Impact of Seed Quality and Crop Management Practices on Fiber Quality

Rob Jarvis, General Manager, Quton Seed Company, Zimbabwe

ICAC 60th Plenary Meeting, Technical Seminar Victoria Falls September 2001

Background

Cotton is a crop that is grown primarily for its fibre. The quality and uniformity of the fibre is vital to its marketability and destined end use. Good crops and sustained, reliable production of quality cotton can only come from an integrated technology system that is in balance with the environment and maximises the opportunity for the crop to convert sunlight into cellulose fibres with the desired characteristics. In Africa, cotton production is largely in the hands of smallholder farmers who are resource poor and lack credit facilities, access to inputs, training and skills to produce top quality crops. This paper explores the reasons why in Zimbabwe high quality cotton is produced by both large scale commercial farmers, who may plant 100 hectares or more of the crop, to smallholders who may only crop half a hectare or less. It examines the issue from the impact of variety and seed through production practices to the standards and strategies demanded and enforced by the growers' and marketing organisations.

Reasons for Poor Fibre Quality

Poor quality fibre has a number of causes and the major ones are listed below. In Zimbabwe, because of the disciplined historical development of the cotton industry and the recent influence of the National Cotton Council and various strategies put in place by the ginning and marketing companies, good quality cotton continues to be produced despite the recent introduction of a liberalised marketing environment.

Table 1: Causes of Poor Quality Cotton

Number	Reason for poor quality	Potential effect on quality
1	Poor choice of varieties for local environment	Low quality fibre, poor staple, strength, maturity, fineness, poor uniformity, high short fibre content, poor elongation, small bolls
2	Varietal admixture	Mixing of qualities
3	Field stress, e.g. nutrition, moisture, excessive weeds, season length, adverse weather	Weak and immature fibres, staining, grey colour
4	Disease incidence	Weak, immature and/or stained cotton
5	Pest damage	Stained, damaged seed cotton, weak immature fibres
6	Honeydew	Sticky cotton, poor processing
7	Contamination	Downstream processing problems and quality claims
8	Poor harvest techniques	Mixing of good seed cotton with poorer quality cotton, contamination with extraneous matter, poor hand picking
9	Poor delivery mechanisms	Mixing of varieties, grades, qualities
10	Poor seed cotton grading	Admixture, loss of uniformity
11	Poor ginning or excessively fast ginning	Poor preparation and eroding of key quality characteristics
12	Poor classing	Failing to identify key attributes

Each of the above potential causes of poor quality cotton is expanded upon below in explaining where Zimbabwe maximises the opportunity to maintain quality, purity and product integrity mainly through the supply of high quality seed, control of varieties, recommended production practices and adherence to industry agreed standards.

1. Varietal Choice

The single largest factor that contributes to the quality of the fibre produced is undoubtedly the choice of variety and the controls or discipline practised in the country to maintain a high standard. Zimbabwe has been fortunate to have a long standing breeding programme, conducted by the Cotton Research Institute (C.R.I.) in Kadoma. CRI is a commodity-based institute in the Government's Department of Research and Specialist Services in the Ministry of Lands Agriculture and Rural Resettlement.

This breeding programme makes use of a fully equipped fibre testing laboratory which is used to distinguish superior material right from the selection of single plants through to the extensive field testing of elite varieties. Over the years it has received additional support to Government funding from the textile industry, growers, the Cotton Marketing Board and its successor The Cotton Company of Zimbabwe. Today the Institute has been partially commercialised and it earns a royalty on seed multiplied by and sold through Quton Seed Company. Any new variety is thoroughly tested over a wide range of sites and a number of seasons prior to release. Lint output from multiplication crops is watched carefully during ginning and sent for full-scale mill tests before committing the variety to commercial production.

The breeders at CRI have always maintained close contact with the marketing organisations and even directly with end-users to make sure that any varieties grown commercially are thoroughly tested and produce the desired fibre qualities and mill performance.

In the 1960's when cotton production started to take off in the country, great efforts were made to ensure that the product was of as high a quality as possible because of the great distance from premium markets that Zimbabwe faces. There has been a steady improvement in the quality of fibre produced by the commercially released cultivars grown. These varieties today compete with the SJV and better Australian cultivars and have an advantage in most cases because the lint comes from hand-picked crops and mechanical damage in the ginneries is minimal. The National Cotton Council of Zimbabwe agrees the varieties to be grown and the geographical allocation of production areas. Quton and the ginning companies then ensure that the correct seed is distributed in the agreed areas.

The mainstream variety today, Albar SZ 9314 has high yield potential, a storm-proof boll and a lint out-turn of 42 to 43%. Its fibre quality is in the good medium staple category with the bulk of the crop stapling out at 1 1/8 to 1 5/32 inches. Albar quality is generally good with strength being in the 90-95 000 PSI bracket, micronaires in the premium range of 3,8 to 4,8 and the fibres being fairly fine and very mature. The hand-picked crop is not subjected to intense cleaning processes during ginning and the overall spinnability of the fibre is thus preserved. Dramatic improvements in lint out-turns have seen the ratio achieved in commercial ginning exceed 40% in recent years.

Zimbabwean varieties have resistance to Jassids and to bacterial blight. There are some available that are more tolerant to Verticillium wilt. These inbuilt traits allow the varieties to weather severe attacks of the pest or disease. Some show improved tolerance to aphid and red spider mite attack and to susceptibility to potassium deficient soils.

2. Avoiding Varietal Admixture: Maintaining Seed Purity

Varietal integrity is maintained by a robust seed multiplication scheme whereby every year a few kilogrammes of pure breeder's seed of each variety under multiplication is released to Quton from the Cotton Research Institute. This seed is used to grow one or two breeder crops that provide the seed the next year for a wave of Foundation crops. These are grown on large scale commercial farms that have

access to irrigation and the crops are closely monitored and rogued at flowering to remove off-types. Seed from Foundation crops is used to grow the Certified crop in the third season. This crop annually occupies in excesss of 10 000 hectares of commercial farmland. In practice once a new variety is released it can totally replace existing varieties within three seasons from a few kilogrammes of seed issued by the Research Institute.

Cotton production in Zimbabwe was initially embraced by the commercial farming sector. Most of their farming operations, and particularly planting, were mechanised and this needed smooth, acid-delinted seed to allow machine planting. The then, Cotton Marketing Board used to produce such seed at first on a concentrated sulphuric acid system that was replaced in 1969 with a dry hydrochloric acid gas plant. Acid delinting has several benefits that go along with the separation of good vigorous heavy seed from less vigorous, lighter seed that is more prone to pest and disease attack and that will give rise to weak crops with poor root systems and fragile superstructure. As smallholder farmers took to the crop more and more during the 1980's and 1990's they were also supplied with processed seed and have always paid for the product on a cost plus basis. This allows the seed industry to invest in research and development and in improved processing technology. Currently Quton operates a dilute sulphuric acid processing plant that has been in operation since 1995 and has the capacity to produce 9 000-10 000 tonnes of acid-delinted, fungicide treated seed every year.

By law, cotton planting seed sold in Zimbabwe has to be certified and is grown under a strictly administered seed multiplication scheme. Seed must be 99% pure and attain a minimum germination of 70%. Quton tries to operate within a more stringent standard of a minimum germination of 85% or more.

However in view of the ongoing land reform programme in Zimbabwe a large proportion of the forthcoming crop will be switched to small-holder farmers who have already been identified to have the requisite skills and access to inputs to grow high quality cotton and seed crops. They are all established producers on The Cotton company's input Credit scheme. The impact of this scheme, improved varieties and better rainfall conditions is illustrated in the attached Chart 2. Despite a much wider spread of cotton production into less suitable cotton areas (Chart 1), crop yields in the small-holder sector have been steadily climbing since the great drought of 1991/92 (Chart 2). They are now getting close to the exceptional result achieved in 1980/81 when a far smaller crop was grown by this sector.

The seed scheme has a number of in-built standards to ensure that only seed of the highest quality is produced. These include identification of the better growers, contracting known volumes, employing a seed inspectorate to physically check each crop for off-types, isolation and field husbandry and monitoring harvesting and delivery procedures and a seed cotton grading system that identifies good seed sources through the grade achieved. The scheme operates under the overall legislative requirements of the Seeds Act (Chapter 133), Seed (Certification Scheme) Notice of 2000 and the actual rules applied by Quton to its contracted growers.

Growers are supplied with new cotton packs to deliver their seed cotton and these are labeled in such a way that the shape identifies the stage of multiplication and the colour of the label, the variety.

Table 2: Zimbabwe Variety Pack Identification Labels for Seed Cotton

Variety and stage	Shape of label	Colour of label
Albar SZ 9314	Foundation square, Certified Triangular, Commercial rectangular	White
Albar FQ 902	Foundation square, Certified Triangular, Commercial rectangular	Grey
Albar BC 853	Foundation square, Certified Triangular, Commercial rectangular	Green

Albar AG 4869	Foundation square, Certified Triangular, Commercial rectangular	Blue
CY 889	Foundation square, Certified Triangular, Commercial rectangular	Red
LS 9219	Foundation square, Certified Triangular, Commercial rectangular	Red and grey

Processing through the ginnery and in the acid-delinting plant is done on a variety by variety basis with thorough cleandowns and inspections done between each run. Ginned seed is bagged in new grain bags and labeled according to the variety, stage, seed crop origin, ginnery and year of production. This coding will follow the seed through the acid delinting plant and the seed code will also indicate a particular batch number that can identify the year of processing, plant producing it, the shift and day processed.

3. Seed Quality: Minimising Field Stress and Optimising Crop Potential

Good crops can only come from good seed and in Zimbabwe extremely high standards are applied throughout the seed conditioning process to ensure that the resultant product sold to growers is of the highest possible quality and purity. Samples of ginned seed are drawn and checked for germination and vigour before processing. During delinting, the seed is treated with measured amounts of acid and temperatures monitored throughout the process. Residual acid is neutralised with calcium carbonate and the seed screened on a series of air screen cleaners and gravity tables to eliminate dust and any light seed that is usually less vigorous than the heavier seed. The seed is treated with a suitable fungicide and in some cases with an aphicide before bagging off for sale.

A continuous trickle sampling of the seed as it is produced is drawn and submitted to the laboratory for evaluation. Quton runs a registered laboratory and this submits one in ten samples to the Certifying Authority, Seed Services to check that results are within acceptable tolerances. All seed is subjected to laboraty germination tests according to ISTA rules and also to field vigour plantings at two sites before being passed for sale.

Good healthy, vigorous seedlings give the grower the best chance of achieving a high yielding, top quality crop. There are a number of factors that it is important the grower addresses to ensure that the crop has the maximum chance of achieving top yields. These include encouraging a good root system mainly through ensuring the crop is planted into a soil at or near field capacity at germination. With irrigation this is relatively easy. However, with the bulk of the small-holder crop it involves encouraging suitable crop rotations and early ploughing at the end of the preceding season thus allowing residual moisture carryover from one season to the next. Other practices to maximise potential include keeping the land weed-free, ensuring there are no undersurface impediments to root growth and that soil drainage is adequate. Early planting, to maximise season length, as much as it is practically and legally possible and employing moisture and soil conservation techniques that minimise run-off and maximise rainfall infiltration contribute significantly towards crop success. These include planting on rip-lines, permanent beds, ridge and ties, pot-holing and maintaining surface mulches from previous crops and planting directly into these.

The crops must be properly supplied with nutrients and kept weed-free especially during the first eight weeks post emergence. Growers in Zimbabwe have to pay particular attention to Potash and Phosphate requirmernts especially for the former on fersiallitic red clay soils and additional supplies may have to applied in the soil prior to planting. Potassium deficient soils will succumb to Alternaria leaf spot and will rapidly defoliate at boll formation and result in weak immature lint from the poorly filled bolls. Deep placement of potassium will eliminate this problem. Cotton specific fertiliser formulations are normally supplied to growers and these cover the crop's basic nutrient requirements of NPK as well as its Boron and Sulphur needs. Top dressing at first flower with ammonium nitrate is a common practice to achieve high

yields. Growers are aware of the dangers of over feeding with nitrogenous fertilisers and the timing of its application is usually done at the recommended times. Excessive nitrogen especially combined with adequate moisture can result in very rank unmanageable crops that result in downgrading of the seed cotton.

4. Minimising Disease Incidence

Inherent resistance or tolerance is the method most commonly used to minimise the effect of diseases upon crop yield and quality. In the case of bacterial blight, the diseases has been kept under control by a combination of inherited resistance and the hygiene effects of supplying only acid delinted seed to grow the commercial crop and adherence to the legislated earliest planting and crop destruction dates.

Verticillium wilt is a more complex problem and although tolerant varieties such as Albar BC 853 and CY 889 allow heavily infected fields to be cropped, this strategy has to be combined with suitable crop rotations, improved nutrition, soil drainage and hygiene to keep infection levels manageable. Cotton usually needs to be grown in rotation with cereal crops to avoid a severe build-up of the disease, especially on heavy clay soils. Cool wet seasons will invariably see an increase in affected fields and farms.

Alternaria leaf spot is usually associated with crops that are grown on soils deficient in potassium and by monitoring the proportion of potassium to total available bases in the soil farmers need to ensure that this is sustained above 3-5%. On most soils is sufficient to stop the crop from becoming pre-disposed to defoliation by Alternaria at peak boll formation. In recent years some variability in Zimbabwean germplasm has been identified for greater ability to extract potassium from otherwise deficient soils and by extension, they show tolerance to defoliation by Alternmaria.

Boll rotting fungi are usually encountered in very wet seasons and on early planted crops that ripen during the main rains. In most years, because of the tailing off of the rains during March and April, they are not a major problem.

5. Minimising Pest Damage

The practice of scouting cotton and spraying only on identifying a particular pest problem is well known and understood in Zimbabwe. The Cotton Training Centre in Kadoma has provided an invaluable service over the past twenty years in educating and training growers, farm workers, smallholder farmers and extension and agrochemical trade representatives in pest identification, scouting and integrated pest management techniques. Pest control strategies developed by the Cotton Research Instiitute try and take advantage of any predator populations that have built up, using inherited leaf hair to protect against Jassids and choosing the least offensive spray option when pest levels have reached economic threshold levels. Spray dosage levels are based upon using a rate that is effective when the pest is at its most vulnerable and at its most vulnerable stage. In the case of the ubiquitous bollworms, scouting is centred upon the eggs laid and spraying with low dosages to control the young larvae as they hatch. The strategy also includes using the most effective pesticides, such as synthetic pyrethroids when they are most required, i.e. during the flowering and boll formation phase. This coupled with pesticide management strategies to minimise the risk of pesticide resistance developing in Zimbabwe has been singularly successful.

Quton is currently marketing some seed treated with Cruiser (a neonicotinoid systemic insecticide) the main effect of which is to provide protection from aphids and some other soil and sucking pests during the first six to eight weeks post emergence. This inclusion of pest control and management systems in the seed is being pursued as a logical way of providing a better product to growers while improving their chances of achieving higher yields and harvesting better quality crops. Precise insecticide applications to the seed during processing or through breeding and biotechnology will in time take much of the guesswork and inherent risk out of the farmers hands. Today they have to contend with poor equipment, sometimes shocking supplies of water for the spray mix and constraints on time and supervision to make sure that the operation takes place both timeously and under optimal conditions. Even well applied insecticides can be completely negated by sudden heavy rainfall soon after application.

6. Honeydew

Although honeydew is usually a symptom of poor pest management, it is treated here as a separate item because of the very serious nature of the problem in the marketplace. Usually it is a result of either a late aphid attack or of whitefly infestation when the bolls start to split and they are contaminated with sugary exudates from these sucking pests. Honeydew is not a serious problem generally in Zimbabwe and this is a result of circumspect use of pesticides during the crop's life, especially the pyrethroids that are believed to encourage the population explosions of whitefly, and of not over-doing the application of nitrogen. Control recommendations are in place for both pests and accurate and timely scouting and preventative measures will normally ensure that they are not a problem.

7. Avoiding Contamination

Man made fibre are the scourge of the modern cotton industry. In Zimbabwe great efforts are taken to minimise the risk of foreign contamination of the crop. Every seed pocket sold to the farmer carries a message warning growers not to use polypropylene bags to harvest their crops. The ginning companies supply fertiliser in unwoven polythene bags which can be used to harvest the cotton crop later with minimal risk. They also supply the grower with polythene picking bags to help them harvest their crops and thereby minimise contamination risk. At the delivery depots strictly enforced penalty prices are paid for any cotton found contaminated with man-made fibres and other contaminants. Strongly worded warnings are exhibited at every depot at the entrance and the message conveyed at every opportunity to growers at field days and depot open days.

Cotton is delivered by the grower in jute packs and these are sewn up and labeled with cotton twine and labeled with cotton cloth to indicate variety. During seed cotton grading a careful watch is kept for contamination and during the emptying of packs on the mixing floor special teams of workers look out for contaminants. As a final check the automatic lint sample taken from each bale produced is again thoroughly checked for unwanted fibres.

8. Maximising Product Quality During Harvest

This is one area in Zimbabwe where the industry has taken a leading stance. Grower education is a continuous process and numerous field days and extension demonstrations are utilised by the marketing companies to achieve this. Growers are encouraged to harvest their crops, by starting early, using two polythene picking bags, one for clean cotton and the second for stained trashy or weak/immature cotton. They are encouraged to further check this cotton on grading tables before packing for delivery. Cotton is only picked after any dew has dried off and at weighing of each pickers out-ptu the cotton is checked for conformance to the grower's standards.

9. Zimbabwe: Delivering to Market to Maximise Lint Quality

Seed cotton is normally packed into the 200-kilogramme packs when ready for market. Seed cotton is checked for moisture content on delivery and only accepted if less than 12,5% moisture.

The packs are made out of jute and annually a huge exercise takes place at ginneries repairing packs to minimise contamination with dust through holes and to reduce the fraying of hole edges which can also cause unwanted contamination of the cotton.

10. Grading for Quality

The seed cotton is bought against nationally agreed standards that are approved each year and distributed to every buying depot. This has implications for seed quality and normally only the top three grades of seed cotton are accepted for seed crop purposes with the seed cotton grading system providing a good indicator of ginned seed suitability for processing for planting purposes.

The industry pays for a National Arbitrator whose job it is to visit depots during the buying season to see that standards are being maintained. He will also arbitrate in the event of a grade dispute and samples are kept from every pack of cotton bought for this purpose. He reports to the Arbitration Committee of the National Cotton Council and provides regular feedback on what is happening at the buying centres.

11. Ginning for Quality

The ginning process in Zimbabwe is almost entirely on saw gins. Several manufacturers are represented but there is an increasing trend to install higher capacity and fewer gin stands that are replacing or superseding the traditional five by 120 saw gin stand set-up. In general though ginning speeds in Zimbabwe are fairly slow and lint cleaners only used where absolutely necessary. The lint produced is relatively free of mechanical neps and ginning preparation good. Mechanical degradation of the fibre and excessive short fibre content are rarely excessive.

12. Classing for Opportunities

Great care has always been taken in classing the Zimbabwean crop. This has been done according to international (USDA) standards as well as by establishing Zimbabwean selling types. For several years the manual classing has been backed up by a 10-20% HVI testing of bales within each ginning lot. The main player in the Zimbabwean market, The Cotton Company has recently up-graded its HVI equipment installing the latest machines to achieve this.

Close liaison between the marketing companies, Quton Seed and the breeders at Cotton Research ensures that the promise of elite germplasm lines is indeed translated into improved fibre qualities in the lint product available.

The Future

There is no doubt that the Zimbabwean cotton industry has been built upon a very sound foundation with the resultant products of lin, ginned seed and planting seed being of very high quality. Although at present the country has not adopted new technology such as Bt and herbicide resistant genetically modified cotton, the legislation is in place and facilities, procedures and monitoring mechanisms are ready to test this technology on the ground. This will start this coming season. It is highly likely that these advances will offer significant improvements to growers and the industry. They will free grower's time to spend more effort on keeping crops better managed and producing even higher output and qualities. The systems and controls in place in Zimbabwe lend themselves to any labeling requirements stipulated by the world markets to identify this type of cotton. Or to continue to identify non-LMO cotton for that matter. However it does seem that genetic modification offers an extremely efficient method of delivering technology advances precisely through the seed. And when advances in fibre quality start to become available as they inevitably will, few countries will be in a position to ignore that opportunity to rapidly improve product quality.

Roots
Bacterial blight
Verticillium wilt
Weeds
Sunshine
Picking equipment
Crop destruction
Pests
Scouting
Spraying

Chart 1: Zimbabwe: Smallholder Cotton Plantings
In Hectares 1970 to 2004 (projected)