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Growth and Productivity of Cotton Grown from Seed Produced Under Four Night Temperatures[1]

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ABSTRACT

The seeds used in this study were produced by growing cotton (*Gossypium hirsutum* L.) plants from first flower through boll maturation in growth chambers where the night temperatures were 11, 15, 21, and 27 C. These seeds were used to evaluate the effect of seed quality on the growth and productivity of matured plants. The cultivars used were 'Acala 1517 Br2,' 'Stoneville 7A,' 'Lankart Sel 57,' 'Stripper 31,' and 'CA 491.' Characters or traits measured were 1) seed weight and percentage of germination of the seed produced in the temperature controlled growth chambers; and 2) rate of seedling emergence, vegetative growth rates, seed cotton per plant, bolls per plant, and production rate index of the plants grown from the seed produced in the chambers.

Low night temperatures during the seed maturation period had a detrimental effect upon seed quality (seed weight and percentage of germination). In field plantings, seedlings from seeds produced under low night temperatures (11 and 15 C) emerged more slowly than those from seeds produced under high night temperatures (21 and 27 C). The plants that developed from seeds produced under low night temperatures (11 C) grew more slowly and were less productive than plants from seeds produced under high night temperatures (21 and 27 C).

Additional index words: Seed quality, *Gossypium hirsutum* L.

PLANTING is one of the most critical and expensive operations in cotton (*Gossypium hirsutum* L.) production. To insure an adequate stand of healthy seedlings, care in the selection of good-quality seeds must be exercised. Seeds of poor quality and vigor may perform poorly even under ideal planting and growing conditions, whereas seeds of high quality and vigor generally perform well even under relatively adverse environmental conditions.

In northern areas of the Cotton Belt, such as the High Plains of Texas, the environmental conditions of some years are not suited to the production of acceptable-quality planting seeds; and in most years, late maturing bolls produce seeds fo poor quality. Gipson (1970) reported that low night temperatures have a detrimental effect on seed development and therefore on seed quality. Seeds produced under low night temperaturs were small in size, low in protein and oil content, and high in free fatty acids. Gipson and Joham (1969) demonstrated that percentage of germination was reduced when seeds were produced under low night temperatures. Evenson (1960) found that seed weight from bolls produced late in the growing season was reduced when compared with the seed weight from bolls produced early in the growing season. Albert (1963) reported that seeds from bolls set in midseason had a higher percentage of germination than seeds from bolls set late in the fruiting season. Peacock and Hawkins (1970) showed that the environment or location in which seeds were produced could affect the seedling vigor, yield, and lint characteristics of the next year's crop. The studies cited above demonstrate that the environmental conditions under which cotton seeds develop affect the ultimate quality of the seed. This study was designed to 1) confirm the effect of night temperatures on seed quality, and 2) evaluate the effect of seed quality on the growth and productivity of cotton.

MATERIALS AND METHODS

Seeds used in this study were obtained from five cultivars that were grown under four controlled night temperatures (Gipson and Joham, 1968): 'Acala 1517 Br2,' 'Stoneville 7A,' 'Lankart Sel. 57,' 'Stripper 31,' and 'CA 491.' These cultivars were chosen because they represented a broad spectrum of cultivar types. Acala 1517 Br2 was bred in New Mexico and is adapted to the western irrigated areas of the Cotton Belt. Stoneville 7A was bred in the Mississippi Delta and has performed well over the entire Cotton Belt. Lankart Sel. 57 and Stripper 31 are best adapted to the High Plains, Rolling Plains, and Blackland production areas of Texas. CA 491 is an early, semidwarf experimental strain.

Thermostatically controlled growth chambers were placed over field plantings of each cultivar during the night and removed during the day (Gipson and Joham, 1968). The night temperature regimes used were 11, 15, 21, and 27C. Seeds produced from each of the cultivars grown under each of the temperature regimes were designated as a treatment-cultivar combination. There were 20 treatment-cultivar combinations.

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Seed weight and percentage of germination were determined on part of the seeds produced under each night temperature; the rest of the seeds were used in field studies. Seed weight was determined by weighing 4 samples of 100 acid-delinted seeds from each treatment-cultivar combination. The percentage of germination was measured on the same four seed samples by standard germination procedures in a laboratory seed germinator. Only fully developed seeds (i..e, seeds that were dark black in appearance and would not crack when pressure was applied by the thumb and forefinger) were used to determine seed weight and percentage of germination. A large percentage of the seeds produced under the lower night temperature (11 and 15 C) was immature and would have been removed in a commercial seed-processing operation.

The treatment-cultivar combinations were planted in the field on May 15, 1972, in a randomized complete-block design with three replications. Twenty-five grams of seed from each treatment-cultivar combination were planted in each replication. A replication consisted of a 10-m row of each treatment-cultivar combination. The rows were spaced 1m apart. After initial plant emergence evaluations, each treatment-cultivar combination was nonselectively thinned to 35 plants/row to eliminate population size as a variable from the experiment.

The nine characters measured were divided into three groups: seed quality traits, growth traits, and productivity traits.

Characters classified as seed quality traits (i.e., seed weight and percentage of germination) were measured on each treatment-cultivar combination before the seeds were planted in the field. Measurements of these seed quality traits not only provided information on the quality of seeds produced by the five cultivars grown under the four night temperatures, but also were used as a reference point for later evaluations.

Characters classified as growth traits were mean emergence date, early growth rate, and late growth rate. The rate of seed emergence from the soil was measured by calculating a mean emergence date (MED). This parameter is an adaptation of the mean maturity date formula devised by Christidis and Harrison (1955). Values were calculated from the following formula:

$$MED = (d_1g_1 + d_2g_2 + \cdots + d_ng_n)/(g_1 + g_2 + \cdots + g_n)$$

where d_n = the nth day from planting and g_n = the number of seeds germinated on the nth day.

The values obtained from this formula are the mean number of days from planting required for the viable seeds of each treatment-cultivar combination to emerge. Early and late growth rates were measured in terms of changes in plant height. This measure of growth has the advantage of being simple and nondestructive. Growth as measured by plant height is usually closely correlated with plant dry weight during the period of vegetative development (Gerard and Cowley, 1969). However, as the plant becomes older, this correlation may become smaller because of the shift in plant development from the vegetative to the reproductive stage. The early growth period was the time from planting until first square (about 30 days). The late growth period was the time from first square until just before the first flower appeared on the early cultivar CA 491.

Characters classified as productivity traits were weight of seed cotton per plant, number of bolls (fruit) per plant, and the production rate index. Seed cotton per plant was determined by hand-harvesting each row and dividing the grams of seed cotton per row by the number of plants per row (35). The number of bolls per plant were counted as the row was harvested. Production rate index (PRI) is a yield-related measure of earliness (Bilbro and Quisenberry, 1973) and is calculated by dividing the grams of seed cotton per plant by a measure of earliness called the mean maturity date (MMD) (Christidis and Harrison, 1955).

RESULTS AND DISCUSSION

Seed Quality Traits. Percentage of germination was not highly associated with seed weight (Table 1). The correlation coefficient (r) of .56 between the treatment-cultivar means for seed weight and percentage of germination was statistically different from zero at the .01 level; however, the coefficient of determination (r^2) indicated that only 31% of the variability in the percentage of germination could be accounted for by seed weight. Seeds produced under 11 C night temperatures were of uniformly poor quality, i.e., low seed weight and low percentage of germination. Seeds producel under 15 C night temperatures varied in quality.

Growth Traits. Rate of seedling emergence was measured by the mean emergence date (MED) (Table 2). Seedlings from seeds produced under 11 C night

Table 1. Effects of four night temperature regimes on seed weight and percentage of germination for five cotton cultivars.

Character	Seed development temp., C	Cultivars					Temp., Avg.
		Acala 1517 Br2	Stoneville 7A	Lankart 57	Stripper 31	CA 491	
Seed weight, mg/seed	11	98	78	98	84	78	87 c*
	15	108	83	107	87	96	98 b
	21	121	95	117	98	91	104 a
	27	115	85	118	88	87	97 b
	Var. Avg.	111 a	85 b	110 a	89 b	88 b	
Germination, %	11	28.0	10.0	28.5	20.0	12.5	19.8 c
	15	82.5	40.0	93.5	70.0	85.0	74.2 b
	21	85.0	96.5	96.5	100.0	85.0	92.6 a
	27	93.5	95.0	98.5	90.0	85.0	92.4 a
	Var. Avg.	72.3 ab	60.4 c	79.3 a	70.0 abc	66.9 bc	

* Averages followed by a common letter were not statistically different at the .05 level according to Duncan's Multiple Range Test. Comparisons were made only within rows or within columns.

Table 2. Emergence rate, growth rate from planting to first square (early growth rate), and growth rate from first square to first flower (late growth rate) of the treatment-cultivar combinations.

Character	Seed development temp., C	Cultivars					Temp., Avg.
		Acala 1517 Br2	Stoneville 7A	Lankart 57	Stripper 31	CA 491	
Mean emergence date, days	11	9.9	9.9	10.2	9.0	11.5	10.1 c*
	15	8.8	9.7	8.8	8.5	8.7	8.9 b
	21	8.2	8.6	8.3	8.4	8.1	8.2 a
	27	8.2	8.1	8.3	7.9	8.1	8.2 a
	Var. Avg.	8.8 ab	9.1 b	8.9 ab	8.5 a	9.1 b	
Early growth rate, cm/day	11	.32	.21	.25	.27	.20	.25 b
	15	.37	.25	.26	.26	.31	.29 a
	21	.37	.29	.26	.31	.29	.30 a
	27	.37	.28	.26	.31	.30	.30 a
	Var. Avg.	.35 a	.26 b	.26 b	.28 b	.28 b	
Late growth rate, cm/day	11	.97	.95	.99	1.10	.70	.94
	15	1.31	1.01	.80	.97	1.02	1.02
	21	1.02	1.05	.84	.88	1.02	.96
	27	.98	1.11	.85	.95	.96	.96
	Var. Avg.	1.05 a	1.03 a	.87 b	.97 a	.93 ab	

* Averages followed by a common letter were not statistically different at the .05 level according to Duncan's Multiple Range Test. Comparisons were made only within rows or within columns.

Table 3. Productivity of cotton plants from the treatment-cultivar combinations.

Characters	Seed development temp., C	Cultivars: Acala 1517 Br2	Stoneville 7A	Lankart 57	Stripper 31	CA 491	Temp., Avg.
Seed cotton, g/plant	11	50	33	32	39	27	36 b*
	15	61	44	36	56	39	47 a
	21	52	52	35	67	44	50 a
	27	58	43	36	50	49	47 a
	Var. Avg.	55 a	43 b	35 b	53 a	40 b	
Bolls, #/plant	11	9.1	7.3	7.1	9.9	6.6	8.0 b
	15	9.2	10.6	6.2	13.7	7.6	9.5 a
	21	8.8	13.4	5.9	16.2	9.9	10.9 a
	27	10.5	9.8	6.5	12.4	10.1	9.9 a
	Var. Avg.	9.4 bc	10.3 b	6.4 d	13.1 a	8.6 c	
Production rate index, g seed cotton/ plant per day	11	.291	.193	.195	.236	.168	.217 b
	15	.365	.259	.203	.339	.267	.287 a
	21	.303	.298	.207	.419	.281	.302 a
	27	.345	.267	.221	.309	.315	.291 a
	Var. Avg.	.326 a	.254 b	.207 c	.326 a	.258 b	

* Averages followed by a common letter were not statistically different at the .05 level according to Duncan's Multiple Range Test. Comparisons were made only within rows or within columns.

temperatures emerged more slowly than those from seeds produced under 15 C night temperatures. In turn, seedlings from seeds produced under 15 C temperatures emerged more slowly than seeds produced under the higher night temperatures of 21 and 27 C.

Plant growth rates from planting until first square (early growth rate) showed that poor-quality seeds produced seedlings with poor vigor and growth (Table 2). Seedlings from seeds produced under 11 C night temperatures had a slow growth rate from emergence to first square; however, seedlings from seeds produced under 15, 21, and 27 C night temperatures were not statistically different in early growth rates. Seedlings from seeds produced under 15 C night temperatures emerged at a slower rate and had a lower overall percentage of germination than seeds produced under 21 and 27 C; however, those seedlings that did emerge in the 15 C treatment-cultivar combination had enough seedling vigor to match the growth rates obtained by the seedlings from seed produced under the higher temperatures.

Plant growth from first square to just before first flower (late growth rate) revealed that the temperature during seed development did not significantly affect the rate of growth (Table 2). During this period of growth, plants from the poor-quality seeds grew at the same rate as those from better quality seeds. However, because of their slow growth during the initial growth stages, plants from seeds produced under 11 C night temperatures were still smaller and less developed than plants from seeds produced under more favorable night temperatures.

Productivity Traits. Productivity of the treatment-cultivar combinations was evaluated by the measurement of three characters: yield of seed cotton per plant, boll number per plant, and production rate index. Each of these characters was affected by seed quality (Table 3). In all cultivars, the yield of seed cotton per plant was sigificantly less from plants grown from seed produced under 11 C night temperatures. Plants grown from seeds produced under the 11 C night temperatures had the least number of bolls per plant. Production rate index is a function of both yield and earliness of maturity. The highest yielding cultivars, Stripper 31 and Acala 1517 Br2, had the highest production rate index. Although CA 491 produced less seed cotton per plant than Stoneville 7A, it had a higher production rate index as a result of its extreme earliness. Thus, in terms of productivity, plants that developed from seeds produced under 11 C night temperatures were less productive than plants that developed from seeds produced under higher night temperatures.

Decreases in the productivity of cotton plants due to the use of planting seeds produced under low night temperatures have not been previously reported. Although the night temperature regimes were artificially imposed, the results from this study suggest that yield can be increased by the production of planting seeds under favorable night temperatures. The average minimum temperature at Lubbock, Texas, during September is 14 C; October, 9 C; and November, 2 C (Bilbro 1967). On the High Plains of Texas, very few seeds have completed their maturation before the onset of the adverse low minimum temperatures of September, October, and November. Therefore, it would seem that earliness of crop maturity should be of prime importance in the production of cotton planting seeds in areas where the night temperatures during the seed maturation period drop below 15 C.

REFERENCES

Albert, W. B. 1963. The effect of recommended herbicides and defoliation practices upon cottonseed germination. Cotton Def. Physiol. Conf., Proc. 17:24-30.

Bilbro, J. D. 1967. Application of rainfall and temperature probabilities to cotton production — Texas High Plains. Tex. Agr. Exp. Sta. Misc. Publ. 847.

———, and J. E. Quisenberry. 1973. A yield-related measure of earliness for cotton, *Gossypium hirsutum* L. Crop Sci. 13: 392-393.

Christidis, B. G., and G. J. Harrison. 1955. Cotton growing problems. McGraw-Hill Book Co., Inc., New York.

Evenson, J. P. 1960. Intraseasonal variation in boll characters in African Upland Cotton. Cotton Grow. Rev. 37:161-177.

Gerard, C. J., and W. R. Cowley. 1969. Interrelationships of growth and fruiting characteristics of cotton. Agron. J. 61: 966-967.

Gipson, J. R. 1970. Temperature-variety interrelationships in cotton. II. Seed development and composition. Cotton Grow. Rev. 47:264-271.

———, and H. E. Joham. 1968. The influence of night temperatures on growth and development of cotton (*Gossypium hirsutum* L.). I. Fruiting and boll development. Agron. J. 60:292-295.

Peacock, H. A., and B. S. Hawkins. 1970. Effect of seed source on seedling vigor, yield, and lint characters of Upland Cotton, *Gossypium hirsutum* L. Crop Sci. 10:667-670.