Organic Cotton Cultivation – a pragmatic approach for resource poor and market-challenged farmers

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Cotton, the most important fibre crop of India plays a dominant role in its agrarian and industrial economy. It is the backbone of our textile industry, accounting for 70 per cent of total fibre consumption in textile sector, and 38 per cent of the country's export, fetching over Rs. 42000 crores. Area under cotton cultivation in India (7.6 million ha) is the highest in the world, i.e., 25 per cent of the world area and employs seven million people for their living. Cotton is a crop most suited to drylands and has flourished there despite the vagaries of nature and poor monsoons. The old cotton varieties were suited to each region and its peculiarities. Hybrid cotton with its promise of high yields changed all that and now in some places farmers are convinced of the need to develop and grow varieties, which are locally suitable.

Cotton-an ideal candidate for organic farming

Cotton is grown over a wide range of climatic conditions and agricultural production systems. Improvements have occurred in cotton productivity over the lasts 5 decades, but at prohibitive costs, both social and environmental. It has seriously affected rural livelihood and environment of our country and today cotton production is at cross roads. Intensive cotton production areas have in recent years encountered severe adverse environmental impacts-reduced soil fertility, loss of bio-diversity, high insecticide resistance, pesticide persistence etc. This situation makes cotton an ideal candidate for organic cultivation. The following factors favour promotion of organic cotton farming:

High levels of pesticide application:
Today about 46% of the pesticide produced in India is applied to cotton, which occupies only 5% of the cultivated area. In absolute terms the average pesticide consumption is 3.25 kg active ingredient per ha of cotton crop. While vast areas of cotton of Gujarat, MP and Maharashtra receive very less pesticides, their application rate is heavy in Haryana, Punjab, AP, Karnataka and Tamil Nadu. Despite such heavy pesticide use, unsatisfactory pest control is often the main reason for low productivity. With biocontrol based pest management strategies that are well-demonstrated and appreciated by farmers, cotton became a natural choice for organic pest management. More over every year 150000 – 250000 tonnes of technical grade pesticides are applied into the cotton ecosystem worldwide and it is high time to revert this trend for a better environment for our future generation.

Consumer pressure:
Consumers are increasingly becoming concerned about the environmental impact of their lifestyles and consumption pattern and are willing to pay a premium price to eco-friendly garments. To promote environmentally benign farming practices, consumers are forcing trading community to evoke non-tariff barriers to prevent import of contaminated fibres. Organic cotton is the ultimate solution to counteract such pressures.

Wide genetic variability:

With four cultivated species and several domesticated races, and a host of varieties and intra/inter specific hybrids cotton offers tremendous genetic variability. Several cultivars with compensation abilities, low fertilizer demand and tolerance to insect pests are available to fit into the organic production system.

Long duration crop with ample scope for compensation:
Cotton is a semi-xerophyte and a forced annual with indeterminate growth habit. Its ability to put forth repeated flushes in response to pest pressures and moisture/nutrient supply is advantageous to minimize yield losses under organic conditions. Due to its lone duration, ample of time is available for assimilating mineralized end products made available from slowly available organic sources. Its ability to absorb foliar applied nutrient formulations is higher than many other crops. These natural physiological mechanisms make cotton a forerunner for organic farming.

Organic farming has been aimed at conservation and optimized utilization of all natural resources for a reasonable profitability under the guiding factors of sustainability of the farm. In order to keep a certain threshold of profit from the farms, all the farming practices have to be redesigned to undo the ill-effects that have crept in the current agricultural scenario while attempting to increase cotton production in the prevalent cropping systems. A sense of balancing act to moderate the resource utilization with anticipation for suspected damage to mother earth is the essence of organic farming. The organic protocols of farming could accentuate and aid in imparting improved momentum to the bio-dynamism of crop fields Less stable and poor bio-dynamism that has caused less-productive farms have altered farmers on the question of long-term sustenance. The genesis for organic farming in our country lies in the adverse experiences that emerged from intensive cotton farming leading to depleting yields and mounting expenses. This was the time farmers were reading Bhaskar Save and Bharat Dabholkar or Masanobu Fukuoka, proponents of natural farming and were trying to experiment on their own. Farmers found they did not have a look elsewhere for natural farming as it was a tradition in India and had nurtured her soils for centuries since the days of ***Rishi kheti.*** They found that organic farming is not some esoteric idea but a means for the farmer to spend less and ensure he/she gets a yield which is not at the cost of the soil or financial abilities.

Many farmers are on their own realising the ill effects of chemical agriculture and it is the large chemical farmers who are setting the trend to adopt low cost techniques and reduce the dependence of farmers on external inputs- a healthy trend that is being slowly adopted in many parts of the country by the discerning farmer. The prospect of selling certified organic cotton, which fetches premiums of 10 to 30 per cent, is a major attraction in certain areas where organic cotton projects are underway. After the initial euphoria over hybrid cotton and the extensive use of fertilizers and pesticides, they is a loss of faith in the magic of the early years and now farmers experiment so as to reduce the use of chemicals and pesticides on their farms.

Pest management as a major risk in cotton cultivation

The modern cotton production technology relies heavily on the use of fertilizers and on chemicals to control insect pests, diseases, weeds and growth regulators. Use of chemicals at such scale causes a lot of hazards to man, i.e., environmental pollution, soil health, and agro-

ecology and poor profitability in cotton farming. This has basically prompted the demand or organically cultivated, eco-friendly or 'green' cotton.

The wide acceptance of moderation in aggressive interventions came up in the world due to the publication of Silent Spring in 1962. From a broad platform of Smith and Allen's (1953) Integrated Control to narrowed one of Stern et. al., (1959) and Smith's (1964, 1975) sensitization to bringing back balance in nature utilising applied pest control with the utilization of biocontrol and chemical control.

Indian cotton plant protection also did not swerve from this pattern of though till the last one and half decades of the last century. We are at the cross road of indecision in cotton protection to identify the road to safety of the agro-ecosystem and the survival of the farmers, who are compulsively tied up to cotton crop, being the saviour in their farmland in different agro-climatic zones of the country. Its implementation is virtually dependent on everybody involved in production and protection of cotton. Chemical insecticides dominated insect suppression in all crops in India from 1960s. For a while, all the insecticides seemed to control pests. But sooner, it was realized that the insecticides could not be a panacea for pest control. Then came the advent of need-based and supervisory control programmes in the late 1970s. Field scouting data on the prevailing pest and natural enemy populations in the crop decided the need of insecticide application. IPM began to be interdisciplinary with the introduction of various components such as pest-tolerant cultivars, modified crop husbandry practices, removal of alternate hosts and affected plant parts, utilization of natural enemies, use of crop terminators and mechanical measures, etc.

A change in the pest species scenario was another historical perspective that found changes in the pest suppression approaches in the last four decades of the century in our country. The conventional pests were Spiny and Spotted bollworms as well as Pink bollworm in addition to the early season onslaught of jassids, aphids and thrips. But the dimension of pest incidence changed with changing cropping patterns and agro-climatic conditions such as the eruption in the population of whitefly and American bollworm. Other pests such as aphids, leaf miners, leaf rollers and even Red and Dusky cotton bugs became increasingly menacing towards the last few decades.

Seeking a reliable and resonant solution in mitigating the problems of protecting cotton crop from herbivory by the noxious pests, IPM was resorted to. However, the prevailing belief was that modulations in the choice, concentrations and timing of spraying of various chemical insecticides could be the major means of IPM. Thus the chemical-based protection of this crop flourished for over two decades from the sixties. The Operational Research Project at CICR Regional Station, Coimbatore and many other R&D approaches brought about consistent debate on the search for alternatives to chemical insecticides in the wake of various perceptible adversities that came to the fore in cotton cropping. Biological options including bio-pesticides such as those of botanical origin and biological control agents were integrated in the package of practice for cotton pest management.

The changes in cropping systems, cultivation practices as well as the change in pest scenario have added newer dimensions to the lack of profitability of cotton growers in the country. The off-resorted pest suppression was the use of xenobiotic chemical molecules to suppress insect pests in the crop. The change in philosophy or mindset from IPM of yesteryears to NPM (no pesticide management), as practiced by cotton growers of Warangal and other districts of Andhra Pradesh brought in better understanding about herbivory and food chains.

Community plant protection (co-operatives)

Yet another major approach for improving the efficiency of protection of cotton farms from noxious organisms is by collective and co-operative steps at village level utilising the expertise available for this purpose. Synchronised and planned action would always be more beneficial to improve the effect of human interventions for ideal crop protection. Decision making regarding suitable and best steps for improving the efficiency of plant protection operations is possible when the entire geographical region, one village or a group of them, as the case may be, would initiate steps in this regard. If insect suppression in cotton has to be detached from constant and injudicious use of insecticides in the crops, much attention has to be paid to conserve natural enemy activity in the crop. This entails a close collaboration and co-operation of farmers on cultural methods in a geographic area. A harmonious pest management programme can be developed only by the integration of biological, chemical and cultural suppression methods, in addition to co-operative efforts of farmers, extension and research staff of all institutions in the region.

Organic cotton cultivation in India – a culmination of non- chemical pest management

Cotton, being a long-duration crop, with rank vegetation and high boll load is quite vulnerable to many biotic stresses including herbivory. Hence, it has become a major consumer of 20-23% of nutrient and hormone chemicals and 55% of the pesticide chemicals produced in our country. Out of the total agro-chemicals that are applied in cotton crop, 75% is used at peak boll development stage. The highly skewed pattern of pesticide use in relation to the crop area (Table: 1) has caused many problems to the agro-ecosystem, viz., development of resistance to pesticides, resurgence of newer pests, elimination of natural enemies, environmental pollution and health hazards to the villagers.

Crop	Area (%)	Pesticide use (%)
Rice	24	17
Oilseeds	10	2
Cotton	5	54
Vegetables & fruits	3	13
Plantations	2	8
Sugarcane	2	3
Others	5	3

Distressed by the negative effects of pesticides for insect suppression in cotton crop, some progressive farmers, reduced the chemical inputs and increased the use of organic manure, developed their own techniques to optimize resources in order to develop sustainable farm.

The avenues opened by the new movement of organic cotton in India in order to establish sustainability of cotton farms is remarkable. The cotton farmers, who are frustrated with continuous poor yield, incurring high cost for large scale pesticide use and its resultant bane, have now turned the corner in order to improve their farm soil microflora with renewed organic sources and to revive the natural ecological niche for the flourished activity of natural enemies for better performance of pest suppression in this crop with the expectation of reviving the lost stability in crop productivity. Indian cotton growers, especially of Maharashtra tend to pick up the thread of traditionally in attempts that help to sustain their farms.

Conversion to organic agriculture- essential requirements

INTERNATIONAL FEDERATION OF ORGANIC AGRICULTURE MOVEMENT (IFOAM) as well as *Codex Elementaris* of European Union manual has provided the essential principles involved in the conversion of farms into organic from conventional cultivation. It is understood that the AGRICULTURAL PRODUCTS EXPORT DEVELOPMENT AUTHORITY (APEDA) of the Ministry of Commerce, Government of India also have formulated standards similar to IFOAM. Conversion means a process of developing a viable and sustainable agro-ecosystem. The whole farm, including livestock should undergo the conversion according to organic standards over a given period of time. This time-frame could be decided by the Certification body. If a farm unit is not converted at once, it could also be done on field bases. The composition of farm unit may vary according to geographical conditions, ownership structure, time span etc. If a farmer of farming community operates two or more farms within a local area, the whole operation may be converted to organic mode.

Elements of organic cotton cultivation

Some key ingredients of the technology developed for organic farming at CICR, Nagpur are presented below (Kairon *et al., 1998*):

Varietals selection

HYVs such as hybrids that respond very well to chemical fertilizers are not always suitable to this type of cultivation. Currently, many arboreum varieties such as **Turab (PA.255)** of Marathwada Agricultural University, **Jawahar Tapti** of *Jawaharlal Nehru Krishi Vishwa Vidyaloaya.* Khandwa possess similar fibre qualities as odf hirsutum (American) cotton. Their fibre is spinnable at 40s count as in the case of NHH.44 or other simila hybrids that are popular in Andhr Pradesh. Straight varieties such as ANJALI (LRK.516), PKV.08, LRA 5166, DHY.286, RAJAT amongst hirsutum cottons and AKA 8401 in arboreum (*Desi*) cotton are found to respond well to organic mode of cultivation.

Seed rate and sowing

25 kg/ha of seeds at 75x15 cm spacing ensures a plant population of 85000 to 90000 is recommended. Fuzzy seeds that are mixed with wet clay containing some amount of FYM or compost is ideally chosen. One row of cowpea (*Vigna inguiculata*) should be planted between two cotton rows for being incorporated at tendril stage. This improves the fertility of soil.

Soil fertility

SOIL (Soul of Infinite Life) is the basis of agriculture. A fertile soil is a pre-requisite for organic cotton production. The native organic C content should be improved and stabilized at such a level that the anticipated production levels do not cause a decline in soil organic Carbon (C). Crop rotation with legumes, cover cropping, green manuring, compost (vermicompost, Trichocompost, FYM), bio-mulches, biofertilizers are generally employed to improve fertility status. Soil amendments and naturally mined permitted (or regulated) chemicals can be employed to supplement native fertility.

Farmyard manure @ 5 tonnes/ha. *In situ* green manure with fodder cowpea incorporated between cotton rows at 40 days after swing (DAS), Spreading loppings from *sesbania* spp.

obtained from 2-m dense rows after 10 cotton rows, in the entire field, Vermicompost @ 1-2 tonnes/ha. Seed inoculation of azotobacter @ 500g commercial product/seed required per ha or any such microorgamnisms such as consortium of effective microbes (EM) and such many useful flora (Mwethylotrophs etc.), utilization of *Trichiderma viride* for composting farm-waste including cotton-stalks etc could improve soil physical properties, foliar application of specific preparations from cattle urine, Biodynamic preparations etc.

Weed Management

Weed management is primarily achieved through preventive techniques (selection of perennial weed-free field, clean seeds, completely decomposed compost/ FYM, crop rotation, cover cropping, mulching, smother crop etc.) and soil solarizataion. Cultural, mechanical and manual methods can be employed to supplement preventive measures.

Pest Management

Pest management is achieved through the selection of pest tolerant varieties, conservation of natural enemies and inundative releases of predators/parasites pathogens and supplemented with botanicals.

Suppressing phytophagous insects using such options has thus realized a myriad of advantages to our society. Other institutions involved in these activities have taken lots of cues from this CICR effort. Today, Cotton Research Institute is a front-runner in modifying the conventional opinion of chemical-based insect suppression and also for popularization of biocontrol-based pest Management. They have come a long way in their gratified dream of substantiating biocontrol as a broad- base of pest management in pesticide intensive crops like cotton.

Biocontrol based Pest Management

- Release of *Chrysoperla* sp, @500 / ha 20-25 DAS and again at 35 DAS
- Release of *Trichogramma chilonis* @ 5 cards / ha at 45 DAS
- Spray of H-NPV @ 250 larval equivalent/ ha (2 x 10^8 PIBS/larval equivalent) for young bollworms of *Helicoverpa armigera*
- Detopping after 80 days of growth
- Alternative spray with B. t. formulation @ 1.5 litre /ha
- Application of neem-based formulations-neem oil @ 1.0 litre/ha and 1% neem-seed kernel extract
- Release of *Bracon hebator* to kill bollworm larvae
- Bird perches @ 4/ha

Mass-production of these biological pest suppressants is possible. However, their quality can be well-maintained if only small scale production is designed instead of production in large volumes. Production by masses instead of Mass production shall be more pragmatic to achieve quality and effectiveness.

Issues of sustainability and stability of organic farming *vis a vis* conventional farming

An analysis of the productivity trend in the intensive chemical based cotton production system in the northern cotton zone of India, encompassing the states of Punjab, Haryana and Rajasthan indicate a declining yield trend from 467 kg lint / ha in 1986-87 to 206 kg lint/ ha in 2001-02. The sustainability of such a production system needs closer introspection. Despite assured irrigation and use of adequate chemical fertilizers and pesticides, the

Coefficient of Variation for yield (during the above mentioned period) was 29.0% in Haryana and 34.9% in Punjab. Such a system is not stable either. On the other hand, the rainfed organic farming systems operating in Central India, offer stable cotton yields albeit at non-exploitative productivity thresholds of 250-300 kg lint/ha. Data from a long-term fertilizer trial operating since 1986 at CICR farm indicate that a completely organic plot gave a mean yield of 390 kg lint/ha with a CV of 26.9%.

The agriculture in the country passed through, a difficult situation during post independence period when the food grain production was only 51 million tonnes during 1950-51, not enough to feed its population. The country was dependent for food on other countries. The condition became more precarious during drought of 1968 when even PL 480 was called off. This was the time when scientist, farmers, planners and extension workers of the country rose to the occasion and world witness the capability of the country to produce enough for their growing population through their own efforts. During this period country brought green revolution and the food grain production crossed 210 million marks. This could be achieved by adoption of high yielding varieties with high input technology i.e. by the use of high dozes of inorganic fertilizers, pesticides, weedicides and irrigation water. This has not only increased food production but area under monoculture and resistance in pests, thus on one hand we achieved self sufficiency in food production, but on the other our soils became sick, underground water depleted, environment polluted, cost of production increased and chemical residues in food products causing hazards to human and animal population.

The scientists have also realized that the 'Green Revolution' with high input use has reached a plateau and is now sustained with diminishing return of dividends. The nutrient use efficiency and factor productivity is on decline. Thus this agro chemical based technology is now not sustainable and has given rise to sustainability problems. This needs to be corrected, by adopting alternate technology of farming. A technology, which should be eco-friendly farmer's friendly and low cost. It should help in preserving traditional biodiversity and knowledge. To know the suitability of such technology, the Government of India constituted a team in 1992 and a working group in 2001. They unanimously advocated 'Organic and Bio-dynamic Farming system as an alternative technology system. Although there are number of other systems prevailing in the world which are non chemical use systems, but in my view the evolved thousands of years back and is a way of life for the Indian farmers. This involves traditional practices followed even by ancient civilization and can be an integrated form of organic farming system.

The experience gained while working with such technology clearly indicates that there is no loss of productivity by its adoption, contrary to this it gives better production, it is cheaper, labour intensive and provides opportunities to increase rural employment. However there are challenges for adoption of this technology, as it requires scientific explanation, formulation of package and practices, post harvest technology for organic produce, quality of its inputs, consumer's awarencess, and formulation of standards for inputs and produce, certification of farm, produce and process etc. Accordingly our strategy should be clearly worked which may be prioritization of area and crop for organic production, development of data base and market intelligence, development of equivalent standards for organic produce, involvement of organic farmers in production processing and marketing, development of courses and training models for organic agriculture, transfer of appropriate technology etc.

There is a global market for organic food, which is estimated to be worth £14 billion in 2002-03. This is likely to increase to an estimated £20 billion by 2004-05. At present U.S.A. is

leading the market with £5.9 billion followed by Germany and U.K. If these countries can shift to an alternative organic technology why India cannot? It requires combined efforts of scientist, field functionaries and farmers. The Government has now come out to encourage in its adoption, obliviously in a phased manner through creation of infrastructure and tax incentives. The Planning Commission of the Government of India has provided adequate resource in tenth five year plan for the development of organic farming of various commercially potentially horticultural and agricultural crops in addition to patronizing crops of dry land including cotton. Organic, Vedic, Biodynamic, *Rishi/Agri Hotra (Homa)* or any name it may be, it appears that Indian farmers shall turn around to practice HOLISTIC AGRICULTURE that shall sustain their land, resources and ambition to make an enterprise in rural settings.

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