Triple Techniques to Relieve Critical-time Stress of Cotton Plants to Maximize Bio-resource Output and Farm Returns

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Abstract

Cotton is grown under irrigated as well as fully rain-fed conditions. However, prolonged water stress at boll maturity and fiber development stage often causes yield reduction and produces poor quality fibers. Besides, heavy infestation by weeds also cause crop loss with adverse effect on fiber and seed quality. The third stress is caused by severe pest attack like bollworms. Transgenic Bollgard (BG) cotton provides protection from bollworms by providing a self-defense mechanism to the cotton plants. However, it is not easy to grow Bt-hybrid cotton, preferably BG-II versions. The paper recommends triple techniques to relieve critical-time stress of cotton plants to maximize bio-resource output and farm returns. Triple techniques include circumventing critical moisture stress period on cessation of rainfall, effectively eliminating severe stress caused by weed competition, and use of BG-II version against bollworms based on research-based recommendations.

1. Introduction

Cotton is grown under both irrigated and fully rain-fed conditions. Rain-fed cotton accounts for 6 mha (about 60%) of the total area under cotton in India. Nearly half of the rain-fed cotton is grown in areas with assured or moderately good rainfall. Unfortunately, even in such areas, often monsoon becomes erratic with one or more prolonged dry intervals may be at seedling or crop maturity stage. Prolonged water/ moisture stress at boll maturity and fiber development stage is often detrimental causing yield reduction and poor quality produce lacking in maturity, fineness and strength of fibers. It normally occurs during cessation of seasonal rainfall. There is a remedy by joint action of a group of farmers which can increase yield level by at least 50-60%, besides protecting crop from environment-induced damage in fiber quality parameters.

Other major setback is created in cotton field during first 60-70 days of crop growth and even at later period when cotton crop is grown taller. Causes are heavy infestation by weeds, which if neglected or improperly managed can cause not less than 30-35% crop loss with adverse effect on fiber and seed quality. Negligence to eliminate weed flora at initial stage, inefficiency of crop management (not enabling the crop to intake nutrients applied), and inefficient control of sucking pests resulting from heavy weed load will cause diminished returns and loss of profit. There is a remedy for this also at affordable cost, and keeping fields free of weeds all through the crop season can swell the yield levels. One year's efficient weeding leads to freedom from heavy weeds for subsequent seven years as per the time-honored global proverb. This is common for both rain-fed and irrigated cotton crop.

The third stress is caused by severe pest attack like bollworms, which can cause huge loss in conventional hybrids to the extent of 25-40%. Now, the transgenic Bollgard (BG) cottons (BG-I followed by BG-II cotton hybrids) which ensure perfect protection from bollworms by providing a self-defense mechanism to the cotton plants represent a boon to the cotton farmers. However, it is not easy to grow Bt-hybrid cotton, preferably BG-II versions, now-a-days. Farmers have to follow integrated pest management (IPM) and integrated resource management (IRM) practices recommended by Central Institute for Cotton Research (CICR), Nagpur, Maharashtra and State Agricultural Universities in the cotton growing states of India. This would ensure maximization of boll number plant^{-1} and its full retention with good development of fiber and seed. This is also common for both irrigated and rain-fed cotton crops.

The paper recommends triple techniques to relieve critical-time stress of cotton plants to maximize bio-resources output and farm returns. Triple techniques include the following:

a. Circumventing critical moisture stress period on cessation of rainfall,

b. Effectively eliminating severe stress caused by weed competition, and

c. Use of BG-II (and later on BG-III when made available) versions against bollworms based on research-based recommendations.

2. Circumventing Critical Moisture Stresses

Though cotton is considered as a crop of the tropics with inherent drought tolerance, it also requires relatively considerable amounts of water for its successful cultivation. Normally cotton requires some 25-40 acre inches of water. Two most important challenges of our future society will be water and power/energy. To produce one kg of cotton with varying to best management practices, some 7000-29000 liters of water is required. Biotechnology and genetically modified (GM) cotton provide scope for growing cotton with less water, and growing cotton as an organic produce is also gaining momentum in such environments.

Mopping up water needs for rain-fed cotton

There is rarely any source of underground water to irrigate the crop especially at the fag-end of the rainy season or just a little after rainfall cessation. Our methods of cultivation, land holdings and soil management are such that farmers are not able to make the best use of total rainfall for crop production. That is to say that if efforts are made to utilize the rain water by collection, conservation and recycling for providing one or two protective or supportive irrigations, the yield advantage could be very significant to dramatic. Following is the total rainfall normally received from south-west monsoon (June to October) by the major rain-fed cotton areas in India:

a. Vidarbha region in Maharashtra state comprising nine districts with over 1.6-1.8 mha under cotton receives about 900-1200 mm rainfall year^{-1} with concentration in south-west monsoon period.

b. Marathwada region of Maharashtra state with fewer districts than Vidarbha having over 100,000 ha under cotton enjoys an annual rainfall of some 700-900 mm.

c. Karnataka state's rain-fed cotton region receive not less than 550-900 mm of annual rainfall, and has scope for harnessing the excess rains at some stage or the other for recycling it to cotton.

d. Gujarat state, which also has a sizable area under fully rain-fed cotton, enjoys varying rainfalls just adequate in many regions to harvest the surplus run-off water and reuse it or adopt other methods of water conservation in the soil to reap the maximum dividends. Gujarat can be considered as a model state for technology adoption including rain water conservation for effective soil moisture status for crops because of which the state's yield levels are very high compared to other states. However, there is a great scope for improvement in the approaches to conserve and reuse rain water.

e. Some regions in Andhra Pradesh state like Adilabad, Kammam, etc. offer similar scope.

CICR Nagpur has very effectively demonstrated the potential for rain water harvesting and recycling for cotton crop during stress conditions either at fag-end of the rainy season or sometime after full cessation of monsoon. CICR Nagpur has demonstrated the potential for rain-water harvesting, saving and recycling especially in Vidarbha region, and farmers of the region should unite to form small rain-water harvesting co-operatives with support and guidance from state agricultural department, CICR Nagpur and Dr PDKV Akola to reap the benefits of effective utilization of rain-water by harvesting the run-off and increasing the cotton yields especially that of Bt-hybrid cottons. Marathwada region too can exploit this advantage.

3. Alleviating Severe Stress by Weed Competition

Very common weeds which occur in the cotton fields are *Amaranthus viridis*, *Echinochloa* sp., *Trianthema portulucastrum*, *Eclipta alba*, *Digitaria* sp., *Panicum repens*, *Cyanodon dactylon*, *Parthenium* sp., *Cyprus rotundus*, *Convolvulus arvensis*, *Abutylon* sp., and a host of others.

Weeds start growing right from the time of sowing or even before the sowing time. Weeds compete with cotton crop aggressively at initial stage itself and deprive cotton plant from full utilization of the applied nutrients and available soil moisture. Often weeds make cotton crop stunted in un-weeded fields, and also harbor pests and diseases that affect the cotton crop. A good example is the mealy bug which has several alternate hosts in weed flora.

Cotton grows slowly during early periods and hence may be shaded out by weeds. If weeds begin to overpower the seedling cotton, significant reductions in yield may result. Later in the season, cotton leaves fully shade the ground and suppress mid-to-late season weeds. Sometimes the latter stage weeds also can affect the developing bolls. Hence weed control is focused on providing a 6-9 weeks weed-free period directly following planting. Farmers employ huge labor force for removal of weeds three to four times in the crop period at high cost. Of late, wage rates have increased and there is also shortage of rural labor especially women-folk for weeding and harvesting. Close cultivation is done and seeds are planted by dibbling deep into moist soil, and leaving weed seeds in high and dry soil. Herbicides are used by some progressive growers along with repeat inter-cultivation that enables to control weeds between the rows. Within the row, manual weeding is essential.

Fluchloralin at 1.0 kg a.i. ha^{-1} or Pendemethalin at 1.5 kg a.i. ha^{-1} as pre-planting application has been found useful. Glyphosate 41SL/71WS can also be applied using a conical hood to direct the spray carefully on the weed flora. Monsanto is offering Roundup Ready Flex herbicide tolerant cotton with potentiality for use of the herbicide in a flexible manner for cotton crop in USA. The same may be available in India in a couple of years and it is reported to protect cotton crop from weed flora in a significant manner relieving the cotton plants to grow and yield well without stress from weed competition and growth suppression. Major Indian seed companies also pursue

this objective aggressively in a collaborative mode.

4. Remedy for Severe Stress from Bollworms

Many of cotton's insects feed on squares and bolls which causes direct yield reduction and leads to delay in crop development, often into the frost or rainy season. Bollworms as a class are serious pests of cotton ever since cultivation of American cotton and hybrids expanded in area and output. These pests are Gram caterpillar or American bollworm (*Helicoverpa armigera*), Spotted bollworm (*Earias insulana* and *E. vitella*) and Pink bollworm *(Pectinophora gossypiella*) which occur one after the other in early to mid-late stages of boll production and cause inestimable damage. Tobacco caterpillar (*Spodoptera litura*) occurs in earlier stage affecting the crop growth.

Hybrid cottons of HxH introduced during 1970s started giving enhanced yields through high boll number plant^{-1}. It was an excellent opportunity for notorious bollworms to stand between the hybrid cotton breeders who made potentially high yielding genotypes and the farmers who planted them with the hope of getting bumper yields and supplying it to the mill for taking a heavy toll on boll loads. This made the 1980s through 1990s an era of synthetic pyrethroid use in cotton, besides other potent chemicals, to arrest the damage by cotton bollworm. On the contrary, farmers caused excessive damage by polluting the environment including life forms and water bodies, and escalating the cost of production. And bollworms developed high immunity due to misuse and abuse of pesticides.

This led private seed companies to develop, with the support of biotechnologists and genetic engineers, Bollgard cottons with toxin producing gene from a soil bacteria (*Bacillus thuringiensis*) with the mediation of another bacteria (*Agrobacterium tumifaciens*), and provided the Indian cotton farmers with BG-I (cry1Ac) technology in 2002 followed by BG-II technology (cry1Ac+cry 2Ab) in 2006. As a result, cotton production got doubled to 560 kg lint and 1120 kg seed ha^{-1} within a short span of 6-7 years. Farmers became happier with reduced cost of production, increased profits, and better quality cotton supply to textile industry with least environmental pollution. *Helicoverpa* sp. almost disappeared from the national cotton pest scenario, while pink bollworm also got controlled. Figure1 and 2 show excellent cotton crop.

Figure 1: Weed-free BG-II cotton crop in USA

5. Conclusion

But the story will not end here even though farmers have been educated to grow superior hybrids with superior production technology adoption coupled with IPM plus IRM. Pink bollworm susceptibility in BG-I cotton was reported in Gujarat in a particular location. Now BG-II is a better choice for protection of cotton against the bollworms. Since bollworms may develop immunity sooner or later, seed companies are employing the idea of a more effective BG-III gene technology that would come up in another 5-6 years. Cotton farmers should avail these new gene technology cottons as and when the seed companies offer better gene products and superior genotypes. Thus the cotton farmers can relieve the third and major stress to cotton crop and save them thereby saving the cotton and textile industry of the country.

VipCot cotton variety, stacked with glyphosate tolerance, is available in USA under PhytoGen cotton seed brand. These are expected to be launched in 2012 to afford protection against key cotton pests, such as cotton bollworm (*Helicoverpa* sp.),

Figure 2: Water-weed-bollworm stress free bumper crop in USA for mechanical harvesting

tobacco budworm (*Heliothis virescens*) and armyworms (*Spodoptera litura*). Similar technologies are likely to be launched in India too in near future.

It would not be about how many hectares are planted with cotton in ground, but it would be about how much best the farmer is able to get out of the ground. This is true for India. Making no decision is the worst thing one can do. Hence farmers should rise up to seize the opportunities offered by global and national cotton R&D to achieve cotton yield levels not attainable over more than a century. Cotton is an immensely important crop for the economy and livelihood of about 4 million farmers and 3 million textile workers in the country. It is cultivated in about 10 mha and contributes to about 20% to the global cotton production. If farmers are able to relieve the stresses and strains of cotton crops by effective application of these modern technologies and manage their cotton crops efficiently, the prosperity of cotton farmers in a sustainable manner will be assured, and India can become number one cotton producer in the world in a short span.