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Comparison of Obsolete and Modern Varieties in View to Stagnancy in Yield of Cotton (*G. hirsutum* L.)

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Abstract: A trial was conducted at Cotton Research Station, Multan for three years (2001 to 2003) to compare developmental characteristics, quality traits, yield and its components among thirty two obsolete and modern varieties of Upland cotton (*Gossypium hirsutum* L). To verify the experimental results, historical data (1986 to 2003) of seed cotton yield, GOT and Staple length of top three high yielding lines was collected from National Coordinated Varietal Trials (NCVT) conducted in Multan region. Significant differences among varieties for node of first fruiting branch, monopodial branches per plant, days taken to first flower and ginning out turn percentage were exhibited. NCVT data showed that among varieties recommended for general cultivation since 1986, variety S-12 showed highest seed cotton yield and ginning outturn (40.5%). The cultivar CIM499 has highest staple length (29.8 mm). From the study, it was concluded that cotton breeders have improved earliness (node of first fruiting branch, monopodial branches per plant, days taken to first flower), lint percentage but improvement in seed cotton yield, yield components and staple length is still needed.

Key words: Cotton, stagnancy, yield, quality characteristics

INTRODUCTION

Cotton is the most important textile fiber crop that accounts for 60% of total foreign exchange earnings. Cotton is not only an export earning crop but it also provides raw material to the local textile industry, the surplus lint is exported. Pakistan ranks fourth in area and production of cotton in world. Pakistan has 9.36% of total world cotton area, 10.18% of production, 8.06% of consumption and 4.5% of total world export of raw cotton[1]. Cotton has been modified over many decades of breeding and selection in an effort to ultimately improve yield. Continued efforts of breeders have resulted in development of cultivars differing in fruit load. However, it is the retention of fruit that is essential for optimum yield and profit. The varieties, which not only produce the highest number of bolls, but are most likely to retain those bolls till maturity would be of great benefit.

Cotton plants grow with a monopodial vegetative, main stem and lateral monopodial and sympodial fruiting branches. In an effort to domesticate cotton plant from perennial to annual, plant breeders have selected for reduced number of lateral monopodial branches that are formed before sympodial fruiting branches, resulting in an earlier onset of flowering[2]. Thus yield potential has been defined as the yield of a cultivar when grown in environments to which it is adopted, with nutrients and water non-limiting and with pests, diseases, weeds, lodging and other stresses effectively controlled[3]. Yield refers to the mass of products at final harvest, for which dry matter content should be specified. The method of harvesting can be important in estimates of genetic progress[4].

Modern cultivars have a greater proportion of their reproductive development at an earlier stage. This results in a greater amount of reproductive growth occurring when maximal leaf area and mass are present. These cultivars also generally produce a greater amount of smaller bolls with a higher lint percentage[5].

According to Jones *et al.*[6], mature cotton plants often exhibited altered fruiting patterns due to the abscission of fruiting forms caused by stress or insect damage during reproductive development. Guinn[7] stated that insect feeding can cause serious losses of yield by interfering with plant growth. This is due to leaf malformation or abscission, increased shedding of squares and bolls, damaged seed and lint, or by a combination of both. The stimulus for square and boll shedding may be either direct or indirect. A direct stimulus is one in which there is feeding on the square or boll. For example, whitefly, Jassid, thrips feed on leaves squares while spotted boll worm, Helliothus and Pectinophora feed on buds and bolls which lead to decrease in yield and quality. An indirect stimulus

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includes a physiological withdrawal of nutrients from leaves, petioles, or a loss of leaf area due to malformation or abscission.

Guinn[7] indicated that the location or position of squares and bolls on the plant also has a pronounced effect upon their retention. Squares present on the first fruiting branch, which is typically shorter than the next one, have a lower possibility of being retained to the mature boll stage. Retention is usually high at the first node and decreases at successive lateral nodes out on the fruiting branch.

The objective of this study was to compare the annual yield data collected from Cotton Research Station, Multan to determine whether cotton has experienced significant yield increases in the recent past with earliness, fiber quality and GOT%.

MATERIALS AND METHODS

The experiment was conducted in 2001, 2002 and 2003 at Cotton Research Station, Multan. The genetic material comprised of thirty-two varieties of upland cotton (*Gossypium hirsutum* L.) viz., 362F, 4F, S-14, CIM-446, MNH-552, MNH-554, FH-634, CIM-1100, MS-240, S-12, NIAB-Karishma, MNH-93, NIAB-78, CIM-448, FH-682, CIM-443, FH-900, B-557, MNH-329, SLS-1, CIM-109, MNH-147, FH-1000, 149-F, AC-134, CIM-70, FH-901, Rehmani, CIM-240, CIM-473, BH-118 and CIM-499. The design of the experiment was Randomized Complete Block Design with three replications. The sowing was done by dibbling three seeds per hill to ensure uniform stand, latter thinned to one plant per hill. Each experimental plot comprised of three row of 3.3 m length and with 30 cm plant to plant distance. The row to row distance was kept 75 cm. The inputs such as water, fertilizer and pest control were applied in optimum quantity and time. Crop growth and development measurements were taken throughout season.

Ginning of individual plant was carried out in laboratory, by roller machine and data was recorded for GOT percentage and staple length.

The data collected were subjected to statistical analysis[8].

Historical data for seed cotton yield, GOT and staple length of top three high yielding varieties was collected from National Coordinated Varietal Trial (NCVT) conducted in Multan region at seven locations during the years 1986 to 2003. The mean values of seven locations were used for comparison.

RESULTS AND DISCUSSION

Analysis of variance for Node of First Fruiting Branch (NFBr), Monopodial branches per Plant (MP), Days taken to First Flower (DFF), Seed cotton yield, Ginning out turn (GOT) and Staple Length (SL) are presented in Table 1, which indicated significant differences among varieties for all traits except seed cotton yield.

The differences among years were non-significant for all traits under study except monopodial branches per plant and seed cotton yield. Non-significant differences due to variety indicated that the genetic constitution of new varieties developed and approved for general cultivation has not improved for seed cotton yield. Seed cotton yield of FH-1000 and AC-134 was 2703.55 and 2821.0 kg ha^{-1}, respectively (Table 2). The variety FH-1000 was approved in 2001 and AC-134 in 1956, the differences for seed cotton yield was non significant (Table 1 and 2). The differences due to year were significant for seed cotton yield indicating that climatic/growing conditions played an important role.

The physical features that determine the yield of a cotton plant include the number of bolls per plant or per unit area, the size of boll (boll weight) and percentage of lint. It has been estimated that increase of 1% ginning out turn is equivalent to 3% increase in seed cotton yield[9].

The number of bolls depends upon retention percentage, which is effected by water stress, excessive nitrogen fertilizer, genetic constitution and climatic condition (day night temperature, humidity and rainfall). The main damage to bud, squares and boll is caused by insect (sucking and bollworms). The availability of water is same but the use of nitrogen fertilizer has increased 59.2% from 1993 to 2003[10] and the use of pesticide has increased 10410% from 1980 to 2002[11]. The import of pesticide was 665 tonnes in 1980 and 69897 metric tones during 2002[11].

Seed cotton yield of Pakistan has increased 730.37% during 1978 to 2002 as production increased from 11,06,000 in 1978 to 1,00,48,000 bales during 2003-04[10].

Table 1: Mean squares of different traits of cotton varieties at Cotton Research Station, Multan for 2001-2002.2003

SOV	DF	NFFBr	MBr	DFF	Yield (Kg ha^{-1})	GOT (%)	SL (mm)
Replications	2	0.23^{NS}	0.31^{NS}	6.79^{NS}	68057.69*	15.5^{NS}	0.075^{NS}
Year	2	8.7^{NS}	12.69*	3.37^{NS}	36054.29*	0.63^{NS}	0.55^{NS}
Varieties	31	24.57*	9.17*	323.35*	5714.68^{NS}	50.24*	1.64*
Year x Varieties	62	1.56^{NS}	1.1^{NS}	67.31^{NS}	4560.77^{NS}	1.91^{NS}	0.159^{NS}
Error	109	3.11	2.07	50.1	3739.05	5.5	0.22

*= Significant, ^{NS}= Non-significant, NFFBr=Node of 1st fruiting branch, MBr=Monopodial branches, DFF=Days to 1st flower, GOT=Ginning outturn percentage, SL=Staple length

Table 2: Average performance of varieties for different traits at Cotton Research Station Multan for 2001, 2002, 2003

Variety	Yield (kg ha^{-1})	Variety	GOT (%)	Variety	Staple length (mm)
AC-134	2821.00	S-14	39.0f	S-14	28.2c
MNH-147	2799.33	CIM-473	38.8f	FH-634	28.0c
S-12	2792.55	MNH-554	38.6ef	MNH554	28.0c
MNH-554	2783.77	CIM-499	38.5e	NIAB78	28.0c
CIM-70	2782.00	S-12	38.2e	CIM499	28.0c
N-KRISHMA	2780.44	MNH-552	37.6e	CIM1100	27.9cd
362-F	2777.33	MNH-147	37.5e	CIM448	27.9d
FH-900	2776.00	FH-1000	37.3ed	FH682	27.9d
MS-240	2775.00	CIM-1100	36.7d	FH1000	27.9d
149-F	2775.00	CIM-448	36.7d	FH-900	27.8d
CIM-109	2774.33	BH118	36.7d	149-F	27.8d
BH-118	2774.00	FH901	36.3d	CIM473	27.5cd
REHMANI	2773.00	MH329	35.9d	BH118	27.5c
MNH-552	2768.44	FH-900	35.8cd	CIM446	27.5c
S-14	2762.66	MNH93	35.5c	MNH552	27.5c
MNH-329	2762.00	N-KRISHMA	35.4c	FH901	27.5c
4-F	2761.55	MS240	35.4c	MNH147	27.4c
FH-634	2761.22	CIM443	35.4c	SLS-1	27.3bc
CIM-240	2760.00	FH634	35.2c	MNH329	27.3b
NIAB-78	2756.11	CIM240	34.8c	CIM443	27.3b
CIM-499	2756.00	CIM446	34.4bc	S-12	27.3b
CIM-1100	2754.22	NIAB-78	34.2b	REHMANI	27.2b
CIM-448	2752.77	CIM70	34.2b	CIM-70	27.2b
B-557	2739.00	SLS-1	33.3b	MNH-93	27.1b
FH-901	2739.00	CIM109	32.9b	CIM109	27.0b
CIM-443	2737.44	REHMANI	32.5ab	B-557	27.0b
SLS-1	2737.44	FH682	23.3a	CIM-240	26.9ab
CIM-446	2735.66	B-557	32.0a	AC134	26.9a
MNH-93	2735.44	149-F	31.8a	N-KRISHMA	26.9a
CIM-473	2723.00	AC-134	31.8a	4-F	26.9a
FH-682	2711.33	362F	31.7a	MS-240	26.8a
FH-1000	2703.55	4-F	31.1a	362-F	26.7a

F ratio non-significant

This increase in yield is mainly due to use of more nitrogen fertilizer and pesticide in Pakistan. But low yield differences in last decade indicated that the management strategies have reached to optimal level due to which lint yield of country is stagnant. Now it is challenge for cotton breeders to change the genetic constitution of cotton plant in such a way that it responds positively to higher doses of nitrogen fertilizer and resist insect damages to certain extent for increased lint production. As the production during 1991-92 was 12.8 million bales and 10.04 million bales in 2003[10].

The significant variation among the varieties for NFFBr, MBr, DFF, GOT and Staple Length indicated that the breeder has changed the genetic constitution of the plant for these traits. The node of first fruiting branch, number of monopodial branches (vegetative) and days taken to first flower are three main morphological feature to determine the earliness of cotton plant[12].In this respect, breeders have succeeded to accumulate earliness-related traits in recent cotton varieties (Table 2). From the perusal of Table 2, it is evident that the obsolete varieties (AC-134, MS-40, 4F) have first fruiting branch above thirteenth node while modern varieties (N-78, CIM-109, FH-901, CIM-443, MNH-552) has first fruiting branch below eighth node. Similarly AC-134, 4F and MS-40 have more than 4 monopodial branches per plant while modern varieties (mentioned above) have less than two monopodial branches per plant. The obsolete varieties took nearly 69 days while modern varieties took about 51 days to first flower. These three features indicated that breeder has improved a lot for these three traits, which determine the earliness of crop and helped the cotton plant to exhibit positive response to high nitrogen fertilizer. Due to early entry into reproductive phase (52 days) plant require more photosynthates to maintain the vegetative growth and boll filling[13,14]. This genetic modification in cotton plant has lead to increased use of nitrogen fertilizers. The improvement in earliness played an important role in early sowing of wheat especially in Punjab where cotton wheat rotation is followed.

The ultimate objective of cotton cultivation is lint production. The modern varieties (developed in last decade) have GOT more than 38%, as compared to obsolete varieties (AC-134, 4F, B-557 and MS-40), which has GOT less than 32 percent. Ginning outturn percent is one of the important factor contributing towards increased lint production. As the GOT of present varieties remained constant or less than S-12 due to which the lint production of Pakistan showed decreased or stagnant trend for last 12 years. It is also evident from NCVT data that S-12 showed highest GOT as compared to all varieties that exhibited highest seed cotton yield in NCVT conducted in Multan region from 1986-87 to 2003-04 (Fig. 1).

It is evident from Fig. 1 that MNH-93, S-12 and NIAB-78 showed highest seed cotton yield during 1987-88, 90-91 in NCVT trials conducted in Multan region and were approved for general cultivation by Government of Pakistan and all the other varieties that were approved in latter years upto 2004 have low seed cotton yield in NCVT than the above mentioned three varieties. These varieties also have lesser GOT percentage than S-12 (Fig. 2).

The fiber length is an important quality trait, which determines spinning ability. The improvement in staple length in Pakistan cotton is remarkable. The staple length of cotton varieties cultivated in Pakistan falls in medium group of fiber length (27.0-30.0 mm). The variety CIM-499 has highest staple length (29.8mm; in NCVT during 2001-2002) among the varieties so far approved for general cultivation in Pakistan. The all other varieties that approved for general cultivation from 1986-2003 have staple length ranging from 27.5 to 28.3 mm (Fig. 3). From the Table 2, it is also evident that obsolete varieties (4F, AC-134 and MS-40) have staple length 26.9 mm while modern varieties (CIM-499, MNH-554) have 28.0 mm staple length.

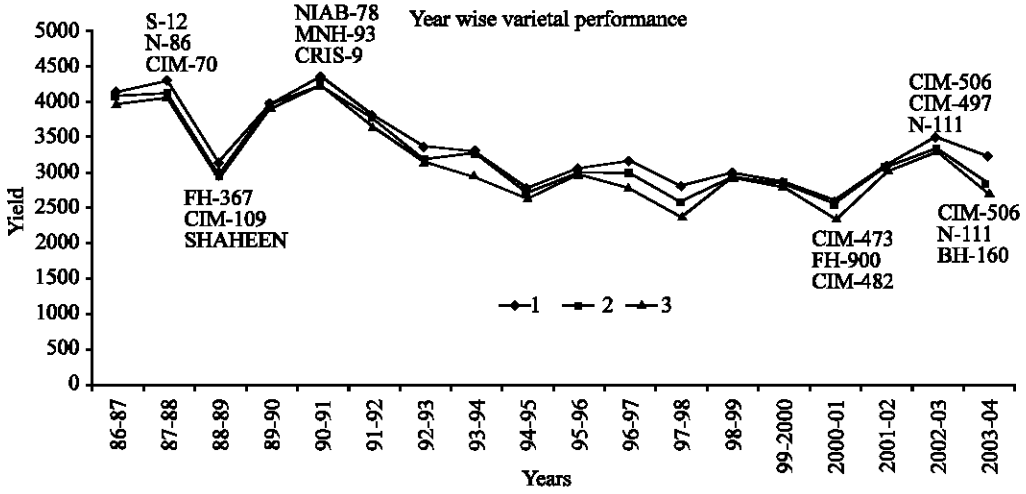

Fig. 1: Seed cotton yield of different varieties of cotton

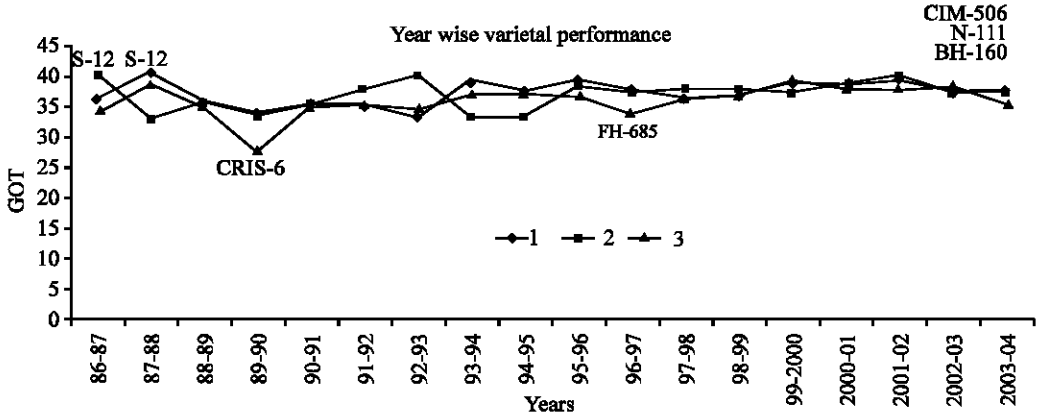

Fig. 2: Ginning outturn of different varieties of cotton

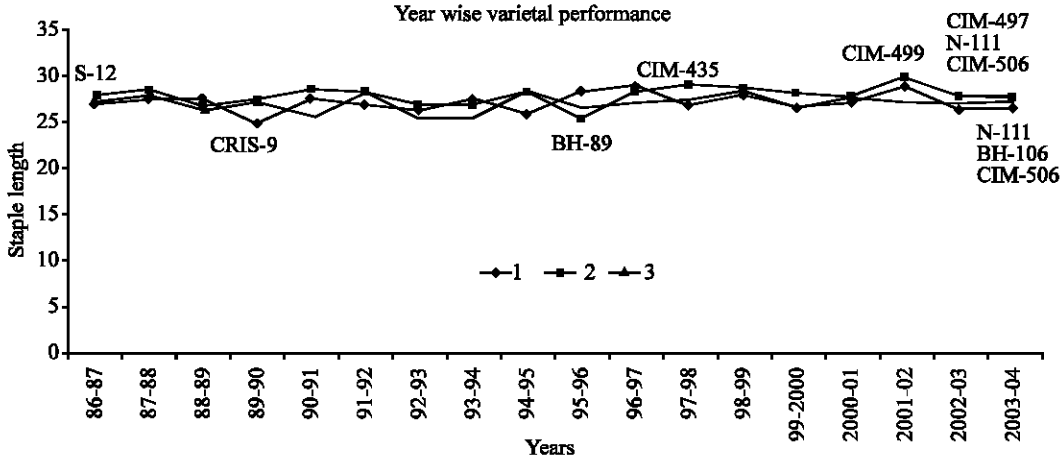

Fig. 3: Staple length of different varieties of cotton

It is concluded from present discussion that cotton breeders have changed the genetic constitution of cotton plant for earliness (Node of first fruiting branch, Monopodial branches and Days taken to first flower), lint percentage and fiber length.

But there is still room to improve seed cotton yield and its components and For this purpose conventional and non-conventional (Introgression, hybridization, genetic engineering, mutation, embryo culture etc.) methods should be used to get break-through for seed cotton yield and its fiber length and other quality traits.

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