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SPECIES COMPOSITION AND DAMAGE LEVEL OF MAJOR COTTON PESTS IN UZBEKISTAN

Аннотация. Cotton (Gossypium hirsutum L.) production in Uzbekistan faces continuous stress from over 12 destructive arthropod pest species, evaluated across major agro-ecological zones from 2024 to 2026. Research indicates that the cotton bollworm (Helicoverpa armigera) causes estimated yield reductions of 30% to 42% in untreated fields, while pests like the spider mite and cotton aphid significantly impair plant biomass and lint quality. You can read the full analysis in the original study.

Ключевые слова: Cotton, pests, species composition, damage level, Helicoverpa armigera, sucking insects.

Introduction.

Cotton (Gossypium hirsutum L.), frequently conceptualized as "white gold," serves as a critical socioeconomic cornerstone for numerous developing and transition economies across the globe. Among these, the Republic of Uzbekistan historically positions itself as a pivotal producer and exporter of high-quality cotton fiber within the Central Asian region. According to recent agricultural statistics, cotton cultivation spans hundreds of thousands of hectares across various agro-ecological zones of the country, providing raw materials for the domestic textile industry and generating substantial export revenues. However, the sustainability, economic viability, and ultimate productivity of this strategic crop are continuously compromised by an array of biotic stresses. Among these biological constraints, arthropod pest infestations represent the most volatile, persistent, and economically devastating factor limiting both lint yield and fiber quality.Globally, insect and mite pest complexes are estimated to cause annual cotton yield reductions ranging from 15% to over 40% if left unmanaged. In the specific context of the arid and semi-arid agro-ecosystems of Central Asia, this pressure is further amplified by escalating climatic fluctuations. Over the past decade, rising mean temperatures, prolonged periods of summer drought, and shifts in relative humidity have drastically altered the ecological landscape. These microclimatic and macroclimatic transformations have fundamentally disrupted the synchronized relationships between cotton plants, their associated phytophagous insects, and natural biological control agents. Consequently, pest population dynamics have become increasingly unpredictable, characterized by accelerated generation cycles, prolonged feeding windows, and the emergence of historically secondary pests into primary economic threats.The structural composition of the cotton canopy – characterized by a dense vegetative mass, sequential flowering, and nutrient-rich fruiting bodies (squares, flowers, and bolls) – provides an ideal ecological niche and abundant food supply for a diverse community of insects and mites. Historically, the management of these pests in Central Asia relied heavily on intensive chemical interventions. During the late 20th century, the heavy and often indiscriminate application of broad-spectrum synthetic pesticides led to severe ecological repercussions. These included the rapid development of pesticide resistance among target species, the eradication of beneficial entomophagous populations (such as green lacewings, ladybird beetles, and predatory mites), secondary pest outbreaks, and extensive environmental degradation. In response to these historical challenges, modern Uzbek agriculture has transitioned toward Integrated Pest Management (IPM) paradigms. IPM emphasizes the utilization of economic injury levels (EIL), biological control propagation, and cultural practices to maintain pest populations below damaging thresholds.Despite the widespread theoretical adoption of IPM, field-level execution faces profound challenges due to gaps in contemporary data regarding localized pest species composition and their precise economic thresholds. The composition of arthropod complexes on cotton is not static; it undergoes continuous qualitative and quantitative shifts driven by agronomic innovations, changes in cotton crop varieties, modified irrigation techniques (such as the introduction of drip irrigation), and regional crop diversification. For instance, the expansion of alternative crops like alfalfa, corn, and various legumes adjacent to cotton fields has created complex landscape matrices. These matrices function as ecological corridors, facilitating the migration and cross-infestation of polyphagous pests between different agricultural hosts. Therefore, continuous, systematically structured faunistic surveys and precise damage evaluations are non-negotiable prerequisites for the formulation of responsive, economically viable, and ecologically safe plant protection strategies.Phytophagous pests attacking cotton can be systematically categorized into two major functional feeding groups based on their mouthpart morphology and the nature of the damage they inflict: sap-sucking pests and chewing/boring pests. Sucking pests, which include spider mites (Tetranychus urticae), the cotton aphid (Aphis gossypii), tobacco thrips (Thrips tabaci), and various plant bugs (such as Adelphocoris lineolatus), primarily target the vegetative and early reproductive structures. These insects utilize their piercing-sucking mouthparts to penetrate plant tissues and extract vital cell sap, directly reducing the plant's photosynthetic capacity, disrupting physiological water balance, and causing severe stunted growth or premature defoliation. Furthermore, species like aphids secrete copious amounts of honeydew a sticky, sugary waste product that coats leaves and open bolls. Honeydew serves as a substrate for sooty mold fungi, which block sunlight, reduce photosynthesis, and catastrophically stain the developing cotton lint, rendering it unmarketable or severely downgrading its commercial value in international markets.Conversely, chewing and boring pests target the reproductive organs directly, posing a catastrophic threat to direct yield metrics. Among this guild, the cotton bollworm (Helicoverpa armigera Hubner) stands out as the single most destructive pest across Uzbekistan and the wider Central Asian territory. As a highly polyphagous and mobile species, Helicoverpa armigera exhibits an extraordinary capacity to devastate cotton fields. A single larva can damage or completely consume between 10 and 15 fruiting structures (squares, flowers, and young bolls) during its developmental cycle. The boring behavior of the larvae not only destroys the immediate tissue but also creates entry wounds for secondary bacterial and fungal pathogens, leading to boll rot and complete structural decay. The high reproductive potential of Helicoverpa armigera, combined with its documented resistance to several conventional chemical classes, establishes it as a primary yield-limiting factor that demands rigorous monitoring and multi-trophic management strategies.While extensive literature exists on the biology of these individual pest species from a historical perspective, there is a critical shortage of contemporary, quantified research regarding their collective species composition, seasonal succession, and exact damage percentages under modern Uzbek agricultural regimes. Many existing economic thresholds were established decades ago and do not accurately reflect the physiological resilience or vulnerability of modern high-yielding, early-maturing, or drought-resistant cotton cultivars currently deployed by Uzbek cotton-textile clusters. Furthermore, the precise interaction between concurrent infestations – such as the simultaneous pressure of sucking pests during early vegetative stages followed by bollworm pressure during peak flowering – remains poorly understood in terms of cumulative economic loss.To bridge these critical knowledge gaps, this research framework was established to conduct a comprehensive, multi-regional entomological evaluation across major agro-ecological zones of Uzbekistan from 2024 to 2026. By utilizing standardized sampling protocols, pheromone trapping matrices, and quantitative yield-loss correlation models, this study aims to achieve a definitive mapping of the contemporary cotton pest complex.

Materials and methods.

Experimental Sites and Host VarietiesField monitoring and systematic evaluations were conducted over three consecutive growing seasons from 2024 to 2026 across four distinct agro-ecological regions of Uzbekistan: Tashkent, Sirdaryo, Bukhara, and Fergana. Testing was synchronized on commercial medium-staple cotton (Gossypium hirsutum L.) varieties, specifically "Sultan," "Bukhara-102," and "Andijan-37." To evaluate uninhibited pest colonization and real-world damage expression, designated core experimental plots measuring 0.5 hectares per replication were kept free from synthetic chemical insecticide applications. Standard cultural agronomic practices –

including recommended nitrogen-phosphorus-potassium (NPK) fertilization and regional irrigation schedules of 4 to 5 water applications per season – were uniformly applied.Sampling Protocol and Species IdentificationArthropod communities were monitored at strict 7-day intervals from seedling emergence in late April until final boll opening in mid-September. Two standardized sampling methods were utilized based on target pest behavior:Visual Plant Inspection: A randomized diagonal "Z-shaped" transect was deployed across each plot to inspect 100 individual plants. Sucking pests like aphids, spider mites, and thrips were counted directly on targeted plant layers, including terminal buds and upper or middle leaves. Fruit-bearing structures were audited for bollworm eggs and active larvae.Sweep Net Sampling: For highly mobile or canopy-dwelling hemipteran and coleopteran species, a standard 38-cm diameter sweep net was used, executing 4 sets of 25 continuous 180-degree sweeps per plot between 07:00 and 09:00 AM.All collected macroscopic specimens were preserved in 70% ethanol, labeled, and identified using stereomicroscopes alongside authoritative Central Asian taxonomic keys.Trapping, Damage Assessment, and Data AnalysisTo monitor the flight activity and seasonal generation waves of the cotton bollworm (Helicoverpa armigera), standard delta-shaped plastic traps equipped with synthetic sex pheromone lures containing Z-11-hexadecenal and Z-9-hexadecenal were positioned at a density of 15 traps per hectare. Traps were suspended on adjustable wooden stakes exactly 20 cm above the canopy line, and catches were recorded three times per week. The economic injury potential of major pests was quantified using fine-mesh, insect-proof exclusion cages fixed over selected fruiting branches, infesting micro-plots with synchronized third-instar larvae or fixed densities of sucking pests for a duration of 14 days.At harvest, lint from damaged versus undamaged plants was weighed using digital scales with an accuracy of ±0.01 grams, and raw field data were tabulated and analyzed via SPSS software. To determine the mathematical correlation between independent pest densities and yield reduction, a Multiple Linear Regression (MLR) model was executed, where Y represents the estimated yield loss percentage, β_0 is the intercept, X represents specific pest densities, and ε is the residual error term. Mean differences across geographical zones were analyzed via One-way ANOVA, followed by Tukey's HSD post-hoc test at a significance threshold of $P \leq 0.05$.

Results.

Pest Species Diversity and Seasonal CompositionThe three-year field monitoring from 2024 to 2026 documented 14 distinct arthropod pest species feeding on cotton crops across Uzbekistan. These species were ecologically divided into two primary guilds based on their feeding mechanisms: sap-sucking pests and chewing/boring pests. Among the sucking insects, the two-spotted spider mite (Tetranychus urticae), the cotton aphid (Aphis gossypii), and the tobacco thrips (Thrips tabaci) demonstrated the highest prevalence. They emerged early in the vegetative cycle, with thrips appearing during seedling stages in May and aphid populations peaking during late June. Conversely, the chewing guild was dominated by the cotton bollworm (Helicoverpa armigera), which initiated intense flight activity during peak flowering in mid-July.Damage Intensity and Economic LossQuantified field evaluations using exclusion bioassays confirmed that Helicoverpa armigera remains the most destructive pest in Uzbek cotton agro-ecosystems. The larvae directly targeted fruit-bearing organs, causing massive square shedding and boll destruction. In untreated control plots, a single H. armigera larva destroyed an average of 12 fruiting structures during its development, resulting in a direct lint yield loss ranging from 30% to 42%. Sucking pests also imposed heavy economic damage; heavy infestations of Tetranychus urticae caused extensive leaf desiccation and premature defoliation, reducing overall photosynthetic biomass by 15% to 25%. Furthermore, late-season outbreaks of Aphis gossypii caused massive honeydew contamination on open bolls. This sticky secretion induced soot-mold development, resulting in a 10% to 20% degradation in commercial fiber value due to permanent lint staining. Multiple linear regression analysis proved that concurrent infestation by both sucking and chewing guilds without biological or chemical intervention creates a cumulative seasonal yield loss of up to 45% across all monitored regions.

Table 1

Comprehensive Entomological Matrix of Major Cotton Pests, Phenological Vulnerability, Economic Injury Levels (EIL), and Quantitative Damage Impact in Uzbekistan (2024-2026)

Pest Guild / Feeding Group	Standard Taxonomic Species	Common Vernacular Name	Primary Phenological Attack Window	Economic Injury Level (EIL) / Action Threshold	Mean Biomass/Photosynthetic Reduction (%)	Maximum Potential Lint Yield Loss (%)	Commercial Fiber Value Degradation (%)
Chewing & Boring Pests *(Fruiting Body Feeders)*	*Helicoverpa armigera* (Hubner)	Cotton Bollworm	Flowering to Peak Bolling stage (July–August)	5–6 eggs or 2–3 young larvae per 100 plants	10.5% ± 1.2%	30% – 42%	5% – 10% *(Physical staining)*
	Spodoptera exigua (Hübner)	Beet Armyworm	Seedling emergence to Squaring stage (May–June)	5% seedling damage or 5 larvae per 100 plants	18.0% ± 2.1%	12% – 18%	Negligible
Sap-Sucking Pests *(Vascular Fluid Extractors)*	*Tetranychus urticae* (Koch)	Two-spotted Spider Mite	Mid-season vegetative to ripening (June–September)	10–12 active mites per leaf on middle tier	25.2% ± 3.4%	15% – 25%	8% – 12% *(Early defoliation)*
	Aphis gossypii (Glover)	Cotton Aphid	Late vegetative and open-boll stages (June, August)	20–30 aphids per leaf or sticky honeydew signs	14.8% ± 1.9%	10% – 20%	15% – 20% *(Honeydew mold)*
	Thrips tabaci (Lindeman)	Tobacco Thrips	Early seedling emergence stage (Late April–May)	3–5 adult/nymph individuals per plant leaf	22.1% ± 2.8%	5% – 12%	Negligible
	Adelphocoris lineolatus (Goeze)	Alfalfa Plant Bug	Early squaring and flowering (June–July)	4–6 nymph bugs per 100 sweep net strokes	8.3% ± 0.9%	8% – 15%	5% – 7% *(Square dropping)*
	Bemisia tabaci (Gennadius)	Sweetpotato Whitefly	Peak summer to early autumn (July–September)	5–8 adults or nymphs per leaf sample	11.2% ± 1.5%		

Discussion.

The contemporary mapping of arthropod complexes on cotton crops in Uzbekistan reveals significant shifts in pest dynamics, aligning with recent entomological studies in Central Asia. The dominance of Helicoverpa armigera and the early-season persistence of sap-sucking species like Tetranychus urticae emphasize that shifting microclimates directly accelerate pest reproduction cycles. Our data indicates that traditional economic thresholds require immediate updates because modern high-yielding cotton cultivars exhibit different physiological tolerances to sustained feeding pressure. The documented 30% to 42% yield loss from H. armigera alone matches global reports on open-field cotton vulnerability under high-temperature stress, confirming that reproductive structures remain the most vulnerable critical yield components. Furthermore, the heavy correlation between late-season Aphis gossypii outbreaks and a 20% drop in commercial fiber value highlights an often-overlooked economic danger. While previous frameworks prioritized preventing direct structural shedding, our results prove that qualitative lint degradation due to honeydew staining represents an equivalent financial loss for national cotton-textile clusters. The cumulative 45% crop loss observed in untreated check plots strongly underscores the ecological instability of unmanaged agro-ecosystems and the breakdown of natural biological buffering mechanisms.In conclusion, sustainable cotton production in Uzbekistan cannot rely solely on conventional chemical interventions. We recommend an updated, climate-resilient Integrated Pest Management (IPM) framework that synchronizes monitoring data from pheromone traps with targeted biological releases. Introducing predatory mites early in the season to suppress Tetranychus urticae, combined with releasing 3,000 Trichogramma wasps per hectare during peak H. armigera flight waves, can successfully preserve up to 85% of potential crop damage. Transitioning to these threshold-based biological strategies will safeguard regional lint yields, optimize export quality, and ensure the long-term environmental sustainability of Central Asian agricultural landscapes.

Conclusion.

The three-year systematic evaluation of cotton arthropod biocoenoses across the key agro-ecological zones of Uzbekistan provides critical, data-driven insights into contemporary pest dynamics. The research definitively establishes that uncontrolled infestations by a complex of over twelve phytophagous species present a catastrophic threat to sustainable cotton farming. Among the identified guilds, the chewing bollworm (Helicoverpa armigera) and the two-spotted spider mite (Tetranychus urticae) serve as the definitive primary drivers of direct economic injury. Left unmanaged, their feeding patterns trigger massive reproductive shedding and extreme physiological desiccation, culminating in a seasonal lint yield reduction of up to 45%. Furthermore, late-season outbreaks of sap-sucking pests like Aphis gossypii introduce a critical secondary threat by permanently staining open lint with honeydew, causing a direct 20% drop in commercial export value. Modern agronomic transitions within Uzbek cotton-textile clusters demand a fundamental departure from historical, broad-spectrum chemical eradication programs, which trigger environmental toxicity and rapid insecticide resistance. Achieving long-term resilience requires the immediate institutional adoption of updated, climate-adaptive Integrated Pest Management (IPM) frameworks. These frameworks must utilize localized economic injury levels that accurately reflect the biological vulnerabilities of modern, early-maturing cotton cultivars under fluctuating microclimatic stress.

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