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From Insect Ecology to Sustainable Agriculture: A Visionary Journey in Entomology, Innovation, and Farmer-Centric Science.

- An Inspiring Conversation with Prof. T.V.K. Singh

Prof. Thakur Vinod Kumar Singh (T.V.K. Singh) is an eminent agricultural entomologist with over four decades of distinguished contributions to teaching, research, extension, academic administration, and institutional development. He obtained his **B.Sc. (Agriculture)** with distinction from the College of Agriculture, Rajendranagar (1976), **M.Sc. (Entomology)** from Andhra Pradesh Agricultural University with a State Fellowship (1978) and **Ph.D. in Entomology** from the Indian Agricultural Research Institute (IARI), New Delhi, under the ICAR Senior Research Fellowship (1989). He also underwent specialized training in **Insecticide Resistance** at the **University of Florida, USA**, as a FAO Fellow.

During his illustrious career, Prof. Singh served in several key academic and administrative positions, including **Senior Professor, Vice Principal, Principal, Associate Director of Research, Dean of Agriculture, Director of Extension, and Comptroller** in ANGRAU and PJTSAU. He has significantly contributed to agricultural education and research through curriculum development, national monitoring committees, QRT committee member, ICAR review missions, and university governance.

His research has primarily focused on **insect ecology, population dynamics, insecticide resistance, integrated pest management (IPM), resistance monitoring, ecological modelling, and molecular characterization of resistance in major agricultural insect pests**. He established the **Insecticide Resistance Monitoring Laboratory** at PJTSAU and pioneered the **F₁ screening technique** for estimating resistance to Bt cotton in India along with his students. His work on resistance allele frequency, fitness costs, and resistance management strategies in *Helicoverpa armigera* and *Spodoptera litura* has



Dr. T.V.K. Singh

(Former Dean of Agriculture & Former Emeritus Scientist, PJTSAU, Rajendranagar, Hyderabad-500030, India)

received national recognition.

Prof. Singh has published **over 170 research papers**, authored **13 books**, contributed **4 book chapters**, edited **2 books**, and delivered more than **40 keynote and lead lectures** at national and international conferences. He has successfully guided **15 M.Sc. and 5 Ph.D. students** as Major Advisor and served as Minor Advisor to more than **30 postgraduate scholars**.

He is a **Fellow of the Royal Entomological Society (London)**,



Prof. TVK Singh addressing during inaugural session of Entomology 2022: Innovations & entrepreneurship

Linnean Society of London, Entomological Society of India, Plant Protection Association of India, and Indian Society of Oilseeds Research. His contributions to agricultural education have been recognized with the **University Meritorious Teacher Award (1996)** and the **State Meritorious Teacher Award (2007)**.

Following his retirement, Prof. Singh served as the **first ICAR Emeritus Scientist at PJTSAU, Consultant at ICRISAT, Adjunct Professor, Visiting Professor, and Chief Content Reviewer for the Plantix mobile application (PEAT GmbH, Germany)**. He has trained more than **4,000 farmers** under joint program of Society for Elimination of Rural Poverty (SERP), government of A.P and ICRISAT, Farmer Producer Organizations (FPOs) and agricultural officials across India and abroad on crop production, integrated pest management, and sustainable agriculture.

At present, Prof. T.V.K. Singh is serving as **Chief Editor of the Indian Journal of Plant Protection** and **Editor of the Indian Journal of Ecology**, and is a member of the editorial boards of several reputed national and international scientific journals. His lifelong contributions have established him as one of India's leading authorities in agricultural entomology, insect ecology, and insecticide resistance management.

MR (Dr. M. Rajashekhar): Sir, Tell something about your early life?

TVK (Dr. TVK Singh): Born in a teachers' family and from childhood, learning and education atmosphere existed. Studied in Hindi medium. Ours was the first batch of SSC, and Intermediate. As a Science student, only one goal was to become Doctor. Wrote MBBS entrance test which was conducted by Government for the first time, could not get through entrance. I feel lucky that I could

not get through M B B S entrance. Destiny brought me to this Profession. Truly speaking I did not know that agriculture is being taught as a subject. One of my mother's colleagues brought the application form, filled it, got admission and joined B.Sc. (Agril.) degree programme. That's how my journey begun.

MR: Sir, Who are your role models?

TVK: In my childhood days, my mother, aunt and maternal grandmother were role models who themselves were teachers, who taught me to be sincere, possess dignity, have patience and be disciplined in life. In our undergraduation days, Entomology as a subject was taught from second year onwards. First course was taught by **Late Prof. G.P.V. Reddy**, who was a very dedicated teacher. His style of teaching attracted many students, his teaching was unique and it appears that it's coming from his heart. I am lucky that later he became my

M.Sc. Guide. In fact I consider him my role model because of his teaching only, I choose Entomology as my professional career. Truly speaking, I try to learn and imbibe few qualities of every one specially teachers. Few faculty members who influenced my professional career and teaching are Dr.K.S.R.K. Murthy, Dr.T.B. Gour, Dr.K.N.Mehrotra and Sri.Sunil Kumr (student of Birch, famous Insect Ecologist). Another role model of mine and to whom, I owe a lot is **Late Dr. K.M. Singh**, my Ph.D. Chairman who was a perfect human / gentlemen. Infact I learnt humility, empathy, integrity, patience from Dr. K M Singh. To me Dr.G.P.V. Reddy and Dr.K.M. Singh are not only teachers but they are real Gurus, whom I adore a lot.

MR: What fascinated you about insects during your formative years?

TVK: For me, born in city and never exposed



Prof. TVK Singh interacting along with Honorable Vice chancellor & university officers with Late Dr. S. Ayyappan (DG-ICAR).



Prof. TVK Singh receiving best teacher award from the hands of Late Dr. Y.S. Rajashekhara Reddy (Chief minister of A.P.)

to village life, insects remained a group of nuance creatures and to name them bed bugs, mosquitoes, houseflies and cockroaches. I had limited exposure to the vast diversity of insects except studying about honeybees and silk worms in Intermediate course. My interest in Entomology and to be an entomologist begun in graduation, wherein I had wonderful teachers of APAU, who kindled interest in the subject.

MR (Dr. M. Rajashekhar): Sir, being a teacher, what should be the qualities of a Good teacher?

TVK: I always treated teaching as the most Noblest Profession. For me each class is similar to that of going to temple, like worshipping God. One should respect and show kindness to students. A teacher must be clear and engage actively in teaching viz., explain things clearly and in simple

language, use fun or creative methods to make lessons interesting. A teacher must be a good communicator with fairness towards one and all students. He should have lot of passion and energy. One must enjoy teaching and shows enthusiasm. Teacher must be supportive and helpful. He must remain student throughout life learning new things and passing it on to students.

MR: As an eminent entomologist specializing in Ecology, Toxicology, Transgenics, and IPM, how do you perceive the transformation of Entomology over the last few decades?

TVK: In my view, entomology especially agricultural entomology has undergone a massive transformation. It has evolved from basic chemical pest control during the Green Revolution into a sophisticated, sustainable science. Today, our

discipline integrates pest forecasting, Host Plant Resistance (HPR), and Artificial Intelligence (AI) to ensure global food security and sustainability.

Immediately after independence, our primary focus was to prevent famines and overcome severe food shortages. We relied heavily on aggressive crop protection to achieve food self-sufficiency. During the Green Revolution era, High-Yielding Varieties (HYVs) were introduced, but they were highly susceptible to pests. To protect them, we relied heavily on organochlorines and organophosphates (OPs), which eventually triggered severe ecological imbalances like pest resistance, resurgence, and other environmental hazards.

This paved the way for the Era of IPM, which combined cultural practices HPR, and biocontrol. The period from 1990 to 2010 can be defined as the Era of Biodiversity and Biotechnology, highlighted by the introduction of Bt cotton in India. Post-2010, we entered the Era of Digital Entomology. New frontiers have emerged, such as digital and AI-based forecasting, invasive pest management, nanotechnology, and insect DNA barcoding. I am heartened to see many young entomologists driving research in these areas. Today, the impact of climate change on insect pests and the role of agroecology have gained immense significance. We are now deeply focused on conserving agriculturally vital insects, particularly pollinators and predators.

MR: In your opinion, why is Entomology considered one of the most dynamic and strategically important disciplines in ensuring global food and nutritional security?

TVK: Entomology is undeniably dynamic and strategically vital because insects represent over half of all living organisms. They are highly

diverse and exceptionally adaptable to changing environments. When discussing global food security, insects play dual, critical roles as both vital pollinators and destructive agricultural pests. As pollinators, they are essential for human survival, with around 75% of our crops depending on them for fruit and seed set. Modern research is also exploring insects as viable alternative protein sources.

Furthermore, many insect species act as vectors for deadly diseases such as malaria, dengue, and kala-azar. By understanding their biology, we can track outbreaks and devise precise control strategies. Because insects are highly sensitive to environmental changes, they also serve as excellent bioindicators for ecosystem health, pollution, and climate shifts. Finally, we see the rise of a circular bioeconomy pioneered by innovations like the Black Soldier Fly, which efficiently converts organic waste into high-quality animal feed and protein.

MR: Sir, modern agriculture is facing increasingly complex pest scenarios. What are the biggest challenges currently confronting the field of crop protection?

TVK: In my opinion, the complex pest scenarios and invasive pest outbreaks confronting modern agriculture especially in the Indian context are largely man-made, driven by systemic greed. The primary culprits are widespread monocropping, an over-dependence on synthetic pesticides, and the overarching effects of climate change. Compounding this issue is the status of Indian soils, which are severely depleted of essential nutrients, indirectly impacting plant health, defense mechanisms, and overall crop productivity.

MR: Climate change is dramatically influencing insect behaviour and pest outbreaks worldwide. From your

scientific perspective, how do changing climatic conditions alter pest ecology and management strategies?

TVK: To understand how climate change accelerates pest outbreaks, we must look at the key drivers: shorter insect life cycles, polyphagous feeding habits, expanding geographical ranges, congenial microclimates, and the continuous availability of host plants. Paradoxically, climate shifts can also alter insect metabolism, leading to extended feeding windows.

Consider the recent devastating outbreaks of the invasive Fall Armyworm (*Spodoptera frugiperda*). FAW became a global agricultural menace due to its extraordinary migratory range, rapid breeding cycle, and ability to feed on over 353 different plant species. Its short life cycle, high reproductive capacity, voracious feeding habits, and cryptic (hidden) behaviour made it exceptionally destructive. Its rapid spread was further aggravated by a lack of native natural predators in newly invaded regions and its rapidly developing resistance to common insecticides.

Similarly, the outbreak of the invasive Chilli Black Thrips (*Thrips parvispinus*) is directly linked to warmer temperatures and high humidity, coupled with the indiscriminate overuse of insecticides and extended crop seasons. This resilient species has aggressively displaced native thrips populations infesting chilli crops across India.

Climate change is centered around global warming, elevated temperatures, rising atmospheric CO₂ levels, frequent droughts, and erratic rainfall patterns. Elevated temperatures directly accelerate the reproduction, development, behavior, and geographical distribution of pests. Furthermore, our generation is witnessing a significant rise in atmospheric CO₂. Higher CO₂

alters plant physiology and weakens natural plant defense mechanisms against herbivores. While elevated CO₂ allows plants to grow faster, it dilutes their nutritional value by altering carbon-to-nitrogen ratios. Consequently, insect pests exhibit compensatory feeding, consuming significantly more foliage to meet their nutritional needs.

These climate shifts disrupt traditional pest management. We must adapt our strategies by modernizing our monitoring networks, moving away from fixed calendar-based spray schedules, increasing the use of biopesticides, adopting targeted chemical applications, and enforcing crop diversification.

MR: Sir, how important is ecological understanding in designing resilient and environmentally sustainable pest management systems for the future?

TVK: Ecology is the fundamental pillar of sustainable plant protection; its primary principle is to shift pest management away from chemical dependency toward preventive, nature-based solutions. Sustainable pest management is deeply aligned with IPM, serving as an ecologically sound, environmentally friendly, and economically viable approach focused on minimizing pesticide usage through a combination of holistic practices.

This approach is vital because it preserves biodiversity, protects soil health, minimizes chemical residues, and safeguards human and environmental well-being. To leverage ecology as a driver for sustainable management, we must deeply analyze predator-prey dynamics, insect life cycles, phenology, and how climate variations alter plant-pest relationships. The future of pest protection relies on Ecological Engineering, pheromone traps, biopesticides, climate-resilient crop varieties, and biotechnology, supported by precision tools

like drones, IoT sensors, and AI for early pest and disease identification.

MR: With increasing concerns over pesticide resistance, residue issues, and environmental safety, what should be the future direction of Integrated Pest Management (IPM) research and implementation?

TVK: Pesticide Resistance (PR) stands as one of the most critical challenges in modern agriculture, driven primarily by the chronic misuse and overuse of chemical inputs. In India, numerous agricultural and public health pests have already developed widespread resistance. In agriculture, major pests like the Cotton Bollworm (*Helicoverpa armigera*), Pink Bollworm (*Pectinophora gossypiella*), Tobacco Caterpillar (*Spodoptera litura*), and Whitefly (*Bemisia tabaci*) show high resistance levels. In public health, vectors like *Anopheles* and *Aedes* mosquitoes, houseflies, and bedbugs present similar challenges.

To effectively delay and manage pesticide resistance, future IPM research and implementation must reduce reliance on single chemical classes. We must prioritize the rotation of insecticides with distinct, diverse modes of action, implement habitat manipulation, expand the use of biopesticides, and strictly enforce applications based on verified Economic Threshold Levels (ETLs).

MR: As a specialist in toxicology and transgenics, how do you evaluate the role of biotechnology and genetically engineered crops in future insect pest management programs?

TVK: In its early years, ecology was viewed largely as an academic or colonial pursuit, but it has since evolved into a robust, multidisciplinary applied science. Following Independence, India

faced severe food shortages; consequently, the focus of ecological research shifted toward applied agricultural entomology to minimize harvest losses, as our nation could simply not afford to lose food to pests.

Here, I must honour the memory of the late **Dr. S. Pradhan**, universally revered as the *Father of Modern Applied Entomology in India*. He pioneered the development of the biometer and biograph, revolutionized desert locust management, and proposed the definitive 'Biotic Theory' of locust cycles. Dr. Pradhan was a true visionary who conceptualized the "Plant Protection Umbrella" and realized very early that agriculture could not solely rely on chemical inputs. He was instrumental in shifting our country's crop protection strategy toward Integrated Pest Management (IPM).

While the Green Revolution achieved food security, its intensive agricultural practices and monocropping systems inadvertently triggered outbreaks of secondary pests. By the 1990s, our research shifted decisively toward ecological IPM, as it became clear that exclusive reliance on chemicals was neither ecologically viable nor economically sustainable.

Lately, our ecological research has shifted toward monitoring and mitigating invasive alien pests. We have transitioned from basic population dynamics, life-table studies, and the documentation of biotic factors to cutting-edge genomic studies designed to resolve cryptic species complexes. Furthermore, comprehensive studies on the multi-trophic effects of global warming and climate change are now in full vogue across state agricultural universities and national institutes.

In population dynamics, we continue to rely on life tables and the calculation of the intrinsic rate of increase for key economic pests, while

measuring how shifting abiotic factors influence pest generations. Mathematical modeling and forecasting are also being utilized but not to a significant extent. Today, considerable research is also being channelled into chemical ecology, focusing on plant secondary metabolites, semiochemicals, sex pheromones, and herbivore-induced plant volatiles (HIPVs) to manipulate pest behavior naturally.

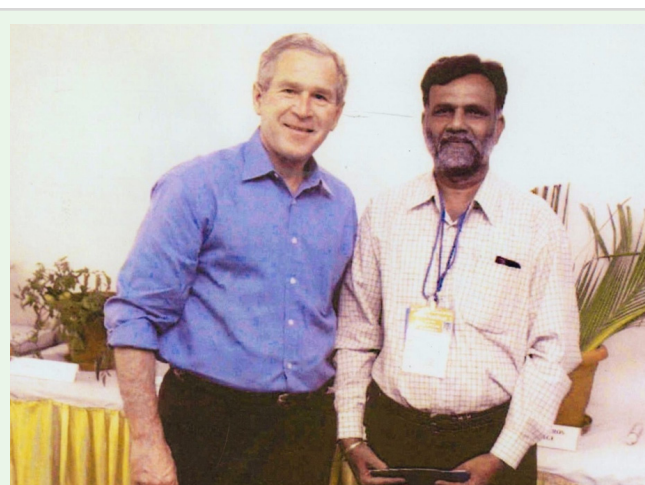
MR: Sir, how can young scientists integrate modern tools such as AI, precision agriculture, genomics, remote sensing, and digital pest surveillance into contemporary entomological research?

TVK: I am immensely gratified to see that many of our younger entomologists are seamlessly merging traditional field work with cutting-edge technology. They are utilizing machine learning algorithms and Artificial Intelligence (AI) for automated insect identification and automated tracking of adult flight patterns.

Young researchers are also actively employing CRISPR-Cas9 gene-editing tools to engineer pest susceptibility or drive population suppression. The field is expanding rapidly with the integration of automated IoT field sensors, smart pheromone traps, high-resolution hyperspectral imaging, and drone-based precision pesticide delivery systems.

MR: What future thrust areas in Entomology do you believe deserve priority attention to address emerging agricultural and ecological challenges?

TVK: Future entomological programs must be oriented toward integrating new, cutting-edge technologies with core basic and applied sciences. Drawing from my personal and research experience, I believe the following thrust areas deserve



Prof. TVK Singh with George W. Bush (President of U.S.A) during his visit to ANGRAU in 2006.

immediate, prioritized funding and attention. Developing macro-level predictive models for pest outbreaks using real-time GIS and satellite data; Studying the detailed biochemical and physiological effects of elevated CO₂ and ambient temperatures on insect biology, host defenses, and compensatory feeding; Investigating how changing climatic parameters alter insect vector-pathogen relationships and transmission efficiencies.

Rigorously monitoring insect biodiversity to protect native pollinators, soil-dwelling decomposers, and natural predatory complexes; Accelerating whole-genome sequencing of major economic pests and beneficial insects, alongside the molecular characterization of insecticide resistance mechanisms; Establishing a synchronized, nationwide digital network for monitoring insecticide resistance levels in real time and Developing eco-friendly nano-formulations and micro-encapsulated biopesticides to ensure targeted delivery with minimal environmental residue.

MR: In your opinion, how can agricultural universities make Entomology education more innovative, interdisciplinary, and globally competitive for present-day students?

TVK: Globally, agricultural entomology is undergoing a paradigm shift, transitioning from conventional pest control to a dynamic matrix of ecology, genomics, and digital technology. To keep pace, our agricultural universities must immediately modernize their course curricula. Currently, a significant portion of our academic syllabi remains outdated, focused almost exclusively on basic taxonomy, chemical insecticides, and standard pest management routines. While the subject is advancing rapidly elsewhere, I am pained to observe that the number of entomology courses has actually been reduced in several of our domestic universities.

To bridge this global gap, we must integrate advanced, forward-looking subjects into the core curriculum, such as Insect Genomics, Bioinformatics, Invasion Biology, Computational Entomology, and the application of AI and Machine Learning in Pest Forecasting.

We must foster interdisciplinary education and research. Universities should establish specialized Centres of Excellence in niche domains where foundational infrastructure and expert faculty are already available. Our academic research must shift toward solving real-world agricultural problems to build robust industry linkages, backed by strengthened, field-based experiential learning.

MR: Sir, many students perceive Entomology as a difficult subject. How can educators inspire young minds to develop a genuine passion and curiosity toward insect science and crop protection?

TVK: Entomology is frequently perceived as a difficult or dry subject in agricultural universities primarily because students assume they are simply expected to memorize an overwhelming number of scientific names and taxonomic keys. In reality, this

is a misconception; it is one of the most vibrant, interactive, and lively disciplines in agriculture.

Educators can make the subject incredibly engaging by moving away from rote learning and shifting toward hands-on, practical experiences. Engaging students in active laboratory rearing of insects allows them to observe live, fascinating transformations across an insect's life cycle firsthand. Encouraging students to conduct active field collections, bringing specimens back to the laboratory, sort them taxonomically, and systematically spread their wings and body parts builds strong morphological clarity.

Excursions: Organizing academic visits to butterfly parks and natural reserves sparks natural curiosity. Leveraging interactive mobile identification applications and encouraging macro-insect photography blends modern student hobbies with scientific observation.

Ultimately, the responsibility rests on the teacher's ability to innovate inside the classroom and ignite that initial spark of curiosity.

MR: Sir, how important is direct farmer interaction and field exposure in shaping a socially responsible and practically oriented entomologist?

TVK: For any agricultural graduate, direct farmer interaction and experiential field exposure are absolutely critical to evolving into a competent, practical professional. An entomologist must be inherently passionate and inquisitive, possessing a natural drive to step out of the laboratory and visit actual farms.

Time and again, whenever we interact with the farming community, their most urgent field queries relate directly to plant protection, pest outbreaks, and yield losses. While theoretical knowledge provides the necessary foundation, it is

practical field exposure that cements the subject deep into a scientist's perspective.

Above all, it is our core social responsibility to guide farmers, helping them protect their crops, secure their livelihoods, and drive national food security and economic growth. By visiting rural fields and engaging in unstructured interactions with farmers, we also learn invaluable lessons from indigenous technical knowledge (ITK) and time-tested rural traditions that no textbook can replicate.

MR: Sir, what opportunities do you foresee for entomologists and plant protection graduates in private-sector crop protection industries, agri-biotech companies, and agri-tech startups?

TVK: The landscape has changed dramatically over the last twenty years, opening up a universe of diverse, lucrative opportunities for young entomologists who possess genuine passion and operational zeal. In earlier days, postgraduate options in entomology were highly restricted; a graduate had to choose between the ICAR system, state agricultural universities, or conventional corporate pesticide marketing.

Today, the private sector has expanded far beyond the traditional agrochemical industry into global biotechnology firms and cutting-edge agri-tech startups. Within the modern corporate agrochemical sector, a graduate can thrive as a Specialized Toxicologist, Field Biologist, or Product Development Manager. Conversely, in the fast-growing agri-biotech domain, positions are open for Molecular Entomologists and Transgenic Trait Specialists.

Exciting new niches are also emerging in digital and precision agriculture. Plant protection graduates are actively being recruited as high-value

Agricultural Consultants, Remote Sensing Market Strategists, and Drone-IPM Operations Specialists. For any young professional willing to innovate and push boundaries, the sky is truly the limit.

MR: How can stronger collaboration between academia, research institutions, industries, and extension systems accelerate innovation in plant protection sciences?

TVK: The traditional system where academia researches in a vacuum, industry sells independently, and extension networks struggle to pass on outdated line-department recommendations is no longer viable.

An optimized collaborative framework should operate across four key pillars:

Academia & Research Institutions: Universities and ICAR bodies must focus their post-graduate research on industry-vetted challenges. Instead of publishing isolated papers on baseline biology, academic laboratories should partner with private R&D centers to co-develop molecular diagnostic tools, map insect resistance genes, and validate eco-friendly biological molecules.

Private Industry & Agri-Tech Startups: The corporate sector must invest heavily in academia through targeted research grants, sponsored chairs, and dedicated student incubation hubs. While major agrochemical and biotech firms can fund large-scale toxicology trials and commercialize nano-formulations, agile agri-tech startups can build the digital infrastructure such as training machine learning models on university insect-museum data to build real-time, automated field-diagnostic smartphone apps.

The Extension System: The transfer of technology must move from a slow, linear process to a real-time, digital pipeline. Krishi Vigyan Kendras



Prof. TVK Singh showing microscopic insects to Late Dr. Y.S. Rajashekhara Reddy

(KVKs) and Farmer Producer Organizations (FPOs) should act as live testing grounds where joint university-industry pilots are evaluated. When an invasive pest like *Thrips parvispinus* emerges, the extension network must instantly feed field data back to University and ICAR labs and industry product developers, enabling the rapid deployment of targeted, data-driven IPM responses.

Institutionalizing Joint Consortia: We need to establish formal, permanent institutional platforms such as a National Plant Protection Consortium driven by bodies like the PPAI, Entomological Society of India, Ecological Society of India, Association for Advancement of Pest Management in Horticultural Ecosystems and many more. This consortium would bring scientists, corporate product heads, and policy makers together quarterly to align research agendas with

actual market and field requirements.

By creating this continuous loop of data, funding, and field feedback, we can ensure that Indian plant protection sciences remain globally competitive, ecologically sustainable, and deeply impactful for the farmers we serve.

MR: Could you share your insights on *Helicoverpa armigera*, an insect pest you have dedicatedly researched for over 20 years?

TVK: The insect *Helicoverpa armigera* fascinates me immensely. When we were students, it was never taught as a major pest; indeed, you will look in vain for any significant mention of its pest status in older entomological textbooks. Today, *Helicoverpa armigera* commonly known as the Cotton Bollworm, Gram Pod Borer, or

Old-World Bollworm is recognized globally as a highly polyphagous, migratory moth and one of the most economically destructive agricultural pests, inflicting billions of dollars in crop damage annually.

The larvae are voracious feeders that attack over 180 plant species, targeting high-value crops such as cotton, tomato, maize, pigeon pea, chickpea, and soybean. Only the larval stage causes damage by boring directly into buds, flowers, and fruiting structures (bolls and pods). In cotton, their feeding leaves distinctive, clean-cut circular boreholes on fruiting bodies, triggers the yellowing and flaring of bracts, and leads to the premature shedding of squares and young bolls. The adults are exceptionally strong fliers, capable of migrating tens of kilometres in a single night, which allows massive populations to expand rapidly across vast geographical areas.

My personal journey with *H. armigera* began in the late 1990s while I was posted at Palem in erstwhile Mahabubnagar district of Telangana. I observed with grave concern that despite farmers in the Gadwal area spraying their cotton fields 15 to 20 times a season, the pest remained completely uncontrolled. This was followed by a devastating outbreak in the red gram (pigeon pea) crop during 1998 across the Vikarabad and Tandur belt of Ranga Reddy district. Driven by these crises, I initiated extensive toxicological research on *Helicoverpa*. Our preliminary bioassays on the resistance ratios of commonly used chemical molecules revealed staggering resistance levels, frequently exceeding 100- to 200-fold compared to susceptible baselines.

H. armigera stands out as an important agricultural pest due to its polyphagous nature, unique metabolic adaptations, high expression of detoxifying esterases, and reduced cuticular permeability via specific glycoproteins. The

selection pressure applied by indiscriminate spraying has been exceptionally high. Throughout the late 1980s and 1990s, recurring outbreaks frequently resulted in regional agricultural calamities, wiping out substantial percentages of total yields. Due to the pest's high reproductive rate, continuous pesticide exposure, and short life cycle, it evolved widespread resistance. Populations of *Helicoverpa* exhibited massive often 50- to >100-fold—resistance to synthetic pyrethroids in India.

In the central and southern states of India, *H. armigera* developed extreme resistance to synthetic pyrethroids, alongside long-term, stable cross-resistance to conventional organophosphates and carbamates like quinalphos and methomyl. Worryingly, modern populations are also displaying reduced susceptibility to newer chemistries like spinosad and indoxacarb.

I also served as the District Coordinator for Mahabubnagar and the State Coordinator for Andhra Pradesh for the Technology Mission on Cotton (TMC) - Mini Mission II (MM-II). This major Government of India initiative was aimed at enhancing cotton production, productivity, and quality. Coordinated primarily by the ICAR-Central Institute for Cotton Research (CICR), this project served as a vital vehicle to transfer advanced plant protection technologies directly from laboratories to farmers' fields.

Interviewed by

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