Final Report for 2023 National Peanut Board funding to the Texas Peanut Producers Board.

1) Subject area: Molecular Genetics & Breeding

a. Project Title: Breeding to Increase Peanut Yields and Production Efficiency in Texas by Developing Breeding Lines with Improved Drought, Heat Tolerance, and Multiple Disease Resistance

b. Funding Year: 2023

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f. Total Funds Requested: $185,090

g. Locations: Lubbock, Gaines, Yoakum, Terry, Collingsworth, Comanche, Erath, Wilbarger, DeWitt, and Frio County, Texas and Clovis, New Mexico

h. Continuing Project ID 329: 2011 to Present: Several varieties have been released that contain traits that improve farmers' overall productivity, with others beginning to emerge. In addition, marker development for these traits and the incorporation of new technologies continue to streamline the breeding process.

Sub-Project I-1 Multiple Disease Resistant Runner-type trials

The TAMU Peanut project had replicated yield trials located in South Texas, (Pearsall, Dilley, Yoakum, and Derby), in Central Texas (Stephenville and Lamkin), in West Texas, (Brownfield, Seminole, and Denver City), the High Plains (Wellington) and in the Rolling Plains (Vernon). We conducted 6 small plot Advanced Line Tests (ALT's) and 2 large plot Combine Trials across Texas in 2023 as well as two replicated screening nurseries for Sclerotinia and Leafspot resistance. We continued testing a release candidate for drought tolerance across the state in addition we included for the first time a hybrid Spanish line that is being targeted for release. This line will represent the first hybrid runner released from our program. In our small plot ALT's 3 new release candidates were included from previous year's results and an additional 5 for included for the third year. In all fifteen breeding lines were included. Eight lines were top performing lines from the 2022 ALT and the remaining 8 lines were top performers in the 2021 Multiple Disease Resistance Test or the High Yield and Grade tests, and 5 commercial checks Georgia 16HO, AG18, Georgia 09B, Georgia 14N, and NemaTAM II were also included. In 2023 the entire state of Texas was again subjected to a prolonged drought that began in the fall of 2021. While there was some rainfall in the winter leading up to the 2023 season, the months of July and August were the hottest ever recorded around the world. Couple this with high wind, hail, and intense spring thunderstorms when it did rain and the 2023 testing results were highly variable for a second consecutive year. During the summer, the temperature extremes caused issues with growers' ability to apply enough irrigation to overcome the high evapotranspiration rates and do this consistently across the season. Another result of the drought was continued extreme animal damage to our small research plot. Control measures were put in place in Central Texas which alleviated the problem, however, some fields in Yoakum were a total loss. Yield and grade data exhibited significant variability both across locations and within repetitions at each location, as previously noted. While individual test results across the state were statistically revealing, the combination of yield and grade results did not yield statistically significant findings. Nevertheless, for the sake of brevity, the combined analysis is presented for discussion in **Table 1**, while individual summaries for each Advanced Line Test are available in supplemental charts S1-S7.

Table 1. Combined analysis of all Advanced Line Runner Tests across Texas in 2023.

	Pods/Ac. lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seeds/lb		SS%		Plant Height (cm)	
Cultivar														
TP200625-3-2	4521	A	659.79	A	69.8	ABCD	59.3	DEFG	772	DEFG	3.7	A	32	ABC
TxL100212-03-03	4423	A	678.73	A	70.5	ABCD	62.5	BCD	731	GHI	3.1	ABCD	37	AB
Georgia 16HO	4257	A	713.93	A	72.7	ABC	63.8	BC	718	HI	3.8	A	30	C
TP200614-1-1-1	4183	A	705.56	A	72.8	AB	55.6	HIJK	824	BC	2.2	BCDEF	30	C
TP200606-7-10	4129	A	681.49	A	69.0	BCD	66.1	B	696	I	2.2	CDEF	35	ABC
TP200606-3-10	4105	A	672.61	A	70.7	ABCD	58.0	FGHIJ	787	BCDEF	1.8	EF	35	ABC
Georgia 09B	4075	A	627.28	A	71.5	ABCD	57.3	FGHIJ	799	BCDE	4.1	A	32	ABC
AG18	4074	A	668.75	A	68.0	D	55.3	IJK	826	BC	1.2	F	35	ABC
TP200606-2-9	4067	A	624.42	A	70.1	ABCD	58.0	FGHIJ	795	BCDE	1.8	EF	38	A
Tx144370	4062	A	650.83	A	70.2	ABCD	57.7	FGHIJ	792	BCDE	3.5	AB	32	BC
TP200610-3-2	4046	A	686.95	A	72.9	AB	59.0	DEFGH	779	CDEFG	1.8	EF	31	C
TP210656-2-1	4045	A	736.41	A	73.4	A	52.2	K	881	A	1.5	EF	31	C
TP200607-1-16	4021	A	659.49	A	69.7	ABCD	56.9	FGHIJ	803	BCDE	2.5	BCDE	32	ABC
TP200609-2-15	4015	A	638.30	A	71.6	ABCD	56.6	FGHIJ	807	BCDE	3.3	ABC	31	C
TP200615-2-1-1	3983	A	620.25	A	73.0	AB	73.3	A	630	J	2.4	BCDEF	32	ABC
TP210624-2-1	3843	A	626.70	A	71.3	ABCD	58.8	EFGHI	781	CDEF	2.3	BCDEF	31	C
TP200607-1-2	3823	A	614.00	A	69.8	ABCD	56.3	GHIJ	816	BCD	3.3	ABC	32	BC
NemaTAM II	3695	A	635.20	A	68.6	CD	61.9	CDE	739	FGHI	4.2	A	33	ABC
TP200609-3-11	3659	A	602.89	A	70.2	ABCD	60.0	DEF	762	EFGH	1.9	DEF	33	ABC
Georgia 14N	3528	A	640.66	A	72.8	AB	54.6	JK	837	AB	1.2	F	30	C
Mean	4028		657.21		70.9		59.2		779		2.6		33	
CV	34.5		48.3		9.4		12.7		12.5		54.8		24.2	
Entry F	NS		NS		NS		<.0001		<.0001		<.0001		NS	

The challenging growing conditions experienced in Texas during the 2023 growing season made it difficult to draw definitive conclusions from the combined analysis. However, when looking at descriptive statistics there was a noticeable difference in the average yield and grade among growing regions across the state. In regions with more limited groundwater, such as West Texas, the average yield and grade stood at 3,750.5 lbs/ac and 64.9% TSMK%, respectively. These figures were lower compared to Central and South Texas, where the average yields were 4,651 lbs/ac and 4,681 lbs/ac, respectively, with average grades of 71.5 and 71.3, respectively. Notably, the Total Kernels (TK%) values for all three areas were very similar at 72.2%, 75.6%, and 74.6%, indicating that the limited irrigation water significantly impacted the yield and grade of the West Texas crop.

We also conducted seven other replicated runner trials for various traits of interest. Three focused on yield and grade with materials bred specifically for these traits. The other four trials were for a combination of multiple disease-resistance traits. This is the first year of testing for some of this material. Lines that performed well in 2022 advanced and were in Test 1 or 2 of either the high yield and grade trials or the multiple disease resistance trials. All these tests had traits that were significant and are presented in summary charts 2-6. In some cases, variability between replications was higher than we preferred, which, again, we are attributing to environmental effects during the season. Yield Trial #1 was planted in South Texas and revealed Murray performed at the top of the trial (**Table 2**) for yield with a total of 6,339 lbs/ac, which was statistically better than Georgia 16HO's 5,670 lbs/ac. The top grading line in the test was TP200606-2-1 with a grade of 75.8%. Results continue to be encouraging with the new breeding lines performing well in this test.

Table 2. Yield Test #1 in South Texas for 2023

	Pods/Ac. lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seeds/lb.		SS%	
Cultivar												
Murray	6940	A	1260.49	A	72.8	CDE	58.1	CDE	782	CDEF	1.4	DE
NemaTAM II	6797	AB	1223.85	ABC	72.1	CDE	64.9	A	701	G	3.2	ABC
TP220671-3	6771	ABC	1202.31	ABCDEF	70.4	EF	61.8	ABCD	734	EFG	1.6	CDE
TP220671-5	6692	ABC	1200.67	ABCDEF	71.4	CDE	63.2	ABC	718	FG	3.9	A
TP220671-4	6688	ABCD	1218.42	ABCD	72.1	CDE	61.4	ABCDE	739	DEFG	2.2	BCDE
TP200606-2-1	6648	ABCD	1251.19	AB	75.8	AB	58.5	BCDE	778	CDEF	1.2	E
TP220671-6	6633	ABCD	1192.23	ABCDEF	70.9	DEF	52.4	FG	866	AB	1.8	CDE
TP200606-3-6	6522	ABCDE	1188.27	ABCDEF	72.1	CDE	60.4	ABCDE	751	CDEFG	1.9	CDE
TP200606-4-5	6517	ABCDE	1208.68	ABCDE	73.6	ABC	56.2	EFG	814	ABC	1.5	DE
TP200606-6-15	6427	ABCDE	1149.68	ABCDEF	71.5	CDE	61.6	ABCD	738	DEFG	1.5	DE
AG18	6410	ABCDE	1169.51	ABCDEF	72.4	CDE	57.8	DEF	787	CDE	1.3	E
Georgia 09B	6226	ABCDE	1132.21	ABCDEF	72.8	CDE	58.3	BCDE	779	CDEF	2.7	ABCDE
TP220671-1A	6208	ABCDE	1087.62	ABCDEF	68.9	FG	61.4	ABCDE	739	DEFG	1.8	CDE
TP220667-3	6057	ABCDE	1090.38	ABCDEF	71.6	CDE	60.6	ABCDE	750	CDEFG	2.9	ABCD
TP220671-1B	6003	ABCDE	1042.17	BCDEF	67.5	G	52.3	G	880	A	2.3	BCDE
TP200606-2-4	5779	BCDE	1036.22	CDEF	71.4	CDEF	60.4	ABCDE	755	CDEFG	3.7	AB
TP220671-2	5696	BCDE	993.00	F	67.6	G	56.6	DEFG	803	BCD	1.3	E
Georgia 16HO	5670	CDE	1066.53	ABCDEF	76.1	A	64.9	A	700	G	2.5	ABCDE
TP200609-3-11	5580	DE	1007.20	DEF	71.6	CDE	63.6	AB	715	FG	2.6	ABCDE
TP220667-1	5438	E	1000.35	EF	73.3	BCD	65.5	A	694	G	1.9	CDE
Mean	6285		1136.05		71.8		60.0		761		2.2	
CV	11.7		12.5		3.5		7.9		8.6		56.5	
Entry "F"	NS		NS		<.0001		0.0011		0.0004		0.0396	

A second yield trial was planted in South Texas (**Table 3**) and contained both previously tested and first-time breeding lines. In this trial, the average yield was 5,571 lbs/ac, but unfortunately, the yields for the individual plots were not statistically significant. However, the grades were significant with the top grade in the test being 77.5%, which was statistically higher than 10 lines in the test.

Table 3. Yield Test #2 in South Texas for 2023.

Cultivar	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs		SS%	
NemaTAM II	6177	A	1144.60	A	74.8	EF	72.4	AB	626	IJ	4.0	AB
TP210624-4-1	5979	A	1145.29	A	77.5	A	67.2	DE	676	FG	3.2	BCDEF
TP210657-1-1-3	5924	A	1109.99	A	75.8	CDE	64.2	EFGH	707	CDEF	3.1	BCDEF
TP210627-4-1	5916	A	1112.56	A	75.8	BCDE	60.9	GHI	745	ABC	3.3	BCDEF
TP230624-2	5913	A	1105.26	A	75.9	BCDE	72.8	AB	623	IJ	2.1	EFG
Murray	5847	A	1112.83	A	77.1	AB	62.7	FGH	724	BCDE	4.3	AB
TP210624-3-4	5785	A	1085.46	A	75.9	BCDE	69.3	BCD	655	GHI	3.3	BCDEF
TP230627-5	5660	A	1028.90	A	72.9	G	61.2	FGHI	741	ABCD	3.9	ABC
AG18	5555	A	1051.63	A	76.4	ABCD	64.6	EFG	703	DEF	2.0	FG
TP210624-3-1	5553	A	1036.96	A	75.3	DEF	67.6	CDE	672	FGH	3.5	BCDE
TP230626-2	5497	A	1036.06	A	76.3	ABCD	63.0	FGH	720	BCDE	1.7	G
Georgia 16HO	5476	A	1046.86	A	77.3	A	71.5	BC	635	HIJ	4.1	AB
TP210651-2-1	5474	A	1035.03	A	76.5	ABCD	58.3	I	778	A	3.6	BCD
TP230625-3-1	5466	A	1029.77	A	76.3	ABCD	76.4	A	595	J	2.2	DEFG
TP210624-3-3	5368	A	1005.52	A	75.3	DEF	69.8	BCD	651	GHI	3.1	BCDEF
Georgia 09B	5349	A	1008.81	A	76.5	ABCD	67.7	CDE	671	FGH	5.1	A
TP230650-3	5231	A	996.96	A	76.9	ABC	60.4	HI	752	AB	2.5	CDEFG
TP230657-1-1	5127	A	960.38	A	76.5	ABCD	69.7	BCD	651	GHI	1.6	G
TP230657-1-2	5085	A	943.98	A	74.4	F	65.1	EF	698	EF	2.3	DEFG
TP210611-1-3-1	5046	A	931.77	A	74.9	EF	64.7	EFG	701	EF	2.1	EFG
Mean	5571		1046.43		75.9		66.5		686		3.1	
CV	11.8		12.2		1.7		7.5		7.5		37.2	
Entry F	NS		NS		<.0001		<.0001		<.0001		0.0017	

Finally, the third yield trial was conducted in West Texas where a hailstorm forced us to replant. The resulting yields were statistically significant with 3 of the 4 checks performing in the top statistical category for yield. However, variation between reps was high and resulted in lower-than-normal confidence in the results. However, due to hailstorms and late-season rains the location was left in the field for 165 days and the grades were highly significant. In this trial, all the checks and the release candidate Murray breeding line TP230662-3-1 performed in the top statistical grouping above all other lines in the trial (**Table 4**).

Table 4. Yield Test #3 in West Texas for 2023.

Cultivar	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seeds/Lb		SS%	
Georgia 09B	5208	A	1056.81	A	72.7	A	64.0	CDE	710	HIJ	3.7	AB
Murray	4985	AB	1011.99	AB	72.4	A	66.5	BC	682	IJK	2.8	ABCDE
TP230662-2-1	4822	ABC	898.62	ABCD	66.4	BC	57.9	GH	784	EF	2.0	DEF
AG18	4484	ABCD	902.76	ABC	71.0	A	64.1	CDE	708	HIJ	2.1	DEF
NemaTAM II	4369	ABCD	871.65	BCD	71.7	A	72.7	A	626	K	2.8	ABCDE
TP230662-3	4271	BCD	845.65	CD	70.9	A	64.0	CD	709	HI	3.8	A
TP230662-1-10	4151	BCDE	770.04	CD	65.5	BC	58.5	FGH	776	EFG	1.8	EF
TP230661-6RN	4023	CDEF	731.45	DEF	63.4	BC	60.4	DEFG	752	FGH	2.2	CDEF
Georgia 16HO	3971	CDEFG	786.10	CD	70.6	A	63.0	CDEF	722	GHI	3.3	ABCD
TP230628-1	3845	DEFGH	737.16	CDE	66.9	B	63.2	CDE	719	GHI	2.8	ABCDE
TP220661-7RN	3375	EFGHI	588.39	EFG	57.5	D	53.1	IJ	858	BCD	1.1	F
TP220663-5RN	3170	FGHIJ	533.29	GHI	57.8	D	54.5	HIJ	834	CDE	2.8	ABCDE
TP220663-3RN	3077	GHIJ	561.72	FGH	63.0	C	60.0	EFG	758	FGH	2.8	ABCDE
TP220663-7RN	2995	HIJ	496.76	GHI	58.9	D	69.5	AB	653	JK	3.5	ABC
TP220663-12RN	2952	HIJK	476.30	GHI	53.8	E	56.1	GHI	812	DEF	2.0	DEF
TP220663-8RN	2762	IJK	422.51	GHIJ	50.9	E	50.3	J	908	B	1.8	EF
TP220663-13RN	2424	JK	388.07	IJ	53.7	E	52.7	IJ	861	BCD	2.5	BCDEF
TP220663-11RN	2323	JK	397.17	HIJ	58.7	D	44.3	K	1030	A	3.4	ABCD
TP220663-14RN	2075	K	293.50	J	51.8	E	51.8	IJ	877	BC	2.2	CDEF
Mean	3678		680.78		63.4		59.5		774		2.7	
CV	28.7		35.9		12.0		12.4		13.4		42.4	
Entry F	<.0001		<.0001		<.0001		<.0001		<.0001		0.0178	

In addition to conducting trials for improved yield and grade, we continued testing several new populations that were created to combine leafspot, sclerotinia, and nematode resistance. Multiple Disease Resistance Trial #1 (**Table 5**) was grown in South Texas and contains lines from several years of crossing programs and represents the lines that have been tested in multiple seasons.

Table 5. Multiple Disease Resistance Test #1 in South Texas for 2023

	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs		SS%		Plant height (cm)	
Cultivar														
NemaTAM II	3578	A	559.51	AB	56.5	CDEF	54.3	AB	838	C	5.8	ABC	3	AB
TP200610-2-4	3482	A	615.62	A	67.2	A	46.6	EF	976	AB	3.8	CDE	3	AB
AG18	3297	A	525.12	ABC	55.7	DEF	46.7	DEF	972	AB	2.0	E	3	A
Georgia 16HO	3202	A	526.02	ABC	62.8	ABC	54.2	AB	842	C	8.1	A	3	AB
TP210625-3-1	3111	AB	484.64	ABCDEF	55.2	DEF	53.8	AB	845	C	2.9	DE	3	AB
TP200610-3-6	2949	ABC	500.45	ABCDE	64.3	AB	52.0	ABC	874	C	4.5	BCD	3	AB
TP210628-1-1	2942	ABCD	445.77	BCDEFG	52.7	F	51.0	ABCDE	891	BC	3.8	CDE	3	AB
TP220670-11RN	2935	ABCD	429.08	BCDEFGH	58.3	BCDEF	51.9	ABCD	876	C	5.7	BC	3	AB
Georgia 14N	2904	ABCD	509.82	ABCD	67.1	A	46.6	DEF	975	AB	5.9	ABC	3	A
Georgia 09B	2744	ABCDE	431.15	BCDEFGH	58.5	BCDEF	46.2	EF	982	A	6.6	AB	3	A
Murray	2734	ABCDE	461.54	ABCDEFG	63.5	AB	52.2	ABC	869	C	3.4	DE	3	AB
TP220670-1RN	2273	BCDE	351.78	EFGH	52.3	F	52.6	AB	867	C	4.9	BCD	2	AB
TP220670-12RN	2247	BCDE	353.26	DEFGH	58.8	BCDEF	56.1	A	809	C	5.9	ABC	2	AB
TP220670-7RN	2226	CDE	339.10	FGH	53.9	EF	55.1	AB	826	C	3.9	CDE	2	AB
TP200610-4-4	2219	CDE	376.44	CDEFGH	63.9	AB	45.2	F	1003	A	4.8	BCD	3	AB
TP200610-4-9	2210	CDE	363.66	DEFGH	59.9	BCDE	47.2	CDEF	963	AB	5.7	BC	3	AB
TP220670-2	2073	DE	320.51	GH	54.3	EF	52.5	AB	869	C	3.9	CDE	2	AB
TP220670-13RN	2017	E	335.08	FGH	61.6	ABCD	52.4	ABC	869	C	3.7	CDE	2	AB
TP200610-2-10	2006	E	325.91	GH	58.6	BCDEF	45.4	F	999	A	4.2	CDE	3	AB
TP220670-8RN	1881	E	281.80	H	52.0	F	50.7	BCDE	895	BC	5.1	BCD	2	B
Mean	2651		426.81		58.8		50.6		902		4.7		2.6	
CV	27.1		29.8		9.8		8.4		8.3		40.1		19.0	
Entry "F"	0.006		0.0077		0.0014		0.0019		0.0089		0.0048		NS	

The best yielding line at this location was NemaTAM II, which yielded 3,577 lbs/ac and was statistically equal to Georgia 09B, which yielded 2,743lbs/ac. The large difference in significant yield is indicative of the variability we saw in 2023. The top grading line was TP200610-2-4 with a grade of 67.2%, which was not expected since the location was dug at 133 days.

Multiple Disease Resistance Test #2 was also grown in South Texas (**Table 6**) while Multiple Disease Resistance Test #3 was grown in West Texas. At these locations several new breeding lines performed very well with respect to yield; within Test #2, TP210612-3-1-1 yielded the most at 6,715 lbs/ac. It was also in the top statistical grouping for grade with a TSMK of 74.2%. This line numerically and statistically outperformed the commercial checks Georgia 09B for both yield and grade for the second year in a row (**Table 6**). In Test #3 TP220674-4 yielded 5,839 lbs/ac but overall could not be distinguished from the test average of 4,690 lbs/ac (**Table 7**).

Table 6. Multiple Disease Resistance Test #2 in South Texas for 2023

Cultivar	Pods/Ac. lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seeds/lb		SS%		Plant height (cm)	
TP210612-3-1-1	6715	A	1241.66	A	74.3	ABC	67.4	A	674	H	1.8	ABCD	3	A
TP210614-1-2-1	6540	AB	1207.01	AB	73.6	BCD	48.0	H	945	AB	1.5	BCD	3	AB
Georgia 16HO	6524	AB	1205.14	AB	74.0	ABCD	65.9	AB	689	GH	2.6	A	3	AB
Murray	6447	ABC	1187.70	ABC	74.1	ABCD	57.7	EF	790	DE	2.5	A	3	AB
TP210621-2-1-5	6436	ABC	1134.95	ABC	71.0	EF	66.5	AB	683	GH	0.9	D	3	A
TP210615-2-2-1	6418	ABC	1166.21	ABC	73.0	BCDE	56.5	FG	804	CD	1.0	CD	3	AB
NemaTAM II	6248	ABCD	1165.45	ABC	74.9	AB	64.9	ABC	699	FGH	2.1	AB	2	AB
TP210625-3-4	6131	ABCD	1092.30	ABCD	70.3	F	62.4	ABCDE	727	DEFGH	1.9	ABC	3	A
TP210614-2-1-5	6076	ABCDE	1140.95	ABC	74.4	AB	49.5	H	916	AB	2.2	AB	3	AB
TP230663-2	5944	ABCDE	1061.14	BCD	71.9	CDEF	66.0	AB	690	GH	1.8	ABCD	3	AB
AG18	5846	ABCDE	1070.04	BCD	73.3	BCDE	58.8	DEF	773	DEF	1.7	ABCD	3	AB
Georgia 14N	5760	BCDE	1081.63	ABCD	75.1	AB	57.7	EF	787	DE	1.4	BCD	2	AB
TP230662-1-13	5743	BCDE	1034.84	CD	71.8	DEF	65.0	ABC	699	FGH	1.8	ABCD	2	AB
TP230736-3-15	5688	BCDE	1072.25	BCD	76.3	A	61.3	BCDEF	741	DEFGH	2.4	A	3	AB
TP230662-1-5	5681	BCDE	934.69	DE	65.1	G	51.3	GH	885	BC	2.1	AB	3	AB
TP230662-1-1	5660	BCDE	941.20	DE	66.1	G	49.1	H	927	AB	2.5	A	3	A
Georgia 09B	5615	BCDE	1031.46	CD	73.8	BCD	56.5	FG	803	CD	2.5	A	2	AB
TP210625-3-8	5573	CDE	1033.44	CD	74.4	AB	64.1	ABCD	708	EFGH	2.2	AB	2	AB
TP230624-3	5330	DE	943.14	DE	70.9	EF	59.9	CDEF	762	DEFG	1.9	ABC	2	B
TP230662-2-4	5146	E	840.86	E	65.0	G	46.7	H	978	A	2.2	AB	2	AB
Mean	5976		1079.30		73.6		58.8		784		2.0		2.6	
CV	11.7		13.4		3.4		12.1		13.0		41.1		19.0	
Entry "F"	NS		0.0027		<.0001		<.0001		<.0001		0.0286		NS	

Table 7. Multiple Disease Resistance Test #3 in South Texas for 2023

Cultivar	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs		SS%	
TP220673-4	5839	A	1165.77	A	71.6	ABC	65.2	BCDEFG	696	BCDEFG	2.2	EFGH
TP220673-3	5537	A	1122.21	A	72.3	AB	63.6	CDEFG	713	BCDEF	1.8	GH
TP220670-6RN	5348	A	1068.31	A	71.0	ABC	68.0	ABCDEF	670	DEFGH	2.5	DEFGH
TP220670-11RN	5296	A	1069.11	A	72.1	AB	68.8	ABCD	661	EFGH	1.6	GH
Georgia 09B	5168	AB	1055.89	A	73.4	AB	66.9	BCDEF	690	CDEFG	5.6	A
Murray	5145	AB	1048.76	AB	73.3	AB	66.9	BCDEF	681	CDEFGH	3.3	BCDEFG
TP210626-2-1	5139	AB	1042.27	AB	73.0	AB	70.0	ABC	650	FGH	2.0	FGH
TP220673-5	5031	AB	1025.42	AB	73.3	AB	63.0	DEFGH	722	BCDE	2.4	DEFGH
TP220673-2	5014	AB	1006.17	ABC	72.0	AB	73.5	A	617	H	2.8	CDEFGH
TP220670-15RN	4751	AB	969.91	ABC	73.4	AB	67.1	ABCDEF	679	CDEFGH	2.6	CDEFGH
TP210614-2-1	4674	AB	966.20	ABC	74.4	A	59.4	GH	765	AB	3.9	ABCDE
TP220673-6	4604	AB	875.79	ABC	67.4	CD	61.7	FGH	738	BCD	2.1	EFGH
NemaTAM II	4445	AB	889.32	ABC	71.9	AB	73.6	A	618	H	4.3	ABC
TP220670-2RN	4380	AB	880.35	ABC	71.7	ABC	71.3	AB	637	GH	4.9	AB
AG18	4234	AB	835.91	ABC	66.0	D	63.4	DEFG	717	BCDEF	1.7	GH
TP210624-3-2	4139	AB	832.71	ABC	72.6	AB	68.4	ABCDE	664	EFGH	3.7	BCDEF
Georgia 14N	4112	AB	835.55	ABC	72.2	AB	62.0	EFGH	749	ABC	3.0	CDEFG
Georgia 16HO	4065	AB	798.05	ABC	69.5	BCD	65.4	BCDEFG	694	BCDEFG	4.1	ABCD
TP220670-16RN	3494	B	641.31	C	60.1	E	56.7	H	810	A	2.1	EFGH
TP220673-1	3402	B	675.44	BC	72.0	AB	68.5	ABCDE	667	EFGH	1.2	H
Mean	4691		940.22		71.2		66.2		692		2.9	
CV	24.5		26.2		6.1		9.5		9.9		51.2	
Entry F	NS		NS		0.0004		0.0018		0.0013		0.0005	

Table 8. Collingsworth County Advanced Line Combine Trial for 2023.

	Pods/Ac. Lbs.	
Cultivar		
TP200625-3-2	4356	A
NemaTAM II	3676	AB
TxL1002 12-03-03	3563	AB
GA09B	3546	AB
Murray	3476	AB
AG18	3389	AB
GA16HO	3162	AB
TP2006 10-3-2	3101	AB
GA14N	2596	B
Mean	3429	
CV (%)	25.2	
Entry "F"	0.6523	

Table 9. Arkansas Combine Variety Trial in Mississippi Co. for 2023.

	Pods/Ac. lbs	**21 DAP Stand[a]**		**Southern blight (%DI)**
Cultivar				
FloRun T61	8,472	49.3	AB	0
Florun 52N	8,178	42	AB	0
Georgia16HO	7,999	42.5	AB	0
Georgia 18RU	7,641	44	AB	0.3
A18	7,584	49	AB	0.3
Georgia 06G	7,580	44.5	AB[b]	1.5
Murray	7,477	53.3	A	1.8
TX 100212-03-03	7,430	50	AB	3.5
NemTAMII	7,120	52	A	0.3
Georgia 20VHO	7,068	38	B	0

[a] Stand count is total number of plants per 10-row ft.

[b] Data are averages of four replications. Averages followed by a different letter within each column are significantly different at α=0.05 according to Tukey’s HSD.

We had 1 Combine Variety trials in Collingsworth Co. Texas (**Table 8**) and 2 in Mississippi and Jackson Co. in our neighboring state, Arkansas. We continue to collaborate with Dr. Travis Faske, the Arkansas Extension Pathologist, who evaluates our materials for yield (**Tables 9** and **10**). It is important to conduct variety testing under different conditions to determine seed robustness. This additional information allows breeders to discern which varieties to recommend for release and identify traits to prioritize when breeding for cultivar improvement. A complete study of the data can be found in the Summaries of Arkansas Cotton Research by Fred Bourland on the Arkansas Agricultural Experiment Station Research Series page. Specific lines considered for release will be discussed later.

In closing for this section, 4 large plot combine trials were conducted, 1 in the High Plains, 1 in Central Texas, and 2 in Arkansas were conducted using 2 row combines. In our program, large plot trials are used as a final look before release to evaluate how candidate breeding lines perform, and the more locations we can do this at, the more accurate readings we get on large-scale harvest. Dr. Travis Faske is the Arkansas Extension Pathologist and has graciously agreed to evaluate our materials in his environment. Additionally, we routinely participate in Dr. Emi Kimura's Statewide variety trials with our most advanced lines

Table 10. Arkansas Combine Variety Trial in Jackson Co. for 2023.

	Pods/Ac. lbs	Sclerotinia blight (%DI)		LLS	
Cultivar					
Georgia16HO	5,937	3.9	A	2.5	C
FloRun T61	5,533	2	AB	2.5	C
NemTAMII	5,361	0.7	AB	4.3	BC
Georgia 06G	4,691	1.4	AB[a]	3	C
Murray	4,672	1.7	AB	3.3	C
Florun 52N	4,592	0.7	AB	3	C
TX 100212-03-03	4,558	0	B	7	AB
Georgia 18RU	4,369	0.9	AB	5.8	AB
A18	4,291	0.6	AB	4.3	BC
Georgia 20VHO	3,985	4.1	A	2.8	C

[a] Data are averages of four replications. Averages followed by a different letter within each column are significantly different at $\alpha = 0.05$ according to Tukey's HSD.

(varietytesting.tamu.edu). The High Plains Combine trial contained a subset of the lines evaluated in the small plot Advanced Line Trial but only yield data was collected (**Table 8**). TP 200625-3-2 was the top yielding breeding line numerically in the test at 4,356 lbs/ac although the test was not statistically significant. The Central Texas Combine trial was not harvested due to poor stands.

Spanish-type Yield Trials

We continued expanding our testing of Spanish-type lines during the 2023 growing season with a large number of new breeding lines entering testing for the first time. Breeding lines represent true Spanish growth and newer hybrid Spanish growth types. Growing conditions were difficult and the test results reflected these conditions. During the 2023 season, we conducted 4 Spanish tests consisting of 64 breeding lines, 3 commercial checks, and 1 historic variety for disease evaluation. One of the trials was grown in certified organic fields and will be discussed in a later section.

Spanish Test #1 (**Table 11**) was grown in West Texas under conventional production and on the Rolling Plains under organic conditions. During the middle of the season, the grower could not keep irrigation levels high enough to meet evapotranspiration levels and it is highly possible it limited yield and grade. The test contained 16 breeding lines with various combinations of nematode and sclerotinia resistance. TP210656-2-1 is a hybrid Spanish candidate release that yielded and graded statistically in the top statistical grouping of the test at 4,566lbs/ac and a TSMK% of 66.6%. Seed size for this breeding line was 48.9 g/100sd.

Table 11. Spanish Test #1 in West Texas for 2023.

	Pods/Ac. lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seeds/lb		SS%	
Cultivar												
AT9899	4871	A	824.18	A	65.1	A	42.4	BCDE	1072	DEFGH	5.1	FGH
TP210656-2-1	4566	A	785.30	A	66.6	A	48.9	AB	929	HI	4.6	FGH
Schubert	3296	B	524.30	B	62.3	ABC	52.0	A	873	I	3.6	H
TP210655-1-1	3205	BC	506.73	B	58.1	BCDE	33.7	GH	1351	ABC	8.9	BCD
TP210652-2-3	3049	BCD	523.30	B	65.1	A	33.1	GH	1384	AB	10.1	BC
TP210640-2-1	2953	BCD	491.73	B	62.8	ABC	44.3	BCD	1025	FGHI	4.0	GH
Olin	2809	BCDE	472.92	BC	64.4	A	45.4	ABC	1015	GHI	5.8	EFGH
TP210653-2-2	2686	BCDE	448.96	BC	63.5	AB	44.4	BCD	1055	EFGH	11.6	AB
#00	2632	BCDE	394.60	BCD	51.8	F	41.0	CDEF	1107	DEFG	3.7	H
TP210641-4-1	2567	BCDEF	421.57	BCD	61.5	ABCD	35.7	FGH	1280	BC	13.3	A
Tamspan 90	2565	BCDEF	436.90	BC	65.6	A	44.6	BCD	1023	FGHI	4.2	GH
TP210641-5-1	2530	BCDEF	433.72	BC	67.1	A	45.8	ABC	997	GHI	6.9	DEFG
TP210639-4-1	2512	BCDEF	382.58	BCDE	57.5	BCDEF	41.5	CDEF	1095	DEFGH	5.8	EFGH
TP210641-1-1	2375	CDEFG	377.56	BCDEF	56.9	CDEF	30.7	H	1477	A	8.6	CDE
TP210655-3-2	2242	DEFGH	369.15	BCDEFG	63.7	AB	37.9	DEFG	1200	CDE	6.3	DEFGH
TP220683-1	2026	EFGHI	322.33	CDEFG	57.6	BCDEF	36.5	EFGH	1243	BCD	7.2	CDEF
TP220683-2	1741	FGHI	261.22	DEFG	56.9	CDEF	43.9	BCD	1041	EFGHI	5.6	FGH
TP220683-4NR	1596	GHI	228.66	EFG	51.9	EF	43.4	BCD	1055	EFGH	4.0	GH
TP220683-2RN	1455	HI	212.73	G	56.0	DEF	45.4	ABC	1005	GHI	3.4	H
TP220683-2-3	1228	I	216.40	FG	66.3	A	38.3	DEFG	1190	CDEF	7.4	CDEF
Mean	2645		431.74		61.0		41.4		1121		6.5	
CV	38.1		41.9		9.3		15.4		15.8		50.1	
Entry F	<.0001		<.0001		0.0003		0.0001		<.0001		<.0001	

The Hybrid Spanish Test (**Table 12**) was located in the same field on Gaines/Yoakum Co. Line and faced similar production challenges as the Spanish Test #1. “Hybrid Spanish” lines are lines that are runner in appearance but have small, Spanish-size seeds. The advantage is higher yield as runners but matures more like a Spanish. The top yielding line in the test was TP210656-2-1 with a yield of 4889 lbs/ac which was statistically equal to the check Span17 at 4738 lbs/ac. The size of the breeding lines varied with TP 23708-2-1 being the largest seeded line in the test at 49.6g/100 seed, which was statistically equal to the runner variety Georgia 14N at 51.1 g/100 seed. In contrast, the smallest-sized line in the test was a sister line from the same original cross, TP 230708-3-1, which had a g/100 seed weight of 37.5 g/100. As mentioned, the best performing of the lines from both tests will be carried forward into 2024 with continued testing and new lines being added.

Table 12. Hybrid Spanish Test in West Texas for 2023

	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs		SS%	
Cultivar												
Georgia 14N	4949	A	902.90	A	71.9	A	51.1	A	888	I	4.0	EFG
AT9899	4749	A	814.80	A	68.4	BCDE	43.2	DEFG	1051	DEF	6.5	CDEFG
Span17	4738	A	852.09	A	70.8	AB	49.4	ABC	922	GHI	9.6	ABC
TP210656-2-1	4589	A	810.32	A	69.1	ABCD	47.5	ABCDEF	957	FGHI	5.3	DEFG
TP220708-3-3	3853	B	652.54	BC	65.8	DEFG	48.8	ABCD	932	GHI	7.4	CDE
TP230713-2-1	3844	B	626.29	BCD	60.7	HI	42.9	EFGH	1057	DEF	5.8	DEFG
TP220708-5A-1	3842	B	679.49	B	69.6	ABC	48.1	ABCDE	946	FGHI	7.0	CDEF
TP220708-3-2	3796	B	654.04	BC	67.7	BCDEF	50.2	AB	904	HI	5.9	DEFG
TP230713-3-1	3408	BC	556.78	BCDE	63.8	GH	45.2	BCDEFG	1005	DEFGH	6.2	CDEFG
TP230713-4-1	3385	BC	578.46	BCDE	65.3	EFG	42.4	FGHI	1072	DE	7.2	CDE
TP230708-1-1	3227	BCD	533.67	CDEF	65.9	DEFG	49.6	ABC	915	GHI	3.0	G
TP230708-2-1	3170	BCD	500.90	DEFG	67.4	CDEF	49.6	ABC	929	GHI	11.0	AB
TP230708-5-3	3056	CDE	472.33	EFGH	59.6	IJ	44.5	CDEFG	1023	DEFG	3.5	FG
TP220714-2-1	2679	DEF	461.99	EFGH	64.9	FG	33.5	J	1361	A	7.5	BCDE
TP230716-1-48	2466	EFG	392.18	GHIJ	61.2	HI	49.0	ABC	928	GHI	8.9	BCD
TP230714-5-1	2433	EFG	408.59	FGHI	65.6	EFG	47.0	ABCDEF	967	EFGHI	6.1	CDEFG
TP230714-4-1	2355	FG	354.57	HIJ	56.6	J	36.8	IJ	1232	B	4.0	EFG
TP230714-6-1	2247	FG	313.20	IJ	53.0	K	45.1	BCDEFG	1010	DEFGH	6.5	CDEFG
TP230716-2-10	1904	G	275.63	J	50.3	K	40.7	GHI	1115	CD	7.0	CDEF
TP230708-4-1	1816	G	291.58	IJ	61.0	HI	37.5	HIJ	1212	BC	13.2	A
Mean	3325		556.62		63.9		45.1		1021		6.8	
CV	30.9		36.2		9.7		12.0		13.2		44.7	
Entry "F"	<.0001		<.0001		<.0001		<.0001		<.0001		0.0015	

In the 2023 season, we conducted the Spanish Test #1 replication across three distinct locations. Additionally, we introduced over 50 new breeding lines outside of the Spanish Test #1 and Hybrid Spanish testing series. In the year in and year out introductions, there were fluctuations in the number of lines of any one market type and this was a year for first-time evaluation of a large number of Spanish lines. For the sake of brevity, we have omitted the detailed presentation of each location, but this information is readily accessible in the appendix.

Sub-Project I-2 Drought Tolerant Runner and Spanish-type yield trials

Runner Populations Evaluated for Tolerance to Water Deficit Stress.

a. Drought-Tolerant, High Oleic Runner

The first runner drought test involves sister lines of what we plan to be our first drought-tolerant runner release, the breeding line TxL100212-03-03. This breeding line did reasonably well in drought tests, and at the top of the test in irrigated trials. However, several years of testing are showing that other breeding lines yield as well as or better under water deficit, and our goal is to see if any of these could be released as an improved water-deficit tolerant variety.

The test was performed under water deficit at two locations, and under full irrigation at the same locations. Water deficit involved irrigating only as much as was necessary to bring total rainfall plus irrigation during June, July, and A ugust, to 1/3 the amount provided to fully-irrigated plots. The test was also grown under what we intended to be full irrigation. The latter is shown here (**Table 13**). Yields were well below what was expected due to several factors- two of the three wells ran dry mid-season, high temperatures delayed pod set, and weed control was not as effective as hoped.

The top 10 breeding lines yielded numerically better than TxL100212-03-03 (not shown), although differences in yield were not significant statistically. Lines TxL100225-03-08, TxL100225-03-05, and TxL100212-07-01 performed well again this year, and yields were numerically higher than Georgia-09B. Unlike in 2022, grades were numerically lower than Georgia-09B. We have selected 6 breeding lines based on performance under severe water deficit for increase in 2024, and intend to make these available for testing in the irrigated runner ALT test, SW UPPT, and Texas varietal trials in 2025.

Table 13. Performance of runner breeding lines. Accessions highlighted in aqua were in the top 10 accessions in 2021 and/or 2022.

	Pod Yield (lb/ac)	Shellout (% TSMK)	Seed Wgt (100 SMK)
TxL100212-07-01	2277 ns	53.11 ns	61.07 ns
TxL100225-05-07	2001	53.33	52.68
TxL100225-06-07	1918	46.11	52.13
TxL100212-07-03	1917	51.88	51.88
TxL100225-03-10	1883	54.99	54.30
ICGS-76	1860	50.46	52.53
TxL100225-03-08	1850	57.23	59.53
FlvRun458	1779	41.40	41.53
TxL100225-03-04	1761	44.78	56.13
TxL100225-03-05	1603	53.29	58.23
TxL100225-06-12	1586	50.97	54.63
TxL100225-03-02	1467	44.92	43.77
...			
Georgia09B	1130	68.17	56.39
TxL100212-02-04	1075	53.69	60.30
TamrunOL02	892	50.35	45.50
Mean	1636	51.51	54.13
LSD	1779	14.72	15.09
CV	50.65%	13.16%	12.93%
P-value	0.822ns	0.213ns	0.187

b. Combining Tolerance to Water Deficit, High Oleic Oil, and Nematode Resistance

The second runner drought test was made to combine tolerance to water deficit with the high oleic trait as well as resistance to root-knot nematode. Previous testing showed that some breeding lines yielded as well or better than check varieties, but either grades were low or promising lines were lacking either nematode resistance or the high oleic trait.

So we re-selected lines from the reciprocal cross, making the cross in the opposite direction (switched which were the male and female parents), and early generation materials were selected with markers for nematode resistance.

These were tested at two locations under water deficit (**Table 14**) and full irrigation. Results of the water deficit trials were also affected by the hot, dry summer. Yields were generally as has been observed in previous years under water deficit, but grades were lower than we have seen since a trial in 2014. Flowering was low for much of the summer, and increased after September rains. Plots were flowering profusely on October 1, too late to produce mature pods. We delayed harvest until early November, but seed sizes were far below normal. A number of breeding lines yielded significantly better than the checks Georgia-09B and Flavorunner 458. Tamrun OL18L yielded better than expected in this trial. It’s difficult to interpret what the grade data meant because they were so low. Several of the breeding lines (highlighted in aqua) have done well in the past two years also. As with the population mentioned above, we have selected 6 lines for increase in 2024 and putting in statewide and regional trials in 2025. We will perform marker analysis to purify these also for nematode resistance and the high oleic trait if they are found to be segregating.

Under funding from the Peanut Research Foundation, we are performing marker-assisted backcrossing to make selections for improved grade along with tolerance to water deficit, resistance to nematodes, and high oleic oil. The first backcross generation was grown and evaluated as single plants in 2023 (data not shown) and will be evaluated as row plots in 2024. Additional backcrosses are in progress.

Table 14. Performance of breeding lines under severe water deficit stress. Breeding lines highlighted in aqua have performed in the top 10 lines in 2021 and/or 2022.

	Pod Yield (lb/ac)	Shellout (% TSMK)	Seed Wgt (100 SMK)
TxL144301-131	1647 a	17.23 e-j	37.25 ab
TxL131901-094	1354 ab	16.62 f-j	31.15 ab
TamrunOL18L	1350 ab	26.60 a-e	41.82 a
TxL144301-016	1348 ab	17.08 e-j	35.75 ab
TxL144301-117	1252 bc	26.97 a-d	43.35 a
TxL144301-001	1245 bc	24.11 b-g	39.22 ab
TxL144301-044	1204 b-d	18.48 c-j	37.10 ab
TxL144301-119	1090 b-e	17.45 d-j	42.08 a
TxL144301-027	1065 b-f	14.62 g-j	30.48 ab
TxL144301-112	1036 b-g	19.15 c-i	33.62 ab
TxL131901-030	956 c-h	26.14 a-f	40.85 ab
TxL144301-171	944 c-h	13.27 ij	29.78 ab
TxL144301-035	944 c-h	27.71 a-c	38.05 ab
TxL144301-025	905 d-i	14.05 h-j	34.30 ab
...			
FlvRun458	869 e-i	18.04 c-j	35.65 ab
Georgia09B	829 e-i	23.28 b-h	33.95 ab
Tx071304	768 e-i	18.11 c-j	37.92 ab
COC270	585 ij	12.20 ij	29.95 ab
TxL144301-192	579 ij	14.22 h-j	32.52 ab
P-value	0.001	0.004	0.588
Mean	963	20.35	36.46
LSD	330	9.71	15.47
CV	20.64%	18.86%	16.34%

Spanish/Valencia Advanced Line Test

The purpose of this is to evaluate newer crosses involving Spanish and Valencia breeding lines, to see if any are superior to Schubert or TamVal OL14. This test also suffered from heat and loss of the two wells that ran dry during the summer, with yields similar to tests under water deficit.

Several Spanish accessions yielded as well as or better than Schubert or OLin, as has been the case in the past (**Table 15**). The best Valencia breeding lines in the test did not perform much differently than TamVal OL14.

The best accessions will be tested again in 2024.

Table 15. Performance of advanced Spanish and Valencia breeding lines. Lines highlighted in aqua performed well in previous years' evaluations.

Genotype	Type	Pod Yield (Lb/Ac)	Shellout (% TSMK)	Seed Weight (g/ 100 SMK)
TxL076240-01	spa	1601 a	55.06 ns	48.18 ns
TxL076231-002	val	1370 ab	56.79	48.98
TxL076225-24	spa	1333 a-c	60.23	45.21
TamValOL14	val	1233 a-d	58.21	50.18
TxL076224-15	spa	1231 a-d	53.42	41.68
TxL076232-004	val	1192 a-e	49.88	44.93
TxL076221-34	spa	1115 a-e	55.37	38.85
TxL076239-16	spa	1110 a-e	63.54	47.01
TxL076238-16	spa	1109 a-e	58.23	44.63
TxL076225-49	spa	1049 a-e	53.58	40.48
TxL076225-28	spa	1001 a-f	49.48	40.35
TxL076221-06	spa	997 a-f	52.92	33.85
TxL054520-27	spa	954 a-f	56.28	47.28
...				
Schubert	spa	744 b-f	54.01	41.28
OLin	spa	732 b-f	57.44	47.41
TxL076232-013	val	713 b-g	50.53	41.93
TxL076236-04	spa	689 b-g	46.46	38.75
TxL076239-12	spa	676 b-g	54.97	44.53
TxL076233-003	spa	627 c-g	51.90	43.63
...				
TxL076225-04	spa	315 fg	48.69	35.65
p		0.032	0.27	0.17
Mean		901	54.69	40.94
LSD		721	11.99	22.77
CV		39.9%	8.6%	22.2%

Virginia New Breeding Lines

We also began testing new materials at one location in West Texas and another in Central Texas. This material had a wide range of parental materials. The candidate lines mentioned above were used as parents for some lines and others has large-seeded runners parents. Others had exotic germplasm from our cultivated germplasm collection. As much as possible these lines were grouped together in tests for evaluation. As mentioned the extreme drought produced high variability among the replications across the field. It is anticipated that if it have acceptable grade and seed size the lines will be tested again in 2023. In the Virginia Test #1 (**Table 16**) TP220694-5 yielded 5595 lbs/ac numerically and statistically better than the commercial check Bailey with a yield of 4815 lbs/ac.

Table 16. Virginia Test #1 in West Texas in 2023

	Pods/Ac. lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lb		SS%	
Cultivar												
TP220694-5	5595	A	129.12	A	68.2	BCD	87.8	ABCD	517	GHI	4.8	ABC
TP220694-2	5503	AB	113.51	AB	66.5	CDE	93.6	A	487	I	2.6	CD
TP220694-3	5068	ABC	112.90	AB	67.0	CDE	90.9	AB	501	HI	3.1	BCD
TP220696-1	4883	ABCD	98.37	BCD	68.9	BC	81.8	DEFGH	555	DEFG	3.3	BCD
TP220694-1	4839	BCD	106.54	ABC	65.8	DE	89.4	ABC	509	GHI	3.3	BCD
Bailey	4815	BCD	85.40	CDEFG	66.8	CDE	82.9	CDEFG	547	DEFGH	2.9	CD
TP220696-2	4787	BCD	85.94	CDEF	66.5	CDE	79.6	EFGHI	572	BCDEF	5.3	AB
TP220688-6	4624	CD	74.97	DEFGH	74.1	A	74.3	IJ	613	AB	3.5	BCD
TP220691-8	4509	CDE	98.26	BCD	68.9	BC	88.8	ABCD	513	GHI	3.7	BCD
TxL09105-07	4450	CDE	94.84	BCDE	68.6	BC	85.6	BCDE	531	FGHI	2.9	BCD
TP220691-1	4325	CDEF	88.95	CDE	67.8	BCDE	77.8	GHI	583	BCD	3.1	BCD
TP220688-8	4308	DEF	94.37	BCDE	65.8	DE	83.4	CDEFG	544	DEFGH	2.4	D
TP220686-10	4293	DEF	81.38	DEFG	67.0	CDE	85.3	BCDEF	535	EFGH	3.6	BCD
TP220688-1	4250	DEF	74.12	EFGH	66.9	CDE	78.0	FGHI	582	BCDE	3.7	BCD
TP220692-1	3829	EFG	63.45	FGHI	67.2	CDE	76.8	GHI	592	BCD	4.8	ABC
TP220689-1	3829	EFG	84.43	CDEFG	70.2	B	83.0	CDEFG	547	DEFGH	4.0	ABCD
TP220692-3	3635	FG	47.70	I	65.1	E	74.5	HIJ	609	ABC	3.5	BCD
TP220691-2	3620	FG	63.60	FGHI	68.2	BCD	80.2	EFGHI	565	CDEF	3.5	BCD
TxL09106-15	3468	G	61.84	GHI	70.1	B	85.5	BCDEF	531	FGHI	6.2	A
TP220686-9	3181	G	56.94	HI	70.0	B	69.3	J	655	A	1.7	D
Mean	4390		85.83		68.0		82.4		554		3.6	
CV	17.4		27.7		3.4		8.7		8.7		43.3	
Entry F	<.0001		<.0001		0.0003		0.0001		<.0001		NS	

Due to space limitations, the Virginia Test #2 (**Table 17**) was grown in Central Texas. Although Central is not a historical Virginia growing regions in Texas it does give us the opportunity to evaluate the lines under higher disease pressure. Due to high variability the 2023 yield for the Central Texas trial were not significant. The average yield for the test was 4477 lbs/ac and it had a TSMK% of 72.8%.

Table 17. Virginia Test #2 in Central Texas in 2023

	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs		SS%		Plant height (cm)	
Cultivar														
TP220694-4	5268	A	933.73	A	72.8	ABC	104.7	ABC	434	CDE	11.2	AB	44.1	BC
TP220691-4	5154	AB	914.62	A	72.3	BC	98.4	DEF	461	ABC	11.2	AB	43.3	C
TP220691-5	5041	ABC	880.75	AB	73.0	ABC	101.4	BCDE	448	BCD	9.2	AB	41.8	C
TP220691-6	4730	ABCD	840.72	ABC	73.2	ABC	94.4	F	483	A	8.9	B	42.8	C
TxL09106-15	4717	ABCD	826.10	ABC	71.9	CD	99.4	CDEF	456	ABCD	10.7	AB	44.6	BC
TP220691-7	4327	ABCD	770.99	ABC	73.3	AB	105.7	AB	429	DE	11.9	AB	46.6	ABC
TP220690-1	4077	BCD	682.02	BC	70.6	D	108.2	A	419	E	12.4	A	50.3	AB
TP220686-5	4002	BCD	717.74	ABC	73.9	A	96.7	EF	469	AB	4.1	C	51.7	A
TxL09105-07	3895	CD	672.50	BC	72.4	BC	102.3	ABCDE	444	BCDE	10.5	AB	47.9	ABC
Wynne	3563	D	646.45	C	74.1	A	103.8	ABCD	437	CDE	9.2	AB	43.6	C
Mean	4477		788.56		72.8		101.5		448		9.9		45.7	
CV	18.7		19.8		1.9		5.0		5.2		28.8		10.6	
Entry "F"	NS		NS		0.0074		0.0026		0.0041		0.0054		NS	

Developing a Wild Species Pathway for Introgression of Drought Tolerance and germplasm maintenance.

This project continues as part of the long-term drought project. It was first funded internally but has been absorbed into our overall drought program. The initial phase of this project was to identify 14 candidate genes associated with drought tolerance by conducting an imposed drought transcriptomics study. Specifically, we identified transcription factors that occur early in genetic pathways and represent excellent candidates for marker development. We received funding for the Peanut Research Foundation to validate the presence of the candidate genes in the original drought-tolerant species and to expand the study to include other related species. Sequencing is complete an in-depth differential gene expression (DGE)study was performed analysis was performed. Personnel changes have led to a delay in the manuscript as we find a new student to work on the project. It remains a vital part of our overall drought program. Transcriptomics is a powerful tool that can not only tell if a gene is present but can also determine how strongly a gene is expressed. Once the genes are validated for expression, level marker development can be conducted and used to aid in introgression of genes into our elite material.

Crossing and chromosome doubling continues as part of the wild species introgression pathway and is under development. When completed this will allow identified genes to be moved into the cultivated peanut. At this point, we have made the initial cross and confirmed hybridization. The next step in pathway development is to double the chromosome number. This is proving to be very challenging. We are exploring alternate pathways using other species and or accessions to move the genes. One related complex hybrid has already been doubled and has cultivated materials that are being backcrossed into more advanced materials. Tamrun OL11 is the recurrent parent in this crossing program, however, several more backcrosses are needed to make the lines commercially viable. We also expanding this backcrossing program to include the candidate line Tx144370.

One final area of interest is our ongoing germplasm maintenance program. We have been coordinating with the Arachis collection curator Dr. Shyam Tallury to assist in germplasm increase and reintroduction into the national collection. This allows us to serve as a vital additional repository for this valuable wild germplasm.

Identify Markers for Drought Tolerance in the Mini-Core Collection

Pot-based identification of peanuts with superior water use efficiency under drought.
Approximately, 80% of production in the state is in West Texas where the primary source of irrigation is the declining Ogallala Aquifer. Under the recent drought and low Ogallala Aquifer levels, it's been very difficult for peanut producers to supply sufficient water amount for maintaining a good yield and high quality peanuts. Water use efficiency (Transpiration Efficiency) (TE) is a crucial component of yield under drought stress. The objectives of this study are to screen the U.S. minicore collection for TE in a rainout shelter or greenhouse conditions and conduct GWAS to identify markers associated with TE. This is to (1) identify accessions with better TE than current varieties, and that can be used as parents to improve the drought tolerance of current varieties, and (2) identify DNA markers that can be scored more efficiently than use of pot-based experiments in the future.

A water use efficiency experiment has been performed in pots at Texas A&M AgriLife Research in Lubbock, TX in two years, and analysis of the second year's data is still underway. Ninety-nine accessions of the U.S. minicore collection plus 7 check varieties were evaluated for

TE in pots. Pots were well-watered until 49 days after planting (DAP) when two plants were harvested and averaged to assess pre-stress biomass, and drought stress was then imposed. Each pot was placed in a 1.5 mil polyethylene bag and tied at the base of the remaining plant to prevent evaporative water loss. Specific leaf area (SLA), SPAD chlorophyll meter reading, shoot and root biomass, and visual wilting ratings were recorded during the experiment. When the plants had reached their permanent wilting point, the experiment was terminated. TE was calculated as dry matter accumulation divided by total water loss. Results of the second year of the experiment are presented here.

Significant differences were observed among genotypes for SPAD chlorophyll content at 12 and 34 days after imposition of drought stress (**Table 18**). SPAD chlorophyll is an easy-to-measure proxy for water use efficiency. There is a consistent trend of maintaining high and low SPAD values for the 10 top and bottom accessions at days 12 and 34 imposition of drought. COC075 has a high SPAD value, remains green and has lowest wilting score.

Significant differences were observed among genotypes for wilting at 76, 105, and 112 days after imposition of drought (**Table 19**) Some accessions were completely wilted by Day 75, whereas others maintained their turgor at that time and for an additional month.

Table 18. Summary of SPAD at 12 and 34 days after imposition of drought. Ten accessions with the highest and lowest SPAD values are shown. along with check varieties.

Genotype	Day 12	Day 34
COC075	48.15 a	39.55 a-j
COC115A	42.85 ab	44.95 a
C76-16	42.45 a-c	41.45 a-d
COC033	42.20 a-d	42.60 a-c
COC233AB	42.20 a-d	37.95 a-m
COC230	42.00 a-e	41.00 a-g
TamrunOL12	41.25 a-f	42.40 a-c
COC812	40.50 a-g	41.40 a-e
COC381AB	40.20 a-h	39.00 a-k
COC433B	40.15 a-h	40.00 a-i
TamrunOL02	39.25 a-k	38.50 a-l
Schubert	37.90 b-o	36.60 a-o
ICGS-76	35.50 b-s	36.90 a-o
Tamspan90	34.40 b-u	33.70 c-p
TMV2	28.95 l-v	29.80 j-r
COC408	28.00 o-v	33.25 c-q
COC526B	27.60 p-v	27.95 m-r
COC643	27.50 p-v	31.90 d-q
COC808	27.45 p-v	28.65 l-r
COC008	26.85 q-v	27.40 o-r
COC552A	26.20 r-v	28.80 l-r
COC097	25.80 s-v	27.40 o-r
COC819	25.05 t-v	24.30 p-r
COC485	24.55 uv	21.45 r
COC189	22.30 v	23.30 qr
P	0.010	0.038
Mean	34.35	34.48
LSD	10.20	10.20
CV	13.05%	12.41%

Table 19. Summary of wilting scores at 58, 76, 98, 105, and 112 days after imposition of drought stress. Plants were scored on a scale of 1 (no wilting) to 5 (completely wilted). Ten accessions with the highest and lowest scores plus check varieties are shown.

Genotype	Day 58	Day 76	Day 98	Day 105	Day 112
COC016	1.33 ns	1.00 i	2.17 ns	2.50 d-f	2.87 de
COC068	1.00	1.00 i	1.67	1.67 f	2.47 e
COC155AB	1.00	1.00 i	2.47	2.47 d-f	3.33 b-e
COC446	1.00	1.00 i	1.50	2.40 d-f	3.00 c-e
ICGS-76	1.00	1.00 i	2.33	3.00 b-f	3.33 b-e
COC075	1.00	1.07 hi	2.00	2.67 c-f	3.67 a-e
COC125	1.00	1.33 g-i	3.33	4.00 a-e	5.00 a
COC552A	1.00	1.33 g-i	4.00	4.67 ab	4.67 ab
COC760	1.00	1.37 f-i	2.67	2.67 c-f	3.33 b-e
COC406	1.00	1.67 e-i	3.67	4.33 a-e	5.00 a
TamrunOL02	1.00	1.67 e-i	3.00	3.33 a-f	3.67 a-e
C76-16	1.33	2.00 d-i	4.00	4.33 a-e	5.00 a
Schubert	1.00	2.33 c-i	4.00	4.33 a-e	4.67 ab
TamrunOL12	1.00	2.67 b-i	3.67	3.67 a-e	4.00 a-d
Tamspan90	1.67	2.67 b-i	3.67	4.33 a-e	5.00 a
TMV2	2.00	3.67 a-f	4.67	5.00 a	5.00 a
COC112	1.33	4.33 a-c	5.00	5.00 a	5.00 a
COC115A	2.67	4.33 a-c	5.00	5.00 a	5.00 a
COC334	2.00	4.33 a-c	5.00	5.00 a	5.00 a
COC012	2.00	4.67 ab	5.00	5.00 a	5.00 a
COC189	2.33	4.67 ab	5.00	5.00 a	5.00 a
COC047	2.33	4.67 ab	5.00	5.00 a	5.00 a
COC579	1.33	4.67 ab	5.00	5.00 a	5.00 a
COC580	2.33	4.67 ab	5.00	5.00 a	5.00 a
COC588	1.33	4.67 ab	5.00	5.00 a	5.00 a
COC481	1.00	5.00 a	5.00	5.00 a	5.00 a
p	0.106	0.047	0.062	0.018	0.010
Mean	1.47	2.88	3.98	4.23	4.64
LSD	NS	2.33	NS	2.00	1.53
CV	37.1%	32.9%	21.0%	18.3%	12.7%

In comparing SPAD chlorophyll content and wilting at day 80 after imposition of drought stress, there appeared to be no correlation the two traits. However, there were a few accessions that had both a high chlorophyll content and low wilting (**Figure 1**). Among these was COC075, one of the three data points circled in red.

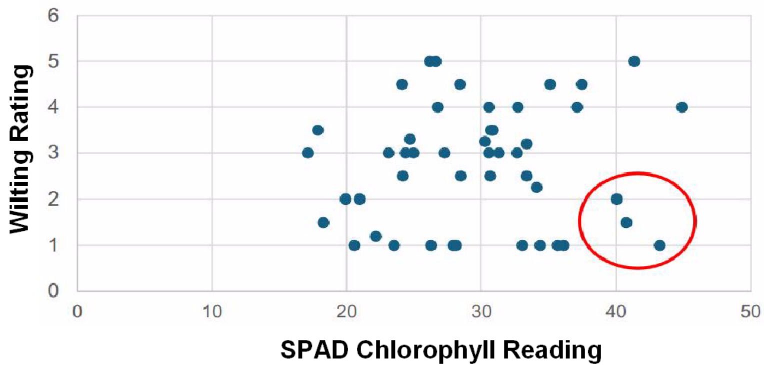


Figure 1. Comparison of SPAD chlorophyll content and wilting score at day 80.

In sorghum, there is a staygreen trait, where certain accessions are drought tolerant and maintain their green color. This has not been reported in peanut to date. In the current experiment, four minicore accessions and a check breeding line appeared to show the stay-green trait, with no wilting 105 days after imposition of drought (**Figure 2**). Several pots contained plants remaining green and with little wilting; by comparison, other pots contained plants that had already died and turned brown. It remains to be seen whether this is a result of low water usage in general (and consequently low photosynthesis and yield overall), or could be a result of adaptation to drought stress. In the latter case, this trait could potentially be used for breeding for drought tolerance.

Figure 2. Photographs of pots with contrasting plant phenotypes- plants still green (at left) with no (top) or little (bottom) wilting, or dead and brown (right).

Current Releases

NemaTAM II, which is a high-yielding, high oleic fatty acid, runner-type peanut cultivar with resistance to root-knot nematodes. The cultivar was developed to provide growers with a replacement option for the former Webb cultivar which had excellent nematode resistance, but also had a very large vine size that made harvest difficult for peanut farmers. Like Webb, NemaTAM II maintains resistance to root-knot nematodes, but has equal to or better yield, higher grade potential and a shorter canopy for easier digging and inverting at harvest. In 2022 there will be approximately 15 acres of foundation seed that was grown at the Texas A&M Foundation Seed offices in Vernon, TX and is available for planting in 2023.

We also sent breeders' seed of our new early maturing runner varieties for increase beginning in 2022. **Tables 20 and 21** show some of the data from the release proposal, with data pooled across runner advanced line tests over 3 years. Tamrun OL18L topped the test for yield, with a yield statistically greater than Tamrun OL11 and numerically greater than TufRun 511, FloRun 107, and Georgia 09B. Grades were similar to these varieties, except lower than Tamrun OL11. Seed weight for Tamrun OL18L (the "L" stands for "larger seed") was similar to Georgia 09B and Webb but larger than Tamrun OL11, TUFRun511, and FloRun107. Tamrun OL19 had a smaller seed than OL18L, similar to Tamrun OL11 but larger than TUFRun and FloRun.

Maturity for Tamrun OL18L was similar to Tamrun OL12, about 2 weeks earlier than Tamrun OL07. Tamrun OL19 was also earlier than Tamrun OL07 by about 1 week. All these runner varieties were later maturing than the large-seeded Spanish variety Tamnut OL06. We have enough seed for planting about 10 acres of TamrunOL18L and 5 acres of Tamrun OL19 for increase in 2023.

Table 20. Yield and Grade Data for Tamrun Ol18L and 19

Variety	**Pod Yield (kg/ha)**		**Grade (% TSMK)**		**Seed Weight (g/100 SMK)**	
Tamrun OL18L	6007	a	73.5	bc	74.8	a
Tamrun OL19	5803	a	73.6	bc	70.2	b
TUFRun 511	5692	ab	73.2	c	67.1	c
FloRun 107	5758	ab	74.4	b	66.1	c
Georgia-09B	5719	ab	73.4	c	75.2	a
Webb	5680	ab	73.1	c	75.6	a
Tamrun OL11	5365	b	76.7	a	68.2	bc
p	0.037		<0.001		<0.001	
LSD	386		1.0		3.2	

Table 21. Maturity and Sclerotinia Data for Tamrun OL18L and Tamrun OL19

Variety	% Black + Brown		Black + Brown + Orange		Sclerotinia Incidence	
Tamrun OL07	4.5	e	32.1	c	3.4	ns
Tamrun OL19	12.8	d	48.4	b	4.6	
Tamrun OL18L	19.4	cd	53.4	b	3.7	
Tamrun OL12	22.6	c	55.9	b	3.9	
Tamnut OL06	58.5	a	72.7	a	3.6	
Tamspan 90	40.7	b	57.2	b	2.0	
p	<0.001		<0.001		0.184	
LSD	7.4		10.1		ns	

Anticipated Virginia Releases

We anticipate releasing two high-oleic Virginia varieties, TxL090105-07 and TxL090106-15. These will be the first Virginias released by AgriLife. Both release candidates yielded well in variety trials, numerically higher than NC-7 and Champs. TxL090105-07 had a smaller seed size than TxL090106-15, and other trials also indicated a smaller seed size. But yield data show a numerically higher yield for TxL090105-07. Both varieties are high-oleic. Both are high-yielding and developed to compete with the industry standard Bailey. Increases of both will be sent to Vernon in the 2024 season.

Other previously released cultivars are also being repurified as part of our ongoing seed program. AG18, Schubert, OLin and TamVal OL14 have all had recent breeders seed increases that will be turned over to the Texas A&M Foundation Seed Service.

Future Releases

The Tx144300's were developed for resistance to Root-knot nematodes and Sclerotinia. While they performed lower in yield to the drought lines mentioned above, Tx144370 has performed well in South Texas, which is where they were developed to give growers a nematode-resistant line with better characteristics than the previously released Webb and NemaTAM II variety. These two lines have yielded 400-600 lbs/ac better than Webb and graded 1-3 percentage points higher. Additionally, they have a much shorter growth habit than NemaTAM II and a slightly smaller seed size in most of the trials over the past four years. The decision was made to move forward with the breeding lines for release. Release paperwork was submitted to the Texas Plant and Seed Board for the official release of Murray in honor of the long-time South Texas peanut farmer, Murray Phillips.

Of the materials developed from the runner drought testing, several lines have done well in irrigated trials. In particular, TxL100212-03-03 (see above) has been in advanced trials multiple years and has consistently done well. We plan to release it because of its high yield potential both under irrigation and water deficit and because it has a high grade during water deficit, unlike many of our other accessions. It was in a ¼ ac row increase last year and is being increased again this year in anticipation of release. We expect to write up the release proposal later this year or early next year.

We have also targeted a hybrid runner as a potential release. Breeding line TP 210656-2-1 has performed well in 2 consecutive years of testing across 11 locations in 2 states. It has a runner plant type that yields and grades well in all our testing locations. We will be starting initial purifications of breeders' seed in 2023 as we complete the third year of yield testing.

Sub-Project IV. SNP Marker Development

This year, we have focused our development efforts on (1) developing a less-expensive marker system, called resequencing, and on (2) developing a rapid marker-based system for confirming identity of varieties, as well as being an improved system for distinguishing hybrids from selfs in progeny obtained from the greenhouse crossing program, and (3) identifying additional genes for resistaqnce to root-knot nematodes.

Genotyping by Resequencing

Although the peanut community has developed a SNP chip for marker analysis (and the AgriLife program donated 4 of the 22 accessions sequenced to develop the SNP chip), it has the drawbacks of still being too expensive for routine analysis in breeding programs, and does not allow focusing on specific gene for traits; for example, genes for oil content.

We have worked with Tecan, Inc. to develop a less-expensive system for genotyping, by focusing on sequencing about 2,500 targets in the chromosomes. Our test experiment worked when genotyping 48 peanut varieties and other accessions simultaneously.

To test further, we extracted DNA from 144 more peanut accessions (mostly from our breeding lines for drought tolerance), produced pooled libraries from the samples, and sent the samples to the TAMU Vet Medical Genome Center for sequencing. We recently received the sequence data and will be working on analysis of the data.

Markers for varietal identification and new markers for drought tolerance. We initially developed a set of 72 highly-polymorphic SNP markers to test for their ability to distinguish different varieties or breeding lines. The goal is to be able to use markers to verify the identity of varieties and reduce the chance of misidentification of varieties. We reduced this set to 24, of which 12 showed differences among multiple varieties and closely-related breeding lines, and 12 were effective but less so. We had the goal of replacing the 12 less-useful markers. To do this, we designed 24 additional markers.

These 24 additional markers relied heavily on a previous analysis, where we identified 558 markers associated with response to water deficit stress. Of these, 169 were associated with either more than one trait, or were repeated across locations (TX, OK, VA) or years. We have identified a set of these markers to synthesize and test on one of our runner drought populations. **Table 22** shows a list of the markers associated with the most traits in that analysis., where the state where a given marker was significant in one year is shown. The markers in this table were among the targets used to make the 24 new primers.

Table 22. Sample markers for yield, field response to water deficit, and grade. Letters tell where the marker was significant (Tx= Texas, Ok=Oklahoma, Va=Virginia, Al=All 3 locations.)

Trait -->	Yield	100SMK	NDVI	Flwr	SPAD	Width	Height	Clos	Wilt	Grade	CTD	NO1	MED	ELK	
Marker	205	59	49	48	37	31	30	26	22	17	8	6	4	2	#Traits
M_0072			Va	AlTxOk	AlVa	AlTx	AlTxVa		AlTx						6
M_0230	Va	TxOk	Va	Al	Tx	TxOk	AlOkVa								7
M_0609		Tx													1
M_0654	AlVa														1
M_0702	TxOkVa	TxOk			AlTxVa	AlTxOk	AlTxOkVa	TxOk	Tx						7
M_0704	AlOk	TxOk	Va	Al	AlTxOkVa	AlTxOkVa	AlTx		AlTx				Tx		9
M_0706	Al				AlTxOkVa	Va	AlTx		AlTx	Tx			Tx	Tx	8
M_0806	AlTx	Ok		Al	AlTx	Tx	TxVa	Ok		Tx	Va				9
M_0854		TxOk													1
M_0887	Tx	Ok	Va	Va	AlOkVa	AlTxOk	Ok	AlTx			Va		Tx		10
M_1412					TxOk	Tx		Ok	AlVa		Tx				5
M_1418	AlOk														1
M_1543	TxOkVa		Va	AlVa	TxOkVa	Al		AlTx		Tx					7
M_1577	TxOkVa		Va	AlVa	TxOkVa	Al		AlTx		Tx					7

Additional genes for root-knot nematode resistance. Over the past several years, we have grown out and increased about 300 third-generation backcross lines (BC3), derived from a cross between the wild species introgression line TxAG-6, and Florunner. These are being used in a NIFA-funded project to bring in more genes for resistance to diseases and pests from wild species.

These have been used to test for presence of multiple nematode-resistance genes in the BC3 population. Out current resistant varieties (NemaTAM II, Murray) rely on one resistance gene. Breeding in more genes would reduce the chance that the nematodes could become resistant (as happened with Palmer amaranth and Roundup resistance).

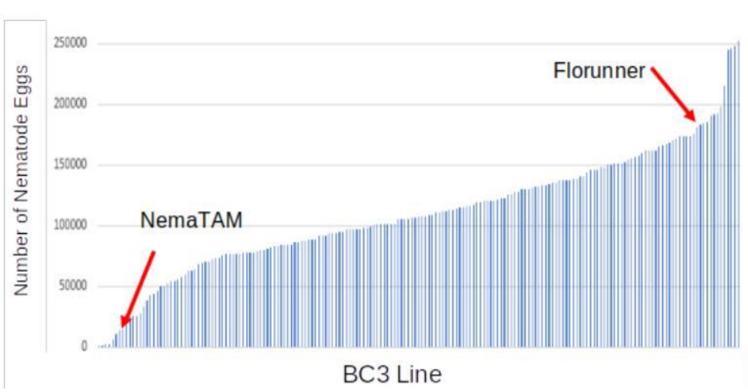
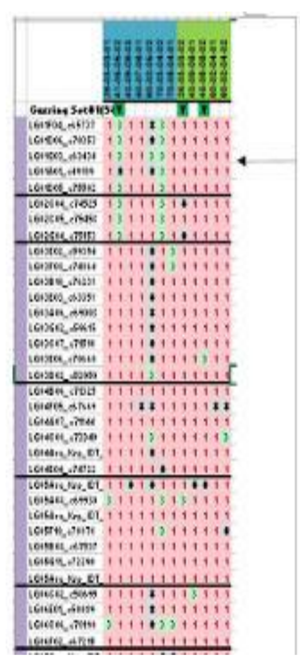


Figure 3. Screen of BC3 lines for resistance to root-knot nematodes. The number of eggs on roots was scored.

Table 23. Marker scores for different nematode-resistant breeding lines. A "2" indicates DNA inherited from the resistant TxAG-6. Arrows show markers for resistance on different chromosomes.



Screen of some of the BC3 lines has shown that several have resistance to nematodes (**Figure 3**), similar to NemaTAM. By contrast, many lines were susceptible, as was Florunner. Comparing these lines to mapped DNA markers shows that different lines have wild species DNA inherited on different chromosomes, meaning that the BC3 lines have different nematode resistance genes (**Table 23**).

BC3 lines with DNA from TxAG-6 on different chromosomes are being backcrossed further as part of the NIFA project to bring in resistance but reduce the presence of undesirable genes (alleles), such as for low yield.

Sub-Project IV. High Throughput Phenotyping

Unmanned Aircraft System (UAS) and sensors is an emerging remote sensing technology that provides imagery datasets with exceptional spatiotemporal resolutions. UAS can collect images quickly and repeatedly under appropriate weather conditions for agricultural applications. UAS-based imagery data also provides advanced phenotypic data using image processing and computer science algorithms, which is very useful and practical to extract crop traits. The ongoing UAS program continues to develop. New units of UAS platforms and sensors were obtained in the late summer of 2022 and were set up for use in 2023. Similar to previous years, UAS data was collected, and UAS-based Hight Throughput Phenotyping system was adopted to extract various crop parameters such as canopy cover, plant height, vegetation indices, etc. Additionally, this year, we measured the length of plots from the obtained UAS data. To better understand the collected UAS data and their association with yield, we closely analyzed and are presenting the data collected from the field trial conducted at the AgriLife center's location. There were 516 plot rows and data were extracted by creating plot boundaries for all of these plot rows.

UAS Data Collection

Texas A&M AgriLife Research at Stephenville conducted UAS data collection using DJI Phantom 4 Pro to acquire RGB and multispectral images. The UAS data collection protocol developed by Texas A&M AgriLife Corpus Christi was followed to collect high quality UAS data. This protocol included UAS flights at 25–30-meter altitude with 80-85% overlaps, depending on the sensors used and proper installation of Ground Control Points (GCPs). The protocol is designed to create a digital representation of the field to facilitate the phenotyping measurements from the digital replica of the field instead of manual measurements. The protocol ensures high quality of the collected data and subsequently the measurements quality.

UAS Data Processing:

The UAS image processing pipeline developed by our team is divided into three levels and presented in **Figure 4**. The workflow starts with the collection of raw overlapping images (Level 0 data product from different sensors and platforms). Level 0 overlapping images are used to triangulate points in the field in the 3D space (point cloud). The process is commonly known as structure from motion (SfM) where it improves the camera locations and orientations during the data collection and reconstructs the 3D point cloud. Part of the triangulation process is to include the GCPs to map the point cloud and the subsequent products to earth surface coordinate system. GCPs help to obtain temporal measurements such as height and volume changes in the canopy over the season. GCPs are also used to verify the quality of the measurements, for instance, the level of accuracy is within 2-3 cm error of test GCPs. Level 1 geospatial data products, such as

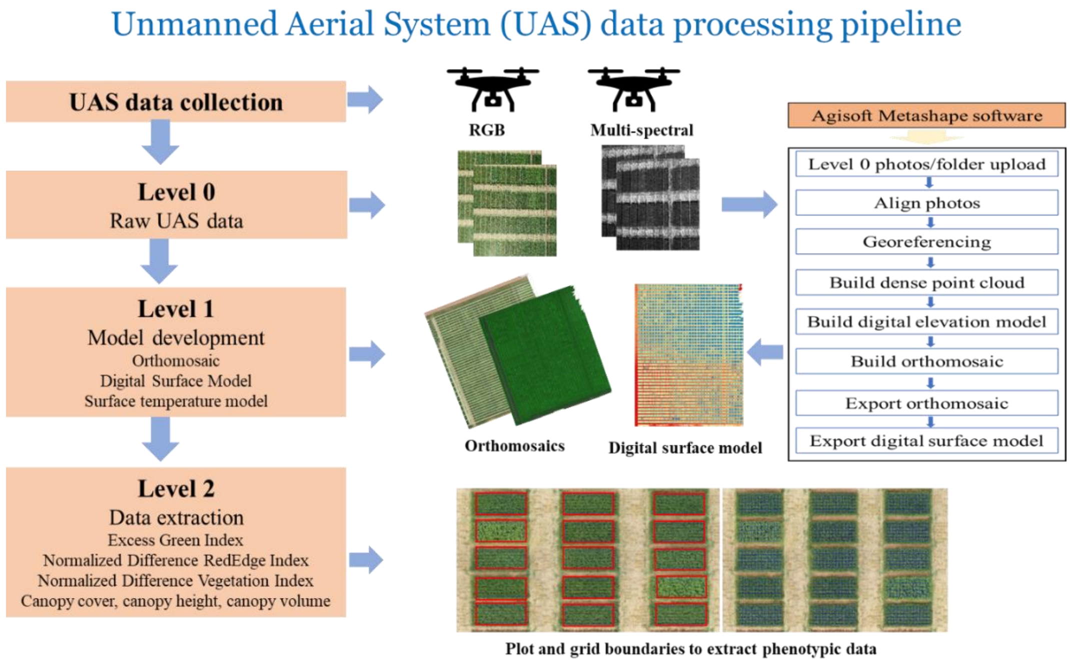


Figure 4. Overall UAS data processing pipeline used to process raw images and obtain phenotypic information.

Digital Surface Model (DSM) and orthomosaic images data. Level 2 data products are generated from the Level 1 data products and represent relevant biological crop features, canopy height, canopy cover, various vegetation indices, such as Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), and Excessive Greenness Index (ExG). Plot boundaries are also developed during level 2 phase to break down the field maps and obtain plot level measurements. All raw data collected from UAS was processed to generate an orthomosaic and DSM. We adopted the Agisoft Metashape software (Agisoft LLC, St. Petersburg, Russia), which is one of the famous commercial software to stitch UAS raw images using SfM GCPs' GPS coordinates were also input in image stitching process for removing distortion and precise geo-referencing.

Once the orthomosaic is generated, canopy features such as canopy height, canopy cover, and vegetation indices were obtained. **Canopy height (CH)** is generated by using two digital elevation models, the first flight is the ground before germination, commonly named digital terrain model (DTM) or the soil. The second map is a subsequent elevation model in the season where plants germinate, and it is known as digital surface model (DSM). The canopy height model (CHM) is the result of subtracting DTM from DSM which results in the height of the field's canopy. A classification algorithm will be used to obtain **canopy cover (CC)** from orthomosaic images. The classification algorithm uses red, green, and blue spectral bands of orthomosaic images and Red Green Blue Vegetation Index (RGBVI) to generate a binary classification that separates canopy areas from non-canopy areas on the image. A plot boundary file with plot/grids will be created and overlaid on the CHM to obtain height measurements and to calculate percentage of green pixels (CC) within each grid/boundary. **Canopy volume (CV)** provides an estimate of plant biomass as a combination of canopy size and height. CV for individual grids is calculated as the sum of pixels classified as canopy multiplied by the individual pixel height. We also calculated multi-spectral and RGB-based vegetation indices to assess canopy efficiency and canopy health (**Figure 5**).

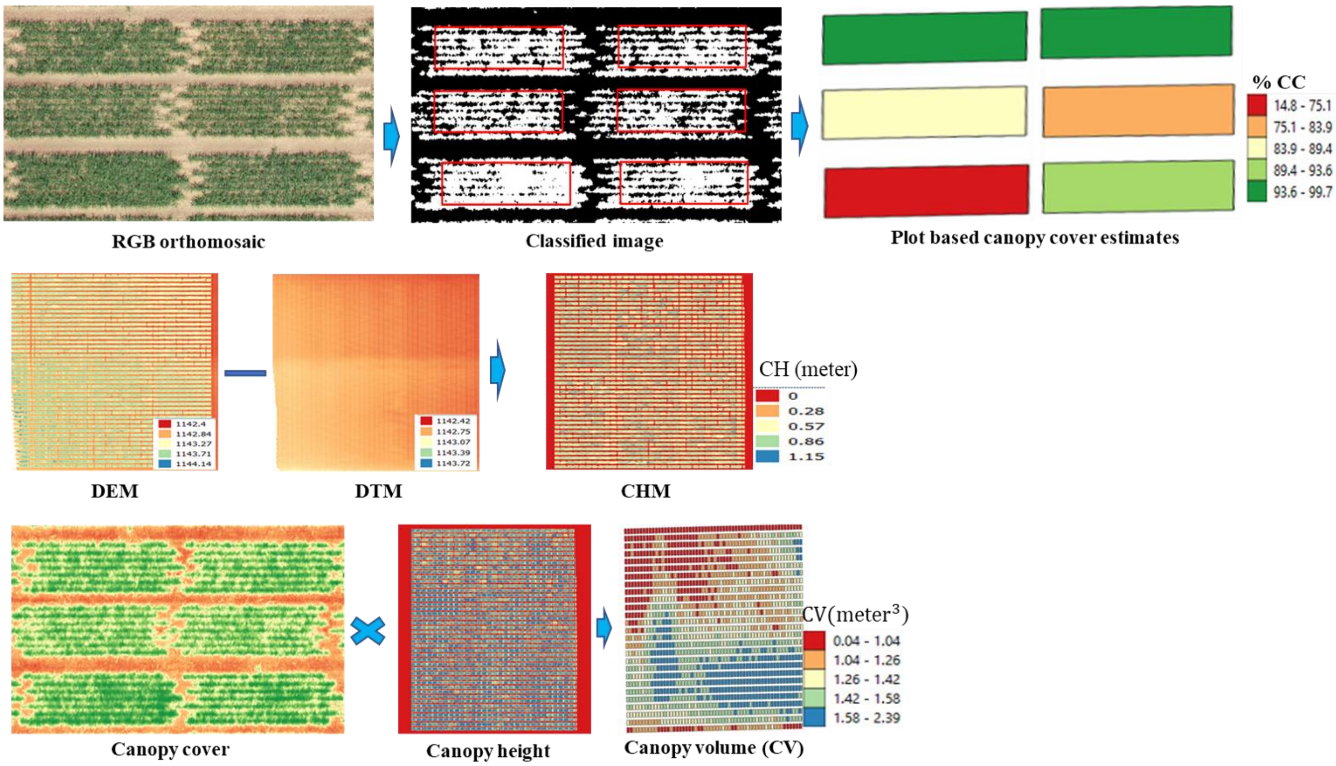


Figure 5. Estimating canopy cover (CC), canopy height (CH), and canopy volume (CV) from Unmanned Aerial Systems (UAS)-based orthomosaic and digital surface models (DSMs)

Data extraction and analysis

There were 516 plot rows and data were extracted by creating plot boundaries (**Figure 6**) for all of these plot rows. Length of the rows for each plot row was calculate as well.

Figure 6. Plot boundaries and row length calculations

Canopy cover (CC), canopy height (CH), canopy volume (CV), and Normalized Difference Vegetation Index (NDVI) features were extracted from the UAS imagery. **Figure 7** shows the box plot graphs for these measurements for all the plots. CC, which is measured in percentage ranged from 0-50 %. Maximum CH reached 0.8 meters in some plots but in average it was 0.5 to 0.6 meters. CV, which provides three-dimensional measurement of the canopy 1-1.25-meter cube per plot. NDVI that normally ranges from -1 to +1 was around 0.2 to 0.7 in this study. The structural features, CC, CV, CH, followed a sigmoidal growth pattern resulting in slow growth early in the season, followed by linear phase, and steady phase until it starts to senescence. Growth analysis can be conducted to further understand the growth dynamics and obtain growth parameters, which will be done in 2024.

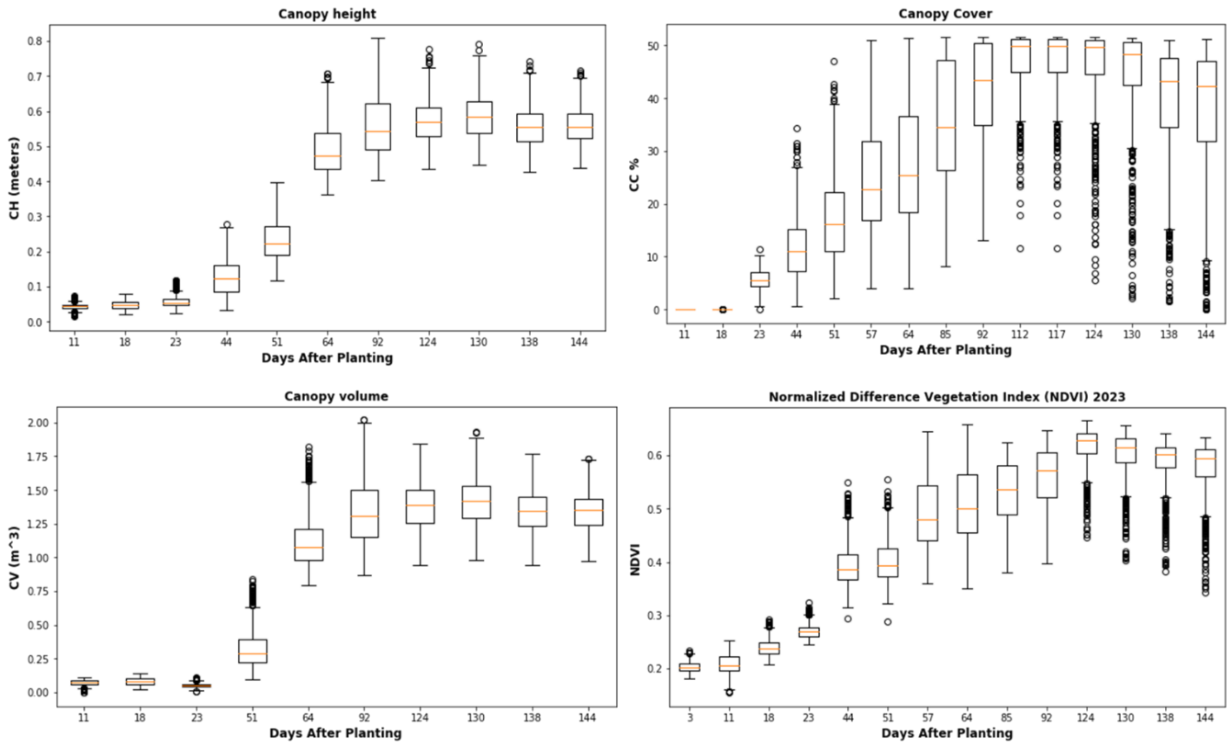


Figure 7: Box plot for all the features obtained from Unmanned Aerial Systems (UAS)

Correlation of UAS-based features with yield: We assessed the relationship between the UAS-based features and peanut yield using Pearson's correlation coefficient (**Figure 8**). As shown in the figure, strong correlation between the UAS-based features and yield was found starting 60 Days After Planting (DAP) (r>0.6) and becomes consistent for the rest of the season. Additionally, among all the features, CV had better correlation with yield starting 40 DAPs. These results are encouraging to develop more non-linear machine learning models for better yield estimations.

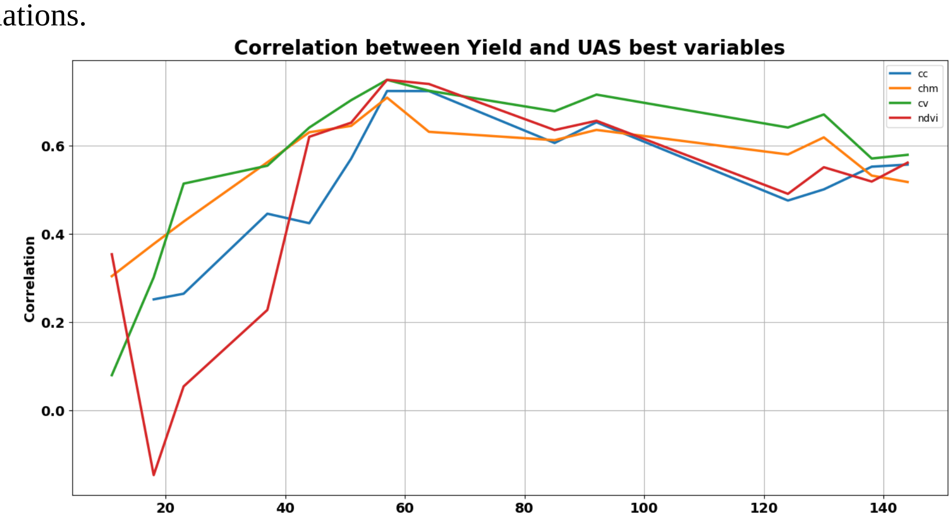


Figure 8. Correlation between yield and UAS best variables.

Data preparation for Machine Learning Model: One of the major problems with using multi-temporal data obtained from UAS is the in-consistency in data collection across environments. To address this issue, we need to define and develop an input framework for training, testing, and using ML models for yield predictions. We used Radial Basis function (RBF), a neural network model (**Figure 9**) to interpolate the data for developing the input vector for training a yield prediction model.

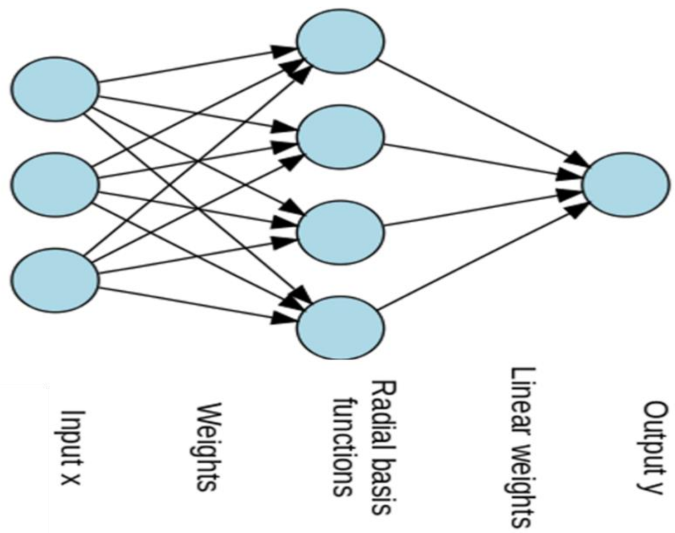


Figure 9. Radial Basis Function (RBF) Neural Network Framework

As shown in **figure 10**, we were able to transfer irregular multi-temporal data for UAS-based features to a continuous dataset from 0 DAP to 140 DAP. This dataset will be the input for the machine learning based yield prediction model. We are planning to focus on developing this framework in 2024.

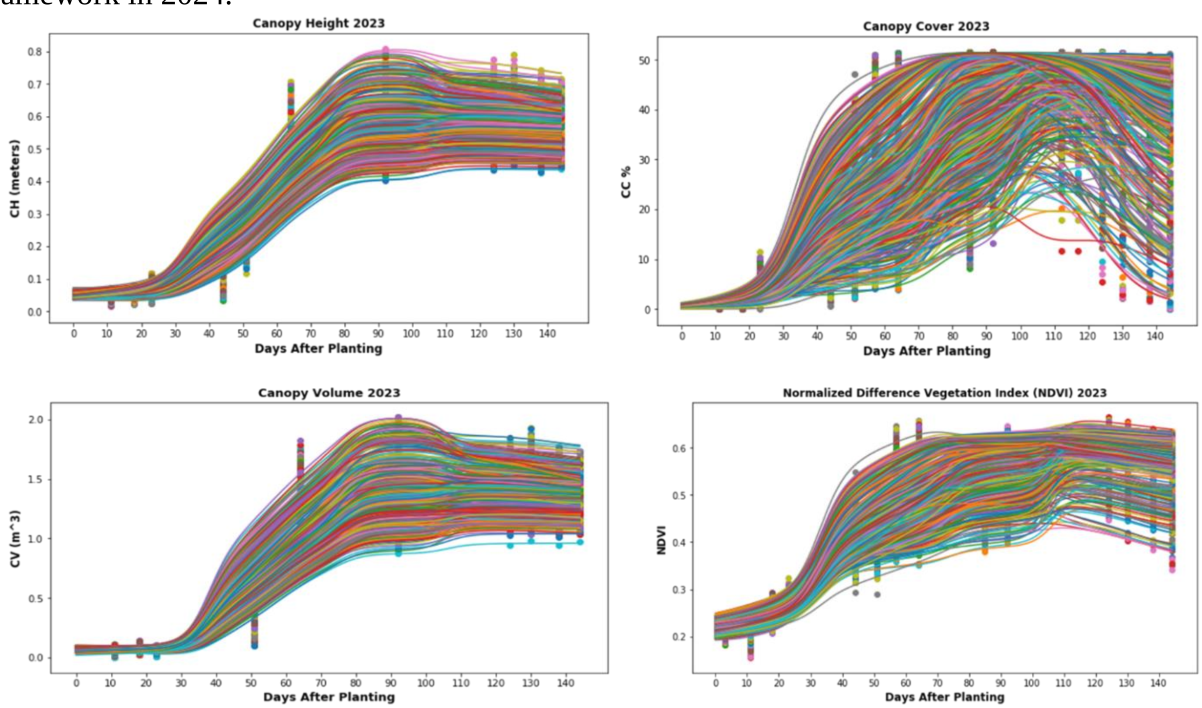


Figure 10. UAS-based features after performing radial basis function interpolation

UAV imaging for drought tolerance. We are beginning to use UAV (Unmanned Aerial Vehicle, drone) imaging to predict performance under water deficit stress (**Figure 11**). Expected benefits of this are (a) ability to take repeated images of the field weekly throughout the growing season. Taking ground-based data is very labor-intensive and can be done at best 2 or 3 times during the growing season, and only for a few of the tests, (b) ability to take different measures of plant responses, allowing for selecting accessions with different favorable responses to water deficit, (c) once methods are good enough, they may allow making selections before harvest or based on photos obtained at harvest. This could allow planting more materials, but harvesting only those that yield the best, making a more efficient use of resources, especially as labor is becoming increasingly scarce and expensive.

Figure 11. Ground photo of Spanish plants grown under water deficit. Curling of leaves can be seen.

Aerial images were taken at the USDA-ARS in Lubbock in collaboration with two groups of researchers. The first is Dr. Wenxuan Guo (Texas Tech and AgriLife Research), who was able to fly multispectral (**Figure 12**) and infrared cameras on two drones before new state restrictions on use of drones stopped the flights.

His graduate student was able to stitch together images to make an orthomosaic of the field. Our crew took ground-based measurements (SPAD chlorophyll, canopy temperature, flowering, leaf folding, wilting) the same day. The images have made a high-resolution image of the entire peanut field, and the data has been transferred to us to correlate with field and postharvest data. In **Figure 13**, different arcs have been labeled, corresponding to different tests grown. Differences between runner irrigated and drought tests are easy to see.

Figure 12. Drone with multispectral camera.

Researchers (Paxton Payton, Andrew Young) at the USDA-ARS have made drone flights since 2018, but were too short-handed to analyze the data. With hire of a postdoc (Ace Pugh) there, they have been able to put the data sets together and have offered to transfer 6 years of raw images to us as well as train one of our graduate students in making orthomosaics and analysis of the data– this will involve correlation of previous years of ground truthing measurements with UAV images and yield. The ARS researchers will be attempting to use advanced computational methods (neural networks) to develop models to correlate plot growth with our yield data.

Because of restrictions on use of UAVs- restrictions involve both certain models (Chinese made) and locations (such as at the Lubbock AREC just north of the airport), we are also attempting to use mobile pole-mounted cameras. We have found that it is possible to take images from a 30 foot-long pole mounted on the back of a Wildcat (**Figure 14**). We will use the same software to stitch these together into a single field image ("orthomosaic") as for the UAV images. A sample images is shown in **Figure 15**. The pinkish tint of this image is from use of an OCN (orange, cyan, infrared) camera, which substitutes an infrared band (for measuring canopy temperature) for the blue band. We plan to use OCN and RGB (red, green, blue) cameras in 2024.

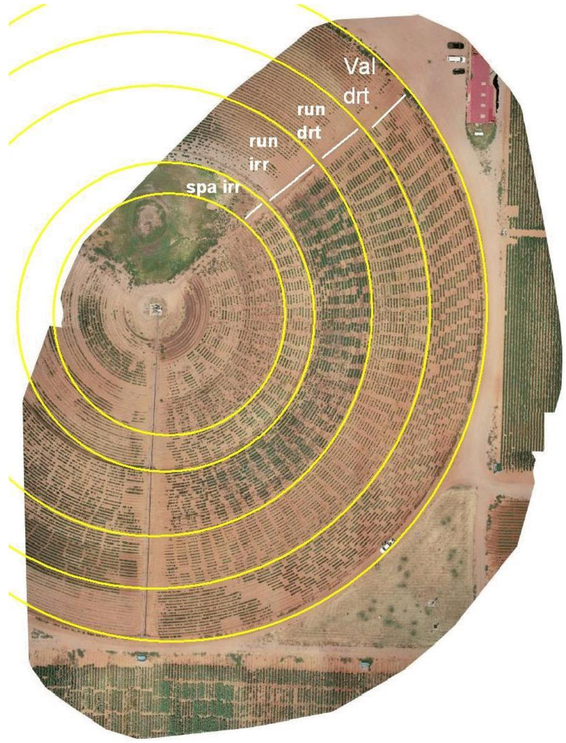


Figure 13. Orthomosaic image of the USDA-ARS field in Lubbock. Experiments were planted in concentric rings to allow for different irrigation treatments. Different groups of tests are labeled.

Figure 14. Pole-mounted cameras (two of them) mounted at end of a pole.

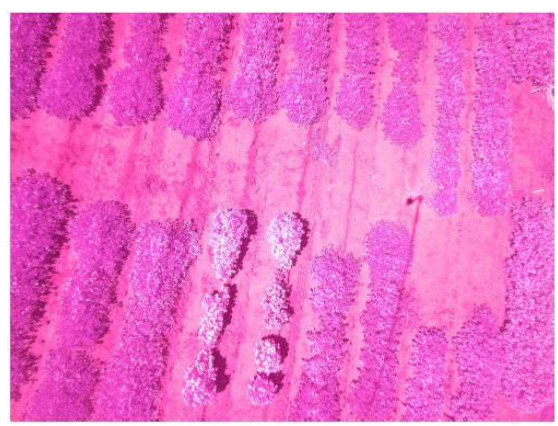


Figure 15. Image taken from an OCN camera mounted on a pole. The plot in the middle with the apparent white leaves is from a marker genotype (Golden Aureus) which has leaves that turn yellow during the growing season.

Sub-Project V. Organic Breeding

We initiated an organic breeding program in the spring of 2019 before the funding for this sub-project began and have continued the program. Initial crosses were grown as plant rows in 2021 and evaluations of breeding lines began in 2022. We are evaluating our current elite breeding lines in certified organic fields in Terry County and Wilbarger Co as well as cooperating with the State organic specialist, Mr. Bob Whitney to test biological products at our Erath Co. location. In 2023 the top yielding line for the Organic Spanish Test #1 was TP210656-2-1 with a yield of 5324 lbs/ac followed by TP210641-5-1 with a yield of 4602 lbs/ac. TP210656-2-1, a possible release candidate was also in the top statistical group for a grade of 72.9% (**Table 23**).

Table 23. Organic Spanish Test #1 Test in West Texas for 2023

	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seeds/Lb		SS%	
Cultivar												
TP210656-2-1	5324	A	969.82	A	72.9	A	50.9	AB	896	GH	5.6	DEFGH
TP210641-5-1	4620	AB	820.56	B	70.3	AB	55.5	A	826	H	6.5	DEFG
AT9899	4039	BC	711.62	BC	68.6	BCD	43.5	CD	1047	DEF	5.6	DEFGH
Schubert	3832	CD	614.50	CD	63.7	EF	51.5	A	885	GH	2.8	H
Tamspan 90	3281	DE	563.34	DE	68.0	BCD	42.0	CDE	1081	CDEF	4.5	EFGH
TP210655-3-2	3161	DEF	563.31	DE	69.8	ABC	36.3	FG	1258	B	7.3	CDEF
Olin	3160	DEF	546.06	DE	67.9	BCD	39.9	DEF	1140	BCDE	6.1	DEFG
TP210655-1-1	3066	EFG	514.61	DEFG	63.9	EF	30.7	H	1481	A	7.0	DEFG
TP210640-2-1	3031	EFG	536.70	DEF	70.6	AB	43.1	CDE	1054	DEF	5.3	DEFGH
TP210652-2-3	2958	EFG	526.63	DEFG	68.5	BCD	32.2	GH	1413	A	10.1	ABC
TP210653-2-2	2940	EFG	506.48	DEFG	68.3	BCD	38.6	EF	1180	BC	6.7	DEFG
TP210639-4-1	2745	EFG	457.69	EFGH	65.4	DE	40.4	DEF	1125	CDE	6.6	DEFG
TP210641-1-1	2499	FGH	411.75	FGHI	60.7	F	31.4	H	1452	A	7.5	CDE
TP210641-4-1	2383	GHI	402.72	GHIJ	66.2	DE	31.8	GH	1428	A	11.7	A
TP220683-2	1920	HIJ	326.78	IJK	68.0	BCD	41.5	DE	1100	CDE	8.2	BCD
TP220683-1	1879	HIJ	334.21	HIJK	70.8	AB	38.9	DEF	1168	BCD	11.5	A
TP220683-4NR	1731	IJ	295.08	IJK	68.2	BCD	46.5	BC	977	FG	6.9	DEFG
TP220683-2RN	1667	IJ	280.63	JK	67.8	BCD	43.7	CD	1042	EF	4.0	GH
#00	1665	IJ	279.93	JK	66.3	CDE	41.8	CDE	1091	CDEF	4.4	FGH
TP220683-2-3	1384	J	252.22	K	72.3	A	42.6	CDE	1071	CDEF	11.2	AB
Mean	2864		495.73		67.9		41.1		1136		7.0	
CV	38.1		39.8		4.9		17.5		17.5		40.4	
Entry F	<.0001		<.0001		0.0001		<.0001		<.0001		0.0001	

Table 24. Organic Spanish Test #2 in West Texas for 2023

	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs		SS%	
Cultivar												
Span 17	4755	A	835.00	A	69.1	B	42.7	C	1067	CD	7.3	ABC
TP230710-2-5	4658	A	803.75	A	68.1	BCD	53.3	A	852	F	3.2	C
TP230721-40-4	4376	A	790.08	A	71.6	A	43.6	C	1040	DE	3.3	C
GP of Toalson	3290	B	554.59	B	67.0	BCD	48.5	B	937	EF	7.6	AB
TP230711-3-4	3130	B	541.84	B	68.5	BC	36.7	D	1243	AB	9.7	A
TP230722-4-37	2992	B	499.69	B	66.0	D	38.2	D	1189	BC	6.6	ABC
Tamnut 74	2718	B	454.39	B	65.7	D	34.7	D	1311	AB	7.5	AB
TP230709-2-2	2663	B	456.13	B	66.4	CD	34.6	D	1315	A	4.7	BC
Mean	3573		616.93		67.8		41.5		1119		6.2	
CV	26.1		27.9		3.3		16.4		15.6		47.1	
Entry F	0.0021		0.0013		0.0082		<.0001		0.0001		NS	

A second Organic Test (**Table 24**) with a total of 20 materials were tested for yield and grade on organic plots at the Texas A&M AgriLife Research Vernon. Planting date was May 18, 2023 and digging date was November 3, 2023. Weeds were removed manually and/or mechanically because herbicide spray is not allowed on organic plots. No fertilizers were applied. Irrigation was conducted during extreme period of drought stress. The location where the study was conducted received less than 10 inches of rainfall during the growing season, leading to low yield. The yield varied from 1,174.9 lb./ac to 1,543.8 lb/.ac, with an average of 1,311.8 lb/.ac.

Grade varied from 53.% to 0.7%, with an average of 58.2%. No major diseases were found during the growing season. However, weed competitiveness was poor for varieties with late canopy closure.

Sub-Project VI. Leafspot Screening and Sclerotinia Screening

Leafspot Resistance

Disease screening is an important part of the multiple disease resistance program. The year-to-year screening gives a good picture of the overall resistance package that is present in breeding lines. Year to year the variability is high in screening nurseries, so it is essential to evaluate lines for several years for a comprehensive picture of their resistance. Unfortunately, in 2023 the lack of precipitation prevented any disease development during the growing season. Coupled with the fact that the small plot research were the only actively growing plants in the area there was not only no disease development, but the plants never set any seed. However, the screening will be repeated in 2024. We did however conduct a yield test for establish yield and grade potential. The test averaged 5626 lbs./ac. but the overall test was not significant for yield in 2023 (**Table 25**).

Table 25. Leafspot Resistance test for yield.

	Pods/Ac. Lbs.		Val/Ac. $		TSMK %		Seed Wt g/100		Seed/Lbs	
Cultivar										
TP230736-2-23	6217	A	1143.34	A	74.3	F	68.8	BCD	660	EFG
TP230723-1-15	6125	AB	1167.17	A	77.3	ABCDE	67.9	BCDE	669	DEFG
TX144370	6083	AB	1140.79	A	75.8	CDEF	64.1	EFGH	708	BCD
TP230736-3-15	6080	AB	1168.32	A	78.0	ABCD	66.2	DEFG	685	CDE
TP230736-3-19	5941	AB	1145.98	A	78.3	AB	71.1	BC	638	FG
NemaTAM II	5889	AB	1099.04	AB	75.3	EF	68.6	BCD	661	EFG
TP230736-4-16	5845	AB	1131.12	AB	78.1	ABC	62.3	GH	729	AB
Georgia O9B	5761	AB	1092.50	AB	76.9	ABCDE	63.1	FGH	719	ABC
TP230736-6-10	5736	AB	1070.21	AB	75.7	DEF	68.7	BCD	661	EFG
TP230736-6-2	5684	AB	1068.23	AB	76.1	BCDEF	68.6	BCD	662	EFG
TP230736-3-3	5667	AB	1071.39	AB	76.4	ABCDEF	66.4	DEFG	684	CDE
TP230723-1-31	5626	AB	1049.02	AB	75.0	EF	71.2	BC	637	FG
TP230723-1-14	5613	AB	1056.89	AB	76.3	BCDEF	77.0	A	589	H
TP230736-2-14	5588	AB	1025.52	ABC	74.2	F	60.5	H	750	A
Georgia 16HO	5509	ABC	1068.50	AB	78.7	A	71.6	B	634	G
TP230736-1-22	5377	ABC	986.03	ABC	74.1	F	70.3	BCD	647	EFG
TP230736-4-1	5231	ABC	994.70	ABC	77.1	ABCDE	67.1	CDEF	677	DEF
TP230736-2-24	5221	ABC	965.61	ABC	74.4	F	68.3	BCDE	664	EFG
TP220736-1-10	4979	BC	912.37	BC	74.4	F	64.2	EFGH	707	BCD
TP220736-4-17	4350	C	810.61	C	75.9	CDEF	69.7	BCD	651	EFG
Mean	5626		1058.37		76.1		67.8		672	
CV	13.1		13.9		2.5		6.1		6.1	
Entry "F"	NS		NS		0.0055		<.0001		<.0001	

Spanish Leafspot Resistance.

We are working with two crosses to add resistance to leaf spots to develop a resistant Spanish peanut. We evaluated the populations in 2021, and kept the most-resistant lines that year for evaluation again in 2022. We planted the material at Yoakum in South Texas for leaf spot evaluation in 2023. However, high heat (15 days of temperatures at least 105° in San Antonio) and predation by deer meant that we were unable to obtain any leaf spot ratings, and obtained only a few pods after digging what was left of the plants. We were able to increase seed in West Texas, however, and will perform leaf spot and yield trials in 2024.

Population Development

Crossing and marker development for improved leafspot resistance from the Burow lab continues with ongoing projects under other funding and will be evaluated in the field in 2022 (see Leafspot-resistant Spanish types section above). The Cason group is also moving forward with population development from a different genetic background in additional materials. Crosses were made in 2021 and were grown as F1 plants in the greenhouses of Texas A&M AgriLife. These show promise for leafspot resistance and will be followed with testing and molecular marker development work. Crosses are ongoing that focus solely on leafspot resistance as well as incorporation into the multiple disease resistance program. Germplasm and arkers for the USDA peanut breeding program in Georgia were obtained and crossing is underway with that material. As field rating and marker development continues, the information gathered will help us determine the best candidates to include in replicated testing.

Table 26. Sclerotinia Resistance in Central Texas for 2023.

Cultivar	Rating	
Langley	6.3	A
TP200625-3-2	6.3	A
TP200615-2-1-1	4.7	AB
TP200614-1-1-1	4.3	AB
Tx144370	3.3	AB
NemaTAM II	3.3	AB
TP200609-2-15	2.7	AB
TxL100212-03-03	2.0	AB
TP210656-2-1	1.7	AB
TP200606-3-10	1.7	AB
Tx901639-3	1.3	AB
TP200610-3-2	1.3	AB
Georgia 16HO	1.0	B
Georgia 14N	0.7	B
TP200606-7-10	0.7	B
TP210624-2-1	0.7	B
AG18	0.3	B
TP200609-3-11	0.3	B
TP200606-2-9	0.3	B
TP200607-1-2	0.0	B
TP200607-1-16	0.0	B
Georgia 09B	0.0	B

Finally, in related testing, **Table 26** presents the same advanced lines that were evaluated for yield and grade as well as leafspot. In Central Texas, these lines were also evaluated for *Sclerotinia minor* resistance as part of an ongoing screening nursery. Overall, disease incidence was very low in 2023, which was not unexpected given the year. No statistical differences were observed with TP 20607-1-16, TP20607-1-2, and Georgia 090B having no hits per plot of 10-row feet. All lines in off-station testing were rated twice in the fall for a total of well over 2,000 plots evaluated. Additionally, UAS data was collected to aid in the development of a screening algorithm.

Closing Comments

Numerous exciting initiatives are currently in progress. Texas A&M AgriLife Research spearheads a significant endeavor aimed at devising climate-smart agricultural practices. Initial focus is on engaging peanut growers to trial these methods and confirm their efficacy. Meanwhile, ongoing work on three new sub-projects, centered around germplasm and algorithms, ensures our program remains at the forefront of research and variety advancement. We are making strides in high-throughput phenotyping utilizing Unmanned Aerial Systems (UAS) and handheld Raman spectroscopy, alongside efforts to develop novel populations geared towards drought resistance, enhanced yield, leafspot resilience, and organic production. Moreover, we've embarked on new ventures addressing peanut nutrition and health, robotics integration in agriculture, and the creation of a high-throughput grading platform. Notably, we've initiated a groundbreaking project in collaboration with Chevron Corporation, focused on high-oil-content peanuts. The unfolding of this endeavor holds transformative potential for peanut production in Texas, as well as the broader landscape of Texas agriculture.

Supplemental Data

S1. Advanced Line Test in Gaines County in 2023.

Cultivar	Pods/Ac. Lbs.		TK		TSMK %		ELK		Med		SMK		SS%		DK		OK		Seed/Lbs	
TP200606-7-10	4194	A	66.9	C	57.4	ABCD	10.8	DEF	31.7	BCDE	13.1	AB	1.8	BCDE	0.3	E	9.2	ABC	794	CDE
Georgia 09B	4047	AB	72.7	A	61.4	ABC	18.8	ABC	31.8	BCDE	7.1	F	3.7	AB	5.4	ABC	5.9	FG	804	CD
Georgia 16HO	4004	AB	69.9	ABC	61.9	AB	19.0	ABC	31.8	BCDE	8.1	CDEF	3.0	ABCD	1.7	CDE	6.4	DEFG	786	CDE
TP200615-2-1-1	3975	AB	69.8	ABC	59.6	ABCD	19.9	AB	26.2	DE	11.2	ABCDEF	2.4	ABCDE	2.2	CDE	8.0	BCDEF	713	E
TP200610-3-2	3871	AB	70.0	ABC	58.0	ABCD	7.5	EF	38.1	B	10.4	ABCDEF	2.1	BCDE	2.8	CDE	9.2	ABC	852	ABCD
TP200614-1-1-1	3849	AB	69.9	ABC	57.6	ABCD	9.3	EF	34.1	BCD	12.5	ABCD	1.7	CDE	1.6	DE	10.7	AB	914	AB
Georgia 14N	3759	AB	70.7	ABC	58.7	ABCD	13.6	BCDE	32.4	BCD	12.2	ABCDE	0.5	E	1.3	DE	10.7	AB	900	AB
TP200607-1-16	3696	AB	70.6	ABC	59.9	ABCD	7.8	EF	39.2	B	11.1	ABCDEF	1.7	CDE	2.9	CDE	7.8	CDEFG	862	ABC
AG18	3517	AB	68.1	BC	55.9	BCD	4.8	FG	35.9	BC	14.6	A	0.6	E	0.9	E	11.2	A	901	AB
TP200607-1-2	3491	AB	67.8	BC	54.9	BCD	7.1	EFG	32.0	BCDE	13.0	AB	2.8	ABCD	3.3	BCDE	9.7	ABC	903	AB
TP200609-3-11	3397	AB	68.2	BC	59.0	ABCD	25.7	A	23.7	E	7.7	DEF	1.9	BCDE	1.7	CDE	7.5	CDEFG	785	CDE
TP200606-3-10	3376	AB	69.8	ABC	60.7	ABCD	13.3	BCDE	34.4	BCD	11.3	ABCDEF	1.7	CDE	1.5	DE	7.6	CDEFG	835	BCD
NemaTAM II	3338	AB	67.4	BC	56.9	BCD	11.1	DEF	33.8	BCD	7.7	DEF	4.3	A	2.9	CDE	7.7	CDEFG	775	DE
TP200609-2-15	3334	AB	71.1	AB	60.3	ABCD	10.3	DEF	36.0	BC	10.8	ABCDEF	3.2	ABCD	2.2	CDE	8.6	ABCDE	865	ABC
TP210656-2-1	3294	AB	71.0	AB	64.5	A	0.0	G	50.1	A	13.0	AB	1.4	DE	0.6	E	5.9	EFG	932	A
Tx144370	3267	AB	67.5	BC	54.0	CD	6.6	EFG	33.8	BCD	9.4	BCDEF	4.2	A	4.9	ABCD	8.6	ABCDE	850	ABCD
TP200606-2-9	3203	AB	68.8	BC	57.3	ABCD	12.0	CDE	31.2	BCDE	12.8	ABC	1.3	DE	2.5	CDE	9.0	ABCD	842	BCD
TP200625-3-2	3018	AB	67.5	BC	53.3	D	13.8	BCDE	28.6	CDE	7.4	EF	3.5	ABC	6.7	AB	7.5	CDEFG	785	CDE
TP210624-2-1	2859	B	70.6	ABC	60.9	ABC	11.6	DEF	36.5	BC	11.0	ABCDEF	1.8	BCDE	2.6	CDE	7.1	CDEFG	866	ABC
TxL100212-03-03	2839	B	70.1	ABC	57.9	ABCD	16.7	BCD	30.8	BCDE	7.6	EF	2.8	ABCD	7.1	A	5.1	G	782	CDE
Mean	3516		69.4		58.5		12.0		33.6		10.6		2.3		2.8		8.2		837	
CV	23.4		4.1		9.2		61.4		19.3		34.8		63.9		103.5		28.4		8.8	
Entry "F"	NS		NS		NS		<.0001		0.004		NS		0.0133		0.027		0.005		0.002	

S2. Advanced Line Test in Terry County in 2023.

	Pods/Ac. Lbs.		TK		TSMK		ELK		Med		SMK		SS%		DK		OK		Seed/Lbs	
Cultivar																				
TP200625-3-2	5223	A	75.0	BCDE	72.0	ABCD	27.8	DEF	35.5	BCDE	6.7	BCDEF	2.1	C	0.1	BC	2.9	EFG	736	DE
TxL100212-03-03	4669	AB	74.0	DE	71.5	BCDE	35.9	C	28.3	F	2.9	IJ	4.3	BC	0.1	BC	2.4	FG	661	F
TP200606-2-9	4639	ABC	75.1	BCDE	71.6	ABCDE	32.0	CD	30.5	EF	5.5	EFGH	3.5	BC	0.2	BC	3.3	DEF	660	F
TP200615-2-1-1	4567	ABCD	76.7	AB	73.8	ABC	50.4	A	16.9	G	2.4	J	4.0	BC	0.3	BC	2.6	EFG	576	G
TP200609-2-15	4417	ABCDE	75.9	ABCD	71.4	BCDE	31.3	CD	32.1	DEF	3.8	GHIJ	4.3	BC	0.2	BC	4.3	BCD	719	E
TP200606-3-10	4306	ABCDE	73.6	EF	68.3	EFG	22.1	FGH	34.5	CDE	8.6	B	3.1	BC	0.5	B	4.9	ABC	790	BC
TP200614-1-1-1	4144	ABCDE	76.1	ABC	73.2	ABCD	28.1	DEF	35.2	BCDE	4.7	FGHI	5.2	AB	0.0	C	2.9	DEFG	770	CD
Georgia 16HO	4143	ABCDE	75.3	BCDE	72.7	ABCD	33.1	CD	30.9	DEF	5.4	EFGH	3.4	BC	0.0	C	2.5	EFG	696	EF
Tx144370	4137	BCDE	75.0	BCDE	72.3	ABCD	24.5	EFG	39.6	BC	5.2	FGH	3.0	BC	0.0	C	2.7	EFG	716	E
Georgia 09B	4111	BCDE	76.1	ABC	72.9	ABCD	30.0	CDE	33.3	DEF	6.2	CDEF	3.3	BC	0.2	BC	3.1	DEFG	810	ABC
AG18	4092	BCDE	73.5	EF	67.6	FG	18.0	H	39.4	BC	8.3	BC	1.9	C	0.4	BC	5.5	AB	784	BC
TP200606-7-10	4023	BCDEF	71.9	FG	65.8	GH	23.1	FGH	31.1	DEF	7.9	BCD	3.8	BC	0.4	BC	5.8	A	693	EF
TP210624-2-1	3907	BCDEF	75.9	ABCD	74.2	AB	30.8	CDE	36.2	BCD	4.8	FGHI	2.4	BC	0.0	C	1.7	G	723	E
TP200607-1-16	3678	BCDEF	71.0	G	64.1	H	17.3	H	33.0	DEF	11.0	A	2.8	BC	1.0	A	5.9	A	843	A
TP200607-1-2	3675	BCDEF	74.3	CDE	70.4	DEF	18.7	GH	40.2	B	7.9	BCD	3.7	BC	0.1	BC	3.8	CDE	783	BC
TP200610-3-2	3580	CDEF	77.8	A	74.8	A	33.5	CD	31.6	DEF	5.4	EFGH	4.3	BC	0.0	C	3.0	DEFG	715	E
TP200609-3-11	3520	DEFG	74.9	BCDE	72.4	ABCD	44.0	B	17.6	G	3.5	HIJ	7.3	A	0.1	BC	2.5	EFG	706	E
TP210656-2-1	3457	EFG	76.9	AB	74.3	AB	0.0	I	64.3	A	7.5	BCDE	2.5	BC	0.2	BC	2.4	FG	822	AB
Georgia 14N	2944	FG	76.0	ABCD	72.7	ABCD	32.1	CD	32.1	DEF	6.4	CDEF	2.1	C	0.1	BC	3.2	DEF	781	BCD
NemaTAM II	2469	G	73.3	EF	70.5	CDEF	30.7	CDE	30.3	EF	5.8	DEFG	3.7	BC	0.2	BC	2.6	EFG	694	EF
Mean	3985		74.9		71.3		28.2		33.6		6.0		3.5		0.2		3.4		734	
CV	20.8		2.5		4.5		38.4		28.5		39.7		53.5		170.4		41.3		9.5	
Entry	0.004		1E-04		<.0001		<.0001		<.0001		<.0001		NS		0.016		<.0001		<.0001	

S3. Advanced Line Test in Erath County in 2023.

	Pods/Ac. lbs.		Val/Ac. $		TK		TSMK %		ELK (21.5 scr.)		Med (18 scr.)		SMK (16 scr.)		SS%		DK		OK		Seed Wt g/100		Seeds/lb		Plant height (cm)	
Cultivar																										
TxL100212-03-03	4579	A	820.87	A	74.6	CDE	71.5	DEFG	25.0	CD	35.9	E	4.8	BCDE	5.8	BC	0.2	A	2.9	AB	59.3	CDE	765	GHI	34	AB
TP200615-2-1-1	4370	AB	810.36	AB	76.8	ABC	73.7	ABCDE	46.4	A	19.2	G	2.8	E	5.3	BCD	0.1	A	3.0	AB	74.8	A	609	K	28	CDEFG
Tx144370	4303	ABC	773.37	ABC	74.4	CDE	71.4	DEFG	17.4	FG	45.0	BCD	4.4	CDE	4.6	CDEFG	0.1	A	2.9	AB	57.1	DEFG	797	FGH	30	BCD
TP200606-2-9	4173	ABC	752.06	ABC	74.5	CDE	71.9	CDEFG	18.6	EFG	44.1	CD	4.7	BCDE	4.5	CDEFGH	0.0	A	2.6	BC	52.3	JK	868	B	36	A
TP200606-3-10	4087	ABCD	744.21	ABCD	75.5	BCDE	73.1	BCDEFG	21.5	DEF	43.2	CD	3.7	DE	4.8	CDEF	0.2	A	2.2	BC	54.4	GHIJ	835	BCDE	31	BCD
AG18	4084	ABCD	727.17	ABCD	74.3	CDE	69.9	G	10.4	H	48.5	B	9.2	A	1.8	I	0.2	A	4.2	A	53.6	IJ	848	BC	31	BCD
Georgia 16HO	4079	ABCD	756.95	ABC	76.4	ABC	73.8	ABCDE	35.4	B	30.0	F	3.5	DE	4.9	CDE	0.0	A	2.6	BC	61.2	BC	741	IJ	25	G
TP200614-1-1-1	4071	ABCD	774.65	ABC	78.9	A	77.1	A	22.1	CDE	46.9	BC	5.0	BCDE	3.1	GHI	0.3	A	1.6	C	55.4	FGHI	819	CDEF	26	EFG
TP200625-3-2	4051	ABCD	734.62	ABCD	75.0	BCDE	72.7	BCDEFG	26.4	C	37.8	E	4.6	BCDE	3.9	DEFGH	0.1	A	2.2	BC	56.2	FGHI	807	DEF	30	CDE
TP200610-3-2	4045	ABCD	757.37	ABC	77.4	AB	74.0	ABCD	18.9	EFG	46.5	BC	5.1	BCD	3.5	EFGH	0.2	A	3.2	AB	56.4	FGH	805	DEF	27	DEFG
TP200609-3-11	4009	ABCD	711.96	ABCD	73.6	DE	70.5	EFG	37.6	B	26.4	F	3.6	DE	3.0	HI	0.0	A	3.0	AB	59.7	CD	762	HI	30	BCD
TP200607-1-16	4006	ABCD	720.28	ABCD	74.5	CDE	71.7	CDEFG	18.2	EFG	45.4	BCD	5.2	BCD	2.9	HI	0.3	A	2.5	BC	55.2	FGHI	824	CDEF	28	CDEFG
TP200606-7-10	3978	ABCD	704.50	ABCD	73.4	E	70.3	FG	25.3	CD	35.5	E	5.1	BCDE	4.4	CDEFGH	0.2	A	3.0	AB	63.9	B	710	J	31	BC
Georgia 09B	3957	ABCD	704.82	ABCD	74.4	CDE	71.5	DEFG	23.4	CD	36.4	E	4.2	DE	7.5	A	0.2	A	2.7	BC	54.8	FGHIJ	828	CDEF	29	CDEFG
TP200609-2-15	3865	ABCD	715.42	ABCD	76.7	ABC	73.7	ABCDE	21.6	DEF	43.4	CD	5.2	BCD	3.5	EFGH	0.1	A	2.9	AB	56.6	EFGH	801	EFG	28	CDEFG
TP200607-1-2	3809	BCD	697.97	ABCD	76.3	ABCD	73.5	BCDEF	15.1	G	45.1	BCD	6.6	BC	6.7	AB	0.3	A	2.5	BC	55.7	FGHI	816	CDEF	28	CDEFG
Georgia 14N	3669	BCD	695.27	ABCD	78.8	A	75.7	AB	26.5	C	41.9	D	4.1	DE	3.2	FGHI	0.2	A	2.9	AB	53.9	HIJ	842	BCD	29	CDEF
TP210656-2-1	3662	BCD	673.31	BCD	76.7	ABC	74.9	ABC	0.0	I	65.3	A	6.7	B	3.0	HI	0.3	A	1.5	C	49.8	K	913	A	27	DEFG
TP210624-2-1	3565	CD	658.99	CD	76.3	ABCD	74.1	ABCD	21.2	DEF	44.4	CD	5.1	BCDE	3.4	EFGH	0.0	A	2.1	BC	57.3	DEF	793	FGH	26	FG
NemaTAM II	3404	D	598.80	D	73.4	E	70.2	FG	16.4	G	42.3	D	4.6	BCDE	6.9	AB	0.3	A	2.9	AB	59.4	CD	764	HI	30	BCD
Mean	3988		726.65		75.6		72.8		22.4		41.2		4.9		4.3		0.2		2.7		57.3		797		29	
CV	14.9		16.0		2.8		3.6		45.1		23.3		36.1		44.5		155.9		32.6		9.6		8.5		12.0	
Entry F	NS		NS		0.0052		0.0112		<.0001		<.0001		0.008		<.0001		NS		NS		<.0001		<.0001		0.0028	

S4. Advanced Line Test in Comanche County in 2023.

	Pods/Ac. Lbs.		TK		TSMK %		ELK		Med		SMK		SS%		DK		OK		Seed/Lbs	
Cultivar																				
TxL100212-03-03	6326	A	73.1	BCDEFG	69.6	CDEF	22.3	DEFGH	34.3	FG	5.0	BCD	8.1	A	0.2	A	3.3	BCDEFG	702	BCD
Georgia 09B	6142	AB	74.2	ABCD	71.2	ABCD	28.6	CD	36.7	EF	4.5	BCDE	1.3	B	0.1	A	2.8	CDEFG	695	BCDE
Georgia 16HO	6027	AB	75.8	AB	73.4	AB	37.2	B	29.6	G	3.4	DE	3.2	AB	0.1	A	2.2	FG	624	FG
TP200625-3-2	5955	AB	74.1	ABCD	70.3	BCDE	27.2	CD	37.5	EF	4.5	BCDE	1.2	B	0.1	A	3.8	BCDEF	726	ABC
TP200606-3-10	5692	ABC	73.7	BCDE	69.3	CDEF	18.8	FGH	43.3	BCD	4.2	BCDE	3.0	AB	0.4	A	4.0	BCDE	697	BCDE
TP200607-1-2	5586	ABC	72.0	DEFGH	67.7	DEF	7.2	J	48.9	B	9.4	A	2.2	AB	0.2	A	4.2	BCD	752	AB
TP200606-2-9	5449	ABC	70.7	GH	66.8	EF	15.5	HI	41.5	CDE	6.1	BC	3.7	AB	0.1	A	3.8	BCDE	736	ABC
TP200614-1-1-1	5441	ABC	77.0	A	74.4	A	24.6	DEF	44.2	BC	4.3	BCDE	1.2	B	0.1	A	2.5	EFG	757	AB
NemaTAM II	5356	ABC	70.8	EFGH	66.5	FG	26.0	DE	33.8	FG	5.1	BCD	1.7	AB	0.5	A	3.8	BCDE	687	CDEF
TP210624-2-1	5287	ABC	72.9	CDEFG	68.2	DEF	23.3	DEFG	38.1	DEF	5.9	BCD	0.9	B	0.3	A	4.4	BC	705	BCD
TP200607-1-16	5278	ABC	73.2	BCDEFG	69.3	CDEF	17.2	GH	43.8	BC	6.3	B	2.0	AB	0.1	A	3.8	BCDEF	754	AB
TP200609-3-11	5188	ABC	70.8	FGH	67.3	EF	32.9	BC	28.8	G	4.4	BCDE	1.3	B	0.1	A	3.3	BCDEFG	745	ABC
Tx144370	5046	ABC	73.6	BCDEF	70.1	BCDEF	20.1	EFGH	44.1	BC	4.7	BCDE	1.2	B	0.1	A	3.4	BCDEFG	729	ABC
TP200606-7-10	5024	ABC	70.7	GH	67.1	EF	23.6	DEFG	36.5	EF	5.1	BCD	1.7	AB	0.1	A	3.6	BCDEFG	633	EF
Georgia 14N	4953	ABC	76.7	A	72.2	ABC	28.8	CD	37.2	EF	4.1	BCDE	2.1	AB	0.1	A	4.3	BC	788	A
TP200610-3-2	4945	ABC	76.8	A	74.2	A	26.5	CDE	41.8	CDE	3.7	CDE	2.3	AB	0.0	A	2.6	DEFG	661	DEF
TP200615-2-1-1	4877	BC	75.3	ABC	72.6	ABC	46.0	A	19.5	H	2.3	E	4.8	AB	0.3	A	2.4	EFG	565	G
TP200609-2-15	4862	BC	74.3	ABCD	69.7	CDEF	18.2	FGH	42.2	CDE	5.6	BCD	3.8	AB	0.2	A	4.4	B	782	A
AG18	4509	C	69.4	H	62.9	G	9.8	IJ	41.2	CDE	11.1	A	0.7	B	0.1	A	6.5	A	778	A
TP210656-2-1	4339	C	75.1	ABC	72.7	ABC	0.0	K	63.9	A	6.2	BC	2.6	AB	0.2	A	2.2	G	782	A
Mean	5314		73.5		69.8		22.7		39.3		5.3		2.5		0.2		3.6		715	
CV	15.8		3.6		4.9		47.4		23.2		43.8		121.2		170.9		33.5		9.3	
Entry "F"	NS		2E-04		1E-04		<.0001		<.0001		NS		NS		NS		0.004		<.0001	

S5. Advanced Line Test in Frio County Location #1 in 2023.

	Pods/Ac. Lbs.		TK		TSMK %		ELK		MED		SMK		SS		Seed/Lbs	
Cultivar					Letters											
TP210656-2-1	6659	A	77.7	BCD	75.7	ABC	0	L	68.173333	A	5.9	B	1.6	F	885	A
TxL100212-03-03	6573	AB	77.3	BCDE	75.1	BC	22.3	DE	45.4	FGH	4.0	CDE	3.4	ABCD	721	HIJ
TP200625-3-2	6222	ABC	76.7	CDE	74.5	C	20.3	DEFG	45.2	FGH	4.9	BC	4.0	AB	755	FGH
TP200614-1-1-1	6086	ABCD	78.5	ABC	75.5	ABC	17.4	FGH	50.6	CDE	4.8	BC	2.7	BCDEF	842	BC
TP200607-1-16	5985	ABCDE	76.4	DE	74.0	C	17.7	EFGH	47.3	EFG	5.8	B	3.3	ABCDE	760	FGH
NemaTAM II	5962	ABCDE	74.3	F	71.5	D	22.2	DE	41.6	H	3.6	CDE	4.1	AB	706	J
Tx144370	5898	BCDEF	76.7	CDE	75.1	BC	8.8	K	59.1	B	4.5	BCD	2.7	BCDEF	818	CD
TP200609-2-15	5805	CDEF	77.9	ABCD	75.2	BC	14.9	HI	51.9	CDE	5.0	BC	3.4	ABCDE	806	CDE
TP200610-3-2	5755	CDEF	78.8	AB	75.8	ABC	16.5	GH	53.1	CD	4.7	BC	1.5	F	785	DEFG
TP200606-3-10	5740	CDEF	77.6	BCDE	75.2	BC	14.5	HIJ	55.0	BC	3.7	CDE	2.0	DEF	775	EFG
TP200607-1-2	5650	CDEF	75.8	EF	74.0	C	10.9	IJK	53.3	C	6.0	B	3.8	ABC	807	CDE
AG18	5592	CDEFG	76.9	BCDE	74.3	C	10.1	JK	53.9	C	8.4	A	1.8	EF	791	DEF
Georgia 09B	5542	CDEFG	77.0	BCDE	74.9	BC	24.0	CD	42.7	GH	3.7	CDE	4.6	A	795	DEF
TP200606-2-9	5497	DEFG	77.1	BCDE	74.3	C	17.8	EFGH	48.2	DEF	5.9	B	2.3	CDEF	804	CDE
Georgia 16HO	5447	DEFG	77.5	BCDE	75.8	ABC	37.7	B	30.4	I	3.1	DEF	4.6	A	708	IJ
TP200606-7-10	5367	EFG	76.1	DEF	74.3	C	22.3	CDE	45.2	FGH	4.1	CD	2.6	BCDEF	689	J
TP200609-3-11	5273	EFG	76.1	DEF	74.1	C	42.2	B	27.6	IJ	2.4	EF	1.9	DEF	723	HIJ
TP210624-2-1	5243	FG	77.3	BCDE	73.9	C	21.4	DEF	44.6	FGH	5.1	BC	2.8	BCDEF	748	GHI
TP200615-2-1-1	4888	GH	79.7	A	77.6	A	48.9	A	24.4	J	1.9	F	2.4	CDEF	624	K
Georgia 14N	4424	H	79.7	A	76.7	AB	27.0	C	43.0	GH	4.7	BC	2.0	DEF	866	AB
Mean	5680		77.3		74.9		20.9				4.6		2.9		770	
CV	11.0		2.0		2.2		55.1		46.5		35.8		45.7		8.6	
Entry "F"	0.0006		0.0017		0.0048		<.0001		22.644663		<.0001		0.0075		<.0001	

S6. Advanced Line Test in Frio County Location #2 in 2023.

	Pods/Ac. Lbs.		TK		TSMK		ELK		Med		SMK		SS%		DK		OK		Seed/Lbs	
Cultivar																				
TP200607-1-16	6173	A	78.5	DE	76.7	CDE	23.9	EFGH	45.1	BCDE	3.7	BCD	4.0	ABC	0.1	CD	1.7	BCDE	709	EFGH
TP200609-2-15	6012	AB	79.1	CD	77.4	ABCD	27.9	DEFG	42.7	DEFG	3.2	BCDE	3.7	BCD	0.1	CD	1.6	BCDEF	762	ABC
TxL100212-03-03	5988	ABC	77.5	FGH	75.6	EFG	33.6	BCD	36.0	FGHI	2.7	CDEFG	3.3	BCDE	0.5	ABC	1.3	DEF	673	HI
TP200614-1-1-1	5966	ABC	79.4	BC	77.6	ABC	31.7	CDE	40.4	EFGH	3.1	BCDE	2.4	DE	0.4	ABCD	1.5	BCDEF	743	ABCDEF
TP210624-2-1	5886	ABC	78.3	DEF	75.0	FGH	28.4	DEF	40.3	EFGH	4.3	AB	2.0	E	0.3	BCD	3.0	A	724	BCDEFG
TP200606-3-10	5821	ABC	77.6	FGH	75.9	DEFG	26.6	DEFG	43.2	CDEF	3.6	BCD	2.6	CDE	0.3	BCD	1.3	DEF	715	CDEFGH
TP200607-1-2	5782	ABC	77.8	EFGH	76.1	CDEFG	17.3	H	50.9	BC	3.4	BCDE	4.5	AB	0.2	BCD	1.5	BCDEF	712	DEFGH
AG18	5771	ABC	77.7	EFGH	75.1	FGH	16.6	H	51.1	B	5.1	A	2.3	DE	0.3	ABCD	2.2	ABC	760	ABCD
TP200609-3-11	5749	ABC	77.0	HI	75.7	EFG	52.1	A	19.4	K	1.7	FG	2.5	DE	0.0	D	1.3	DEF	725	BCDEFG
TP210656-2-1	5699	ABC	79.0	CD	77.1	BCDE	6.7	I	63.9	A	3.3	BCDE	3.2	BCDE	0.5	ABC	1.3	DEF	788	A
Georgia 09B	5504	ABCD	78.0	EFG	75.9	DEFG	41.1	B	27.4	J	2.8	CDEFG	4.6	AB	0.6	AB	1.5	CDEF	745	ABCDEF
TP200606-7-10	5473	ABCD	77.9	EFG	76.6	CDEF	31.3	CDE	38.5	EFGH	2.4	EFG	4.4	AB	0.4	ABCD	0.9	EF	586	J
TP200615-2-1-1	5413	ABCD	79.6	BC	78.6	AB	56.6	A	15.0	K	1.7	G	5.4	A	0.2	BCD	0.9	F	550	J
TP200625-3-2	5410	ABCD	77.1	GHI	74.5	GH	32.3	CDE	35.2	GHIJ	3.4	BCDE	3.7	BCD	0.8	A	1.8	BCD	701	FGHI
TP200606-2-9	5371	ABCD	78.3	DEF	76.8	CDE	19.6	GH	50.2	BCD	3.8	BC	3.3	BCDE	0.1	BCD	1.4	DEF	709	EFGH
Tx144370	5230	BCD	78.0	EFG	76.2	CDEF	21.4	FGH	48.5	BCD	3.5	BCDE	2.8	CDE	0.2	BCD	1.6	BCDEF	755	ABCDE
Georgia 16HO	5216	BCD	78.3	DEF	76.9	CDE	42.4	B	28.7	IJ	2.3	EFG	3.6	BCD	0.3	BCD	1.1	DEF	656	I
Georgia 14N	5165	BCD	80.7	A	78.8	A	39.0	BC	34.3	HIJ	2.5	DEFG	3.1	BCDE	0.2	BCD	1.6	BCDEF	766	AB
NemaTAM II	5164	CD	76.5	I	74.0	H	37.5	BC	29.3	IJ	3.1	BCDE	4.1	ABC	0.2	BCD	2.3	AB	677	GHI
TP200610-3-2	4696	D	80.3	AB	78.8	A	37.2	BC	35.9	FGHI	2.9	CDEF	2.8	CDE	0.1	CD	1.5	CDEF	727	BCDEF
Mean	5575		78.3		76.5		31.1		38.8		3.1		3.4		0.3		1.6		709	
CV	11.4		1.5		2.1		40.9		31.4		36.8		39.2		118.8		45.4		9.1	
Entry F	NS		<.0001		<.0001		<.0001		<.0001		5E-04		0.004		NS		0.002		<.0001	

S7. Advanced Line Test in La Salle County in 2023.

Cultivar	Pods/Ac. Lbs.		TK		TSMK		ELK		Med		SMK		SS%		DK		OK		Seed/Lbs	
TxL100212-03-03	3099	A	71.2	CDEF	62.4	DE	0.0	A	47.2	ABC	11.6	EFGH	3.5	CDEF	0.4	CDE	8.5	CD	828	DE
TP200625-3-2	3045	A	71.6	CDE	63.1	BCD	0.0	A	47.2	ABC	9.9	GH	6.0	A	0.4	ABCDE	8.1	CD	916	BC
Georgia 16HO	2977	AB	71.4	CDEF	62.5	CD	0.0	A	46.9	ABC	9.7	GH	5.9	AB	0.3	CDE	8.6	CD	835	DE
TP210624-2-1	2932	AB	71.4	CDEF	61.9	DEF	0.0	A	45.4	BCD	13.3	CDE	3.1	CDEF	0.1	E	9.5	BCD	928	BC
NemaTAM II	2741	ABC	67.5	J	58.9	EFGHI	0.0	A	44.5	CD	10.3	FGH	4.0	BCDE	0.3	CDE	8.3	CD	893	CD
Georgia 14N	2660	ABC	74.3	A	66.2	AB	0.0	A	49.9	A	12.7	DEFG	3.6	CDEF	0.2	CDE	7.9	CDE	938	BC
AG18	2646	ABC	70.4	DEFGH	58.2	GHI	0.0	A	38.1	FG	18.1	A	2.1	F	0.7	ABCD	11.5	AB	943	BC
TP200610-3-2	2585	ABC	73.7	AB	63.8	ABCD	0.0	A	46.9	ABC	13.7	CDE	3.2	CDEF	0.1	CDE	9.8	BCD	929	BC
TP200606-3-10	2525	ABC	70.9	DEFG	62.1	DE	0.0	A	46.6	ABC	11.2	EFGH	4.3	ABCDE	0.4	CDE	8.5	CD	889	CD
Tx144370	2493	ABC	70.6	DEFGH	62.3	DE	0.0	A	45.1	BCD	13.2	DEF	4.0	BCDE	0.0	E	8.3	CD	894	CD
TP200606-7-10	2489	ABC	69.6	FGHI	60.6	DEFGH	0.0	A	43.9	CD	13.3	DEF	3.3	CDEF	0.7	ABC	8.4	CD	803	E
TP200606-2-9	2418	ABC	71.4	CDEF	60.4	DEFGH	0.0	A	42.7	DE	14.6	BCD	3.0	DEF	0.2	CDE	10.9	AB	977	B
TP210656-2-1	2390	ABC	72.9	ABC	66.9	A	0.0	A	46.3	ABCD	17.1	AB	3.5	CDEF	0.1	DE	6.0	E	1077	A
TP200607-1-16	2321	ABC	69.1	GHIJ	57.2	HI	0.0	A	40.1	EF	13.5	CDE	3.6	CDEF	1.0	A	10.8	AB	900	BCD
TP200614-1-1-1	2198	BC	74.7	A	66.0	ABC	0.0	A	48.3	AB	12.6	DEFG	5.1	ABC	0.4	BCDE	8.3	CD	948	BC
Georgia 09B	2147	BC	69.8	EFGHI	61.1	DEFG	0.0	A	44.4	CD	11.1	EFGH	5.6	AB	1.0	AB	7.7	DE	932	BC
TP200607-1-2	2071	C	68.9	HIJ	56.1	I	0.0	A	35.3	G	16.3	ABC	4.5	ABCD	0.7	ABCD	12.1	A	970	BC
TP200609-3-11	2060	C	68.1	IJ	58.5	FGHI	0.0	A	46.2	BCD	9.9	GH	2.5	EF	0.1	DE	9.5	BCD	902	BCD
TP200609-2-15	2018	C	71.9	BCD	61.5	DEFG	0.0	A	45.4	BCD	11.1	EFGH	4.9	ABC	0.4	BCDE	10.1	ABC	934	BC
TP200615-2-1-1	2001	C	69.6	FGHI	60.6	DEFGH	0.0	A	47.5	ABC	8.8	H	4.4	ABCDE	0.4	ABCDE	8.5	CD	802	E
Mean	2491		71.0		61.5		0.0		44.9		12.6		4.0		0.4		9.1		912	
CV	21.4		3.0		5.6		0.0		9.2		22.6		36.2		104.0		21.3		8.8	
Entry "F"	**NS**		<.0001		0.0001		NS		<.0001		<.0001		0.007		0.043		0.002		0.0002	

S8. Spanish Test #3 in La Salle County in 2023.

	Pods/Ac. Lbs.		TK		TSMK		ELK		Med		SMK		SS		DK		OK		Seed/Lbs	
Cultivar																				
AT9899	4035	A	70.4	A	60.6	ABC	0.0	A	22.3	GH	31.9	A	6.4	BCD	0.1	CD	0.1	CD	1229	ABCD
TP230710-2-5	3697	AB	69.9	AB	62.2	A	0.0	A	41.6	A	17.3	DEFG	3.3	GHI	0.6	BCD	0.6	BCD	860	J
TP230710-1-1	3481	AB	69.2	ABC	60.7	ABC	0.0	A	40.2	ABCD	15.7	EFG	4.8	EF	1.0	ABCD	1.0	ABCD	951	GHIJ
TP230710-1-3B	3316	ABC	66.2	CDE	56.0	ABCD	0.0	A	34.1	ABCDE	19.8	BCD	2.1	I	1.3	ABC	1.3	ABCD	960	GHIJ
TP230710-2-3	3292	ABC	68.7	ABC	61.5	AB	0.0	A	41.2	AB	18.0	CDEF	2.2	I	0.2	CD	0.2	BCD	838	J
TP230710-2-4	3037	BCD	69.1	ABC	59.5	ABC	0.0	A	40.9	ABC	16.8	EFG	1.9	I	0.8	BCD	0.8	ABCD	874	IJ
TP230710-1-2	2494	CDE	68.0	ABCD	56.5	ABCD	0.0	A	33.8	ABCDE	20.2	BCD	2.5	I	0.8	BCD	0.8	ABCD	884	HIJ
TP230710-40	2338	DEF	64.3	EFG	54.0	BCDE	0.0	A	32.0	DEF	15.2	FG	6.8	BC	0.1	D	0.1	D	1016	FGHI
TP230710-3-2	2261	DEF	65.2	DEF	53.1	CDE	0.0	A	30.8	EF	19.7	BCD	2.5	HI	0.1	D	0.1	D	1124	CDEF
TP230710-4E-2	2237	DEF	53.5	J	44.6	F	0.0	A	27.9	EFGH	11.5	I	5.3	DEF	0.7	BCD	0.7	BCD	1028	EFGH
TP230710-1-3	2221	DEF	65.2	DEF	53.2	CDE	0.0	A	32.7	CDEF	16.2	EFG	4.2	FG	1.4	AB	1.4	ABC	1047	EFG
Tamspan 90	2126	EF	65.0	DEF	54.7	ABCDE	0.0	A	31.3	EF	17.7	CDEFG	5.8	CDE	0.6	BCD	0.6	BCD	1232	ABCD
Schubert	2125	EF	58.5	I	47.5	EF	0.0	A	30.3	EFG	12.0	HI	5.2	DEF	0.1	CD	0.1	CD	1053	EFG
TP230710-4E-1	2119	EF	59.6	HI	50.3	DEF	0.0	A	32.9	BCDEF	15.5	EFG	1.9	I	0.8	BCD	0.8	ABCD	989	FGHIJ
TP230710-4C-6	2050	EF	64.7	EFG	50.2	DEF	0.0	A	27.9	EFGH	18.3	CDE	4.0	FGH	1.5	AB	1.5	AB	1173	ABCDE
TP230710-4C-3	2009	EF	64.2	EFG	49.8	DEF	0.0	A	21.2	H	21.6	B	7.0	BC	0.5	BCD	0.5	BCD	1276	AB
Olin	1955	EF	63.9	EFG	54.2	BCDE	0.0	A	30.3	EFG	18.1	CDEF	5.9	CDE	2.0	A	2.0	A	1323	A
TP230711-2-17	1899	EF	66.9	BCDE	54.7	ABCDE	0.0	A	25.2	FGH	20.4	BC	9.0	A	0.4	BCD	0.4	BCD	1258	ABC
TP230710-3-5	1897	EF	61.6	GHI	51.0	DEF	0.0	A	31.9	EF	14.8	GH	4.3	FG	0.6	BCD	0.6	BCD	1084	DEFG
TP230710-4-1	1555	F	62.5	FGH	49.8	DEF	0.0	A	27.0	EFGH	15.1	G	7.7	AB	0.8	BCD	0.8	ABCD	1131	BCDEF
Mean	2507		64.8		54.2		0.0		31.8		17.8		4.6		0.7		9.9		1067	
CV	32.6		6.9		10.9		0.0		21.7		25.1		49.6		121.6		28.8		15.3	
Entry "F"	0.0002		<.0001		0.0042		NS		0.001		<.0001		<.0001		0.049		NS		<.0001	

S9. Spanish Test #4 at Frio County Location #1 in 2023.

	Pods/Ac. Lbs.		TK		TSMK		Med		Med		SMK		SS		DK		OK		Seed/Lbs	
Cultivar																				
TP230721-40-4	6159	A	77.4	ABC	75.2	BCD	0.0	A	59.4	C	11.3	DEF	4.5	I	0.1	B	2.0	CDEF	925	FGHI
TP230721-40-11	5813	AB	78.8	A	77.6	AB	0.0	A	67.2	A	3.6	J	6.8	CDEFGH	0.0	B	1.2	EFG	675	L
TP230721-40-1	5750	ABC	77.8	AB	76.8	ABC	0.0	A	65.7	AB	4.9	HIJ	6.2	FGHI	0.0	B	1.0	FG	755	JKL
TP230721-40-9	5577	ABC	79.3	A	78.1	A	0.0	A	66.4	A	5.0	HIJ	6.6	DEFGHI	0.3	AB	0.9	G	696	KL
TP230721-42-19	5289	ABC	75.9	BCD	74.1	CDEF	0.0	A	61.3	BC	4.2	IJ	8.7	BCDE	0.2	B	1.5	DEFG	821	HIJK
Tamspan 90	5129	ABCD	72.0	GH	69.2	HIJ	0.0	A	49.9	EFG	12.4	CDE	7.0	CDEFG	0.1	B	2.6	ABC	1067	ABCD
Olin	5082	ABCD	73.4	FG	70.9	GH	0.0	A	53.5	DE	9.5	EFG	7.8	BCDEF	0.1	B	2.5	BCD	1019	BCDEF
TP230721-42-10	5055	ABCDE	76.0	BCD	74.3	CDE	0.0	A	60.2	C	5.4	GHIJ	8.7	BCDE	0.3	AB	1.3	EFG	836	HIJ
AT9899	4644	ABCDEF	74.7	DEF	72.2	EFG	0.0	A	44.9	GHI	22.6	A	4.7	HI	0.0	B	2.5	BCD	1073	ABC
Schubert	4569	BCDEF	69.0	IJ	67.0	JKL	0.0	A	52.5	DE	8.0	FGHI	6.5	EFGHI	0.1	B	2.0	CDEF	882	GHI
TP230721-1-39	4283	BCDEFG	68.0	J	65.5	KL	0.0	A	50.9	EF	8.9	EFGH	5.7	FGHI	0.3	AB	2.2	BCDE	932	EFGHI
TP230721-4-1	4219	CDEFG	69.8	IJ	65.3	L	0.0	A	41.3	I	18.9	AB	5.2	GHI	0.8	A	3.6	A	1142	AB
TP230721-42-31	4202	CDEFG	75.5	CDE	72.7	DEFG	0.0	A	58.6	C	5.1	HIJ	9.1	BC	0.6	AB	2.2	BCDE	815	IJK
TP230722-3-17	3600	DEFGH	70.0	IJ	68.1	IJK	0.0	A	52.6	DE	6.7	GHIJ	8.8	BCD	0.5	AB	1.4	EFG	942	DEFGH
TP230711-1-17	3495	EFGH	74.9	DEF	72.1	EFG	0.0	A	44.4	HI	15.9	BC	11.8	A	0.0	B	2.8	ABC	1167	A
TP230721-1-41	3393	FGH	70.8	HI	67.9	IJKL	0.0	A	46.4	FGH	15.9	BC	5.7	FGHI	0.0	B	2.8	ABC	1072	ABC
TP230711-3-4	3288	FGH	74.8	DEF	71.6	FGH	0.0	A	45.4	GHI	14.7	BCD	11.5	A	0.1	B	3.2	AB	1069	ABC
TP230721-42-15	3230	FGH	74.7	DEF	71.9	EFGH	0.0	A	56.7	CD	5.7	GHIJ	9.6	AB	0.6	AB	2.2	BCDE	861	GHIJ
TP230721-39-1	2751	GH	74.1	DEF	71.3	GH	0.0	A	52.3	DE	13.0	CDE	6.0	FGHI	0.0	B	2.9	ABC	980	CDEFG
TP230722-4-37	2107	H	73.6	EFG	70.4	GHI	0.0	A	43.3	HI	15.7	BC	11.4	A	0.0	B	3.2	AB	1054	ABCDE
Mean	4382		74.0		71.6		0.0		53.6		10.4		7.6		0.2		2.2		939	
CV	30.3		4.5		5.4		0.0		15.5		56.0		32.7		178.0		41.9		16.2	
Entry "F"	0.001		<.0001		<.0001		NS		<.0001		<.0001		<.0001		NS		<.0001		<.0001	

S10. Spanish Test #5 in Clovis New Mexico in 2023.

	Pods/Ac. Lbs		TSMK %	
Cultivar				
TS-90	4253.33	A	72.8733	AB
Olin	4090.63	AB	70.81	BCDE
NMSU-Dh	3918.75	ABC	74.145	A
656-2-4	3829.38	ABC	69.295	DEFG
652-2-3	3650.63	ABCD	73.255	AB
640-2-1	3581.88	ABCDE	71.96	ABC
NMSU-Nar	3554.38	ABCDE	68.385	EFG
631-4-1-1	3526.88	ABCDE	69.4	CDEF
631-2-1	3224.38	BCDEF	66.73	G
Schubert	3148.75	CDEF	68.535	EFG
633-3-1	3128.13	CDEF	67.15	FG
641-5-1	2839.38	DEF	68.6	EFG
00-18	2777.5	EF	67.35	FG
656-2-5	2523.13	F	71.33	BCD
Mean	3432		70	
CV (%)	21.5		4.1	
Entry "F"	0.0082		<.0001	