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A YIELD-RELATED MEASURE OF EARLINESS FOR COTTON, *GOSSYPIUM HIRSUTUM* L.[1]

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ABSTRACT

We propose a Production Rate Index (PRI) as a means of expressing crop maturity, or earliness for cotton (*Gossypium hirsutum* L.). The PRI values are judged to be generally more suitable than MMD values for earliness measures because they are yield-related; they express a production rate (i.e., amount produced per unit time). An example is given that compares the two measures applied to actual data.

Additional index words: **Crop maturity, Cotton breeding, Mean maturity date, Production rate index.**

THE attainment of earliness of crop maturity and high lint yield has been a primary research objective of cotton (*Gossypium hirsutum* L.) breeders and agronomists. Earliness of crop maturity is important in the avoidance of frost damage, insect and disease buildups, soil moisture depletion, and weathering of the open cotton. Yields are of paramount importance if the crop is to be competitive.

Yield determination is a straightforward technique. On the other hand, an evaluation of the earliness of maturity can be made by any one of several methods. Richmond and Radwan (3) made a comparative study of seven methods of measuring earliness. Three of the measurements were based on the number of days from planting to the date of a specific phenological event (i.e., date of first square, first bloom, and first open boll). The other four measurements were based on the ratios of various fractions of the crop yield to the total crop yield. Richmond and Radwan concluded that of the seven methods used, the most practical was the combined weights of the first and second pickings expressed as a percentage of the total seedcotton harvested.

Richmond and Ray (4) compared three product-quantity measurements of earliness: amount of crop harvested (ACH); percentage of crop harvested (PCH); and mean maturity date (MMD). They pointed out that the ACH or PCH measurements were more effective than MMD when the major consideration was maximum yield in minimum time; and of the two, ACH appeared to be the most desirable. They also noted the importance of the date or period upon which the calculations were based. On the other hand, MMD was considered to be the most discriminating and reliable of the three measurements when earliness, without regard to yield, was the prime objective. The MMD estimate used data from the entire crop maturity period, whereas PCH and ACH estimates used data from a single period.

For some types of studies, one or more of the above methods is probably adequate for estimating earliness. However, we believe that in most breeding and testing programs a simple, yield-related method of estimating earliness would be more useful. In this paper we present such a method and discuss its application.

MATERIALS AND METHODS

To illustrate the method we used data from an experiment conducted in 1961. The field plot layout was a split plot design replicated four times. Specifically, the treatments were as follows:

i) Irrigation regimes (main plots): one irrigation applied on May 18; and one irrigation applied on May 18, August 8, and August 24.

ii) Planting dates (sub-plots): April 27, and June 9.

iii) Cultivars (sub-sub-plots): 'Acala 1517BR-1'; 'Gregg'; 'Lankart Selection 57'; and 'M 8' (doubled haploid of Deltapine 14).

The cultivar plots were eight rows wide (1 m between rows) and 10.7 m long. The stands were thinned to a spacing of 15 cm between plants. Beginning on September 26, all mature bolls from one row of each plot planted on April 27 were hand harvested at approximately 1- or 2-week intervals until all bolls had been harvested. Beginning on October 24, the same procedure was used for each plot planted on June 9. Plots planted on April 27 were harvested eight times, and plots planted on June 9 were harvested four times. The seedcotton was ginned and the lint weights were recorded.

Two rows of each plot were harvested with a mechanical stripper harvester to provide yield estimates. Each harvested sample was weighed and a 1,000-g subsample taken. The subsamples were ginned, the lint percentages were determined, and the lint yields per plot were calculated and converted to kg/ha.

The mean maturity date (MMD) for each plot was calculated from the lint weights obtained from the periodic harvests. The procedure used is the one given by Christidis and Harrison (1) which may be generalized as follows:

$$\mathrm{MMD} = \frac{(W_1 H_1) + (W_2 H_2) + \ldots (W_n H_n)}{W_1 + W_2 + \ldots W_n} \quad [1]$$

where W = weight of lint (weight of seedcotton or number of open bolls can also be used); H = number of days from planting to the harvest (Christidis and Harrison used the number of days from an arbitrary base date to the harvest); and 1, 2, . . . n = consecutive periodic harvest numbers.

The total lint weight (in kg/ha) obtained from the two stripper-harvested rows was divided by the MMD values calculated from the periodic hand harvests of the adjacent row of the same plot. Because the MMD value is a relative maturity period in "days," dividing the total yield by this value results in a relative production rate (i.e., amount per unit time), which we term a Production Rate Index (PRI) value. A general formula for this value would be:

$$\mathrm{PRI} = \frac{\text{Total plot weight}}{\mathrm{MMD}} \quad [2]$$

In cases when the total yield and MMD values are calculated from hand harvests of the same group of plants (on the same plot area), the formula becomes:

$$\mathrm{PRI} = \frac{(W_1 + W_2 + \ldots W_n)^2}{(W_1 H_1) + (W_2 H_2) + \ldots (W_n H_n)} \quad [3]$$

where W = weight of lint in kg/ha; H = number of days from planting to the harvest; and 1, 2, . . . n = consecutive periodic harvest numbers.

The lint yields, MMD, and PRI values were analyzed statistically and the averages separated by the Multiple Range Test (2).

RESULTS AND DISCUSSION

The cultivar MMD ranking from earliest to latest was Gregg, Acala 1517BR-1, M 8, and Lankart Selection 57 in every treatment except that planted on June 9 (Table 1). The ranking for earliness was significantly altered, however, if yield is taken into ac-

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Table 1. Lint yields, mean maturity dates (MMD), and Production Rate Indices (PRI) for four cultivars.

Cultivar	Yield, kg/ha	MMD, days	PRI, kg/ha/day	Yield, kg/ha	MMD, days	PRI, kg/ha/day
	One irrigation on May 18†			Three irrigations on May 18, Aug 8, and Aug 24†		
Acala 1517BR-1	658 ab*	164.6 b	4.0 b	759 b	174.5 b	4.3 b
Gregg	741 a	159.2 a	4.6 a	872 a	170.4 a	5.1 a
Lankart Sel. 57	733 a	169.1 c	4.3 ab	727 b	180.3 c	4.0 b
M 8	629 b	167.3 bc	3.8 b	700 b	179.6 c	3.9 b
Avg	690	165.0	4.2	764	176.2	4.3
	Planted on April 27‡			Planted on June 9‡		
Acala 1517BR-1	833 ab	176.4 b	4.7 ab	584 b	162.7 a	3.6 b
Gregg	860 ab	170.2 a	5.0 a	753 a	159.3 a	4.7 a
Lankart Sel. 57	881 a	183.1 c	4.8 ab	579 b	166.3 b	3.5 b
M 8	776 b	179.4 b	4.3 b	553 b	167.4 b	3.3 b
Avg	838	177.3	4.7	617	164.0	3.8
	Averages for all treatments					
Acala 1517BR-1	709 b	169.5 b	4.2 b			
Gregg	806 a	164.8 a	4.9 a			
Lankart Sel. 57	730 b	174.7 c	4.2 b			
M 8	665 b	173.4 c	3.8 b			
Avg	727	170.6	4.2			

* Any averages, within a column, followed by the same letter are not significantly different at the 0.05 level. † Average of planting dates. ‡ Average of irrigation regimes.

count in the earliness measure (PRI values). Gregg had the highest PRI (i.e., was the earliest) in every treatment and M 8 had the lowest.

An example of the advantage of using PRI instead of MMD in assessing earliness can be seen in the cultivar averages (Table 1). The yields of Acala 1517BR-1 and Lankart Selection 57 were not significantly different but the mean maturity dates indicated that Lankart Selection 57 matured later than Acala 1517BR-1. However, the PRI values indicate that Lankart Selection 57 was as early as Acala 1517BR-1 when yields and earliness were combined into a single earliness index. That is, Lankart Selection 57 produced lint at a rate equal to that of Acala 1517BR-1.

The PRI method for measuring earliness should be a valuable tool to plant breeders and agronomists in advanced breeding and testing programs. In the initial stages of cultivar development, independent estimates of yield and earliness of crop maturity are important selection criteria. However, as cultivar development enters the advanced stages, independent estimates of yield and earliness become less important than the interrelationship of yield and earliness. For example, a strain could be early in maturity but deficient in yield potential, or a strain could have a high yield potential but insufficient earliness to achieve this potential. PRI takes into account both yield and earliness of maturity. Therefore, it should be very useful for identifying those strains and cultivars that have superior combinations of yield and earliness characteristics.

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INTERACTION OF TWO BASIC COLOR FACTOR GENES IN ALFALFA[1]

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ABSTRACT

A basic color factor gene C_1 in diploid alfalfa (*Medicago sativa* L.) (S-2128) was found to be nonallelic with the basic color factor gene C_2 in tetraploid alfalfa. The tetraploid recessive c_2 was transferred down to diploid level by haploidy, and the diploid recessive c_1 was transferred up to the tetraploid via 2n gametes. Both genes produced monohybrid segregation ratios of about 3:1 at the diploid level and tetrasomic ratios of about 35:1 in the tetraploid. The dihybrid F_2 segregation of both genes at the diploid level was about 9:7, indicating recessive epistasis. The homozygous recessive condition of either c_1 or c_2 produces a white flowered, white seeded phenotype. Additional research is needed to determine the independence or linkage of the two genes. The genetic stocks were made available for this and other research.

Additional index words: ***Medicago sativa*, Genetics, Chromosome, Haploid, Gamete.**

PRODUCTION of anthocyanins in tetraploid alfalfa (*Medicago sativa* L.) is known to require the dominant allele of a basic color factor gene C plus a dominant allele of a pigment locus P (1, 2, 6, 7). Plants which are homozygous for the recessive allele c cannot synthesize anthocyanin, even in the presence of P, and have white flowers and seeds and green hypocotyls and stems.

Studies in diploid alfalfa have been carried out utilizing a line which produces a phenotype identical to the tetraploid factor and assumed to be the same gene (1, 5). The diploid stock (S-2128) originated from J. L. Bolton, Saskatchewan, Canada. This paper reports the finding that the diploid basic color factor gene from S-2128 is nonallelic to the common tetraploid gene. The diploid gene was transferred to the tetraploid level, and the tetraploid transferred to the diploid level. Interaction of the two basic color factor genes is reported in this paper at both ploidy levels.

Two different diploid basic color factors were previously reported in a biochemical study identifying the pigments controlled by each of the major flower color genes (6). One of the factors was from S-2128. The establishment of genetic symbols for the gene from S-2128 and the common tetraploid gene is another objective of this paper.

MATERIALS AND METHODS

Diploid stock descending from S-2128 was obtained in 1964 from Wm. M. Clement, Jr., University of Minnesota (at Vanderbilt University, Nashville, Tenn.) who earlier received it from J. L. Bolton, University of Saskatoon, Saskatchewan, Canada. Tetraploid stocks carrying the common tetraploid basic color factor in the recessive condition were obtained from cultivars as discussed in the text, and a stock was also obtained from Clement who originally obtained it from E. H. Stanford, University of California, Davis. When homozygous recessive white stocks were crossed with purple stocks at either ploidy level, the purples were known from previous test crosses to be homozygous dominant for the basic color factor loci and for the P locus. All crosses and classification of seedlings by hypcotyl pigmentation

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