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A Comparison of the Processing Performance of a Hand Picked and Machine Picked South African Cotton Cultivar

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A COMPARISON OF THE PROCESSING PERFORMANCE OF A HAND PICKED AND MACHINE PICKED SOUTH AFRICAN COTTON CULTIVAR

BY DE V. ALDRICH

ABSTRACT

The lint produced from both hand picked and machine picked Deltapine 5826 cotton was evaluated for processing efficiency, and yarn and fabric properties. The machine picked cotton contained more trash, was of a shorter 2,5 per cent span-length, had a lower length uniformity ratio and produced weaker yarns containing considerably more neps than the hand picked cotton.

Plain all cotton sheeting fabric was produced from each and the results showed no difference between the hand picked and machine picked cotton regarding the mechanical properties of the bleached fabrics.

KEY WORDS

Hand picked cotton — machine picked cotton — fibre properties — spinning performance — yarn properties — weaving performance — sheeting fabric — fabric properties.

INTRODUCTION

Although mechanical picking of cotton was only introduced in South Africa in 1973, it is well known in countries like the U.S.A., Australia, Israel, etc., where almost the entire crop is picked by mechanical means. It is estimated that approximately 35 *per cent* of the world cotton crop is now harvested by machines. In 1973 a number of mechanical harvesters were sold to local cotton producers and it is estimated that there are approximately 60 cotton pickers in South Africa at present.

In view of the differences between the fibre properties of hand picked and machine picked cotton[1] and the introduction of mechanical harvesting to South Africa it was decided to investigate the problems associated with the mechanical picking of cotton under South African conditions. In collaboration with the Department of Agricultural Technical Services a comparative investigation of hand picked cotton and machine picked cotton was made, with respect to:

(a) the spinning performance, and

(b) the subsequent processing into fabric, as well as the fabric properties.

EXPERIMENTAL

Raw Materials

Two lots of cotton lint were supplied by the Department of Agricultural Technical Services and consisted of one bale (200 kg) each of hand picked and machine picked Deltapine 5826. Both lots were grown under irrigation on the same field in the Komatipoort District.

Machine picking was performed by a spindle type picker after defoliation. Both lots were ginned at the same ginnery under commercial conditions typical for seed cotton picked by these two methods.

TABLE I

PROCESSING DETAILS

		15 tex	30 tex	25 tex
Card production rate	(kg/hr)	5,8	5,8	5,8
Flat speed	(mm/min)	100	100	100
	(inches/min)	4,0	4,0	4,0
Doublings at Drawframe		6 x 6	6 x 6	6 x 6
Draft at Drawframe		6,7 x 6,1	6,7 x 6,1	6,7 x 6,1
Draft at Speedframe		7,6	7,6	7,6
Roving tex		410	410	410
Roving twist	(t p m)	51	51	51
	(t p i)	1,3	1,3	1,3
Spindle speed	(r/min)	10 500	9 600	10 000
Traveller No. (Flat wire)		3/0	7	5
Nominal Twist Constant *		38	38	42 (Warp) 40 (Weft)
Nominal Twist Factor **		4,0	4,0	4,4 (Warp) 4,2 (Weft)

* Twist Constant = t p cm x $(tex)^{1/2}$

** Twist Factor = t p i/$Ne^{1/2}$

Mechanical processing

Each bale of approximately 200 kg was opened and left for 48 hours at 23°C and 55 *per cent* relative humidity to condition before blowroom processing commenced. Subsequent processing was carried out under the same conditions. A minimum of 100 kg (made up of five 20 kg portions selected at random from the entire bale) was processed in the blowroom.

The cotton was hand fed into a bale breaker, and then transported by air current to a hopper-blender, feeding a porcupine opener. The outlet of the latter discharged the fibre into a second hopper-blender followed by a double-scutcher line containing a double-bladed and a Kirschner beater. The grid-bar section at every beater was set to extract as much trash as possible without losing too much good fibre.

Carding was carried out on a conventional cotton card clothed with metallic wire and having a production rate of 5,8 kg per hour. The normal processing sequence of two drawframe passages and a speedframe passage was used to prepare a 420 tex roving for spinning. The yarns were spun on a 48-spindle ring-spinning frame equipped with 50 mm (2-inch) rings and a double-apron SKF/PK211 drafting system. Three yarn linear densities were spun (15 tex, 25 tex and 30 tex). To facilitate carrying out a weaving efficiency test, approximately 25 kg of the 25 tex yarn was produced in each case. The warp yarns were spun to a nominal twist constant of 42,5 and the weft yarns to one of 40. All other relevant processing details are given in Table I.

Testing

All fibre and yarn tests were conducted under standard atmospheric conditions of 20°C and a relative humidity of 65 *per cent*. The samples were allowed to condition in this atmosphere for 24 hours before testing.

Micronaire values were determined on a Port-Ar instrument and the immaturity index on an Arealometer. Fibre fineness (dtex) was calculated using the formula given by Hertel and Craven [2], who also reported a correlation coefficient of -0,93 between the immaturity index obtained from the Arealometer instrument and the percentage maturity obtained from the caustic soda method. The regression formula as reported by Hertel and Craven [2] was used to calculate the percentage maturity.

The Stelometer was used for measuring bundle breaking strength of the fibres at zero and 3,2 mm (1/8 inch) – gauge length. The results were adjusted to the established Pressley value by using a correction factor obtained from calibration samples supplied by the U.S. Department of Agriculture.

A Fibrograph Model 330 was used for fibre length determinations (with suction during testing). Trash content (non-lint content) was determined on the Shirley Analyser. The ultra violet reflection (fluorescence) of the samples was measured with a Spinlab UV-meter, Model 280. Yarn twist was determined by means of a Zweigle Automatic Twist Tester (Type D130) employing the double untwist-twist test.

The single thread breaking strength tests were carried out on an Uster automatic yarn breaking strength tester (constant rate of load) with 200 tests per lot being performed. The mean breaking strength, extension at break and coefficient of variation of breaking load and extension at break were calculated in the normal manner. A rupture time of 20±3 sec (ISO specifications) was used throughout the tests.

The lea strength of the yarns was determined using 80 wraps of 1,5 yards each. The results are expressed as the count – strength – product (CSP = English Cotton Count (Ne) X Lea strength in lbf).

The Shirley Template method was used to determine the number of neps and impurities per 100 sq. inches of card web.

The trash (non-lint), extracted by each of the three opener/cleaners in the blowroom (after a predetermined mass of cotton lint had been processed), was carefully collected and expressed as a percentage of the total mass processed. In addition to this the fine fibrous dust, extracted through the two condensers and the two cage-sections of the blowroom line, and which was deposited in the air-filter box, was collected and also expressed as a percentage of the total mass processed. These individual percentages are given in Table III.

The licker-in waste and flat-strips at the card were collected separately and expressed as a percentage of the total mass carded.

End-breaks during spinning were determined over a period of approximately 1 000 spindle-hours for the 15 tex yarn, 2 000 spindle-hours for the 25 tex yarn and 500 spindle-hours for the 30 tex yarn. All end-breaks which occurred during the first and last 30 minutes of each doff were excluded. The number of end-breaks was normalised to 1 000 spindle-hours. New travellers were inserted at the start of every linear density.

A 20 cm gauge length was used on an Instron Tester for testing the fabric strength in the warp and weft directions. The test samples were 5 cm wide and the cross-head speed was such that breaking occurred after 30 ± 3 seconds in accordance with ISO-specifications[3].

The bursting strength of the fabrics was determined on a standard Mullen Tester. The tear strength of the fabrics was determined with an Elmendorf Tear Strength Tester.

The abrasion resistance of the fabrics is given as the percentage loss

in mass after 10 000 cycles on a Martindale Abrasion Tester (795 g headweight).

Weaving:

The 25 tex yarns were autoclave steamed at 100°C for 10 minutes under a vacuum of 660 mm Hg and then allowed to condition in an atmosphere of 65 *per cent* RH and 20°C before further processing.

After steaming, the 25 tex yarns were electronically cleared by means of an Uster Classimat, with the clearing levels set at B4C3.

Warps were prepared on a Hergeth Sample Warper. All the warps were sized under identical sizing conditions. The following sizing recipe (Bevaloid Technical Bulletin on Bevaloid 174) was used:

3400 g Solvitose XI — (Scholten Soxhol)
454 g Bevaloid 174 (binder) — (Bevaloid)
360 g Bevaloid 356 (anti-static wax) — (Bevaloid)
and
90 g Bevaloid 581 B (defoamer) — (Bevaloid)
added to 40,2 litres of water at 96°C.

The percentage size pick-up for both warps was 13 *per cent*.

The two fabrics were woven to the same construction on a Saurer 100W 4-box, 190 cm loom, each weft with its respective warp. The fabric produced was a plain all cotton sheeting (SABS Spec. 338 — 1971 for Cotton Sheeting). The relevant weaving details were as follows:

Ends per cm	25
Picks per cm	25
Gram per m^2 (loomstate)	135
Width of fabric after bleaching	130
Warp yarn linear density	25 tex
Weft yarn linear density	25 tex

Weaving performance studies were carried out to determine the difference in weavibility between the two lots of yarn. The two warps were knotted together at the beamer to ensure continuity of weaving. All stoppages were timed and recorded and from the results a warp weaving efficiency was calculated as follows:

$$\text{Warp weaving efficiency (\%)} = \frac{\text{Picks produced} \times 100}{(A-B) \times \text{Loom speed}}$$

where A = Total running time (minutes)
B = All stopped time other than for warp breaks

Scouring and bleaching

Scouring and bleaching of the loomstate cloth were carried out in a Longclose winch according to the established recipe from Laporte Chemicals for a standard alkaline peroxide bleach. The solution was made up as follows:-

Liquor volume	120 ℓ
Sodium hydroxide	0,5 g/ℓ
Sodium silicate	7,0 g/ℓ
Sodium carbonate	1,8 g/ℓ
Tergitol Speedwet (Union Carbide)	1 g/ℓ
Hydrogen peroxide (50%)	1,26 g/ℓ
Liquor Ratio	30 : 1

The cloth was left in the solution for 5 minutes at 50°C after which the temperature was raised to 100°C and maintained for 90 minutes. It was subsequently rinsed and treated with 1 g/ℓ sodium hydrosulphite at 100°C for 20 minutes.

To ensure that scouring and bleaching conditions were identical for each fabric, 9 m lengths of each were joined together to make a composite sample.

RESULTS AND DISCUSSION

The trash content (by mass) of the machine picked cotton was 42 *per cent* higher than that of the hand picked cotton. The two lots also differed significantly in the character of the trash. The trash from the machine picked cotton contained a very large proportion of green weed particles (dry leaf, stalks, etc.) whereas this type of trash was completely absent from the hand picked lot. The difference in the type and character of the trash is illustrated in Figures 1 and 2. Figures 1a and 1b show the trash extracted on a Shirley Analyser from the machine picked cotton before and after blowroom processing. Figures 2a and 2b are similar photographs of trash extracted from the hand picked cotton.

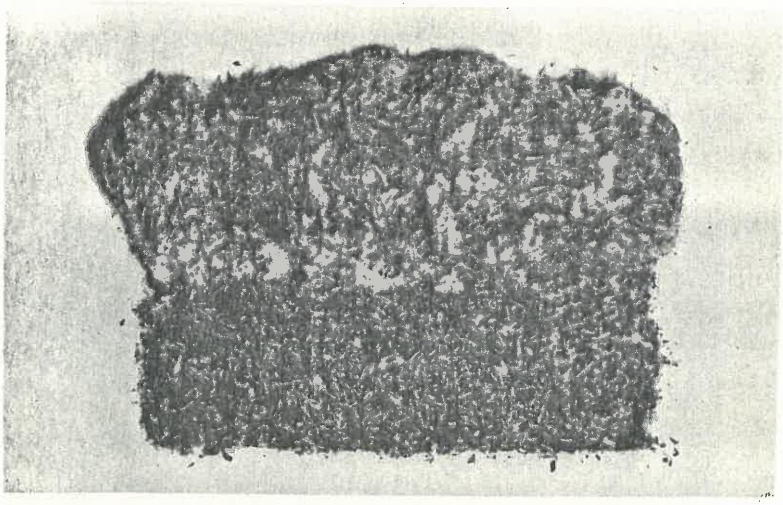

Fig. 1(a) Machine picked cotton – before blowroom processing

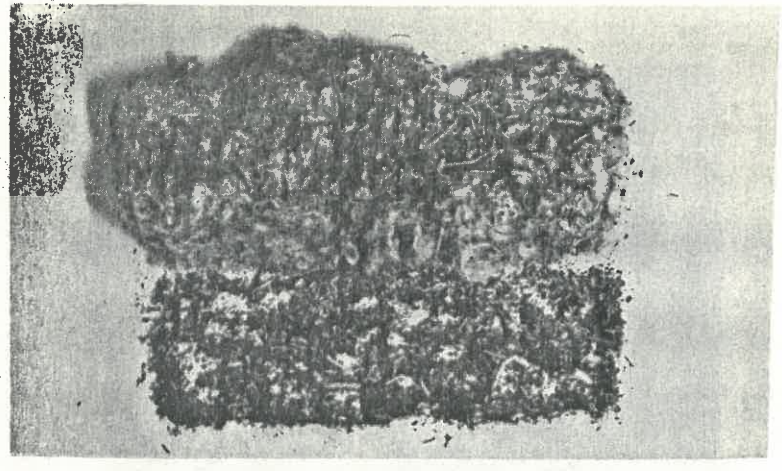

Fig. 1(b) Machine picked cotton – after blowroom processing

TRASH EXTRACTED ON A SHIRLEY ANALYSER FROM HAND PICKED COTTON

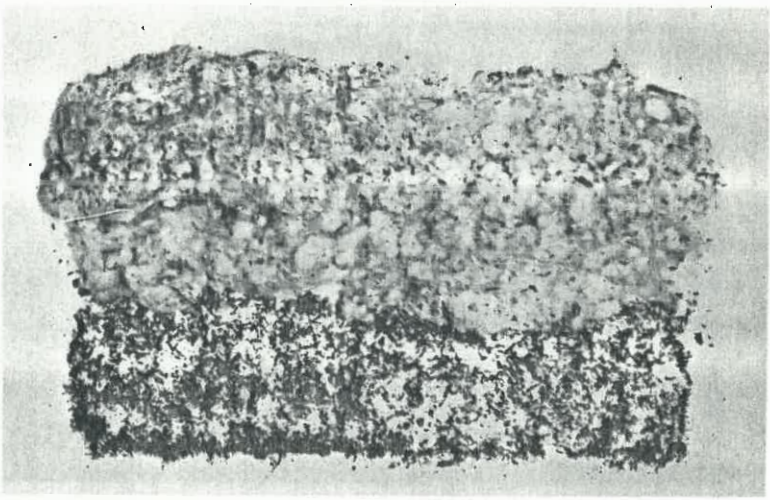

Fig. 2(a) Hand picked cotton – before blowroom processing

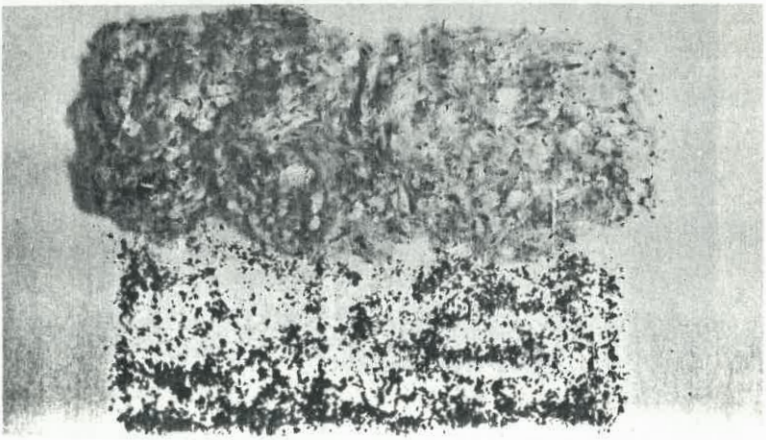

Fig. 2(b) Hand picked cotton – after blowroom processing

Apart from the fact that the mechanically picked cotton contained more trash than the hand picked cotton, the former also had a slightly off-white colour compared with the hand picked cotton.

TABLE II

FIBRE CHARACTERISTICS OF THE MACHINE PICKED AND HAND PICKED COTTON

		Machine Picked Cotton	Hand Picked Cotton
Trash Content (Shirley Analyser)	(%)	2,35	1,65
Micronaire Value		3,57	3,64
Fibre Length Characteristics:			
2,5% Span length	(mm)	28,2	29,1
50% Span Length	(mm)	11,9	13,3
Uniformity Ratio	(%)	42	46
Fibre Strength Characteristics (Stelometer):			
Zero-gauge	(gf/tex)	37,1	38,7
	(1 000 lbf/sq.in.)	74,9	78,1
3,2 mm-gauge	(gf/tex)	19,2	18,5
Elongation at break	(%)	7,8	7,9
Immaturity Index (Arealometer)		2,16	2,17
Percentage Maturity		68	68
Fibre Linear Density :	(dtex)	1,58	1,51
	(µg/inch)	4,01	3,86
Ultra-violet reflection value		42	43

The fibre characteristics of the machine picked cotton and the hand picked cotton are given in Table II.

The micronaire values of the two lots were not significantly different (3,57 against 3,64). The 2,5 *per cent* span length of machine picked cotton was 0,9 mm lower than that of the hand picked cotton. Furthermore, the length uniformity ratio (ratio of 50 *per cent* span length to 2,5 *per cent* span length) of the machine picked cotton was 42 *per cent* against 46 *per cent* of the hand picked cotton, which indicates that the fibre length uniformity of the machine picked cotton was much lower than that of the hand picked cotton. This difference in length characteristics which is normal for machine and hand picked cotton might have been caused by the differences in ginning practices.

The fibre bundle strength characteristics of both lots were very similar. At O-gauge the hand picked cotton had a strength of 38,7 gf per tex against 37,1 gf per tex for the machine picked cotton. At 3,2 mm-gauge (1/8-inch) the ranking was reversed but the differences in both cases were not statistically significant.

The ultra violet reflection values of the two lots are given in Table II. There is no significant difference between the two values and, therefore, according to the manufacturers of the instrument the dye uptake of the two samples is not expected to be different.

The maturity of both lots was 68 *per cent.* According to the maturity ratings quoted by Lord[4], both these lots must be considered as somewhat immature.

The percentages of trash and waste extracted in the blowroom and at the card are given in Table III. These results show very clearly that in all the processes where waste was extracted, the machine picked cotton produced more waste than the hand picked cotton. When the blowroom waste and the card waste were combined, the machine picked cotton produced 37 *per cent* more waste than the hand picked cotton.

The laps produced at the scutcher contained 1,70 *per cent* and 1,0 *per cent* trash for the machine and hand picked cotton respectively. After blowroom processing, the machine picked cotton therefore contained 70 *per cent* more trash than the hand picked cotton. Before processing however, it contained 42 *per cent* more trash than the hand picked cotton. These results indicate that it was more difficult to extract the trash from the machine picked cotton than it was from the hand picked cotton.

Visual observations during mechanical processing also showed very clearly that much more dust and fly were generated in the blowroom and during carding when the machine picked cotton was processed compared with the hand picked cotton. In all the subsequent processes, including spinning, much more fibre shedding was also observed during the processing of the machine picked cotton.

The card web from the machine picked cotton contained twice as many

TABLE III

PROCESSING PERFORMANCE IN BLOWROOM, CARDING AND SPINNING

		Machine Picked Cotton	Hand Picked Cotton
Blowroom Waste:			
Total trash extracted by cleaners	(%)	1,05	0,96
Short fibre and dust extracted by condensers and cages	(%)	0,16	0,13
Total waste extracted in blowroom	(%)	1,21	1,09
Card Waste:			
Licker-in waste	(%)	1,72	1,37
Flat strips	(%)	2,04	1,17
Total card waste	(%)	3,76	2,54
Overall Total waste extracted	(%)	4,97	3,64
Trash content of scutcher laps	(%)	1,70	1,00
Neps per 100 sq. inches of card web		27	13
Impurities per 100 sq. inches of card web		13	3
End-breaks per 1 000 spindle-hours:			
	15 tex	49	23
	30 tex	39	19
	25 tex *	22	15
Average number of end-breaks for all linear densities		37	19

* Average for two twist constants

neps as that from the hand picked cotton. The only fibre characteristic which could have had an unfavourable effect on the nepping potential of the machine picked cotton was its reduced fibre length uniformity. It is doubtful, however, whether this was the only cause of its increased nepping potential. Mechanical picking as well as ginning procedure might have been

contributory causes of the increased nep formation in the machine picked cotton.

The number of end-breaks per 1 000 spindle-hours for the 15 tex, 30 tex and 25 tex yarns are given in Table III. In all three cases the machine picked cotton produced considerably more end-breaks than did the hand picked cotton. When the end-breaks for all three of these yarns were averaged, the machine picked cotton produced twice as many end-breaks as those produced by the hand picked cotton.

TABLE IV

CHARACTERISTICS OF THE 15 TEX AND 30 TEX YARNS SPUN FROM THE MACHINE PICKED AND HAND PICKED COTTON

		15 tex		30 tex	
		Mach. Picked	Hand Picked	Mach. Picked	Hand Picked
Nominal Twist Constant *		38	38	38	38
English Twist Factor		4,0	4,0	4,0	4,0
Measured twist (t p m)		1040	1044	730	735
Count-Strength-Product (CSP): (Ne x Strength in lbf)		2065	2165	2260	2368
Single-thread breaking strength (gf/tex)		13,2	15,0	15,7	16,0
CV of Single-thread strength	(%)	12,7	10,9	8,9	9,4
Extension at break	(%)	8,1	8,5	8,9	9,0
Yarn Irregularity	(CV%)	21,9	20,7	17,3	16,8
Neps per 1 000 metres		812	469	268	148
Thin places per 1 000 metres		208	105	5	12
Thick places per 1 000 metres		696	515	128	128

* Twist Constant = t p cm x $(\text{tex})^{½}$

The characteristics of the yarns (spun from these two lots) are given in Tables IV and V. In all three cases the hand picked cotton produced a stronger yarn. The differences between the means of the single thread strength values are significant at the 1 *per cent* level for the 15 tex and

TABLE V

CHARACTERISTICS OF THE 25 TEX WARP AND WEFT YARNS SPUN FROM THE MACHINE PICKED AND HAND PICKED COTTON

	Machine picked		Hand picked	
	Warp	Weft	Warp	Weft
Measured twist (t p m)	905	851	890	849
Measured yarn tex	25,3	24,8	25,5	25,2
Count-Strength-Product (Ne X Strength in lbf)	2238	2113	2321	2261
Single-thread breaking strength (gf/tex)	15,0	14,5	15,9	15,8
CV of Single-thread strength (%)	9,6	8,6	9,6	9,2
Extension at break (%)	8,2	8,3	8,8	9,1
Yarn irregularity (CV%)	18,6	18,4	17,9	17,6
Neps per 1 000 metres	363	376	155	181
Thin places per 1 000 metres	62	36	10	24
Thick places per 1 000 metres	277	222	163	182

25 tex yarns and at the 5 *per cent* level for the 30 tex yarn. The CSP-values of the yarns from the hand picked cotton are also higher than those from the machine picked cotton in all the cases. The 15 tex yarn produced from the machine picked cotton had a coefficient of variation of 12,7 *per cent* of single thread breaking strength against 10,9 *per cent* of that of the 15 tex yarn produced from the hand picked cotton. In the case of the other two yarns the coefficient of variation of single thread strength was similar. The extension at break of all the yarns from the hand picked cotton was higher than that of the yarns from the machine picked cotton.

The yarns spun from the hand picked cotton consistently had a slightly lower irregularity (CV-per cent). All the yarns spun from the machine picked cotton contained approximately double the number of neps per 1 000 metres compared with the yarns from the hand picked cotton.

Weaving Efficiency

The warp weaving efficiency of the 25 tex yarns was 96 and 95 *per cent* for the machine and hand picked cotton respectively. The differences in yarn properties (Tables IV and V) were, therefore, not reflected in the weaving efficiency of the two lots.

Fabric Properties

The mechanical properties of the fabrics (loomstate and bleached) made from the 25 tex yarns are given in Table VI.

All the fabric properties given in Table VI indicate that there was very little difference, if any, in the mechanical properties of the two fabrics. In

TABLE VI

FABRIC PROPERTIES

	Machine Picked		Hand Picked	
	Loomstate	Bleached	Loomstate	Bleached
Fabric mass per unit area (g/m^2)	145	148	148	156
Warp breaking strength: (kgf)	50,9	46,0	52,3	43,2
(CV%)	7,1	7,7	7,1	6,6
Weft breaking strength: (kgf)	47,5 *	45,4	52,8	48,5
(CV%)	3,8	6,7	4,7	8,1
Average of warp and weft breaking strength (kgf)	49,2	45,7	53,0	45,9
Warp extension at break (%)	18,1 *	23,1	16,1	25,2
Weft extension at break (%)	17,6	23,2	18,1	22,8
Tear strength (gf) (Mean of warp and weft)	1 900 *	980	2 080	1 030
Bursting strength (kgf/cm^2)	10,8	11,4	11,1	11,5
Martindale abrasion: Mass Loss at 10 000 cycles (%)	–	4,4	–	4,6

* Significantly different from Hand Picked at 95 *per cent* confidence level.

TABLE VII

NUMBER OF TRASH PARTICLES PER UNIT AREA IN FABRICS

	NO. OF PARTICLES PER m^2	
	Machine Picked	Hand Picked
Loomstate	1 895	1 200
Bleached	27	3

the loomstate only the differences in the tear strength, breaking strength (weft) and warp extension at break between the two fabrics were significant at the 95 *per cent* level. After bleaching none of the differences in Table VI was significant at the 95 *per cent* level.

The appearance of the loomstate fabrics, however, differed widely, as is indicated by the number of vegetable (trash) particles per square metre counted in transmitted light (see Table VII). Scouring and bleaching decreased the number of trash particles to 27 and 3 per m^2 for the machine and hand picked cotton respectively. The longer trash particles which were intimately spun into the body of the yarn proved the most difficult to remove during bleaching. Those remaining in the fabric from the machine picked cotton were mainly long trash particles firmly embedded in the body of the yarn.

Apart from the difference in the number of trash particles in the bleached fabric produced from the two lots of lint, no other differences in appearance could be detected.

SUMMARY AND CONCLUSIONS

The fibre properties, spinning performance, yarn properties, weaving performance and fabric properties of hand picked and machine picked South African Deltapine 5826 cotton, have been compared.

The machine picked cotton contained 42 *per cent* more trash than the hand picked sample and subsequently produced 37 *per cent* more waste in processing up to carding. It also proved more difficult to remove the trash from the machine picked cotton during blowroom processing.

The fibre characteristics of the two lots were similar, except for the 2,5 *per cent* span length of the machine picked cotton which was 0,9 mm

(just more than 1/32-inch) shorter than the hand picked cotton. The length uniformity ratio of the machine picked cotton was 42 *per cent* compared with 46 *per cent* of the hand picked cotton.

The card sliver from the machine picked cotton contained twice as many neps as that from the hand picked cotton. This difference in nepping potential was also reflected in the neppiness of the yarns.

Yarns of the 15 tex and 30 tex with twist constants of 38 and yarns of 25 tex with twist constants of 42,5 and 40 were spun in each case.

The single thread breaking strength (gf/tex) of the 15 tex yarn spun from the machine picked cotton was 12 *per cent* lower than that spun from the hand picked cotton. The 30 tex yarns spun from the machine picked cotton however, were only 2 *per cent* weaker. This tendency was not supported by the CSP values.

Although there was a tendency for the yarns from the machine picked cotton to be more irregular than those from the hand picked cotton, it was only for the 25 tex yarns that it was significant at the 95 *per cent* confidence level.

The warp weaving efficiency of the 25 tex yarns of both cottons was high with no significant difference between them. Similarly no significant differences could be detected between the various mechanical properties of the two fabrics after bleaching.

The loomstate fabric produced from the machine picked cotton contained many more trash particles than that produced from the hand picked cotton. After bleaching, this difference was still perceptible but the trash particles were mainly longer ones embedded in the yarn. This was especially the case for the fabric produced from the machine picked cotton.

The differences in yarn properties were, therefore, not reflected in the mechanical properties of the fabrics produced from the two lots of lint. The increased trash content of the machine-picked cotton was, however, clearly noticeable in the fabric. With increased cleaning of the machine-picked cotton during blowroom processing this could possibly be reduced or eliminated.

The differences found between the hand picked cotton and the machine picked cotton may be summarised as follows:

(i) The hand picked cotton contained far less trash than the machine picked cotton, and produced less waste during processing.
(ii) The hand picked cotton could be spun at higher productivity levels than the machine picked cotton.
(iii) The yarns spun from the hand picked cotton were of a better quality than those spun from the machine picked cotton although it was only slightly better in certain cases.

(iv) No statistically significant differences in the mechanical properties of the bleached fabrics could be found.

ACKNOWLEDGEMENTS

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THE USE OF PROPRIETARY NAMES

The fact that equipment and substances with proprietary names have been mentioned in this report does not in any way imply that SAWTRI recommends them or that there are not substitutes which may be of equal value or even better.

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