NEW TOOLS FOR CHOOSING COTTON VARIETIES

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Abstract

Choosing the best cotton variety for a given situation can be highly beneficial to a cotton producer, but identifying that variety can be a difficult task. Since there is no one perfect variety, a producer must establish specific priorities for each situation and identify the variety that best meets those priorities. A variety that produces stable, high yields and premium fiber quality are most desired. Several tools can be used to assist with identifying such varieties are available. Accuracy of identifying stable, high yielding varieties increases as the number of test sites (locations and years) of variety test data increases. Adequate amount of data to determine stability is usually not available for newly released varieties. Use of yield components, particularly fiber density, may assist with developing and identifying stable, high yielding varieties. Stability may also be increased by improvement of host plant resistance traits. Q-score combines weighted data for four cotton quality parameters into one easy to use index. Q-score may help to identify varieties that combine high yields and high fiber quality. COTVAR is an online computer program, which assists with comparing data for varieties from different state variety tests. Combinations of these tools should assist producers to identify the varieties, which best meets their specific priorities.

Introduction

When choosing a cotton variety, producers usually will first determine whether and which transgenes are desired. Thereafter, they primarily desire to have a variety that can be expected to produce stable, high yields of high quality cotton. Within specified technologies, seed costs of different cotton varieties are relatively equal. However, performance and adaptation of the varieties may vary greatly. Therefore, choosing the optimum variety for a given situation can pay large dividends while choosing a poor variety can result in disaster. The number of available cotton varieties has greatly increased over the past 10 years. This increase has made it more difficult to characterize and determine which is the best variety for any given situation. Four specific concepts / tools that may assist with choosing cotton varieties will be discussed.

Identifying Stable, High Yielding Varieties

It is easy to find cotton varieties that produce stable yields, but it is difficult to find ones that produce stable, high yields. Comparison of varieties based on yield data at one location in one year simply indicates their relative performance in that one environment. Since that specific environment may never occur again, such data provide little information on yield stability. Varieties that produce the highest mean yields over a wide range of environments may be considered to be the most stable. Evaluation over multiple locations within a year may not provide a wide range of environments since weather tends to be relatively similar over locations within a year. Such environmental trends are particularly true for temperatures experienced during the growing season. Also, information on specific adaptation is lost when data for multiple locations are combined. Evaluation over multiple years at a location can provide good information on specific adaptation, but new varieties are excluded as years of testing increases. With the current rapid turnover of varieties, new varieties are often marketed with less than three years of yield data within a region. Insight on yield stability of these varieties is limited.

When estimating yield stability, increased number of years of testing may be offset to some extent by increased number of locations within a year – as long as the locations provide some contrasts. Various regression techniques can be used to identify stable yielding varieties. One method is to regress the stability standard deviation (square root of variance associated with genotype by environment interaction) for a variety by mean of variety over locations (McNew et al, 2005). Stable, high yield varieties are ones having high average yields and low stability standard deviations. Disadvantages of this approach are that statistical expertise is needed, a large number of test sites is required, stability is only measured with respect to other varieties in the analysis, and the final result is not a single number indicator of stability.

Use of yield components is another approach to identifying stable, high yielding varieties. Lewis et al. (2000) indicated that cotton yield is simply a product of weight of lint per seed times the number of seed per acre. They proposed that yield stability might be increased by growing varieties that proportionately depended more on increased lint per seed to increase yield rather than increased number of seed per acre. The logic of this approach is that the plant requires less energy to produce fiber than to produce seed.

Lint index (weight of lint per 100 seed) provides a measure of lint per seed. Varieties with large seed (high seed index) tend to have high lint index. Therefore, selecting for high lint index will likely result in high seed index. In contrast, selection for high lint percentage tends to lead to lower seed index. Both extremes in seed size are related to negative agronomic and/or ginning properties. Attempts are being made to identify lines with high lint index within standardized seed size. Initially, we simply selected lines having high lint index and a medium sized seed. To focus on just one variable, we are now selecting for higher "fiber density", where fiber density is defined as the number of fiber per unit area of seed surface. Fiber density is very similar to the parameters "lint frequency index" and "lint density index", which were sometimes used in breeding programs 50-60 years ago (Breaux, 1954; Thurman, 1953).

In the 2007 Arkansas Main Cotton Variety Test, high yielding varieties tended to have higher fiber density than low yielding varieties (Table 1). However, significant variation in fiber density was found among the highest and lowest yielding varieties. Additional work is underway to confirm the value of fiber density for identifying stable, high yielding varieties. If this relation is confirmed, we will suggest that producers give priority to varieties that produce the high yields and high fiber density. Among the top varieties that do not differ significantly in lint yields, the producer would then pick the one with the highest fiber density. In the example in Table 1, DP454 BG/RR meet these criteria. All data from the Arkansas Cotton Variety Tests are available at www.ArkansasVarietyTesting.org.

Table 1. Lint yield and fiber density for varieties with highest and lowest four lint yields across locations in the 2007 Arkansas Cotton Variety Test (37 entries).

Variety	Lint yield	Rank	Fiber density	Rank
	lb/a		no./mm^2	
PHY 370 WR	1473	1	28.7	8
DP 454 BG/RR	1444	2	34.5	1
DP 515 BG/RR	1435	3	29.8	4
PHY 310 R	1415	4	29.2	6
CG 3020 B2RF	1232	34	28.3	13
CG 4020 B2RF	1227	35	26.6	23
FM 9063 B2F	1175	36	24.8	32
FM 955 B2LL	1170	37	21.6	37
LSD 0.10	87		1.4	

Increasing Yield Stability with Host Plant Resistance Traits

Varieties having enhanced host plant resistance should also have improved yield stability. The ability to resist damage from multiple pests permits a variety to express its agronomic ability over a wider range of conditions. Due to the widespread use of Bt cottons and the advance of the Boll Weevil Eradication Program, tarnished plant bug (TBP) has become the most severe insect pest in many areas. Populations of TPB have also been exasperated by the increase in corn acreage. None of the present transgenes provide any control of TPB. Jenkins and Wilson (1996) reviewed articles indicating the absence of nectaries on leaves and flowers confer resistance to TPB. Despite considerable effort by numerous cotton breeders, limited success in developing well-adapted, nectariless varieties has been achieved.

Maredia et al. (1994) developed a simple method for screening germplasm for resistance to TPB. Their method involving slicing squares and examining anthers for TPB damage. Without boll weevils present, this method can be modified to examining anther damage in white flowers. In tests at Keiser, AR, we evaluate varieties and breeding lines for resistance to TPB in a field, which is managed to encourage high populations of TPB. A Frego bract line is used as a susceptible check. In small, one-row plots, about 50 white flowers over a two-week period are examined for darkening of anthers ("dirty blooms"). Sampling is initiated when a considerable proportion of Frego flowers are expressing damage. An accumulate (over sample days) percentage of "dirty blooms" is then calculated. In 2007, all varieties had significantly less "dirty blooms" than the susceptible check (Table 2). Significant variation in "dirty blooms" was found among normal-bract varieties, and this measure appeared to be relatively independent to yield in the variety test. Work is now underway with entomologists to determine how best to utilize this level of resistance.

Table 2. Tarnished plant bug damage expressed as percentage "dirty blooms" and lint yield (across locations) for varieties with highest and lowest four damage in the 2007 Arkansas Cotton Variety Test (37 entries).

Variety	"Dirty blooms"	Rank	Lint yield	Rank
	%		lb/a	
ST 4664 RF	35	1	1372	13
ST 5327 B2RF	35	2	1261	29
ST 5283 RF	35	3	1316	21
DP 454 BG/RR	38	4	1444	2
DP 147 RF	46	34	1360	16
DP 515 BG/RR	46	35	1435	3
FM 1600 LL	47	36	1415	5
PHY 310 R	48	37	1418	4
Frego, sus check	85	-		
LSD 0.10	6		87	

Cotton breeders have had varying degrees of success in improving resistance of cotton varieties to diseases. Most varieties express some degree of resistance to Verticillium wilt and Fusarium wilt. Degrees of resistance to bacterial blight and root-knot nematode are available and have been incorporated into some varieties.

Identifying High Quality Cotton

High quality cotton is sometimes defined as cotton that receives premium (or non-penalty) loan values. However, the increase proportion of U.S. cotton that is exported has caused high quality cotton to be redefined. To meet the changing demand, we have developed Q-score, an index for cotton quality (Jones et al., 2007). Q-score incorporates weighted values of four HVI fiber parameters: length, micronaire, length uniformity, and strength. These four parameters are normally measured in variety tests. Q-score may vary from 0 to 100, with higher scores equal to better quality.

Data from both 2006 and 2007 demonstrates that Q-score and lint yield tend to be inversely related (Tables 3 and 4). This dilemma has long existed in cotton varieties. It is difficult to breed varieties that possess high yielding ability and high fiber quality. Q-score may assist with this effort. Since Q-score defines quality with one number, it should be easier to develop varieties that combine yield and quality.

Table 3. Q-score and lint yield across locations for varieties with highest and lowest four Q-score ratings in the 2006 Arkansas Cotton Variety Test (26 entries).

Variety	Q-score	Rank	Lint yield	Rank
			lb/a	
FM 955 B2LL	80	1	930	1
FM 958 LL	78	2	1034	2
FM 965 B2LL	75	3	919	3
DP 434 RR	73	4	1158	4
DP 454 BG/RR	50	34	1320	23
ST 5599 BR	50	35	1289	24
PHY 310 R	47	36	1273	25
PHY 370 WR	47	37	1276	26
LSD 0.10	6		89	

Table 4. Q-score and lint yield across locations for varieties with highest and lowest Q-score ratings in the 2007 Arkansas Cotton Variety Test (37 entries).

Variety	Q-score	Rank	Lint yield	Rank
			lb/a	
FM 9063 B2F	81	1	1175	36
DP 167 RF	79	2	1325	19
DP 143 B2RF	77	3	1255	30
FM 958 LL	76	4	1291	25
DP 454 BG/RR	46	33	1444	2
DP 515 BG/RR	46	33	1435	3
PHY 310 R	45	35	1418	4
DG 2490 B2RF	44	36	1274	26
PHY 370 WR	43	37	1473	1
LSD 0.10	6		87	

Q-score does not include any consideration of trash or color. Trash is usually not measured in samples from variety tests because the samples are often hand-picked and/or ginned on small gins without lint cleaners. Color is primarily determined by field conditions between boll opening and harvest, and thus has little genetic control. Low pubescence levels on cotton leaves have been associated with improved seedcotton cleaning efficiency and low foreign matter levels in harvested lint, and thus higher leaf grades in ginned cotton (Novick et al., 1991). Morey et al. (1976) found that bracts are a major contributor to leaf trash in harvested cotton. This seems reasonable since bracts are in closer proximity than leaves to the cotton fibers on the plant and most leaves are removed from the plant prior to harvest if defoliation is successful. Bract tissue has also been implicated as a causative agent in byssinosis, a lung disease of cotton mill workers (Ayer, 1971).

Bourland and Hornbeck (2007) developed sampling procedures and examined a wide array of Upland cotton varieties and breeding lines and found that all had hairs on the margins of bracts. As demonstrated with data from the 2007 Arkansas Variety Test, marginal bract trichome density tends to be higher in hairy leaf than smooth leaf varieties (Table 5). Also, significant variation in bract trichome density was found among the most hairy and among the most smooth leaf varieties. In this test, leaf pubescence was quantified from 1 as being smooth leaf and 7 as being very hairy (Bourland et al., 2003). With this variation, hairy leaf varieties with low density of marginal bract trichomes may be identified.

Table 5. Leaf pubescence (Bourland et al, 2003) and marginal bract trichome density for varieties with highest and lowest four leaf pubescence in the 2007 Arkansas Cotton Variety Test (37 entries).

Variety	Leaf pubes.	Rank	Bract trichome	Rank
			no./cm	
DP 117 B2RF	6.6	1	53	2
DP 454 BG/RR	6.6	2	47	5
PHY 425 RF	6.3	3	43	9
PHY 480 WR	6.1	4	45	7
PHY 485 WRF	5.9	5	57	1
DP 167 RF	1.6	33	28	35
DP 434 RR	1.5	34	47	5
FM 9068 F	1.5	35	35	29
FM 1600 LL	1.4	36	24	37
DP 455 BG/RR	1.3	37	33	33
LSD 0.10	1.1		6	

Comparing Varieties with COTVAR

Cotton varieties are annually evaluated in most states that grow cotton. Data from most of these tests are available as hardcopies and/or online at sites established by each state. Links to these online sites have been established on the Cotton Incorporated website http://www.cottoninc.com/AgriculturalResearch/StateVarietyTrialData/?S=A. COTVAR was developed as an online program to assist with summarizing data from state cotton variety tests. COTVAR is a supplement of variety test publications, which : 1) provides maintenance and updates of variety names and status, 2) permits fast and easy access to data, 3) summarizes data over specified locations, and 4) establishes uniform data presentation (Bourland and Jones, 2007). COTVAR became available online at http://cotvar.uaex.edu/intro.asp, in February 2007. Changes to the program are being made as needed and the program is presently being expanded to include data from state cotton variety tests in other states.

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