International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 11, Issue: 06 "November-December 2025"

AGRONOMIC TRAITS, GINNING APTITUDE AND JASSID (*Amrasca biguttula*) TOLERANCE OF COTTON (*Gossypium hirsutum* L.) VARIETIES IN CAMEROON

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DOI: https://doi.org/10.51193/IJAER.2025.11614

Received: 08 Dec. 2025 / Accepted: 22 Dec. 2025 / Published: 29 Dec. 2025

ABSTRACT

Increasing rainfall variability, growing pest pressure, and strong global market competition highlight the need for high-yielding, resilient, and locally adapted cotton varieties in Cameroon. This study evaluated the agronomic and ginning performance as well as jassid (*Amrasca biguttula*) tolerance of four newly developed *Gossypium hirsutum* L. varieties (IRMA L2026, L2033, L2146, L2168) in the Sudano-Sahelian zone. These genotypes were compared with two reference varieties, IRMA Q302 and IRMA A2249, during the 2023/2024 and 2024/2025 rainy seasons across four sites (Sanguéré, Pitoa, Mouda, Kodek) using a Fisher block design with six replications. Agronomic, phenological, and pest-tolerance traits were recorded. The new varieties exhibited good emergence (70%) and plant stand (84.5%) and were generally earlier than the controls, with flowering occurring 56–61 days after sowing and boll opening 107–119 days after sowing. They displayed reduced plant height compared with Q302. Yield performance was encouraging: in 2023, L2146, L2033, and L2026 produced 1.0–2.3 t/ha, while in 2024 all varieties achieved high yields, with A2249 slightly superior (2 t/ha). The new genotypes produced competitive boll weights (4.5 g) and high lint percentages (43–45%), with L2026 showing the highest ginning outturn (45%). Seed indices were similar across genotypes (8 g). Jassid infestation peaked at flowering; L2026 showed the greatest tolerance, yielding 1.2 t/ha without insecticide, whereas L2146 recorded the lowest performance (519 kg/ha). Overall, the four new varieties demonstrated promising productivity, fiber potential, and pest tolerance. L2033 and L2026 appear best suited to the Far North, L2168 to the North, while L2146 shows broader but variable adaptability. Further multilocation trials under semi-operational conditions are recommended to confirm their suitability and refine fiber and seed quality assessments.

Keywords: Cotton variety, Jassids, Agronomic performance, Varietal tolerance, Cameroon's cotton-growing zone.

1. INTRODUCTION

Agricultural development in tropical regions is increasingly challenged by environmental, technical, and economic constraints. Recent years have been marked by strong rainfall variability, intensifying pest pressure, declining soil fertility, and rising input costs, all of which have significantly reduced crop performance (PR-PICA, 2024). In Sub-Saharan Africa, where agriculture is mainly rainfed and dominated by small family farms, these constraints directly threaten productivity, food security, and rural income. Among tropical cash crops, cotton (*Gossypium hirsutum* L.) holds a strategic position. It is the world's leading natural fiber crop and an essential source of monetary income for millions of farmers. In Francophone Africa, particularly in the Sudanian–Sahelian zones, cotton remains central to rural development strategies, sustaining a complete value chain that includes fiber production, oil extraction, cake production, and industrial by-products such as biodiesel (Estur, 2006; Folefack, 2011). Despite this socio-economic importance, yields in the region remain below the global average and have stagnated or declined over the past decade (PR-PICA, 2024; Yao, 2011).

This decline results from combined abiotic and biotic stresses. Climatically, increased variability manifested through erratic rainfall, dry spells, and early cessation of rains affects the growth cycle and yield potential of current varieties (Olina, 2008). Soil degradation and rising fertilizer prices further reduce productivity and limit farmers' capacity to invest. Biotically, pest pressure has intensified with the emergence of new leafhopper species, especially *Amrasca biguttula*, whose severe infestations since 2022 have caused yield losses reaching 50% in several countries of the sub-region, including Cameroon (PR-PICA, 2022; Housseini *et al.*, 2024). These issues are particularly acute in Cameroon's cotton-growing regions of the North and Far North. The area is characterized by a dry tropical climate, leached ferruginous soils, water scarcity, and limited technical resources, contributing to stagnating yields. Traditional varieties, although partially adapted, no longer meet the requirements for improved productivity, resilience, and technological fiber quality.

In this context, genetic improvement is a key strategy for sustainable intensification of cotton systems. The development of new varieties adapted to local agroecological constraints, tolerant to pests, and aligned with technological standards is considered essential for restoring competitiveness (Bourgou *et al.*, 2013; Ndoye *et al.*, 2011). In Cameroon, varietal improvement is led by the Agricultural Research Institute for Development (IRAD). Building on breeding programs initiated with IRCT in the 1950s, IRAD now relies primarily on genealogical selection to stabilize desirable traits across generations (Loison *et al*., 2017; Palai Oumarou *et al*., 2019). This approach is increasingly complemented by modern breeding tools, including marker-assisted selection, genomic mapping, and participatory selection, which improve efficiency and precision (Jean-Louis Belot *et al*., 2006). However, newly developed varieties must undergo rigorous evaluation before release. Multi-location trials are necessary to assess their agronomic performance, adaptability, drought tolerance, pest resistance particularly to jassids and technological fiber quality under real agroecological constraints. These evaluations ensure that selected varieties meet the expectations of producers, ginners, and industrial actors. The present study is conducted within this framework. It aims to assess the agronomic performance, yield potential, and jassid tolerance of newly developed *G. hirsutum* varieties in the Sudanian–Sahelian cotton zone of Cameroon. By integrating agroecological, phytosanitary, and socio-economic considerations, this work seeks to identify genotypes capable of addressing the current challenges faced by cotton producers in northern Cameroon and to support the renewal of the country’s varietal portfolio.

2. MATERIALS AND METHOD

2.1 Study Area and Experimental Sites

The study was conducted during the 2023/2024 and 2024/2025 rainy seasons in four representative cotton-growing locations of the Sudanian–Sahelian zone of Cameroon : Sanguere (Garoua, North Region, 8th and 13th degrees north latitude, and 9th and 15th degrees east longitude), Pitoa (North Region, 9° and 23° north latitude, and 13° to 32° east longitude), Mouda (Far North, 10°22’12’’ north latitude and 14°13’46’’ east longitude), and Djarengol-Kodek (Far North, 10.58473° north latitude and 14.2623° east longitude). These sites are characterized by a dry tropical climate with unimodal rainfall, marked inter-annual variability, and mean seasonal temperatures ranging between 25–33 °C. Altitudes range from 295 to 468 m and soils are predominantly ferruginous, weakly structured, and susceptible to nutrient depletion (INS, 2023). Seasonal rainfall data for all sites and years are presented in Table 1 (SODECOTON, 2022).

Table 1: Rainfall for the 23/24 and 24/25 campaigns (SODECOTON, 2022)

Campagne	Site	Region	Total Rainfall	Total Days
23/24	Kodek	Far North	560.17 mm	32
	Sanguéré	North	1228.7 mm	57
	Pitoa	North	904.8 mm	39
	Mouda	Far North	809.3 mm	33
24/25	Kodek	Far North	1032 mm	45
	Sanguéré	North	1203 mm	62
	Pitoa	North	802.2 mm	35
	Mouda	Far North	703.1 mm	30

2.2 Rainfall Monitoring and Climatic Data

Rainfall was recorded daily using rain gauges installed at each experimental station. Total seasonal rainfall and monthly distribution for both cropping seasons were used to characterize the climatic context and compare inter-site variability. Detailed rainfall values appear in Table 1.

2.3 Plant Material

The study evaluated four new cotton varieties developed by IRAD IRMA L2026, L2033, L2146, and L2168 and compared them with two reference cultivars: IRMA Q302 (widely cultivated) and IRMA A2249 (in the scaling phase). The genealogies and main agronomic characteristics of the newly developed lines are presented in Table 2. These varieties were selected through genealogical breeding carried out under the improvement program (SODECOTON, 2022).

Table 2: Characteristics of new varieties (SODECOTON, 2022)

New Varieties	Characteristics
1. IRMA L2026	It is early maturing and has a good seed cotton yield. At ginning, its fiber yield is higher than the controls.
2. IRMA L2033	It is early maturing, has a good field yield, and a high fiber rate at ginning.
3. IRMA L2146	It is productive and has large seeds with good fiber
4. IRMA L2168	It is early maturing with good field yield and high fiber content at ginning.
Varieties	**Genealogies**
1. IRMA L2026 :	MA10-1751 * Q297 = H204-16-J411-5-K1023-5-L2026
2. IRMA L2033 :	MA10-1751 * Q297 = H204-18-J412-2-K1028-3-L2033
3. IRMA L2146 :	B2026 * Q297 = H214-25-J472-6-K1159-6-L2146
4. IRMA L2168 :	B2026 * Z2424 = H215-10-J481-4-K1182-5-L2168
5. IRMA A2249 :	Q295 * L457-V342-10-W602-3-Z1621-5-A2249. (In the scaling phase)
6. IRMA Q302 :	IRMA BLT-PF * IRMA I466-M412-258-N372-485-P477-475-Q302 (widely cultivated)

2.4 Agronomic Equipment and Inputs

Standard field equipment was used for crop establishment and data collection, including tractors, sprayers, hygrometers, rulers, ginning devices, and laboratory tools. Fertilizers (NPK and urea), herbicides, and insecticides were provided by SODECOTON following recommended commercial formulations. The insecticide program used in the trial and its active ingredients are summarized in Table 3, which outlines the predefined control method (PDM) implemented uniformly across sites.

Table 3: Insecticide treatment

Treatment No	Periods	Plots
1	July 1–14	Emamectine benzoate + teflubenzuron (Tema 135 WG), Bt (Rapax)
2	July 15–28	Emamectine benzoate + teflubenzuron (Tema 135 WG, Dinel 270 EC)
3	July 29–August 11	Spinetoram (Cobra 120 EC, Radian 120 SC)
4	August 12–25	Rynaxypyr (Coragen 20 SC)
5	August 26–September 8	Rynaxypyr (Coragen 20 SC)
6	September 9–22	Indoxacarbe (Moran 30 DF, Indoxan 150 EC) + acetamipride;
7	September 23–October 6	Indoxacarbe (Moran 30 DF, Indoxan 150 EC) + acetamipride
8	October 7–20	Emamectine benzoate (Expert 50, Emacot Fort, Emacot Pro)
9	October 21–November 4	Emamectine benzoate (Expert 50, Emacot Fort, Emacot Pro)

2.5 Experimental Design

Trials were established using Fisher block design with six varieties and six replications per site. Each plot consisted of four rows, with standardized spacing between and within rows. Border rows were included to minimize edge effects. Treatments were fully randomized within each block. Figures 1 and 2 illustrate the field layout and experimental arrangement.

Figure 1: Overview of the experimental setup before flowering **Figure 2**: Overview of the experimental setup at harvest tim

2.6. Crop Management Practices

2.6.1. Cultivation Calendar

All agronomic practices were applied uniformly across sites. Sowing was performed at the onset of rains, followed by fertilizer applications and insecticide treatments according to the technical itinerary prescribed by SODECOTON. Key operations including sowing, thinning, weeding, and harvest are presented in Table 4.

Table 4: Cultural Calendar

Year	Site	Sowing	Emergence	NPK dose (kg/ha)	Urea dose (kg/ha)	Insecticide treatment (LPD)
2023	Garoua	12/06/2023	19/06/2023	200	50	Predefined Fight
2023	Maroua	23/06/2023	30/06/2023	200	/	Predefined Fight
2024	Garoua	25/06/2024	03/07/2024	200	50	Predefined Fight
2024	Maroua	02/07/2024	10/07/2024	200	/	Predefined Fight
2024	Pitoa	10/07/2024	17/07/2024	200	50	Predefined Fight
2024	Mouda	13/07/2024	20/07/2024	200	/	Predefined Fight

2.6.2. Pest Management

Pest control followed the **predefined control method (PDM)** described in Table 3. Treatments targeted major cotton pests and were synchronized with crop phenology. Products, active ingredients, and treatment periods followed national recommendations.

2.7. Field Observations and Measurements

2.7.1. Emergence and Plant Density

Emergence rate was assessed at 7 days after sowing (DAS), and final plant density was recorded before harvest by counting the number of surviving plants per plot.

2.7.2. Phenological Traits

The dates of first flowering and first boll opening were recorded for each plot to estimate earliness and cycle duration.

2.7.3. Morphological Traits

Ten plants were randomly sampled in each plot to measure:

- Number of vegetative branches,
- Height of the first fruiting branch,
- Total plant height.

2.7.4. Boll Characteristics

A sample of 30 bolls per variety per replicate was collected to determine average boll weight.

2.7.5. Leafhopper (Amrasca biguttula) Infestation

Jassid pressure was evaluated at three key stages: pre-flowering, flowering, and boll formation. Measurements included:

- Number of attacked plants,
- Insect density per plant,
- Severity, score (scale 1–5). These observations were used to characterize varietal tolerance.

2.8. Laboratory Analyses

Post-harvest analyses were conducted at the IRAD Maroua ginning laboratory. Parameters included:

- Seed cotton yield per plot,

- Lint and seed percentage after ginning,
- Ginning speed,

Seed Index (SI). Illustrative steps of the procedures and samples appear in Figures 3, 4, 5, 6, and 7.


Figure 3: Harvesting


Figure 4: Ginning


Figure 5: Seed Index


Figure 6: SI Sample


Figure 7: Cotton seeds

2.9. Measurement Procedures and Calculation Methods

All biometric and technological data were collected following IRAD and SODECOTON protocols. Calculated variables included:

- Emergence rate (%),
- Plant density (plants ha^{-1}),
- Cycle duration (days),
- Mean boll weight (g),
- Leafhopper infestation index,
- Lint percentage,
- Seed Index (g 100 $seeds^{-1}$).

Each measurement followed standardized procedures to ensure reproducibility across sites and seasons.

3. RESULTS

3.1. Emergence and Plant Density

All new varieties exhibited good emergence rates, ranging from 68% to 72%, with an average of 70%, while plant density at harvest averaged 84.5%. Emergence and density were generally higher in the Sanguéré site and slightly lower at Kodek and Mouda, consistent with the observed rainfall patterns (Table 1). Reference varieties showed similar emergence but slightly higher variability in density due to local soil conditions. (Figures 8 and 9, Table 6 and 7)

Figures 8 and 9 shows the germination rates of the varieties compared. The number of seeds germinated varied from 50 to 86% in Sanguere and from 56 to 88% in Kodek. This shows that all the varieties tested had good emergence rates at both experimental sites (Kodek and Sanguere) and during both growing seasons. The results of the analysis of variance (ANOVA) reveal that at Kodek there is no significant difference between varieties at the 5% threshold. However, in Sanguere in 2023, the controls Q302 and A2249 showed the best emergence rates (67% and 69%), while in 2024, it was the new variety L2033 that stood out with a value of 91%. The L2146 and L2168 varieties were on par with the controls, and L2026 had the lowest emergence rate during the two campaigns in Sanguere (50% and 77%).

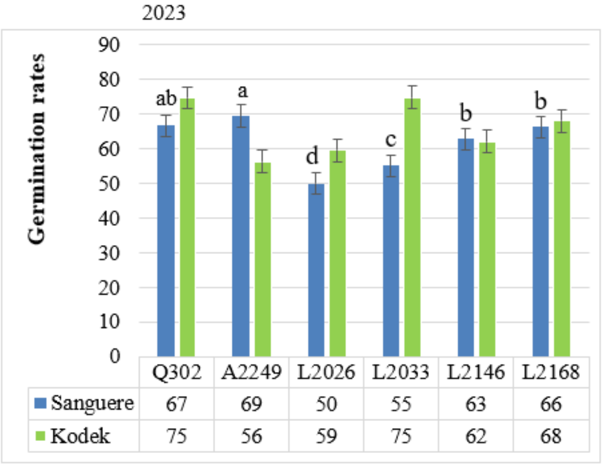


Figure 8: *Germination rates 1*

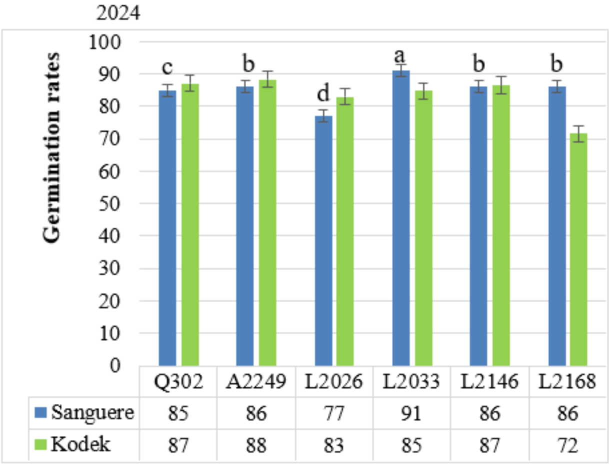


Figure 9: *Germination rates 2*

3.2. Phenology

Regarding phenology, regardless of variations in rainfall and soil quality, the new varieties were generally earlier with shorter cycles than the reference cultivars, except for L2168.. Flowering occurred between 56 and 61 days after sowing, while boll opening ranged from 107 to 119 days. Early flowering and shorter cycle duration were particularly observed in L2026 and L2033, indicating potential suitability for semi-arid regions with erratic rainfall. Reference variety Q302 flowered later and had a longer maturation cycle. Table 5-1 and Figures 10, 11, 12, and 13 present the results relating to the phenology of the cotton varieties tested. Flowering for all varieties tested occurred between 57 and 64 days after emergence and boll opening between 107 and 119 days.

Table 5.1: Comparison of flowering precocity (D1FAL) of cotton varieties in 2023 and 2024

Hypothetical merged graph

Varieties	D1FJAL 2023	D1FJAL 2024
IRMA L2026	60^{a}	61^{a}
IRMA L2033	61^{a}	61^{a}
IRMA L2146	60^{a}	60^{a}
IRMA L2168	62^{a}	61^{a}
IRMA A2249	63^{b}	62^{a}
IRMA Q302	64^{b}	63^{b}

Legend :

D1FJAL = Number of days between emergence and the date of appearance of the first flower.

Averages followed by the same letter in the same column do not differ significantly according to the Newman-Keuls test at the 5% threshold.

The letters a and b indicate statistically different groups. The further the letter is in the alphabet, the more significantly different the value is.

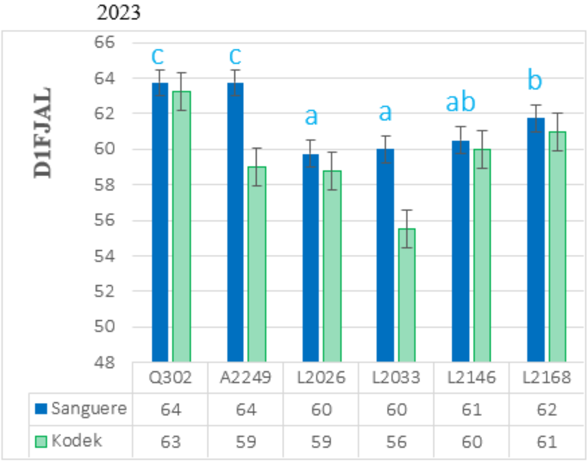


Figure 10: *D1FJAL 1*

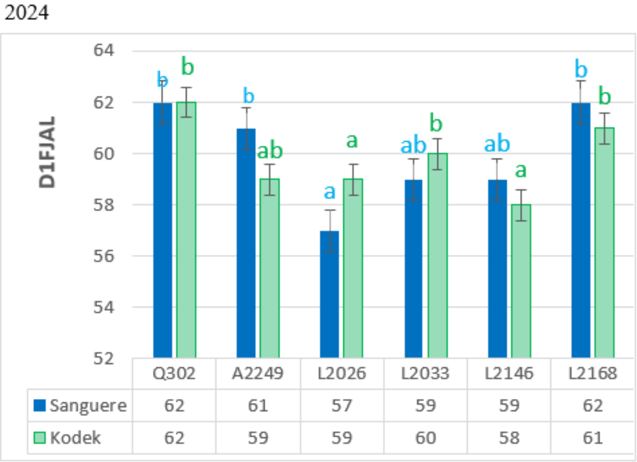


Figure 11: *D1FJAL 2*

The analysis of variance performed on the variable "date of first flower appearance" revealed a statistically significant difference between the six genotypes tested. This result suggests marked genetic variability in terms of floral precocity, an important characteristic in water-stressed environments.

In Sanguéré, the results show that the four new varieties (IRMA L2026, L2033, L2146, and L2168) are significantly earlier than the two traditional controls (IRMA Q302 and IRMA A2249). The new varieties reached flowering between 60 and 62 days after emergence, compared to 62 to 64 for the controls. This behavior was confirmed in Kodek, where the new varieties maintained a phenological advantage over the controls, with a lower average number of days to flowering. Notably, IRMA Q302 stood out as the latest variety in the trial, reaching flowering on average at 63. Conversely, IRMA A2249 showed a similar earliness to L2026, reflecting the potential for better adaptability of this control variety to the agroclimatic conditions at the Kodek site (Table 5.3, Figures 10 and 11)

With regard to capsulation, statistical analysis revealed a highly significant difference between the different varieties, also indicating significant variability in the cycle time to reproductive maturity.

In Sanguéré, the data show a clear precocity of the new varieties, which reached the opening of the first capsule between 107 and 112, compared to 112 to 117 for the two controls (Figure 12). These differences are particularly relevant in the context of tropical agriculture, where rainfall is not only low but also poorly distributed. The ability of varieties to reach physiological maturity more quickly therefore represents a definite agronomic advantage. However, at Kodek, the differences observed between varieties in terms of capsulation are not statistically significant. However, numerical differences were noted: IRMA A2249 showed the first signs of capsulation at 115, proving to be numerically the earliest in the batch, while IRMA L2168 proved to be the latest, reaching capsulation at 118 on average (Figure 13).

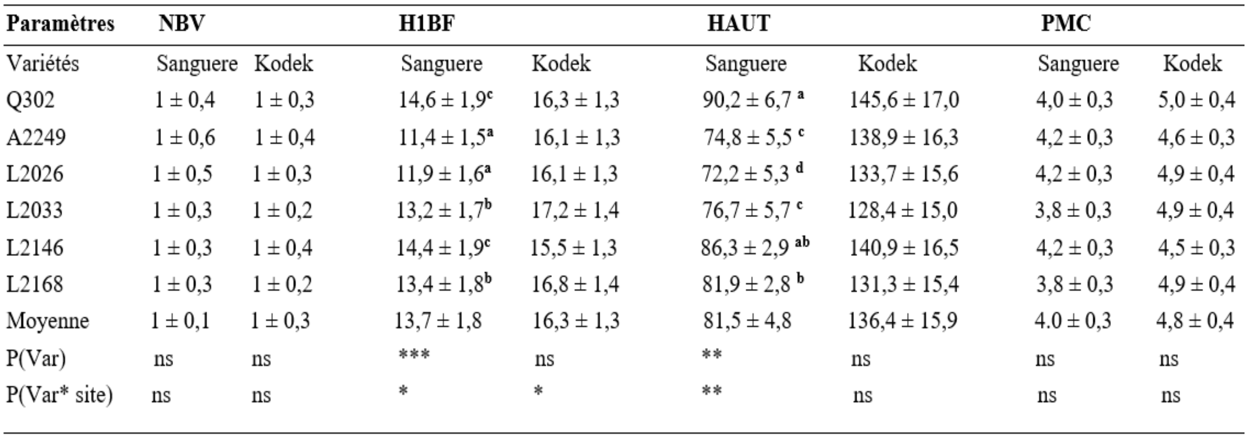
Figure 12: *D1CJAL 1*

Figure 13: *D1CJAL*

3.3. Morphological Traits

At all sites, the new yields were less exuberant, with small heights and a shorter cycle. Plant height of the new genotypes ranged from 98 to 105 cm, shorter than Q302, which reached 117.9 cm. The new varieties also produced fewer vegetative branches, with L2026 and L2033 displaying a single branch per plant. The height of the first fruiting branch was generally lower in the new varieties compared to the controls, reflecting reduced vegetative growth and potential for easier management and harvesting. The results shown in Tables 5-2 and 5-3 highlight the number of vegetative branches (NBV), the height of the first fruiting branch (H1BF), plant height (HP), and average capsule weight (PMC) for both sites over the two growing seasons. For all cotton varieties tested, the number of vegetative branches is “1.” In 2023, statistical analysis of these results shows that there is a highly significant difference in the insertion height of the first fruiting branch and the height of cotton plants according to the Newman-Keuls test at the 5% threshold. The insertion height of the first fruiting branch ranges from 11.4 to 14.6 cm in Sanguere and 16.1 to 16.8 cm in Kodek, with averages of 13.7 cm and 16.3 cm, respectively. In Sanguere, L2026 and the control A2249 stand out (11.9 and 11.4 cm respectively) and the control Q302 has the lowest value (15.4 cm). In Kodek, no significant differences were observed between them. Plant height varied between 72.2 and 90.2 cm, with an average of 81.5 cm in Sanguere. Q302 was significantly the tallest (90.2 cm) and the L2026 variety (72.2 cm) was the shortest. The other varieties are statistically similar, with little difference between them and the control A2249. However, there are differences in size between these intermediate varieties. In Kodek, however, no significant difference was observed between varieties. Finally, in terms of average capsule weight (PMC), all varieties are equivalent with an average of 4.0 g. In 2024, the ANOVA results reveal that all modalities are statistically similar, but numerical variations are observed that confirm the behavior of the varieties during the previous season. (Table 5.3).

Table 5.2: Varietal effect on agronomic parameters (Haut, H1BF, NBV, and PMC) evaluated in 2023



Paramètres	NBV		H1BF		HAUT		PMC	
Variétés	Sanguere	Kodek	Sanguere	Kodek	Sanguere	Kodek	Sanguere	Kodek
Q302	1 ± 0,4	1 ± 0,3	14,6 ± 1,9^{c}	16,3 ± 1,3	90,2 ± 6,7 ^{a}	145,6 ± 17,0	4,0 ± 0,3	5,0 ± 0,4
A2249	1 ± 0,6	1 ± 0,4	11,4 ± 1,5^{a}	16,1 ± 1,3	74,8 ± 5,5 ^{c}	138,9 ± 16,3	4,2 ± 0,3	4,6 ± 0,3
L2026	1 ± 0,5	1 ± 0,3	11,9 ± 1,6^{a}	16,1 ± 1,3	72,2 ± 5,3 ^{d}	133,7 ± 15,6	4,2 ± 0,3	4,9 ± 0,4
L2033	1 ± 0,3	1 ± 0,2	13,2 ± 1,7^{b}	17,2 ± 1,4	76,7 ± 5,7 ^{c}	128,4 ± 15,0	3,8 ± 0,3	4,9 ± 0,4
L2146	1 ± 0,3	1 ± 0,4	14,4 ± 1,9^{c}	15,5 ± 1,3	86,3 ± 2,9 ^{ab}	140,9 ± 16,5	4,2 ± 0,3	4,5 ± 0,3
L2168	1 ± 0,3	1 ± 0,2	13,4 ± 1,8^{b}	16,8 ± 1,4	81,9 ± 2,8 ^{b}	131,3 ± 15,4	3,8 ± 0,3	4,9 ± 0,4
Moyenne	1 ± 0,1	1 ± 0,3	13,7 ± 1,8	16,3 ± 1,3	81,5 ± 4,8	136,4 ± 15,9	4.0 ± 0,3	4,8 ± 0,4
P(Var)	ns	ns	***	ns	**	ns	ns	ns
P(Var* site)	ns	ns	*	*	**	ns	ns	ns

In the same column, averages followed by the same letter do not show a significant difference according to Newman's keuils test at the 5% threshold. HAUT: Plant height (cm); NBV: number of vegetative branches and H1BF: height of insertion of the first fruiting branch (cm), PMC = average capsule weight in g.

Table 5.3: Varietal effect on agronomic parameters (Haut, H1BF, NBV, and PMC) evaluated in 2024

Paramètres	**NBV**		**H1BF**		**Haut**		**PMC**	
Variétés	Garoua	Kodek	Garoua	Kodek	Garoua	Kodek	Garoua	Kodek
Q302	1 ± 0,3	1 ± 0,4	18,1 ± 1,7	16,3 ± 0,5	105,9 ± 17,3	97,7 ± 21,9	5 ± 0,5	4,8 ± 0,4
A2249	1 ± 0,3	1 ± 0,4	16,3 ± 2,3	16,8 ± 1,4	95,1 ± 10,5	88,0 ± 26,4	5 ± 0,4	4,9 ± 0,5
L2026	1 ± 0,2	1 ± 0,2	15,5 ± 2,0	16,4 ± 0,9	110,6 ± 14,8	84,4 ± 16,3	5 ± 0,2	4,6 ± 0,6
L2033	1 ± 0,3	1 ± 0,4	16,7 ± 0,9	16,5 ± 0,6	92,7 ± 15,4	79,4 ± 21,9	5 ± 0,8	4,9 ± 0,6
L2146	1 ± 0,2	1 ± 0,5	16,8 ± 2,1	16,3 ± 0,6	106,2 ± 14,8	86,0 ± 15,5	5 ± 0,6	5,0 ± 0,3
L2168	1 ± 0,4	1 ± 0,3	19,4 ± 2,3	16,6 ± 1,2	103,4 ± 11,2	94,3 ± 16,2	5 ± 0,2	4,7 ± 0,4
Moyenne	1 ± 0,3	1 ± 0,4	17,1 ± 1,9	16,5 ± 0,9	102,3 ± 14,0	88,3 ± 19,7	5 ± 0,5	4.8 ± 0,5
P (Var)	ns	ns	ns	ns	ns	ns	ns	ns
P (Var*site)	ns	ns	*	*	*	*	ns	ns

In the same column, averages followed by the same letter do not show a significant difference according to Newman's keuils test at the 5% threshold. HAUT: Plant height (cm); NBV: number of vegetative branches and H1BF: height of insertion of the first fruiting branch (cm), PMC = average capsule weight in g.

3.4. Seed Cotton Yield

Yield performance varied across seasons and sites.

- 2023 season: L2146, L2033, and L2026 achieved yields between 1 and 2.3 t/ha.
- 2024 season: All varieties were productive, with A2249 slightly superior at 2 t/ha.

These results indicate the potential of the new varieties to produce competitive yields under variable climatic conditions. Analysis of seed cotton yield results (RDTCG), expressed in kilograms per hectare (kg/ha), highlights the variability in performance of the varieties tested at different sites and during different growing seasons. Figures 14 and 15 illustrate the trends observed for the 2023 and 2024 growing seasons, respectively. The analysis of variance (ANOVA) performed at a significance level of 5% did not reveal any statistically significant differences between varieties. However, notable numerical variations were recorded, indicating potential heterogeneity in varietal performance under different environmental conditions.

In Sanguere

In 2023, the IRMA L2146 variety recorded the highest yield at 1,431.8 kg/ha, closely followed by IRMA L2026 and IRMA L2168. Conversely, IRMA L2033 performed the worst, with an average yield of 1,435.5 kg/ha over the two seasons.

In 2024, there was a clear overall improvement in yields at the site. The control IRMA A2249 performed best, followed by L2168, L2146, and L2026, with yields ranging from 1,909.3 to 2,094.5 kg/ha. The L2033 variety remained the least productive at this site during both years.

At Kodek

In 2023, this site had higher yields than Sanguere. IRMA L2026 and IRMA L2033 were the best performers with 2327.7 kg/ha and 2314.8 kg/ha, respectively, while L2146 was the least productive with 1833.6 kg/ha.

In 2024, yields decreased dramatically. The control A2249 and varieties L2026, L2168, and L2146 produced yields ranging from 835 to 1057 kg/ha, while L2033 had the lowest yield at 783 kg/ha.

These observations show that the varietal response to yield varies greatly depending on the location and agricultural season, reflecting the combined effect of soil and climate factors and biotic pressures (Figures 14 and 15).

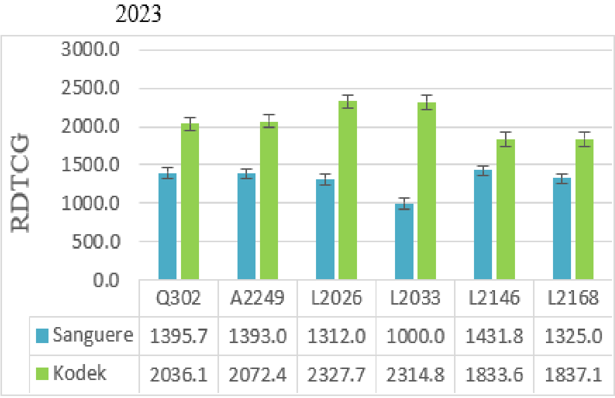


Figure 14: RDTCG 1

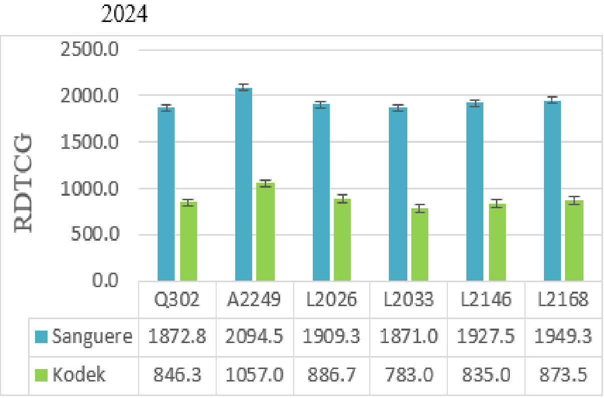


Figure 15: RDTCG 2

3.5. Ginning Performance

At ginning, the new varieties were the most performant across all sites and during both seasons.The new varieties produced Ginning percentages high, ranging from 43–45%, with L2026 achieving the highest ginning outturn (45%). Reference varieties Q302 and A2249 recorded higher seed percentages (58–59%) and faster ginning speeds (4.5–4.7 F/S/H). The seed index was consistent across all genotypes (8 g) (Figures 16-23, Table 5-1).

3.5.1. Net fiber percentage

Figures 16 and 17 shows the results for the ginning yields of the cotton varieties tested (PFN = net fiber percentage). This yield varied for all varieties from 41 to 45% in Garoua and from 40 to 44% in Kodek.

Averages followed by the same letter do not differ significantly, according to the Newman-Keuls test at the 5% level. PFN= Net Fiber Percentage

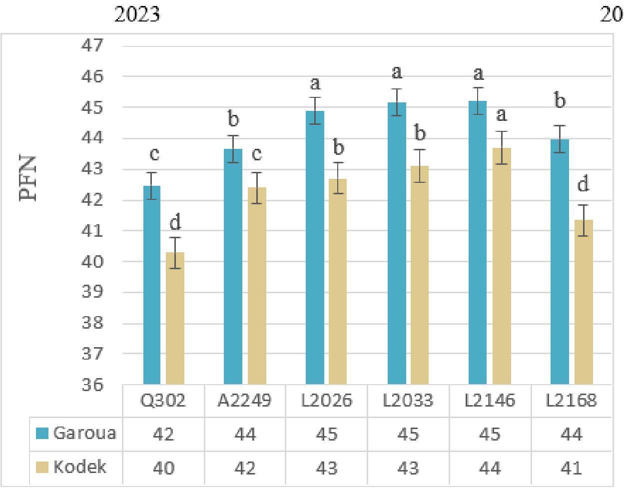


Figure 16: PFN 1

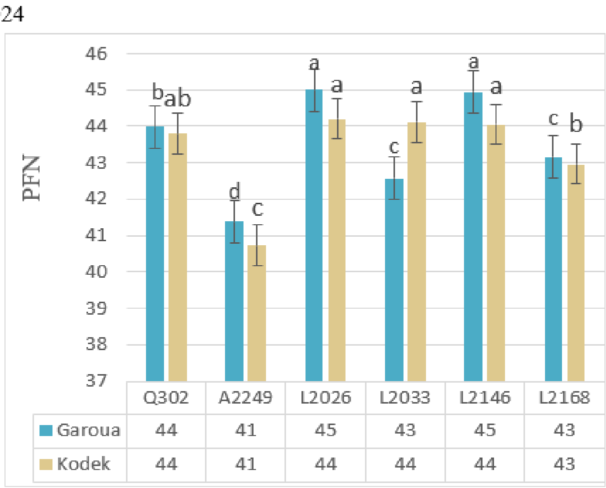


Figure 17: PFN 2

The ANOVA results show that there is a highly significant difference between the varieties. Of the four new varieties compared in Garoua Sanguere in 2023, three have higher fiber percentages than the controls. These are L2026, L2033, and L2146 (45%), while L2168 is similar to control A2249 (44%). The Q302 variety had the lowest fiber percentage (42%). In 2024, however, the L2026 and L2146 varieties had the best values (45%), followed by the Q302 control (44%). The L2033 and L2168 varieties recorded 43% and were superior to A2249, which was the lowest control with 41%. At Kodek, the histograms showed the same trend and the varieties confirmed their behavior during the two campaigns and at both sites. (Figures 16 and 17).

3.5.2. Seed Percentage

Figures 18 and 19 shows the results for the seed percentage at ginning (PG) of the cotton varieties tested. This percentage varied for all varieties from 53 to 59% in Garoua and from 55 to 59% in Kodek.

Averages followed by the same letter do not differ significantly, according to the Newman-Keuls test at the 5% level. PG = Percentage of Seeds

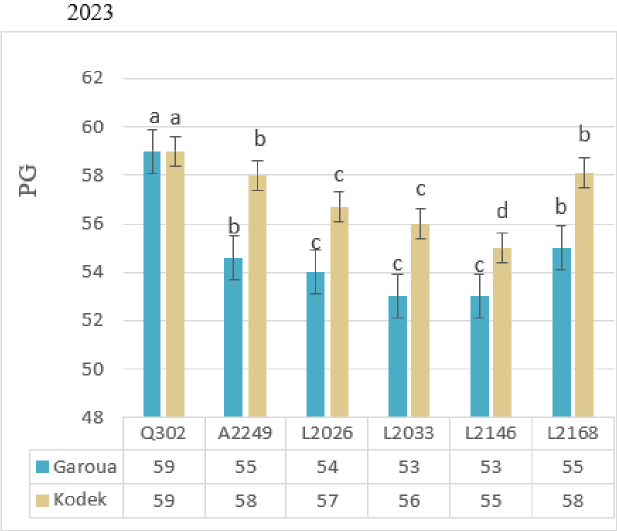


Figure 18 : PG 1

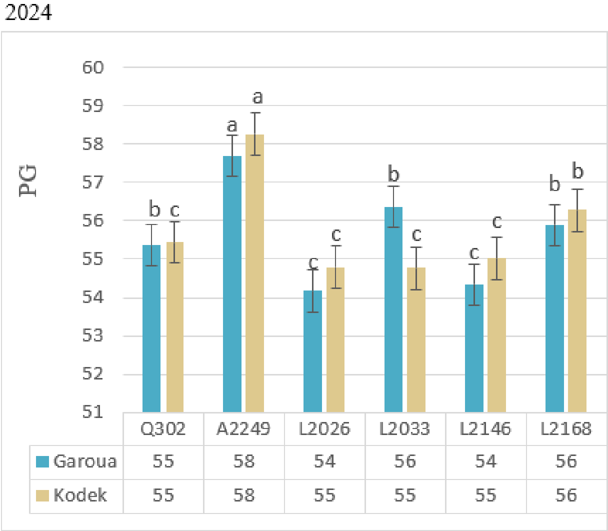


Figure 19 : PG 2

The ANOVA results show that there is a highly significant difference between varieties. In 2023, the Q302 control had the highest seed percentage (59%) at both sites, followed by A2249 and L2168 with an average of 57%. The new varieties L2026, L2033, and L2146 had the lowest percentages at both sites (54% to 56% on average). (Figure 18). In 2024, however, control A2249 had the highest seed percentage (58%) at both sites, followed by L2168 and control Q302 (56% and 55% respectively). The new varieties L2026, L2033, and L2146 had the lowest percentages at both sites (54 to 55% on average). (Figure 19).

3.5.3. Ginning speed

Figures 20 and 21 below show the ginning speed of the varieties. These results varied for all varieties from 4.2 to 6.4 F/S/H in Garoua and from 4.5 to 6.5 in Kodek.

The averages followed by the same letter do not show a significant difference, according to the Newman-Keuls test at the 5% threshold. FSH = Fibers/Saws/Hour, Ginning Speed

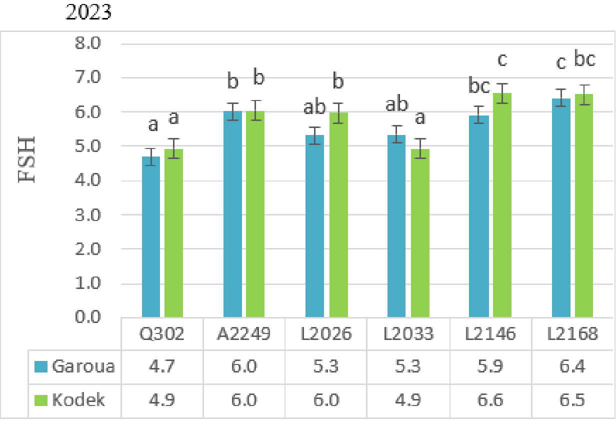


Figure 20: PG 1

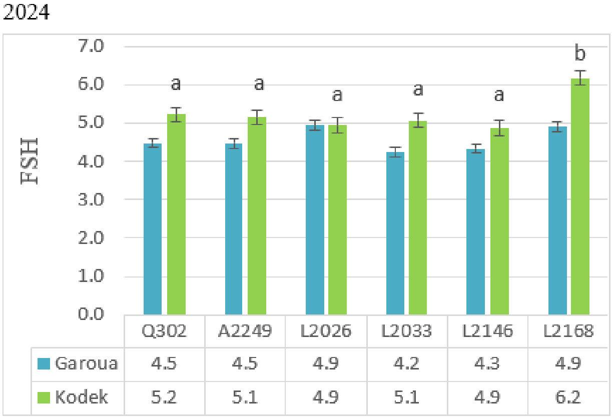


Figure 21: PG 2

Variance analysis reveals that there is a significant difference between varieties. In Garoua, the Q302 control variety threshes more quickly (4.6 F/S/H on average), while the L2068 variety threshes more slowly (5.7 F/S/H) and the other varieties are equivalent. In Kodek, on the other hand, L2026 threshes more quickly (4.9 F/S/H on average), followed by the control Q302 (5 F/S/H), while L2068 threshes more slowly (6.3 F/S/H). The other varieties are equivalent. Nevertheless, all the varieties compared show acceptable values.

3.5.4. Seed Index (Weight of 100 seeds)

Figures 22 and 23 below show the Seed Index (SI) of the varieties at the two sites and during the two growing seasons. These results varied for all varieties from 8 to 9 g, with an average of 8.5 g. The ANOVA results show that there are no significant differences between the varieties. All the varieties compared showed good values.

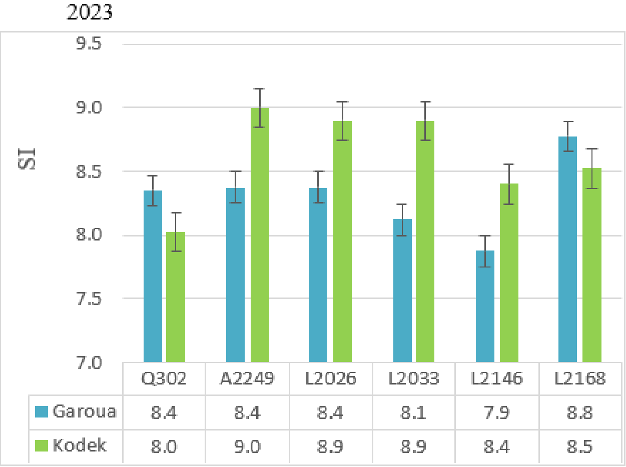


Figure 22: PG 1

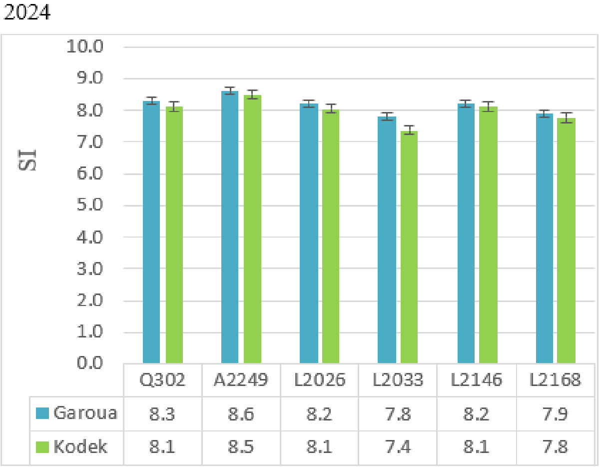


Figure 23: PG 2

3.6. Jassid (*Amrasca biguttula*) Tolerance

At all sites, peak infestation was observed at flowering for all varieties.

- L2026 showed the highest tolerance, producing an average of 1.2 t/ha without insecticide treatment.
- L2146 exhibited lower tolerance, yielding only 519 kg/ha under the same conditions.

Other varieties displayed intermediate tolerance, with reduced severity scores (1–3) compared to the susceptible reference cultivars. These results highlight the importance of varietal selection in mitigating pest pressure.

Varietal tolerance was evaluated based on the following observations and measurements: the number of plants attacked, the number of leafhoppers per plant, and the severity of attacks before flowering, during flowering, and during capsule formation. The results of the behavior of the six varieties compared in the absence of phytosanitary treatment containing the active ingredient effective against the cotton leafhopper (Amrasca bigutulla) are presented below.

Tables 6 and 7 shows the number of plants attacked, the number of leafhoppers per plant, the severity of attacks before flowering, during flowering, and during boll formation, the cotton seed yield, the percentage of fiber, the percentage of seed, and the seed index (g) at the two sites .The ANOVA results show that at both sites, varieties L2146 and L2168 had the highest densities (94% and 93% respectively), followed by the controls and varieties L2026. The new variety L2033 had the lowest density (70%).

In terms of the number of leafhoppers per plant at flowering (NJF), varieties L2026 and L2033 were less susceptible to attacks by the cotton leafhopper (21 leafhoppers/plant on average), while the control Q302 and the new varieties L2168 recorded the highest numbers of leafhoppers (29 and 28 leafhoppers/plant, respectively). In terms of seed cotton yield, the new variety L2026 was the most tolerant to leafhopper attacks with an average yield of 1,186 kg/ha, followed by the control Q302 (939 kg/ha), while the variety L2146 was the most susceptible to leafhoppers with a yield of 519 kg/ha. The intermediate varieties were equivalent. At ginning, the L2026 and L2146 varieties had the best ginning yield with 42% fiber, while Q302 had the lowest yield with 38% fiber. In terms of seed percentage, the control Q302 stood out with 61% seeds, while the L2026 variety recorded the lowest seed percentage at 57.5%. The other varieties compared are similar to each other. In terms of the number of plants attacked at emergence, the number of leafhoppers per plant at pre-flowering and capsule formation, the severity of attacks, and the Seed Index, all the varieties compared are arithmetically similar. (Tables 6 and 7).

Table 6: Assessment of Tolerance to Leafhoppers (Pitoa)

Varieties	Density	NPAL	NJP	NJF	NJC	SJP	SJF	SJC	RDTCG	% F	% G	SI
Q302	90 ± 6,8^{c}	1 ± 0,4	2 ± 0,8	24 ± 3,7^{a}	1 ± 0,4	0	4 ± 0,3	5 ± 0,4	1024 ± 121,8^{b}	38 ± 0,4	61 ±0,4^{a}	9 ± 0,5
L2026	70 ± 5,3^{d}	1 ± 0,3	3 ± 1,3	17 ± 2,6^{c}	2 ± 0,8	1 ± 0,5	3 ± 0,2	4 ± 0,3	1200 ± 142,8^{a}	42 ± 0,5	57 ± 0,3^{c}	8 ± 0,4
L2033	69 ± 5,2^{d}	1 ± 0,3	2 ± 0,8	17 ± 2,6^{c}	3 ± 1,2	0	3 ± 0,2	4 ± 0,3	718 ± 85,4^{c}	41 ± 0,5	58 ± 0,3^{b}	8 ± 0,4
L2146	93 ± 7,1^{a}	1 ± 0,4	2 ± 0,7	20 ± 3,1^{b}	2 ± 0,8	0	4 ± 0,3	5 ± 0,4	567 ± 67,5^{e}	42 ± 0,5	57 ± 0,4^{c}	8 ± 0,4
L2168	93 ± 7,1^{a}	1 ± 0,4	2 ± 0,8	25 ± 3,9^{a}	2 ± 0,8	0	4 ± 0,3	5 ± 0,4	771 ± 91,7^{c}	41 ± 0,5	58 ± 0,3^{b}	7 ± 0,3
A2249	92 ± 6,9^{b}	1 ± 0,4	2 ± 0,7	21 ± 3,2^{b}	3 ± 1,2	0	4 ± 0,3	5 ± 0,4	696 ± 82,8^{d}	41 ± 0,5	58 ± 0,3^{b}	8 ± 0,4
Moyenne	84 ± 6,4	1 ± 0,4	2 ± 0,8	20 ± 3,1	2 ± 0,8	0,1 ± 0,5	3,7 ± 0,3	4,6 ± 0,4	829 ± 98,6	41 ± 0,5	58,2 ± 0,3	8 ± 0,4
P (Var)	***	ns	ns	***	ns	ns	ns	ns	***	**	**	ns

In the same column, averages followed by the same letter do not show a significant difference according to the Newman keuils test at the 5% threshold. NPAL: Number of plants attacked at emergence, NJP: Number of whiteflies at pre-flowering, NJF: Number of whiteflies at flowering, NJC: Number of whiteflies at boll opening, SJP: Severity of attacks at pre-flowering, SJF: Severity of attacks at flowering, SJC: Severity of attacks at boll opening, RDTCG: Cotton Seed Yield, % F: Percentage of fiber, %G: Percentage of seed, SI: Seed Index (g)

Table 7: Assessment of Tolerance to Leafhoppers (Mouda)

Varieties	Density	NPAL	NJP	NJF	NJC	SJP	SJF	SJC	RDTCG	% F	% G	SI
Q302	85 ± 5,8^{c}	1 ± 0,4	4 ± 1,6	33 ± 5,4^{a}	4 ± 1,6	2 ± 0,9	5 ± 0,4	5 ± 0,4	854 ± 109,3^{b}	38 ± 0,3^{d}	62 ± 0,6	9 ± 0,6
L2026	75 ± 5,1^{d}	1 ± 0,3	6 ± 2,5	25 ± 4,1^{b}	6 ± 2,5	3 ± 1,3	4 ± 0,3	4 ± 0,3	1172 ± 150,1^{a}	42 ± 0,4^{a}	58 ± 0,5	9 ± 0,6
L2033	71 ± 4,8^{e}	1 ± 0,4	4 ± 1,6	24 ± 3,9^{b}	9 ± 3,7	1 ± 0,4	4 ± 0,3	4 ± 0,3	598 ± 76,5^{c}	40 ± 0,3^{c}	59 ± 0,5	9 ± 0,6
L2146	94 ± 6,4^{a}	1 ± 0,3	4 ± 1,5	25 ± 4,1^{b}	4 ± 1,6	1 ± 0,4	5 ± 0,4	5 ± 0,4	471 ± 60,3^{d}	42 ± 0,4^{a}	58 ± 0,5	8 ± 0,4
L2168	93 ± 6,3^{a}	1 ± 0,4	4 ± 1,6	30 ± 4,9^{a}	4 ± 1,6	1 ± 0,4	5 ± 0,4	5 ± 0,4	643 ± 82,3^{c}	41 ± 0,3^{b}	59 ± 0,5	8 ± 0,4
A2249	87 ± 5,9^{b}	1 ± 0,4	4 ± 1,6	26 ± 4,3^{b}	6 ± 2,5	1 ± 0,4	5 ± 0,4	5 ± 0,4	580 ± 74,2^{c}	41 ± 0,3^{b}	59 ± 0,5	9 ± 0,5
Moyenne	84 ± 5,7	1 ± 0,4	4 ± 1,6	27 ± 4,4	6 ± 2,5	1,5 ± 0,6	4,7 ± 0,4	4,6 ± 0,4	719,6 ± 92,1	41 ± 0,3	59 ± 0,5	9 ± 0.4
P (Var)	***	ns	ns	*	ns	ns	ns	ns	***	**	**	ns
P (Var*site)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

In the same column, averages followed by the same letter do not show a significant difference according to the Newman keuils test at the 5% threshold. NPAL: Number of plants attacked at emergence, NJP: Number of whiteflies at pre-flowering, NJF: Number of whiteflies at flowering, NJC: Number of whiteflies at boll opening, SJP: Severity of attacks at pre-flowering, SJF: Severity of attacks at flowering, SJC: Severity of attacks at boll opening, RDTCG: Cotton Seed Yield, % F: Percentage of fiber, %G: Percentage of seed, SI: Seed Index (g)

3.7. Agro-Ecological Suitability

Based on combined performance for yield, fiber content, and pest tolerance:

- L2026 and L2033 are best suited for the Far North,
- L2168 is adapted to the North,
- L2146 shows moderate adaptability to both zones.

Further multi-location trials under semi-commercial conditions are recommended to validate these findings and evaluate fiber and seed traits under broader agroecological contexts.

4. DISCUSSION

4.1. Emergence and Plant Density

The high emergence rates (70%) and plant densities (84.5%) observed in the new varieties indicate good adaptability to the studied environments. These values are consistent with earlier reports in semi-arid zones of Cameroon, where emergence is influenced by rainfall distribution and soil type (Olina, 2008; INS, 2023). Slightly lower densities at Kodek and Mouda correlate with reduced rainfall (Table 1), highlighting the importance of selecting varieties resilient to local water stress.

4.2. Phenology and Morphology

Earlier flowering and shorter cycles in L2026 and L2033 suggest suitability for regions with erratic rainfall, as early maturation reduces exposure to drought and terminal heat (Bourgou *et al*., 2013). Reduced plant height and fewer vegetative branches, compared to Q302, facilitate crop management and harvesting while maintaining reproductive efficiency. These morphological traits are desirable in semi-arid cotton production systems (Ndoye *et al*., 2011). The precocity of the new varieties (IRMA L2026, L2033, L2146, L2168) is a major asset in terms of adaptation to climate change affecting cotton-growing areas in Cameroon. Indeed, the current trend in these regions indicates a gradual reduction in the length of the rainy season and an increase in interannual rainfall variability. According to Traoré *et al*. (2021), the selection of early-maturing varieties is one of the most effective agronomic strategies for coping with recurrent water deficits. Varieties that are able to complete their physiological cycle more quickly reduce their exposure to abiotic stresses such as terminal drought, while optimizing their production potential. In addition, in a context of intensive crop rotation, the use of early-maturing varieties would allow land to be freed up earlier for other crops, thus contributing to better management of agricultural space and diversification of production systems. Furthermore, this precocity is not unrelated to other yield and technological quality parameters. Some studies indicate that early flowering and maturation can positively influence fiber quality (length, uniformity, tenacity), provided that the plant benefits from optimal vegetative development in the early stages of growth (Bourland *et al*., 2014).

The results obtained confirm the advantageous phenological behavior of the new cotton varieties tested. Their earliness, which is consistent across several environments, suggests a better ability to adapt to the agro-climatic constraints of the Sudano-Sahelian zone of Cameroon. This characteristic positions them as promising alternatives to traditional varieties, particularly IRMA Q302, whose slow flowering could be a handicap under current production conditions. The data from this study therefore argue in favor of adopting these new varieties in cotton genetic improvement strategies adapted to the African tropical climate

4.3. Yield Performance

The seed cotton yields of the new varieties were comparable to or higher than the reference cultivars, particularly under variable rainfall conditions. L2146, L2033, and L2026 reached yields of up to 2.3 t/ha in 2023, demonstrating their potential under stress conditions and in relation to soil quality. Yield stability across seasons confirms the importance of varietal selection as a key strategy for sustaining cotton production in the Far North and North regions of Cameroon (SODECOTON, 2022). These results are generally higher than those reported by Nogbou Amangoua *et al*. (2022) in Côte d'Ivoire, where the average seed cotton yield of the varieties tested did not exceed 1.5 t/ha (i.e., 1,500 kg/ha). Our varieties L2026 and L2033, with peaks of 2.3 t/ha, far exceed this average. This demonstrates interesting agronomic potential under the ecological conditions of northern Cameroon. On the other hand, the significant drop in yields observed in Kodek in 2024 corroborates the findings of PR-PICA (2022), which report yield declines of between 10 and 50% in West Africa. This decline is mainly attributed to leafhopper attacks, constraints that were also noted in our trials.

4.4. Ginning aptitude

On all the sites and during both campaigns, high ginning percentages (43–45%) and consistent seed index (8g) indicate that new varieties produce fiber suitable for industrial processing. L2026 exhibited the highest lint yield, suggesting that varietal improvement can simultaneously enhance both agronomic and technological traits. Reference varieties maintained faster ginning speeds, likely due to longer experience with industrial processing (Folefack, 2011). These results are similar to those obtained by Clouvel *et al*. (2007), who highlight a slight improvement in seed cotton yield in the varieties tested, while a marked effect was observed on their ginning yields and commercial characteristics. Results are higher than those obtained by Hougni *et al*. in 2016 in Burkina Faso, where the seed percentages of their varieties ranged from 52 to 54%. The present study revealed percentages of 54 to 56% for the new varieties.

4.5. Jassid Tolerance

On all the sites, L2026 demonstrated the highest tolerance to Amrasca biguttula, with a yield of 1.2 t/ha without insecticide application, highlighting its potential for integrated pest management (IPM). L2146's lower tolerance emphasizes the need for strategic selection and monitoring. The observed variability underscores the importance of incorporating pest resistance into breeding objectives (Housseini *et al*., 2024). These results are consistent with those of M.R. Amin *et al*. In 2016, which show that the significant differences in tolerance observed among the cotton varieties compared are one of the main varietal characteristics for identifying pest-resistant varieties. M.A. Leghari *et al*. In 2021 similarly showed that the levels of pest infestation of 22 cotton varieties proved that six varieties were moderately resistant.

4.6. Agro-Ecological Recommendations

- L2026 and L2033: Best suited for the Far North, combining early maturity, yield potential, and pest tolerance.
- L2168: Adapted to the North region with good yield and fiber content.
- L2146: Moderately adaptable across both zones, though limited by pest susceptibility.

Multi-location and on-farm trials are recommended to validate these results under commercial production conditions, and to further assess fiber quality and seed traits.

CONCLUSION

The four newly developed *Gossypium hirsutum* L. varieties (L2026, L2033, L2146, and L2168) demonstrated promising agronomic performance, with good emergence, satisfactory plant density, early phenology, and competitive seed cotton yields. L2026 and L2033 combine early maturation with superior tolerance to jassid, making them suitable candidates for the Far North region, while L2168 is recommended for the North. High ginning percentages across new varieties indicate suitability for industrial processing, aligning with both local and international production standard.

These results highlight the importance of varietal improvement as a strategic lever for sustainable cotton intensification in Cameroon's semi-arid regions. Further multilocation trials under semi-commercial conditions are essential to confirm performance stability, evaluate fiber quality, and integrate new varieties into local production systems.

ACKNOWLEDGEMENTS

We thank the management of: ENSPM, UMA, UGA, IRAD, and SODECOTON,

The authors thank also the entire journal team for the valuable interest shown in this publication.

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