

## THE STAY GREEN TRAIT AS AN INDICATION OF DROUGHT TOLERANCE IN GRAIN SORGHUM

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### ABSTRACT

Drought stress is a major constraint to sorghum production worldwide. The stage of growth at which moisture stress occurs is important in determining the response of sorghum to soil moisture stress. The post flowering stress occurs when plants are under severe moisture stress during the grain filling stage. The term stay green is used to describe post flowering drought resistance. Plant symptoms indicating either a desirable or undesirable response to stress at this stage have been described and can be visually rated in the field. The distinct visual responses are reliable indicators of a genotype's response to drought and are predictable and repeatable across locations and years under similar stress conditions. Three hybrid tests for post flowering drought resistance i.e. the preliminary drought hybrid test the stay green hybrid test, and the drought hybrid test; were evaluated and screened in limited irrigation fields and a dry land farming conditions at Texas Experimental Station, Lubbock, Texas. Data were collected on days to 50% flowering and leaf plant death (LPD) rating as an indication to stay green character. The days to 50% flowering for the dry land farm flowered earlier than the other two test locations. Several female lines i.e. ATX 3197; A35. ATX 623 and A4R showed the lowest LPD ratings in their hybrids and could be used in the breeding program.

**Key words:** *Grain sorghum, Drought tolerance, Post flowering stress, Leaf plant death rating, Stay green.*

### INTRODUCTION

Water is the primary factor limiting yields in most of the world's sorghum producing regions (Seatharama *et al* 1982). There is no question that irrigation results in dramatic increases in yield under those circumstances, but many areas will continue to produce under rainfed conditions because they lack either the available water resources or the capital to develop them. Crop improvement for greater drought resistance is one means of increasing yields or enhancing yield stability where supplemental water is not available. Drought resistance is complex and not amenable to modification through selection for simple phenological traits. Selections should be tested repeatedly under environments where the seasonal and interacting patterns of temperature and water stress are similar to those in the target regions (Jordan and Sullivan 1983). Development of crops with improved drought tolerance is receiving increased emphasis within various agricultural research agencies. The procedures to accomplish this are often complex and progress at times is slow (Rosenow and Clark 1981). Improving drought tolerance in sorghum has recently received

increased emphasis internationally. Only in recent years have sorghum breeding and screening nurseries been devoted primarily to selecting for improved drought tolerance. This emphasis on field screening under severe drought stress at different stages of growth has enhanced our understanding of drought tolerance in sorghum and how it could be manipulated in breeding programs (Rosenow *et al* 1996). Two distinctly different types of drought stress responses have been identified and described in sorghum and are related to the stage of growth at which stress occurs (Rosenow and Clark 1981, Rosenow *et al* 1983; Rosenow 1993a, b). The pre-flowering response occurs when plants are under significant moisture stress prior to flowering in (G52), specifically from panicle differentiation or shortly thereafter until flowering. Symptoms of pre-flowering drought stress susceptibility include, leaf rolling, uncharacteristic leaf erectness, leaf bleaching, leaf tip and margin burn, delayed flowering, saddle effect, poor panicle exertion, panicle blasting and floret abortion and reduced panicle size. Since the panicle is directly affected, severe pre-flowering stress can result in drastic reductions in grain yield.

Post flowering response occurs when plants are under severe moisture stress during the grain filling stage (GS3), and especially during the latter portion of grain fill. Symptoms of post-flowering drought stress susceptibility include premature plant (leaf and stem) death or plant senescence, stalk collapse and lodging and stalk rot, along with a significant reduction in seed size, particularly at the base of the panicle. Tolerance is indicated when plants remain green and fill grain normally. Tolerant genotypes are referred to as having good "stay green". This term is now commonly used by sorghum workers to describe post flowering drought resistance and is considered an important drought resistance trait.

El-Bakry (1998) in Egypt, reported that drought stress caused significant reduction in grain yield and most of the studied characters. Drought tolerance of grain sorghum appears to be specific to certain growth stages, though some genotypes showed drought tolerance at both stages. Khizzah *et al* (1995) evaluated 4 sorghum lines (RTX 430, BTX 3197, RTX 7000 and B 35) and their hybrids under post flowering drought stress and reported that heritability estimates indicated that either B35 or BTX 3197 could be used as a parent for the improvement of plant water status. Oosterom *et al* (1996) studied the genetics of the stay-green trait and its components in sorghum. They found that inheritance of slow senescence was dominant over fast rate. A large relative green leaf area duration (GLAD) was partially dominant over a small relative (GLAD). Because of dominance of large leaf area at flowering the partial dominance in relative GLAD

translated into over-dominance for a large absolute GLAD. They suggested that their results offer an opportunity for improving drought tolerance of sorghum in environments with post-flowering drought stress. Eastin *et al* (1989) suggested that the selection of more optimal genotypes under different environments should be based on both satisfactory performance under poor environments (stress resistance characteristics), and responsiveness characteristics associated with high yield under good environments.

Zavala Garcia *et al* (1992b) found that indirect selection for yield of grain sorghum from any single environment was less efficient than indirect selection based on combination of yield from stress, intermediate and non-stress environments.

In this investigation we only deal with post flowering stress and the leaf plant death rating or the stay green character.

### **MATERIALS AND METHODS**

This investigation was done at Texas Experimental Station, Lubbock, Texas during a post-doctoral research in the period from October 1993 to March 1994 working under the supervision of Dr. Rosenow. The materials included several hybrids between male sterile lines and restorer lines and divided in three hybrid tests:

1. The Preliminary Drought Hybrid Tests (PDHT) including 100 hybrids.
2. The Stay Green Hybrid Test (SGHT) including 70 hybrids.
3. The Drought hybrid Test (DHT) including 49 hybrids.

The three tests were evaluated and screened at three major field screening locations using the randomized complete block design. The Halfway (F.13) and Lubbock (F.403) limited irrigation nurseries which are used to screen for post-flowering drought tolerance. The Lubbock dry land nursery (F.308) commonly shows stress during much of the season.

Planting was on May 27 for F.13 at Halfway, May 24 for F.403 and June 24 for F.308. The Halfway and Lubbock limited irrigation nurseries are used to screen for post-flowering drought tolerance. The fields were irrigated well during the early stages of growth to allow for good growth and yield expression, then irrigation was stopped to allow moisture stress to develop. The dry land nursery commonly shows stress during most of the season

Data were collected for the three tests for days to 50% flowering and leaf plant death rating (LPD). Rating are made on a 1 to 5 scale, where 1 = completely green, 3 = 50% of leaf area dead and 5 = all plants dead. Ratings

are normally made at or soon after physiological maturity. Data were

statistically analyzed according to Steel and Torrie (1980).

## RESULTS AND DISCUSSION

### 1. The preliminary drought hybrid test (PDHT)

Data presented in Table (1) show highly significant differences between genotypes for days to 50% flowering and leaf plant death rating. Also, data presented in Table (2) when combined over location showed that there were no differences between locations, but there were highly significant differences between genotypes and the interaction between location and genotypes.

Table 1. Analysis of variance for 50% flowering and leaf plant death rating (LPD) for the preliminary drought hybrid test (PDHT) at F.13 and F.403 at Texas Experimental Station, Lubbock, Texas.

Source of variation	Degree of freedom	F.13		F.403	
		Mean square		Mean squares	
		Flowering	LPD	Flowering	LPD
Replication	1	9.68	3.98	4.50	2.18
Genotypes	99	16.89**	0.942**	14.69**	0.609**
Error	99	1.08	0.238	2.05	0.202

\*, \*\* Significant at 0.05 and 0.01 probability levels, respectively.

Table 2. Combined analysis of variance over locations for 50% flowering and leaf plant death rating (LPD) for the different tests, Texas Experimental Station, Lubbock, Texas.

Source of variation	The preliminary drought hybrid test (PDHT)			The stay green hybrid test (SGHT)			The drought hybrid test (DHT)		
	d.f.	Flowering	LPD	d.f.	Flowering	LPD	d.f.	Flowering	LPD
Location (L)	1	0.250	69.639	2	1043.57**	4.260	2	383.58**	2.044
Error	2	7.090	3.080	3	3.798	0.534	3	0.946	0.027
Genotypes (G)	99	26.645**	1.080**	69	30.118**	0.965**	48	14.54**	1.380**
L x G	99	4.932**	0.471**	138	4.248**	0.332**	96	4.026**	0.512**
Error	198	1.565	0.220	207	2.049	0.102	144	0.786	0.080

\*, \*\* Significant at 0.05 and 0.01 probability levels, respectively.

The average performance of the PDHT test for days to 50% flowering and leaf plant death rating (LPD) for F.13 and F.403 (limited irrigation) and the average over locations are presented in Table (3). Days to 50%

flowering for F.13 ranged from 54 (ATX3197 x TX7078) to 66 (A8618 x 88 E 2668) with an average of 61.4 days. For F.403, it ranged from 55 (ATX 3197 x TX7078) to 71 (A 35 x MR 732) with an average of 61.4 days. The overall average of the two locations ranged from 54 (ATX 3197 x TX 7078) to 69 (A35 x MR 732) with an average of 61.4 days.

The LPD for the PDHT for F.13 ranged from 1.6 (ATX 3197 x TX 7078) to 4.9 [A1 x (R 8505 x R 3338)] with an average of 3.5. For Field 403 LPD ranged from 1.2 (A 35 x MR 732) to 4.2 (A BON 34 x 91 cc 515) with an average of 2.8. The overall location LPD for the PDHT ranged from 2.0 (A 35 x MR 732) to 4.1 (A 8618 x P 37.3) with an average of 3.2.

## **2. The stay green hybrid test (SGHT)**

Highly significant differences were shown between genotypes (Table 4) for days to 50% flowering and leaf plant death rating (LPD). Also, data presented in Table (2) when combined over locations showed highly significant differences for locations, genotypes and genotypes x locations interactions for days to 50% flowering. For LPD there were no significant differences between locations, while there were highly significant differences for genotypes and genotypes x location interactions. The average performance of the SGHT for days to 50% flowering and leaf plant death rating are presented in Table 6.

Days to 50% flowering for F.13 ranged from 54 (ATX 3197 x TX 7078) to 68 (A 35 x R 3324) with an average of 61.1 days. For field 403, days to 50% flowering ranged from 56 (ATX 3197 x TX 7078) to 71 (A 35 x R 3224) with an average of 61.3 days. Days to flowering for field 308 ranged from 51 (ATX 3197 x TX 7078) to 61 (A 4R x 3574) with an average of 56.8 days. The over-location average for days to 50% flowering ranged from 53 (ATX 3197 x TX 7078) to 66 (A 35 x R 3224) with an average of 59.8 days.

Leaf plant death rating (LPD) for the SGHT for Field 13 ranged from 1.4 (ATX 3197 x TX 7078) to 4.3 (A1 x 86 E0361) with an average of 2.95. For Field 403 LPD ranged from 2.7 (ATX 3197 x TX 7078) to 4.5 (A1 x P37.3) with an average of 3.19. LPD ratings for Field 308 ranged from 2.3 (A1 x 1790L) to 4.8 (ATX 3197 x TX 7078) with an average of 3.30. The overall location average ranged from 2.4 (A 35 x 5674) to 4.3 (A1 x P37-3) with an average of 3.15 (Table 5).

**Table 3. Days to 50% flowering and leaf plant death rating (LPD) for the Preliminary Drought Hybrid Test (PDHT) at F.13, F.403 and over location at Texas Experimental Station, Lubbock, Texas.**

No.	Pedigree	F.13		F. 403		Overall average	
		Days to 50% flowering	LPD	Days to 50% flowering	LPD	Days to 50% flowering	LPD
1	A1 x Tx 430	59	3.8	60	2.8	59.5	3.30
2	A BON 23 x Tx 430	63	3.9	62	3.2	62.5	3.55
3	A 35 x Tx 430	57	2.2	59	2.1	58.0	2.15
4	A 803 x Tx 430	58	2.7	58	2.5	58.0	2.60
5	A 806 x Tx 430	58	4.1	59	2.4	58.5	3.25
6	A 807 x Tx 430	59	4.0	59	2.9	59.0	3.45
7	A 8618 x Tx 430	62	2.5	62	2.7	62.0	2.60
8	A (378x3048) x Tx 430	63	3.2	62	2.5	62.5	2.85
9	A 801 x TAM 428	63	4.8	63	2.8	63.0	3.80
10	A 807 x TAM 428	61	4.2	62	2.7	61.5	3.45
11	A2-28 x Tx 2817	65	4.4	64	2.3	64.5	3.35
12	A 801 x Tx 2817	65	4.7	64	2.8	64.5	3.75
13	A 803 x Tx 2817	63	3.7	62	2.5	62.5	3.10
14	A1 x R 3224 (Sh)	63	4.2	62	2.6	62.5	3.40
15	A1 x R 3224 (t)	65	4.0	63	2.8	64.0	3.40
16	A 35 x R 3224 (t)	65	3.0	68	2.4	66.5	2.70
17	A 807 x Tx 436	62	3.8	60	2.8	61.0	3.30
18	A1 x Tx 2794	60	4.1	59	3.2	59.5	3.65
19	A 4 R x R 7730	62	3.1	60	2.5	61.0	2.80
20	A 807 x R 7730	58	4.7	60	3.1	59.0	3.90
21	A BON 34 x R 7730	61	3.9	61	3.2	61.0	3.55
22	A35 x R 7730	60	3.0	58	2.4	59.0	2.70
23	A 807 x 86 E 0.361	59	4.5	60	3.4	59.5	3.95
24	A BON 34 x (Tx 430 x R 9188)	64	3.4	62	3.3	63.0	3.35
25	A 803 x (Tx 430 x R 9188)	58	2.8	59	3.0	58.5	2.90
26	A1 85 DG 4300-5	58	3.7	59	3.6	58.5	3.65
27	A2-2B x 8 BE 2668	63	2.8	63	2.8	63.0	2.80
28	A 4 R x 8 BE 2668	64	3.6	64	2.3	64.0	2.95
29	A BON 23 x 8 BE 2668	66	3.6	65	2.7	65.5	3.15
30	A BON 34 x 8 BE 2668	65	3.6	63	2.8	64.0	3.20
31	A 806 x 8 BE 2668	62	4.2	61	3.6	61.5	3.90
32	A 8618 x 8 BE 2668	66	4.2	64	3.7	65.0	3.95
33	A1 x Tx 2864	61	4.0	60	3.8	60.5	3.90
34	A35 x Tx 2864	59	3.1	62	2.4	60.5	2.75
35	A 807 x Tx 2864	60	4.0	60	3.4	60.0	3.70
36	A BON 34 x P46-1	62	3.3	66	2.7	64.0	3.00
37	A 35 x P 46-1	61	2.0	64	2.3	62.5	2.15
38	A BON 34 x P37-3	63	3.9	60	3.6	61.5	3.15
39	A 8618 x P 37-3	64	4.7	63	3.5	63.5	4.10
40	A1 x P 33-1	60	3.5	62	3.1	61.0	3.30
41	A 35 x P 33-1	63	3.0	62	2.3	62.5	2.65
42	A 35 x P40-1	61	3.4	58	3.1	59.5	3.25
43	A1 x P69-2	58	3.3	59	3.4	58.5	3.35
44	A35 x P 69-2	58	2.6	58	3.4	58.0	3.00
45	A 807 x SC 599-11E	61	3.4	60	3.4	60.5	3.40
46	A1 x Tx 433	65	3.7	61	3.3	63.0	3.50
47	A 35 x 89 cc 132	60	2.2	61	2.7	60.5	2.65
48	ATX 626 x 89 cc 132	59	3.2	60	3.5	59.5	3.35
49	A 807 x 89 cc 132	59	4.1	60	3.0	59.5	3.55
50	A2-1 x NSA 440	65	3.7	65	2.7	65.0	3.20
51	A 35 x NSA 440	65	2.4	64	2.5	64.5	2.45
52	A1 x 1790 E	58	3.7	59	3.0	59.5	3.35
53	A 35 x 1790 E	59	3.3	59	2.1	59.0	2.70
54	A 35 x 88 B 928	62	3.1	61	2.8	61.5	2.95
55	A BON 23 x (Tx 435 x R 3338)	66	3.9	67	2.3	66.5	3.10
56	A 803 x P 46-1	59	3.8	64	2.3	61.5	3.05
57	A 807 x P 37-3	57	3.8	58	3.6	57.5	3.70
58	A1 x MR 732- Niger	64	2.8	66	2.7	65.0	2.75
59	A 35 x MR 732- Niger	66	2.7	66	1.7	66.0	2.20
60	A 35 x 91 cc 515	65	2.6	65	2.5	65.0	2.55
61	A 807 x 91 cc 515	61	4.5	61	3.0	61.0	3.75
62	A1 x 91 BE 7414	61	4.4	59	3.1	60.0	3.75
63	A 35 x 91 BE 7414	61	2.9	59	2.1	60.0	2.50
64	AQL 40 x 82 BDM 499	63	2.9	62	2.5	62.5	2.70
65	A (-6B) x 8503	59	4.0	59	2.6	59.0	3.30
66	A (-6B) x (Tx 430 x R 9188)	62	3.5	61	3.6	61.5	3.55
67	93 PRB x 2048 x 2070	59	2.7	59	3.3	59.0	3.00
68	93 PRB x 2058 x 2070	62	4.1	62	3.0	62.0	3.55
69	93 PRB x A1 x 2122	64	4.2	63	2.5	63.5	3.35
70	93 PRB x ATX 635 x 2122	66	3.5	64	2.5	65.0	3.00
71	93 PRB x 2050 x 2177	63	3.7	64	2.2	63.5	2.95
72	A BON 23 x (Tx 435 x R 3338)	65	4.1	62	2.9	63.5	3.50
73	A BON 34 x (Tx 435 x R 3338)	63	3.8	66	2.5	64.5	3.15
74	A1 x (B 35 XT x 7000) F6	57	2.8	57	2.4	57.0	2.60

**Table (3): Cont.**

No.	Pedigree	F.13		F. 403		Overall average	
		Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>
75	A1 x (B 35 XT x 7000) F6	57	2.2	58	1.9	57.5	2.05
76	ATX 623 x (B 35 XT x 7000) F6	57	2.6	57	1.9	57.0	2.25
77	A1 x (B 35 XT x 7000) F6	61	2.5	59	2.2	60.0	2.35
78	ATX 623 x (B 35 XT x 7000) F6	61	3.4	59	2.9	60.0	3.15
79	ATX 623 x (B 35 XT x 7000) F6	62	1.9	62	2.5	62.0	2.70
80	A1 x (R 8505 x R 3338)	63	4.9	64	2.8	63.5	3.85
81	A BON 34 x 90CW 6142	64	4.2	62	3.6	63.0	3.90
82	A BON 34 x 91 cc 515	64	4.0	62	4.2	63.0	4.10
83	AQL 41 x Tx 430	59	2.4	59	2.4	59.0	2.40
84	AQL 41 x R 3224	63	2.4	66	2.4	64.5	2.40
85	AQL 41 x 87 EO 366	59	3.5	61	2.3	60.0	2.90
86	AQL 41 x 85 EO 4300-5	61	2.3	66	1.8	63.5	2.05
87	A1 x Tx 430	59	4.0	60	3.3	59.5	3.65
88	A 803 x R 8503	58	3.3	60	3.0	59.0	3.15
89	A4 x SC 599-11 E	62	3.1	61	2.7	61.5	2.90
90	Az-2 (B) x SC 599-11E	63	3.9	63	2.8	63.0	3.35
91	A 803 x (Tx 2536 x R 1177)	58	3.8	60	2.3	59.0	3.05
92	A 807 x (Tx 2536 x R 1177)	58	4.1	58	3.9	58.0	4.00
93	A 801 x (Tx 430 x R 9188)	63	4.0	61	2.8	62.0	3.40
94	A BON 34 x 89 cc 443	64	3.8	62	3.5	63.0	3.65
95	A BON 23 x P 46-1	65	3.2	64	2.7	64.5	2.95
96	A 807 x P 33-1	59	3.5	61	2.9	60.0	3.20
97	ATX 3197 x Tx 7078	54	1.6	55	2.5	54.5	2.05
98	ATX 399 x Tx 430	61	3.3	59	3.5	60.0	3.40
99	DK 41 Y	59	3.5	62	2.0	60.5	2.75
100	DK 46	60	3.9	59	2.5	59.5	3.20
Mean		61.37	3.49	61.35	2.81	61.36	3.15
LSD at 0.05		2.06	0.97	2.84	0.89	2.45	0.92
LSD at 0.01		2.68	1.28	3.76	1.18	3.23	1.21

Leaf and plant death rating: 1 = all green, 3 = 50% of leaf area dead, 5 = entire plant dead.

**Table 4. Analysis of variance for 50% flowering and leaf plant death rating (LPD) for the stay green hybrid test (SGHT) at F.13, F.403 and F.308 at Texas Experimental Station, Lubbock, Texas.**

Source of variation	Degree of freedom	F.13		F.403		F.308	
		Mean square		Mean squares		Mean square	
		Flowering	LPD	Flowering	LPD	Flowering	LPD
Replication	1	3.78	0.038	6.01	0.021	1.607	1.54
Genotypes	69	15.25**	0.850**	10.91**	0.316**	12.45**	0.462**
Error	69	0.996	0.107	2.83	0.099	2.32	0.101

\*, \*\* Significant at 0.05 and 0.01 probability levels, respectively.

### 3. The drought hybrid test (DHT)

Data in Table (6) show highly significant differences between genotypes for days to 50% flowering and leaf plant death ratings. Also, data in Table (2) show significant differences between locations, genotypes and location x genotypes interactions for the same traits. The average performance for the DHT test for F.13, F.403 and F.308 for days to 50% flowering and leaf plant death rating are presented in Table (7).

**Table 5. Days to 50% flowering and leaf plant death rating (LPD) for the stay green hybrid test (SGHT) at F.13, F.403, F 308 and over location at Texas Experimental Station.**

No.	Pedigree	F. 13		F. 403		F. 308		Overall average	
		Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>
1	A1 x Tx 430	59	3.6	60	3.9	56	3.3	58	3.6
2	A 35 x Tx 430	57	2.4	57	2.8	53	3.4	56	2.8
3	ATX 635 x Tx 430	61	2.8	61	3.1	56	3.3	59	3.1
4	A x TAM 428	63	3.8	63	3.3	58	3.9	61	3.6
5	A 35 x TAM 428	62	3.2	62	3.0	58	3.4	60	3.2
6	A1 x R 3224 (Sh)	63	3.8	62	3.2	56	3.4	60	3.5
7	A 35 x R 3224 (Sh)	65	2.9	67	2.8	59	3.0	63	2.9
8	A1 x #3224 (t)	64	3.9	62	3.3	59	3.7	62	3.6
9	A 35 x R 3224 (t)	68	2.4	71	2.7	59	2.9	66	2.7
10	A1 x Tx 436/R 8505	65	3.8	63	3.1	54	3.5	60	3.5
11	A 35 x Tx 436/R 8505	66	2.4	62	2.8	56	3.3	61	2.8
12	A1 x R 8503	59	3.5	60	3.9	56	3.5	58	3.6
13	A 35 x R 8503	60	3.4	58	2.7	53	3.0	57	3.0
14	A1 x (Tx 430 x R 9188)	58	3.4	59	4.0	54	4.1	57	3.8
15	A35 x (Tx 430 x R 9188)	64	2.9	62	3.1	59	2.8	62	2.9
16	A1 x 85 DG 4300-5	64	3.7	61	3.4	58	3.4	61	3.5
17	A35 x 85 DG 4300-5	62	2.4	61	3.0	58	3.0	60	2.8
18	A1 x 88 E 2668	62	3.4	62	3.1	58	2.9	61	3.1
19	A 35 x 88 E 2668	64	2.3	63	2.9	59	3.2	62	2.8
20	A1 x SC 599-11E	62	3.2	62	3.3	59	3.0	61	3.2
21	A 35 x SC 599-11E	60	2.4	60	2.9	58	2.6	59	2.6
22	A1 x 88B 1016	60	2.4	60	3.7	58	3.3	59	3.1
23	A 35 x 88 B 1016	59	1.9	60	3.0	59	3.0	59	2.6
24	A1 x SC 35-14 E	65	2.4	65	2.8	59	2.4	63	2.5
25	A 35 x SC 35-14 E	63	2.7	62	2.8	61	2.6	62	2.7
26	A1 x 59 US	63	2.4	63	3.0	59	2.7	61	2.7
27	A 35 x 59 UC	61	1.9	61	2.8	54	3.2	59	2.6
28	A1 x 82 BDM 499	62	3.3	64	3.2	59	3.4	61	3.3
29	A 35 x 82 BDM 499	65	2.6	64	2.8	58	3.5	62	3.0
30	A1 x SC 56-14 E	62	2.4	62	2.9	59	2.8	61	2.7
31	A 35 x SC 56-14 E	63	1.8	61	2.8	60	2.7	61	2.4
32	A1 x NSA 440	64	3.0	62	3.0	58	3.4	61	3.1
33	A1 x NSA 440	64	3.3	62	3.0	59	3.4	61	3.2
34	A2-1 x NSA 440	65	3.3	64	2.9	59	3.0	63	3.1
35	A2-1 x SC 56-14 E	62	2.0	60	3.0	54	3.7	59	2.9
36	A4R x SC 56-14 E	63	2.0	61	2.8	55	3.0	60	2.6
37	A1 x 1790 E	58	2.3	60	3.0	54	3.2	57	2.8
38	A 35 x 1790 E	57	2.0	59	2.7	53	3.1	56	2.6
39	A1 x 88 B 943	61	3.5	61	3.5	60	3.8	60	3.6
40	A 35 x 88 B 943	60	2.7	61	3.2	59	3.3	60	3.1
41	ATX 623 x SC 599-11 E	61	2.9	60	4.0	59	3.2	60	3.4
42	A1 x R 9188	58	2.9	60	3.7	53	4.4	57	3.7
43	A 35 x R 9188	65	2.3	62	2.9	56	3.5	61	2.9
44	ATX 623 x R 9188	61	2.7	59	4.1	53	4.4	58	3.7
45	A1 x KS 19	55	2.2	58	2.9	53	3.6	55	2.9
46	A 35 x KS 19	58	2.3	59	2.9	54	3.3	57	2.8
47	A1 x R 1922	61	2.9	64	3.1	60	3.0	61	3.0
48	A1 x 1584	65	3.3	67	2.9	60	2.5	64	2.9
49	A1 x 1790 L	64	2.5	61	2.9	60	2.3	61	2.6
50	A1 x Tx 432	63	3.7	60	3.6	59	3.1	61	3.5
51	A1 x Tx 435	61	3.3	59	3.4	56	3.4	59	3.4
52	A 35 x Tx 435	61	2.2	61	2.8	59	2.9	60	2.6
53	ATX 3197 x Tx 7078	54	1.4	56	2.7	51	4.8	53	3.0
54	A 35 x Tx 7000	64	3.0	63	3.1	56	3.5	61	3.2
55	ATX 378 x Tx 7000	65	4.1	61	3.1	54	4.3	60	3.8
56	A1 x Tx 433	63	3.5	61	3.5	58	3.5	60	3.5
57	ATX 635 x 87 EO 366	63	3.6	64	3.1	60	2.8	62	3.2
58	A1 x 87 EO 366	61	3.8	59	3.7	53	3.8	58	3.8



Table 6. Analysis of variance for 50% flowering and leaf plant death rating (LPD) for the drought hybrid test (DHT) at F.13, F.403 and F. 308 at Texas Experimental Station, Lubbock, Texas.

Source of variation	Degree of freedom	F.13		F.403		F.308	
		Mean square		Mean squares		Mean square	
		Flowering	LPD	Flowering	LPD	Flowering	LPD
Replication	1	2.00	0.074	0.01	0.002	0.827	0.004
Genotypes	48	13.65**	1.212**	5.312**	0.618**	3.635**	0.574**
Error	48	1.042	0.139	0.698	0.056	0.618	0.046

\*, \*\* Significant at 0.05 and 0.01 probability levels, respectively.

Table 7. Days to 50% flowering and leaf plant death rating (LPD) for the Drought Hybrid Test (DHT) locations and over locations at Texas Experimental Station.

No.	Pedigree	F. 13		F. 403		F. 308		Over locations	
		Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>	Days to 50% flowering	LPD <sup>1</sup>
1	A1 x Tx 430	58	4.4	59	4.5	57	3.6	58	4.2
2	A 35 x Tx 430	57	2.6	60	3.1	58	3.4	58	3.0
3	A 807 x Tx 2817	64	4.1	61	3.8	59	3.6	61	3.8
4	A2-2 (B) x R 3224 (Sh)	63	4.2	60	3.9	56	4.4	59	4.2
5	A 807 x R 3224 (Sh)	61	4.3	60	3.9	56	3.9	59	4.0
6	A1 x R 32274 (t)	66	4.3	62	3.4	58	3.5	62	3.7
7	A 803 x R 3224 (t)	64	3.2	61	3.5	56	3.7	60	3.5
8	A 807 x R 3224 (t)	64	4.2	61	4.0	57	3.8	61	4.0
9	A1 x Tx 436	65	4.7	63	3.9	58	3.4	62	4.0
10	A1 x R 8503	63	4.4	61	4.0	63	3.3	62	3.9
11	A 35 x R 8503	59	2.7	58	3.4	58	2.8	58	3.0
12	A 807 x R 8503	61	4.6	60	4.1	57	3.7	59	4.1
13	A2-2 (B) x Tx 2783	66	4.1	63	3.4	60	2.5	63	3.3
14	A 803 x Tx 2783	64	3.5	62	3.5	57	3.2	61	3.4
15	A 807 x Tx 2783	62	3.6	60	4.2	58	4.7	60	4.2
16	A BON 23 x 86 EO 361	65	4.7	66	3.0	61	3.0	64	3.6
17	A BON 34 x 86 EO 361	67	3.9	62	3.0	59	2.8	62	3.2
18	ATX 635 x 86 EO 361	63	4.4	62	3.5	61	2.4	62	3.4
19	A1 x (Tx 430 x R 9188)	58	3.8	60	4.1	58	4.2	58	4.0
20	A 35 x (Tx 430 x R 9188)	65	2.8	63	2.8	58	2.9	62	2.8
21	A 807 x (Tx 430 x R 9188)	58	3.9	60	4.6	57	4.6	58	4.4
22	A 35 x 85 DG 4300-5	63	2.7	62	3.4	59	3.0	61	3.0
23	A1 x 86 E 2668	64	3.7	62	3.2	59	3.5	62	3.5
24	A 35 x 86 E 2668	65	2.4	62	3.1	59	3.2	62	2.9
25	A 803 x 86 E 2668	63	2.3	60	3.0	58	3.2	60	2.8
26	A 807 x 86 E 2668	63	4.3	62	3.8	58	3.7	61	3.9
27	A1 x 89 cc 443	61	3.9	61	4.0	59	3.4	60	3.8
28	A 35 x 89 cc 443	62	2.5	61	2.8	59	3.0	61	2.8
29	A 35 x 89 cc 445	61	2.9	59	3.9	58	3.6	59	3.5
30	A1 x Tx 2864	61	4.1	61	3.8	58	3.3	60	3.7
31	A 35 x Tx 2864	61	2.2	60	3.1	58	3.4	60	2.9
32	A1 x P46-1	60	4.2	61	4.2	58	3.6	59	4.0
33	A1 x P 37-3	60	4.5	61	4.3	58	3.9	59	4.2
34	A 35 x P 37-3	61	3.3	61	3.5	58	3.6	60	3.5
35	A1 x 88 B 1016	60	3.1	60	3.5	58	3.8	59	3.5
36	A 35 x 88 B 1016	58	2.1	59	3.7	58	3.1	58	3.0
37	A 35 x 82 BDM 499	65	2.5	64	3.0	59	3.2	62	2.9
38	A1 x NSA 440	64	3.7	61	3.6	58	3.3	61	3.5
39	A 35 x 1790 E	59	2.0	58	2.8	57	3.3	58	2.7
40	A BON 34 x (Tx 435xR 3338)60	4.0	61	3.0	61	2.4	61	3.1	
41	A BON 34 x Tx 436/R8505	64	3.8	63	3.8	58	3.4	61	3.7
42	A1 x P40-1	57	3.5	58	4.5	57	3.9	57	4.0
43	ATX 635 x 87 EO 366 515	67	4.6	64	3.4	61	2.5	64	3.5
44	A1 x 82 BDM 499	61	3.2	61	3.7	57	3.6	60	3.5
45	A1 x 91 cc 515	63	4.4	60	4.3	58	3.9	60	4.2
46	A BON 34 x 91 cc 515	65	4.3	64	3.4	58	3.3	62	3.7
47	ATX 2752 x Tx 430	62	3.3	61	3.5	57	3.6	60	3.5
48	ATX 399 x Tx 430	60	4.0	59	4.0	57	3.7	59	3.9
49	Dekalb Dk-46	61	2.6	58	3.0	57	3.8	58	3.1
Mean		62.12	3.6	61.0	3.6	57.10	3.5	60.3	3.55
LSD at 0.05		2.05	0.75	1.58	0.48	1.58	0.43	1.01	0.32
LSD at 0.01		2.74	1.00	2.24	0.63	2.11	0.57	1.34	0.43

Leaf and plant death rating: 1 = all green, 3 = 50% of leaf area dead, 5 = entire plant dead.

Days to 50% flowering for field 13 ranged from 58 (A 35 x 88B 1016) to 67 for (ATX 635 x 87E0366) with an average of 62.1 days. For field 403 days to flowering ranged from 58 (A 35 x 8503) to 66 (A BON 23 x 86E0361) with an average of 61 days. Days to 50% flowering for F.308 ranged from 56 (A 807 x R3224) to 61 (ATX 635 x 86 E0366) with an average of 57.1 days. Days to flowering when averaged over locations ranged from 58 for (A1 x TX 430) and several other hybrids, to 64 for (ATX 635 x 87 E0366) with an average of 60.3 days.

The LPD rating for F.13 ranged from 2.0 (A 35 x 1790 E) to 4.7 (A BON 23 x 86 E0361) with an average of 3.6. F. 403 LPD ratings ranged from 2.8 (A 35 x 179 DE) to 4.6 [A 807 x (TX 430 x R 8181)] with an average of 3.6. The LPD ratings for F.308 ranged from 2.4 (AT x 6.5 x 86 E0366) to 4.7 (A 807 x TX 2783) with an average of 3.5. The LPD rating when averaged over locations ranged from 2.7 (A 35 x 179DE) to 4.4 [A 807 x (TX 430 x R 8188)] with an average of 3.55.

In general from it is noted that the hybrids in the dry land test flowered earlier than the hybrids in the other test locations. It is also noted that the hybrid (ATX 3197 x TX 7078) in all test locations showed the lowest LPD ratings and flowered earlier than most hybrids in the tested locations.

In the PDHT test the female parents which showed the lowest LPD ratings in the hybrids are ATX 3197 (2.0); AQL 41 (2.4); A 35, ATX 623, AQL 40 (2.7); A 4R (2.9); and A2-2, A 803, ATX 635 (3.0). In the SGHT the female parents showing the lowest LPD ratings were A 35, A4-R (2.8); and ATX 3197, A6 (3.0). For the DHT the female parents exhibited the lowest rating are A 35 (3.0) and A 803 (3.2). All these females could be used in breeding programs as sources for the post flowering drought stress tolerance.

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## صفة إستمرار الخضرة كدالة على مقاومة الجفاف في اختبارات

### هجن الذرة الرفيعة

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يعتبر الجفاف مشكلة عالمية لإنتاج الذرة الرفيعة. وتعتبر مرحلة النمو التي يمر بها النبات عند حدوث الإجهاد مهمة جدا في تحديد استجابة الذرة الرفيعة للجفاف وللإجهاد المائي للتربة. وينتج الإجهاد الذي يحدث للنبات بعد التزهير عندما تكون النباتات تحت تأثير الإجهاد المائي أثناء فترة إمتلاء الحبوب. ويستخدم اصطلاح إستمرار الخضرة لوصف مقاومة النبات في مرحلة المقاومة للجفاف في مرحلة ما بعد التزهير. وتعتبر هذه الملاحظة البصرية دليلا حقيقيا لاستجابة التركيب الوراثية لمقاومة للجفاف. يمكن التنبؤ بها كما يمكن أن تتكرر خلال مواقع وسنوات الاختبار عند تماثل ظروف الإجهاد. في هذه الدراسة تم إقامة ثلاثة اختبارات للمقاومة للجفاف في مرحلة

ما بعد التزهير وهى الاختبار الأولى للهجن تحت ظروف الجفاف والثانى هو استمرار خضرة النبات أثناء مرحلة ما بعد التزهير تم اختبار المقاومة للجفاف بعد التزهير. وقد تم إجراء هذه الاختبارات فى ثلاثة حقول أثنان منها حقول للزراعة جزيئية والثالث حقل زراعة جافة فى محطة البحوث الزراعية بجامعة تكساس وتم تسجيل البيانات على عدد الأيام حتى ٥٠% تزهير وكذلك ظاهرة موت الأوراق كتليل لظاهرة استمرار الخضرة حيث لوحظ أن عدد الأيام حتى ٥٠% تزهير للهجن فى الزراعة الجافة كان أكثر تبكيراً وبالنسبة لموت الأوراق فإن هناك عدد من الأمهات أظهرت أقل قيم لموت الأوراق فى هجتها لتحمل الجفاف ويمكن استخدامها فى برامج التربية وهى ATX 3197, A35, ATX 623, A 4R.

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