THE FEASIBILITY OF BLENDING COTTON AT THE GIN INSTEAD OF THE SPINNING MILL

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This study was initiated to determine the effect of gin blending on fibre, yarn and fabric processing performance and quality and the potential economic return to the grower. As the biggest discounts for a grower are mainly for grade, length and micronaire, one set of stripper harvested irrigated seed cotton, with different micronaire and length properties, were blended together in four different ratios (80/20%, 60/40%, 40/60% and 20/80%) at the gin. The results show that gin blending can benefit the grower with the processing performance and yarn and fabric quality of the blended product seldom different from that of the unblended cotton, indicating no serious consequence to the spinner.

INTRODUCTION

Cotton is currently grown in over 60 countries world-wide, with the blending of cotton lint from various parts of the world a standard practice for spinning mills, utilizing a number of different blending techniques. Fibres are generally blended before the carding process by laydown selection, tuft blending during the opening and cleaning process, the use of single or multiple blending chambers and blending during multiple drawing passages. The blending process starts with the selection of an appropriate number of bales from lots in the warehouse. Lots are generally segregated by consignments and quality parameters, and are chosen to ensure continuity of supply, avoidance of batch-to-batch variation, cost savings in raw materials, utilization of discount cotton and the production of special effects, with minimal blending occurring during the harvesting and ginning processes. The controlled blending of seed cotton prior to ginning is not common in countries where cotton production is highly mechanized, e.g., Australia, USA and Brazil. But it is quite common in developing countries where seed cotton lots from small growers are aggregated by gins to increase the size of consignments to merchants.

Blending of seed cotton needs to be conducted prior to the ginning process as blending during the ginning process is impractical. A major reason for this is the equipment and process set up; with modern gins able to produce a bale of cotton in less than a minute provided that a continuous flow of seed cotton is provided into the gin. There is virtually no reserve capacity in gins or process that allows for any significant blending to take place. There are essentially three practical methods of blending seed cotton prior to ginning:

- Mixing seed from different varieties in equal or varying amounts prior to planting.
- Sowing different varieties in an alternating row configuration, which are then harvested together.
- Feed different cotton qualities simultaneously into the gin (Baker & Wanjura 1976; Bechere et al. 2008; Faircloth et al. 2003).

A number of studies have been conducted to determine the potential of blending seed cotton from different varieties to maintain yield and improve fibre quality. These have shown that fibre length, length uniformity, strength, and micronaire can be influenced by blending in the field, but that the result provided little, if any, economic benefit to the grower. Despite these studies there is considerable interest within the cotton producing industry to blend at the gin. This could potentially be of benefit to both the grower and the textile mill. From a grower's perspective, blending at the gin provides an opportunity to avoid discounts, mainly for grade, length and micronaire, due to variable or damaged cotton. The interest has coincided with the rapid uptake of the round module harvesters, which produce a smaller round module, which because of its size and sample area is inherently more variable in its fibre properties. Since round modules do not blend cotton from multiple parts of a field the way conventional modules did, the risk of inter-modular variation in fibre properties is greater with round modules (van der Sluijs et al. 2015). By blending seed cotton from modules during the ginning process, these discounts could possibly be avoided and ensure consistency of fibre quality. From a spinners perspective blending at the gin provides an opportunity to reduce variability and improve consistency of fibre quality which could lead to improved processing performance and yarn quality.

The introduction and rapid adoption of harvesters with on-board module building capacity is seen as an ideal opportunity to make blending prior to ginning a reality. Gins have been forced to make major changes to their operations to enable the processing of these modules, which has resulted in a number of gins now having the capability of feeding their gins with multiple modules (conventional and/or round) simultaneously. Although previous studies have shown that there is no significant economic return for a grower when blending seed from various varieties or sowing different varieties in an alternating row configuration, the effect of blending at the gin on fibre quality, particularly from round modules, is not clear.
Furthermore, few of the previous studies determined what effect blending prior to the spinning mill will have on textile processing performance and yarn and fabric quality

METHODS AND MATERIALS

In the present study, small seed cotton modules, from irrigated and dryland cotton, were used to conduct small batch testing. Fibre quality data from an Uster® Technologies Incorporated HVI™ and AFIS PRO instruments was used to determine the blending ratios and their effect on ginned quality. Quality was validated by small scale textile processing trials, conducted at USDA-ARS-SRRC Cotton Structure and Quality facility Research (CSQRU) Unit in New Orleans, LA, to determine the effects of blending on mill processing performance and quality of yarn and fabric.

Three bags of seed cotton, each weighing 14 kg, were collected at random after harvesting and ginned at the USDA-ARS Cotton Production & Processing Research Unit (CPPRU) in Lubbock, TX on a 21 saw Continental research gin. Seed cotton was cleaned by an extractor-feeder prior to the gin stand and the lint was cleaned by one saw-type lint cleaner. Three fibre samples produced from each bag of seed cotton was collected and forwarded to CSQRU, for testing on one HVI 1000. Five replicates of each sample were tested for colour (reflectance Rd, and yellowness +b), trash count and % trash area, upper half mean length (UHML) in mm, % length uniformity (UI), Short fibre Index (SFI), bundle strength (g/tex), % bundle elongation, and micronaire, as per ASTM D5867-12. Fibre samples were also subjected to analysis by the AFIS PRO instrument. Three replicates, of 5000 fibres were tested of each sample to determine total and seed coat neps (SCN), trash and dust per gram, % visible foreign matter, fineness and maturity as per ASTM D5866-05.

Only the results from the seed cotton from the varieties that exhibited the biggest difference in micronaire, UHML, and strength will be discussed in this paper.

The average fibre quality was calculated for the two samples, the means for the HVI 1000 presented in Table 2. The AFIS PRO values appear in Table 3.

Table 1. HVI™ determined fibre properties

Variety	+b	Rd	UHML mm	UI %	SFI %	Str g/tex	El %	Mic
A	6.6	77.5	30.99	83	8.4	34.3	6.8	3.8
C	8.7	73.9	27.18	82	9.2	30.2	8.1	4.7

By any measure, the quality of the fibre produced by both varieties can be considered as good for stripper harvested cotton. The average micronaire ranged from 3.8 to 4.7, which was within the base range of 3.5 to 4.9, UHML ranged from 29.21 mm to 30.99 mm, UI from 82 to 83 %, SFI from 8.4 to 9.2 %, bundle strength from 30.2 to 34.3 g/tex and elongation from 6.8 to 9.3%. In terms of colour, the Rd ranged from 73.9 to 77.5 units and the +b from 6.6 to 8.7 units. This translated into a colour classing grade of 41-1 and 41-3, which are both considered to be Strict Low Middling.

Variety A produced fibre with the best quality producing the finest, longest, and strongest fibre. In contrast, variety C produced the coarsest, shortest and weakest fibre.

In terms of AFIS PRO measurements - see Table 3, the average nep level ranged from 222 to 295 neps/gram, SCN from 9 to 15 neps/gram, dust content from 234 to 478 particles/gram, trash content from 74 to 164 particles/gram, and visible foreign matter from 1.28 to 2.75%. Fibre fineness ranged from 168 to 189 mtex and maturity ratio from 1.01 to 0.99.

There were no clear trends in terms of nep content, although the coarser fibre (Variety C) did produce the least number of neps and also contained the least amount of dust and trash, resulting in lower percent visible foreign matter.

Table 2. AFIS PRO determined fibre properties

Variety	Nep Cnt/g	SCN Cnt/g	Trash Cnt/g	Dust Cnt/g	VFM %	Fn mtex	MR
A	295	15	164	478	2.75	168	0.99
C	222	9	74	234	1.28	189	1.01

Details of the various ratios are presented in Table 4.

Table 3. Varieties and blend ratios

Variety	Blend Ratio in %						Variety
A	100	80/20	60/40	40/60	20/80	100	C

The blends were made by weighing out 91 kg of seed cotton and then blending the seed cotton with pitchforks prior to the seed cotton being conveyed into the gin.

All the cottons were ginned under standard commercial conditions using standard processing stages with the pre-cleaning system consisting of a tower dryer, an inclined hot air cylinder cleaner, and a combination burr and stick machine. It was followed by a second tower dryer, a second inclined hot air cylinder cleaner, and a stick machine. The dryer burner controls were set to 93 °C for the processing of all samples. Seed cotton was then fed by an extractor-feeder to the 93-saw Continental Double Eagle saw gin stand. The fibre was cleaned by one saw-type lint cleaner prior to baling.

Fibre samples from each of the 6 blends were collected at random and subjected to testing, as outlined previously.

The USDA small-scale processing plant, at CSQRU, was used to convert the fibre into 20/1 Tex (30 Ne) carded ring-spun yarns with a twist factor of α_e 3.8. Single jersey knitted fabrics of approximately 160 g/m^2 were produced on a Lawson Hemphill FAK-S (Swansea, MA) sample knitting machine. Four knitted fabric samples were prepared for each lot. They were scoured and bleached together with one of the four samples being dyed separately with a reactive dye Novacron Blue LS-3R.

Twenty spinning packages from each lot were tested for yarn strength and elongation utilizing an Uster® Technologies Incorporated Tensorapid 4 with 20 breaks per package as per ASTM D2256-10. Yarn uniformity, imperfections (thin/thick/neps) and hairiness index were measured on an Uster® Technologies Incorporated Evenness Tester 4, as per ASTM D1425-14. Fabrics were characterized after bleaching and after dyeing. Fabric colour was measured in five locations per fabric using a Gretag Macbeth ColorEye 7000a instrument.

As this study was an initial evaluation, with no true replication only descriptive statistics were conducted. The average fibre, yarn and fabric qualities, as well as their processing performance, were calculated from the results of the two different varieties and blended fiber. The standard deviation, designated as sd, was also calculated to provide a measure of the amount of variation.

RESULTS AND DISCUSSION

The seed cotton from the varieties that exhibited the biggest difference in micronaire, UHML, and strength were chosen to process as 100% and in various blends as stipulated in Table 4. Tables 5 and 6 show the HVI and AFIS PRO results for varieties A and C and their four gin blends. As can be seen there were substantial differences in terms of micronaire, UHML, SFI, and strength. The extremely high strength result for the finer variety A was in all likelihood due to the fact that more fibres were present in the beard during strength testing. Although there was a substantial difference in colour in terms of Rd and +b values, there was only a slight difference in the average colour grades for the two varieties, with the colour grade for variety A = 41-1 and variety C = 41-3. As can be seen in Table 5, there were also substantial differences in terms of fibre fineness and maturity. Finer (lower) micronaire cotton fibres form neps more easily than coarser fibres since the former are less rigid and therefore more easily bent, buckled, and entangled during mechanical handling manipulation due to their relatively low rigidity.

Blended

There were no substantial differences in terms of SFI, UI, and trash between the unblended and the gin blended fibre results. However, there were substantial differences between the unblended and the gin blended fibre results in terms of micronaire, UHML, strength, and elongation. Although there were differences in terms of the colour (Rd and +b), there were no practical differences as the colour grades ranged from 31-2, marginal Middling to 41-3 Strict Low Middling.

As could be expected the average micronaire increased as increasing amounts of the coarser variety (C) were blended with the finer variety (A), with the average micronaire increasing from 3.77 to 3.98 to 4.10 to 4.23 and to 4.44. There was a similar trend in terms of UHML and strength, the average UHML decreasing as more of the shorter variety (C) was added to the longer variety (A). The average UHML decreased from 30.99 to 30.48 to 29.21 to 28.70 and to 28.19 mm as the percentage of C was increased from 20% to 80%. Similarly, the average strength decreased as the percentage of the weaker variety (C) increased, with the average strength initially increasing from 35.14 to 35.24 and then decreasing 33.38 to 32.50 and to 33.08 g/tex.

There was also a trend for the elongation to increase as the percentage of the variety with the higher elongation (C) was increased in the blend, with the average elongation increasing from 6.6 to 7.0 to 7.2 and to 7.4% as the percentage of C increased from 20% to 80%. Interestingly, the elongation of the blend with the highest percentage of C was even higher than that of the variety with the highest individual elongation. It is hypothesized that this was due to issues associated with the HVI elongation measurement, i.e., high replicate variation as well as fibre slippage and crimp.

Table 6 shows the AFIS PRO results for A and C varieties and for their four blends, from which it can be seen that there were no real differences in terms of dust, trash, VFM%, nep and SCN content. There was, however, a trend for the average linear density to increase as the percentage of the coarser variety (C) increased, with the average fineness increasing from 169 to 165 to 171 and to 177 mtex. Although there was a substantial difference between the two unblended varieties in terms of maturity ratio, increasing the percentage of C did not seem to result in any significant change in maturity. This was not unexpected, as both varieties had a maturity ratio close to 1 and can thus be considered as be very mature.

Table 5. HVI™ determined fibre properties for 100% vs gin blended.

Code	+b	sd	Rd	sd	UHML mm	sd	UI %	sd	SFI %	sd	Str g/tex	sd	El %	sd	Mic	sd
A	6.7	0.1	78.7	0.3	30.99	0.33	81.9	0.5	8.2	0.2	35.14	1.46	6.6	0.2	3.77	0.03
C	8.8	0.1	74.1	0.3	26.92	0.31	81.8	0.5	8.7	0.4	31.04	0.67	6.8	0.2	4.70	0.02
80A/20C	7.0	0.1	77.6	0.4	30.48	0.72	81.3	0.3	8.9	0.5	35.24	1.47	7.0	0.2	3.98	0.03
60A/40C	7.6	0.1	76.7	0.3	29.21	0.53	81.5	0.6	8.6	0.4	33.38	1.38	7.2	0.3	4.10	0.04
40A/60C	7.8	0.2	76.2	0.4	28.70	0.85	80.8	1.2	9.8	0.7	32.50	1.11	7.4	0.2	4.23	0.07
20A/80C	8.4	0.2	74.8	0.5	28.19	0.60	81.0	1.2	9.0	0.8	33.08	1.29	7.8	0.4	4.44	0.02

Table 6. AFIS PRO and HVI™ determined fibre properties for 100% vs gin blended.

	AFIS PRO														HVI™					
Code	Nep Cnt/g	sd	SCN Cnt/g	sd	Fn mtex	sd	MR	sd	VFM %	sd	Trash Cnt/g	sd	Dust Cnt/g	sd	Leaf	sd	% Area	sd	Trash Count	sd
A	356	14	9	4	169	3	0.97	0.01	1.05	0.10	62	5	357	60	2.2	0.4	0.23	0.03	40	7
C	194	9	7	3	190	3	1.01	0	1.26	0.81	42	11	303	100	1.6	0.9	0.21	0.07	33	3
80A/20C	305	76	7	3	165	4	0.96	0.01	1.22	0.15	62	3	422	73	2.2	0.4	0.24	0.04	40	8
60A/40C	283	36	7	5	171	3	0.97	0.01	0.85	0.12	49	6	321	33	2.0	0.7	0.25	0.08	40	6
40A/60C	257	37	6	3	171	3	0.97	0.01	0.90	0.11	61	10	347	58	1.8	0.4	0.18	0.04	30	8
20A/80C	244	14	4	0	177	3	0.96	0	0.54	0.08	37	9	237	38	1.6	0.5	0.17	0.07	25	8

Economic considerations

It is important to determine what the gain from a grower's perspective would be in blending the three varieties. In order to determine the potential impact on the grower's bottom line the fibre properties of the three varieties and their various blends were assessed using the 2016 Commodity Credit Corporation (CCC) Loan Schedule of Premiums and Discounts for Upland Cotton. The average loan rate ($US/lb) was calculated using micronaire, length, uniformity, strength and colour grade from the five HVI test replicates. Loan rate and blend code were used to calculate the value of a bale of each single variety or blend. A rudimentary analysis of the prices suggests that in terms of the unblended fibre, variety A achieved the highest price at US$266.16/bale and variety C the lowest at US$256.08/bale. The study showed that blending seed cotton with this particular quality, the grower would benefit economically by blending variety A with C, with at US$265.82/bale the 80A/20C and 60A/40C at US$265.30/bale the most profitable blend ratios.

Yarn processing performance

Textile mills are focused on realization (output vs. input), and, as a consequence, many mills install elaborate systems to capture and accurately record waste figures from the various processes. To determine whether production levels and quality standards could be achieved, end breakages were recorded during the spinning process.

Unblended

Table 7 gives the percent waste and ends down for the two cotton varieties and their gin and mill blends. The amount of fibre loss/waste extracted from variety C was much higher, at 27%. As there were no substantial differences in terms of trash in the fibre from the two varieties, the difference between A and C are in all likelihood due to the fact that the fibre from variety C was coarser and shorter, the later probably explaining the higher waste. The number of ends down during the spinning process for variety C were substantially higher than variety A.

Blended

In terms of the gin blended fibre, there was no substantial increase in the percent card loss as variety C was blended with variety A. Surprisingly, there were much fewer ends down with the blends than for the unblended fibre from variety A and C, even though C was both coarser and shorter than A. Overall the best processing, in terms of card loss and ends down, was achieved with the 60A/40C blended fibre.

Table 4. Mill processing data

Code	Opening/Card Loss (%)	Ends Down (/1000hr)
A	19.8	96.9
C	27.0	171.9
80A/20C	25.3	43.8
60A/40C	22.3	29.2
40A/60C	23.0	43.8
20A/80C	20.2	64.6

Yarn quality

Unblended

Table 8 presents the yarn results for the A and C varieties and their four gin and mill blends. In order to spin medium staple cotton into an acceptable quality ring-spun, yarn a spinner needs at least 80 fibres in the yarn cross section (McCreight et al. 1997). The number of fibres in the yarn cross section was calculated as follows;

$$\text{Number of fibres} = \frac{\text{Tex x 25.4}}{\text{Micronaire}}$$

At 135 and 108 fibres in the yarn cross section respectively, varieties A and C, exceeded this minimum number of fibres for an acceptable 20/1 Tex ring-spun carded yarn.

There were considerable differences, in the yarn quality from variety A and C, in terms of yarn strength and the number of imperfections in terms of neps and thin places. Due to the fact that the yarn produced from variety A contained more fibres in the yarn cross section (due to its the lower micronaire value) and the fact that the fibres were longer and stronger it was anticipated that the yarn produced would be of higher quality than the yarns produced from variety C. However, interestingly, whilst the yarn from variety A was in fact the strongest (17.8 cN/tex), it was also the most uneven yarn, with more thick places and neps and the highest CV%. As noted earlier, the higher number of thick places and neps were in all likelihood due to the fact that the fibres were finer and more flexible and could be more easily bent, buckled and entangled during mechanical manipulation (as noted in the number of neps in the ginned lint as measured by the AFIS PRO).

Blended

There were substantial differences between the unblended and blended yarn results in terms of strength, evenness and the number of imperfections (thin and thick places and neps per km).

There was a trend for the average number of neps to decrease as the percentage of variety C increased, with the average number of yarn neps reducing from 245 to 163 per km. There was a similar, although not as clear, trend in terms of thick and thin places. The average number of thick places reduced as the percentage of variety C increased from 20 to 60%, with the average number of thick places reducing from 843 to 733 per km. However as the percentage of C increased to 80%, the number of thick places increased to 810 per km. The average number of thin places reduced as the percentage of C increased to 40 and 80%. This improvement in the yarn results due to blending variety C with A is not surprising as the yarn evenness results for variety C was better than that of variety A.

In terms of strength, there was a trend, with the yarn becoming weaker as the percentage of variety C increased, with the average yarn strength reducing from 17.76 to 17.32 to 16.34 to 15.90 and to 15.50 cN/tex in accordance with the blend ratio. This was not unexpected as variety C was both shorter and coarser than A and the yarn strength for variety C was lower than that of variety A. Overall, in terms of evenness and strength, the best yarn quality was achieved with the 80A/20C blended fibre.

Table 8. Yarn results for 100% vs gin blended.

Code	CV %	sd	Thick (+50)	sd	Thin (-50)	sd	Neps (+200)	sd	H	sd	Ten cN/tex	sd	El %	sd	CV% El	sd	CV% Ten	sd
A	18.9	0.5	843	121	73	23	245	32	5.7	0.3	17.8	1.5	5.2	0.4	6.6	1.2	7.8	2.1
C	18.5	0.7	689	142	89	42	153	25	5.8	0.4	15.0	1.5	5.0	0.4	7.5	1.4	8.8	1.7
80A/20C	18.2	0.6	667	119	57	35	171	41	5.6	0.3	17.3	1.5	5.0	0.4	7.3	1.5	8.1	1.6
60A/40C	18.6	0.8	734	153	76	38	180	43	5.7	0.3	16.3	1.4	4.9	0.4	7.5	1.5	7.8	1.6
40A/60C	18.6	0.5	733	120	70	26	164	27	5.7	0.3	15.9	1.5	5.0	0.4	7.1	1.1	8.3	1.8
20A/80C	19.1	0.6	810	148	105	40	163	34	5.9	0.4	15.5	1.5	5.0	0.5	8.3	1.6	8.8	1.6

Fabric quality

As mentioned previously, the colour of the fabrics was measured using a laboratory grade spectrophotometer, which measures colour based on the CIELab colour model. The CIELab model reports colour in terms of lightness (L*), white to black, (a*) redness to greenness and (b*) blueness to yellowness.

The average colour difference, designated as Delta E, was calculated, using the CIE76 formula, to determine the colour differences between the two varieties and the gin and mill blended fibre for the fabrics from the greige (fabric produced from yarn without any further processing) and the dyed processing stage.

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

The average Delta E values, as calculated using the above formula, for the greige fabrics produced from for varieties A and C was 3.6. It is universally accepted that a Delta E value between 2.0 and 3.5 is considered a medium difference which is noticeable to the untrained eye and that a Delta E value between 1.0 and 2.0 is considered a small difference which is only just noticeable to the trained eye (Mokrycki & Tatol 2011). These differences between the two greige fabrics was not entirely unexpected as the Rd and +b values for the fibre was also substantially different.

The Delta E, for the dyed fabrics produced from A and C was 1.7, this colour difference being barely noticeable to the trained eye. This was not unexpected as the scouring and bleaching process, prior to dyeing, is often able to reduce, or even eliminate, colour differences present in raw cotton.

In terms of the gin blended fibre, the average Delta E values, for the greige fabrics produced from variety A and blend 80A/20C was 1.0, for A and 60A/40C was 1.5, for A and 40A/60C was 2.2 and for A and 20A/80C was 2.8. These differences between A and the four blends became more noticeable to the trained eye, as indicated by the Delta E values, as the percentage of C was increased. The average Delta E values, for the dyed fabrics produced from variety A and blend 80A/20C was 1.8, for A and 60A/40C was 1.3, for A and 40A/60C was 1.4 and for A and 20A/80C was 2.0. All these colour differences would be barely noticeable to the trained eye.

CONCLUSION

There is considerable interest within the cotton producing industry to blend seed cotton at the gin for the benefit of both the grower and the textile mill. From a grower's perspective blending at the gin provides an opportunity to avoid discounts. From a spinner's perspective blending at the gin provides an opportunity to reduce variability. Although previous studies have shown that there were no significant economic returns for a grower when blending seed from various varieties or sowing different varieties in an alternating row configuration, the effect of blending at the gin on fibre quality was not clear. Furthermore, few of the previous studies determined what effect blending prior to the spinning mill had on textile processing performance and yarn and fabric qualities. This study was initiated to determine the effect of gin blending on fibre, yarn, and fabric processing performance and quality and the potential economic return to the grower.

As the biggest discounts are mainly for grade, length and micronaire, seed cotton with varying micronaire and length properties was blended at the gin in four different ratios (80/20%, 60/40%, 40/60% and 20/80%). This was done to determine whether there would be an economic advantage to the grower and what the consequence of gin blending would be on processing performance and product quality during textile processing. Gin blending benefitted the grower. The biggest economic benefit, when blending seed cotton with this particular quality, was obtained from the 80A/20C and 60A/40C blend ratios. This economic benefit was mainly due to the fact that blending at the gin had a significant effect on micronaire and fibre length - both of which play a major part in determining the value of cotton lint. These results were obtained using seed cotton as described in this paper. Results from blending seed cottons having different fibre properties could vary.

This preliminary study has shown that the overall processing performance and yarn and fabric quality of the gin blended product was seldom different from that of the superior quality cotton, indicating no serious consequence to the spinner. Hence the grower benefits financially and the spinner incurs no processing or quality issues.

However, despite the benefits, a word of caution is necessary. Firstly, this study was conducted on a small scale, where variables can be closely monitored and although the two varieties that were blended had different fibre properties they were still within the base grade. Secondly, the fibre properties of the varieties were known prior to blending by conducting small scale ginning and fibre testing. Blending varieties which are more variable may improve the economic return to the grower, but may result in processing performance and quality issues during textile processing which could damage the reputation of the growth and country of origin. Furthermore, blending varieties with different lint turn out can result in different blend ratios than originally intended. It is also clear that in order to achieve intimate and accurate blending, that a gin would need to install multiple module feeders.

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