Reducing Photoperiod Response of Tropical Maize Germplasm for use in Midwestern Maize Introgression

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Introduction:

Tropical maize germplasm is an important source of alleles for biotic and abiotic stress resistance and numerous value-added traits (VATS). Reducing photoperiod response of tropical maize germplasm is necessary for successful introgression in a Midwestern environment and is possible for some genotypes if daylight hours are reduced to 8-10 hours. Covering plants with a 30 gallon galvanized can from emergence to six weeks post-emergence can reduce photoperiod response (personal communication with Dr. Marty Sachs at the USDA-ARS Maize Genetics Cooperation Stock Center in Urbana, IL). This method was used successfully for reducing photoperiod for *Zea diploperennis* in Minnesota and reported by Carlson (1996). Breeding with tropical maize is limited in the US due to photoperiod sensitivity, resulting in very late or non-flowering, tall plants. Research on the genetics of maize photoperiod response is an important objective and efforts are underway to clone a photoperiod QTL (Coles 2007).

Fig. 4. Enlarged shade house covering 4 rows

Fig. 5. Shade houses (uncovered)

Objectives:

To determine if artificial control of day length could effectively reduce/eliminate photoperiod response in various sources of tropical germplasm to result in flowering date similar to B73. Secondly, determine the optimum method and duration of shade treatment to effectively utilize to reduce photoperiod in Midwestern environment. Thirdly, generate crosses of CUBA164 (pollinator) with B73 and PHB47 to create a mapping population in 2007 for future genetic studies.

Fig. 1. A - frame shade house covering 1 row

Fig. 2. A - frame shade house with 4-week old plants

Fig. 3. Galvanized can shade treatment

Methods:

A two year study was conducted in 2006 and 2007. In 2006, seven tropical genotypes were used (four F1 crosses and three accessions), representing six maize races which originated from five countries. Treatment one consisted of seven A-frame "shade houses," one meter in height, constructed from 22 mm galvanized pipe and black woven landscape fabric **(Fig 1 and 2).** Treatment two used 30 gallon galvanized cans, placed over 3-4 plants per genotype **(Fig 3).** Treatment three consisted of un-shaded plants. Shaded plants experienced eight hours of natural daylight daily (0700 - 1500 hours), from emergence to six weeks post-emergence. In 2007, only the CUBA164 genotype was used, and a larger scale version of the shade house was constructed which enabled coverage of four rows, five meters in length **(Fig 4 and 5).** Seven shade houses were used and approximately 460 plants of CUBA164 were covered from emergence to six weeks as described for 2006. Comparisons were made for shading treatments conducted for three, four, five, and six weeks. Four to eighteen plants were sampled per treatment in 2007 due to loss of stand from excessive rainfall.

Table 1. Days to Pollen Shed, Plant Height, Ear Height and Internode Diameter for 7 Tropical Genotypes in 2006

Pedigree	BG002 x T26a		BO80082 x T26a		BR106 x T33a		CUBA164 x T33a		BR52051		CHIS775		CUBA164	
Race	Unclassified		Cuban yellow		Composite		Mixed (Creole)		Dente Amarelo		Tuxpeño		Mixed (Creole)	
Country of Accession	Venezuela		Bolivia		Brazil		Cuba		Brazil		Mexico		Cuba	
Treatment	Control	Shaded	Control	Shaded	Control	Shaded	Control	Shaded	Control	Shaded	Control	Shaded	Control	Shaded
Avg. Days to Pollen Shed *	82	68	83	69	90	68	83	68	84	69	89	68	84	68
Avg. GDU to Pollen Shed (Celsius)	1059	845	1070	860	1161	845	1070	845	1085	860	1149	845	1085	845
Shaded Germplasm GDU Shed - B73 GDU		54		69		54		54		69		54		54
Avg. Plant Height (cm)	320	200	330	210	320	210	320	200	290	230	350	250	320	230
Avg. Ear Height (cm)	200	110	230	110	210	110	210	110	210	150	210	140	260	120
Avg. 3rd Internode Diameter (mm)	27	20.5	31	17.5	30	20	30	21	31	24	30	22	30	20

*** B73- 64 days (791 GDU) to pollen shed**

Table 2. Days to Pollen Shed, Plant Height, Ear Height and Internode Diameter for CUBA164 in 2006 and 2007

	2006		2007	
Planting Date	17-May		21-May	
Treatment	Control	Shaded	Control	Shaded
Avg. Days to Pollen Shed*	84	68	88	72
Avg. GDU to Pollen Shed (Celsius)	1085	845	1121	884
Avg. Plant Height (cm)	320	230	280	250
Avg. Ear Height (cm)	260	120	200	140
Avg. 3rd Internode Diameter (mm)	30	20	31	22

*** B73 - 64 days (791 GDU) to pollen shed in 2006**

*** B73 - 65 days (785 GDU) to pollen shed in 2007**

The Germplasm Enhancement of Maize Project (GEM) is a cooperative effort of USDA-ARS, public and private sector scientists to broaden the genetic diversity of maize germplasm.

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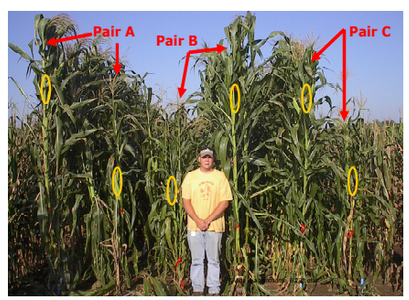

Fig. 6. Ear height and plant height of adjacent control and shaded rows of (A) CUBA164 x T33a; (B) BG002 x T26a; and (C) BR106 x T33a

Table 3. Days to Pollen Shed, Plant Height, Ear Height and Internode Diameter for CUBA164 for 3, 4, 5, and 6 Weeks of Shading Duration in 2007

Planting Date: May 21st	Control	3 Week	4 Week	5 Week	6 Week
Avg. Days to Pollen Shed*	88	84	84	78	72
Avg. GDU to Pollen Shed (Celsius)	1121	1064	1064	971	884
Avg. Plant Height (cm)	280	280	230	260	250
Avg. Ear Height (cm)	200	220	160	180	140
Avg. 3rd Internode Diameter (mm)	31	30	28	26	22

*** B73 - 65 days (785 GDU) to pollen shed; PHB47 - 62 days (744 GDU) to pollen shed**

Fig. 7. Hand pollinated CUBA164

Needs:

- More information is required on a wider array of tropical races to determine how to optimize successful introgression with tropical germplasm in the Midwest.

- Development of an automated photoperiod control system would facilitate introgression and maintenance of exotic germplasm.

Results:

2006: The two shade treatments for six weeks were equally effective in reducing photoperiod response of the genotypes, resulting in an average reduction of 17 days or 254 GDU to pollen shed, from 85 days (1099 GDU) to 68 days (845 GDU) for shaded entries. Shading treatments effectively reduced average plant and ear height by 103 and 98 cm, respectively **(Table 1 and Fig 6)**. Average days to pollen shed of shaded tropical germplasm (mean of seven genotypes) were four days (54 GDU) later than B73, and 21 days (323 GDU) later for un-shaded plants. The targeted inbred shed date, B73, was 64 days (791 GDU) to pollen shed and was four days earlier than CUBA164 in 2006.

2007: The six week shade treatment for CUBA164 reduced the time to pollen shed by 16 days (237 GDU) relative to the unshaded CUBA164 plants **(Table 2)**. This was comparable to the results of 2006. Inbred B73 was seven days earlier than shaded CUBA164 in 2007 but GDU shed was similar to 2006 (791 vs 785 GDU, **Table 2**). Plant height and ear height were reduced 30 cm and 60 cm respectively in 2007, and internode diameter was reduced 9 mm relative to the unshaded control. From 460 shaded plants of CUBA164, 400 crosses were made to B73 and PHB47. Over 200 plants were intermated among the CUBA164 plants to increase seed supply **(Fig 7)**. Days to pollen shed were reduced 4 days, 10 days, and 16 days for the 3 and 4 week, 5 week, and 6 week shading treatments, respectively **(Table 3)**. The greatest reduction in plant height, ear height, and internode diameter was found using six weeks of shading, which matched most closely to B73's flowering maturity date, and sufficiently close to PHB47 flowering date to make crossing possible.

Conclusions:

- Shading for six weeks was effective in reducing photoperiod response in six races of maize. Covering plants for less than six weeks was not as effective in CUBA164 (although this was not determined for other genotypes).
- Covering plants with landscape fabric was equally effective in reducing photoperiod response as using galvanized cans.
- Although stalk diameter was reduced with shading, the reduced plant and ear height facilitated making crosses, and lessened the likelihood of stalk lodging.
- Consistent use of shade structures to control day length for a six week period after germination can facilitate use of exotic germplasm for Midwestern maize introgression programs.

References:

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