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Cotton Yields and Production Research

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The 1997/98 season is characterized by above-average prices with production and consumption nearly in balance at approximately 19 million tons. The forecast balance between production and consumption is not a coincidence, but reflects an underlying relationship fundamental to the world outlook. World production is being held in check by farmers' difficulties in raising yields, and growth in consumption is affected primarily by tightness in cotton supplies in the world.

Central to the outlook for prices is that 1997/98 ending stocks outside China (Mainland) are expected to remain tighter than usual relative to use. Combined with further reductions in the use of barter by exporters in Central Asia, the tightness in forecast stocks suggests that the Cotlook A Index will remain above the average maintained from the mid-1980s through the early 1990s of 67 cents per pound, and higher even than the average during the 1970s and early 1980s of 76 cents. However, cotton imports by China (Mainland) may decline in 1997/98, alleviating some of the upward pressure on world prices. Current projections suggest that the Cotlook A Index will rise from an average 79 cents per pound in 1996/97 to 80 cents in 1997/98.

Worldwide, cotton consumption is rising, but by less than the rate of population growth. Consequently, per capita cotton consumption is declining, and cotton is losing market share to chemical fibers. Cotton's share of world textile fiber mill use fell from 50% in 1986 to 45% in 1995, and further erosion is likely.

World cotton mill use is rising to a record of 19 million tons in 1996/97 and further growth is forecast for 1997/98, after a decade of no growth at about 18.5 million tons. Most of the growth is occurring in India and Turkey. Mill use is also rising this season in China (Mainland), but not to a record level, and North American mill use is climbing to a record. Mill use is declining in East Asia and Europe, but gains are occurring in Africa and the Middle East. Improvements in technology are raising the proportion of total yarn production costs accounted for by cotton alone, and mill use is tending to move to regions that produce cotton. The proportion of world cotton mill use accounted for by the ten largest cotton producing countries rose from 55% in 1984/85 to 70% this season.

Economics of Cotton Production

In the recent past two major factors had a significant impact on the economics of cotton production. They are extensive use of agrochemicals and yield stagnation. Among all agrochemicals, fertilizers and insecticides are of utmost importance. There are no efficient alternatives to synthetic fertilizers and cotton production has to bear the use of nutrient supplements in the form of inorganic fertilizers. At least there are two good things about the use of synthetic fertilizers versus the other major group of agrochemicals i.e. insecticides. Synthetic fertilizers are not expensive and they are also not as harmful to the environment as insecticides. In addition to meeting plant needs, synthetic fertilizers have played a great role in manipulating the cotton plant for utilizing its maximum potential. Large increases in yield, occurred in every country of the world, can directly be attributed to fertilizer use.

Among pesticides, insecticides is another group of agrochemicals which is extensively used on cotton, though herbicides are also commonly applied to cotton in Australia, Colombia, Cote d'Ivoire, Greece, Israel, Spain, Syria and the USA. During 1970s and 80s, the use of insecticides increased tremendously in almost all cotton producing countries of the world. Insects, being living organisms, adjusted with the injurious chemicals and learned to survive with insecticides. Consequently, insecticide use kept increasing causing a serious impact on the economics of cotton production. While countries like Australia and China (Mainland)

are faced with insecticide resistance problem, some Central American countries had to stop cotton production because of inability to control insects. Australia has been able to overcome the problem to some extent and control the use of insecticides through an effective resistance management program. China is currently implementing a resistance control program and yield increases in 1995 and 1996 could be attributed to success of the program. I wonder if two other major cotton-producing countries, i.e. India and Pakistan, will be launching similar programs in the next few years.

Currently, there is a greater need for new developments in production research but more and more researchers are confronted with maintaining the current status of yields in their countries.

Stagnation in Cotton Yields

A very straightforward statement is that world cotton yields are not increasing any more. Lack of growth in world cotton yields since 1991 reinforces the impression that the world cotton industry has entered into a long-term period of slow growth in production. Apparently, the stagnation in cotton yields is attributed to specific difficulties affecting productivity in several of the largest producing countries of the world. But, it has scientific reasons. Situation of cotton yields in the 10 largest cotton-producing countries is given here.

In the USA, cotton yields were almost flat during 1960s & 1970s ranging between 500 to 600 kg/ha. Cotton yields rose to 790 kg/ha during the 1980s on account of better plant protection against vagaries of the pests. Over the last nine years, cotton yields have not increased in the USA. Looking at the cotton growing conditions at world level, it is observed that cotton production conditions have been comparatively more steady in the USA compared with the largest cotton producing countries of the world and yet yields have not increased. The trend line shows the behavior since 1991/92.

In China (Mainland), during 1980/81 the average yield was 550 kg/ha. The average yield rose to over 900 kg/ha during 1984/85, which was exceptionally high. The 1991/92 average yield stood at 867 kg/ha and since then there has been no increase in yields in China. Cotton production has seriously been affected in the Hebei and Shandong provinces, as it has become extremely difficult to control the cotton bollworm. Consequently, cotton production has fallen by about 60% in both provinces since 1991/92. Cotton production has moved to the west and some new areas have been brought under cotton production. Anyhow, the trend line since 1991/92 shows that there is no increase in cotton yields in China.

India had a record crop during 1996/97 and produced over 2.8 million tons, partly attributed to higher yields. The average yield was 322 kg/ha, which is also a new record. According to recent ICAC estimates, India may not be able to sustain the same productivity level during 1997/98. The average yield is expected to be 312 kg/ha with a total production of about 2.6 million tons. India is one of the few countries where the trend line still shows a slight increase in yields meaning thereby that the full potential has not been utilized yet. What the limit is under current growing conditions is not known.

In Pakistan, the production problem is more apparent compared with other countries. Highest yields were achieved during 1991/92 and since then there has been no increase in yields. Rather, how much less than 1991/92 has become more important. The leaf curl virus disease is a difficult problem to tackle. There is no chemical defense against the disease and genetic resistance is not available, though varieties vary in their level of tolerance. A multidimensional approach has been followed and ICAC is also helping to produce transgenic cotton resistant to the disease.

The fifth largest cotton producing country of the world is passing through a transitional period of structural changes which have affected cotton yields. In 1980/81, the average yield in the Central Asian countries was as high as 890 kg/ha. After 16 years, during 1996/97 the average yield in Uzbekistan was 714 kg/ha. On account of expected better weather conditions and organization of input arrangements, the average yield may rise to 786 kg/ha, significantly less than in early 1980s.

Cotton yields in the five other largest cotton producing countries of the world i.e. Argentina, Australia, Egypt, Greece and Turkey, are not increasing either with the exception of Turkey. In Turkey, extension in the irrigation system may have contributed to an increase in yields.

The ten largest cotton-producing countries mentioned here constitute about 85% of world production. The trends in these countries show that cotton yields have stagnated.

Why Cotton Yields Have Stagnated?

Yield improvements come from technological innovations including genetic improvements in the plant. Unfortunately, the mechanism of genetic determination of yield is not properly understood in cotton and may be true for other crops. Breeders and geneticists do not have control over inheritance of hereditary material. The nature of genetic control of yield or factors responsible for determination of yield does not permit breeders to manipulate the plant genetics according to their wishes. It seems that the available technological innovations have been utilized and consequently yields have stagnated.

Yields vary among countries because growing conditions and levels of adoption of production technology are different. Given the limitation of growing conditions and adoption of technology, the available options have been utilized in most countries. This includes the world's highest yielding countries like Australia and Israel that apparently do not have limitation of physical and technical inputs and yet yields are not increasing.

How Cotton Yields Could Be Improved?

Currently available technology has been utilized and consequently yields have stopped growing. Cotton producing countries that have not utilized the technologies to their fullest extent have a chance to improve yields. Further perfecting the technology can also bring in slight improvements in yields. Slow growth in some countries may be coming from similar improvements. But, for any significant increases in world yields, like the one achieved during the last 2-3 decades until 1991, there is a need to invent new technology. This technology has to be different from the routine work done to develop varieties, assess agronomic requirements of varieties, control insect pests, etc.

At this stage, it is not known what the new technology is. But, it is certain that the cotton plant has a huge genetic potential for yield and only a part of it is utilized. The target could be to increase the number of bolls equal to the number of leaves on the plant. How to get there is an issue for researchers.

Role of Genetic Engineering

Recent advances in the field of genetic engineering have provided an additional tool in the hands of breeders and geneticists for directed breeding. The technology provides induction of non-species genes into the cotton plant and utilize them generation after generation. Single or multiple genes can be identified in the relative and non-relatives of the cotton plant, isolated and fused into the cotton genome. The effect is permanent and stable. One such example is Bt cotton wherein a gene from the soil bacteria was inserted into the cotton plant for obtaining resistance to bollworms particularly the tobacco and cotton bollworms.

Genetic engineering technology through the insertion of a specific gene intensifies a particular aspect of the plant mechanism. In the case of currently available Bt cottons, endotoxin for resistance to bollworms and to avoid cell injuries due to specific herbicides are available. During 1996/97, Bt cotton was grown on about 800,000 hectares in the USA and about 30,000 hectares in Australia. It is also expected that Bt cotton resistant to bollworms be planted on about 1.2 million hectares in the USA during the current season. Bt cotton resistant to herbicides may be grown on over 100,000 hectares in the USA. Directed breeding has tremendous prospects. It is expected that genetic engineering will play a major role for bringing improvements in cotton yields.

Improve Photorespiration

During the process of photosynthesis, carbohydrates are formed from water and CO_2 absorbed from the air. Some plant species are capable of utilizing all the carbohydrates and are called C_4 plants. Some plant species, including cotton, are unable to utilize all the amount of carbohydrates formed during the process of photosynthesis and are called C_3 plants. The unutilized carbohydrates are either burnt or released into the atmosphere. C_3 plants usually grow at a slower rate. Cotton is a C_3 plant and photorespires about 30% of the photosynthetic rate. If cotton is converted from C_3 to C_4 there may be a large increase in yield.

Fiber Quality

Unlike many other agricultural commodities, the price of cotton is based on quality. The value of cotton fiber can be improved and the economics of cotton production improved by accurate measurement of fiber quality. Once the quality is there its accurate and reliable measurement not only improves the confidence in marketing but also provides best use of fiber properties. Reliable methods of length and strength measurement are available but they are slow. Micronaire, one of the third most commonly measured fiber characters, is not a true reflection of either fineness or maturity. A lot of work is going on to use image analysis for maturity measurement and integrate it with the other efficient systems. But, one of the recent achievements in the field of quality measurement is the invention and commercial use of High Volume Instrument (HVI). As of early July, about 1,000 partial and complete HVI systems are working in 63 countries of the world compared to only 30 at the start of the previous decade. About one half of the total HVI units are installed in mills, ¼ used by the USDA in classing of cotton while ¼ are used by all other segments of the cotton industry including research institutes. Since 1992, all cotton in the USA is classed on HVI and one day all cotton in the world may be tested on HVI.

Maintenance of standard laboratory conditions at 70°F ±1°F temperature and 65% ±1% RH is very critical for reproducibility of results. Until 1993, samples had to be conditioned for 48 hours before testing. Now, the Rapid Conditioning Unit has reduced the period to only 5-10 minutes. The recent HVI units are capable of measuring six different characters (length, strength, micronaire, color, elongation and trash content) in about 21 seconds.

Advanced Fiber Information System (AFIS) is another area of significant achievements. Since the late 1980s, about 360 AFIS units have been installed in 40 countries around the world. AFIS has several different models for measuring a single or two characters at the same time. AFIS is complementary to HVI and capable of measuring individualized fibers, neps and trash.

High speed and automation of cotton processing in the textile industry demand more improvements.