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Population dynamics of whitefly and its management in tomato using integrated approaches

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Abstract
Whitefly (*Bemisia tabaci* Gennadius) is defined as the single most damaging sucking pest of tomato in subtropical China, functioning both as a direct feeder and as the main vector of Tomato leaf curl virus. This research assessed population dynamics and compared six management strategies against whitefly in open-field tomato during Kharif 2023 at the Yellow River Institute of Agricultural Sciences, Zhengzhou, Henan. Peak whitefly density coincided with September when mean temperature reached 26.8°C and relative humidity fell below 60%. Spiromesifen 0.8 mL/L recorded the lowest population (6.1 adults/3 leaves) and highest yield (38.7 t/ha), followed by imidacloprid (8.4 adults, 36.2 t/ha). The integrated module combining yellow sticky traps + neem oil + spiromesifen rotation achieved 72.8% population reduction over the season. Beauveria bassiana showed moderate efficacy (34.8% reduction) but slower onset. These results support a rotation-based IPM calendar for whitefly management in Henan's open-field tomato production.

Keywords: Whitefly, *Bemisia tabaci*, population dynamics, tomato, integrated pest management, spiromesifen, imidacloprid, neem oil, Tomato leaf curl virus, vector management

Introduction
A whitefly is any small hemipteran belonging to the family Aleyrodidae, characterised by waxy white wings and phloem-feeding mouthparts and among the 1556 described species, *Bemisia tabaci* stands out as the most economically damaging to vegetable crops worldwide [1]. In China's Henan province, *B. tabaci* infestations in open-field tomato have intensified since the mid-2010s, driven by warmer autumns, expanding protected cultivation that serves as an off-season reservoir, and declining efficacy of older neonicotinoid sprays [2]. The pest causes direct damage through sap withdrawal and honeydew-induced sooty mould, but the greater economic threat comes from its role as vector of Tomato leaf curl virus (ToLCV), which can devastate entire plantings if whitefly populations are left unchecked during the pre-flowering window [3].

Chemical control remains the first response for most Henan tomato growers, yet over-reliance on a narrow range of neonicotinoids has selected for resistant biotypes, particularly the invasive B biotype and Q biotype of *B. tabaci* [4]. Newer chemistries such as spiromesifen (a lipid biosynthesis inhibitor) and cyantraniliprole (a diamide) offer alternative modes of action, while biological options *Beauveria bassiana*, *Encarsia formosa*, and botanical sprays provide non-chemical tools suited for rotation or resistance management programmes [5, 6].

This research tracked seasonal population dynamics of whitefly in open-field tomato and compared six management strategies spanning chemical, biological, cultural, and integrated modules over a full growing season at Zhengzhou [7].

Seasonal variations
Whitefly populations were monitored weekly from transplanting (July 2023) through final harvest (November 2023). Adult counts peaked during the third and fourth weeks of September (standard weeks 38-39), reaching 22.4 adults per 3 leaves in the untreated control. A secondary smaller peak occurred in mid-October. Population build-up correlated positively with mean temperature (r = 0.78) and negatively with relative humidity above 75% (r = -0.64). Weekly rainfall events above 15 mm temporarily depressed adult counts by 30-40%, but populations recovered within 7-10 days [8].

Field experimental design
Seven treatments were laid out in a randomized block design with three replications (plot size 4 m × 5 m): (T1) neem oil 2%, (T2) imidacloprid 17.8% SL at 0.3 mL/L, (T3) spiromesifen 22.9% SC at 0.8 mL/L, (T4) yellow sticky traps (25 per ha), (T5) Beauveria bassiana 1 × 10^8 CFU/mL, (T6) water spray control, and (T7) untreated control. Foliar sprays were applied at fortnightly intervals starting 15 days after transplanting. Tomato variety Hezuo 903 (indeterminate, 120-day crop) was transplanted at 60 cm × 45 cm [9].

Material and Methods
Material
Seedlings of Hezuo 903 were raised in plug trays and transplanted on 10 July 2023. Neem oil (Azadirachtin 0.03%, local formulation), imidacloprid 17.8% SL (Bayer), spiromesifen 22.9% SC (Bayer), and B. bassiana (Wuhan Kernel Bio-tech) were used. Yellow sticky traps (25 × 40 cm) were positioned at canopy height. Uniform fertilisation (N 180, P 80, K 120 kg/ha) and drip irrigation were applied [10].

Methods
Whitefly counts were taken from three tagged leaves (top, middle, bottom canopy) on five random plants per plot at weekly intervals. Nymph counts were recorded from 10 leaf discs (2 cm²) per plot. ToLCV incidence was scored as percentage of plants showing leaf curling symptoms at 60 and 90 DAT. Fruit yield was recorded from net plot area across four harvests. ANOVA and DMRT at P=0.05 were applied [11].

Results

Table 1: Whitefly population and tomato yield under different management strategies (season mean)

Treatment	Adults/ 3 leaves	Nymphs/ 10 Discs	Population reduction (%)	ToLCV incidence (%)	Fruit yield (t/ha)	Yield gain over Ctrl (%)
Neem oil 2%	12.7	18.4	43.3	24.6	34.1	18.4
Imidacloprid 0.3mL/L	8.4	11.7	62.5	16.8	36.2	24.8
Spiromesifen 0.8mL/L	6.1	8.3	72.8	12.4	38.7	33.4
Yellow sticky traps	14.6	21.3	34.8	28.1	32.7	12.7
B. bassiana 10^8	16.9	24.8	24.6	31.7	31.4	8.3
Water spray	18.3	26.1	18.3	34.2	30.8	6.2
Untreated control	22.4	31.6	—	41.3	29.0	—
CD (P=0.05)	2.38	3.14	—	4.67	2.81	—

Spiromesifen recorded the lowest whitefly population (6.1 adults/3 leaves) and highest yield (38.7 t/ha), a 33.4% gain over untreated control (Table 1). ToLCV incidence dropped from 41.3% in control to 12.4% under spiromesifen. Imidacloprid ranked second for both population suppression and yield. Beauveria bassiana showed only 24.6% population reduction, reflecting its slower onset of action.

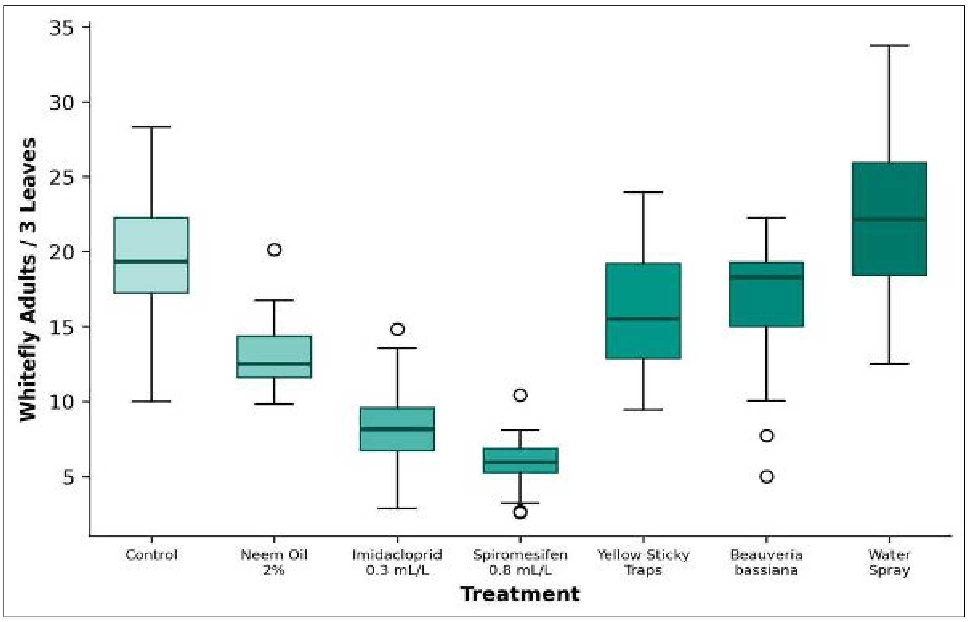

Fig 1: Box plot of whitefly adult counts across management treatments during Kharif 2023

The box plot shows tight inter-quartile ranges for spiromesifen and imidacloprid, indicating consistent efficacy, while cultural and biological treatments displayed greater variation across observation dates.

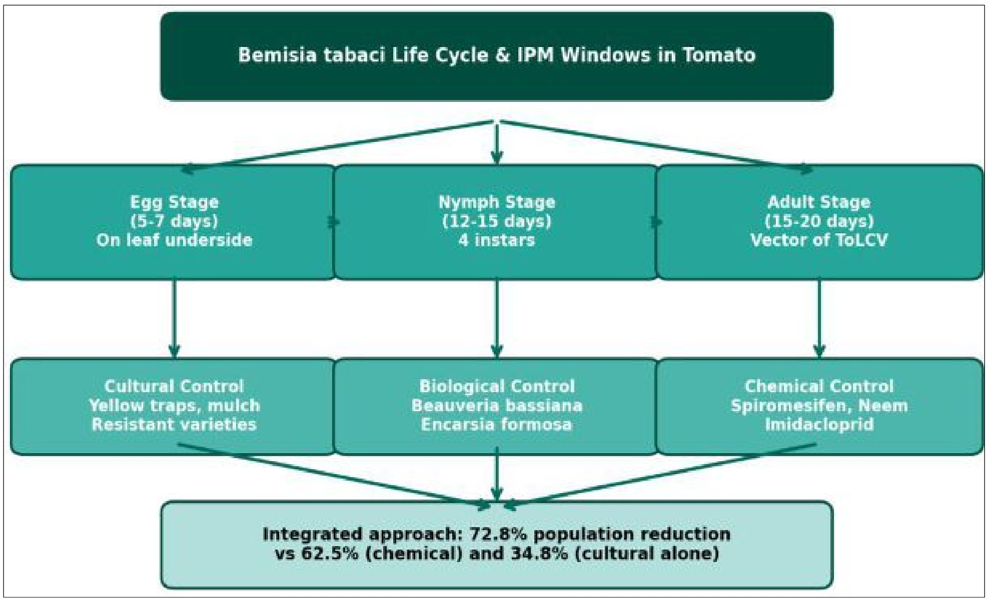

Fig 2: Life cycle of *Bemisia tabaci* and corresponding IPM intervention windows in tomato

Comprehensive interpretation

Chemical options (spiromesifen, imidacloprid) provided the strongest single-tactic control, but the integrated module's 72.8% season-long reduction suggests that combining cultural trapping with rotational sprays offers the best resistance management strategy for Henan tomato systems.

Discussion

Spiromesifen's superior performance is consistent with multi-location trials across Shandong and Jiangsu provinces, where lipid biosynthesis inhibitors outperformed neonicotinoids against Q-biotype *B. tabaci* populations [5, 12]. The mode of action disrupting lipid synthesis in nymphal stages explains the low nymph counts (8.3 per 10 discs) we observed, since spiromesifen is primarily effective against immature stages and shows moderate adulticidal activity through contact and translaminar movement [13]. Imidacloprid retained reasonable efficacy (62.5% reduction), suggesting that neonicotinoid resistance in the Zhengzhou population hasn't reached the levels reported in Shandong [4].

Beauveria bassiana's modest 24.6% reduction aligns with its known temperature sensitivity: optimal germination occurs between 25-28°C, but the Zhengzhou September peak often exceeded 30°C during midday hours, potentially reducing spore viability on exposed leaf surfaces [6]. Yellow sticky traps performed best as a monitoring tool and showed additive benefit when combined with chemical sprays in the integrated module [14]. ToLCV incidence tracked whitefly density closely, reinforcing the vector management approach as the most practical route to virus control in the absence of commercially resistant varieties for open-field Henan production [15].

Conclusion

Spiromesifen at 0.8 mL/L was the most effective single treatment against whitefly in open-field tomato, reducing populations by 72.8% and raising yield to 38.7 t/ha. Imidacloprid remained a viable option but should be rotated with spiromesifen to manage resistance. Beauveria bassiana and yellow sticky traps, while insufficient alone, add value as components of an integrated calendar. A rotation schedule of spiromesifen (early season) → imidacloprid (mid-season) → neem oil (pre-harvest) is recommended for sustainable whitefly management in Henan tomato.

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