Cotton Production Systems - Need for a Change in India

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The views expressed in this column are his own and not that of Cotton Association of India)

India has the largest cotton acreage in the world with 35 to 36% of the global acreage of 32 to 33 m hectares. While the area in India has been increasing continuously over the past 10 years, it is on decline in several countries including the major cotton producers such as China and the USA. As a result India is now poised to become the world's largest cotton producer. Though India cultivates cotton in 36% of the global area, it contributes only 25% of the global production of 26 million tonnes. It is matter of concern that the productivity continues to be low in India at an average of about 500 to 568 kg per hectare over the past 5 years, despite the wide-spread adoption of some very advanced technologies such as 'hybrid cotton' and 'Bollgard-II' at more than 90% of the acreage in the country over the past 5 years. There is thus an imminent need to examine and explore for ideas and technologies that can enhance the yields in India. More importantly, the reasons for low productivity in the 100% irrigated area of Punjab, Haryana and Rajasthan must be examined and remedied. This article is an attempt to analyse the current imbroglio and suggest possible solutions for the low productivity in the country.

EXPERT's Column

Dr K.R. Kranthi

Input issues and possible solutions

Cotton is a labour intensive crop. Currently more than 95% of the cotton area in India is under Bt-hybrids. Hybrid seeds are planted in a grid of 90x60 cm or 90x90 cm in rainfed farms and 90x90 cm or 90x120 cm in irrigated areas. The grid can vary under different conditions and requires intensive labour for marking and dibbling. On an average, a total of about 100-110 man-days are required for one hectare cultivation to include all operations such as sowing, weeding and harvesting. Inputs such as seeds, fertilizers, pesticides and water are other key factors that determine productivity. One packet of Bt cotton hybrid seed costs Rs. 950 per packet of 450 grams Bt-hybrid seed + 120 grams non-Bt cotton seed. For normal spacing of 90x90 cm, 4 to 5 packets are required per hectare. Irrigated cotton generally requires more fertilizers, extends over a longer duration of 180 to 240 days and attracts more insect pests, thus necessitating the application of more pesticides. Surveys conducted by CICR show that the usage of fertilizers and insecticides has been increasing over the past 8 years. Estimates show that 0.9 to 1.2 million tonnes of fertilizers were used per year for cotton cultivation during 1990-2000. The usage increased rapidly to 1.8 million tonnes by 2007, mainly due to the increase in acreage of hybrid cotton from 38% in 2000 to 70% in 2007. Fertilizer usage increased to 2.0 to 2.5 million tonnes by 2013 especially after the rapid spread of hybrid cotton and all across North India during 2006 to 2013. The cost of seeds, fertilizers, insecticides and labour increased to more than double over the past

Table 1. Global cotton production & productivity 2013

	*Area M ha	Production M bales (170 kg)	*Productivity kg/ ha	Irrigation %
India	11.7	39.09	568	40
China	4.9	40.98	1422	90
USA	3.05	16.52	921	40
Pakistan	3.0	12.15	689	100
Brazil	1.12	9.98	1516	2
Australia	0.44	5.3	2047	74
World	32.77	151.51	786	73
World (excl. India)	221	1189	907	90

**Source: USDA -Cotton: World Markets and Trade July 2014.*

6 to 7 years compared to previous years. The market prices of cotton were above the minimum support price over at least the past 8 years, primarily because of export of raw cotton and increase in the domestic use by the textile industry. The increase in market price to an extent of Rs. 6500 to 6800 per quintal raw cotton during 2011 led to an increase in the cotton acreage by an additional 0.8 to 1.0 million hectares during the subsequent three years. However, the domestic market prices have declined in recent months, presumably due to a possible decline in export of raw cotton.

Introduction of Bt cotton in India in 2002 led to a significant decline in the insecticide usage on cotton from 1.0 to 1.2 kg/ha (prior to 2002) to 0.5 kg/ha by 2006. But, increased infestation of whiteflies in North India and whiteflies, thrips and leaf hoppers across the country necessitated intensive application of insecticides in the subsequent years, especially during 2013 and 2014. The rapid introduction of more than 1000 new cotton hybrids after 2006 and the increase in the area of hybrid cotton from about 45% in 2006 to 95% in 2013 quite possibly led to increased infestation of sap-sucking insect pests and the concomitant insecticide usage to 11,598 M tonnes (0.9 kg/ha) by 2013.

Interestingly, the nitrogen use on cotton in USA has been about 0.4 to 0.5 million tonnes per year over the past 50 years but the yields increased over the years. The use of nitrogen fixing crops such as alfalfa, soybean, cowpea, peas, field beans, rice bean and other legumes in the cotton cropping systems greatly helped many countries to reduce the application of chemical nitrogen fertilizers. Additionally, these crops provide excellent support systems for naturally occurring biological control of insect pests. Other strategies such as conservation tillage, crop residue recycling and application of organic manure has helped in enhancing the soil organic carbon content and efficient utilisation of nutrients. In many parts of India, crop residues are burnt. Currently cotton is grown as a mono-crop and cropping systems are commonly devoid of leguminous crops. There is an imminent need to strengthen research in these areas so that nutrient efficient cropping systems should be developed to reduce the additional need for chemical fertilizers. Such systems which build and conserve organic residues containing adequate micro-nutrients not only assist the cotton crop to utilize macro-nutrients more efficiently but also help plants to combat sap-sucking pests and diseases in a very effective manner. Thus, with well defined cropping

Table 2. Insecticide usage on cotton

	Quantity of insecticides in Metric tonnes					Cotton Area and Yield			
Year	Sucking pests	Bollworms	Other pests	Total insecticides on cotton	Total insecticides	Total area lakh ha	Bt area lakh ha	Bt area %	Yield Kg/ha
2000	3716	6647	625	10988	30120				
2001	3312	9410	454	13176	34910				
2002	2110	4470	283	6863	25962	78	0.294	0.38	331
2003	2909	6599	537	10045	32571	77.85	0.931	1.2	387
2004	2735	6454	178	9367	35432	89.2	4.985	5.59	463
2005	2688	2923	302	5914	32750	88.17	10.148	11.51	468
2006	2374	1874	375	4623	31363	91.73	34.61	37.73	519
2007	3805	1201	536	5543	35807	94.39	63.34	67.1	567
2008	3877	652	528	5057	26624	94.06	76	80.8	524
2009	5816	500	410	6726	35404	101.52	83	81.76	486
2010	7270	249	366	7885	36761	111.41	101.2	91.54	495
2011	6372	222	234	6828	34469	121.91	112	91.87	496
2012	6872	178	184	7234	42595	115.53	108.86	94.23	552
2013	11366	121	111	11598	45500*	119.78	114.58	95.66	567

**estimate data compilation: Dr K. R. Kranthi and Dr A. R. Reddy, CICR* system strategies it can be possible to reduce the application of chemical fertilizers and pesticides in cotton ecosystems.

Yield enhancement and effective pest and disease management

In 2013, China produced 6.96 million tonnes from 4.9 million hectares with productivity of 1,422 kg/ha, while India managed to produce 6.64 million tonnes from 11.7 million hectares with an average productivity of 568 kg/ha. Interestingly, India has about 4.9 million hectares under irrigation which is actually equivalent to the total cotton acreage of China. Why does India produce only 3.3 million tonnes from its irrigated area of 4.9 million hectares compared to 6.96 million tonnes from an equivalent total area in China? It is certainly an issue to ponder as to why the productivity is low in irrigated regions of India, despite being saturated with a high yielding technology such as hybrid cotton, and that too incorporating Bollgard-II which very effectively controls bollworms.

Analysis shows that the low productivity in India could be mainly because of the fact that many of the currently cultivated hybrids are inherently designed to perform best under high input conditions of fertilizers and pesticides. However, farmers have been unable to properly apportion inputs in a timely and appropriate manner, thus resulting in lesser yields. It is important to note that long duration varieties or hybrids are not ideally suited for rain-fed tracts, which suffer from severe soil moisture deficit during the boll formation stage. Unfortunately, majority of hybrids currently under cultivation in rainfed tracts of India belong to the category of long duration. To complicate the problem, spurious seed in the market and spurious pesticides also lead to low yields.

Low yields in rainfed farming systems are primarily because of the cultivation of late maturing varieties that enter into reproductive stage of flowering and boll formation to coincide with moisture stress especially in shallow and marginal soils after withdrawal of monsoon. This phenomenon becomes more severe under late sown conditions. In late maturing varieties and hybrids the crop period extends to 180 to 240 days with the vulnerable reproductive phase that extends over 80-90 days especially in hybrid, wherein the expectations are 80-100 bolls per plant in the existing low density systems of 11,000 to 15,000 plants per hectare. Such systems also create severe moisture stress during the reproductive phase of the crop, thus leading to poor boll retention. It is also important to note that the crops needs about 2 to 3 mm water per day during vegetative phase and 6-7 mm per day during reproductive phase. Unfortunately under rain-fed systems, water availability is un-necessarily high during vegetative phase and very low at less than 2 to 3 mm per day during the reproductive stage. The most effective strategy is to cultivate early maturing varieties of 150 days duration under early sown conditions in rain-fed farms. Reproductive phase in such plants coincides with adequate availability of soil moisture and thus yields can be enhanced. Early sown -early maturing varieties also help the plants to escape bollworm peaks. For example, the American bollworm peaks in central and south India occur in September and October and the Pink bollworm infestation starts in winter during late November. Early maturing varieties when sown by the second week of June develop mid-stage green bolls by mid September which are not very amenable for damage by American bollworms. Such crop is harvested by late November and thus escapes the pink bollworm and also the spotted bollworm. The vulnerable window for bollworm attacks is actually about 20-25 days in early maturing compact varieties under high density planting systems (about 167,000 plants per hectare) with expectations of 5-6 bolls per plant. In the less likely possibility of bollworm infestation during the vulnerable reproductive phase, the recent introduction of new insecticides provides robust pest management options. The availability of a few new insecticides such as Chlorantraniliprole, Flubendiamide, Spinosad and Emamectin benzoate, has provided excellent option of controlling bollworms very effectively with just one or two sprays during the vulnerable window period. Thus pest management becomes much simpler in early sown early maturing high density cotton. It is also important to note that avoidance of synthetic pyrethroids helps in preventing the American bollworms and whitefly infestations.

In North India the productivity is low despite 100% irrigation, primarily due to the cultivation of bushy varieties or hybrids under low density conditions. In the early vegetative stage plants put forth excessive vegetation and exhaust soil nutrient reserves, which become deficient during the reproductive phase with poor source to sink ratio for boll formation when the plant needs nutrients the most. There are several other yield limiting factors, but poor harvest index in north India is one of the major reasons for low yields. Thus, early maturing varieties with high harvest index can enhance yields in North India.

The occurrence of whiteflies and the whitefly transmitted leaf curl virus are problems that need effective solutions. It is commonly known that whitefly infestations are easily aggravated by insecticide usage. Several countries rely on simple solutions of appropriate cropping systems with legume crops to strengthen biological control, application of organic manure, vermi-composting, proper micronutrient management and sprays of KCl that help cotton plants to combat the whiteflies instead of worsening the problem with insecticide applications. Late sown crop suffers high level of the disease. Therefore, the most effective strategy to combat the dreaded cotton leaf curl virus (CLCuV) in north India is to take up early sowing of early maturing varieties that tolerate CLCuV to ensure effective escape from the disease.

Our experience with implementation of high density planting systems in small scale farming systems showed that with the existing systems, farmers are unable to maintain a 10 cm distance between plants within each of the rows spaced at 60 cm between rows. Therefore machine planting is essential to maintain proper spacing to obtain high performance from the high density crop. Also, machine harvesting is the best possible option for high density planting systems, since the height of the plants rarely increase over 100 cm, a condition that is best suited for machine pickers.

Conclusion

High yields can be obtained with low chemical (fertilizer and pesticide) input usage and efficient pest management can be achieved with minimum intervention by exercising simple strategies which are being followed in several countries across the globe. To achieve such stable sustainable cropping systems in India, it is essential to develop robust compact early maturing varieties that are resistant to sap-sucking insects and amenable for high density planting. This is certainly feasible in the near immediate future. It is also important to strengthen research to devise nutrient-efficient cropping systems in high density planting for effective pest management and soil carbon and nutrient enhancement to obtain high yields in a sustainable manner.

Courtesy: Cotton India 2014