Phytoparasitica (2026) 54:73
https://doi.org/10.1007/s12600-026-01406-7

RESEARCH

Biological performance of *Melanaphis sorghi* (Theobald, 1904) (Hemiptera: Aphididae) on different host plants

D. G. Santos · K. A. S. Rezende · T. F. Silva · B. L. Silva · V. M. Marques · N. M. Santos · P. S. Pereira · F. D. Tardin · A. M. Auad · M. L. F. Simeone · S. M. Mendes

Received: 10 March 2026 / Accepted: 2 June 2026

Abstract The sorghum aphid, *Melanaphis sorghi* (Theobald, 1904) (Hemiptera: Aphididae), is a significant pest. This study classified the host suitability of seven Poaceae genotypes: commercial and wild sorghum (*S. bicolor*, *S. sudanense*, *S. bicolor verticilliflorum*), pearl millet (*Pennisetum glaucum*), and maize (*Zea mays*). Aphid biological performance was assessed via leaf-disc bioassays under controlled conditions (24 ± 2 °C, 60 ± 10% RH). Infestation progression and plant injury were evaluated in greenhouse trials. Plant cell wall composition was analyzed using NIRS spectroscopy. Results established a clear host suitability gradient. All Sorghum genotypes were suitable hosts, supporting positive population growth. The commercial hybrid AG1090 exhibited the highest net reproductive rate ($R_0 = 16.17$). Pearl millet and maize were non-hosts, with reproduction virtually absent ($R_0 \leq 0.08$). Greenhouse data confirmed this pattern, with sorghum genotypes (e.g., *S. sudanense*, *S. bicolor verticilliflorum*) reaching infestation levels above 84%, while pearl millet and maize remained below 24% with no visible injury. Statistical analysis revealed that plant susceptibility was positively correlated with leaf hemicellulose content. Principal Component Analysis (PCA) segregated susceptible sorghum genotypes from the non-host species based on this biochemical factor. It is concluded that pearl millet and maize are not hosts for *M. sorghi*. The cell wall composition, specifically hemicellulose content, is a key factor influencing aphid infestation levels. These findings provide a basis for developing sorghum cultivars with reduced susceptibility.

Highlights • Pearl millet and maize are non-hosts for *Melanaphis sorghi*, showing no reproduction.

• All evaluated Sorghum genotypes are suitable hosts for *M. sorghi* proliferation.

• Leaf hemicellulose content is positively correlated with *M. sorghi* infestation levels.

• Infestation in sorghum reached over 70%.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12600-026-01406-7.

D. G. Santos · T. F. Silva · V. M. Marques · P. S. Pereira
Department of Biosystems Engineering, Federal University of São João del Rei (UFSJ), Dom Bosco Campus – LANEC – Dom Helvécio Square, 74, Fábricas Neighborhood, São João del-Rei, MG, Brazil

K. A. S. Rezende
Department of Agricultural Sciences, Federal University of São João del-Rei (UFSJ), Sete Lagoas Campus, MG-424 Highway, Km 47, Indústrias Neighborhood, P.O. Box 56, Sete Lagoas, MG 35701-970, Brazil

B. L. Silva · N. M. Santos
Department of Entomology, Federal University of Lavras (UFLA), Aquenta Sol, Lavras, MG 37200000, Brazil

F. D. Tardin · A. M. Auad · M. L. F. Simeone ·
S. M. Mendes (✉)
Brazilian Agricultural Research Corporation (Embrapa), MG 424 Highway, Km 45, P.O. Box 285, Sete Lagoas, MG 35701-970, Brazil
e-mail: simone.mendes@embrapa.br

Keywords Sorghum bicolor · Sorghum aphid · Near-infrared spectroscopy · Insect-plant interaction

Introduction

The sorghum aphid, *Melanaphis sorghi* (Theobald, 1904) (Hemiptera: Aphididae), is considered a pest of sorghum crops on a global scale, resulting in production losses (Uyi & Toews, 2024). Direct damage to the plant is caused by sap-sucking, which leads to yellowing, foliar necrosis, and in extreme cases, plant death (Figueroa-Brito et al., 2024; Uyi & Toews, 2024). Additionally, the excretion of honeydew on the leaves promotes the growth of sooty mold, causing reduced photosynthetic efficiency and complications during harvest (Toledo-Hernández et al., 2024). These problems are primarily caused by the rapid population growth and spread of this pest (Thudi et al., 2024).

Host specificity is a crucial ecological trait in herbivorous insects (Michielini et al., 2024). Evaluating pest performance on different host plants, whether preferred, marginal, or non-host, can reveal plant defense mechanisms and the insect's adaptive capacity (Kumaraswamy & Huang, 2024; Villacis-Perez et al., 2024).

To understand the relationship between the aphid *M. sorghi* and its potential host plants, it is necessary to evaluate a wide range of plant species (Hayashida et al., 2024; Khanal et al., 2024; Uyi & Toews, 2024). Within the sorghum genus, there is genetic variability, including commercial hybrids, lines with distinct biochemical characteristics, and wild relatives (Liu et al., 2024; Mwamahonje et al., 2024; Reddy & Pitha, 2024; Yan et al., 2024). In parallel, the evaluation of taxonomically close grasses such as pearl millet (*Pennisetum glaucum*) and maize (*Zea mays*) is crucial to delimiting host suitability and identifying constitutive barriers that limit colonization by the aphid (Uyi & Toews, 2024).

This comparative approach is supported by studies with other insect pests. For example, *Spodoptera littoralis* (Boisduval, 1833) (Lepidoptera: Noctuidae) demonstrated dietary plasticity, being capable of surviving on various wild plants even without prior exposure (Roy et al., 2024). In a complementary manner, two populations of *Henosepilachna yasutomii* (Katakura, 1981) (Coleoptera: Coccinellidae) showed a marked reduction in acceptance and survival on a non-host plant (wild thistle) when compared to their performance on the original host plant (blue cohosh) (Matsubayashi & Katakura, 2012).

The genetic diversity within the Sorghum genus and related Poaceae offers opportunities to identify resistance genes (Guo et al., 2024). Furthermore, sorghum lines with distinct biochemical profiles may exhibit natural defenses against herbivores (Shrestha et al., 2024; Sahu et al., 2024). In this context, the interaction between *M. sorghi* and its hosts is a fundamental aspect for the development of resistant cultivars (Khanal et al., 2024).

The identification of the *RMES1* and *RMES2* genes serves as an example of how genetic diversity is leveraged to develop pest resistance. *RMES1* confers resistance by reducing the fecundity of the sorghum aphid without affecting non-target species such as *Rhopalosiphum padi* (Linnaeus, 1758) (Hemiptera: Aphididae) (VanGessel et al., 2024). *RMES1* is more significant for plant conditioning during the mid-cycle, while *RMES2*, which is more frequent in local landraces and historical lines, contributes to resistance during both the early and mid-cycle (VanGessel et al., 2024).

Therefore, this study aimed to evaluate a set of seven Poaceae hosts from the Panicoideae subfamily: the AG1090 hybrid (*Sorghum bicolor*), the SC84 (*S. bicolor*), CMSXS180R (*S. bicolor*), and TX2784R (*S. sudanense*) lines, wild sorghum (*S. bicolor* ssp. *verticilliflorum*), the BRS1503 pearl millet variety (*P. glaucum*), and the SHS7010Pro3 maize hybrid (*Z. mays*), as potential hosts for *M. sorghi*. The objective was to determine the impact of these different hosts on the insect's biological parameters and life table, and, reciprocally, to assess the correlation between aphid infestation and the fibrous composition of the plants, in order to elucidate the specificity of the insect-plant interaction.

Materials and methods

Rearing and maintenance of the *Melanaphis sorghi* colony

The trials were conducted at the Ecotoxicology and Pest Management Laboratory of Embrapa Maize and Sorghum, in Sete Lagoas, Minas Gerais, Brazil

(19°28' S, 44°15′08″ W). The *M. sorghi* colony was established from individuals collected in the institution's sorghum experimental field and maintained in a climate-controlled chamber under regulated conditions (24 ± 2 °C, 60 ± 10% relative humidity, and a 12 h photoperiod).

For colony maintenance, plants of the BRS Ponta Negra sorghum variety were placed in cylindrical PVC cages (60 × 30 cm), with their stems immersed in a sucrose solution (20 g L^{-1}) to prevent premature senescence. The periodic replacement of the plants ensured optimal nutritional conditions for the continuous development of the aphids.

Host plant cultivation and experimental design

The host plants were cultivated in a greenhouse. Pots with a 5 L capacity were used, filled with commercial substrate (Tropstrato HT Hortaliças—Vidaverde®, Mogi Mirim, Brazil). Three seeds were sown per pot, followed by thinning to maintain one plant per container.

The selected plants encompass a broad agronomic diversity. The AG1090 hybrid is a commercial grain sorghum with an early cycle and high yield potential (Agro Bayer, 2024). This genotype is recorded as highly susceptible, expressed by the elevated fecundity of *M. sorghi* (Avellar et al., 2022; Santos et al., 2025a, 2025b, 2025c). In contrast, CMSXS 180R, SC 84, and TX 2784R are parental lines used in breeding programs. CMSX S180R is employed to restore fertility in grain sorghum hybrids (Julio et al., 2022), while SC84 is a reference line in genetic studies for the identification of phenolic compounds (Lee et al., 2022). The TX 2784R line, a sudangrass-type sorghum, is intended for forage production, characterized by intense tillering and regrowth capacity (Ferreira et al., 2018).

Representing undomesticated material, *S. bicolor subsp. verticilliflorum* was included. It is morphologically characterized by abundant tillers and slender culms, with the absence of rhizomes being one of its main distinguishing features in relation to other close relatives, such as *S. halepense* (Hsieh et al., 2023). Additionally, the pearl millet variety BRS1503, with characteristics of hardiness and drought tolerance (Silveira et al., 2024), and the maize hybrid SHS7010Pro3, featuring biotechnology for Lepidopteran resistance (Santa Helena Sementes, 2024), were used. Each of the cited plants and genotypes was considered a separate treatment.

The evaluated plants also differ in their biophysical characteristics. In sorghum, traits such as trichome density and epicuticular wax composition have been reported to influence insect movement, feeding, and oviposition (Juma et al., 2016; Zhang et al., 2025). Pearl millet is characterized by hairy leaves and ligules, traits associated with insect resistance, while maize hybrids may exhibit hairiness along the entire leaf blade (Chaffey, 2000; Kellogg, 2015). Furthermore, the genotypes *S. bicolor subsp. verticilliflorum* and *S. sudanense* (TX2784R) may retain physical characteristics found in wild relatives, such as a canopy with abundant tillers and narrow leafs. Although the present study does not focus on the biophysical differences among the evaluated genotypes, these observed variations may interfere with aphid colonization.

Basal fertilization consisted of applying 5 g per pot of the NPK 8–28-16 formulation (Fertilizantes Heringer, Iguatama, Brazil). A top-dressing fertilization was subsequently performed at the five fully expanded leaves stage using 5 g per pot of urea (Fertilizantes Heringer, Iguatama, Brazil).

Biology of *Melanaphis sorghi*

The bioassay to evaluate the aphid's biological performance was conducted in a climate-controlled chamber (24 ± 2 °C, 60 ± 10% RH, 12 h photoperiod), with 25 °C being the optimal temperature for this aphid (Peña-Martínez et al., 2024). Leaf discs (3.8 cm in diameter), cut near the midrib of leaves from plants at the nine fully expanded leaves stage, were individually placed in 50 mL containers on a layer of agar (20 g L^{-1}). The discs were replaced every three days (Avellar et al., 2022; Santos et al., 2025a, 2025b, 2025c).

To individualize the nymphs, one parthenogenetic adult female of *M. sorghi* was transferred to each leaf disc. After 24 h, the female and all offspring, except for one first-instar nymph, were removed, thus establishing one replicate.

The experimental design was completely randomized, with 50 replicates. The nymphs were monitored daily to assess the following parameters: duration of the pre-reproductive and reproductive periods, longevity, and fecundity. The offspring generated were quantified and removed every 24 h.

Life and fertility table analysis

Based on the daily offspring per female (m_x), daily female survival (l_x), and time in days (x) data, the parameters of the fertility life table were calculated. The TABVIDA software (Penteado et al., 2010) was used to calculate the net reproductive rate (R_0), the mean generation time (T), the intrinsic rate of population increase (r_m), the finite rate of population increase (λ), and the doubling time (DT). The standard error was estimated using the Jackknife technique, and the means were compared using Student's t-test at a 5% significance level ($p < 0.05$).

Assessment of aphid infestation parameters

This assay was conducted in a greenhouse (12×4×5 m) covered with diffusive polyethylene film. Environmental conditions were controlled for temperature (26 ± 6 °C), regulated by an automatic exhaust system activated above 30 °C, and relative humidity (73 ± 5%), maintained by a ventilation and evaporative cooling system. Conditions were monitored using a digital thermo-hygrometer. The experimental design was completely randomized, with ten replicates, each plot consisting of one pot with a single plant.

Artificial infestation was performed when plants had three to four fully expanded leaves, by transferring ten adult aphids onto each plant. Infestation severity and damage were assessed weekly using a visual rating scale (Santos et al., 2025a, 2025b, 2025c). The infestation level was determined as a percentage (0 to 100%) based on a visual assessment that integrated three parameters: aphid density, their distribution on the plant, and the presence of exuviae and symptoms. The criteria for each percentage interval were as follows: 20% infestation corresponded to fewer than 10 aphids per leaf, restricted to lower leaves and stems, with no exuviae; 40% was characterized by fewer than 50 aphids per leaf, on lower and middle leaves, with exuviae present; 60% featured more than 50 aphids per leaf on lower and middle leaves, with exuviae and leaf discoloration; 80% involved more than 200 aphids per leaf on midribs and leaf margins, with exuviae and visible symptoms; and 100% represented colonization of the entire plant, with foliar necrosis. Concurrently, the damage scale (scores 0 to 6) documented symptom progression: initial lesions and chlorosis (scores 1–3), bronzed leaves, sooty mold, desiccation, and necrosis (scores 4–5), and plant death (score 6) (Santos et al., 2025a, 2025b, 2025c).

After harvest, stems and leaves were separated. The plants were frozen at −10 °C for subsequent counting of the number of aphids. Subsequently, the samples were dried in a forced-air circulation oven at 65 °C for 96 h.

Proximate composition analysis

After the drying process, the samples were ground using a knife mill and sent for proximate composition analysis via near-infrared spectroscopy (NIRS). For spectrum acquisition, the samples were placed in glass cells with an internal diameter of 90 mm. Data collection was performed using a Büchi NIRFlex N-500 FT-NIR spectrometer (Flawil, Switzerland) equipped with a diffuse reflectance accessory. Data acquisition was carried out using NIRWare Operator software (version 1.5), and the subsequent processing to determine lignin, cellulose, and hemicellulose contents was conducted in the MATLAB environment (version 7.13) utilizing the PLS Toolbox (version 6.5) PLS tool (Guimarães et al., 2014).

Data analysis

Data on the biological parameters of *M. sorghi* were subjected to analysis of variance (ANOVA) using Minitab software (version 21.1.0) (Alin, 2010). For significant factors ($p < 0.05$), means were compared by Tukey's test. For the life and fertility table parameters (e.g., R_0, r_m), the standard error was estimated using the Jackknife technique with the TABVIDA application (Penteado et al., 2010), and differences between means were analyzed using Student's *t*-test ($p < 0.05$).

Data on infestation severity and injury were analyzed by ANOVA ($p < 0.05$) using SISVAR software (version 5.8) (Ferreira, 2019). For significant factors, linear regression analyses were applied to evaluate the progression of the variables over time. The mean number of aphids per plant, determined after harvest, was compared among treatments using the Dwass-Steel-Critchlow-Fligner multiple comparison test ($p < 0.05$) in JAMOVI (version 2.4.11) (Şahin & Aybek, 2019).

All graphs were generated using R (Battist & Smolski, 2019), JAMOVI (version 2.4.11) (Şahin & Aybek, 2019), and Minitab (version 21.1.0) (Alin, 2010) software.

Results

Biological performance of *Melanaphis sorghi* under laboratory conditions

The survival curves of *M. sorghi* (Fig. 1) graphically illustrate aphid survival on each host plant over time. The commercial sorghum AG1090 exhibited a survival curve with a slower decline rate. In contrast, pearl millet and maize plants (BRS1503 and SHS7010Pro3, respectively) showed an abrupt population decline. Sorghum plants such as *S. sudanense* (TX2784R) and *S. bicolor verticilliflorum* displayed decreasing survival patterns at variable rates.

No significant differences ($p > 0.05$) were observed in the reproductive parameters and longevity of *M. sorghi* among the evaluated sorghum hosts. The mean values were: pre-reproductive period (4.90 ± 0.67 days), reproductive period (10.77 ± 2.36 days), post-reproductive period (1.05 ± 0.89 days), total fecundity (50.41 ± 13.41 nymphs), nymphs per day rate (4.22 ± 0.74), and total longevity (16.72 ± 2.64 days).

The host plants BRS1503 pearl millet and SHS7010Pro3 maize exhibited only one individual that reached the adult stage, displaying reduced values across all evaluated parameters compared to the overall averages (reproductive period of 1–2 days; fecundity of 4–5 nymphs; longevity of 6–7 days). Consequently, these genotypes could not be included in the statistical analysis.

The parameters of the *M. sorghi* life table (Table 1) showed that the net reproductive rate (R_0) ranged from 16.17 ± 0.24 females/female/generation on AG1090 sorghum to values close to or equal to zero on BRS1503 (0.08) and SHS7010Pro3 (0.00), indicating an inability for population growth on the latter hosts.

The mean generation time (T) was longest on *S. bicolor verticilliflorum* (11.96 ± 0.22 days) and

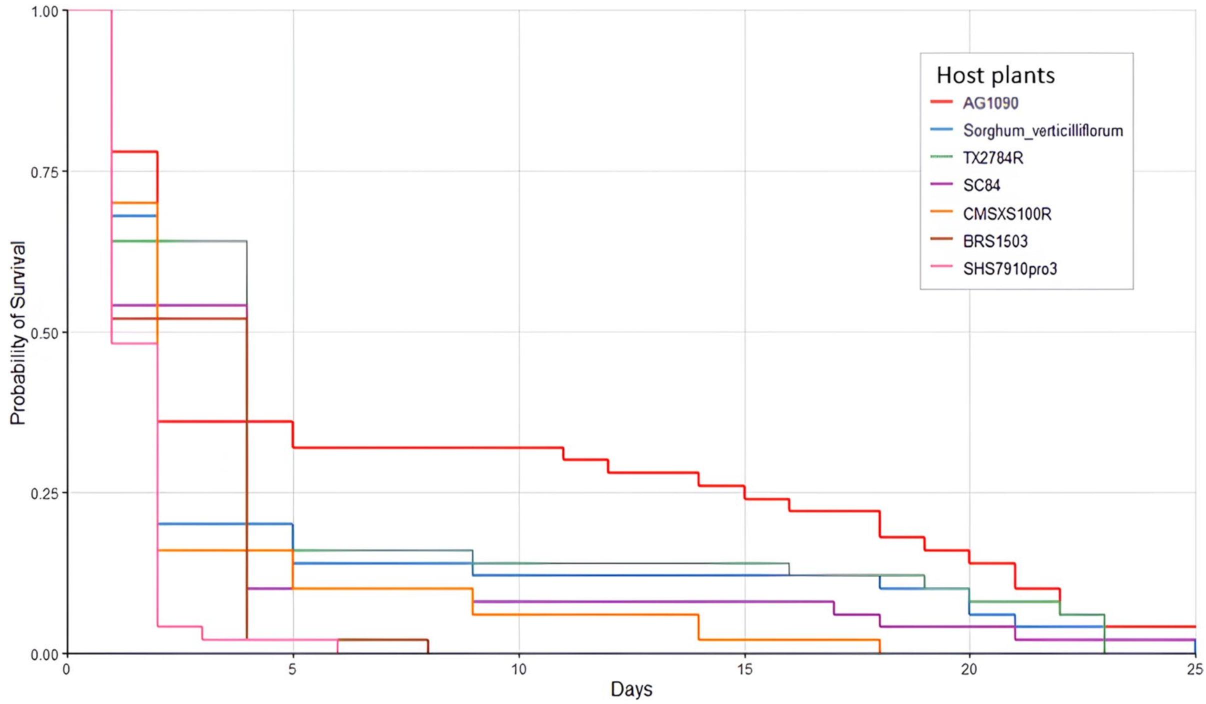


Fig. 1 Survival curves of *Melanaphis sorghi* on different host plants over time (days) in a bioassay evaluating biological performance under controlled conditions (24 ± 2 °C, 60 ± 10% RH, 12 h photoperiod). The host plants are represented by distinct lines, highlighting variations in resistance to the aphid. Lower survival values indicate greater resistance of the genotype

Table 1 Life Table Parameters from a bioassay evaluating biological performance under controlled conditions (24 ± 2 °C, 60 ± 10% RH, 12 h photoperiod). R_0—Net Reproductive Rate (Females), T—Mean Generation Time (days), r_m—Intrinsic Rate of Increase (Females/day), λ—Finite Rate of Increase, DT—Doubling Time (Days), followed by ± standard error, for *Melanaphis sorghi*

Host Plants	Species	R_0 (females)	T (days)	r_m (females/day)	λ (females/female/day)	DT (days)
AG1090	*Sorghum bicolor*	16.17 ± 0.24 a	9.67 ± 0.03 a	0.288 ± 0.0015 a	1.334 ± 0.002 a	2.41 ± 0.012 a
TX2784R	*Sorghum sudanense*	8.85 ± 0.26 b	9.84 ± 1.32 a	0.222 ± ND*	1.248 ± ND*	3.13 ± ND*
Wild Sorghum	*S. bicolor subsp. verticilliflorum*	6.13 ± 0.39 c	11.96 ± 0.22 b	0.152 ± 0.0047 b	1.164 ± 0.005 b	4.57 ± 0.13 b
SC84	*Sorghum bicolor*	3.80 ± 0.25 d	10.85 ± 0.30 ab	0.123 ± 0.0063 c	1.131 ± 0.007 c	5.63 ± 0.29 c
CMSXS180R	*Sorghum bicolor*	1.91 ± 0.28 e	7.48 ± 0.29 c	0.086 ± 0.023 d	1.090 ± 0.025 d	8.02 ± 1.76 d
BRS1503	*Pennisetum glaucum*	0.08 ± ND*	7.00 ± ND*	−0.361 ± ND*	0.697 ± ND*	−1.92 ± ND*
SHS7010Pro3	*Zea mays*	0.00 ± ND*	ND*	0.000 ± ND*	0.000 ± ND*	0.00 ± ND*

Different letters indicate significant differences ($p < 0.05$) among treatments, based on Student's t-test. ND: Not detected or not determinable due to the absence of survivors

shortest on the pearl millet and maize host plants. The intrinsic rate of increase (r_m) followed the same trend as R_0, being highest on AG1090 sorghum (0.288 ± 0.0015 females/female/day) and negative on BRS1503 pearl millet (−0.361).

The finite rate of increase (λ) was greater than 1 (indicating population growth) on all sorghum-type hosts (*S. bicolor*, *S. sudanense*, and *S. bicolor verticilliflorum*), with a notable peak in AG1090 sorghum (1.334 ± 0.002). In contrast, it was below 1 in pearl millet (0.697) and maize (0.000), indicating population suppression. The doubling time (DT) was shortest in AG1090 sorghum (2.41 ± 0.012 days) and increased considerably in the other genotypes.

The analysis of the *M. sorghi* fertility curve (Fig. 2) revealed differences in the aphid's reproductive capacity among host plants. AG1090 sorghum presented the highest average offspring production per female, characterized by an early reproductive peak and high prolificacy. In contrast, BRS1503 pearl millet and SHS7010Pro3 maize exhibited reduced or null fertility, consistent with the life table parameters. Sorghum plants such as TX2784R, *S. bicolor verticilliflorum*, SC84, and CMSXS180R demonstrated variable fertility profiles, with less pronounced peaks and a more accentuated decline over time.

Assessment of *Melanaphis sorghi* infestation on different host plants

The progression of *M. sorghi* infestation varied significantly among the evaluated host plants over time (Table 2; Fig. 3). Sorghum-type hosts such as CMSXS180R, *S. bicolor verticilliflorum*, and TX2784R exhibited the highest cumulative infestation rates, reaching 98%, 92%, and 84% respectively at 28 days. These were modeled by high-precision linear regression equations ($r^2 \geq 0.97$), indicating an accelerated infestation progression. In contrast, pearl millet and maize proved unsuitable for aphid population growth, with infestation not exceeding 24% by the end of the experimental period, modeled by negligible or negative growth equations. Sorghum genotypes considered intermediate, such as AG1090 and SC84, presented moderate infestation patterns, with lower slope coefficients and final infestation between 66 and 70%.

The progression of damage (injury scores) caused by *M. sorghi* also varied significantly over time (Table 3; Fig. 4). Pearl millet and maize plants maintained an injury score of zero in all assessments, confirming the absence of visible damage. Among the sorghum genotypes, AG1090 and TX2784R presented the lowest injury scores (maximum of 1.5). In contrast, the hosts *S. bicolor verticilliflorum*, CMSXS180R, and especially SC84 (score 3.6 at 28 days) exhibited more severe progressive damage. The regression equations suggest a slow progression of damage over the evaluation period.

In Fig. 5 (number of aphids on the stem), it can be observed that *S. sudanense* (TX2784) exhibited the highest population density on the stem, being statistically superior to most other treatments. This was followed by *S. bicolor* (CMSXS180R), *S. bicolor*

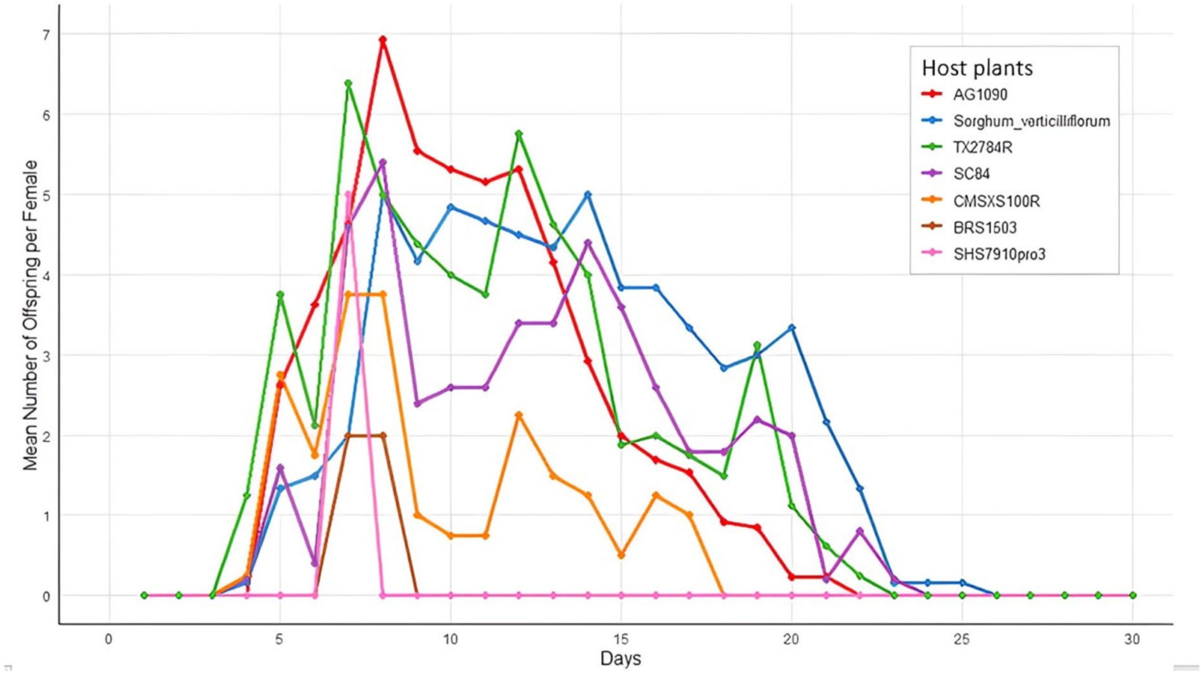


Fig. 2 Fertility curve (mean number of offspring per female per day) of *Melanaphis sorghi* in a bioassay evaluating biological performance under controlled conditions (24 ± 2 °C, 60 ± 10% RH, 12 h photoperiod) on different host plants over time (days). Plants are represented by distinct lines, highlighting variations in host suitability for aphid reproduction

Table 2 Percentage of infestation (%) of *Melanaphis sorghi* on different host plants at 7, 14, 21, and 28 days after infestation (grenhouse conditions), accompanied by the linear regression equations and coefficients of determination (r^2) that model the temporal progression of survival. Different letters in the same column indicate statistically significant differences among genotypes ($p < 0.05$) according to Tukey's test

Host Plants	Species	7 Days	14 Days	21 Days	28 Days	Regression Equation
AG1090	*Sorghum bicolor*	20% b	48% c	60% b	70% c	y = 2.31x + 9; r^2 = 0.94
TX2784R	*Sorghum sudanense*	20% b	36% bc	66% bc	84% d	y = 3.17x—4; r^2 = 0.99
Wild Sorghum	*Sorghum bicolor subsp. verticilliflorum*	20% b	36% bc	74% c	92% de	y = 3.62x—8; r^2 = 0.97
SC84	*Sorghum bicolor*	20% b	30% b	76% c	66% c	y = 2.63x + 2; r^2 = 0.76
CMSXS180R	*Sorghum bicolor*	20% b	44% c	70% bc	98% e	y = 3.71x—7; r^2 = 0.99
BRS1503	*Pennisetum glaucum*	0% a	0% a	10% a	10% a	y = 0.57x—5; r^2 = 0.80
SHS7010Pro3	*Zea mays*	0% a	0% a	10% a	24% b	y = 1.17x—12; r^2 = 0.87

verticilliflorum, and SC84, which displayed intermediate infestation levels. The maize (SHS7010Pro3) and pearl millet (BRS1503) treatments were grouped at the lower extreme, with the lowest number of aphids.

In Fig. 6 (number of aphids on leaves), the TX2784 host maintained the highest number of aphids (group a), followed by *S. bicolor verticilliflorum* (group ab) and SC84 (group bc). CMSXS180R (group cd) and AG1090 (group d) exhibited moderate leaf infestations, while maize and pearl millet (both group e) demonstrated the lowest infestation levels.

Correlation between cell wall composition and number of *Melanaphis sorghi* on host plants

Principal Component Analysis (PCA) (Fig. 6) revealed distinct patterns in the relationship between the chemical composition of leaf cell walls

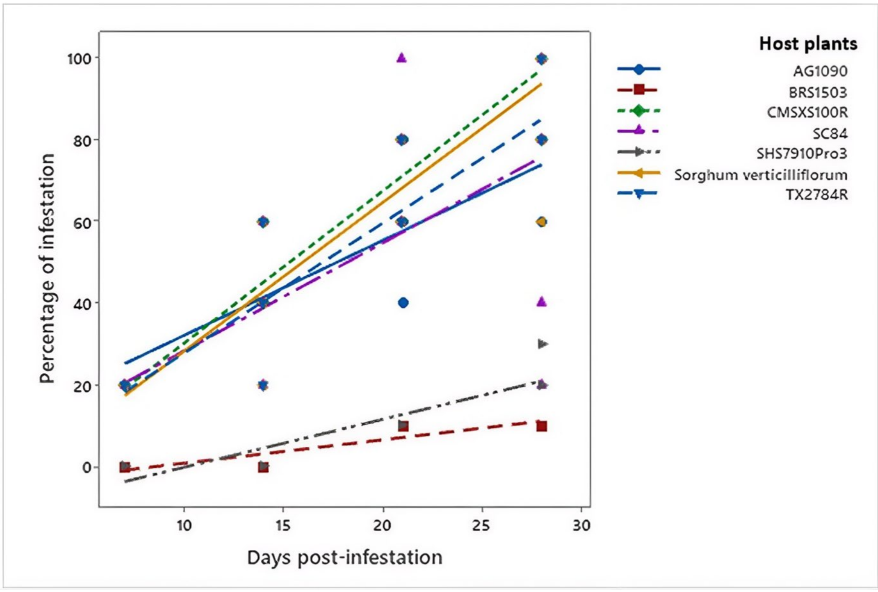


Fig. 3 Infestation percentage (%) of *Melanaphis sorghi* on different host plants at 7, 14, 21, and 28 days after infestation, under grenhouse conditions. Sete Lagoas, MG—Brazil

Table 3 Damage scores caused by *Melanaphis sorghi* on different host plants at 7, 14, 21, and 28 days after infestation under grenhouse conditions, accompanied by the linear regression equations and coefficients of determination (r^2) that model the temporal progression of damage. Different letters in the same column indicate statistically significant differences among genotypes ($p < 0.05$) according to Tukey's test

Host Plants	Species	7 Days	14 Days	21 Days	28 Days	Regression Equation
AG1090	*Sorghum bicolor*	1b	1b	1b	1b	mean = 1
TX2784R	*Sorghum sudanense*	1b	1b	1b	1.5c	0,21x + 0,75; r2 = 0,60
Wild Sorghum	*Sorghum bicolor verticilliflorum*	1b	1b	1b	2.3d	0,06x + 0,35; r2 = 0,60
SC84	*Sorghum bicolor*	1b	1b	1b	3.6e	0,11x – 0,3; r2 = 0,60
CMSXS180R	*Sorghum bicolor*	1b	1b	1b	2.1d	0,05x + 0,45; r2 = 0,60
BRS1503	*Pennisetum glaucum*	0a	0a	0a	0a	Mean = 0
SHS7010Pro3	*Zea mays*	0a	0a	0a	0a	Mean = 0

and aphid infestation across five host plant species. The first two principal components (PC1 and PC2) explained 58.8% and 23.0% of the total data variance, respectively, representing a combined 81.8% of the variability.

The plant distribution in the biplot revealed a pattern of aphid infestation. Sorghum-type hosts, *S. sudanense*, *S. bicolor*, and *S. bicolor verticilliflorum*, clustered along the positive direction of the "aphids on leaves" vector, indicating that these species present the highest insect infestations. In contrast, *Z. mays* and *P. glaucum* were positioned in the opposite direction of the graph, demonstrating the unsuitability of these plants as hosts.

Regarding the relationships with the fiber variables, PC1 represented an overall fiber content gradient, with positive loadings for all components (NDF: 0.528; ADF: 0.506; cellulose: 0.457; lignin: 0.374; hemicellulose: 0.342). PC2 contrasted positively with hemicellulose (0.528) and negatively with ADF (−0.220) and cellulose (−0.279).

The plants most suitable for aphid colonization (*S. sudanense*, *S. bicolor*, and *S. bicolor verticilliflorum*) were located in the region of high hemicellulose contribution (positive side of PC2). This spatial association was corroborated by a Pearson correlation analysis (Fig. 7), which revealed a significant positive correlation between

Fig. 4 Damage scores caused by *Melanaphis sorghi* on different host plants at 7, 14, 21, and 28 days after infestation under grenhouse conditons. Sete Lagoas, MG—Brazil

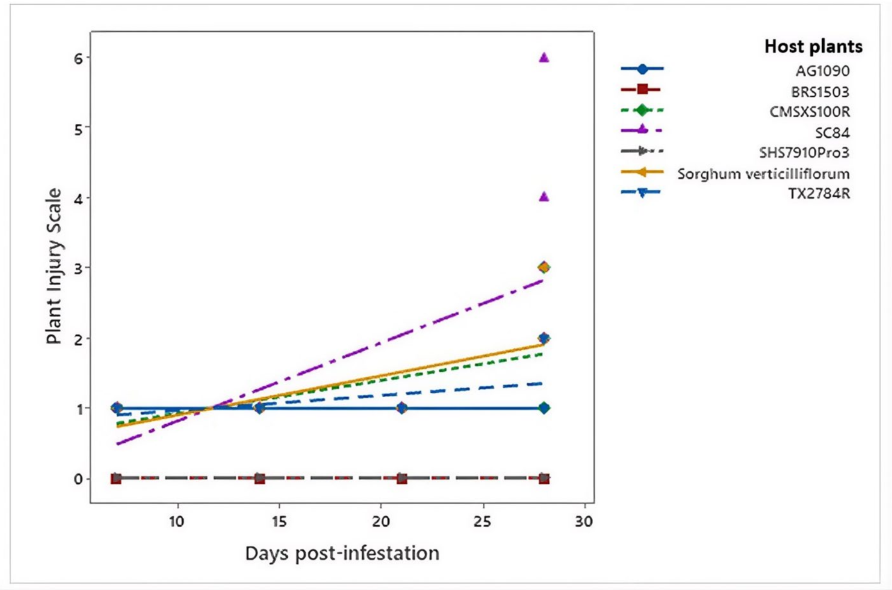
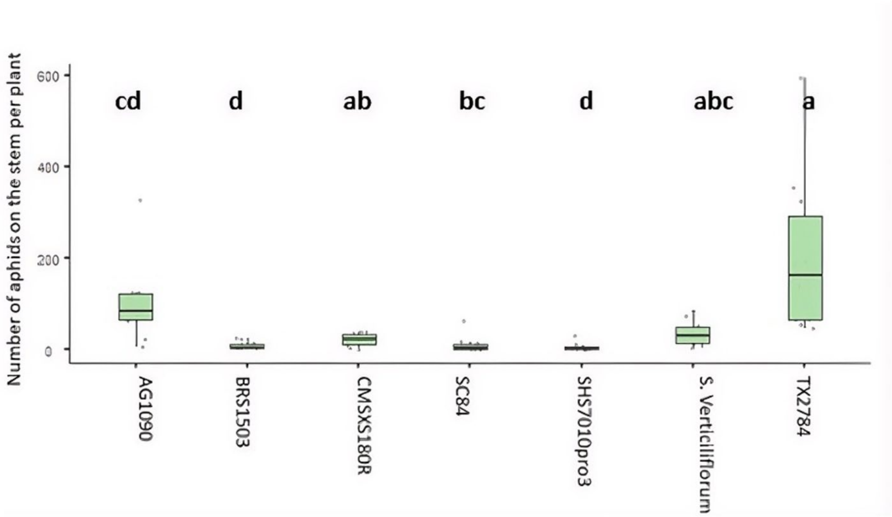


Fig. 5 Median number of aphids (*Melanaphis sorghi*) per host plant under greenhouse conditions. Different letters above the bars indicate statistically significant differences (p < 0.05) according to the Dwass-Steel-Critchlow-Fligner multiple comparison test



leaf hemicellulose content and aphid infestation (r = 0.40; $p < 0.001$). This combined result indicates that a higher leaf hemicellulose content is a chemical factor favoring aphid infestation in these species.

The stem PCA (Fig. 8), similar to the leaf analysis, explained 59.3% and 24.1% of the total data variance, respectively, representing a combined 83.4% of the variability in the dataset.

The first principal component (PC1) proved to be an axis representative of the overall fiber content in the stem, presenting positive correlations with all analyzed components: NDF (loading = 0.52), ADF (0.49), lignin (0.37), hemicellulose (0.36), and cellulose (0.39). This strong integration among components was confirmed by correlation analysis, which showed positive and significant coefficients between ADF and the other fiber components (NDF: r = 0.55;

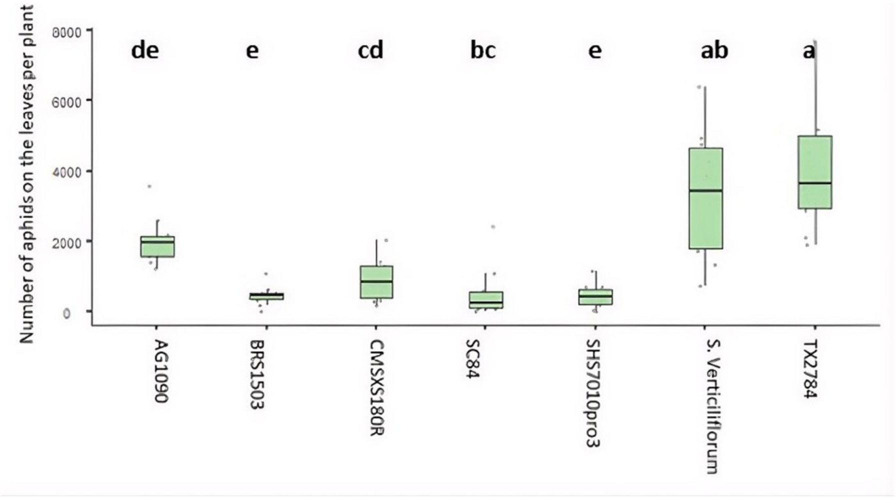


Fig. 6 Median number of aphids (*Melanaphis sorghi*) on leaves per plant in different host plants. Host plants are ordered from highest to lowest infestation. Different letters indicate statistically significant differences ($p < 0.05$) among genotypes according to the Dwass-Steel-Critchlow-Fligner test

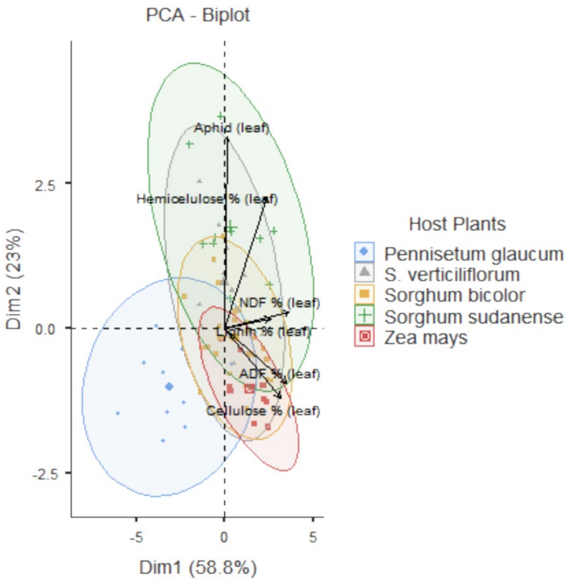


Fig. 7 Biplot from Principal Component Analysis (PCA) showing the relationship between leaf fiber components and aphid load on leaves (arrows) and host plant species (colored points) along the first two principal components (PC1: 58.8%; PC2: 23.0%). The direction of the vectors indicates correlation with the components, and their length represents their contribution to the variance

lignin: r = 0.54; hemicellulose: r = 0.57; cellulose: r = 0.37).

The second principal component (PC2) represented a contrast between specific fiber constituents, showing a positive correlation with lignin (0.52) and hemicellulose (0.54), and a negative correlation with cellulose (−0.59) and ADF (−0.28). This pattern suggests an opposition between plants with higher lignin and hemicellulose contents versus those with higher cellulose and ADF contents (Figs. 9 and 10).

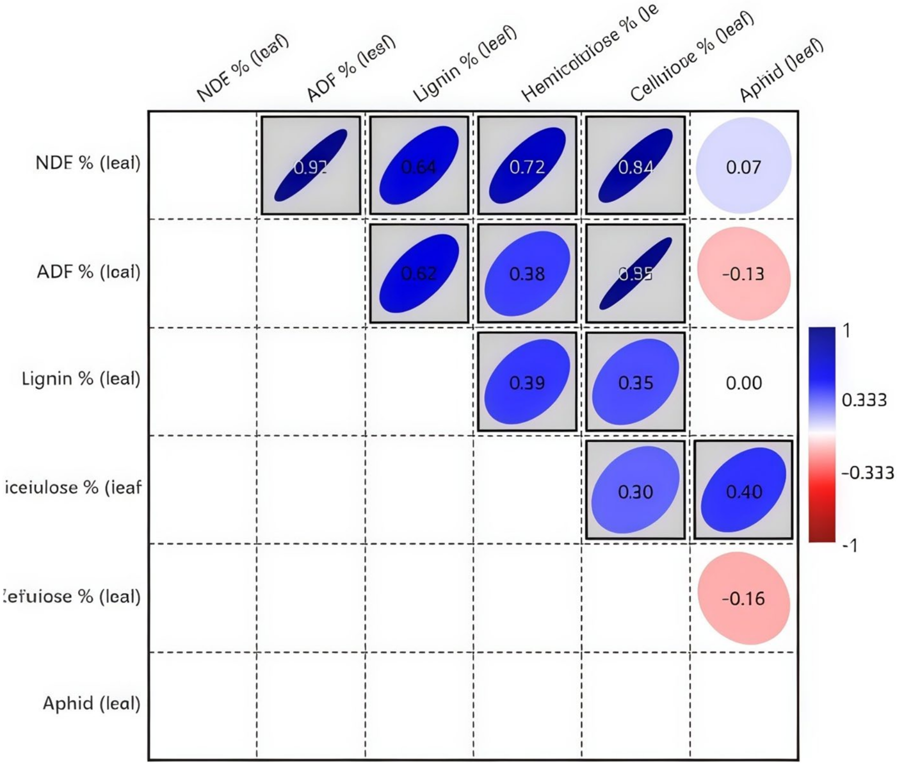
The distribution of species in the biplot space revealed a segregation. The sorghum groups clustered along the positive direction of the "aphids on stem" vector, indicating greater susceptibility to infestation in these species. In contrast, *Z. mays* and *P. glaucum* were positioned in the opposite region of the graph, demonstrating lower stem aphid infestation.

The correlation analysis for the stem revealed a pattern distinct from that observed in the leaves, with significant associations between fiber components and aphid infestation. The analysis demonstrates that stem susceptibility to aphids is influenced by the specific chemical architecture of the cell wall, with particular emphasis on the contrasting roles of hemicellulose, cellulose, ADF, and NDF contents. The relationship between cellulose and aphid numbers was consistent in both the multivariate (PCA) and bivariate correlation analyses.

Discussion

The results of this study enabled the categorization of Poaceae species from the Panicoideae subfamily based on their suitability as hosts for the development of *M. sorghi*. The integrated analysis of insect biological parameters and plant biochemical

Fig. 8 Correlation matrix between fiber components and aphid infestation on leaves. Figure 8. Correlation matrix between fiber components and aphid infestation on leaves. The values represent Pearson's correlation coefficients (r). Significant correlations ($p < 0.05$) are highlighted with shading. NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber



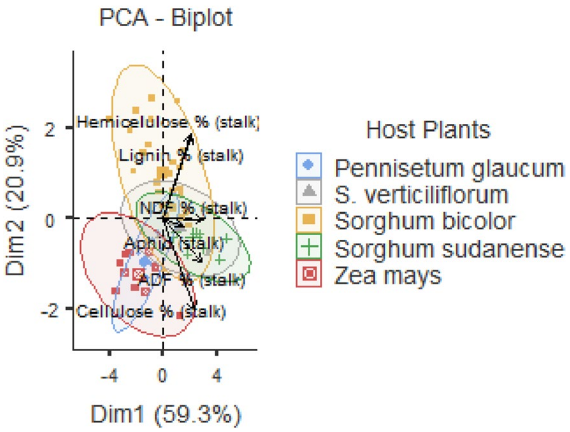


Fig. 9 Biplot from Principal Component Analysis (PCA) showing the relationship between stem fiber components and aphid load on stems (arrows) and host plants species (colored points) along the first two principal components (PC1: 59.3%; PC2: 20.9%). The direction of the vectors indicates correlation with the components, and their length represents their contribution to the variance

composition revealed a gradient of interactions, ranging from incompatible relationships to associations conducive to aphid proliferation.

Pearl millet and maize plants exhibited infestation levels below 24% and a survival rate of only 2.0% (only one out of 50 nymphs reached the adult stage). The insect was unable to establish viable populations, as evidenced by the negative intrinsic rate of increase (r_m) in pearl millet and null in maize. Values of $r_m \leq 0$ indicate that a population is not self-sustaining and will tend towards decline and local extinction (Hudgens, 2007; Karley et al., 2003). This population collapse, characterized by high nymphal mortality and practically null fecundity, is indicative of the pest's low adaptability to the host (Karley et al., 2004; Hafiz, 2006). Our data corroborate studies in maize with the sugarcane aphid, *Melanaphis sacchari* (Zehntner, 1897) (Hemiptera: Aphididae), a sibling species of *M. sorghi*, which also showed only an insignificant percentage of feeding, indicating potential resistance or low nutritional quality affecting population growth on this host (Souza & Davis, 2019, 2020).

In contrast, all treatments from the Sorghum genus demonstrated the capacity for the establishment and exponential proliferation of *M. sorghi*. Infestation reached levels above 70%, and the aphid's reproductive performance was optimal, resulting in a positive

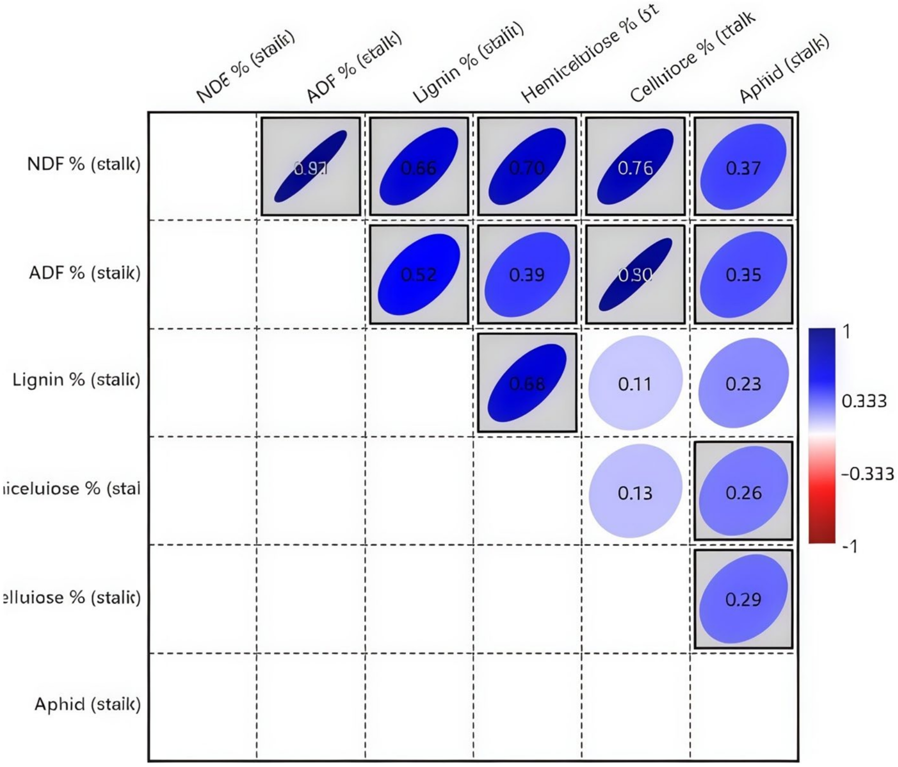


Fig. 10 Correlation matrix between fiber components and aphid infestation on stems Fig. 8. Correlation matrix between fiber components and aphid infestation on leaves. The values represent Pearson's correlation coefficients (r). Significant correlations ($p < 0.05$) are highlighted with shading. NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber

intrinsic rate of increase (r_m). This corroborates previous studies showing that *M. sorghi* can infest various sorghum types, including grain, forage, biomass, and sweet sorghum, as well as other genera such as Johnsongrass, Sudangrass, energy cane, Columbus grass, and giant miscanthus (Avellar et al., 2022; Casiraghi et al., 2023; Harris-Shultz et al., 2022; Santos et al., 2025a, 2025b, 2025c).

The analysis of aphid distribution within the plant revealed a trophic preference for leaves over stems. This observation points to distinct composition and structure in different plant parts. A more rigid epidermis can hinder initial establishment and stylet probing by the aphid (Hao et al., 2020). While probing, aphids may detect these compounds and abandon the tissue in search of a more palatable one (Hopkins et al., 2017).

Since leaves are the preferred location, the presence of aphids on the stem is likely a secondary phenomenon, driven primarily by population density on the leaves. On hosts that exhibited high aphid density, reproduction on the leaves is so explosive that the population quickly reaches the local carrying capacity. Intraspecific competition for space and resources forces individuals to migrate to adjacent tissues, such as the stem (Strong, 2006). It is crucial to emphasize that the aphid's preference for leaves does not exclude the stem as a vital component of infestation. In scenarios of high susceptibility, as demonstrated by *S. sudanense* (TX2784R), even if triggered by migration, robust colonies became established on the stem. Although a secondary site, the stem can harbor and permit the reproduction of a significant number of individuals, substantially contributing to overall plant damage and the survival of the pest population.

The analysis of fiber composition supports the hypothesis of organ-specific chemical/structural preferences. Leaf infestation was positively correlated with hemicellulose, whereas stem infestation appeared to be influenced by a more complex combination of hemicellulose, cellulose, ADF, and NDF. This indicates that the factors determining the reproductive success of colonies in one organ may not be the same as in another.

This differential role of hemicellulose can be explained by its specific physicochemical properties. As a structural polysaccharide of the primary cell wall matrix, it confers less rigidity compared to cellulose and lignin (Bajpai, 2022). The overall cell wall architecture, defined by the balance between cellulose, hemicellulose, and lignin, is a component for the successful establishment of colonies (Scheller & Ulvskov, 2010). Higher levels, or a specific composition of hemicellulose, may result in a less rigid cell wall, facilitating the mechanical penetration of the aphid's stylet through the mesophyll towards the phloem vessels (Silva-Sanzana et al., 2019, 2020).

The variability in *M. sorghi* infestation observed among *S. sudanense*, *S. bicolor verticilliflorum*, and different *S. bicolor* genotypes cannot be attributed exclusively to structural biochemical factors. The greater reproductive success of colonies may be intrinsically associated with the morphological structures of these species, which can act as factors facilitating colonization and providing protection for the aphid.

Plants of *S. sudanense* and *S. bicolor verticilliflorum*, which supported high aphid numbers, possess a forage-type plant morphology. Their high tillering index results in a dense, closed canopy, favoring the formation of a protected microclimate with high humidity and shading, which reduces abiotic stress (Chen et al., 2020). Additionally, thinner stems and narrower leaves represent a reduced physical barrier that facilitates stylet penetration, while their high leaf-to-stem ratio provides an abundance of feeding sites (Sosnovsky, 2016).

Wild sorghum, *S. bicolor verticilliflorum*, consolidates its status as a suitable host for *M. sorghi* not only due to its favorable morphophysiological characteristics but also due to its reproductive capacity, evidenced by a fertility curve showing constant nymph production throughout the reproductive period. This status as an efficient host confers significant phytosanitary importance to the species as a weed. Thus, its presence in border areas or within sorghum fields can constitute green bridges, ensuring the maintenance and dispersal of aphid colonies between seasons and during the crop cycle.

In contrast, *S. bicolor* genotypes were selected for a robust main stem and less tillering; most present a more open and airy canopy, increasing aphid exposure. Thick stems, often accompanied by a thick layer of epicuticular wax, act as a physical barrier, hindering insect locomotion and attachment. Leaves are generally thicker and exhibit greater sclerification (Rincón-López et al., 2022).

However, the particular case of *S. sudanense*, which, despite supporting high infestations of *M. sorghi*, exhibited low injury scores (mean of 1.5) compared to *S. bicolor* genotypes, stands out. This dissociation between insect population density and the manifestation of plant injury suggests a mechanism of tolerance. The introgression of this characteristic into breeding programs emerges as a strategy for developing cultivars capable of sustaining lower damage even under aphid pressure, thereby conferring greater stability to the production system.

Conclusions

This study classifies the evaluated plants into two distinct categories: non-hosts (pearl millet and maize), in which *M. sorghi* is unable to establish or reproduce, and hosts (genus Sorghum), which support the development and proliferation of the pest. The results indicate that cell wall composition, specifically hemicellulose, shows a positive correlation with the number of *M. sorghi* aphids on the plants. These findings provide new insights into host suitability and highlight hemicellulose as a potential target for resistance breeding. Future research should explore the genetic regulation of hemicellulose biosynthesis and validate these patterns across diverse environments and sorghum genotypes under field conditions.

Acknowledgements We would like to thank the Postgraduate Program in Bioengineering (PPBE) at the Federal University of São João del-Rei (UFSJ) for their scientific support. We thank Embrapa Maize and Sorghum for the structure made available for the bioassay. FAPEMIG and FINEP for financial support, and CAPES for funding the publication fees (CAPES - Springer Nature transformative agreement).

Author contributions D. G. Santos: investigation (equal); methodology (equal); original draft writing (equal). S. M. Martins: methodology (equal); funding acquisition (equal); project and lab administration (equal); resources (equal); writing and editing (equal). K. A. S. Rezende: methodology (equal), T. F. Silva: methodology (equal). B. L. S. Silva: methodology (equal). N. M. Santos: methodology (equal). V. M. Marques: methodology (equal). P. S. Pereira: methodology (equal). F. D. Tardin: critical writing, review, and editing (equal). A. M. Auad: critical writing, review, and editing (equal). M. L. F. Simeone: critical writing, review, and editing (equal).

Funding The Article Processing Charge (APC) for the publication of this research was funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) (ROR identifier: 00x0ma614).

Data availability The statistical data supporting the findings of this study are available in the supplementary material.

Declarations

Conflict of interest The authors declare no competing interests.

Competing interests The authors declare no competing interests.

References

Agro Bayer. (2024) Copyright © Bayer Crop Science 2024. Sorgo Agroceres *AG1090*. Acessado em 01 de setembro de 2025. Acessível em: https:// https://www.agro.bayer.com.br/d/sorgo-agroceres-ag-1090-safrinha-sorgo-br

Alin, A. (2010). Minitab. *Wiley Interdisciplinary Reviews: Computational Statistics, 2*(6), 723–727. https://doi.org/10.1002/wics.113

Avellar, G. S., Mendes, S. M., Marriel, I. E., Menezes, C. B., Parrella, R. D. C., & Santos, D. G. (2022). Resistance of sorghum hybrids to sorghum aphid. *Brazilian Journal of Biology,82*, Article e264139. https://doi.org/10.1590/1519-6984.26413

Bajpai, P. (2022). Physical and chemical characteristics of lignocellulosic biomass. Lignocellulosic Biomass in Biotechnology, 11–24. https://doi.org/10.1016/B978-0-12-821889-1.00001-1

Battist, I. D. E., & Smolski, F. M. D. S. (2019). *Software R: Análise estatística de dados utilizando um programa livre*. Editora Faith, Bagé, RS. Available at: https://www.researchgate.net/profile/Felipe-Smolski/publication/335854013_Software_R_Analise_estatistica_de_dados_utilizando_um_programa_livre/links/5d803ed592851c22d5dd3599/Software-R-Analise-estatistica-de-dados-utilizando-um-programa-livre.pdf. Accessed 15 Feb 2025.

Casiraghi, A., Addelfio, N., Ardenghi, N. M., & Hidalgo, N. P. (2023). First record of *Melanaphis sorghi* (Theobald, 1904)(Hemiptera aphididae) in Italy and Spain. bioRxiv, 2023–05. https://doi.org/10.1101/2023.05.02.539111

Chaffey, N. (2000). Physiological anatomy and function of the membranous grass ligule. *New Phytologist,146*(1), 5–21. https://doi.org/10.1046/J.1469-8137.2000.00618.X

Chen, A., Liu, Y., Liu, X., Xuan, J., Qiao, C., Miao, R., & Zhao, C. (2020). Pruning from spheroidal to cubic canopy induced aphid outbreak by altering the plant performance in Box tree. https://doi.org/10.21203/rs.3.rs-45207/v1

Ferreira, D. F. (2019). SISVAR: A computer analysis system to fixed effects split plot type designs. *Brazilian Journal of Biometrics,37*(4), 529–535. https://doi.org/10.28951/rbb.v37i4.450

Ferreira, D. A., Gonçalves, L. C., & Rodrigues, J. A. S. (2018). Ruminal degradability of brown-midrib sorghum-sudangrass hybrids for cutting and grazing. *Revista Ciência Agronômica,49*, 141–149. https://doi.org/10.5935/1806-6690.20180016

Figueroa-Brito, R., Vargas-Cardoso, O. R., Ramos-López, M. Á., Salinas-Sánchez, D. O., Tagle-Emigdio, L. J., & Sotelo-Leyva, C. (2024). Effect of Technical Insecticides Against the Sorghum Aphid *Melanaphis sorghi1*. *Southwestern Entomologist,49*(4), 1224–1231. https://doi.org/10.3958/059.049.0414

Guimarães, C. C., Simeone, M. L. F., Parrella, R. A., & Sena, M. M. (2014). Use of NIRS to predict composition and bioethanol yield from cell wall structural components of sweet sorghum biomass. *Microchemical Journal,117*, 194–201. https://doi.org/10.1016/j.microc.2014.06.029

Guo, Y., Wang, Z., Jiao, Z., Yuan, G., Cui, L., Duan, P., & Shi, Y. (2024). Genome-Wide Identification of Sorghum Paclobutrazol-Resistance Gene Family and Functional Characterization of SbPRE4 in Response to Aphid Stress. *International Journal of Molecular Sciences,25*(13), 7257. https://doi.org/10.3390/ijms25137257

Hafiz, N. A. (2006). Use of life tables to asses host plant resistance in cowpea to *Aphis craccivora* Koch (Homoptera: Aphididae). *Ass Univ Bull Environ Res,9*(1), 1–6. https://doi.org/10.21608/auber.2006.150243

Hao, Z. P., Zhan, H. X., Gao, L. L., Huang, F., Zhu, L. N., & Hou, S. M. (2020). Possible effects of leaf tissue characteristics of oilseed rape *Brassica napus* on probing and feeding behaviors of cabbage aphids *Brevicorynebrassicae*. *Arthropod-Plant Interactions,14*(6), 733–744. https://doi.org/10.1007/s11829-020-09782-5

Harris-Shultz, K., Armstrong, J. S., Carvalho, G., Jr., Segundo, J. P., & Ni, X. (2022). *Melanaphissorghi* (Hemiptera: Aphididae) clonal diversity in the United States and Brazil. *Insects,13*(5), 416. https://doi.org/10.3390/insects13050416

Hayashida, R., Carey, C., Springer, T., Knighten, B., Armstrong, J. S., & Hoback, W. W. (2024). Interactions between Sudangrass Lines Selected for Differing Nitrate Expression and Sorghum Aphid. *Agronomy,14*(10), 2250. https://doi.org/10.3390/agronomy14102250

Hopkins, D. P., Cameron, D. D., & Butlin, R. K. (2017). The chemical signatures underlying host plant discrimination by aphids. *Scientific Reports,7*(1), 8498. https://doi.org/10.1038/s41598-017-07729-0

Hsieh, W. H., Liao, H. C., Chin, H. S., Kuo, Y. T., Chen, C. H., Tsai, Y. C., & Lin, Y. R. (2023). The geographic distributions and complex genetic relationships among four Sorghum taxa identified in Taiwan. *Weed Research,63*(5), 317–327. https://doi.org/10.1111/wre.12594

Hudgens, B. R. (2007). Quantifying spatial correlations in extinction risk for an aphid metapopulation. *Population Ecology,49*(1), 63–73. https://doi.org/10.1007/s10144-006-0017-1

Julio, B. H. M., Parrella, N. N. L. D., Santos, C. V., da Silva, K. J., Campos, A. F., Reis, I. M. D., & de Menezes, C. B. (2022). Phenotypic selection of grain sorghum restorer lines. *Revista Brasileira de Milho e Sorgo,21*, e1230. https://doi.org/10.18512/rbms2022v21e1230

Juma, G., Juma, G., Juma, G., Clément, G., Ahuya, P., Hassanali, A., Derridj, S., Gaertner, C., Gaertner, C., Linard, R., Le Ru, B., Frérot, B., Calatayud, P.-A., & Calatayud, P.-A. (2016). Influence of Host-Plant Surface Chemicals on the Oviposition of the Cereal *StemborerBusseolaFusca*. *Journal of Chemical Ecology,42*(5), 394–403. https://doi.org/10.1007/S10886-016-0704-0

Karley, A. J., Pitchford, J. W., Douglas, A. E., Parker, W. E., & Howardh, J. J. (2003). The causes and processes of the mid-summer population crash of the potato aphids Macrosiphum euphorbiae and Myzus persicae (Hemiptera: Aphididae). *Bulletin of Entomological Research,93*(5), 425–438. https://doi.org/10.1079/BER2003252

Karley, A. J., Parker, W. E., Pitchford, J. W., & Douglas, A. E. (2004). The mid-season crash in aphid populations: Why and how does it occur? *Ecological Entomology,29*(4), 383–388. https://doi.org/10.1111/j.0307-6946.2004.00624.x

Kellogg, E. A. (2015). VIII. Subfamily Panicoideae Link (1827) (pp. 271–345). Springer, Cham. https://doi.org/10.1007/978-3-319-15332-2_22

Khanal, N., Vitek, C., & Kariyat, R. (2024). Variation in Sorghum Aphid (*Melanaphissorghi*) 1 Populations Translates into Life History Traits on Sorghum-Sudangrass (*Sorghum´ drummondii*). *Southwestern Entomologist,49*(4), 1192–1210. https://doi.org/10.3958/059.049.0415

Kumaraswamy, S., & Huang, Y. (2024). Molecular interactions between plants and aphids: Recent advances and future perspectives. *Insects,15*(12), 935. https://doi.org/10.3390/insects15120935

Lee, H. S., Santana, Á. L., Peterson, J., Yucel, U., Perumal, R., De Leon, J., ... & Smolensky, D. (2022). Anti-adipogenic activity of high-phenolic sorghum brans in pre-adipocytes. Nutrients, 14(7), 1493. https://doi.org/10.3390/nu14071493

Liu, F., Wodajo, B., & Xie, P. (2024). Decoding the genetic blueprint: Regulation of key agricultural traits in sorghum. *Advanced Biotechnology,2*(4), 31. https://doi.org/10.1007/s44307-024-00039-3

Matsubayashi, K. W., & Katakura, H. (2012). Differential acceptance of and survivorship on a non-host plant between two geographically separate populations of the phytophagous ladybird beetle *Henosepilachnayasutomii*. *Entomologia Experimentalis Et Applicata,144*(2), 157–164. https://doi.org/10.1111/j.1570-7458.2012.01277.x

Michielini, J. P., Yi, X., Brown, L. M., Gao, S. M., Orians, C., & Crone, E. E. (2024). Novel host plant use by a specialist insect depends on geographic variation in both the host and herbivore species. *Oecologia,204*(1), 95–105. https://doi.org/10.1007/s00442-023-05490-y

Mwamahonje, A., Mdindikasi, Z., Mchau, D., Mwenda, E., Sanga, D., Garcia-Oliveira, A. L., & Ojiewo, C. O. (2024). Advances in Sorghum improvement for climate resilience in the global arid and semi-arid tropics: A review. *Agronomy,14*(12), 3025. https://doi.org/10.3390/agronomy14123025

Peña-Martínez, R., Lomeli-Flores, J. R., Bujanos-Muñiz, R., Salas-Monzón, R., Hernández-Torres, O. E., Marín-Jarillo, A., & Muñoz-Viveros, A. L. (2024). Comparative biology and life tables of sorghum aphid *Melanaphissorghi* (Theobald)(Hemiptera: Aphididae) from Mexico, at different temperatures. *Phytoparasitica,52*(2), 33. https://doi.org/10.1007/s12600-024-01152-8

Penteado, S. D. R. C., De Oliveira, E. B., & Lazzari, S. M. N. (2010). TabVida: sistema computacional para cálculo de parâmetros biológicos e de crescimento populacional de afídeos. Available at: https://www.infoteca.cnptia.embrapa.br/infoteca/bitstream/doc/870882/1/Doc203.pdf. Accessed 15 Feb 2025.

Reddy, K. R. A. K., & Pitha, C. C. (2024). Exploring genetic variability, path analysis and divergence in sorghum (Sorghum bicolor (L.) Moench). *Journal of Experimental Agriculture International,46*(8), 49–62. https://doi.org/10.9734/jeai/2024/v46i82679

Rincón-López, B., Naveda, A. F., Lara, U. A., Hernández, M. E. T., & Tafolla-Arellano, J. C. (2022). Sorghum and Aphid (*Melanaphis sacchari*) Interaction: Plant Physiology, Breeding, and Molecular Overview. In Biocontrol Systems and Plant Physiology in Modern Agriculture (pp. 237–256). Apple Academic Press. https://doi.org/10.1201/9781003277118-14

Roy, A., Wäschke, N., Chattington, S., Modlinger, R., Chakraborty, A., Chirere, T. E., & Schlyter, F. (2024). Diet breadth in two polyphagous Spodoptera moths in a wide range of host and non-host plants and the potential for range expansion. bioRxiv, 2024–07. https://doi.org/10.1101/2024.07.25.605058

Şahin, M., Aybek, E. (2019). Jamovi: An easy to use statistical software for the social scientists. *International Journal of Assessment Tools in Education, 6*(4), 670–692. https://doi.org/10.21449/ijate.661803

Sahu, N., Gowda Gadratagi, B., Guru-Pirasanna-Pandi, G., Patil, N. B., Basak, N., Rath, P. C., & Rath, L. K. (2024). Antixenosis and antibiosis mechanisms of resistance to Asian rice gall midge, *Orseoliaoryzae* (Wood-Mason) in rice land races. *Annals of Applied Biology,185*(2), 183–194. https://doi.org/10.1111/aab.12876

Santa Helena Sementes. (2024). *SHS 7010 PRO3 - Corn Hybrid*. Retrieved September 1, 2025, from https://santahelenasementes.com.br/produtos/shs-7010

Santos, D. G., Dias, L. L. C., Avellar, G. S., Simeone, M. L. F., Parrella, R. A. C., Santos, N. M., Silva, T. F., Neto, A. A., & Mendes, S. M. (2025). Biomass Sorghum (*Sorghum bicolor*) Agronomic Response to *Melanaphissorghi* (Hemiptera: Aphididae) Infestation and Silicon Application. *Insects,16*(6), 566. https://doi.org/10.3390/insects16060566

Santos, D. G., de Avellar, G. S., da Costa Parrella, R. A., dos Santos, N. M., Damasceno, N. C. R., Rezende, K.

A. S., ... & Mentes, S. M. (2025). Biology and Life Table of *Melanaphis sorghi* (Theobald, 1904)(Hemiptera: Aphididae) on Sweet Sorghum Hybrids (Sorghum bicolor). Genetics and Molecular Research, 24(2), 1–12. https://doi.org/10.4238/f7c0js71

Santos, D. G. D., Dias, L. L. C., Avellar, G. S. D., Simeone, M. L. F., Oliveira, I. R. D., Menezes, C. B. D., & Mendes, S. M. (2025). Effect of silicon on *Melanaphis sorghi* (Theobald, 1904)(Hemiptera: Aphididae) infesting grain sorghum (*Sorghum bicolor*). International Journal of Pest Management, 1–10. https://doi.org/10.1080/09670874.2025.2453838

Scheller, H. V., & Ulvskov, P. (2010). Hemicelluloses. *Annual Review of Plant Biology,61*(1), 263–289. https://doi.org/10.1146/annurev-arplant-042809-112315

Shrestha, K., Huang, J., Yan, L., Doust, A. N., & Huang, Y. (2024). Integrated transcriptomic and pathway analyses of sorghum plants revealed the molecular mechanisms of host defense against aphids. *Frontiers in Plant Science,15*, 1324085. https://doi.org/10.1007/s00442-023-05490-y

Silva-Sanzana, C., Celiz-Balboa, J., Garzo, E., Marcus, S. E., Parra-Rojas, J. P., Rojas, B., & Blanco-Herrera, F. (2019). Pectin methylesterases modulate plant homogalacturonan status in defenses against the aphid *Myzus persicae*. *The Plant Cell,31*(8), 1913–1929. https://doi.org/10.1105/tpc.19.00136

Silva-Sanzana, C., Estevez, J. M., & Blanco-Herrera, F. (2020). Influence of cell wall polymers and their modifying enzymes during plant–aphid interactions. *Journal of Experimental Botany,71*(13), 3854–3864. https://doi.org/10.1093/jxb/erz550

Silveira, M. C. T., Simeão, R., Leandro, T., Ribeiro, A., Gontijo Neto, M. M., De Sousa, S. M., & Tardin, F. D. (2024). Caracterização da produção de forragem de cultivares tropicais anuais em resposta a diferentes estratégias de manejo e aprimoramento de uso. Embrapa Pecuária Sul. Boletim de pesquisa e desenvolvimento, 57. 26

Sosnovsky, Y. (2016). Sucking herbivore assemblage composition on greenhouse Ficus correlates with host plant leaf architecture. *Arthropod-Plant Interactions,10*(1), 55–69. https://doi.org/10.1007/s11829-015-9408-6

Souza, M. F., & Davis, J. A. (2019). Determining potential hosts of *Melanaphissacchari* (Hemiptera: Aphididae) in the Louisiana agroecoscape. *Environmental Entomology,48*(4), 929–934. https://doi.org/10.1093/ee/nvz072

Souza, M. F., & Davis, J. A. (2020). Detailed characterization of *Melanaphissacchari* (Hemiptera: Aphididae) feeding behavior on different host plants. *Environmental Entomology,49*(3), 683–691. https://doi.org/10.1093/ee/nvaa036

Strong, D. R. (2006). Insect Herbivore-Host Dynamics: Tree-Dwelling Aphids. *Environmental Entomology,35*(6), 1718–1718. https://doi.org/10.1603/0046-225X(2006)35[1718:IHDTA]2.0.CO;2

Thudi, M., Reddy, M. S., Naik, Y. D., Cheruku, V. K. R., Sangireddy, M. K. R., Cuevas, H. E., & Punnuri, S. M. (2024). Invasive sorghum aphid: A decade of research on deciphering plant resistance mechanisms and novel approaches in breeding for sorghum resistance to aphids. *Crop Science,64*(5), 2436–2458. https://doi.org/10.1002/csc2.21301

Toledo-Hernández, E., Peña-Chora, G., Mancilla-Dorantes, I., Torres-Rojas, F. I., Romero-Ramírez, Y., Palemón-Alberto, F., & Sotelo-Leyva, C. (2024). A review of biological control one decade after the sorghum aphid (*Melanaphissorghi*) outbreak. *Plants,13*(20), 2873. https://doi.org/10.3390/plants13202873

Uyi, O., & Toews, M. D. (2024). Melanaphis sorghi: a review and synthesis of its control options 10 years post detection of a new invasive haplotype in the United States of America. CABI Reviews, 19(1). https://doi.org/10.1079/cabireviews.2024.00

VanGessel, C., Rice, B., Felderhoff, T. J., Charles, J. R., Pressoir, G., Nalam, V., & Morris, G. P. (2024). Globally deployed sorghum aphid resistance gene RMES1 is vulnerable to biotype shifts but is bolstered by RMES2. *The Plant Genome,17*(2), Article e20452. https://doi.org/10.1002/tpg2.20452

Villacis-Perez, E., De Graeve, F., De Beer, B., Ali Alshami, S., De Jong, R., De Meyer, T., & Van Leeuwen, T. (2024). Independent genetic mapping experiments identify diverse molecular determinants of host adaptation in a generalist herbivore. Molecular Ecology, e17618. https://doi.org/10.1111/mec.17618

Yan, H., Lv, N., Yin, F., Wang, Y., Niu, H., Lv, X., & Ping, J. (2024). The Genetic Diversity of 69 Widely Used Chinese Sorghum Hybrids Released between the 1970s and 2010s. *Agronomy,14*(10), 2180. https://doi.org/10.3390/agronomy14102180

Zhang, Q., Zhang, K., & Zhang, Z. (2025). Leaf trichome density influences oviposition preference in *Phytoseius leaki Schicha (Acari: Phytoseiidae).* Systematic & Applied Acarology. https://doi.org/10.11158/saa.30.4.13