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Zoological and Entomological Letters

Impact of pink bollworm on cotton fiber and its management strategies: A review

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Abstract

Cotton is one of the important crop all around the world and also a basic source of economic development. In Pakistan, it contribute 50-62 percent of oil generation and fibre production. There are subsequent problems of cotton growers regarding insect pest, flighty atmosphere, work issues and disappointment from the government sector. Agronomic practices basically impact on picking and also in yield. Fibre of Pakistan is better in all qualities but yield of fibre and quality of fibre is declining year by year. These losses are due to diseases like pink bollworm. The main causes are insignificant by the growers at the time of picking and post-harvesting. The growers cannot follow directions about clean picking. Losses during picking affect the quality of fibre that's why the international markets cannot refer to the fibre which is exported by Pakistan. There must be a training need assessment of cotton growers to overcome these problems. There must be a dire need of provision of technical knowledge with motivation to the growers. There must be proper coordination of public and private sector. Training session must be conduct at regular interval.

Keywords: Pink bollworm, cotton fiber, management strategies

Introduction

Agriculture represents the foundation of Pakistan's economy 19.5% of the country's overall production, utilizing 42.3 percent of the work drive and giving basic material to a few esteem included segments. It accordingly assumes a focal portion in national improvement, nourishment safety and neediness decrease. The rapid urbanisation of Pakistan demonstrates the interest for high-esteem perishable items, for example, organic products meat, dairy and vegetables is increasing. Government is concentrating to expand the production for country cultivators through significant foundation speculations containing dependable transportation systems and other construction obstruct for present day supply networks. Agricultural section performance was up to scratch in 2016-17, achieving growth of 3.46% against a target of 3.5% and a year before minor growth of 0.27%. This was made feasible by increased supplies of agriculture commodities such as water, farm loans, and intensive fertiliser offtake, which allowed for improved harvesting of main crops. Crop growth was 3.02%, compared to a negative 4.97% increase in the same time the previous year. Pakistan has two agricultural seasons, with *Kharif* being the first, beginning in April-June and ending in October-December. *Kharif* crops include maize, sugarcane, maize, bajra, cotton, moong, jowar and mash. The second seeding phase, Rabi starts from October-December and ends in April or May. (Government of Pakistan, 2016-17).

Table 1: Sowing and harvesting time of crops

Sr. No.	Kharif crops	Sowing time	Sr. No.	Rabi crops	Sowing time
1	Cotton	April-June	1	Wheat	Oct-December
2	Sugarcane		2	Oilseeds	
3	Rice		3	Gram	
4	Mung		4	Barley	
5	Mash	Harvesting time	5	Rapeseed & Mustard	Harvesting time
6	Maize		6	Tobacco	
7	Bajra	Oct-December	7	Masoor	April-May
8	Jawar		8	Chillies	

Source: Economic Survey of Pakistan 2016-17

Table 2: Agriculture Growth Percentages of crops (Base= 2005-06)

Sector	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Agriculture	1.96	3.62	2.68	2.50	2.13	0.27	3.46
1) Crops	0.99	3.22	1.53	2.64	0.16	-4.97	3.02
2) Important Crops	1.50	7.87	0.17	7.22	-1.62	-5.47	4.12
3) Other Crops	2.27	-7.52	5.58	-5.71	2.51	0.59	0.12
Cotton Ginning	-8.48	13.83	-2.90	-1.33	7.24	-22.12	5.59
Livestock	3.39	3.99	3.45	2.48	3.99	3.36	3.43
Forestry	4.76	1.79	6.58	1.88	-12.45	14.31	12.49
Fishing	-15.20	3.77	0.65	0.98	5.75	3.25	1.23

Source: Pakistan Bureau of Statistics, 2016-17

World Cotton Outlook

Cotton is one of the world's most significant crops and a basic source of monetary advance. China, India, USA and Pakistan are top makers of cotton representing about 60 percent of the world generation. There are 50 cotton species on the planet. Fiber making is the genuine capacity of cotton. For the confine build up from its seed, seed cotton picked from the harvest is additionally taken for ginning. Because of the generation of garments, towels and other family unit things material industry relies on cotton textures. Cotton meal is full of protein which is used for nourishment of animal. The important source of cellulose is linters which are used in mattresses. For the production of oil the compressed seed is used. It is used for different purposes like that cooked oil, plastics and soaps (Vitale *et al.*, 2009)^[36]. The yield and usage of main cotton production countries

are shown in table.

Table 3: Production of Major Cotton Growing Countries (Million Tonnes) E: Estimated and P: Projected

Production	2014-15 E	2015-16 P	2016-17
India	6.56	5.75	5.80
China	6.50	4.75	4.74
USA	3.55	2.81	3.75
Pakistan	2.30	1.51	1.68
Brazil	1.56	1.29	1.44
Uzbekistan	0.88	0.83	0.79
Others	4.82	4.10	4.58
World Total	26.19	21.04	22.78

Source: Pakistan Central Cotton Committee, Ministry of Textile Industry (April, 2017).

Table 4: Major Cotton-Growing Countries' Consumption (Million Tonnes) E: Estimated and P: Projected

Production	2014-15 E	2015-16 P	2016-17
India	7.48	5.75	5.80
China	5.26	4.75	4.74
USA	0.78	2.81	3.75
Pakistan	2.49	1.51	1.68
Brazil	0.80	1.29	1.44
Europe and Turkey	1.69	1.69	1.63
Bangladesh	1.20	1.32	1.40
Vietnam	0.87	1.01	1.14
Others	3.86	4.10	4.58
World Total	24.44	21.04	22.78

Source: Pakistan Central Cotton Committee, Ministry of Textile Industry (April, 2017).

More than millions of Pakistani producers work directly with the cash crop cotton. They are indirectly associated with cotton growing and are a member of the cotton value chain, as are many others. As a result, tens of millions of farmers and people engaged through the cotton value chain rely on this one crop for their livelihood (Hassan, 2011)^[41]. Cotton crop is uncovered to biotic weight. The greatest risk of cotton is from insects and pests. In Pakistan sucking and biting bugs are the major dangers to the products. In view of climate states of agro-industrial regions are reasonable for variety of population of irritations to some degree. Chewing pests are detrimental to crop growth, development, and output, and controlling them is a difficult task for scientists and farmers (Hassan, 2011)^[41]. Cotton yield was anticipated at 10.671 million bales

estimating in 2016-17, up 7.6% rise in yield from 9.917 million bales in 2015-16, but still well short of the objective of 14.1 million bales. Cotton generates 5.2% of agricultural value addition and accounts for 1.0% of GDP. Cotton yield is primarily due to a 14.2 percent decrease in sowing area, which was lower than expected repossession in which existed at 2489 thousand hectares during 2016-17 especially in comparison to 2902 thousand hectares throughout the following duration of previous year due to matchless failures from previous season's pest infection and reduced household costs at the time of sowing, which forced farmers away from cotton and toward other competitive crops (sugarcane and maize). Following table showing the land, output, and yield of cotton during the previous five years (Government of Pakistan, 2016-17).

Table 5: Area, Production and Yield of Cotton

Year	Area/hectare		Production/Bales		Yield/hectare	
	(000 Hectare)	Percent Change	(000 Bales)	Percent Change	(kgs / Hec)	Percent Change
2012-13	2879	-	13031	-	769	-
2013-14	2806	-2.5	12769	-2.0	774	0.6
2014-15	2961	5.5	13960	9.3	802	3.6
2015-16	2902	-2.0	9917	-29.0	582	-27.4
2016-17	2489	-14.2	10671	7.6	730	25.4

Source: Pakistan Bureau of Statistics (July-March)

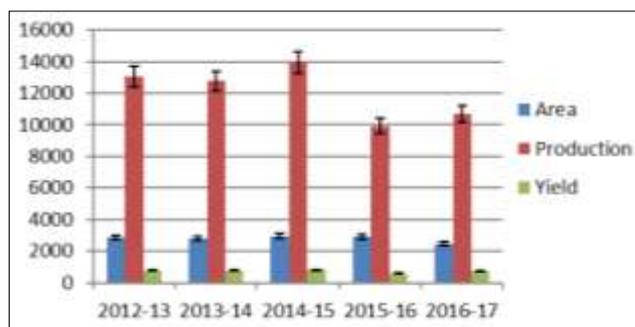


Fig 1: Area, Production and Yield of Cotton

General Cotton

Labour force and its crop growing and employment to 40percent of industrial labour in textile industries. In addition, cotton seed oil accounts for 60percent of total edible oil usage (Adeel *et al.*, 2017) [1].

Cotton is among the utmost significant crops in the nationwide enormity. It is grown in tropical and subtropical climates. United States, Australia, Argentina, Egypt, Pakistan, China, Brazil, India, Greece, and Uzbekistan are all major cotton producers in the world today. These nations partake about 85percent around the nationwide cotton production (Wakelyn *et al.*, 2003; ICAC, 2002) [37]. Pakistan is the fifth-biggest cotton grower, third-largest supplier of faded cotton, fourth-largest cotton user, and largest exporter of cotton yarn in the world. Between 30 and 40% of cotton is used in certain home products. The leftovers are shipped out as raw cotton, yarn, fabric, and garments (Muhammad *et al.*, 2015) [25].

Cotton is the world's most considerable crop and the second most noteworthy oil seed crop. Cotton is grown in every part of the planet, including Antarctica and more than 60 countries worldwide. In many nations, cotton crop provide occupation and millions of people work in its manufacture, handling, and marketing to earn money (Chaudhry and Guitchounts, 2003) [8].

Cotton fibre crop characterises for nearly half of the price of yarn, and there is a significant relationship between certain fibre quality features and yarn quality characteristics. Cotton crop prices were typically extremely high in dominating variables like staple length, colour, grade and micronaire. These are still the most important pricing variables, but today's spinners are also concerned in other fibre qualities that impact the quality of their yarns and the efficacy with which they are produced. The textile industry has been determined to improve efficiency and quality via the use of high-speed machines on a regular basis, Modern technologies exert increasing technical demands on textile fibres, enhancing the significance of cotton's other characteristics: strength, maturity, uniformity, fineness, short fibre content, elongation, spinning performance, cleanliness and dyeing ability. Spinners paid a greater premium for better, longer and stronger cotton lint that is

white, shiny, and completely grown, assuming all other factors are equal (Gerald, 2008) [10].

Cotton fibre is utilized for cloth and cotton seed is the second uppermost resource of vegetable oil production around the world (Singh *et al.*, 2004) [34]. In Pakistan cotton partaking approximately 50-62 percent of combined local unpreserved oil generation. It contributed 24.61 percent share in absolute esteem development of major agrarian yields of Pakistan (Government of Pakistan, 2011) [14].

Cotton crop is the major imperative and cash crop and it plays a major part in the agricultural economy and industrial economy of the nation. Some production strategies, including such plant to plant and row to row distance, as well as other crop qualities, such as an indefinite growth pattern, make the crop vulnerable to a variety of diseases and pests at all phases of growth and over a long period of time. Cotton stalks have a nitrogen content of 1.11 percent, a phosphorus content of 0.1 percent, and a potassium content of 3.98 percent. This indicates that the produced crop could supplement 1.5 tons of carbon, 20-25 kilogrammes of nitrogen, and 72 kilogrammes of potassium from cotton stubbles gathered from a hectare of cotton planted land. The stubbles could be crushed or powdered using a chipper. If we cannot chop stubbles, these will become a host of pink bollworm (Government of India, 2010) [12].

Moisture is decisive at the initial stage of each stage that's why irrigation should be provided every 15 days. There are 100 destructive insects of cotton. Out of these 15 insects can affect severe losses. Some of them are mite, aphid, jassid, whitefly, thrips, pink bollworm, spotted bollworm army worm, and American bollworm. Cotton is picked and stored in a safe and clean manner, which leads to improved rates and sales. When it comes to seed quality, picking time is very critical. Cotton should only be picked after the bolls have begun to open and the cotton is fully grown. Because bolls mature every two to three months, a lot of harvesting may be required. Cotton seeds that are picked early have a greater chance of germinating. (Govt. of India, 2010) [12].

Table 6: Growth stages of cotton plants:

Growth Stages	Days
Planting to emergence	4-9
Emergence to first square	27-28
Square to flower	20-25
Planting to first flower	60-70
Flower to boll open	45-65
Planting to 1 st picking ready	125-65

Problems of Cotton Growers

There are following problems of cotton producer's insect sprays and flighty atmosphere, work issues, dark promoting by the private brokers, disappointment of Government arrangements and issue of power (Turkhade, 2012). The

Pink Bollworm of cotton is a major issue for cotton ventures.

Pink Bollworm

Cotton (*Gossypium hirsutum* L.) is recognized as silver fibre because to its economic value across the world. The amount of insect pests that attack cotton in Pakistan leads in a 30-40% drop in cotton yield (Ahmed, 1980) [4]. The pink bollworm is the most devastating pests among all the bollworms of cotton crops, not only reducing yield by direct feeding, but also affecting the quality of the fibre (Waleed, 2003) [37]. Annual losses from this insect in Pakistan are estimated to be over one million bales (Ahmed, 2009) [5].

The introduction of BT. cotton in many cotton-growing regions of the globe resolved the issue of bollworm complex in 1983, but the problem reappeared again in 1996, and this time only pink bollworm showed first-time resilience to Bt. cotton (Simmons *et al.*, 1998) [32]. The repeated assaults of this insect have been observed to cause considerable destruction to the cotton crop (Wan *et al.*, 2004; Tabashnik *et al.*, 2005; Prasad and Rao, 2008) [39, 35, 37]. The use of synthetic pesticides perform a fundamental part in controlling this insect pest in any case the frequently and plenty application of similar group of pesticides created resistant in pest and seemed various occurrence of pest occurrence (Ruscoe *et al.*, 1996) [31]. Nevertheless botanical pesticides are well-known and very significant group of naturally occurring substances in alternative control measures. These are very viable with their moderate influencing activity in the field of yield security and for the most part thought to be protected to living life form especially to common enemies (Isman *et al.*, 1990) [20].

By the application of different plant-extract on BT cotton and non-BT cotton, population of pink bollworm is affected. It is much effective in plants tobacco and such consequence was observed maximum until 48 hours after its using. It is effective as it use as local bio products. It plays a fundamental function being safe bio-pesticides for living organisms (Rajput *et al.*, 2017) [30].

Cotton is hampered by an infestation of the cotton bollworm complex, of which the pink bollworm is a limiting factor in the crop's productivity. As a result, developing resistant nectar-free cotton cultivars is a significant tactic in the fight against bollworms. Plant resistance, on the other hand, is influenced by a mixture of physical and environmental elements rather than a single one. There are several more elements that impact the pink bollworm infection as well. These elements might be physical, morphological, or biochemical in nature, and they could interact to have a positive or negative effect on the pink bollworm infection (Khan *et al.*, 2002) [22].

Over ambitious plant protection methods adopted by farmers for this commercial crop resulted in tragic crop failure in spite of heavy expenditure, which was followed by many cotton growers. The attack of bollworms on cotton is severe. Loss in cotton becomes very high due to this attack. The results of the attack of Boll Worm are improper opening of bolls, young bolls may drop off, Lint colour is discoloured and fibre quality, ginning percentage and oil

content are affecting (Jothi, 2007) [21]. These are the most dangerous for cotton. A critical attack is shown on neighbouring and Bt. cotton because of lost their protection against bollworm in Pakistan. Organic pesticides are viable less expensive for controlling the populations of pest than manufactured pesticides (Khuhro *et al.*, 2014) [23]. Its effect does not only decrease the quantity but it also damages the quality of cotton (Waleed, 2003) [37].

Pink bollworm is a most horrible enemy of cotton crop which affect on oil content, quality of cake and lint quality. It is one of the main harmful in financial terms. By the help of some important safety measures its effect can be minimized. 4-6 sprays of deltamethrine + triazophos at weekly intervals. Normal spray of pesticides is favourable for the environment and cotton plants. Don't allow excessive use of pesticides. The best control of pink bollworm has been shown with the utilization of pheromone. Fields treated with pheromone additionally have a higher population of predators and parasites that are a vital segment of integrated pest management. The pink bollworm a hatchlings stage eats the seed and influence the germination nature of the seed. The loss in weight of seed cotton will be there (DAWN, 2005) [9].

The pink bollworm is back with revenge. Cotton, jute, Hibiscus and okra are among the crops that the larvae eat. Flowers, young bolls, axils of petioles, and the underside of young leaves are all places where eggs are placed. During two days of hatching, the juvenile larvae go through the young bolls or ovaries of flowers. In 3-4 days after hatching, the larvae become pink. The intensity of pinkness is determined by the larvae's diet. When they ingest mature seeds, you get a dark pink colour. Moths are filthy brown in colour and grow to be around 5 mm long. Larvae love to feed on growing seeds and usually pupate within the bolls and seeds. Overstated bolls also open ahead of time or become imperfectly affected due to decomposing. Fibre characteristics, for example, length and quality are brought down. Secondary fungal infection damages the cotton lint in insect-infested bolls. Seed cotton transported to market yards serves as a vector for the pest's propagation. Pink bollworm appears at the beginning of winter and remains on the crop as long as blooms and bolls are present. Long-term commitment cotton permits the pest to achieve a bit more for a sustained duration of time in several cycles, harming the cotton crop after that. The pink bollworm hibernates in the lack of cotton or as a hereditarily susceptible state, allowing it to lie inactive for 6-8 months until the following season (Singh, 2015) [33]. Outside material during picking practices might be inadvertently presented and ginning where seed coats may not be sufficiently expatriate and wire or metal can sever apparatus and stay inserted inside the filaments (Govt. of India, 2012) [13].

Symptoms of Attack

- Stained lint in open bolls
- Pheromone moth trap catches
- Rosette flowers
- Exit holes on green bolls



Fig 2: Symptoms of pink bollworm

Reasons for Pink Bollworm Occurrence

- A large range of hybrids with different blooming and fruiting seasons that supply continuous feed for the bollworms in abundant.
- Raw cotton is stored for a long time in market yards and ginning mills, which serves as a supply of pink bollworms for the following crop.
- The early-sown crop began flowering in April-May, coinciding with the modest seasonal spike of pink bollworm in June-July.
- In immature bolls, Bt-toxin expression is decreased in squares, flowers, and developing seeds.
- Shortage of timely and suitable control actions resulted in the insect pest's continued expansion. On Bt-cotton, farmers do not use any control techniques over any bollworms.

Management Strategies

- Assessment of bollworm resilience to BT cotton on a regular basis.
- Using the parasitic *Trichogramma* bacteria to control pink bollworms in BT cotton crops.
- Crop termination as soon as possible, preferably before December, to prevent a protracted crop.
- Crop leftovers and cotton stalks should be used or destroyed shortly after harvesting.
- Crop rotation is essential for breaking the pest cycle.
- Single-pick types with a short duration (150 days) produce large yields at high density while avoiding the pink bollworm.
- During the season, install pheromone traps and light traps in fields, as well as near go-downs, ginning mills, and market yards to catch post-season moths.
- By using pheromone traps, mating disruption and mass trapping are possible.
- Frequent monitoring and control interventions using green boll dissection and pheromone traps depending on economical threshold values of 8 moths per trap each night and/or 10% damage in green bolls.
- To avoid whitefly infestations, avoid spraying pyrethroids before November or other pesticide mixes at any stage.
- Choose cultivars that are resistant to sucking pests.

Training need assessment

Expertise, learning and state of mind an individual require with a specific end goal to beat issues and also to abstain from making issue circumstance is characterize as a preparation require (Training is a fundamental asset which will coordinate information and ability towards creation (Adesoji *et al.*, 2006) ^[2]. Recognizing preparing wants frequently remains the obligation of outside preparing administrators. It is in this method portrayed by their investigation of the circumstance (frequently outside) and by the goals that they are seeking after (regularly sectorial, quite often controlled by their institutional prerequisites). Therefore it is chosen all things considered, what is useful for the agriculturists, what is important, and later, the farmer's absence of energy to take after the sessions sorted out for them is lament (Mercoiret and Mercoiret, 2003) ^[24]. Pakistan is an agriculture based country and for survival most of the people directly or indirectly rely on agriculture. The Pakistani government has taken a variety of steps to train the farming population. For this objective, a variety of ways have been attempted, but none have shown to be as productive as usual. After seeing its achievement throughout the world, the Pakistani government decided to implement the Farmer Field School (FFS) strategy for the purpose of building capacity of farmers. Their aim is to advance and increase the awareness of farmers in farming via human capacity building. This strategy uses modern methods to train and enhance the capability of the agricultural community in vegetable and fruit production. For higher rate of profits for their outputs across the world school was constructing for training of farmers with advance marketing techniques (Iqbal *et al.*, 2016) ^[40]. The nature of cotton quality is subjective genuinely amid various agronomic practices and in addition amid picking, transportation, stockpiling and ginning process. The junk substance is the fundamental purpose behind delivering low quality yarn. Amid the transportation the cotton trim is secured with jute packs, and jute fibre blends with the cotton edit and makes issue in ginning and additionally turning process which crumbles the nature of yarn for trade purposes. Distinctive assortments of cotton put away together is another factor that impact the nature of harvest as the diverse assortments have distinctive fibre attributes like staple length, fineness, quality, shading grades, junk substance (Iftikhar *et al.*, 2012) ^[18].

For the adoption of new techniques and knowledge extension officer wants to guide the farmers to as farmers are not fully aware of appropriate farming techniques, management skills and relevant programs offered by extension services. So, training plays a very important responsibility in the lives of farmers as well as agricultural personnel (Priya and Sirvanaryana, 2013) [28]. In-service training of the Agriculture Officers problem solving discussion, participatory sessions, and demonstrations are the most appropriate and important methods (Chaudhry, 2016) [81]. Most important training needs of the cotton growers are plant protection measures, identification of quality seed, and use of refuge line (Padaria *et al.* 2009) [26]. The most common needed training areas were soil test, insect pest management, disease management, manure and fertilizer management in the main field and manure and fertilizer application before planting in pits for both the areas (Ashutosh and Basu, 2008) [7].

At any level training is an important instrument for Human Resource Development (HRD) which cannot be ignored. For planning a good training programme first and main activity is to attain the training needs. Need assessment distinguishes the present issues and future difficulties to meet through preparing and improvement. With a specific end goal to make any preparation significant and viable, it is basic with respect to the preparation coordinators to distinguish the preparation need of the farmers in view of which a reasonable preparing module can be created so the suitable preparing is given to the specific individuals in the correct form, at the ideal time the level of effectiveness and assistance can be proficient (Archana and Sailaja, 2013) [36]. Need assessment is the way toward attaining the association, workers and compile assignment to figure out what type of preparing, assuming are essential. The idea of need appraisal can likewise be alluded to as the procedure used to decide whether preparing is fundamental. Needs examination starts with issue distinguishing proof and definition. It is trusted that a primary advance in any preparation program is to decide if preparing is required and if so to indicate what that preparation ought to give. Preparing needs are abilities, information and states of mind an individual requires so as to conquer issues and in addition to abstain from making issue circumstances. A need examination may recognize in excess of one preparing need. These necessities ought to be organized and either put into a formal preparing plan, or to set up a database for future preparing (Archana and Sailaja, 2013) [36].

Conclusion

Fibre of Pakistan is better in all qualities. But yield of cotton and quality of fibre is declining year by year. These losses are due to the natural terrible like rain, smog and diseases like pink bollworm and the main causes are insignificant by the growers at the time of picking and post-harvesting. The farmers can not follow directives about clean picking. Losses during picking affect the quality of fibre that's why the International markets cannot prefer to the cotton which is exported by Pakistan. To overcome these, there must be training need assessment of cotton growers. There is an urgent demand for technical knowledge/training combined with motivation. Cotton growers urgently need to be trained on suggested cotton cultivation procedures. Because knowledge is a condition for adoption.

Recommendation

- There must be proper training of farmers regarding production technologies.
- There must be subsidy on agriculture inputs.
- Inputs must supply at proper time.
- There must be soil testing regular interval.
- There must be coordination of public and private sector.
- Training session must be conduct at regular interval.

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