

Current status of organic cotton production in India

V Mageshwaran¹, Varsha Satankar², S K Shukla³ and M S Kairon⁴

ICAR-Central Institute for Research on Cotton Technology, Nagpur 440 023, Maharashtra

Cotton is the major fibre crop grown worldwide. India leads production of cotton among the different cotton growing countries. The demand for cotton in textile sector is increasing due to its inherent fibre properties. In recent years, the awareness among the world community about ill effects of toxic chemicals and pesticides used in cultivation and processing on health is increasing due to which the people are looking for organic products of different commodities. Cotton is one of the agricultural crops grown organically and India leads organic cotton cultivation in the world. The guidelines set for organic cotton cultivation have to be strictly followed for its certification. The practices such as selection of biotic and abiotic resistant varieties, use of compost, vermi-compost and organic manures, intercropping with green manures, crop rotation, use of bio-fertilizers, bio-pesticides and botanicals, etc. form integral components in organic cotton farming. The use of locally available biological inputs significantly reduces the cost of cultivation. Thus, organic cotton cultivation is a systematic approach for maintaining biological diversity and bringing sustainable yield and income. The area under organic cotton farming is declining due to decrease in premium prices offered to organically grown cotton. The government of India should take measures and formulate policies to promote organic cotton cultivation through guidelines in traceability and transparency for cultivation and marketing of organic cotton, and offering premium prices of organic cotton keeping in view of the welfare of organic cotton growers and sustainable environment in large.

Key words: Cotton, India, Organic, Production

Cotton is the major fibre crop grown in India and plays a dominant role in agricultural and industrial sectors. Cotton contributes 70% of total fibre consumption in textile sector and 38% of the country's export, fetches over ₹ 42,000 crore. The area and production of cotton during the year 2018-19 was 12 million ha and 362 lakh bales (170 kg of each bale), respectively. Organic cotton production is a systematic knowledge intensive approach which establishes a diverse and sustainable farming ecosystem with cotton as one of the component. The main aim of organic cotton cultivation is restoration of soil fertility, reduction of production cost, and better price for the certified

organic harvest. In long term, organic cultivation aims at development and maintenance of biological diversity for sustainable crop yield. International Federation of Organic Agriculture Movements (IFOAM) is the unique agency which supports organic agriculture worldwide and provides guideline of farming practices for organic certification.

In 2015-16, the world organic cotton production was 1.08 lakh tonnes. The major organic cotton producing nations are India, China, Kyrgyzstan, Turkey and USA and their respective production (in tonne) recorded during the year 2015-16 were 60,184; 14,187; 7,981; 7,577 and 4,524. Organic cotton production is not related to farming

by merely replacing synthetic fertilizer and pesticide with organic ones. Organic cotton by definition refers to any cotton that is cultivated and certified according to the organic agriculture standards. It includes cotton that is grown, harvested and processed without the use of chemical fertilizer, pesticide or herbicide, growth regulator or defoliant. The exact cultivation practices vary across region or even from farmer to farmer but the use of genetically modified seed, toxic and persistent agrochemical synthetic pesticide, fertilizer and growth regulator is non-negotiable.

Standard Production Practice

Organic cotton production

practices in India are an amalgamation of traditional wisdom and modern scientific knowledge. Management of ecosystem and use of local natural resources are inherent to all the organic cotton programmes. Today, organic cotton encompasses a range of farming systems including those known as biological, low-input, organic, regenerative, green eco-friendly or sustainable. These alternate systems involve crop-rotation, bio-control based Integrated Pest Management (IPM), conservation tillage, crop diversification including cover cropping and green-manuring, genetic improvement, disease/pest prevention and soil health amelioration. According to Eyhorn, sound organic cotton production packages are developed based on the following principles:

- Promotion of natural processes- nutrient cycling, N fixation, cotton plant-pest-natural energy integration of these complementary processes into the production system.
- Avoiding the use of those off-farm inputs that are a potential threat to the soil and aquatic environment, as well as health of farmer, farm animal and consumer.
- Allowing the biological/genetic potential of the variety/hybrid to be expressed fully with minimum interventions.
- Improved farm management to conserve soil, water, energy, and biological diversity and on-farm agro-wastes.
- A fertile soil is a pre-requisite for organic cotton production.
- The organic C content of soil should be improved and stabilized at such a level that the anticipated production levels do not decline it.
- Crop rotation with legume, cover cropping, green manuring, compost (vermicompost, Trichocompost, FYM), bio-mulch, bio-fertilizer are generally employed to improve fertility status.
- Soil amendments and naturally mined permitted (or regulated) chemicals can be employed to supplement native fertility.
- Weed management is primarily achieved through preventive

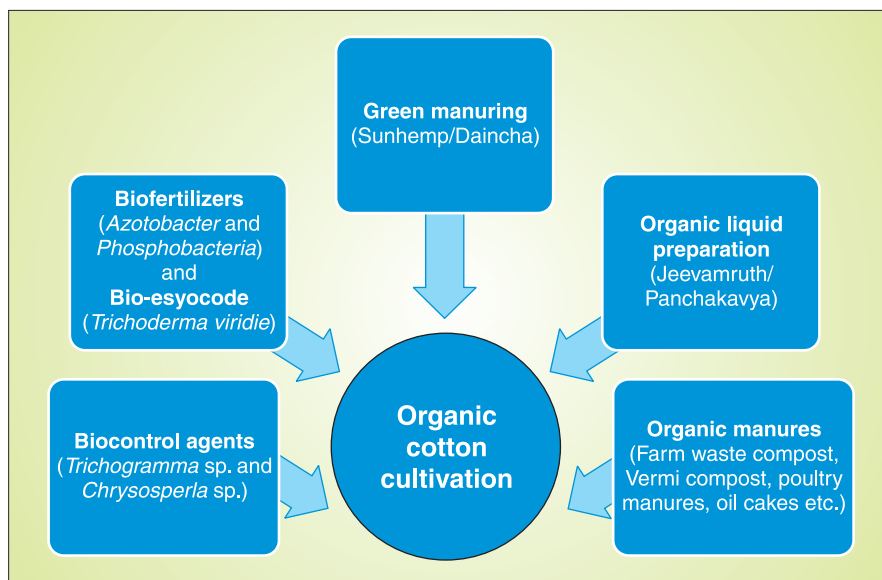


Fig. 1. Biological inputs in organic cotton cultivation

techniques (selection of perennial weed-free field, clean seeds, completely decomposed compost/FYM, crop rotation, cover cropping, mulching, smother crop etc.) and soil solarization. Cultural, mechanical and manual method can be employed to supplement preventive measures.

- Pest management is achieved through the selection of pest tolerant variety, conservation of natural enemy and inundative release of predator/parasite pathogen.
- Since promotion on locally available on-farm resources is implied in all organic production system, no clear-cut package of practices can be prescribed. Farmers use their innovative power and in consultation with any certifying agency decide the inputs used.
- ICAR-CICR, Nagpur has developed a package of practices for organic cotton cultivation. The farmers can contact the Institute for more information.

The biological inputs used in organic cultivation such as green manuring, organic liquid preparation, organic manure, biocontrol agent, and biofertilizer and biopesticide are depicted in Fig. 1.

Selection of varieties

Hardy plants which are capable to resist biotic and abiotic stresses would be ideal for organic cotton cultivation. Early maturing variety

that is less exhaustive would escape major pest damage. Variety which responds well to chemical inputs may not be suitable for organic farming. The varieties having a combination of characters of the desi varieties (hardy, drought resistant) with those of *hirsutum* varieties (high yield, long fibre) may be preferred for organic cotton cultivation. The farmers should consider the factors such as soil quality, rainfall, availability of irrigation water, availability of manure, possibility of pest management, buyer's requirement on staple length and other fibre quality aspect etc. before the selection of varieties. Farmer can adopt the seed rate of 25 kg/ha to ensure a final plant population of 85–90 thousand plants/ha. One row of fodder cowpea (*Vigna unguiculata*) should be drilled between two rows of cotton. This crop could be ploughed down and buried in soil just before its flowering.

Soil fertility management

The soil type forms the basis for developing a strategy for soil fertility management. Light soil usually has a lower waterretention capacity and the nutrients are more easily leached out than in heavy soil. The application of compost is particularly important for increasing water retention and nutrient supply. Intercropping of drought resistant crops like sorghum, safflower, sesame or castor can buffer the risk of crop failure in drought

prone areas. In deep or heavy soil, intensive production is possible with sufficient inputs of organic manure, intensive crop rotation and green manuring. Cotton prefers fertile soil with good water holding capacity and sufficient nutrient supply. Organic matter plays a crucial role in keeping the soil well porous and good infiltration of water. It also avoids the formation of hard soil due to continuous application of chemical fertilizer in conventional farming.

The organic matter in soil increases the biological activity of the soil by promoting activity of earthworms and microbes, which continuously work toward improving the soil fertility. The strategy such as crop residue management, intercropping application of compost, green manuring, and crop rotation improve the organic matter content in the soil. The crop residue such as cotton stalk derived from cotton cultivation could be converted into organic compost for its use in next season. A bio-enriched compost having nutrient value three times higher than conventional farmyard manure was prepared from cotton stalk and the method of preparation was demonstrated to the farmers. The farmers can grow moong bean, cowpea or chickpea as inter crops for harvesting, and green manure crop such as sunhemp or cowpea, to be cut and ploughed back into soil before flowering. The crops particularly pulse (soybean, chickpea, pigeonpea, groundnut), vegetable crop [chilly, *bhendi* (lady's finger) etc.], sugarcane and wheat could be included for crop rotation. The inclusion of pulse crop in crop rotation is important to maintain soil fertility and for availability of nutrients to the subsequent cotton crop.

Crop nutrition

Crop rotation and intercropping with legume, recycling of crop residue and the application of farm-produced organic manure (farmyard manure and compost) need to form the basis for nutrient management in organic cotton farming. The cotton crop requires two-third of the nutrients during the first two months

of its growth. The cotton stalk could be recycled into soil by composting using *Trichoderma* sp. or any other lignin degrading microorganism. The well decomposed farmyard manure or *Tricho*-compost could be applied at the rate of 5 t/ha as the basal dose. If vermi-compost is available, it may be applied at the rate 2 t/ha. This could be supplemented with one or two head applications of compost and organic manure rich in nitrogen (eg. oil cakes, poultry manure etc.) at 2-3 weeks before the start of square bud formation, as the nutrient are available only after the organic manure decomposes. The green manure fodder cowpea may be incorporated between cotton rows at 40 days after sowing of cotton crop. Fig. 2 depicts the intercropping of cowpea in organic cotton (*G. hirsutum*) cultivation.

The balanced nutrient requirement for organically grown cotton are Nitrogen (N), Phosphorus (P_2O_5) and Potassium (K_2O) in the ratio 100-120: 50-60: 40-50 kg/ha respectively. The nitrogen in the soil could be supplemented by residue from previous crop, nitrogen fixation through pulse, compost, vermi-compost, FYM, oil cake, biofertilizer and liquid manure. The sources such as residue from previous crop, compost, FYM, rock phosphate, wood ash, biofertilizer could supplement the phosphorus nutrient. The residue from previous crop, FYM, muriate of potash, wood ash could supplement potassium content to the cotton crop. The biofertilizers such as *Rhizobium*, *Azotobacter*, *Azospirillum*, Phosphate solubilising bacteria (PSB) and Mycorrhiza (VAM) could be effectively used in organic farming. The *Rhizobium* fixes atmospheric nitrogen symbiotically in root nodules of pulse crop. The *Azotobacter* and *Azospirillum* fix atmospheric nitrogen through non-symbiotic and associative symbiotic mechanism. Mycorrhiza associates with root of higher plant and mobilize phosphorus, zinc and other micronutrients from soil to the host plant and prevents the infestation of pathogenic fungi in host plants. The *Rhizobium*, *Azotobacter*, *Azospirillum* and Mycorrhiza could be used for

pulse, cotton and vegetable, cereal and higher plant respectively. The PSB bacterium *Bacillus megaterium* could be applied to soil irrespective of the crop along with organic phosphorus manure like bone meal, rock phosphate etc. The PSB aids in solubilisation of organic and fixed inorganic P and make it available to the crop. The bio-fertilizer could be applied through seed treatment and direct field application. The commercial biofertilizers (solid and liquid formulation) are available in the market. The solid formulation of biofertilizer is available in 200 g packet. The organic cultivators must be alert of the quality of these formulations available in the market and the quality can be checked in the reputed public or private laboratory. The principal parameter to be checked in quality of biofertilizers is microbial count (cfu/g or ml) and it must have minimum of 10^9 cfu/g or ml.

The seed treatment with biofertilizer can be undertaken by treating one kg of seed with 20 g of biofertilizer strain along with 200 g of rice kanji (water extracted from boiled rice) or gum arabic. The biofertilizer treatment should be the last seed treatment to be done before 30 min. of sowing. Pesticide should not be contacted with biofertilizer since, the chemical pesticide may kill the live cells of biofertilizer strains. The direct field application could be done by applying 600 g of biofertilizer strain mixed with two tonnes of well decomposed *Tricho*-compost or Vermicompost for one acre of land. In recent days, the awareness is increasing among the organic growers about locally prepared liquid manures such as *panchakavya*, *dasakavya*, *jeevamruth* etc. For example, *panchakavya* could be prepared by mixing cow dung, cow urine, cow milk, jaggery and curd in the proportion of 10 kg, 2 litres, 2 litres, 3 kg and 2 kg respectively. These ingredients may be mixed in 100 litres of water and kept for 10 days. After the incubation time, the extract is separated and 3% of solution is prepared and applied through knapsack sprayer or drip irrigation at 30, 60, 90 days after

sowing and flowering stage.

Pest and disease management

In conventional farming, cotton is one of the crop where huge amount of chemical pesticide like organo-phosphate are sprayed to control the incidence of insect. Cotton crop itself consumes about 50 % of pesticide usage in insect pest management of agricultural crops. The best strategy in pest and disease management in organic cotton cultivation is to maintain diverse balance in farm ecosystem through increasing the population of natural enemies. The other strategies to support plant health are: diverse cropping system, intercropping, balanced nutrition, appropriate water management and employment of biocontrol system. The unbalanced application of fertilizer may enhance the incidence of sucking pests (aphid, whitefly, thrip, jassid etc.). Farmers should observe the Economic Threshold Level (ETL) before taking the pest control measure. The cost and effort of control measures taken below the ETL is higher than the damage it causes. As long as pest infestation remains below the ETL, the farmers should allow the natural enemies to multiply and control the pests which results in negligible damage to the crop. The innate defence mechanism of cotton crop should be preserved for better pest management. For example, gossypol, polyphenolic compound and hairy leaves provides resistance to cotton against infestation of weevil and hopper respectively.

Crop rotation with sunflower, okra, castor prevent the infestation of bollworm complex (American boll worm, pink bollworm and spotted bollworm). The intercropping with cowpea augments ladybird beetle and other natural enemies for the control of sucking pest. The natural enemies promoted for management of cotton pest are assassin bug, predatory beetle, ant, lacewing larvae, spider, parasitic wasp (eg. *Trichogramma*), parasitic fly and praying mantis. The release of *Chrysosperla* sp. at the rate of 500/ha at 20–25 days after sowing and *Trichogramma chilonis* at the rate of 5 cards/ha at 45 days after sowing can



Fig. 2. Inter-cropping of cowpea in organic cotton (*G. hirsutum*) cultivation

effectively control the bollworm complex. Similarly, alternative spray of Bt (*Bacillus thuringiensis*) spray at the rate of 1.5 l/ha could be done for the control of bollworm. The spray of H-NPV (*Helicoverpa* Nucleo Polyhedrosis Virus) at the rate of 250 larval equivalent/ha could control the *Helicoverpa armigera* (American bollworm). The light trap and pheromone trap could be employed for mass trapping of insect pest which can drastically reduce the pest population. For instance, yellow sticky trap is used to trap whitefly. The botanicals such as neem extract, de-oiled need cake, pyrethrum, garlic-onion-chilli extract, giant milkweed extract, lantana leaf extract, coriander seed spray, buttermilk spray etc. could be effectively used for management of pest and disease under organic cultivation of cotton.

The monitoring of pest is foremost importance in organic cotton cultivation. For monitoring, farmers randomly inspect a number of cotton plant while crossing the field in diagonal and record the pest infestation. The ETL of various pests could be recorded by monitoring survey. The standard ETL level and the major pests are American bollworm (1 larva per 5 plants), pink bollworm (5% rosette flower), spotted bollworm (1 larva per 5 plants), aphid (20% infested plant), white fly (5% infested plant), thrip (5–10 nymphs/adult per leaf) and

Jassid (5–10 insects per plant). Farmers can adopt various strategies of pest control as described earlier only after the pest infestation reaches above ETL.

The most common disease occurs in cotton cultivation are root rot, fusarium wilt and bacterial blight. The root rot and fusarium wilt are the frequent soil borne fungal diseases in cotton which can be effectively controlled by use of biopesticide, *Trichoderma viridie* and *Pseudomonas fluorescens* under organic farming. The method of application of the biopesticide is similar to biofertilizer. Water logging is the major cause for soil borne pathogen and thus keeping the field under well-drained condition is utmost important in disease management. The general practice to be followed in pest and disease management in organic cotton cultivation is breaking of life cycle of pest and disease by recycling of infested and other crop residue by conversion into bio-enriched compost. The composting of residue results in increase in temperature in the compost heap and thus the pathogen and eggs present in the residue get destroyed and the resultant compost could be enriched with plant growth microorganisms such as *Azotbacter*, *Azospirillum*, *Rhizobium*, *Trichoderma viridie*, *Pseudomonas fluorescens* and phosphate solubilizing bacteria to produce bio-enriched compost. The application of

bio-enriched compost in organic farming is balance of soil fertility and supports the plant health as well.

Water management

The irrigation in cotton during critical growth period is essential for proper yield. Organic soil management usually leads to better soil structure and thus results in better infiltration of water. The excessive irrigation may leads to water logging. Cotton is very sensitive to water-logging, which causes increased boll shedding and affects the yield. The problem of water logging is more in heavy soil due to poor drainage of water. The improvement of soil structure is a must in this kind of soil. In conventional farming, the continuous application of fertilizer hardens the soil and affects the infiltration of water. The addition of organic matter in organic farming improves the soil structure, increase infiltration of water and provides aeration to the root. The practice of organic farming thus not only improves the soil chemical and biological properties but also soil physical properties. The improvement of soil physical properties enhances the water management capability. In rain-fed cotton, emphasis is, given on conservation of soil moisture. The application of compost and organic manure enhances the water holding capacity, which is crucial in organic farming for conservation of soil moisture. The mulching of soil improves the soil moisture retention and suppress weed. Bio-mulch is degradable and add organic matter into the soil (Fig. 3).

Post-harvest management

The quality of cotton fibre depends on staple length, strength, micronaire value, uniformity index etc. and more importantly, the amount of trash content in cotton. The trash content is non-fibrous material such as leave or dust, pest or disease infested fibre present in the fibre. The marketability of the cotton increases with decrease in trash content. The farmers should pay off considerable attention to improve the quality of cotton. It could be

improved by following some of the post harvest management practices:

- Fully ripen and opened cotton boll should be harvested
- Synthetic bag should be avoided for picking and storing of cotton instead farmer may use clean cotton cloth material
- Non-fibrous material should be removed from cotton seed
- Cotton should be stored in clean and dry place.

Organically grown cotton should be processed for ginning, spinning, wet processing separately to avoid contamination with conventional cotton. Care must be taken to label the organic lots to avoid mixing with conventional cotton. Major market for organic cotton textile are Europe, USA and Japan. Most of the organic cotton was processed into garment containing 100 % organic cotton fibre. In certain cases, 5–10 % of organic cotton is blended with conventional cotton to produce garment.

Economics of organic cotton cultivation

In organic cotton cultivation, other crops are grown along with cotton as intercrop or crop rotation. Pulse crops such as cowpea, soybean, groundnut etc. are commonly taken as intercrop or crop rotation to maintain soil fertility. The crop diversity reduces the burden of fluctuating cotton prices and provides farm work opportunities throughout

the year. For better income under organic cotton cultivation, the farmers can adopt the strategies such as increasing farm yield through improved soil fertility, reducing the cost of production, getting better market price and reducing risk of production especially in drought and pest damage. The organically grown cotton fetches better premium prices in the market. The premium price of organically grown cotton is usually 10–20 % higher than market price of cotton. The balanced nutrient application under organic cultivation not only improves soil fertility but also brings sustainable crop yield. The farmers use locally prepared inputs such as compost, botanical pesticide, liquid manure etc. under organic cultivation, thus the cost of production is greatly reduced. The multiple cropping strategy followed in organic cultivation prevents the climatic risk of drought, pest damage etc. The benefits of alternate crop grown under organic cotton farming, substitute the risk associated with climatic variability's, helps in sustainable yield, and income to the farmers.

It is expected that the yield of cotton is higher in conventional cotton than organic cotton cultivation during the initial few years. This is due to the chemical fertilizer and pesticides application in conventional cotton which results in quick response of crop chemical.



Fig. 3. Bio-mulching with sunhemp sticks in organic cotton (*G. arboreum*) cultivation

However, the long term continuous application of chemical in conventional farming results in breakdown of biodiversity, soil infertility, hardness of the soil, new pest emergence etc. The dependency on chemicals will increase with time in conventional farming. However, in organic farming, the long term continuous application of biological inputs improves soil fertility, soil structure, soil biological activity, increases niche biodiversity and thus, the improvement in system as a whole could be realised in organic farming. The yield of the crop would be stabilised after 3-4 years in organic farming as there would be improvement in the system itself. Thus, the income and yield is sustainable under organic cotton cultivation.

Emerging issues in organic cotton cultivation

The organic cotton production in India had fallen from 1.03 (lakh tonnes) in 2011-12 to 0.6 (lakh tonnes) in 2015-16. The experts pointed out several reasons for decline in area and production of organic cotton. One of the main reason is decline in incentive/premium offered over and above the price of conventional cotton. It has come down from 15% to hardly 5%. Farmers are switching over and registering themselves to other sustainable ventures like Better Cotton India (BCI) and continue with good ecological management options. Non-availability of non-GM seeds of the desired fibre quality is another reason for fall in production of organic cotton. The difficulty in keeping records, traceability and certification issues limit the uneducated farmers to be involved in organic cotton production. Due to insecurity in demand, farmers are often forced to sell their organic produce as conventional cotton in the open market. Growth in global organic trade volumes is not matched

with equity and benefits are not shared in the same proportion to the farmers. The integrity and transparency of Indian organic cotton continues to be a challenged, both at the farm level and further up the textile supply chain. Lower yield of organic cotton (around 14-15q/ha, compared to 18-20q/ha for conventional), makes organic cotton cultivation less profitable in the initial stage. The failure of support and guidance to the farmers on productivity especially during the conversion process demotivates the farmers towards organic cotton cultivation.

Way ahead

Providing good quality biotic and abiotic stress tolerant non-GM seeds to organic growers on time and training farmers to produce seeds of cotton varieties on their own. Improving organic farming techniques to raise yields and reduce yield gaps vis-a-vis Bt cotton. Assuring good quality organic inputs is equally important. Increasing farm diversification through combinations (rotation and intercrop) of crop with strong consumer demand (domestic and international) in the organic sector. Providing value addition opportunities at producer level and sustaining the interest of farmers, particularly the younger generation. Bringing transparency and trust in certifying systems and promoting farmer-executed certifying systems to reduce certification cost. There is a need to bring in traceability into the system. The Government of India, through APEDA, has introduced Tracenet, an online tracking system for all organic production, and reduction in group size for ICS (internal control systems) to a maximum of 500 farmers. The nurturing and growth of a strong domestic market for organic fiber could play a significant role in strengthening producer groups and reducing their dependence on the

export markets. Creating consumer awareness in India and explore domestic market demand through novel initiatives by big retail outlets. Formulating and enforcing guidelines for minimizing contamination from GM cotton. Systematic research focus on organic farming practices is required.

Conclusions

- Organic cotton farming is not merely farming, it is a system of improvement in biological diversity, cultivation practices, soil fertility, pest, disease and post harvest management practices for obtaining sustainable yield and income.
- Intercropping with green manure, crop rotation, use of compost, organic manure and botanicals are the inevitable components of organic cotton farming.
- Practice of organic farming enhances soil organic carbon content and microbial population; which are considered as ecological indicators of soil fertility.
- Use of biological and locally available organic input would drastically reduce the cost of cultivation of organic cotton, and bring out sustainable yield and income.
- Organically grown cotton should be separately tagged for its processing and marketing to differentiate it from conventional cotton.
- Organically grown cotton fetches higher premium than conventional cotton and its demand in international market is growing. The government should come forward to support the organic cotton production and processing for the interest of organic growers, and for sustainable environment.

^{1,3}Seintist, ²Principal Scientist, and ⁴President, M S Kairon Research Foundation, Nagpur. Corresponding author's e mail : mageshbio@yahoo.co.in

Everything can wait but not Agriculture!

—Jawaharlal Nehru