAP students		TCAP students	
	n	%	n	%
Selection theory and techniques				
χ^2 (2, N = 57) = 2.695, p-value = 0.260				
Somewhat	8	32%	5	16%
Moderate	12	48%	16	50%
Very	5	20%	11	34%
Total	25	100%	32	100%
Methods for breeding in selfing and outcrossing systems				
χ^2 (2, N = 57) = 1.022, p-value = 0.600				
Somewhat	4	16%	7	22%
Moderate	11	44%	10	31%
Very	10	40%	15	47%
Total	25	100%	32	100%
Teaching strategies (e.g. Inquiry-based learning approaches)				
χ^2 (2, N = 51) = 2.802, p-value = 0.246				
Somewhat	11	55%	15	48%
Moderate	9	39%	12	39%
Very	0	0%	4	13%
Total	20	100%	31	100%
Factors in crop plants that impact productivity				
χ^2 (2, N = 56) = 0.332, p-value = 0.847				
Somewhat	5	21%	7	22%
Moderate	10	42%	11	34%
Very	9	38%	14	44%
Total	24	100%	32	100%

Table 3. Comparison of students' confidence in plant breeding skills.

How confident do you feel in the following skills?	NON-TCAP students		TCAP students	
	n	%	n	%
Work cooperatively				
χ^2 (2, N = 57) = 1.681, p-value = 0.432				
Somewhat	1	4%	2	6%
Moderate	12	48%	10	31%
Very	12	48%	20	63%
Total	25	100%	32	100%
Design experiments				
χ^2 (2, N = 56) = 0.675, p-value = 0.713				
Somewhat	5	19%	4	13%
Moderate	13	54%	16	52%
Very	7	27%	11	35%
Total	25	100%	31	100%
Define and solve problems				
χ^2 (2, N = 57) = 0.469, p-value = 0.791				
Somewhat	2	8%	4	13%
Moderate	11	44%	15	47%
Very	12	48%	13	41%
Total	25	100%	32	100%
Manage data				
χ^2 (2, N = 57) = 7.182, p-value = 0.028				
Somewhat	6_a	24%	4_a	13%
Moderate	15_a	60%	12_a	38%
Very	4_a	16%	16_b	50%
Total	25	100%	32	100%
Consider alternative hypotheses				
χ^2 (2, N = 57) = 4.092, p-value = 0.129				
Somewhat	6	24%	5	16%
Moderate	15	60%	14	44%
Very	4	16%	13	41%
Total	25	100%	32	100%
Communicate your scientific ideas				
χ^2 (2, N = 57) = 1.250, p-value = 0.535				
Somewhat	5	20%	6	19%
Moderate	14	56%	14	44%
Very	6	24%	12	38%
Total	25	100%	32	100%
Observe and interpret results				
χ^2 (2, N = 57) = 1.665, p-value = 0.435				
Somewhat	4	16%	2	6%
Moderate	12	48%	15	47%
Very	9	36%	15	47%
Total	25	100%	32	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 3. Comparison of students' confidence in plant breeding skills *(continued…)*.

How confident do you feel in the following skills?	NON-TCAP students		TCAP students	
	n	%	n	%
Statistical analysis				
χ^2 (2, N = 57) = 1.028, p-value = 0.598				
Somewhat	6	24%	5	16%
Moderate	13	52%	16	50%
Very	6	24%	11	34%
Total	23	100%	32	100%
Molecular techniques				
χ^2 (2, N = 54) = 2.374, p-value = 0.305				
Somewhat	6	25%	8	27%
Moderate	14	58%	12	40%
Very	4	17%	10	33%
Total	25	100%	30	100%
Identify new alleles to use for improvement				
χ^2 (2, N = 53) = 6.486, p-value = 0.039				
Somewhat	10_a	44%	6_a	20%
Moderate	10_a	44%	11_a	37%
Very	3_a	13%	13_b	43%
Total	23	100%	30	100%
Make phenotypic selections				
χ^2 (2, N = 56) = 0.603, p-value = 0.740				
Somewhat	2	8%	2	6%
Moderate	11	46%	12	38%
Very	11	46%	18	56%
Total	24	100%	32	100%
Make marker assisted selections				
χ^2 (2, N = 52) = 4.666, p-value = 0.097				
Somewhat	8	35%	5	17%
Moderate	9	39%	8	28%
Very	6	26%	16	55%
Total	23	100%	29	100%
Make genome wide selections				
χ^2 (2, N = 50) = 3.090, p-value = 0.213				
Somewhat	10	48%	14	48%
Moderate	10	48%	9	31%
Very	1	5%	6	21%
Total	21	100%	29	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 3. Comparison of students' confidence in plant breeding skills *(continued…)*.

How confident do you feel in the following skills?	NON-TCAP students		TCAP students	
	n	%	n	%
Utilize single nucleotide polymorphisms (SNPs) or genotype by sequencing (GBS)				
χ^2 (2, N = 53) = 4.012, p-value = 0.134				
Somewhat	10	42%	6	21%
Moderate	10	42%	12	41%
Very	4	17%	11	38%
Total	24	100%	29	100%
Choose parents and make crosses				
χ^2 (2, N = 55) = 2.816, p-value = 0.245				
Somewhat	8	32%	4	13%
Moderate	10	40%	16	53%
Very	7	28%	10	33%
Total	25	100%	30	100%
Mentoring skills				
χ^2 (2, N = 57) = 0.893, p-value = 0.640				
Somewhat	10	40%	9	28%
Moderate	9	36%	14	44%
Very	6	24%	9	28%
Total	25	100%	32	100%
Networking skills				
χ^2 (2, N = 53) = 2.001, p-value = 0.368				
Somewhat	6	25%	3	10%
Moderate	11	46%	16	55%
Very	7	29%	10	34%
Total	24	100%	29	100%
Resource management skills				
χ^2 (2, N = 57) = 5.768, p-value = 0.056				
Somewhat	5_a	20%	5_a	16%
Moderate	17_a	68%	14_a	44%
Very	3_a	12%	13_b	41%
Total	25	100%	32	100%
Leadership skills				
χ^2 (2, N = 56) = 2.542, p-value = 0.281				
Somewhat	4	17%	7	22%
Moderate	10	42%	7	22%
Very	10	42%	18	56%
Total	24	100%	32	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 4. Comparison of students' exposure levels to educational experiences.

Please indicate the highest level of exposure you have in the following experiences:	NON-TCAP students		TCAP students	
	n	%	n	%
Plant breeding				
Participate in small plot testing				
χ^2 (2, N = 51) = 3.821, p-value = 0.148				
Observation only	1	5%	7	24%
Participation with guidance	7	32%	6	21%
Independent participation	14	64%	16	55%
Total	22	100%	29	100%
Choose parents and make crosses				
χ^2 (2, N = 52) = 3.672, p-value = 0.159				
Observation only	6	26%	2	7%
Participation with guidance	10	44%	15	52%
Independent participation	7	30%	12	41%
Total	23	100%	29	100%
Make phenotypic selections				
χ^2 (2, N = 52) = 0.670, p-value = 0.715				
Observation only	2	8%	2	7%
Participation with guidance	11	46%	10	36%
Independent participation	11	46%	16	57%
Total	24	100%	28	100%
Make genotypic selections				
χ^2 (2, N = 45) = 2.544, p-value = 0.280				
Observation only	7	35%	4	16%
Participation with guidance	6	30%	12	48%
Independent participation	7	35%	9	36%
Total	20	100%	25	100%
Implement markers in breeding				
χ^2 (2, N = 45) = 2.701, p-value = 0.259				
Observation only	6	35%	4	14%
Participation with guidance	6	35%	13	46%
Independent participation	5	29%	11	39%
Total	18	100%	28	100%
Measure phenotypes				
χ^2 (2, N = 57) = 4.288, p-value = 0.117				
Observation only	1	4%	2	6%
Participation with guidance	5	20%	1	3%
Independent participation	19	76%	29	91%
Total	25	100%	32	100%
Determine genotypes				
χ^2 (2, N = 50) = 4.227, p-value = 0.121				
Observation only	5	24%	3	10%
Participation with guidance	9	43%	8	28%
Independent participation	7	33%	18	62%
Total	21	100%	29	100%

Table 4. Comparison of students' exposure levels to educational experiences (*continued…*).

Please indicate the highest level of exposure	NON-TCAP students	TCAP students

you have in the following experiences:	n	%	n	%
Experimental design				
Design a field experiment				
χ^2 (2, N = 55) = 4.665, p-value = 0.097				
Observation only	4	17%	1	3%
Participation with guidance	5	21%	13	42%
Independent participation	15	63%	17	55%
Total	24	100%	31	100%
Design a lab experiment				
χ^2 (2, N = 48) = 0.731, p-value = 0.694				
Observation only	0	0%	1	4%
Participation with guidance	9	45%	12	43%
Independent participation	11	55%	15	54%
Total	20	100%	28	100%
Collect field data				
χ^2 (2, N = 55) = 1.415, p-value = 0.493				
Observation only	1	4%	0	0%
Participation with guidance	3	13%	5	16%
Independent participation	20	83%	26	84%
Total	24	100%	31	100%
Collect genotyping data				
χ^2 (2, N = 49) = 3.897, p-value = 0.142				
Observation only	4	20%	1	3%
Participation with guidance	6	30%	8	28%
Independent participation	10	50%	20	69%
Total	20	100%	29	100%
Troubleshoot and resolve a research problem				
χ^2 (2, N = 57) = 3.323, p-value = 0.190				
Observation only	2	8%	1	3%
Participation with guidance	10	40%	7	22%
Independent participation	13	52%	24	75%
Total	25	100%	32	100%
Data management and analysis				
Utilize a database to manage your data				
χ^2 (2, N = 46) = 5.698, p-value = 0.058				
Observation only	6	32%	2	7%
Participation with guidance	6	32%	7	26%
Independent participation	7	37%	18	67%
Total	19	100%	27	100%
Perform statistical analysis of field data				
χ^2 (2, N = 55) = 1.434, p-value = 0.488				
Observation only	1	4%	0	0%
Participation with guidance	5	21%	8	26%
Independent participation	18	75%	23	74%
Total	24	100%	31	100%

Table 4. Comparison of students' exposure levels to educational experiences (*continued*...).

Please indicate the highest level of exposure	NON-TCAP students		TCAP students	
you have in the following experiences:	n	%	n	%

Data management and analysis				
Perform statistical analysis of lab data				
χ^2 (2, N = 49) = 4.268, p-value = 0.118				
Observation only	0	0%	2	7%
Participation with guidance	8	36%	4	15%
Independent participation	14	64%	21	78%
Total	22	100%	27	100%
Learn new software for management or analysis				
χ^2 (2, N = 55) = 1.496, p-value = 0.473				
Observation only	1	4%	1	3%
Participation with guidance	8	33%	6	19%
Independent participation	15	63%	24	77%
Total	24	100%	31	100%
Use of genetic tools				
Utilize single-nucleotide polymorphism (SNP) data				
χ^2 (2, N = 46) = 10.691, p-value = 0.005				
Observation only	7_a	35%	1_b	4%
Participation with guidance	4_a	20%	2_a	8%
Independent participation	9_a	45%	23_b	88%
Total	20	100%	26	100%
Utilize genotype by sequencing (GBS) data				
χ^2 (2, N = 37) = 1.145, p-value = 0.564				
Observation only	8	50%	7	33%
Participation with guidance	4	25%	6	29%
Independent participation	4	25%	8	38%
Total	16	100%	21	100%
Identify new alleles for improvement				
χ^2 (2, N = 44) = 6.823, p-value = 0.033				
Observation only	9	53%	5	19%
Participation with guidance	4	24%	6	22%
Independent participation	4	24%	16	59%
Total	17	100%	27	100%
Make marker trait associations				
χ^2 (2, N = 46) = 11.921, p-value = 0.003				
Observation only	7_a	37%	0_b	0%
Participation with guidance	3_a	16%	5_a	19%
Independent participation	9_a	47%	22_b	81%
Total	19	100%	27	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 4. Comparison of students' exposure levels to educational experiences (*continued…*).

Please indicate the highest level of exposure	NON-TCAP students		TCAP students	
you have in the following experiences:	n	%	n	%
Use of genetic tools				

Utilize other markers systems (e.g. STS-PCR, SSRs)				
χ^2 (2, N = 41) = 1.818, p-value = 0.403				
Observation only	5	29%	3	13%
Participation with guidance	3	18%	5	21%
Independent participation	9	53%	16	67%
Total	17	100%	24	100%
Hands-on experiences				
Participate in all aspects of a complete breeding cycle, including making crosses, setting up field plots, plant, making selections, and harvest				
χ^2 (2, N = 48) = 1.705, p-value = 0.426				
Observation only	7	33%	5	19%
Participation with guidance	9	43%	12	44%
Independent participation	5	24%	10	37%
Total	21	100%	27	100%
Develop a budget for a research project				
χ^2 (2, N = 36) = 6.997, p-value = 0.030				
Observation only	7_a	58%	6_b	25%
Participation with guidance	5_a	42%	9_a	38%
Independent participation	0_a	0%	9_b	38%
Total	12	100%	24	100%
Scientific communication				
Write a paper (i.e. report or article)				
χ^2 (2, N = 50) = 2.335, p-value = 0.311				
Observation only	1	5%	1	3%
Participation with guidance	10	48%	8	28%
Independent participation	10	48%	20	69%
Total	21	100%	29	100%
Write a literature review				
χ^2 (2, N = 43) = 4.074, p-value = 0.130				
Observation only	0	0%	1	4%
Participation with guidance	7	37%	3	13%
Independent participation	12	63%	20	83%
Total	19	100%	24	100%
Make a presentation of research plan, progress report, and results				
χ^2 (1, N = 52) = 1.727, p-value = 0.189				
Observation only	—	—	—	—
Participation with guidance	8	36%	6	20%
Independent participation	14	64%	24	80%
Total	23	100%	30	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 4. Comparison of students' exposure levels to educational experiences (*continued…*).

Please indicate the highest level of exposure you have in the following experiences:	NON-TCAP students		TCAP students	
	n	%	n	%
Scientific communication				

Make a scientific presentation to lay audiences				
χ^2 (2, N = 52) = 3.580, p-value = 0.167				
Observation only	4	17%	1	4%
Participation with guidance	8	34%	7	25%
Independent participation	12	50%	20	71%
Total	24	100%	28	100%
Write a grant or project proposal				
χ^2 (2, N = 46) = 2.178, p-value = 0.337				
Observation only	4	20%	2	8%
Participation with guidance	12	60%	15	58%
Independent participation	4	20%	9	35%
Total	20	100%	26	100%
Research management				
Manage a project				
χ^2 (2, N = 53) = 4.243, p-value = 0.120				
Observation only	2	8%	0	0%
Participation with guidance	10	42%	8	28%
Independent participation	12	50%	21	72%
Total	24	100%	29	100%
Manage workers (e.g. student intern)				
χ^2 (2, N = 50) = 0.715, p-value = 0.700				
Observation only	1	5%	2	7%
Participation with guidance	6	27%	5	18%
Independent participation	15	68%	21	75%
Total	22	100%	28	100%
Leadership and teamwork				
Take a leadership role in some aspect of the research project				
χ^2 (2, N = 50) = 1.727, p-value = 0.422				
Observation only	1	5%	0	0%
Participation with guidance	4	20%	8	27%
Independent participation	15	75%	22	73%
Total	20	100%	30	100%
Initiate a project				
χ^2 (2, N = 48) = 2.304, p-value = 0.316				
Observation only	2	10%	1	4%
Participation with guidance	6	30%	14	50%
Independent participation	12	60%	13	46%
Total	20	100%	28	100%

Table 4. Comparison of students' exposure levels to educational experiences (*continued…*).

Please indicate the highest level of exposure you have in the following experiences:	NON-TCAP students		TCAP students	
	n	%	n	%
Leadership and teamwork				
Collaborate with faculty or students outside your group, but in the same discipline				
χ^2 (2, N = 50) = 0.152, p-value = 0.927				
Observation only	2	9%	2	7%
Participation with guidance	6	26%	6	22%
Independent participation	15	65%	19	70%
Total	23	100%	27	100%
Collaborate with faculty or students on a multidisciplinary team				
χ^2 (2, N = 49) = 4.589, p-value = 0.101				
Observation only	2	9%	6	22%
Participation with guidance	10	46%	5	19%
Independent participation	10	46%	16	59%
Total	22	100%	27	100%
Use online technology to collaborate to solve problems				
χ^2 (2, N = 49) = 10.607, p-value = 0.005				
Observation only	5_a	23%	4_a	15%
Participation with guidance	8_a	36%	1_b	4%
Independent participation	9_a	41%	22_b	81%
Total	22	100%	27	100%
Contribute to a project with international collaboration				
χ^2 (2, N = 37) = 0.750, p-value = 0.687				
Observation only	4	24%	5	25%
Participation with guidance	9	53%	8	40%
Independent participation	4	24%	7	35%
Total	17	100%	20	100%
Networking				
Interact with commercial plant breeders				
χ^2 (2, N = 53) = 0.299, p-value = 0.861				
Observation only	1	4%	1	3%
Participation with guidance	4	17%	7	23%
Independent participation	18	78%	22	73%
Total	23	100%	30	100%
Establish new professional contacts				
χ^2 (2, N = 54) = 0.636, p-value = 0.728				
Observation only	1	4%	2	7%
Participation with guidance	4	17%	3	10%
Independent participation	19	79%	25	83%
Total	24	100%	30	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 4. Comparison of students' exposure levels to educational experiences (*continued…*).

Please indicate the highest level of exposure you have in the following experiences:	NON-TCAP students		TCAP students	
	n	%	n	%
Networking				
Interact with scientists of different race, ethnicity, or country of origin				
χ^2 (2, N = 54) = 0.577, p-value = 0.749				
Observation only	1	4%	1	3%
Participation with guidance	1	4%	3	10%
Independent participation	21	91%	27	87%
Total	24	100%	31	100%
Computer Programming				
Programming for data storage and/or retrieval				
χ^2 (2, N = 39) = 3.627, p-value = 0.163				
Observation only	6	40%	4	17%
Participation with guidance	4	27%	5	21%
Independent participation	5	33%	15	63%
Total	15	100%	24	100%
Programming for data visualization				
χ^2 (2, N = 42) = 3.347, p-value = 0.188				
Observation only	5	29%	2	8%
Participation with guidance	4	24%	8	32%
Independent participation	8	47%	15	60%
Total	17	100%	25	100%
Programming for statistical analysis				
χ^2 (2, N = 51) = 4.796, p-value = 0.091				
Observation only	5	23%	1	3%
Participation with guidance	3	14%	7	24%
Independent participation	14	64%	21	72%
Total	22	100%	29	100%

Table 5. Comparison of students' perceptions of educational processes.

How important do you believe the following are in the process of educating graduate students?	NON-TCAP students		TCAP students	
	n	%	n	%
One-on-one mentoring				
χ^2 (2, N = 54) = 1.004, p-value = 0.605				
3	4	17%	5	17%
4	11	46%	10	33%
5 – Extremely important	9	38%	15	50%
Total	24	100%	30	100%
Collaboration with faculty other than the advisor				
χ^2 (2, N = 54) = 2.405, p-value = 0.300				
3	0	0%	2	7%
4	10	44%	9	29%
5 – Extremely important	13	56%	20	65%
Total	23	100%	31	100%
Collaboration with other graduate students in this institution (in this or other labs)				
χ^2 (2, N = 0.203) = , p-value = 0.904				
3	2	8%	2	7%
4	8	33%	12	39%
5 – Extremely important	14	58%	17	55%
Total	24	100%	31	100%
Collaboration with graduate students from other institutions				
χ^2 (2, N = 51) = 4.982, p-value = 0.083				
3	4	18%	8	28%
4	12	55%	7	24%
5 – Extremely important	6	27%	14	48%
Total	22	100%	29	100%
Teaching experience				
χ^2 (2, N = 53) = 0.303, p-value = 0.859				
3	8	35%	9	30%
4	9	39%	14	47%
5 – Extremely important	6	26%	7	23%
Total	23	100%	30	100%
Independent development of hypotheses				
χ^2 (2, N = 55) = 0.132, p-value = 0.936				
3	1	4%	1	3%
4	6	25%	9	29%
5 – Extremely important	17	71%	21	68%
Total	24	100%	31	100%

Table 5. Comparison of students' perceptions of educational processes *(continued..)*.

How important do you believe the following are in the process of educating graduate students?	NON-TCAP students		TCAP students	
	n	%	n	%

Independent development of research designs				
χ^2 (2, N = 55) = 0.188, p-value = 0.910				
3	1	4%	2	7%
4	7	29%	8	26%
5 – Extremely important	16	67%	21	68%
Total	24	100%	31	100%
Field experience				
χ^2 (2, N = 54) = 3.649, p-value = 0.161				
3	0	0%	2	7%
4	1	4%	5	16%
5 – Extremely important	22	96%	24	77%
Total	23	100%	31	100%
Laboratory experience				
χ^2 (2, N = 54) = 5.227, p-value = 0.073				
3	3	13%	5	16%
4	12	52%	7	23%
5 – Extremely important	8	35%	19	61%
Total	23	100%	31	100%
Exposure to diverse research methods and tools				
χ^2 (2, N = 55) = 0.622, p-value = 0.430				
3	—	—	—	—
4	5	21%	4	13%
5 – Extremely important	19	79%	27	87%
Total	23	100%	31	100%
Experience writing grants				
χ^2 (2, N = 52) = 0.675, p-value = 0.714				
3	2	9%	3	10%
4	9	41%	9	30%
5 – Extremely important	11	50%	18	60%
Total	22	100%	30	100%
Experience presenting results (e.g. meetings and papers)				
χ^2 (1, N = 55) = 0.024, p-value = 0.876				
3	—	—	—	—
4	5	21%	7	23%
5 – Extremely important	19	79%	24	77%
Total	24	100%	31	100%

Table 5. Comparison of students' perceptions of educational processes *(continued..)*.

How important do you believe the following are in the process of educating graduate students?	NON-TCAP students		TCAP students	
	n	%	n	%
Exposure to plant breeding students from different ethnic backgrounds				
χ^2 (2, N = 51) = 10.261, p-value = 0.006				
3	2_a	10%	14_b	47%
4	12_a	57%	6_b	20%
5 – Extremely important	7_a	33%	10_a	33%
Total	21	100%	30	100%

Note: Z-test results are denoted by the subscripts. When subscripts differ across a given row, it means the column proportions are significantly different at the $\alpha = 0.05$ level; i.e. the proportions for a response category are statistically significant between groups.

Table 6. Comparison of students' interests and experiences in the plant breeding field.

	NON-TCAP students		TCAP students	
	n	%	n	%
To what extent are you interested in a plant breeding career in **industry**?				
χ^2 (2, N = 54) = 1.388, p-value = 0.500				
Not at all interested	1	4%	2	7%
A little interested/Somewhat interested	2	9%	6	19%
Moderately interested/Extremely interested	20	87%	23	74%
Total	23	100%	31	100%
To what extent are you interested in a plant breeding career in **academia**?				
χ^2 (2, N = 54) = 2.011, p-value = 0.366				
Not at all interested	4	17%	2	7%
A little interested/Somewhat interested	10	44%	18	58%
Moderately interested/Extremely interested	9	39%	11	35%
Total	23	100%	31	100%
Have you ever participated in an internship in the plant breeding industry?				
χ^2 (1, N = 54) = 0.202, p-value = 0.653				
Yes	8	35%	9	29%
No	15	65%	22	71%
Total	23	100%	31	100%
Have you ever been employed (i.e. held a full-time position) in the plant breeding industry?[1]				
Yes	3	13%	—	—
No	20	87%	—	—
Total	23	100%	—	—
How interested would you be in an industry internship that lasts **between 1-4 weeks**?				
χ^2 (3, N = 54) = 1.411, p-value = 0.703				
Not at all interested	1	4%	1	3%
Somewhat interested	5	22%	5	16%
Moderately interested	5	22%	4	13%
Very interested	12	52%	21	68%
Total	23	100%	31	100%
How interested would you be in an industry internship lasting **more than 4 weeks**?				
χ^2 (3, N = 54) = 3.760, p-value = 0.289				
Not at all interested	4	17%	2	7%
Somewhat interested	3	13%	8	26%
Moderately interested	4	17%	9	29%
Very interested	12	52%	12	39%
Total	23	100%	31	100%

[1] TCAP students were not asked this question.

Table 7. Comparison of students' networking experiences.

How often have you interacted with the following types of people?	NON-TCAP students		TCAP students	
	n	%	n	%
Undergraduates that I am mentoring/My mentee/s				
Never	4	27%	2	8%
Once a year or less	1	7%	0	0%
Once every three months or less	1	7%	0	0%
Once a month or less	1	7%	4	17%
Once a week or less	2	13%	4	17%
More than once a week	6	40%	14	58%
Total	15	100%	24	100%
Other undergraduates at my institution				
Never	3	14%	2	7%
Once a year or less	0	0%	3	10%
Once every three months or less	5	24%	4	14%
Once a month or less	3	14%	6	21%
Once a week or less	4	19%	5	17%
More than once a week	6	29%	9	31%
Total	21	100%	29	100%
Students in my lab				
Never	0	0%	1	3%
Once a year or less	0	0%	0	0%
Once every three months or less	1	4%	1	3%
Once a month or less	0	0%	1	3%
Once a week or less	2	9%	4	13%
More than once a week	20	87%	24	77%
Total	23	100%	31	100%
Other graduate students at my institution				
Never	0	0%	0	0%
Once a year or less	0	0%	0	0%
Once every three months or less	1	4%	0	0%
Once a month or less	2	9%	2	7%
Once a week or less	7	30%	6	19%
More than once a week	13	56%	23	74%
Total	23	100%	31	100%
Students from other institutions in the U.S.				
Never	0	0%	1	3%
Once a year or less	7	32%	2	7%
Once every three months or less	8	36%	11	37%
Once a month or less	6	27%	9	30%
Once a week or less	0	0%	5	17%
More than once a week	1	5%	2	7%
Total	22	100%	30	100%

Table 7. Comparison of students' networking experiences *(continued...)*.

How often have you interacted with the following types of people?	NON-TCAP students		TCAP students	
	n	%	n	%

Students from minority serving institutions (MSIs)				
Never	8	42%	8	31%
Once a year or less	3	16%	12	46%
Once every three months or less	2	11%	4	15%
Once a month or less	3	16%	2	8%
Once a week or less	0	0%	0	0%
More than once a week	3	16%	0	0%
Total	19	100%	26	100%
Students from institutions outside of the U.S.				
Never	3	13%	6	20%
Once a year or less	12	52%	8	27%
Once every three months or less	4	17%	8	27%
Once a month or less	1	4%	5	17%
Once a week or less	1	4%	2	7%
More than once a week	2	9%	1	3%
Total	23	100%	30	100%
My advisor				
Never	0	0%	0	0%
Once a year or less	0	0%	0	0%
Once every three months or less	1	4%	0	0%
Once a month or less	3	13%	2	7%
Once a week or less	8	35%	11	36%
More than once a week	11	48%	18	58%
Total	23	100%	31	100%
Researchers at my institution				
Never	0	0%	0	0%
Once a year or less	0	0%	1	3%
Once every three months or less	3	13%	0	0%
Once a month or less	6	26%	6	20%
Once a week or less	6	26%	12	40%
More than once a week	8	35%	11	37%
Total	23	100%	30	100%
Researchers at minority serving institutions (MSIs)				
Never	8	44%	11	42%
Once a year or less	4	22%	9	35%
Once every three months or less	1	6%	2	8%
Once a month or less	2	11%	2	8%
Once a week or less	1	6%	1	4%
More than once a week	2	11%	1	4%
Total	18	100%	26	100%

Table 7. Comparison of students' networking experiences.

How often have you interacted with the following types of people?	NON-TCAP students		TCAP students	
	n	%	n	%
Researchers at other institutions in the U.S.				
Never	2	9%	1	3%
Once a year or less	8	35%	8	27%

Once every three months or less	12	52%	12	40%
Once a month or less	0	0%	5	17%
Once a week or less	0	0%	3	10%
More than once a week	1	4%	1	3%
Total	23	100%	30	100%
Researchers outside of the U.S.				
Never	3	13%	4	13%
Once a year or less	9	39%	10	33%
Once every three months or less	7	30%	11	37%
Once a month or less	4	17%	2	7%
Once a week or less	0	0%	2	7%
More than once a week	0	0%	1	3%
Total	23	100%	30	100%
Researchers from businesses and/or private companies				
Never	3	14%	1	3%
Once a year or less	7	32%	12	40%
Once every three months or less	6	27%	8	27%
Once a month or less	3	14%	5	17%
Once a week or less	3	14%	2	7%
More than once a week	0	0%	2	7%
Total	22	100%	30	100%

A comparison of TCAP PI's results by year

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 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 perceptions of the principal investigators (PIs) involved in the project. This report compares the 2013 and 2014 survey responses from PIs.

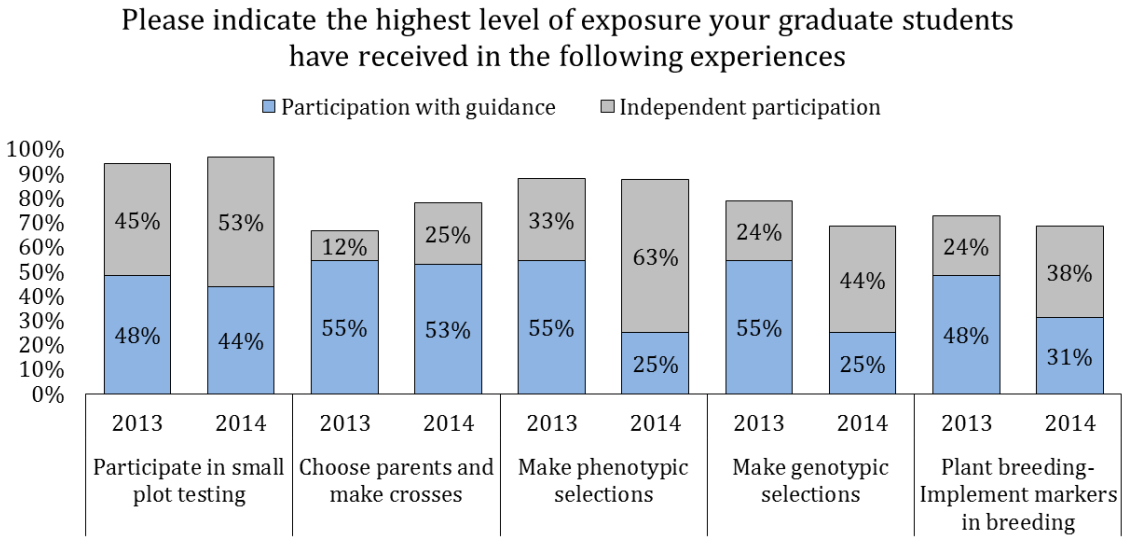

Figure 1. Comparison of Level of Exposure to Experiences in Plant Breeding by Years

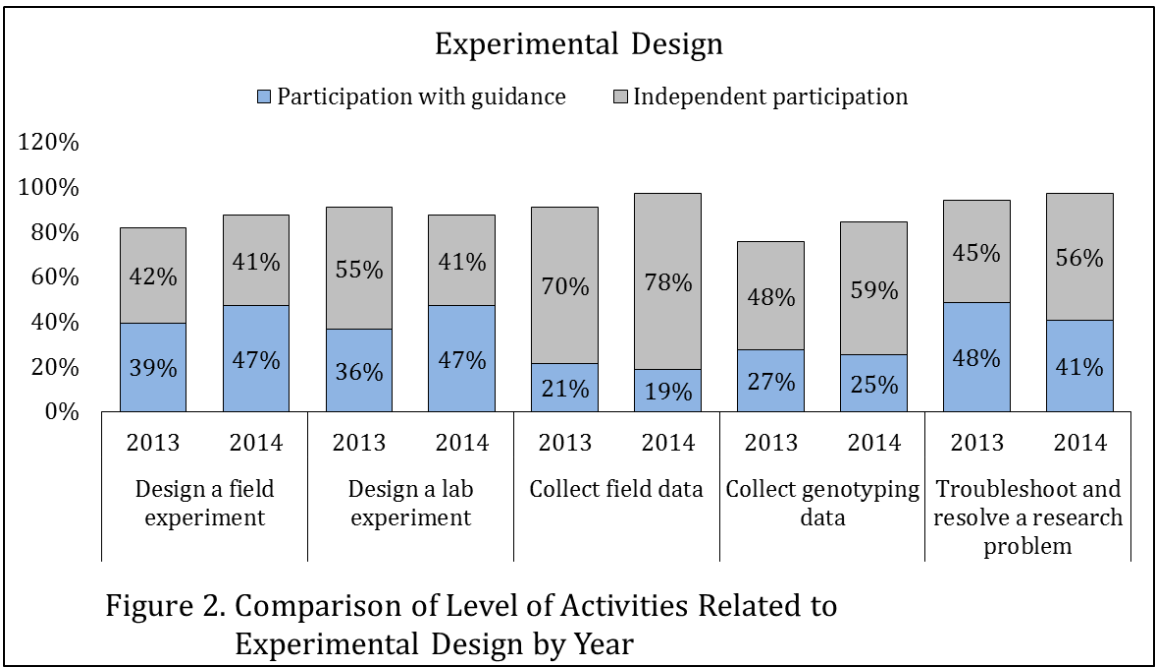

Figure 2. Comparison of Level of Activities Related to Experimental Design by Year

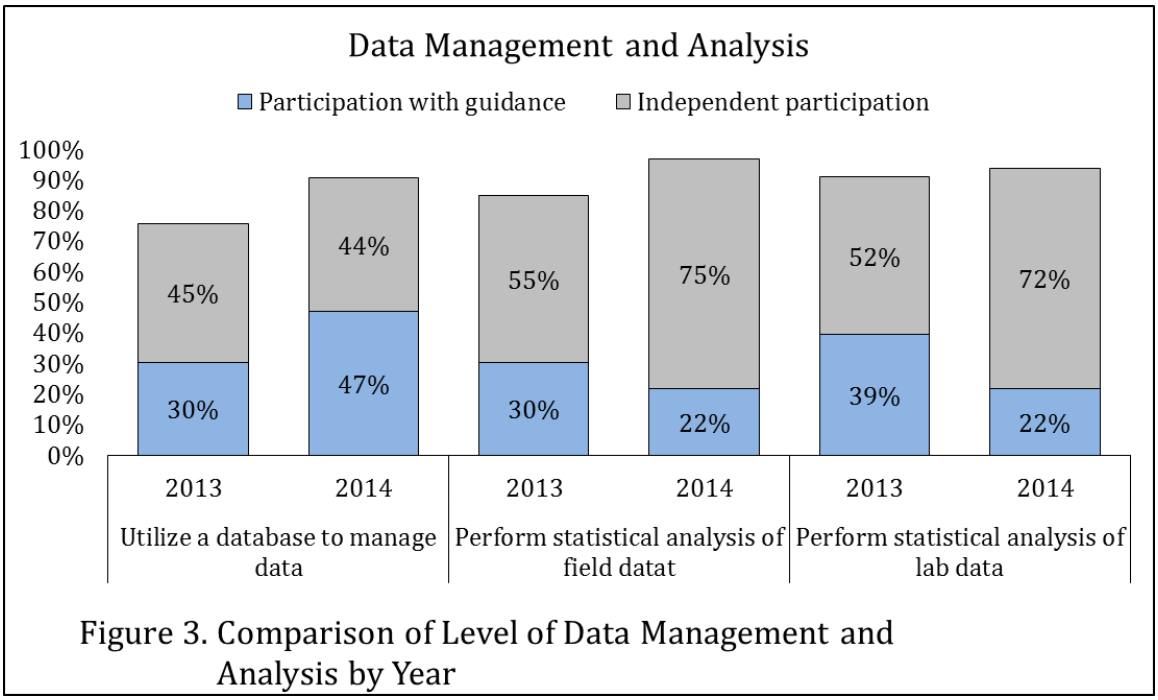

Figure 3. Comparison of Level of Data Management and Analysis by Year

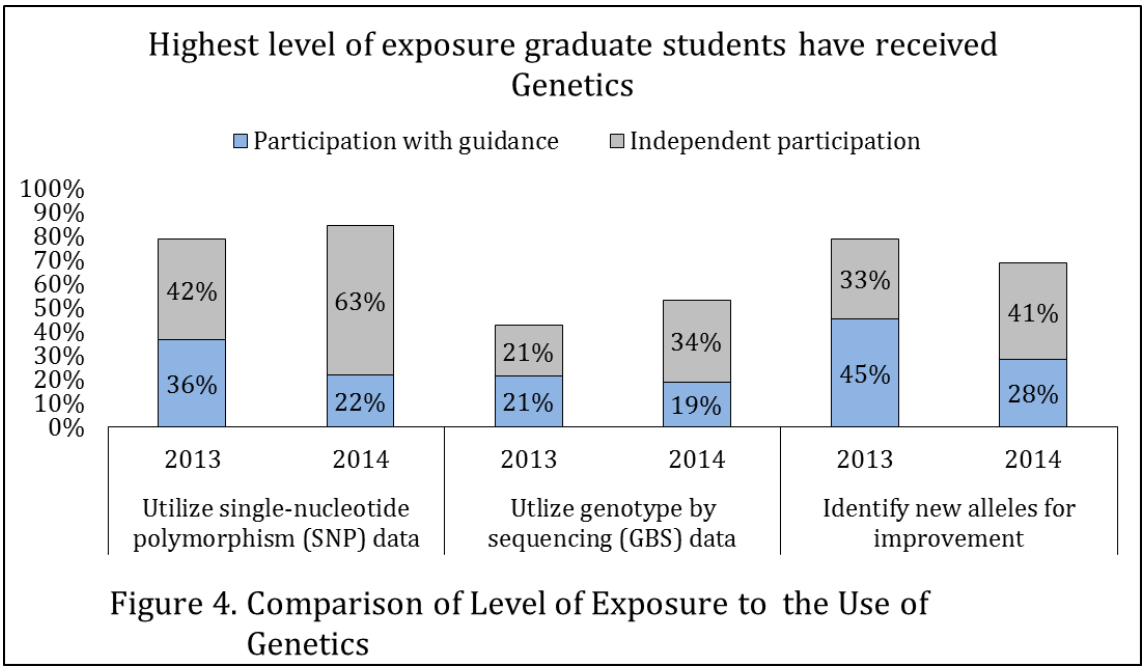

Figure 4. Comparison of Level of Exposure to the Use of Genetics

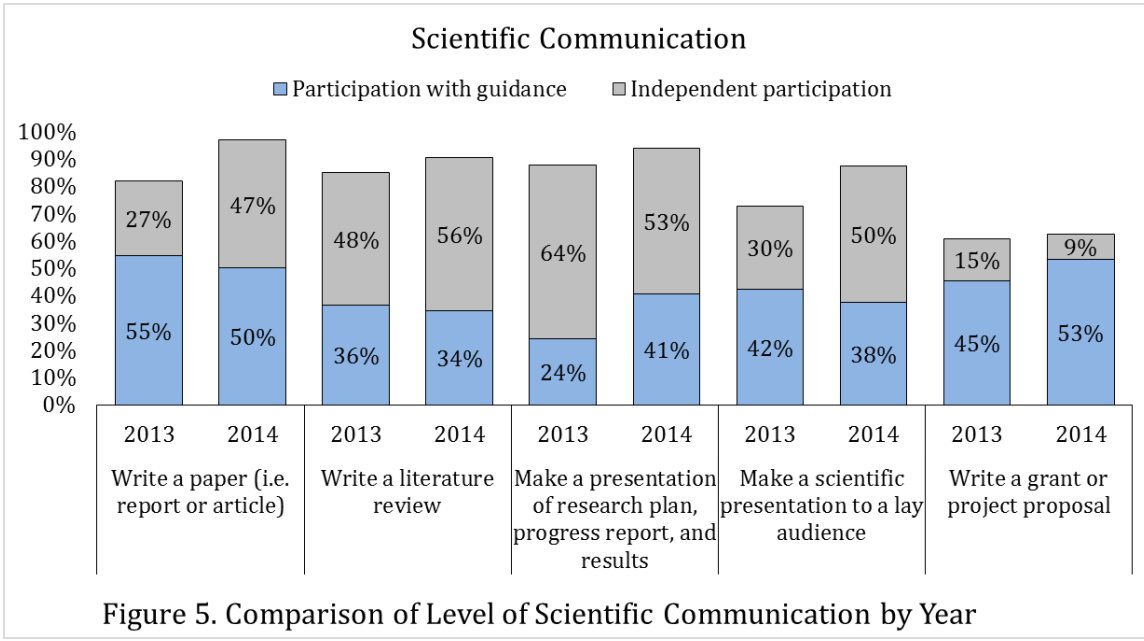

Figure 5. Comparison of Level of Scientific Communication by Year

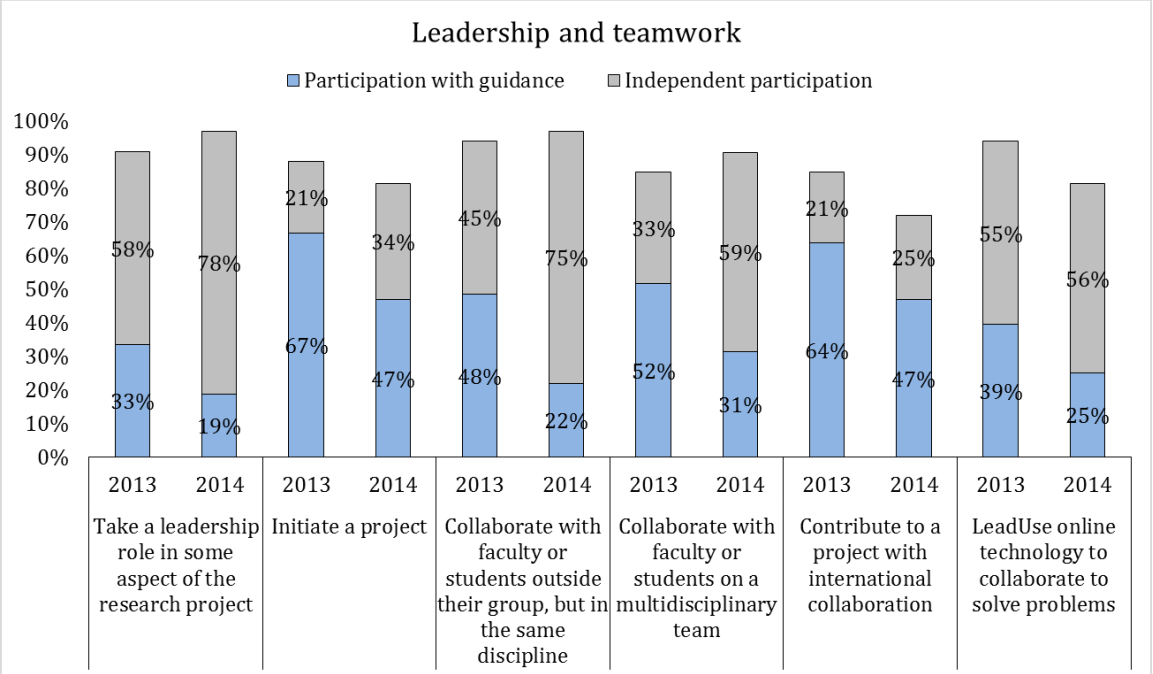

Figure 6. Comparison of Level of Leadership and Teamwork by Year

Results from the 2014 Undergraduate Student Survey

This report summarizes the survey responses from those undergraduates who participated in TCAP as research interns in the 2013-2014 academic year.

Methods

The evaluation team worked collaboratively with members of the TCAP educational committee to revise the previous year's survey. Surveys were administered online to undergraduate students from mid-April to mid-May of 2014. The survey assessed students' perceptions of the TCAP, mentoring experience, research experience, interests in graduate school, and interests plant breeding and plant sciences. Undergraduate students include both those attending TCAP institutions, as well as those attending minority serving institutions (MSIs).

Table 1: Respondents' gender.

What is your sex?	Female	Male
MSI students	7/9	2/9
TCAP students	3/9	6/9
Total	10/18	8/19

Table 2: Respondents' age.

What is your age?	MSI students	TCAP students	Total
18 to 19 years old	—	—	—
20 to 21 years old	1/9	3/9	4/18
22 to 23 years old	4/9	5/9	9/18
24 to 25 years old	2/9	1/9	3/9
26 years old or older	2/9	—	2/9

Table 3: Respondents' ethnicity.

Are you of Spanish, Hispanic, or Latino/Latina origin?	Yes	No
MSI students	—	9/9
TCAP students	—	9/9
Total	—	18/18

Table 4: Respondents' race.

What is your racial background?	MSI students	TCAP students	Total
American Indian or Alaskan Native	—	1/9	1/18
Asian	1/9	1/9	2/18
Black or African American	7/9	—	7/18
Native Hawaiian or Pacific Islander	—	—	—

White	1/9	7/9	8/18
Mixed race	—	—	—

Table 5: Respondents' major.

What is your major?	MSI students	TCAP students	Total
Agricultural biotechnology	—	1/9	1/18
Applied Plant Science/Plant science	—	4/9	4/18
Biological Engineering and Plant sciences	—	1/9	1/18
Biology	8/9	—	1/18
Food science	—	1/9	1/28
Genetics	—	1/9	1/18
Mechanical engineering	—	1/9	1/18
Plant breeding	1/9	—	1/18

Table 6: Respondents' knowledge of TCAP goals.

How much do you know about the goals of the TCAP?	Nothing at all	A little	A lot
MSI students	—	7/10	3/10
TCAP students	2/10	7/10	1/10
Total	2/20	14/20	4/20

Table 7: Respondents' participation in TCAP activities.

How often do you participate in the following TCAP activities?	Not at all often	Somewhat often	Moderately often	Very often	Not applicable, I have not done this activity
Planning research					
MSI students	3/10	3/10	2/10	1/10	1/10
TCAP students	2/10	3/10	2/10	2/10	1/10
Total	5/20	6/20	4/20	3/20	2/10
Being mentored					
MSI students	1/10	4/10	2/10	3/10	—
TCAP students	—	3/10	—	6/10	1/10
Total	1/20	7/20	2/20	9/20	1/20
Participating in a community of researchers **on campus**					
MSI students	4/10	2/10	2/10	1/10	1/10
TCAP students	—	1/10	2/10	5/10	2/10
Total	4/20	3/20	4/20	6/20	3/20
Participating in a community of researchers **online**					

MSI students	1/10	4/10	1/10	1/10	3/10
TCAP students	6/10	1/10	1/10	—	2/10
Total	7/20	5/20	2/20	1/20	5/20
Gathering, analyzing, and managing data					
MSI students	1/10	2/10	2/10	5/10	—
TCAP students	—	1/10	3/10	5/10	1/10
Total	1/20	3/20	5/20	10/20	1/20
Participating in a research experience at **your institution**					
MSI students	—	3/10	2/10	4/10	1/10
TCAP students	—	1/10	—	7/10	2/10
Total	—	4/20	2/20	11/20	3/10
Participating in a research experience at **another institution**					
MSI students	2/10	1/10	3/10	—	4/10
TCAP students	7/10	—	—	—	3/10
Total	9/20	1/20	3/20	—	7/20

Table 7: Respondents' participation in TCAP activities (*continued…)*.

How often do you participate in the following TCAP activities?	**Not at all often**	**Somewhat often**	**Moderately often**	**Very often**	**Not applicable, I have not done this activity**
Reporting research results					
MSI students	1/10	4/10	3/10	2/10	—
TCAP students	2/10	1/10	4/10	2/10	1/10
Total	3/20	5/20	7/20	4/20	1/10
Application of course concepts through hands-on experiences					
MSI students	2/10	1/10	3/10	3/10	1/10
TCAP students	—	3/10	6/10	—	1/10
Total	2/20	4/20	7/20	3/20	2/20
Participating in research in a **laboratory** setting					
MSI students	1/10	2/10	3/10	3/10	1/10
TCAP students	—	2/10	3/10	3/10	2/10
Total	1/20	4/20	6/20	6/20	3/20
Participating in research in a **field** setting					
MSI students	3/10	3/10	1/10	2/10	1/10

TCAP students	1/10	5/10	2/10	—	2/10
Total	4/20	8/20	3/20	2/20	3/20

Table 8: Respondents' value of TCAP activities.

How valuable are the following TCAP activities to you in your education?	**Not at all valuable**	**Somewhat valuable**	**Moderately valuable**	**Very valuable**
Planning research				
MSI students	—	1/10	3/10	6/10
TCAP students	1/9	—	1/9	7/9
Total	1/19	1/19	4/19	13/19
Being mentored				
MSI students	—	—	2/10	8/10
TCAP students	1/9	—	2/9	6/9
Total	1/19	—	4/19	14/19
Participating in a community of researchers **on campus**				
MSI students	—	1/10	1/10	8/10
TCAP students	1/9	2/9	1/9	5/9
Total	1/19	3/19	2/19	13/19
Participating in a community of researchers **online**				
MSI students	1/10	2/10	3/10	4/10
TCAP students	2/9	3/9	3/9	1/9
Total	3/19	5/19	6/19	5/19

Table 8: Respondents' value of TCAP activities (*continued…*).

How valuable are the following TCAP activities to you in your education?	**Not at all valuable**	**Somewhat valuable**	**Moderately valuable**	**Very valuable**
Gathering, analyzing, and managing data				
MSI students	—	1/10	1/10	8/10
TCAP students	1/9	—	1/9	7/9
Total	1/19	1/19	2/19	15/19
Participating in a research experience at **your institution**				
MSI students	—	—	3/10	7/10
TCAP students	1/9	—	1/9	7/9
Total	1/19	—	4/19	14/19
Participating in a research experience at **another institution**				

MSI students	—	1/10	3/10	6/10
TCAP students	3/9	2/9	3/9	1/9
Total	3/19	3/19	6/19	7/19
Reporting research results				
MSI students	—	—	2/10	7/10
TCAP students	1/9	1/9	3/9	4/9
Total	1/19	1/19	5/19	12/19
Application of course concepts through hands-on experiences				
MSI students	—	2/10	1/10	7/10
TCAP students	1/9	1/9	1/9	6/9
Total	1/9	3/9	2/9	13/19
Participating in research in a **laboratory** setting				
MSI students	—	1/10	1/10	8/10
TCAP students	1/9	1/9	1/9	6/9
Total	1/19	2/19	2/19	14/19
Participating in research in a **field** setting				
MSI students	—	2/10	3/10	5/10
TCAP students	2/9	1/9	1/9	5/9
Total	2/19	3/19	4/19	10/19

Table 9: Respondents' mentoring experiences

	MSI students		TCAP students		Total	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Is there anyone involved in your research experience that you would consider a mentor?	8/10	2/10	8/9	1/9	16/19	3/19
Are you being mentored by more than one person?	6/8	2/8	5/8	3/8	11/16	5/16

Table 10: Respondents' mentor's role.

What is your primary mentor's role?	**MSI students**	**TCAP students**	**Total**
Faculty member	7/8	4/8	11/16
A laboratory technician	1/8	—	1/16
Graduate student	—	4/8	4/16
Some other role	—	—	—

Table 11: Respondents' perceptions of the most liked aspect of their mentoring experience.

What do you like the most about your mentoring experience?
MSI students
Advice.
Hands on learning experience. Regular interaction with my mentor on academic issues.
I love the hands on training and learning my mentor provides as well as knowledge and experience in that field.
The life lessons.
The mentor continues to challenge me as a researcher and I appreciate that.
TCAP students
Being able to ask immediate questions and getting reliable answers where I can ask for clarification to ensure I understand correctly.
Being introduced to the actual side of research and learning about what it takes to establish real data is excellent, and not just sitting in a classroom being lectured at.
I enjoy getting involved in problem solving and learning what he's working on.
It is like 1:1 tutoring, and I get to know more in dept about the experiment that I'm doing.
She is always willing to answer any questions I have.
The chance to learn from an experienced individual and grow as a scientist.
This semester, my faculty mentor has been relatively "hands off" because my research abilities have developed enough to design experiments, collect data, perform analyses, and present my work independently. I appreciate the opportunity to function in such a way in his program. He readily follows up with me to see how I'm doing and is always available to answer questions or if I need advice on some aspect of my experimental design or analysis.

Table 12: Respondents' thoughts on improving their mentoring experience.

What could make your mentoring experience better?
MSI students
Having exchange program with other TCAP members to learn more on research activities of other members. I believe this will expand our scope beyond our individual projects.
More hands on experience with the mentor.
My mentoring is very good. I don't think it needs to be better.
Weekly meetings.
TCAP students
Even with spending 12-15hrs per week in a lab there still isn't enough immersion, I could learn SO much more... 20 would be better. By incentivizing the research students do with class credit this position as an undergraduate researcher would not only be more appealing, but retention would improve considerably...namely myself
I think spending time with the mentor is crucial in the beginning but the mentor needs to help student to independently work on their project.
If there was a build up of information instead of everything getting thrown at me at once.
More hands on experience.
Nothing! I can't think of anything off the top of my head besides time. Throughout my undergraduate, I learned the *most* from my own individual research experiences. I wish I had had more time to devote to them because it would have allowed for working through my experiments with my mentor more thoughtfully instead of the rushed manner that I seemed to always have to do everything in order to get to class.
Nothing.

Table 13: Length of respondents' research experience.

Number of months[a]	**MSI students**	**TCAP students**	**Total**
1 to 2 months	—	—	—
3 to 4 months	1/10	1/8	2/18
5 to 6 months	—	—	—
7 to 8 months	1/10	1/8	2/18
9 to 10 months	—	2/8	2/18
11 to 12 months	2/10	—	2/18
Greater than one year	6/10	4/8	10/18

[a] Number of months were calculated using the month and year students reported starting their research experience to the month of either April or May 2014 when the student completed the survey.

Table 14: Respondents' thoughts on what they want to gain from their research experience.

What do you hope to gain from your research experience?
MSI students
Applicable experience.
I hope to gain results and experience that will allow me to do research at a more advanced level.
Leadership skills and research skills.
Masters degree.
My greatest hope is to be trained all around in conventional and classical wheat breeding and genetics and apply this knowledge to make a difference in humanity.
Networking opportunities and a better understanding of plant biochemistry.
New knowledge of procedures, materials, and to use this knowledge for future research projects.
TCAP students
A better understanding of what types of questions can be answered and how you go about doing that.
A foundational experience with planning, acquiring, and presenting agriculturally related research.
Experience in a research setting and with preparation, organization, and presentation of the design and results of experiments.
I hope to co-author a paper and make important connections with people in the field.
N/A
Organizing skill needed for research and variety of experience dealing with mistakes and errors during experiment.
Skills that I can apply in the work place.
To be able to get more experience in this particular area and to network.
When I began, I think I wanted to gain "experience," but I didn't have a good idea of what that meant. Over the course of my research experiences, I gained a working knowledge of experimental design, phenotyping techniques for small grains and plant pathology, various statistical analyses tools, and computer programming tools with regards to data analysis. I also gained valuable experience and feedback from the various poster and oral presentations I gave (at the ASA-CSSA-SSSA meetings funded by a TCAP travel grant, at the TCAP meeting at PAG, and through multiple online presentations to the TCAP network). Finally, I wrote up my work into a 111-page "dissertation" which was reviewed and edited by three readers, including my faculty mentor. In retrospect, out of all of those I think I could have gained more in the area of analysis techniques. I had all this data, but I haven't necessarily had enough statistics or introduction to genomic tools to know what to do with it. I should add, however, that the TCAP online lecture and lab series on association mapping was what enabled my project. I think having more of those kinds of opportunities available for learning the new genomic tools that are coming about could be really beneficial for students.

Table 15: Respondents' participation in research activities.

In your research experience, how often do you do the following?	Not at all often	Somewhat often	Moderately often	Very often	Not applicable, I have not done this activity
Conduct miscellaneous basic lab duties (e.g. wash glassware, weigh samples, tend to plants, enter data, etc.)					
MSI students	1/9	—	2/9	6/9	—
TCAP students	—	2/9	3/9	3/9	1/9
Total	1/18	2/18	4/18	9/18	1/18
Conduct skilled lab work duties (e.g. DNA isolation, PCR, immunoassays, etc.)					
MSI students	3/9	2/9	2/9	2/9	—
TCAP students	1/9	1/9	1/9	4/9	2/9
Total	4/18	2/18	3/18	6/18	2/18
Work with another undergraduate in learning to do research					
MSI students	2/9	1/9	2/9	4/9	—
TCAP students	4/9	2/9	—	1/9	2/9
Total	6/18	3/18	2/18	5/19	2/19
Work with a graduate student					
MSI students	2/9	2/9	1/9	2/9	2/9
TCAP students	1/9	3/9	1/9	3/9	1/9
Total	3/18	5/18	2/18	4/18	3/18
Teach someone else how to performed skilled lab work tasks					
MSI students	1/9	1/9	4/9	2/9	1/9
TCAP students	1/9	5/9	1/9	—	2/9
Total	2/18	4/18	5/18	2/18	3/18
Prepare a report with research results					
MSI students	2/9	1/9	3/9	3/9	—
TCAP students	2/9	3/9	2/9	1/9	1/9
Total	4/18	4/18	5/18	4/18	1/18
Present at a scientific conference					
MSI students	1/9	2/9	1/9	4/9	1/9
TCAP students	3/9	2/9	—	1/9	3/9

Total	4/18	4/18	1/18	5/18	4/18

Table 15: Respondents' participation in research activities (*continued…)*.

In your research experience, how often do you do the following?	**Not at all often**	**Somewhat often**	**Moderately often**	**Very often**	**Not applicable, I have not done this activity**
Present at a student symposium					
MSI students	2/9	3/9	—	4/9	—
TCAP students	4/9	2/9	—	1/9	2/9
Total	6/18	5/18	—	5/18	2/18
Be involved in writing a manuscript for publication					
MSI students	3/9	2/9	2/9	1/9	1/9
TCAP students	3/9	3/9	—	1/9	2/9
Total	6/18	5/18	2/18	2/18	3/18

Table 16: Respondents' perception of the most liked aspect of their research experience.

What do you like most about your research experience?
MSI students
Hands on lab experience.
I enjoyed the hands on experience, and the guidance I received to be able to accomplish my research goals during the internship.
I have so far learned a lot and I am much better than the first day that I joined the project.
I like the actual practice and repeated trials to get results.
Interacting with people.
Learning new things.
Working with another undergraduate student on trying to find out information on the research of interest.
TCAP students
Acquiring a skill set which will benefit my lab expertise for the rest of my life.
Being able to understand the thought process that goes into research which has helped me think more methodically then in the past.
Conducting and organizing one particular experiment independently.
I am independent when it comes to decisions regarding the direction of the research and I am left to decide or determine what steps to take to achieve the goals.
I really enjoyed the critical thinking involved with carrying out my own experiment independently. This wasn't a typical undergraduate project in which I was told what to do at each step along the way. It was up to me to figure out what was going wrong, how to analyze my results, how to best interpret the analysis, etc. These are things that I *rarely* get to do in the classroom, but they are experiences that will be extremely valuable to have under my belt already when I begin graduate school in the fall.
N/A

That I can work and learn something that has always been of interest to me.
That I'm working on an interesting project and practicing techniques.

Table 17: Respondents' perceptions on improving their research experience.

What could make your research experience better?
MSI students
Exchange programs, more online courses especially in quantitative genetics and statistics.
For someone to actually be with me showing me how to do the experiment rather than having me figure it out on my own by using the internet and talking to other people on campus.
I wanted to actually have a specific topic of research present, although I did have various tasks I completed; a set research topic to present would have been more logical.
It could be better if I had more time to do research from classes I am taking.
More hand-on experiences with the mentor.
TCAP students
Giving students option about different ways of conducting same experiment.
I don't think anything needs to change in order for my experience to get better.
It could be better if I got to participate in the intellectual side more and writing papers.
Like I mentioned before, I really struggled with having enough time to do what I needed to do. I assayed two populations, each consisting of roughly 300 lines, against three races of leaf rust. That was *a lot* of planting, inoculating, and screening. I did this on top of six classes, while visiting five graduate schools and attending six conferences in the past year. My research always seemed like something I would have to squeeze into the five minutes I had available here or there. I know this is outside the scope of what TCAP can do, but I think it would be really nice if undergraduate programs in the applied sciences shifted some of the emphasis on completing coursework over to students' practical experiences in whatever they plan to do after graduation (i.e. research, field work/production, etc.)
More field and greenhouse work, which is what I'll be doing all summer :)
More hands on experience in more one in our time with professionals.
N/A
Time conflicts with classes and other work made it difficult to complete the project timely, however this was unavoidable.

Table 18: Respondents' report of the skills and/or abilities they have developed.

What skills and/or abilities have you developed (if any) as a result of your research experience?
MSI students
HPLC, spectroscopy, rotovac, vacuolar extraction.
I have developed many skills such as maintaining a lab notebook, cleaning, PCR, DNA extraction, gel electrophoresis, primer dilution, etc…
Leadership and a better understanding of research protocols and scientific papers.
I learned basic lab techniques and also how to collect and analyze data.
I learned how to analyze data and put together research reports.
I learned a lot about detecting leaf rust, and also some basic procedures for wet work.
I am able to analyze and interpret accurately high throughput genotyping data, I have improved in scientific writing skills, e.g. research proposal, papers, and reports.
TCAP students
A more scientific mind set.
how to conduct research, time management, responsibility, dealing with situations in the lab and interpersonal skill.
I have learned how to thresh barley heads. I have also learned how to stay organized and precise in research, since that is really important.
I've developed communication and troubleshooting skills, besides specific task skills like running PCRs and gels.
Molecular biology and microbiology skills, greenhouse care, and observation skills.
N/A
Oh my gosh there are so many! Experimental design: how to ask the right question, how to set up an experiment to answer that question, how to modify your experiment as you find out more information, etc. Phenotyping: how to set up and run a large greenhouse-based experiment, how to phenotype for disease resistance in small grains, how to begin thinking about new and more accurate ways to phenotype. Analysis: statistics and computing with R, association mapping in R, preparing genotypic datasets of analysis with computing tools, visualizing data with computing tools, etc. Interpretation: literature review, designing follow-up experiments given a result. Presentation: how to effectively create and communicate a scientific poster, how to effectively create and communicate an oral presentation online and in person, how to write a manuscript/dissertation.
PCR, KASPar, ABI, GeneMarker software, ArcGIS, Crossing techniques and emasculation, data analysis and conclusion synthesis, data presentation, teamwork with professionals.

Table 19: MSI respondents' perceptions of collaborators.

To what extent do you feel comfortable approaching the following types of collaborators at the other institution?	Not at all	Somewhat	Moderately	Very
Faculty members	1/7	1/7	—	5/7
Students	—	—	3/7	4/7

Table 20: Extent of which MSI respondents have travelled to work with collaborators.

	Yes	No
Have you spent time working with collaborators at their campus?[a]	3/9	6/9

Table 21: Perceptions of faculty and students from collaborating TCAP institution[a].

To what extent do you agree or disagree?	Strongly disagree	Disagree	Agree	Strongly agree
I feel welcome at the other institution	—	—	1/3	2/3
The faculty members at the other institutions are respectful	—	—	1/3	2/3
I work well with the faculty members at the other institution	—	—	1/3	2/3
The students at the other institution are respectful	—	—	1/3	2/3
I work well with the students at the other institution	—	—	1/3	2/3

[a] These questions were only asked to those three students who reported spending time at their collaborators' campus.

Table 22: Respondents' interest in graduate school.

To what extent are you interested in graduate school?	Not at all interested	A little interested	Somewhat interested	Moderately interested	Extremely interested
MSI students	2/9	—	—	2/9	5/9
TCAP students	—	—	2/9	—	7/9
Total	2/18	—	2/18	2/18	12/18

Table 23: Respondents' perceptions of whether their research experience has impacted their interest in graduate school.

Has your research experience impacted your interest in pursuing graduate school?	**Yes**	**No**
MSI students	7/8	1/8
TCAP students	5/6	1/6
Total	12/14	2/14

Table 24: Ways respondents' have been impacted by their research experience to pursue graduate school.

In what ways has your research experience impacted your interest in pursing graduate school?
MSI students
I am pursuing studies and my research experience has solidified my interest in graduate school.
I looked up to my post-doc mentors, and speaking with them about expanding education and experience is something that is valuable.
I'm considering attending the school I'm doing research at for graduate school.
It has given me confidence.
It really prepared me for the tasks of laboratory work and I soon became used to the environment.
My research had really gave me the extra drive to pursue this as a career making me want to go to graduate school.
TCAP students
At the most basic level, my research experience through TCAP essentially tested whether or not graduate school was something I wanted to do. I think over the past year I probably experienced as close to what a graduate student experiences in day-to-day life as any undergraduate student could. I took on a project the size of a typical Master's degree project. I had to write a proposal to receive my own funding. I was 100% responsible for my own plants in the greenhouse. I had to drop everything to attend to the plants when they were ready to be phenotyped. I had to juggle my research with classes and personal life. I experienced the frustrations of things not working out the way I had originally planned. I had to work as part of a team, being mindful of others' projects, getting assistance when I needed it, and contributing feedback on others' research. I had to figure out how to analyze data and interpret results on my own. I worked crazy hours, evenings and weekends, returning to the lab at 7 pm after dinner to put in just as much work as I had before dinner in the evening. There were of course parts of it that I didn't enjoy, but in the end I felt I could be 100% sure that I had enough experience to know that graduate school was what I wanted to do next and that I could likely be successful at it.
Before this experience, I didn't have any clue what graduate school would look like. This research experience is something that I enjoy and I can see myself going into graduate school.

It gives me a clear idea of what may be expected of/from me if I were to be in a graduate setting
It has inspired me to become a developed scientist and graduate school is one way to achieve that goal
It's made me think about gaining work experience before going back for grad school.

Table 25: MSI respondents' thoughts on attending their collaborators' institution for graduate studies.

	Yes	No
Would you consider pursuing graduate studies at the other institution that is collaborating with your on your research project?	3/6	3/6

Table 26: Reasons why MSI respondents would attend their collaborator's institution.

Why would you consider pursuing graduate studies at this other institution?
I would consider this because I would like to be where I am learning and getting as much out of my experience as possible. If another institution has another institution has similar research I do not mind attending.
They had better resources
They have a good genetics program.

Table 27: Reasons why MSI respondents would NOT attend their collaborator's institution.

Why would you not consider pursuing graduate studies at this other institution?
I'm looking to pursue medical school.
Location.

Table 28: Respondents' report of the top two barriers to graduate school.

What are the top two barriers that might stop you from going to graduate school?			
MSI students		**TCAP students**	
First barrier	**Second barrier**	**First barrier**	**Second barrier**
Changing of opinion later on in life	Money	Admittance	Finances
Financial	Location	Finance	Interpersonal skills
Financial aid	Job conflicting	Financial	Advisor/program appeal
GRE	Costs	Grade point average	GRE
I would like to go to medical school	I'm not interested in graduate school	I have already accepted an offer, but one of the biggest struggles that I had during the admissions process was that many institutions	

		seemed to be hurting for funding this year, and it was difficult to find a project that was both of interest to me and had funding.	
Not applicable	Not applicable	Money	Undergraduate Grades
Not getting accepted	Lack of funds	Money and return on investment	Getting into graduate school
Not getting accepted in the program that I want	Not getting a full scholarship with stipend	Moving far away from my family	Financial set backs
		Not knowing what I want to study	Committing two years to something I might not like.

Table 29: Respondents' report of needed supports for graduate school.

What kinds of support would you need if you were to pursue graduate school?
MSI students
Scholarship and stipend and close to home.
Financial support, as well as daycare.
Fellowships and possible work opportunities to gain extra money.
Financial
Financial support
Financial support
Not applicable
TCAP students
Academic support to know how much my grade point average actually matters.
Financial support would be awesome and also just support in general from friends and family.
Financial, mostly.
Help developing an academic plan and help knowing how to use resources efficiently.
I would definitely need support from my family. Also, financial stability is necessary because I don't want to take out unnecessary loans.
I would need either a Teachers Assistant position or Research Assistantship with a professor to help cover the expenses of graduate school
More experience about being a grad student, I think the program is providing enough support.
Speaking as someone who has just gone through the process, I used the career center at

[institution] to read my CV and personal statement. I also sought out the CV and personal statement of a current graduate student who had just a few years before gone through the process so I would have an idea of how to get started. I talked to a lot of people, graduate students and faculty, about the do's and don't's of recruitment visits. And when I had offers on the table, I tapped in to just about everyone in my network of graduate students and faculty to evaluate the best options.
The freedom to change my mind, but that's not really possible.

Table 30: Changes in perceptions about a career in plant science and plant breeding.

	Yes	**No**
Have your perceptions of a career in **plant science** changed since you joined the TCAP?		
MSI students	5/9	4/9
TCAP students	6/9	3/9
Total	11/18	7/18
Have your perceptions of a career in **plant breeding** changed since you joined the TCAP?		
MSI students	3/9	6/9
TCAP students	6/9	3/9
Total	9/18	9/18

Table 31: Ways respondents' perceptions about plant science and/or plant breeding has changed since participating in their research experience.

In what ways have your perceptions of a career in **plant science** changed?
MSI students
I have been shown the possibilities and many areas as possible careers that I never imagined were available.
I have learned the importance of plant breeding and plant science.
I was able to see another part of science that I was not that much exposed to. It is always rewarding to gain new experiences, and I actually enjoyed the information that I gained about plant science.
It is more interesting than I at first thought.
TCAP students
At first I thought it would be a bit boring, but when I can apply what I've learned I found it interesting. Also, I got to see why plant breeding and genetic modification and identification is important in agriculture industry/
I had always heard that, "It's such a great time to become a plant breeder because there are so many careers." But then I've watched my friends struggle to get jobs after finishing their PhDs. I'm skeptical about how good the industry actually is for getting jobs. Also, my dream job was also to go into international agricultural research for development, i.e. working at one of the CGIAR centers. I had the opportunity to go down to CIMMYT in Obregon, Mexico this past March, and while I had an amazing experience there, I was a bit discouraged by what I saw. The

international agricultural research community felt much less welcoming to women than perhaps I had expected them to be. I was left feeling like if you're not a white woman from the U.S. or Europe, you may as well forget pursuing a career there, and even if you are American or European, there will be many barriers along the way. As I've progressed through my undergraduate, I've also heard many women express how unforgiving this career field is to having a family (if you're a woman). That became especially apparent when I visited CIMMYT. It was discouraging to me to see so many men who were able to have the career I wanted and have a family, while women in the same situations numbered so few.
I have a more optimistic perception on the abilities and opportunities that specifically plant breeding can accomplish in the field of crop improvement in comparison to my prior beliefs
I wanted initially to study more biotechnology, but now I would like to pursue a more general plant breeding education
It seems a lot more difficult to get meaningful results and conduct experiments.
It's a lot of grunt work for not a lot of recognition.
In what ways have your perceptions of a career in **plant breeding** changed?
MSI students
I have learned the importance of it.
TCAP students
I didn't really have any perceptions at first. Now I know that plant breeding is important work.
I have come to appreciate it more.
I perceive there to be more possibilities in plant breeding than I once foresaw.
I was more diversity in what plane breeders mean come across in their work. Or has also shown me the companies that design support equipment to make data collection easier.
I've come to realize that plant breeding more or less isn't what it used to be. To ask what a plant breeder does nowadays may elicit a hundred different answers. The different roles that people with plant breeding and genetics can take in industry and academia have really expanded and diversified with the advent of technology.
Seeing what I've just seen in books in genetics class, it was interesting to see the procedures in real life.

Table 32: Respondents' motivation to pursue a plant science and/or plant breeding career.

	Not at all motivated	A little motivated	Somewhat motivated	Moderately motivated	Extremely motivated
To what extent are you motivated to pursue a career in **plant science**?					
MSI students	2/9	3/9	2/9	—	2/9
TCAP students	—	1/8	2/8	—	5/8
Total	2/17	4/17	4/17	—	7/17
To what extent are you motivated to pursue a career in **plant breeding**?					
MSI students	3/9	3/9	1/9	—	2/9

TCAP students	3/9	3/9	—	—	3/9
Total	6/18	6/18	1/18	—	5/18

Table 33: Reasons for not being motivated to pursue a career in plant science and/or plant breeding.

Why are you not motivated to pursue a career in **plant sciences**?[a]
MSI students
Have another career goal in mind.
I'm not interested in this field.
Why are you not motivated to pursue a career in plant breeding?
MSI students
Have other careers in mind.
I dislike genetics.
I'm not interested in this area.
TCAP students
I don't like the specialized nature of the field. I don't like the fact that our funding is tied to special interests. I don't like the fact that most of the work is inside.
I am more interested in molecular plant science.
I just graduated in engineering

[a] All TCAP students were at least "a little" motivated to pursue a career in plant science, so this question was not asked to any TCAP students.

Table 34: Students' experiences that have contributed to interests in plant sciences and/or plant breeding.

In general, what experiences, if any, have you had that contributed to your interest in **plant sciences**?
MSI students
Classes such as botany, and the lab work done within that course.
Experience with plant research in the lab I work in.
Extraction and analysis.
My interest dates back to elementary school where we practiced agricultural science and learned basic biological processes such as photosynthesis and respiration. However my turning point was during my post-secondary internship when I learned how to make crosses and develop hybrid seed. This sparked my interest to pursue plant science specifically majoring in plant breeding.
N/A
Nematode research.
TCAP students
Experiments and being around plants a lot in the green house. Also, lectures related to what we apply in experiments.
Growing up with horticultural immersion (gardening and farmers market participation). Plant science curriculum, middle school through college. Plant science research, with TCAP discussions with plant science researchers and professors.
Having an interest in plants to begin with from parents.
High school experience, parents, undergraduate classes, internships.
I grew up on a farm, so I knew I wanted to get into a career dealing with plants.
I just like plants and they are pretty important.
My engineering foundation has prepared me with the necessary science and math skills. I look forward to adapting these to my interest in plant science.
My research through TCAP, my attendance and presentations at national conferences, my work as a laboratory assistant during my first two years of undergraduate, my two internships in industry.
Working on my family farm when I was younger.
In general, what experiences, if any, have you had that contributed to your interest in **plant breeding**?
MSI students
My interest dates back to elementary school where we learned basic biological process such as photosynthesis and respiration. My turning point however, was in post-secondary education where I learned how to make hybrid seed through crossing. This sparked my interest in plant science, which was solidified during my attachment in undergraduate studies.
N/A.
Presentations.
TCAP students
Being outside. Seeing the differences between different varieties.
Farming for my family. Working at the university for the benefit breeding program. Working for a company that smiths equipment for other breeders to collect real time data in the field.
I have written term papers on plant breeding.
I would say all of the answers I gave for this question with regards to plant science would also apply here.
Identifying a gene in the lab doing experiments.

Internships, undergraduate classes.
Knowing what hundreds of years of plant breeding has accomplished.
Nothing really, I just wanted to invest time into something related to agronomy. This research job was open, so I decided to take it.
Working with this research and discussing the benefits of transgenic methods with opposing individuals gave me insight to the likelihood that plant breeding will always be more accepted by the public than transgenic cultivars.

Table 35: Reasons that motivate students to pursue a career in plant science and/or plant breeding.

Please list reasons, if any, that motivate you to pursue a career in **plant sciences**?
MSI students
N/A
Plant science is an interesting and real field where you sow a seed and get returns multiplied several fold. In my opinion, it's sort of scientific banking process where you invest and get return to investment and this subsequently sustains the entire food chain. This motivates my interest and also I have special interest in nature and the environment and plants play a crucial role in this regard.
Stability and the added benefits such as stipends, etc, while going to school to prepare for these careers.
To help in the quest of finding more drought tolerant wheat.
TCAP students
1. I want to be involved in the production of something that can immediately benefit a large amount of people.
A better chance to learn things by being able to control for more variables.
Having more experience about why plants are important to agricultural industry. Understanding of experiments being conducted.
I believe there is a need for a more technical and molecular approach to plant science, and I hope I can do that!
I enjoy working with plants - I like working outside - I would love to work with farmers
I perceive an inevitable difficulty associated with crop production in the next 30 years that will inexorably negatively effect the world. By addressing these difficulties now, from the bottom up, with food, I believe we (as scientists) may mitigate these upcoming difficulties in the world
In previous experience in farming.
The main reason I am pursuing this career is to better the lives of others and the environment. I also enjoy being around people from different backgrounds.
Please list reasons, if any, that motivate you to pursue a career in **plant breeding**?
MSI students
Plant science is real where you sow a seed and get returns several folds! Its sort of scientific banking process where you invest seed and get returns to investment in terms of yield. This is how farmers livelihood is improved and this motivates me. Making lives better and better drives my passion.
To cultivate cures, I do believe cures to various diseases lie in plants; and breeding could help stimulate a plant/drug to help alleviate diseases.

TCAP students
Again, for me the answer to this question with regards to plant science would also apply here.
Being around plant environment, green house, and doing experiments sort of related to plant breeding
I want to have a positive impact on my environment...culturally, financially, health, physical environment, GLOBALLY. Changing a source of life for the better affects all who utilize it for the better
N/A. (2 respondents)
None.
You know, I'll probably be a plant breeder, but not in the University sense. I'll use what I've learned here to run my farm better.
You're working towards an end goal that is physically tangible.

Table 36: Reasons that discourage students from pursuing a career in plant science and/or plant breeding.

Please list reasons, if any, that discourage you from pursuing a career in **plant sciences**?
MSI students
Bad mentors.
Field work.
Lack of funds.
Lack of interest.
No where close to home promoting their program.
None. (2 students)
TCAP students
As I stated before, I feel there are certain aspects of careers in plant sciences that make it less attractive to women.
I don't like working with plants in an extremely strict environment. I also can't stand the thought of focusing on just one crop or bouncing around between crops. I'd like to work on them all together, perhaps like a cropping systems specialist. I also don't like what I perceive to be the structure of the career paths out of plant science. It's corporate work or university work.
I have a degree in another career path.
N/A
Not applicable. Nothing discourages me.
Nothing.
Research seems tedious at times and especially so when there are thousands of seeds involved.
Takes very long time to get results, has to do repeating experiments over and over, but I think this is same for researchers in other fields, too.
The red tape and costliness that prohibits certain transgenic and impedes breeding practices frustrates me. However, I remain optimistic with a sunny disposition.
Please list reasons, if any, that discourage you from pursuing a career in **plant breeding**?
MSI students

Bad mentors.
I am interested in medical school.
Lack of interest.
None.
TCAP students
Competition and lack of resources.
Finances and limited opportunity.
I am more interested in other aspects of plant science.
I just graduated in a different field.
In addition to barriers to women, I would be more hesitant to pursue a career as a more traditional plant breeder. I feel that so much of what these individuals do is now dictated by what technology is telling us, so I'd rather be more involved in the more technological applications within plant breeding.
Molecular biology doesn't come as easy to me as soil science, management techniques, and other passions. It worries me this will be a difficulty in my work for decades to come.
None.

Table 37: Students' responses towards the offer of career information in plant sciences and/or plant breeding.

Would you like to learn more about careers in **plant sciences**? If so, please let us know what kinds of career information you would find useful.
MSI students
I'm not sure, I'm not into genetics. I like the analysis process of different varieties and studying nutritional attributes.
N/A
No.
Seed industry careers, plant breeding and genetics academic careers, CGIAR careers.
Yes, I would like to know specifics on what types of jobs are available.
TCAP students
Graduate schools (preferably west coast). Research opportunities specifically for graduate students.
I want to know more about processing different kinds of plant into food products.
I'd like to learn more about careers besides plant breeding. Understanding physiology better would be nice, as would soil-plant interactions.
In retrospect, I learned a lot of careers in academia and industry, but I think it would have been nice to have more involvement from the USDA and international agriculture research institutions in educating students on their future career options.
No thank you.
No.
Opportunities; industry versus academia.
Yes, about what career paths exist outside of research.
Yes, I have always imagined that I would be an agronomist, but it would be nice to see what other options I have especially since I do want to go to graduate school in Agronomy.

Would you like to learn more about careers in **plant breeding**? If so, please let us know what kinds of career information you would find useful.

MSI students

- N/A.
- No. (2 students)
- Seed industry careers, CGIAR careers, national programs, university careers.

TCAP students

- Again, see answer for this question with regards to plant science. I would like to know more about breeding careers within the USDA and international agricultural research institutions.
- No. (3 respondents)
- Not really.
- Research assistantships for graduate students.

TCAP Interview Reports

TCAP Graduate Student interviews

Students were initially selected to participate in the interviews based on information compiled by the educational committee of students' level of participation in TCAP activities. However given the low response rate, students received an open call from the educational committee to participate in the interviews. Students received an incentive of a $10 Visa gift card for completing the interview. All interviews were completed between November and December of 2013 over the telephone and all interviews were audio recorded. Recordings were used to transcribe quotes, but complete interviews were not transcribed.

A total of 8 out of 39 graduate students were interviewed as part of the third year evaluation of the TCAP. Three students were fully funded by the TCAP, while the remaining five students received partial TCAP funding[1]. Five of the students have been involved in the TCAP since its inception, while the remaining three students have been in the TCAP between one and two years. In addition, four of the students have been interviewed in previous years.

Of the students interviewed, there were four female students and four male students. Students represented a total of seven different TCAP institutions. Of the eight students, all were in a doctorate's program, except for one student who was completing a master's degree.

Students were asked about their perceptions of the Plant Breeding Training Network (PBTN) and perceptions of their educational training in the plant breeding field. Interviews were conducted over the phone and lasted about 25 to 60 minutes. A copy of the interview protocol is provided in Appendix A.

Summary of key findings

Eight graduate students from seven different institutions were interviewed as part of the third year evaluation of the TCAP.

Perceptions of the PBTN

All eight students reported being a member of the PBTN, meaning they are registered with the online community and receive email communications about news and activities.

Most, if not all, of the students have participated in the different aspects of the PBTN, including face-to-face scientific meetings (n=7), online classes (n=6), webinars (n=8), online discussion forums (n=7), and online meeting rooms (n=7). For each of these different aspects, students were asked about their participation and thoughts on the strengths and weaknesses of each.

- ***Face-to-face meetings.*** Students reported having attended the Plant and Animal Genome (PAG) meeting (n=7), the National Association of Plant Breeders meeting (n=2), the Technical Workshop for Jazz Spectrometer (n=1), the International Triticeae Mapping Initiative (ITMI) Workshop meeting (n=1), and a small grain conference (n=1). Students generally responded to strengths and weaknesses of the face-to-face meetings in reference to the PAG meeting. They felt face-to-face meetings were a great way to

[1] One student self-reported receiving partial TCAP funding, as funding information was "unknown" for this student.

bring TCAP students together and learn about each other's research, as well as network and create rapport with TCAP students and faculty. One student also added that the face-to-face meetings complimented the online interactions by making the online interactions more "personable," as students and PIs get to meet each other and are able to "put a face to a name." As for weaknesses, a couple students felt the conference (i.e. PAG meeting) required a lot of time and finances to attend. A couple other students also felt the conference was quite big with many events going on at once that it was easy to feel "lost" at the conference. A few other students felt the structure of TCAP's all day meeting needed improvement, including having less "cheesy" activities, more structure and organization, and more time to socialize with TCAP students and PIs. A couple students also mentioned that despite the weaknesses they identified, the meetings have improved within the last year.

- ***Online classes.*** Several online classes were specifically mentioned by students including, association mapping (n=4), entering mentoring (n=4), quantitative genetics (n=3), and genomic selection (n=2). There were a few students who reported completing online classes; however, did not remember which ones they participated in. Students felt the online classes were a great resource as many of the classes are recorded, are focused on advanced topics, and are taught by well-known faculty across the nation. One student also felt that the association mapping course, in particular, helped to standardize research approaches. As for weaknesses of the online classes, students felt it is difficult to conveniently schedule classes across different time zones and balance the online courses with their course load. Additionally, the topics may not always match all students' skill level and students can be easily distracted with the course being in a digital setting. One student, who did not complete any of the online classes, reported watching some of the recorded classes and felt it would be helpful to have access to the materials shared in the class so that students who were not able to sit in on the class live would still be able to follow along and do the exercises/activities.
- ***Webinars.*** All eight students reporting having had participated in the TCAP webinars. While several students could not remember which webinars they participated in specifically, a few students mentioned participating in webinars in the following topics: genomic selection, data collection and equipment use, jazz spectrometer, experimental design, and type 2 augmented design. Among those students who did not name any webinars specifically, two students reported participating in most of the webinars to date while another two students reported participating in webinars in the last academic year rather than the current year. Students identified many varied strengths of the webinars. A few students felt the webinars was a good way to bring faculty and students together in terms of learning about each other's research,

collaborating with one another, having an opportunity to solve problems, and sharing expertise and knowledge. A few students also made comments in terms of the variety of topics offered and clear manner in which topics are presented. One student felt the webinars were most useful when interactive discussions occurred, while another student complimented the work of fellow students who helped organize the webinars. As for weaknesses of the webinars, a few students felt that there were communication issues such as audio and technical issues, a lack of advertising the webinars, and the webinar be nonconductive to having conversations and discussions. A student commented that it was difficult to get students to be active in helping to organize the webinars, while another student felt that some of the topics were not relevant or related to their own research. There were a few students who could not think of any weaknesses.

- ***Online discussion forum.*** Six students reported having used the online discussion forum. There were a couple students who only used the online discussion forum as a requirement for an online course (e.g. Entering Mentoring), while other students reported using the forum to solve problems or analyze data related to the canopy spectral reflectance or jazz instrument. For those students who have used the online discussion forums, they felt the strengths of that aspect included having a way to keep in contact with students; being useful if discussions threads included questions that they themselves have in their research; and being able to trouble shoot, share, and talk with others who have similar research interests. Students also expressed their thoughts on the weaknesses of the online discussion forums. Several students commented that they don't think the discussion forums are used very often and that it is not very engaging for students. One student felt that it was easier and quicker to communicate with people directly rather than posting on the forum, while another student commented that it was difficult to navigate through the discussion forum but that improvements have been made.
- ***Online meeting rooms.*** Five students reported having used the online meeting room (facilitated by Adobe Connect) outside of participating in the online courses and webinars. One person did not remember what they used it for, while the other students have participated in meetings held in the online room. Strengths identified by a few students included the online room being a nice option to have for interacting with TCAP students and PIs, being easy to use, being convenient, and being a good way to interact with people. In terms of weaknesses, a couple students felt it was difficult to use in terms of getting PowerPoint presentations to work and navigating software tools and options. A couple students also felt there were often audio, technical, and connectivity issues with using the room. One student also added that it was overwhelming when there were a lot of people in the room and multiple

people would talk at the same time. Additionally, two students were unsure of how scheduling the room worked or whether there was a formal way to reserve the online room, but have not had problems with the room being double booked.

In addition to the different aspects of the PBTN, students were asked whether there were activities that the PBTN should offer and/or discontinue. Three students could not thinking of anything that the PBTN should offer, while the remaining five students provided suggestions and thoughts. A few students felt there could be more available on the PBTN website, including materials and handouts from previously recorded online courses and webinars, and having an informational page that lists symposiums related to plant breeding. A student also commented on having the webinars posted on E-extension. Another student felt it was important to continue to provide financial funding for students, including both graduate and undergraduate students, to attend conferences and be involved in mentoring. And lastly, one student expressed disappointment that the trip to the International Maize and Wheat Improvement Center (CIMMYT) did not happen earlier as planned because some students who have been in the TCAP since its inception are unable to attend the trip next year as they will have graduated by then. As for aspects that the PBTN should discontinue, students either felt there wasn't anything that the PBTN should be discontinued or they could not think of anything.

Perceptions of students' educational training in plant breeding

Educational experiences in the TCAP and the development of skills

Students were asked about their experience and development of several skills including managing a project, collaborating in a multi-disciplinary team, communicating research, and mentoring.

- ***Managing a project.*** All eight students have had some experience in managing a project. When asked to describe such an experience, most of the students shared their experience managing their dissertation or thesis research. Several students also shared experiences of managing field trials and/or experiments, as well as managing undergraduates and other personnel within their lab. When asked whether students felt their TCAP experience has helped to develop their management skills, all but one student said yes. Most of the students mentioned having the opportunity to mentor an undergraduate student and managing not only their own research, but also supervising the research of their mentees.
- ***Collaboration skills.*** Only four students reported having had experiences collaborating in a multidisciplinary team. Students reported working with physiologists, soil scientists, molecular scientists, chemical engineers, geneticists, computer programmers, bioinformaticians, field technicians, and plant physiologists. All students felt that their TCAP experience has helped to develop their collaboration skills. Students said that they have interacted and networked with other students, PIs, and researchers as a result of their participation and involvement in the TCAP. Students primarily spoke about how

the TCAP has facilitated connections to solve problems or meet people with similar research interests rather than collaborating on formal research projects.

- ***Communicating research to a lay audience.*** Only three students felt their TCAP experience has helped them to develop skills in communicating research to a lay audience. A few students were unsure because they have not had an opportunity to do so through the TCAP, but commented that the TCAP does emphasize the importance of this skill. A couple students felt they have had opportunities to explain their research in lay terms to less knowledgeable audiences such as students in other agricultural areas or undergraduate students.
- ***Mentoring.*** Seven of the eight students felt their TCAP experience has helped them to develop their mentoring skills. One student was fairly new the to program and had not had the opportunity to mentor an undergraduate student. Students made positive comments about the Entering Mentoring course, having the opportunity to mentor an undergraduate student, and learning and improving their mentoring skills over time.

Students were asked whether there were barriers they face in developing the aforementioned skills in management, multidisciplinary teams, collaboration, communication to a lay audience and mentoring. Three students did not feel there were any barriers for them, while the remaining students felt they faced some barriers. One student felt a barrier was generally not having an opportunity to apply and practice the skills that they have learned. The other students mentioned barriers related to a specific skill. A few students felt they faced barriers to developing collaboration skills, such as not knowing how to initiate collaboration, not having the need to collaborate given their straightforward research, collaborating across different time zones, and managing collaborations while managing one's own research project. One student felt that being shy and their limited English proficiency were a barriers to being able to communicate well to large audiences. Another student felt that there was not enough direction from supervisors to know how to manage roadblocks in projects.

Despite whether students felt there were barriers to developing the aforementioned skills, all students felt the skills were important to their future career to some extent. Students felt they would eventually need to apply their management, collaboration, communication, and mentoring skills in their future career whether they chose to go into academia or industry.

Knowledge of other plant breeding communities

Students were asked whether their TCAP experience has affected their awareness of other plant breeding communities of practice. Five of the eight students felt their TCAP experiences have done so. Several students felt their TCAP experiences have increased their awareness of other plant breeder communities through attending the National Association of Plant Breeders meeting, learning about other research areas of plant breeding outside of their own. The three students who felt the TCAP experiences have not affected their awareness of other plant breeding communities either already knew about different communities before joining the TCAP or felt the TCAP did not play a big role in increasing their awareness and knowledge of other communities.

Future aspirations and knowledge of the plant breeding industry

Students were asked whether they see themselves working in academia or in industry after they graduate. Three students were undecided, two students felt they could go into either academia or industry, two students planned to go into industry, and one student planned to go into academia.

Students were then asked several questions about the plant breeding industry.

- All but one student reported having interacted with industry representatives. Three students said plant breeding industry representatives were often at their institution for networking or student recruitment events. Two students reported interacting with industry professionals (although not necessarily in plant breeding) through previous internships and jobs. Two other students reported interacting with industry researchers at conferences, meetings, and TCAP sponsored workshops (e.g. the TCAP annual meeting, the National Association of Plant Breeders meeting, and TCAP graduate student workshops).
- When asked what TCAP activities have students participated in that helped them to increase their knowledge of industry positions, students mentioned learning about industry positions through online courses, webinars, and workshops. A couple students mentioned a workshop where students had the opportunity to learn from a panel of industry researchers. Only one student felt s/he had not learned more about industry positions through the TCAP because s/he had not been aware of any activities.
- Five students felt their understanding of the nature of plant breeding positions in industry has changed since participating in the TCAP. They mentioned learning more the daily work of plant breeders, the differences among different industry companies, industry expectations, and the corporate work culture. Two students mentioned not knowing anything about plant breeding positions before they joined the TCAP. As for the three students who felt their understanding of industry positions have not changed since participating in the TCAP, they already knew and understood industry positions through prior internships or through their graduate program.
- Lastly, students were asked about what activities the TCAP should offer to increase students' understanding of plant breeding in industry. Students had a variety of suggestions such as sponsoring trips for students to visit plant breeding industry companies, having in-person workshops or panel discussions with industry representatives, having industry researchers present in webinars or meetings, and having in-person networking opportunities with industry representatives at conferences. All students felt they would participate in the activities that they suggested.

MSI PI Interviews

This report presents the findings from interviews with principal investigators (PIs) from minority serving institutions (MSI).

Methods

All seven MSI PIs were interviewed. Interviews lasted between 15 to 30 minutes. All interviews were completed between November and December of 2013 over the telephone. All interviews were recorded, except for one interview due to a malfunction with the recording device. Notes taken during the interviews were used to identify quotes for each section, which were later transcribed using the recordings.

MSI PIs were asked about their students' career and graduate school decisions, as well as the impact of the TCAP-MSI collaboration on their students and institution. A copy of the interview protocol is provided in Appendix A.

Summary of key findings

What experiences or conditions do you think had the most effect on your students' decisions about attending graduate school and/or future career?

The MSI PIs felt many things were involved in career choices. Most important was the student's experience with careers and the type of skills necessary. Many want medical school because they know what that career is like. If they had experience with plant breeding, they might choose it instead, especially if the experience is early (e.g., in the sophomore year). The webinars really help with this, as do the personal visits from scientists from other campuses and attending and presenting at meetings. Being able to work at a TCAP institution is also a great opportunity. Of course, experience is not enough, the experience has to mesh with the students' own interests. They could learn about plant breeding and this could reinforce or conflict with their personal interests. Mentoring is also important to help students understand what plant breeding is like. Another important consideration is finances so if there are possibilities for funding, students would be more interested. Another consideration is the students' grades. They have to be good students before they could consider going to graduate school.

How do you think the collaborative research process affects student opinions of careers in plant breeding/plant genetics research?

The PIs felt this affected student opinions through the opportunity to know more about the area and make informed decisions. Guest lectures and on line experiences are a good influence and offer different perspectives. The experiences are good even if the students don't go on into plant breeding. The experience allows them to develop skills that would be useful in any graduate program such as data analysis, basic research, writing papers and doing presentations. Students also learn well through direct experience. They get to interact with others and get to know people in other areas, which affect their decisions. It takes a lot of effort like this to have the students move away from biomedical careers.

How do you think your research collaboration has affected your institution and its students?

There is perhaps some institutional impact in unique circumstances but in general very little spread of the impact from the individual PI. One instance is where the students do presentations, and other students want to be able to do that to. It becomes a prestigious thing that has some

glamor and allows the students to see that they could actually do this. Involved students talk to others and that spreads the word. In another instance the administration values the outside interaction that TCAP brings and wants to increase this type of collaboration and recognition. The webinars and other events are used by all students in some places and this is well received; other places restrict participation to only the supported students.

How do you think we could spread out and increase the effects of your collaboration across your institution?

There were different suggestions. One felt reaching out directly to different departments might be effective. Another felt that having more supported research opportunities in the summer would be helpful. Another comment was that the common data base and the webinars on how to use it were good. Another felt that it would be good to lay out a plan for institutionalization so that they would know what to work toward. Increasing the number of students funded was suggested, as was providing more funding and summer research opportunities for mentors.

Additional comments

There were several positive comments about TCAP being a good program. PIs were grateful for the funding provided; it had helped them maintain their research and support students. There were suggestions for more money for student support and travel to professional meetings. Perhaps more scholarships for the students to go to graduate school would be good. It would be great if students could just work on getting good grades in their classes and not having to work at outside jobs. A research assistantship would be double stimulation. One PI mentioned how the TCAP really leveraged other collaborations and knowledge sharing. Another suggestion was to work more with industry perhaps have TCAP more involved in the actual testing of industry lines.

Issues to consider

- Overall, the MSI PIs believe participating in the TCAP project is valuable for them and their students, and that the experience is very positive. They continue to believe that more support for existing students and supporting more students would be helpful. Thus, as in previous years, the educational committee should consider whether it is possible to provide more funding to MSIs to be able to support more students. Additionally, if it is a priority to have an impact beyond just those MSI students and faculty involved in the TCAP, it may also be worthwhile to consider ways that the TCAP activities and components can further spread across MSIs.

- MSI PIs believe that student choices for graduate study are complex and involve a variety of personal and external influences. With that said, they believe that providing experiences with plant breeding helps to clarify students' career goals one way or the other. They believe contact with the TCAP institutions in terms of visits to the MSI campuses and MSI students and faculty visiting TCAP campuses are quite valuable. The educational committee should consider whether there could be more funding and

opportunities for faculty and graduate students from TCAP institutions to visit and interact with faculty and students at MSIs.

PI Interview Results

Employers want more from PhD students. They are looking to universities to provide students with stronger communication, collaboration and management skills. What are your thoughts about this expectation?

All agreed that this was reasonable and many felt it was imperative. Some also mentioned that training in specific areas was necessary. Students should have initiative and drive and be able to work independently. They felt that the public sector was not really competing with the private sector so both needs were compatible. They agreed that students are learning about being on teams and are well socialized into the plant breeding community. Students are required to do talks to lay audiences and develop fact sheets to share with others. The on line meetings and presentations sponsored by the educational component of TCAP help to provide experience with teamwork and socialization.

How do you think the TCAP educational experience both through the PBTN and/or through your own efforts has helped to develop your students' management skills?

The PIs felt that the students were getting good experience with management skills. The students learn to multi task and to manage time, data and other students e.g., undergraduate assistants. TCAP forces students to deal with large data sets and complex planting and harvesting logistics. Generally students almost completely manage their own smaller projects but also manage parts of the larger ones. They learn to be responsible and complete work on the projects in a timely fashion regardless of other things going on in their lives. They probably do not get experience with budgeting and resourcing parts of management.

How do you think the TCAP educational experience both through the PBTN and/or through your own efforts has helped to develop your students' skills in communicating research to lay audiences?

The PIs felt that the students learned to communicate with peers and science audiences. Some students also learn to communicate with lay people like growers through the students doing local presentations and working with commodity boards. Some students are involved with communicating with community members through special events such as field days. The PIs felt the students need to work on being very clear and not using statements that could be open to different interpretations. Students also communicate with undergrads.

How do you think the TCAP educational experience both through the PBTN and/or through your own efforts has helped to develop your students' collaboration skills?

PIs felt that the TCAP really helped with the development of the student's collaboration skills. The joint projects and experiments with people not on their home campus as well as the extensive sharing of data develop collaboration in many areas. There is also local collaboration with people on their home campuses with people from other departments to ensure the successful implementation of projects. Also students complete group projects with each other which helps with collaboration skills. They are

learning to be part of a team and to interact with scientists and technical staff. The work on the projects and work in the webinars and courses helps the students to feel at ease asking questions of others. They need to feel they can talk to everyone at all levels. These connections are supported by face-to-face meetings. All of this together provides critical socialization to the discipline.

How do you think the TCAP educational experience both through the PBTN and/or through your own efforts has helped to develop your students' mentoring skills?

The PIs suggested that they mentor the students and then the student use the PI as a model to mentor other students and undergraduates. The students work together with each other and mentor each other. The students are responsible for making sure the undergrads gather high quality data and have to communicate how to do that. One PI said that he discusses with his student how to mentor the undergraduate in their lab. One mentioned that the student took the mentoring class and learned a great deal.

Describe how your students have participated in experiences in the area of "managing a project."

PIs felt that students manage projects at different levels. At one level that have their own thesis to complete. At another level students are responsible for managing the details and logistics of collecting data and organizing the laying out of experiments. They have to coordinate all of the equipment and decide what to do when, and what to be prepared for. They look at data across years and decide the most efficient ways to proceed. They also learn to communicate with others to ensure success. There is probably less experience at the higher level of really designing experiments because the experiments are set up before the students are involved. They can modify things but not really redo them or start from a clean slate.

Describe how your students have participated in experiences in the area of "collaborating with a multidisciplinary team."

The PIs felt that the students had mixed experience. They certainly had experience with people from different disciplines and with different expertise but often this was one-on-one rather than within a team. Students also have experience with faculty from different disciplines on their graduate committees. Also the online seminars and courses and attending meetings such as PAG. Additionally students have different expertise and when they work as a group, it is similar to a multidisciplinary team. The webinars are another example of experience with different disciplines.

In what ways could the TCAP better prepare graduate students for work in the plant breeding industry? Work more closely with industry partners? Remove barriers? Change training?

Experience in industry or at different sites would be good. It would be good to have experiences as early as possible such as freshmen. It would be most convenient if the experience could be short term or in the summer. A week at a center or a different site can be really beneficial. It would be nice if the experience covered as many different areas as possible, such as management, budgets, and developing proposals. Learning how to communicate well and in a timely fashion are key skills to develop. It would

help if the communication within the TCAP were more timely and specific. Some more summer programs like the drought program in CO would be good and more on line things.

Anything else???

Not really it is a great program and builds community. Perhaps more opportunities for scholarships especially with industry or collaborative projects with industry. There should be more recognition of how much effect this project will have in the long term.

MSI PI Interview Results

Thank you for agreeing to talk with me today. I will be asking you questions about the preparation you provide your students in relation to their future careers. If it is OK with you, I will be recording your answers but no one other than the evaluation team will know who you are. Do you have any questions?

What experiences or conditions do you think had the most effect on your students' decisions about attending graduate school and/or future career?

The MSI PIs felt many things were involved in career choices. Most important was the student's experience with careers and the type of skills necessary. Many want medical school because they know what that career is like. If they had experience with plant breeding they might choose it instead. Especially if the experience is early e.g., in the sophomore year. The webinars really help with this, as do the personal visits from scientists from other campuses and attending and presenting at meetings. Being able to work at a TCAP institution is also a great opportunity. Of course experience is not enough, the experience has to mesh with the students' own interests. They could learn about plant breeding and this could reinforce or conflict with their personal interests. Mentoring is also important to help students understand what it is like. Another important consideration is finances so if there are possibilities for funding, students would be more interested. Another consideration is the students' grades. They have to be good students before they could consider going to college.

How do you think the collaborative research process affects student opinions of careers in plant breeding/plant genetics research?

The PIs felt this affected student opinions through the opportunity to know more about the area and make informed decisions. Guest lectures and on line experiences are a good influence and offer different perspectives. The experiences are good even if the students don't go on into plant breeding. The experience allows them to develop skills that would be useful in any graduate program such as data analysis, basic research, writing papers and doing presentations. Student also learn well through direct experience. They get to interact with others and get to know people in other areas which affects their decisions. It takes a lot of effort like this to have the students move away from biomedical careers.

How do you think your research collaboration has affected your institution and its students?

Maybe some impact in unique circumstances but in general very little spread of the impact. One instance where the students do presentations, other students want to be able to do that to. It becomes a prestigious thing that has some glamor and allows the students to see that they could actually do this. Involved students talk to others and that spreads the word. In another instance the administration values the outside interaction that TCAP brings and wants to increase this type of collaboration and recognition. The webinars and other events are used by all students in some places and this is well received other places restrict participation to only the supported students.

How do you think we could spread out and increase the effects of your collaboration across your institution?

There were different suggestions. One felt reaching out directly to different departments might be effective. Another felt that having more supported research opportunities in the summer would be helpful. Another comment was that the common data base and the webinars on how to use it were good. Another felt that it would be good to lay out a plan for institutionalization so that they would know what to work toward. Increasing the number of students funded was suggested as was providing more funding and summer research opportunities for mentors.

Anything else?

There were several positive comments about it being a good program. PIs were grateful for the funding provided; it had helped them maintain their research and support students. There were suggestions for more money for student support and travel to professional meetings. Perhaps more scholarships for the students to go to graduate school would be good. It would be great if they could just work on their grades. An RA ship would be double stimulation. More assistance would be good. One PI mentioned how the TCAP really leveraged other collaborations and knowledge sharing. Another suggestion was to work more with industry perhaps have them more involved in the actual testing of lines.