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News

Organic Cotton Summit 2021

The global organic cotton platform, Organic Cotton Accelerators (OCA) organized Organic Cotton Summit 2021 from November 8-9, 2021. Theme of the virtual summit was 'Pushing Past the 1%'. Now, less than 1% of the cotton currently grown worldwide is certified organic. Many suppliers of textile merchandize are coming up to utilize the organic cotton as demand of organic cotton is increasing with increased awareness about environment. Paul Holmbeck, organic policy and market consultant was the key note speaker on day-1 of the summit, other sessions discussed topics like the supply chain issues, sustainability of organic cotton, impact of organic cotton on farm to fashion, regenerative organic agriculture, scaling up organic cotton supply and investment in organic cotton supply were the major topic came under discussion.

79th Plenary Meeting of the International Cotton Advisory Committee -ICAC

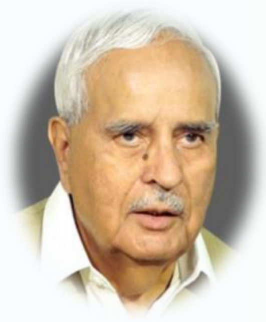
The 79th Plenary Meeting of the International Cotton Advisory Committee (ICAC) organized from 6-9 December 2021 with the theme "Fortifying the Cotton Supply Chain-New Approaches to New Challenges". The meeting held virtually with 575 persons registered including representatives from 24 Member Governments, 8 international organizations and 21 non-member countries. The ICAC secretariate uploaded country statements from 16 countries, and deliberated reports from the secretariat, world cotton trade, production and trade subsidies affecting cotton industry, global textiles fibres demand, and private sector advisory council. The aspects related to fortifying the cotton supply chain, labeling to provide transparency and traceability also discussed. The technical session also included global status of biotech cotton, challenges of hybrid cotton, prospects & potential of organic cotton. The meeting also deliberated stakeholders for collaboration in sustainability and climate change issues especially for the most vulnerable elements including small farmers, women, and textile industry workers. The Steering Committee of the ICAC also met during the plenary meeting.

The Committee decided that the 80th Plenary meeting would also be held virtually in December 2022 with the Theme for Technical Seminar "How Regenerative Agriculture Can Contribute to a Sustainable Cotton Sector".

International Seminar on Pink Bollworm Management:

Pink bollworm remained a serious pest management issue for the last several years. To address this issue, Central Cotton Research Institute, organized the first seminar in 2015 and the activity continued till 2021. This year some foreign researchers were also invited to share their findings to understand the PBW and its management in more holistically. Local scientists, pesticide and seed industry personals, cotton grower, extension agents and policy makers participated in the seminar. The CCRI also organized an exhibition of cotton and its input suppliers for the interest of growers. Dr. Keshav Kranthi, Head of scientist, ICAC-USA, and Prof. Dr. AG Sreenivas from India shared their research findings. The seminar was well attended, and finding were placed before provincial and federal governments for implementation and policy formulation.

Demise of Pakistan's Leading Cotton Scientists



Dr. Zahoor Ahmad (1942-2021), a leading cotton scientist of Pakistan, suffered from Corona virus and passed away on 21.04.2021. Dr. Ahmad was the founding Chairman of the Asian Cotton Research & Development Network, established in June/July 1999. Dr. Ahmad has Director, Central Cotton Research Institute, Multan, hosted a Regional Consultation on Insecticide Resistance Management in Cotton. The Consultation resulted in the formation of the Network, one of the strongest among the four Networks supported by the ICAC.

Dr. Ahmad was Entomologist by education, received his Ph.D. from the Washington State University in the early 1970s and started his career at Pakistan Central Cotton Committee (PCCC) and served PCCC for 30 years. Dr. Ahmad has promoted cotton IPM in Pakistan and contributed many basic and applied research experiments to answer pest management issues. He also served Food and Agriculture Organization to implement a pest control project in Myanmar in 1981. He earned remarkable reputation and received numerous awards including the Presidential Pride of Performance Award in 1996, Dr. Borlog Award (1995), FAO Gold Medal (1995), and Chaudhry Muhammad Afzal Award (1996). He was associated with seed industry after retirement. He was a great man, truly dedicated to his cause.

Dr. Mahbub Ali (1923-2015), was born in Gurdaspur, British India on 13th August 1923. He obtained B.Sc. (Agri.) and M.Sc. (Agri.) degree from Punjab Agricultural College & Research Institute, Lyallpur (Faisalabad), Pakistan and PhD in 1955 from Agricultural and Mechanical College, Texas, USA and got training in Cotton Cultivation from USSR. He started his career in agriculture department of Punjab province and served CCRI Multan and provincial agriculture department in different capacities like Cotton Botanist, Agriculture Officer and Research Assistant. During his illustrious career, Dr Mahbub Ali held various prestigious positions, including Managing Director, Punjab Seed Corporation, Govt. of Punjab, Founding Director, Central Cotton Research Institute, Multan, He was elected Fellow of the Pakistan Academy of Sciences. Dr. Mahbub Ali had considered himself a retired person, rather kept guiding as Scientist Emeritus to young scientists and cotton breeders till his last days. Dr. Ali earned many honors and awards which included civil award of Pride of Performance by Government of Pakistan, 1971; Open Gold Medal by Pakistan Academy of Sciences, Award of Scientist Emeritus (Punjab), Award of Scientist Emeritus (Pakistan), and Shield of Distinction, University of Agriculture, Faisalabad. Dr Mahbub Ali remained member of several committees at various levels and contributed for the development of cotton crop in the country. His areas of research were evolution of new varieties and cotton agronomy. He was considered a founding father in cotton R&D and a mentor to the next generation of cotton research, During the cotton season, one would spot him almost every day visiting cotton fields of farmers or researchers and kept interacting with them. Dr Mahbub Ali possessed a pleasing personality, he was a very kind and humble person, with all-time smiling face.

COMBATING PINK BOLLWORM: A CHALLENGING PEST OF COTTON

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Introduction:

Cotton is of crucial important crop for the economy of Pakistan as it is a major source of foreign exchange earnings, employment and provides raw materials to over 400 textile industries. Cotton has an impressive and wide-ranging multiplier effect on the rural economy. One million bales create on-farm employment of Rs. 10.50 billion and that of Rs. 2.25 billion at the ginning factories. Total value of four main by-products of one million bales is about Rs. 83 billion of which lint, cotton cake, cotton oil, and fuelwood are worth Rs. 49 billion, Rs. 17 billion, Rs. 7 billion, and Rs. 10 billion, respectively. In total, the economic benefit to the rural economy amounts to Rs. 95.75 billion. Most of these economic benefits accrue to the poor people, especially women, in the rural areas.

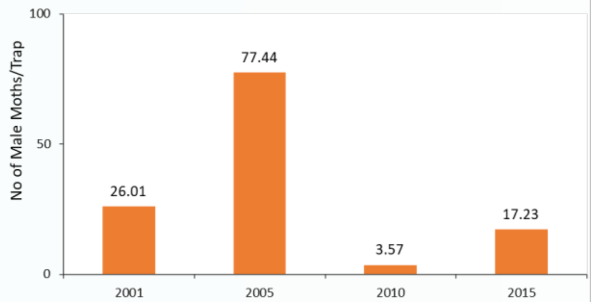

Fig 1: Pink Bollworm moth catches in pheromone traps

Source: CCRI Multan

Pink bollworm has been a serious pest for long time, however after the introduction of GMO cotton in 2010, its incidence declined to some extent, but since 2015, it erupted once

Seasonal Population buildup:

The population dynamics studies over years show an identical pattern, a small peak commonly known as suicidal emergence in June-July followed by a progressive population buildup reaching to a high-peak in September-October (Fig 2). Cotton sticks in Pakistan are used for burning in rural kitchen as firewood and saved after last pick. Though, small ruminant animals are offered to graze on left over bolls after last picking, but still not all bolls are consumed by goats and infested bolls on cotton plants are stack stored beside cotton fields for future use as firewood, which serve as PBW reservoir for the first emergence. Cotton ginning waste also contains hundreds and thousands of PBW larvae which is another source of first emergence, if not disposed off properly. PBW larvae hibernate in cotton seeds commonly known as “double seed”. Cottonseed saved for the following season in stores of seed companies also serves as source of first emergence of PBR.

Early planting (March-April) of cotton has been gaining popularity over the time-sown (May-June) as later gets infected with cotton leaf curl virus (CLCV) disease, whereas the developmental phase of early sown crop varieties escapes from the disease severity period and are able to give good produce despite having moderate resistance against the disease. Such plantation is usually practiced on small scale, in fallow fields or fodder-cotton rotation. In wheat-cotton rotation, cotton is being planted at its recommended sowing time (May 15 to June 15). Although area under early sown cotton is very limited, but it serves as host for population buildup of early emergence (suicidal emergence) of PBW. In such area, time-sown cotton gets severely hit by PBW at flowering stage, necessitating early application of pyrethroids or some highly toxic OP insecticides, which wipe off natural enemies. Such ecological disruption in early season triggers large number of insecticide-applications and emergence of un-managed whitefly or mealy bug infestation.

Delay First Application of Insecticide:

Experiments show none of the insecticides is safe for beneficial fauna, however, delaying first application for about 60 days after sowing, allow cotton fields to develop population of beneficial fauna good for early management of whitefly and PBW. To deal with insects reaching economic threshold level (ETL) in some fields, botanical insecticides were used which have been proved effective to drop the pest population below ETL and were soft on natural enemies as well. Delaying first application of insecticide proved effectively in lowering the PBW infestation and reduced total number of insecticide applications during the crop season. Quality control of home-made recipes of botanical insecticides remains a challenging factor for varying its effectivity.

Installation of PB-Rope:

Use of PB-rope or male disruptive technique for the management of PBW proved its effectivity in trials at the Central Cotton Research Institute, Multan (Table 1). However, the pre-requisite of these to install on large sized compact block of at-least 50-acres, and area wide application for desired results are some challenging factors. High temperatures in cotton belt probably increases the pheromone dispensation rate and the long fruiting period is also a limiting factor for its effectiveness later in the season. The pheromone-release lasts up to 90-days, until 45-day with very effective release, whereas varieties with long fruiting period having peak flowering period synchronized with its depleted pheromone-release phase, probably require a second application of PB rope.

Table 1: Performance of PB Rope (after 90 days) installed @ 120/acre at CCRI Multan

	Treated Block	Untreated Block
Weeks & Months		
Sept. I	0.0	2.0
II	0.0	10.5
III	0.0	2.0
IV	0.0	9.0
Oct I	0.0	4.5
II	0.0	2.5
III	0.0	5.5

Source: Central Cotton Research Institute (CCRI), Multan

Natural Enemy Field Reservoir (NEFR):

NEFR technology was developed by CABI Biosciences and had been used very effectively for the management of mealy bug in the past. An insect reservoir is maintained in the middle of field for multiplication of its natural enemies to disperse in cotton fields. Large sized 3x5x2 feet metallic containers were placed in a top-covered station preferably in the middle of field. Host insects, infested bolls and ginning waste with PBW larvae were placed in such containers and covered with mesh cloth to avoid escape of any adult moth (Fig 3). Pheromone traps were also installed to catch the accidentally escaped moths. The natural enemies/ parasitoids reared on PBW larvae, emerge from host insects pass through the mesh cloth and freely infest PBW larvae or egg in field. Though, it requires initial investment and is considered a labor-intensive technology but it gives a sustainable management of PBW. The technology is being tested in Sindh province by CABI international with collaboration of provincial government and gaining growers preference

Fig 3: NEFR Technology developed by CABI
Source photo: CABI Pakistan

PBW Manager:

It has always been desired to cope with source of PBW in order to reduce population build up in early season. Department of agriculture always run campaigns and sometime take help of legal framework for left over boll management, sun facing stacking of cotton sticks, turning over piles of cotton sticks once in every fortnight, burning of ginning waste etc. but managing such a large area and working with 1.2 million cotton farmers remained a point of concern for the department. The mechanical boll picker developed by CCRI; Multan has been tested for it efficacy in post-season PBW management in cotton.

Fig 4: Pink Boll Worm Manager developed by Central Cotton Research Institute (CCRI), Multan
Source photo: CCRI Mutlan

PINK BOLLWORM MANAGEMENT: CRITICS, APPRECIATION & PATH FORWARD

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INTRODUCTION

For the last 40 years, Pink Boll Worm (PBW) damage to cotton crop is enormous: for instance, in 1983, damage was about 50%, which dropped to 25% in the year 2001, mainly because of pheromones were initiated for monitoring and well-timed applications of pyrethroids tank mixed with organophosphates, and PB-ropes for management as mating disruptors. Later, during the years 2008-2011, GMO cotton varieties were widely adopted, which ultimately reduced the use of synthetic insecticides and mating disruptors, however pest damages ranged up to 30%. In the current year, 2021, the damages due to PBW, in some fields across the cotton growing belts, remained more than 50%, because *Bt* varieties lost resistance against pink bollworm. Despite the insecticidal control of PBW is difficult, in many cases it is reported ineffective as well. The increase in frequency of sprays (6-8 applications) needs a critical review of management practices. Below are some critics, appreciation and path-forward on the subject discussed.

Critics: Over the years, a lot has changed for the cotton crop; due to climate change, the cotton growing season is altered, currently crop planting is shifted 4-6 weeks earlier (from May-Jun to Apr-May); extended summer season and comparatively shorter winter season had dramatic effects on PBW population buildups. Early spring-cum- and cause first infestation in June-July on early planted crop.

Apparently, PBW have 4-5 generations than previously reported 3-4 generations. Prolonged crop cycle, overlapping generations, delayed harvests give ample opportunity to the pest to multiply particularly during the months of September and October. PBW is highly adaptive to changing climatic conditions. Cotton variety(ies) with late maturing characteristics and crops grown for extended periods are well reported for heavy PBW infestations (with up to 80% boll damage).

Integrated Pest Management (IPM) model can effectively manage PBW, as this pest feeds on cotton only. Biological control of PBW needs much attention (predatory beetles, bugs, wasps, egg and larval parasitoids can better be explored and integrated); and there is need to consider ways to increase their effectiveness including compatibility with synthetic insecticides. Crop variety development program has not focused on host plant resistance against PBW. The breeding program requires rigorous screening of germplasm for traits like nectari-lessness, densely hairiness, high in gossypol and antibiosis contents, and earliness for PBW management. Proper cultural and mechanical tools are yet to be utilized for PBW management. Failing to manage hotspot fields with high infestations and poor pest control remain as source of infestation to nearby cotton fields.

Transgenic cotton has its own pre-requisite protocol to grow globally, *Bt* is recommended to cultivate with non-*Bt* refugia, which is not being followed in case of Pakistan which resulted in breakdown of resistance of *Bt* gene in an accelerated way. *Bt* gene expression in varying degree coupled with long duration of crop cycle that results in dilution of protein is also a reason for PBW infestation on *Bt* cotton.

Over reliance on synthetic pesticides and using them without insecticide resistance management strategies (IRMS), chemical control can be a disaster: In any crop, pesticide use is always subjected to strict compliance of pest management principles based on 5R (risks, residues, resurgence, resistance and return on investment) – hence demanding sound IRM strategies. Correct time of application is a thumb rule in chemical control of pest. Economic Threshold Level needs revisiting as it may not suit to *Bt* cotton and it must incorporate moth catch as it is a good indicator of population buildup and future damage. A wide range of broad-spectrum pyrethroids, and organophosphates giving effective control of bollworms, can be still extended effectively by using alternatively, in rotation, or as mixtures.

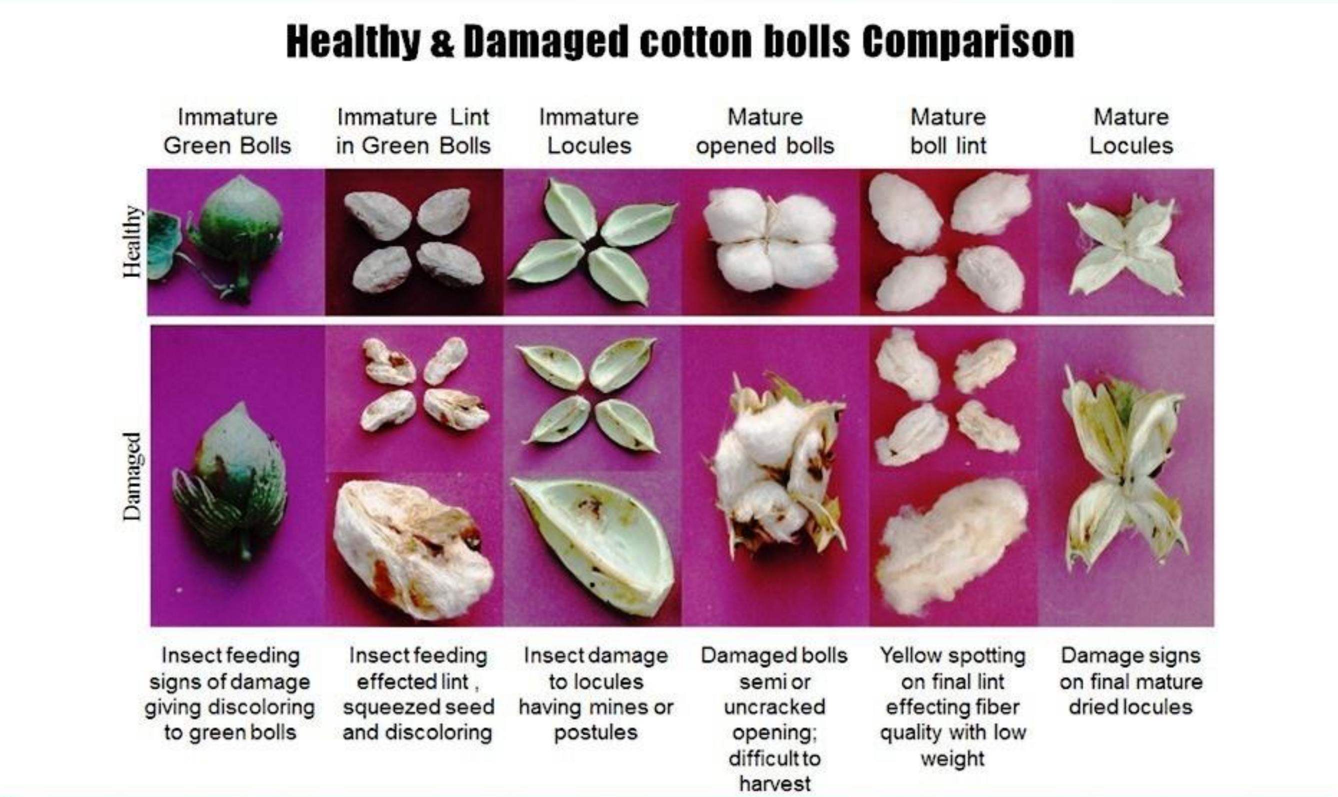
New insecticides have no exceptions from resistance development; failures of insecticides are sometime misreported as "non-effective" to an improper application technique. New insecticides with unique target site activity are much more effective, if rightly timed with the right pest stage. These insecticides are environmentally best suited.

Appreciation: In recent years, awareness on PBW off seasonal management is much raised among stakeholders associated with cotton production. Effective pest management during the season is a function of how better it was managed during the off season. PBW carryover is well documented that 80% population comes through left over bolls and unmanaged plant sticks, 15% through cotton seeds from previously infested crops, and 5% through crop and gin trash. In un-open/left over bolls, PBW overwinters and stays well protected for many months. Despite varying infestation levels during the active crop growth, the pest is unique for having population peaks near at harvest; hence requiring special activities/checks during its off-season management. Cultural control of PBW includes eliminating hibernating larvae between two crop seasons. Farmers/progressive growers/farms must focus short duration of crop, and thus timely harvesting enables a good management of crop residues. In short busting the population at two times in the life cycle, in spring/early summer emergence and winter diapause, will check the pest population in successive years. Much focus can be drawn by awareness campaigns on timely (early) harvest for a good seed cotton yield and more quality cotton seed.

It proved that efforts about awareness regarding disposal of crop residues (from field and ginneries) worked perfectly in reducing the PBW damage in the following crop season. Mobilization of private sector to support outreach activities and PBW management transforming into community work from realizing to implementation can provide a sustainable solution. Use of mechanical cotton boll picker developed at PCCC-CCRI, Multan is also very effective for timely management of leftover bolls and storing the cotton sticks without fear of hibernating PBW larvae.

Path forward: Managing crop and pest in an integrated way is the most efficient way of raising crop and controlling the pests. In case of cotton: planting window, crop input use, sampling and pest scouting, knowledge-based decision making, selection of soft pesticide, efficient application techniques, and employment of resistance management strategies for insecticides and transgenic crop are some key factors. Region and country level working groups may be established consisting of the scientists, extension agents, academia and private sectors to work closely and transferring of updated knowledge to growers.

Focusing crop phenology can be divided to stage wise crop periods (Table 1) with needful activities as tools in an integrated way for crop and pest management. Proactive approach should be opted in active growing season and off season. Active season can further be divided into 3 stages (Planting to 1st flower, 1st flower to open boll, and 1st open boll to harvest); whereas off season management into two: Post harvest activities and pre-plant planning. Biological control facilities established under Pakistan Atomic Energy Commission, Provincial Governments, Federal Government or in private sector can play a vital role in rearing of general predators or host specific parasitoids for the management of PBW.



PBW damage and no. of sprays for past 40 years:	1983: ≈ 50%	2001: ≈ 25% 3-4 sprays	2011: ≈ 30% 4-6 sprays	2021: ≈ > 50% 6-8 sprays ≈ 8-10 sprays

Despite that the insecticidal control of this pest is not only difficult but in many cases it is ineffective, yet increase in frequency of sprays against this pests needs a review on its management practices

Table 1. Crop growth based IPM program: key aspects and major activities for active growing season and close season

<table>
<tr><th colspan="8">Active Growing Season</th><th colspan="5">Close Season (crop) and Off-season (pest)</th></tr>
<tr><th colspan="8">Proactive approach is recommended over reactive approach</th><th colspan="5">Proactive approach</th></tr>
<tr><th>½ Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>½ Apr</th></tr>
<tr><td colspan="4">Planting to 1st flower</td><td colspan="4"></td><td colspan="3" rowspan="4">Post-harvest
Observing Official Close Season: timely crop termination, shredding and burying/ of crop stubbles/residue no live cotton or its parts: sticks/ leftover bolls.

Offseason pest management:
in time disposing off of left over bolls, cutting of cotton sticks, deep disc plowing, disposing of gin wastes at ginneries, vertical stacking of plant sticks, burning at brick kilns</td><td colspan="2" rowspan="4">Pre-planting planning for crop inputs, implements, promising PBW resistant cum early maturing varieties; planning Bt and non Bt refugia; irrigation, nutrient and spray plans; field preparations, seed dressing/ acid delinting, discarding PBW damaged seeds</td></tr>
<tr><td colspan="3" rowspan="3">Timely planting: Promising cultural practices, IPM tools for early plant protection; Monitoring, encouraging beneficial fauna, release of Chrysoperla, coccinelids; Plant growth mapping, tolerate non-economic pest damage, preventing pest damages; Avoiding broad spectrum insecticides like pyrethroids / OPs, mixtures; Use of soft and ecological safe and selective insecticides for early season pests, following available IRMs; Sex pheromone traps; use yellow sticky cards</td><td colspan="3">1st flower to open boll</td><td colspan="2"></td></tr>
<tr><td colspan="2" rowspan="2">Matching pest and predator/parasitoid ratios, actions to encourage beneficial fauna; Release of biocontrol agents (incl. Trichogramma); Monitor PBW, Sex pheromone traps (20/ha), use of mating-disruptors for larger fields and area wide control; Monitor pest and managing rosette flowers, fruit-shedding, boll inspections (15-30 days old bolls are much preferred by PBW); Observing the thresholds to apply new chemistry insecticides in time (during Jul and Aug) and with good spray techniques (using 300L spray volume/ha).</td><td colspan="3">1st open boll to harvest</td></tr>
<tr><td colspan="3">Observing short-cycled PBW; as part of IPM, follow ETL: 5 moths catches/3 consecutive nights OR 5% damage fruit damage (destructive boll inspection); spray at 10 days interval, follow IRMS (alternate in rotation of new novel insecticides), use of pyrethroids and their mixtures (in Sep and Oct only), no back to back spraying, preferring power sprayers or tractor operated booms (using 300L spray volumes/ha), observing last spray and labeled PHI. Use defoliants to add crop termination. Stop irrigation and fertilizer inputs (including chemicals) at 40-50% boll opening. Consider early picking 1st in Aug-Sep, 2nd in Oct, and rest in Nov. Avoid last pick for seeding next season crop. Do not mix early harvest with next pickings. Observing long-cycled PBW, timely crop termination and timely harvest</td></tr>
</table>

ECONOMIC AND FINANCIAL BENEFIT OF PINK BOLLWORM MANAGER

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INTRODUCTION

Cotton is considered as lifeline of economy of Pakistan and is known as "White Gold". Pakistan is the 5th largest cotton producer and 3rd largest consumer of cotton in the world. It contributes 0.8% in GDP and 4.5% in value addition in agriculture. The cotton was grown on 2,373 thousand hectares in 2018-19 and that production remained at 9.861 million bales. The crop is a source of raw material for national textile industry and a main source of domestic edible oil production. About 1.5 million farmers in Pakistan are engaged in cotton production.

Pink bollworm (PBW), Pectinophora gossypiella re-emerged as a serious threat to cotton after about 15 years of successful Bt cotton cultivation. Pink bollworm is a monophagous insect and a major damaging pest invading cotton crop in Pakistan. Cotton in Pakistan is hand-picked and usually three to four pickings are done during the season. A reasonable number of 4-5 green/ un-opened bolls are left after last picking due to lowering down of temperature. The cotton sticks in Pakistan are not shredded into soil rather saved to use year-round as fire wood in rural area. The pest (PBW) survives in residual bolls on cotton sticks and in ginning waste during off season which serve as source of pink boll worm infestation in following crop season. PBW can be

The left-over bolls are not picked due to unjustified labour cost, and overlapped period of last picking and wheat sowing. To catch the wheat sowing, farmer axe cotton plants and store for use as a fuel wood in rural areas. The left-over green bolls in heaps of cotton sticks become a potential source of PBW that start emerging when temperature becomes favorable and may survive on early sown cotton crop.

Central Cotton Research Institute (CCRI) Multan designed and manufactured, indigenously, a mechanical boll picking machine named "Pink Bollworm Manager" (PBM) that removes more than 95% unopened/ left over bolls from the cotton plant (Fig-1). The machine is equally effective on different types of plant shapes and variable height. Successful demonstration of PBM has been carried out in different locations of the cotton belt in Punjab province. The previously used machines like stick shredder, stick puller and shredder to mechanically remove and shred cotton sticks could not be popularized as cotton sticks could not be saved for fuel purpose after the operation of those machine.
The PBM can play a vital role in off-season management of PBW as well as in lowering the subsequent seasonal population built-up. Some technical details of PBM are given in Table-1.

Table-1: Manufacturing cost & Operational Feasibility of PBM

Manufacturing Cost (Pak Rupee)	0.75 million
Area covered/ acre (Swath)	4 rows
Line x line distance	2.5 ft
Diesel used /acre	5-6 lit
Diesel cost /acre (Pak Rs.)	600-700
Time required to service an acre	40-50 minutes
Plant height range for the machine operation	3-7 ft
Plant shape/ type machine can service	All plant type/shape and canopy

BENEFITS OF PBM

i) Additional cotton lint:

It is estimated that 1-1.5 million additional bales can be obtained if leftover bolls are saved with the help of PBW manager, nationwide. If only 3 bolls/plant are saved, out of 2.4 million ha cotton area additional revenue of Rs. 5-5.7 billion can be obtained by using PBM.

Table-2 depict that, on an average, 15 and 12 left over bolls per plant were present on cotton varieties CIM-775 and CIM 785, respectively and up to 49.4% of the bolls were damaged by PBW where PBM was not operated. After the operation of PBM no left-over bolls were found in both the varieties. The PBM effectively removed all residual bolls after the operation.

Table-2: Efficacy of PBM in the field

Variety	No MBP			MBP		
	Mean leftover bolls	% boll damage	% live larvae	Mean left over bolls	% infested bolls	% live larvae
CIM-775	15	32.7	34.3	0	0	0
CIM-785	12	49.4	31.5	0	0	0

ii) Pink boll worm management

Losses due to PBW infestation in cotton have been estimated to about Rs. 125 billion rupees annually. If not managed properly, PBW can entail a catastrophic crisis for 1.3 million cotton farmers in the country. As the PBM harvests every single boll left on the plant after last picking, and thus provides an effective off-season PBW management option. Off-season management of PBW may help in suppressing population buildup in the next crop during fruiting phase and thus possibly save up to 80% of the expenditures incurred on agrochemicals for PBW management.

iii) Timely wheat plantation

Mechanical boll picker will help in timely wheat planting as the field will be evacuated as one-time operation hence providing an opportunity to plant the wheat at appropriate time.

iv) Safe Preservation of Cotton Sticks

After the operation of PBM, cotton sticks can be safely kept for longer periods without posing a threat of PBW to the next season crop as there are left no green (infested) bolls on cotton sticks.

Fig. 1: Pictures of Pink Bollworm Manager

BOLLWORM PECTINOPHORA GOSSYPIELLA: CURRENT STATUS AND FUTURE PERSPECTIVES IN SOUTHERN PAKISTAN

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Cotton crop in Pakistan is experiencing a new and emerging threat from pink bollworm (PBW) that has attained the status of a serious pest. The pest has been reported from all cotton producing countries of the world. From Pakistan, it has been recorded as a serious pest since 2010 on cultivated cotton in Sindh (CCRI-Sakrand, 2010). Surveys were made to assess the widespread infestation of pink bollworm in southern Pakistan. The infestation of PBW was observed throughout the cotton growing areas of the region with yield losses ranging between 5 and 35% (Figure 1).

The results of surveys conducted during the years 2016 – 2020 showed that the average highest infestation of PBW was recorded 26.1% in 2019 followed by 24.6% and 24% in 2017 and 2020, respectively. The average lowest damage was observed 10.4% in 2016 (Figure 2, Table 1). The results of surveys of different districts also showed that the average highest infestation of PBW was recorded 32.5%, 31.1%, 30.8%, and 26.1% in Sanghar, Mirpurkhas, Umerkot, and Tando Allahyar, respectively, while the average lowest damage was observed 12.9% and 13.2% in Ghotki and Sukkur (Figure 2, Table 1). Furthermore, the PBW infestation was not found in Dadu and Jamshoro (Figure 1). The highest infestation of PBW in Sanghar and its surroundings is most probably due to the presence of more than120 cotton ginning factories. Based on the results of surveys, it PBW population throughout the region. In addition, it is also suggested that the west side of the province (Dadu and Jamshoro) has huge scope for cotton cultivation.

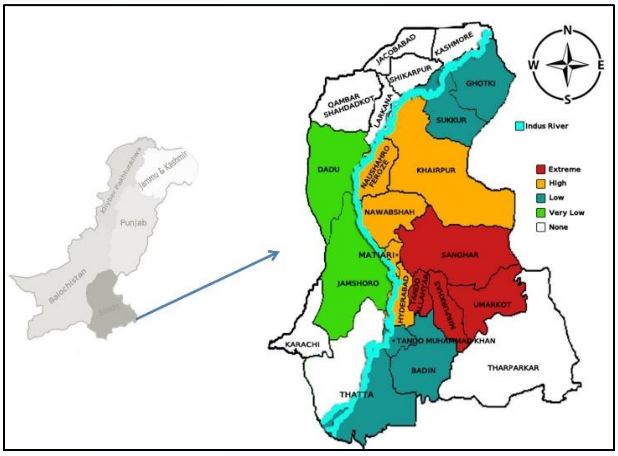

Figure 1. Occurrence and distribution pattern of pink bollworm in Southern Pakistan

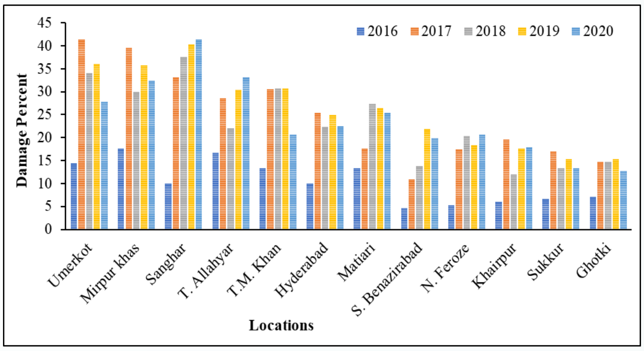

Figure 2. Widespread infestation of pink bollworm in Southern Pakistan

Table 1. Average damage percentage throughout cotton growing areas during 2016 to 2020.

Locations	2016	2017	2018	2019	2020	Average
Umerkot	14.5	41.4	34.1	36.1	27.8	30.8
Mirpur khas	17.7	39.6	30.0	35.7	32.5	31.1
Sanghar	10.0	33.1	37.5	40.4	41.4	32.5
Tando Allahyar	16.7	28.5	22.0	30.4	33.2	26.1
Tando Muhammad Khan	13.3	30.5	30.7	30.8	20.6	25.2
Hyderabad	10.0	25.4	22.3	25.0	22.5	21.0
Matiari	13.3	17.6	27.3	26.5	25.3	22.0
Shaheed Benazirabad	4.6	11.0	13.8	21.9	20.0	14.2
Naushehro Feroze	5.2	17.5	20.3	18.4	20.6	16.4
Khairpur	6.0	19.6	12.0	17.7	18.0	14.6
Sukkur	6.7	17.1	13.3	15.4	13.4	13.2
Ghotki	7.1	14.7	14.7	15.3	12.7	12.9
Average	10.4	24.6	23.2	26.1	24.0	-

Pink bollworm is a stenophagous insect, which has been recorded from cotton, okra, roselle and decan hemp (CABI, 2021). In surveys, this pest was found on cotton, okra, brinjal and China rose. Approximately, 70 plant species across the world are considered as alternative food plants of this pest (Shiller et al., 1962). Furthermore, it has also been well documented that this destructive pest is developing resistance against transgenic cotton (Kranthi, 2015; Wan et al., 2017; Tabashnik et al., 2021). We observed its infestation on both transgenic and non-transgenic cotton varieties. However, the percent damage on transgenic cotton was low as compared to non-transgenic cultivars. Besides, this notorious pest has the capacity to tolerate adverse climatic conditions and to adopt new conditions. Different haplotypes of pink bollworm have also been reported from various geographic regions (Liu et al. 2009; Naik et al. 2020).

Taking this scenario into consideration, it is required to develop an integrated approach for the better management of pink bollworm. Hence certain important management measures are summarized below for the sustainable management of this pest. The major sources of pink bollworm are infested cotton seed, leftover bolls, and ginning factories wastes. It is required to find some possible ways to destroy these sources. Farmers were advised to cultivate delinted seeds in order to kill the pink bollworm larvae hibernating in double seeds. Leftover bolls can be managed by allowing the grazing of harvested cotton fields by sheep and goats. Also, we can collect leftover bolls by using the pink bollworm manager, which is recently developed by Central Cotton Research Institute Multan (CCRI-Multan). The collected bolls can be used for fuel and some additional yields. Ginning factories wastes are the prime source of pink bollworm, that can be utilized to produce biofertilizer, ethanol, chipboards etc. Conservation of natural enemies in cotton field is also very important strategy among all the measures of pink bollworm management. Bracon, Brachymeria, Apanteles, Chelonus, Elasmus, Trichogramma, Chrysopa, Orius, and Geocoris are the major biocontrol agents of this pest. The parasitoids of pink bollworm can be conserved by adopting the Natural Enemies Field Reservoir (NEFER) Technology, which is introduced in the country by CABI-Pakistan (CABI, 2018). However, this technology involves intensive labor. The integration of the NEFER technology with pink bollworm manager could be an effective and less labor consuming approach in the integrated pink bollworm management system. Cultivation of non-transgenic cotton as refuge with transgenic varieties is supposed to be most effective strategy in delaying the process of resistance development in pink bollworm. The integration of some promising approaches such as installation of sex pheromone traps and PB-ropes, pest scouting twice a week and application of proper insecticide at proper time, could also keep the pink bollworm populations below economic threshold level. Moreover, some major initiatives are also required for the successful eradication of pink bollworm; i) development of early maturing varieties of cotton, ii) proper management of ginning factories wastes, and iii) establishment of

Sterile Insect Technique (SIT) laboratories in each province.

Consequently, the integration of traditional practices with recently developed approaches could be an effective strategy for pink bollworm management. A coordinated program needs to be designed from all stakeholders of cotton sector for successful eradication of this pest. Further, innovative efforts are required in refuge strategy, releasing of sterile insects, seed mixture, and genome editing.

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PINK BOLLWORM MANAGEMENT: FIELD EXPERIENCE OF A COTTON FARMER

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I am a cotton farmer for the last 50 years, and my family has been cultivating cotton and other field crops on our land for 3 generations. During the cotton season 2021-22, I had cultivated cotton on 120 acres of land in village Chak No. 150/P of Tehsil Sadiqabad, in the southern most district Rahim Yar Khan of Punjab. Cotton cultivation is a passion crop for me and I always look for new developments, technologies across the globe, and interact with experts and scientists to keep myself updated. I am keen in testing new technologies and do lots of experiments at my farm. In addition to cotton, we cultivate sugarcane, maize, wheat and medicinal crops. We do maintain mango, citrus and guava orchards on our family farms at Rahim Yar Khan. Our farm is partially mechanized, whereas some operations like cotton picking, sowing and late season hoeing is done manually. It is a canal irrigated farm with heavy clayey soil having moderate fertility levels.

For the last few years, we had realized that cotton cultivation was no longer a profitable business mainly because of high costs of fertilizer and pest management. We had experienced unmanageable whitefly and pink bollworm infestation right up to the peak time of the boll opening phase. The pesticides used for PBW and whitefly are getting expensive, and also these chemicals were unable to give an effective control. Rather we noticed whitefly eruptions after each application of insecticide. Even with an average yield of 2,000 kg/ha from 50 ha during 2019-20, the net profit was negligible. So, rather half-heartedly, I planted cotton on 44 ha during 2020-21. In Pakistan a significant number of farmers switched to other crops because of low profitability in cotton cultivation and the area in the Punjab province under cotton dropped by 17% in 2020-21, as compared to last year. Luckily, the cotton prices in international market as well as in the domestic market remained high during the current season, and so no one wanted to lose any fruiting bodies, that they should be eaten up by pink bollworm.

I interacted actively on the issue of PBW control with eminent scientists and was able to successfully manage my cotton crop without the use of any mentionable amounts of pesticide. The practical way in which I achieved this was that I installed pheromone traps @ 8 to 10 per acre. Cylinderical yellow sticky pads for the management of whitefly were also attached to the posts which supported the traps. The pheromone capsules were replaced after every 15-20 days in the PBW traps, and also the sticky raisins on yellow pads was also renewed at the same interval of time. (Fig 1 and 2). In addition, 100 PB ropes per acres were also installed at around the 1st of August, about 90 days after sowing.

I am glad that with such integration of multiple management tools I could achieve the PBW damage to negligible level and was successful to get good harvest of my cotton crop.

Figure 1. pheromone capsules and sticky raisins traps

Figure 2. pheromone capsules and sticky raisins traps

INTROGRESSION FOR COTTON LEAF CURL VIRUS TOLERANCE IN UPLAND COTTON

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The goal of many breeding programs is to mobilize a gene(s) from a donor parent into an elite parent, usually through conventional breeding methods. Cotton (Gossypium *spp.*) is the most important fiber crop and the second most important source for edible oil and protein in the world. On global basis, cotton is grown by more than 80 countries. It is infected by several pathogens and pests, and among them cotton leaf curl disease (CLCuD) is one of the major causes of loss of cotton cultivation. The disease has significantly challenged the sustainability of cotton production in Pakistan with annual yield penalty of two million bales. Commercial cultivars with low to moderate tolerance have been developed by traditional breeding programmes. However, a highly resistant cotton variety is unavailable. Different scientists worked on interspecific hybridization for transferring resistant genes for favorable traits from wild diploid species into tetraploid cultivated cotton like transferred resistant genes against cotton rust caused by *Puccinia cacabata*. from G. *anomalum* L. and G. *arboreum L*. into G. *hirsutum L.* through interspecific hybridization, induction of polyploidy and back crossing accompanied by continuous screening for resistance. It is worthwhile to combine the genes for Cotton Leaf Curl Virus resistance and other diseases and drought resistance between G. *hirsutum L*. and G. *arboreum L.* cotton. At present, no single variety of G. *hirsutum L.* is resistant to BSCV, whereas G. *arboreum L.* is known to have immunity against Cotton Leaf Curl Disease. last many years in transferring desirable characters of wild species to the cultivated ones through complex crosses. While screening 30 Gossypium species in hand, it was observed that the diploid species of cotton viz. G. *herbaceum*, G. *arboreum*, G. *anomalum*, G. *captis viridis*, G. *gossypioides*, G. *laxum*, G. *stocksii*, G. *areysianum*, G. *somalense* and G. *longicalyx* showed resistance to Burewala stain of cotton leaf curl virus.

Materials and Methods

i) G. *anomalum* Wawra et. Payer (2n= 26)-B1 was crossed with G. *hirsutum* Linn (2n=52) (AD)1 as female. The resultant triploid hybrid was treated with 0.2% aqueous solution of colchicine for 72 hours using seedling dip method for doubling the chromosomes. The hexaploid was further crossed with G. *hirsutum* to make a pentaploid which was further back crossed four times to get a stable tetraploid.
ii) G. *anomalum* Wawra et. Payer (2n= 26)-B1 was crossed with G. *arboreum*. Linn (2n=26) A2. The resultant diploid inter-specific hybrid was treated with 0.2% aqueous solution of colchicine for 72 hours using seedling dip method for doubling the chromosome. The resultant tetraploid hybrid was crossed and back crossed with G. *hirsutum*.
iii) Both the above mentioned species hybrids viz., [{4hirs. x 2 (*hirs.* x G. *anom.*)} x {2hirs. x 2 (*arbo.* x *anom.*)}] x *hirs.* were also crossed with each other.

The synthesized material was grafted with virus affected petioles of CIM-473 to check its virus resistance against BSCV in green house. Later on these resistant plants were shifted to field for assessment of their resistance against BSCV in field conditions.

Results

The diploid species that cross directly with upland cotton produce sterile triploid F1 hybrids. Such triploid hybrids have to be treated with Colchicine to produce hexaploids (Joshi and Johri, 1972). We synthesized Triploid hybrid plants of (G. *hirs*. L. × G. *anom*.) L. and 2 (G. *arbo*. x G. *anom*) treated with 0.1 % Colchicine solution for seven days using cotton swab method. There was no effect of Colchicine as these plants were old. 2431 plants of the material developed by species hybrids were grafted with virus affected of petiole of CIM-473 to check their virus resistance against BSCV in green house. Out of these 342 plants which did not show BSCV symptoms were transplanted in the field. Only 61 plants showed resistant against BSCV till maturity of crop.

The data showed in following tables revealed that first Gossypium species hybrid viz., 4G. *hirs* x 2(G. *hirs* x G. *anom*), resistance to BSCV was 0.66%, where G. *anomalum* alone resistant to BSCV was used. While in the second combination viz., 2G. *hirs* x 2(G. *arbo* x G. *anom*), the resistance to BSCV was 2.32%. When two Gossypium i.e. G. *arboreum*. and G. *anomalum* resistant to BSCV were used.

In the third combination i.e, [{4G. *hirs*. x 2 (*hirs*. x G. *anom*.)} x {2G. *hirs*. x 2(G.*arbo*. x G.*anom*)}] x G. *hirs*. where G. *anomalum* has been used twice and G. *arboreum* once, the resistance against BSCV was 3.0%.

Virus resistant plants having good seed cotton yield with good fiber quality traits will be utilized in breeding programme for introgression of cotton leaf curl virus resistance in elite interspecific combinations. CIM-608 developed from introgressed hybrids has been approved for general cultivation in 2013 while Cyto-124 has been approved for general cultivation during 2016 which will increase seed cotton production and will be a source of food security. This material will be used for insect resistance having good fiber quality.

Screening of resistant material during 2008-09

Material	Total No. of plants grafted in greenhouse	No. of plants not Showing symptoms and transplanted in the field	BSCV affected plants in the field	Resistant plant	% Age resistance
^{4}*G. hirs*. x 2 (*hirs*. x G. *anom*.).	303	13	11	2	0.66
^{2}*G. hirs*. x 2(*G. arbo*. x G. *anom*.)	774	115	97	18	2.32
[{^{4}*G. hirs*. x 2 (G. *hirs*. x G. *anom*.)} x {^{2}*G. hirs*. x 2 (*G. arbo*. x G. *anom*)}] x *G. hirs*	1354	214	173	41	3.0
TOTAL	**2431**	**342**	**281**	**61**	

Screening of material in the field during 2009-10

Material	Total number of plants In the field	BSCV Affected Plants In the Field	Resistant plant	% Age resistance
[4]*G. hirs.* x 2 (G. *hirs.* x G. *anom.*).	1231	1193	38	3.1
[2]*G. hirs.* x 2(*G. arbo.* x G. *anom*)	121	85-	36	29.7
[{[4]*G. hirs.* x 2 (*hirs.* x G. *anom.*)} x {[2]*G. hirs.* x 2(*G. arbo.* x G. *anom*)}] x *G. hirs.*	88	59 -	29	33.0
TOTAL	**1440**	1337	103	

Performance of resistant plants of [{3G. hirs. x 2 (G. *hirs.* X G. *anom.*)} x {2G. *hirs.* X 2(*arbo.* x G. *anom.*)}] x G. *hirs.*

Plant No.	Seed cotton yield/plant (g)	Lint (%age)	Fibre length (mm)	Fibre fineness (µg/inch)	Fibre strength (G/Tex)
CP-3/Z2	23	44.1	28.9	3.6	32.2
CP-4/Z4	114	37.7	33.4	3.5	32.5
Z5	418	41.9	32.3	4.1	29.1
Z6	303	39.0	34.3	3.4	31.9
CP-5/Z15	60.3	35.2	33.8	3.6	29.9
Z18	141.0	35.1	30.0	4.1	29.1
CP-7/Z24	86.0	38.6	30.4	4.5	33.9
Z27	148.2	35.4	30.9	4.4	30.2
CP-8	188.8	39.4	29.0	4.8	27.0
CP-11/Z32	120.4	45.3	31.1	3.4	36.0
Z34	144.3	37.6	32.3	3.6	34.2
Z42A	89.0	40.1	30.0	3.3	34.5
P6 (2009)	37.6	36.9	26.2	4.4	27.1
P-22 (2010)	24.0	33.3	31.1	3.2	32.8
CIM-496 (C.S)	90.3	40.2	28.1	4.8	26.5
CIM506 (C.S.)	86.1	37.2	27.8	4.9	26.3

ELECTROSPUN NANOFIBRES FOR PLANT PROTECTION: A NOVEL AND BIOLOGICAL APPROACH FOR COTTON PROSPECTIVE

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The use of nanotechnology is expected to make a new desirable era, considering its suitability to any area, it is assumed that it will make possible the development of a technology that offers a clean, durable and intelligent products with optimal results for home, medicine, environmental remediation, transport and agriculture: summarizing it, for the whole industry. Use of nanotechnology in terms of sex pheromones, pesticides and fungicides encapsulation in biopolymers through electrospinning has a vast researchable area but very limited published data are available on cotton crop. So, there is a need to focus in this area for sustainable organic cotton production.

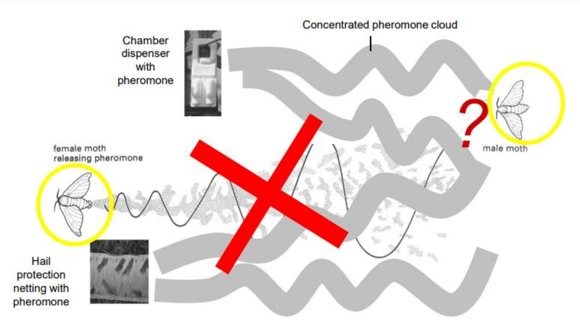

Figure 1. Confusion method in by means of added artificial pheromone dispensers

Applications of Nanofibres in Agriculture

Nanotechnology renown has influenced the characteristics and structure of materials, particularly in agriculture and food industry. The applications of the electrospinning as well as in agriculture, even though electrospinning still considered a method that has not fully advanced in the latter area.

In nanotechnology, nanoencapsulation has been a novel technique to protect and transport active compounds. The encapsulation in electrospinning technique will be facilitated monitoring the pore size, the surface area ratio, and the volume of the nanofibres. Regular method for encapsulation is coaxial electrospinning, which provides more controlled release of the material, with a high influence in the diffusion and degradation mechanisms of the polymer, as well as its hydrophobicity.

Nanofibre Fabrication by Electrospinning Technique

The electrospinning technique also known as electrostatic spinning is a top-down micro and nanoscale process technique, from different blends of polymer solutions, that is very efficient, simple, and versatile in a wide expression. Typical electrospinning equipment requires a high voltage electric field system, a syringe with a metal needle, and a metal collector, which require certain parameters to control the desired morphology.

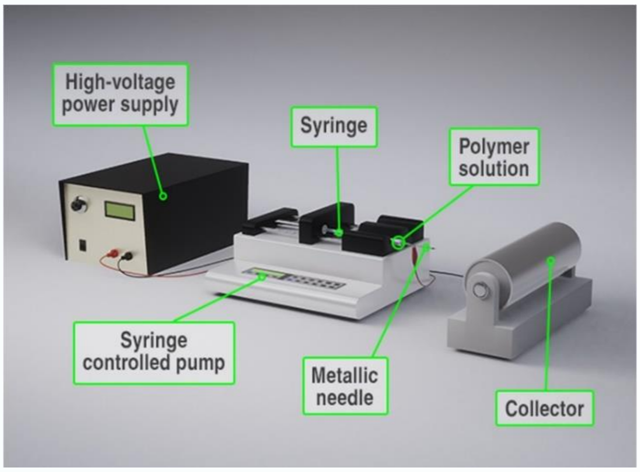

Figure 2. Schematic representation of the electrospinning setup

Protection of Plants by Nanofibres Loaded with Pheromones

The application of pheromones in plant protection for the control of insect pests is a sustainable method of pest management, considered to reduce the use of synthetic pesticides significantly. In conventional crop protection, insecticides are used to hit the insect pest with a lethal dose of active ingredient. Agrochemicals (synthetic insecticides) used for plant protection are always associated with health and environmental concerns. The mating disruption technique, in contrast, is a pre-emptive approach, which impedes successful mating between male and female moths. As a result, female oviposition of fertilized eggs is minimized and prevented by purely behavioral, non-toxic modification (pheromones are nontoxic). Major environmental benefits are high species specificity, very low concentrations of residues, minimal risk of development towards insect resistance, and sustainability.

The aim of loaded and encapsulation of nanofibres is mainly to find novel approaches to insect control as current dosing technologies do not fully satisfy the agricultural industry. Investigations have been done regarding nanofibres with high concentrations of encapsulated and immobilized pheromones for the protection of plants, avoiding a high population of insects, and that their components do not go to waste due to rainfall and evaporation, bypass economic losses.

Pheromones from Medfly Ceratitis capitata (trimedlure), from Lobesia botrana in polymers such as polyamide (PA), cellulose acetate (CA), polycaprolactone (PCL), polyvinylpyrrolidone (PVP), polyvinyl acetate (PVAc), polyethylene glycol (PEG), ethylcellulose and blends of different polymers have been encapsulated, obtaining stability in water and pheromones release up to approximately 2 months.

The selection of the polymer will depend on the amount of incorporated pheromone and also on the morphology, which will contribute to release kinetics. Grapholita molesta pheromone was encapsulated in cellulose acetate, polyvinyl acetate, polycaprolactum, polyvinylpyrrolidone and styrene-butadiene-styrene copolymer, observing that the higher pheromone content was related to higher capture.

Recent studies on pheromones releasing on different crops are addressed hereunder; Nanofibres with high porosity and surface area can be good candidates for this purpose. For the first time, Hellmann et al. (2011) investigated the use of polyamide (PA) and cellulose acetate nanofibres as carriers for pheromones. Transmission Electron Microscope (TEM) investigations of pheromone-loaded PA nanofibres revealed the formation of bead-free nanofibres. Also, pheromones were observed as separate aggregations into nanofibres. To study pheromones release, the nanofibres were stored in containers at room temperature, and the Thermogravimetric Analysis (TGA) technique was applied at different time intervals. The findings demonstrated that pheromones release occurred in a linear fashion which is necessary in practical applications. Also, there was some release even after 31 and 55 days in the case of PA and CA nanofibres, respectively.

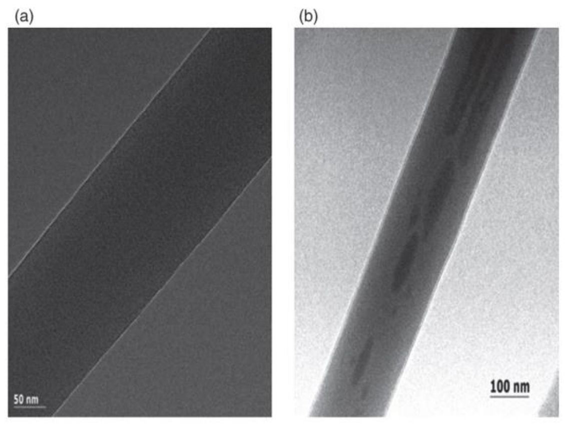

Figure 3. (a) Polyamide electrospun nanofibres without pheromone loading, (b) pheromone loaded Polyamide nanofibres

Bansal et al. (2010) immobilized pheromone eluting oligolactide microcapsules from Lobesia botrana on polyester nanofibres, observing water stability and biodegradability. Furthermore, enhanced germination has been observed in lettuce and tomato seeds, as well as an increase in plant growth due to continued release, protecting them from pathogens by the use of CA nanofibres with gelatin loaded with Cu2+ as a coating layer on the seeds (Xu et al. 2020).

Pesticides have been described as generally toxic and create/increase phytopathogenic organism resistance and pollute phreatic zone. Therefore, the use of encapsulation is increasing to reduce the aforementioned problems. The case of encapsulated fertilizers and pesticides is similar to pheromones. Bioagents have been applied for the growth and protection of the plant, Trichoderma viride spores have been successfully encapsulated in biodegradable and environmentally friendly polymers such as chitosan, PEO and polyacrylamide. This has prevented the growth of phytopathogens such as Fusarium and Alternaria in Capsicum sprouts (Spasova et al. 2011).

A research study for made nanofibre dispensers used were made from the commercially available, organic, biodegradable polymer Ecoflex® (BASF). The incorporation of the Lobesia botrana sex pheromone (E,Z)-7,9-dodecadienyl acetate into the fibres occurs during the electrospinning process. The resulting non-woven nanofibres served as pheromone dispensers. The Ecoflex® nanofibre-pheromone-dispensers show a mating disruption effect which is comparable to the efficacy of the Isonet LE dispensers for at least three weeks (Hummel et al. 2016).

New systems progressed for the controlled release of 1,7-dioxaspiro [5.5] undecane and (Z)-7-tetradecenal, the sex pheromones of olive fruit fly, Bactrocera oleae, and olive moth, prays B. oleae, respectively, by utilizing electrospun micro/nanofibre matrices from inexpensive, biodegradable polymers, namely polycaprolactone, cellulose acetate and polyhydroxybutyrate (Kikinos et al. 2017).

The encapsulation by electrospinning technology for insects and pests' resistance for cotton plant has a large potential but still not in research phase. It is need of the day to research in this new area for the sustainable production of organic cotton. Bio and biodegradable polymers that are easily electrospun for encapsulation of pheromones and pesticides may be applicable in the protection of cotton plant against pests and diseases in the near future.

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