

THE MAIZE TRUST

FINAL REPORT FOR MYCOTOXIN PROJECTS

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Report due date	30 June 2026	Date range of activities reported	2022 - 2025
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1. Details of principal investigator

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2. Project title, duration and funding

Project title:	The characterisation of mycotoxigenic species of the <i>Fusarium graminearum</i> species complex, and their management in maize using crop rotation and tillage practices	MTM project no. 21-04
Duration:	2022 - 2025	
Total MT funding received for project:		
All other funding received for this project (contributor and amount):	Western Cape Department of Agriculture (greenhouse and field trial localities); Syngenta (field trial localities).	

3. Summary (description of the project, capturing the main findings; maximum 250 words)

Production of cereal grain crops including maize, wheat and sorghum are threatened by fungal pathogens within the *Fusarium graminearum* species complex (FGSC). These pathogens cause Gibberella ear rot (GER) of maize, Fusarium head blight (FHB) of wheat, sorghum grain mould (SGM) and Fusarium root rot (FRR) of soybean; and contaminate grain with harmful mycotoxins. Increasing adoption of conservation agriculture practices, including reduced tillage, residue retention and crop rotation, may favour inoculum survival and increase disease risk where susceptible host crops are grown in succession. Understanding the composition and biology of FGSC populations across crops is, therefore, critical for developing sustainable disease management strategies.

Five FGSC species were isolated and identified from maize, wheat, sorghum and soybean seed using morphological characteristics, species-specific and chemotype PCR assays, and translation elongation factor-1 α gene sequencing. The species identified were *F. graminearum* s.s. (15ADON), *F. boothii* (15ADON), *F. meridionale* (NIV), *F. acacia-mearnsii* (NIV) and *F. cortaderiae* (NIV). Species composition differed among crops and seasons. *F. meridionale* was the dominant species on maize during the 2020/21 season, representing its first report on maize in South Africa, while *F. boothii*

predominated in 2023. *F. graminearum* s.s. was dominant on wheat, *F. acacia-mearnsii* was most common on sorghum, and *F. meridionale* was recovered from soybean. Grain analyses detected DON, NIV, ZEA and fumonisins in maize, DON in wheat, and ZEA in sorghum and soybean. These findings highlighted the importance of molecular tools for accurate species identification and monitoring.

Cross-pathogenicity trials were conducted to determine whether isolates from one crop could infect others. An *F. cortaderiae* isolate was the most aggressive on maize, while *F. acacia-mearnsii* and *F. meridionale* were the most aggressive on wheat in 2023 and 2024, respectively. The pathogens also caused FRR symptoms in soybean, with *F. graminearum* s.s. and *F. meridionale* showing the highest aggressiveness. These results demonstrate that FGSC species can infect multiple host crops and produce mycotoxins across different production systems. Consequently, crop rotation strategies involving susceptible hosts and conservation agriculture practices should carefully consider the potential for inoculum carry-over and disease development.

4. Tasks, Milestones and Verification

Project goal:			
<i>List all tasks/activities (one per row) as mentioned in Section 4 of original proposal. This list should be comprehensive and include experimentation, publications, presentations, databases, manuals, human capacity development, etc.) Full details of scientific outputs can be given in Section 7.</i> Activity			
	Milestones	Means of verification	Reason(s) if not achieved
Objective 1: To determine the mycotoxin contamination by the <i>Fusarium graminearum</i> species complex (FGSC) on maize grain and its rotation crops in South Africa	The research results for this objective were presented at a local conference in 2024 and 2025. MSc and final year student graduated	Poster presentation at the 53rd Southern African Plant Pathology Congress held in 2024. Oral presentation at the National Grain Research Program Annual Research Day held in 2025. Ms S. Cronje obtained her BScAgric degree in 2023. Ms K. Potgieter obtained her MSc in Plant Pathology in March 2026.	
Collection of maize, wheat, soybean and sorghum from farms (Feb to Sep 2022 – 2023).	All samples were collected for the project.	Catalogue of samples including production and sampling history.	NA
Processing and extraction of mycotoxin from grain samples (Apr to Nov 2022 – 2023)	All samples were processed appropriately for their analyses.	Catalogue of samples including production and sampling history.	NA

Statistical analyses and comparison of mycotoxin levels and profiles annually as well as over the years of study (2022 – 2025).	All data analyses were performed.	Statistical analyses comparing mycotoxin accumulation in maize and other host crops. Data files detailing the statistical analyses of mycotoxins levels over years of study.	NA
Objective 2: To determine the species composition, cross-pathogenicity and mycotoxigenic potential of the <i>Fusarium graminearum</i> species complex (FGSC) isolated from maize and rotation crops	The research results for this objective were presented at local and international conferences as well as at industry workshops during 2025 and 2026.	Oral presentation at the 54 th Southern African Plant Pathology Congress held in 2026. Invited speaker for the Farmers Agricare Preplant (Voorsaai) held in 2025. Invited speaker at the Gordon Research Conferences Meeting of Mycotoxins and Phycotoxins, held in 2025.	
Collection of maize, wheat, soybean and sorghum from monoculture and conservation agriculture systems	Collected of maize, wheat, soybean and sorghum from monoculture and conservation agriculture systems	Single-spored cultures maintained in the culture collection of Dept. of Plant Pathology, SU.	NA
Isolation and identification of FGSC species	Isolated and identified the FGSC species	Curated database detailing FGSC species, locality sample obtained, crop rotation practised, tillage practised	NA
Chemotyping of FGSC species isolates	Chemotyped the FGSC species isolates	Curated database detailing FGSC species, chemotype as determined by PCR and/or in vitro	NA

		confirmation of ability to produce specific mycotoxin.	
Validation of FGSC species identification by MLGT.	Validated the FGSC species identification by multiple gene sequence phylogeny.	Curated database detailing FGSC species as determined by sequence phylogeny.	NA
Perform cross-pathogenicity and mycotoxin contamination by FGSC species from maize and other host crops	Conducted greenhouse and field-based cross-pathogenicity on wheat, maize, sorghum and soybean using FGSC isolates from the different crops	Excel datasheet with statistical analyses represented by graphs and figures indicating the pathogenicity and mycotoxigenic potential of FGSC species on different crops from which it was originally obtained from.	NA

5. Results, Tables, Figures (provide a concise summary of results supported by tables and/or figures as appropriate)

Objective 1: To determine the mycotoxin contamination by the *Fusarium graminearum* species complex (FGSC) on maize grain and its rotation crops in South Africa

The grain sampled in this project were found to be contaminated with mycotoxins. The mycotoxins detected in maize grain showed the presence of DON, ZEA, NIV as well as fumonisins (FUM) co-occurring across the two seasons ([Table 1](#)). The mycotoxin, ZEA, was the most abundant (83.3%) and was quantified in higher concentrations (129.1 – 129 494.9 ($\mu\text{g kg}^{-1}$) when compared to the other mycotoxins. Mycotoxins, DON (45.8%) and NIV (54.2%), produced by FGSC species, were the least frequent mycotoxin quantified in maize grain while 62.5% of samples were also contaminated by FUM. All wheat grain sampled during 2022 and 2023 seasons contained only DON at low concentrations with no NIV or ZEA detected ([Table 2](#)). All the grain samples of sorghum and soybean from the 2023 season contained detectable levels of ZEA only ([Table 3](#)).

Objective 2: To determine the species composition, cross-pathogenicity and mycotoxigenic potential of the *Fusarium graminearum* species complex (FGSC) isolated from maize and rotation crops

Sequence comparison of the TEF-1 α gene region of 47 isolates from maize (2020/2021); 36 from maize (2022/2023); 31 from wheat season 2022; 17 from wheat (2023); 39 from sorghum and 18 from soybean (2023) was performed to review the FGSC associated with these crops. The putative FGSC isolates were identified through GenBank and identified as one of the six previously identified FGSC species from South Africa ([Fig. 1](#)). *Fusarium meridionale* was the most frequently isolated complex species from maize sampled in 2022, maize and soybean sampled in 2023, but was not isolated from wheat or sorghum. *Fusarium boothii* was the most frequent on M23 maize, and was also isolated from wheat, sorghum, and soybean. *Fusarium graminearum* s.s. was the most abundant FGSC species isolated from wheat, but it was also isolated from maize, sorghum, and soybean. Three *F. graminearum* s.s. isolates were found on W23 wheat but is not illustrated. *Fusarium acacia-mearnsii* was the most frequently isolated complex species in sorghum seed and one isolate was found in maize. It was not isolated from wheat, soybeans or maize produced in 2023. *Fusarium cortaderiae* was only isolated from sorghum and was not isolated from maize, wheat or soybean.

The FGSC isolates from maize showed NIV as the most abundant chemotype for the 2021/22 season while a 15-ADON was the most abundant chemotype produced by FGSC isolates from the 2022/23 season ([Fig. 2](#)). The FGSC isolates obtained from wheat from both the 2022 and 2023 seasons showed the 15ADON chemotype as the most abundant. For FGSC isolates from sorghum from the 2023 season, the NIV chemotype was most abundantly observed in the multiplex PCR. Similarly, FGSC isolates from soybean sampled in 2023 showed that the NIV chemotype was the most abundant amongst the isolates evaluated.

Five FGSC species isolated from maize, wheat, sorghum and soybean seed were successfully re-inoculated onto these crops to test cross-pathogenicity. The FGSC species reproduced symptoms associated with diseases such as Gibberella ear rot (GER) of maize, Fusarium head blight (FHB) of wheat, Sorghum grain mould (SGM) and Fusarium root rot (FRR) of soybean ([Fig. 3](#)).

Cross-pathogenicity of FGSC isolates to cause GER of maize and SGM was successfully performed during the 2024/25 season under greenhouse conditions. The pathogenicity of FGSC isolates to cause soybean pod blight was not successful as no visual disease symptoms were observed for the duration of the experiment. The FGSC species *F. meridionale* and *F. boothii* produced the highest levels of ZEA in maize grain ([Fig. 4](#)). The highest level of DON quantified in maize grain was produced by *F. graminearum* s.s. and *F. boothii*, while the highest accumulation of NIV was produced by *F. meridionale*

and *F. acacia-mearnsii*. Apart from one *F. boothii* (S23-15) isolated, the occurrence of DON and NIV are not observed in high quantities together. In the sorghum grain, the NIV concentration was higher on average in grain inoculated with *F. meridionale* or *F. cortaderiae* treatments and more variable, while DON accumulation was higher in sorghum grain inoculated with *F. graminearum* s.s. and *F. boothii* (Fig. 5).

The maize field trial successfully tested the pathogenicity of FGSC species to cause GER (Table 4). The Sg23-02 (*F. cortaderiae*) treatment caused the greatest disease severity (33.8%), which was significantly greater than the control (water; 1.3%), natural (no treatment; 0%), wheat isolates W22-08 (*F. graminearum* s.s. ID; 0%), W2-922 (*F. graminearum* s.s.; 2.5%) and M22-22 (*F. graminearum* s.s.; 0%) treatments. The treatments Sg23-01 (*F. graminearum* s.s.; 103 798 $\mu\text{g kg}^{-1}$), M22-02 (73 830.8 $\mu\text{g kg}^{-1}$) and W22-21 (47 789 $\mu\text{g kg}^{-1}$) produced the greatest DON concentrations, significantly more than the water, natural, M22-22, Sg23-03 and Sg23-05 treatments. For NIV concentrations, treatments Sg23-04 (*F. acacia-mearnsii*; 5 953.3 $\mu\text{g kg}^{-1}$), M22-21 (4 541.8 $\mu\text{g kg}^{-1}$), Sg23-02 (5 347.8 $\mu\text{g kg}^{-1}$), M22-01 (4 235.3 $\mu\text{g kg}^{-1}$), S23-02 (2 105.0 $\mu\text{g kg}^{-1}$), Sg23-05 (1 977.3 $\mu\text{g kg}^{-1}$), Sg23-03 (1 077.8 $\mu\text{g kg}^{-1}$) and S23-04 (702.0 $\mu\text{g kg}^{-1}$) were significantly greater than the other treatments but did not differ significantly from each other. Treatments S23-15 (*F. boothii*; 6 481 $\mu\text{g kg}^{-1}$) and M22-02 (7 271.3 $\mu\text{g kg}^{-1}$) produced the highest ZEA concentration that was significantly more than the water (3.6 $\mu\text{g kg}^{-1}$), natural (4.1 $\mu\text{g kg}^{-1}$) and W2-922 (0.0 $\mu\text{g kg}^{-1}$) treatments. The natural treatment (658.7 $\mu\text{g kg}^{-1}$) had the highest levels of FUM and was significantly more than the other treatments, except for M22-22 (318.0 $\mu\text{g kg}^{-1}$) and M22-01 (189.9 $\mu\text{g kg}^{-1}$).

The ANOVA indicated a significant cultivar x year interaction when FGSC species were inoculated onto wheat heads under field conditions, thus the data is presented for each cultivar and year (Table 5 and Table 6). The treatment of M22-05 (*F. acacia-mearnsii*) had the highest disease severity, FDK score and DON contamination in cultivars SST0147 and SST8155 and was significantly greater than treatment Sg23-03 (*F. cortaderiae*) (Table 3.7). For the SST806 cultivar, the M22-23 (*F. graminearum* s.s.) treatment had the highest disease severity (75%) but was not significantly higher than any of the other treatments. The M22-23 inoculation also resulted in the highest FDK (45.3%) score and DON (2 861.8 $\mu\text{g kg}^{-1}$) contamination, which was significantly higher than the water control (4.3 $\mu\text{g kg}^{-1}$). Sg23-01 (*F. graminearum* s.s.) had the greatest NIV accumulation in SST0147 (2 328.1 $\mu\text{g kg}^{-1}$) and SST806 (9 376.7 $\mu\text{g kg}^{-1}$), while M22-04 (*F. meridionale*) produced the most NIV in cultivar SST8155 (15 990.6 $\mu\text{g kg}^{-1}$).

Table 1. Naturally infected maize samples from the 2021/22 season with levels of deoxynivalenol, zearalenone, nivalenol and fumonisins ($\mu\text{g kg}^{-1}$).

CROP	YEAR	LOCATION	DON	ZEA	NIV	FUM AV.
Maize	2021/22	KZN	ND	1 025.1	1 827.7	ND
Maize	2021/22	KZN	ND	129 494.9	424.9	287.9
Maize	2021/22	KZN	BLD	1 196.0	ND	ND
Maize	2021/22	KZN	1 339.7	34 249.8	ND	ND
Maize	2021/22	KZN	ND	1 311.8	ND	1 127.5
Maize	2021/22	KZN	ND	6 216.0	ND	ND
Maize	2021/22	KZN	BLD	1 433.7	ND	ND
Maize	2021/22	KZN	179.0	ND	ND	ND
Maize	2021/22	KZN	ND	ND	569.9	BDL
Maize	2021/22	KZN	ND	ND	554.1	ND
Maize	2021/22	KZN	219.3	ND	ND	ND
Maize	2021/22	KZN	ND	476.1	1 827.7	ND
Maize	2022/23	EC	ND	3 600.1	77.3	35.2
Maize	2022/23	EC	ND	4 268.3	390.9	110.6
Maize	2022/23	EC	105.0	5 628.4	152.6	219.7
Maize	2022/23	EC	ND	937.7	ND	32.8
Maize	2022/23	EC	552.5	12 091.6	273.2	408.0
Maize	2022/23	EC	BLD	6 267.7	ND	57.9
Maize	2022/23	EC	BLD	11 488.3	780.0	2 422.7
Maize	2022/23	EC	BLD	3 432.7	361.3	898.6
Maize	2022/23	EC	105.1	161.5	74.0	3 533.6
Maize	2022/23	EC	ND	129.1	ND	43.6
Maize	2022/23	EC	ND	192.1	ND	BDL
Maize	2022/23	EC	ND	8 097.0	334.9	659.1

DON – deoxynivalenol; NIV - nivalenol and ZEA - zearalenone given in $\mu\text{g kg}^{-1}$.

The limit of quantification of DON was $100 \mu\text{g kg}^{-1}$, $20 \mu\text{g kg}^{-1}$ for ZEA, NIV and FUM.

ND – not detected; BDL – below the detectable level

Table 2. Naturally infected wheat samples from the 2022 and 2023 seasons with deoxynivalenol, zearalenone, and nivalenol ($\mu\text{g kg}^{-1}$).

CROP	YEAR	LOCATION	DON	ZEA	NIV
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	149.5	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	157.1	ND	ND
Wheat	2022	NC	214.5	ND	ND
Wheat	2022	NC	143.4	ND	ND
Wheat	2022	NC	112.4	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2022	NC	BLD	ND	ND
Wheat	2023	FS	BLD	ND	ND
Wheat	2023	FS	BLD	ND	ND
Wheat	2023	FS	BLD	ND	ND
Wheat	2023	FS	170.6	ND	ND
Wheat	2023	FS	BLD	ND	ND

DON – deoxynivalenol; NIV - nivalenol and ZEA - zearalenone given in $\mu\text{g kg}^{-1}$.

The limit of quantification of DON was $100 \mu\text{g kg}^{-1}$, $20 \mu\text{g kg}^{-1}$ for ZEA and NIV.

ND – not detected; BDL – below the detectable level

FS – Free State; NC – Northern Cape.

Table 3. Naturally infected sorghum and soybean samples from the 2023 season deoxynivalenol, zearalenone and nivalenol ($\mu\text{g kg}^{-1}$).

CROP	YEAR	LOCATION	DON	ZEA	NIV
Sorghum	2023	EC	ND	119.5	ND
Sorghum	2023	EC	ND	381.3	ND
Sorghum	2023	EC	ND	4 747.9	ND
Soybean	2023	EC	ND	248.0	ND
Soybean	2023	EC	ND	557.0	ND

DON – deoxynivalenol; NIV - nivalenol and ZEA - zearalenone given in $\mu\text{g kg}^{-1}$.

The limit of quantification of DON was $100 \mu\text{g kg}^{-1}$, $20 \mu\text{g kg}^{-1}$ for ZEA and NIV.

ND – not detected; BDL – below the detectable level

EC – Eastern Cape.

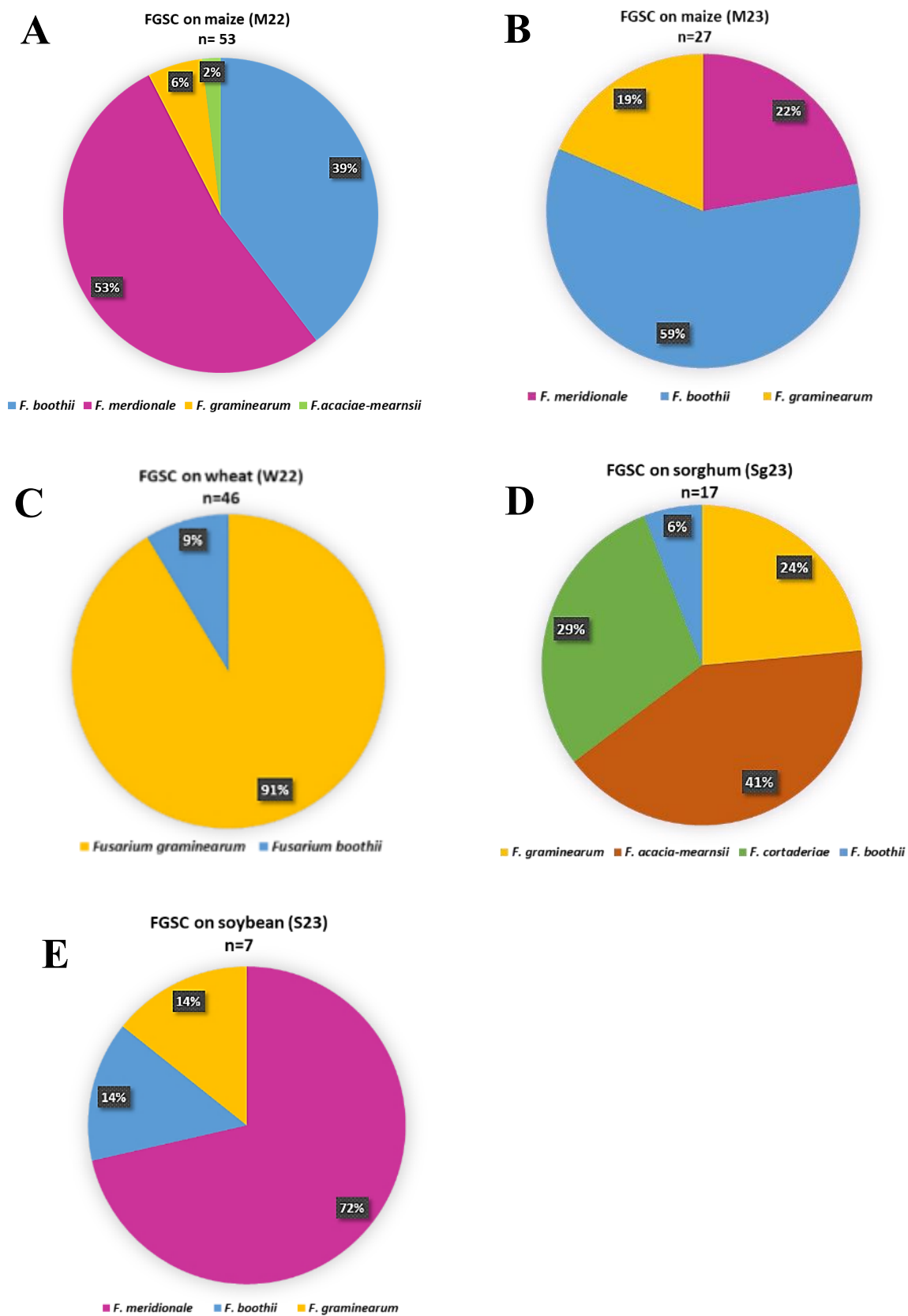


Figure 1. The *Fusarium graminearum* species complex (FGSC) species identified from **A.** and **B.** maize, **C.** wheat, **D.** sorghum and **E.** soybean grain identified for the 2021/22 and 2022/23 seasons.

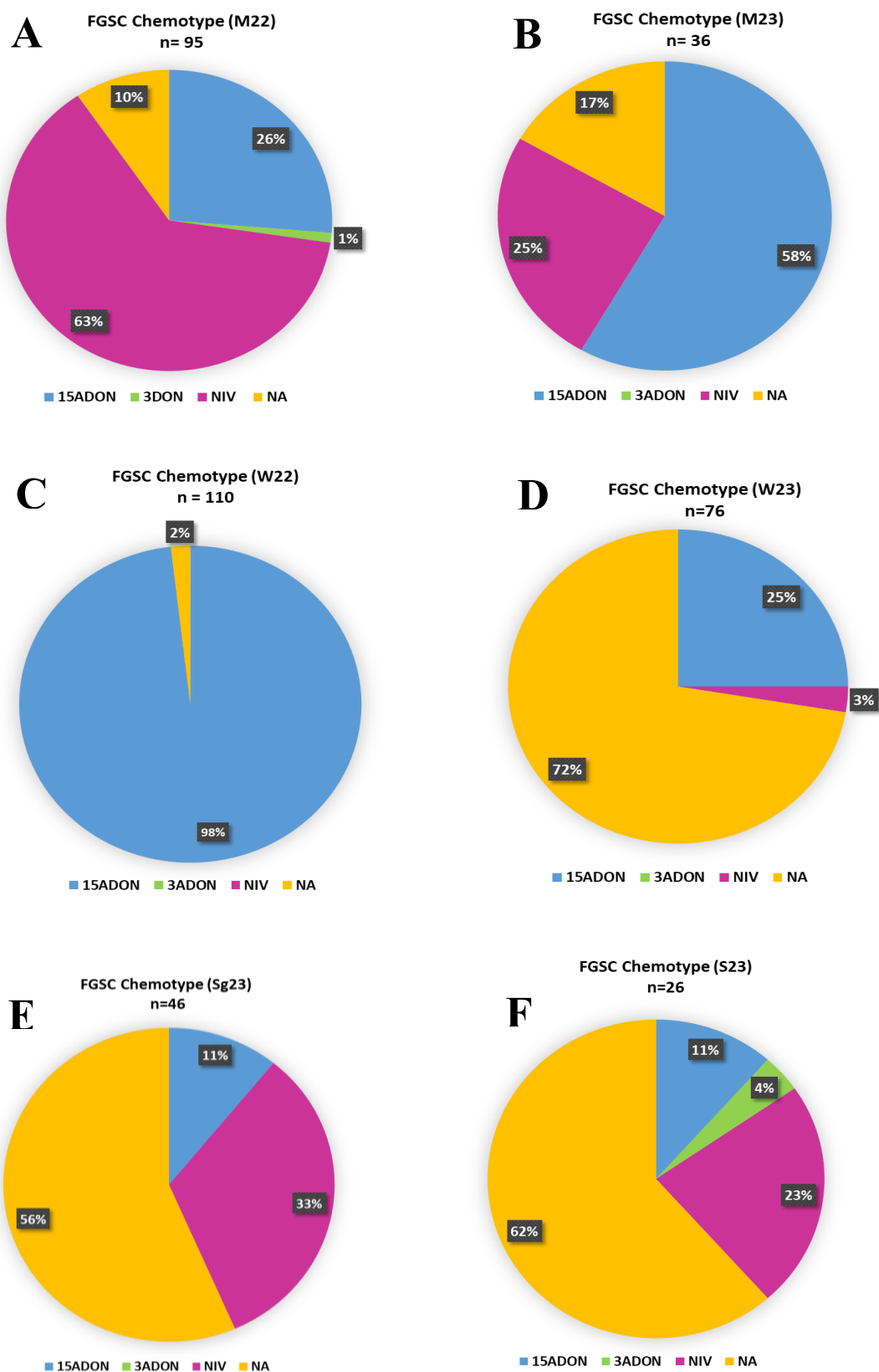
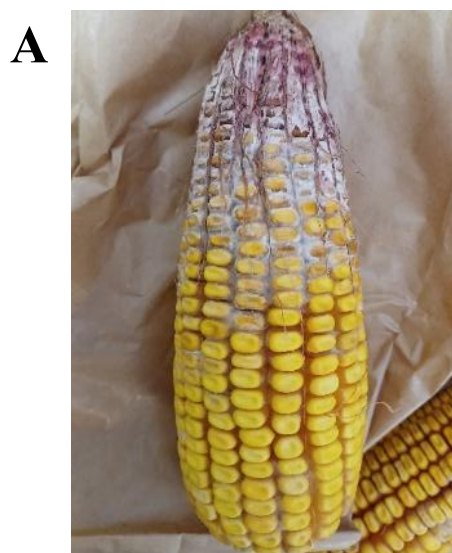


Figure 2. The mycotoxin chemotype profiles for 15-acetyl-deoxynivalenol (15ADON), 3-acetyl-deoxynivalenol (3ADON) and nivalenol (NIV) of putative *Fusarium graminearum* species complex (FGSC) isolates from maize (A & B), wheat (C & D) sorghum (E) and soybean (F).



S23-14 *Fusarium meridionale*



Sg23-01 *Fusarium graminearum* s.s.



M0100 *Fusarium boothii*



S23-05 *Fusarium meridionale*

Figure 3. Disease symptoms caused by *Fusarium graminearum* species complex species on various crops. **A.** Gibberella ear rot of maize caused by *F. meridionale* from soybean. **B.** Fusarium head blight of wheat caused by *F. graminearum* s.s. from sorghum. **C.** Sorghum grain mould caused by *F. boothii* from maize. **D.** Fusarium root rot of soybean caused by *F. meridionale* from soybean.

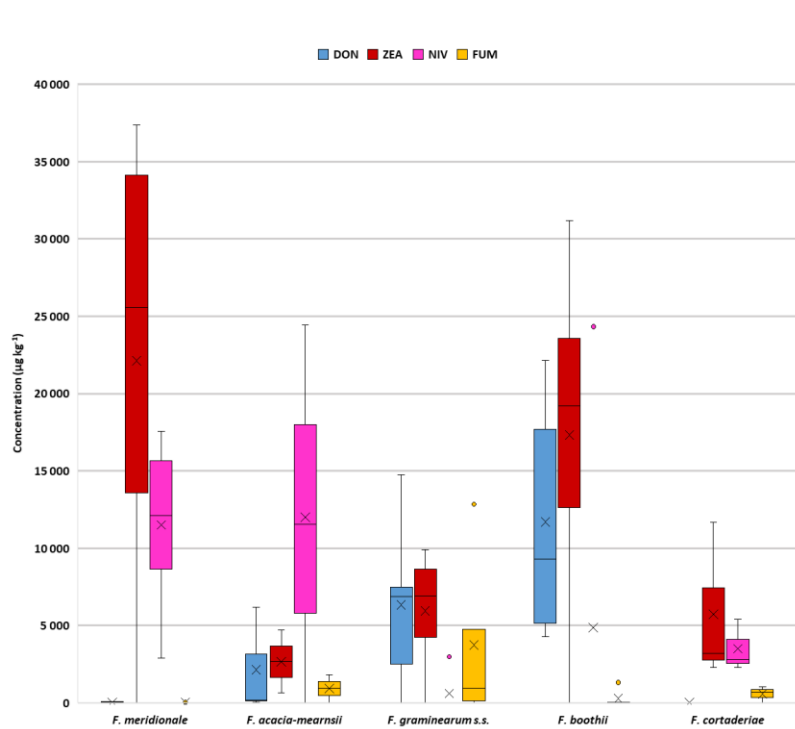


Figure 4. The distribution of mycotoxin accumulation in maize grain for deoxynivalenol (DON), nivalenol (NIV), zearalenone (ZEA) and fumonisins (FUM) is shown resulting from inoculation with five *Fusarium graminearum* species complex species.

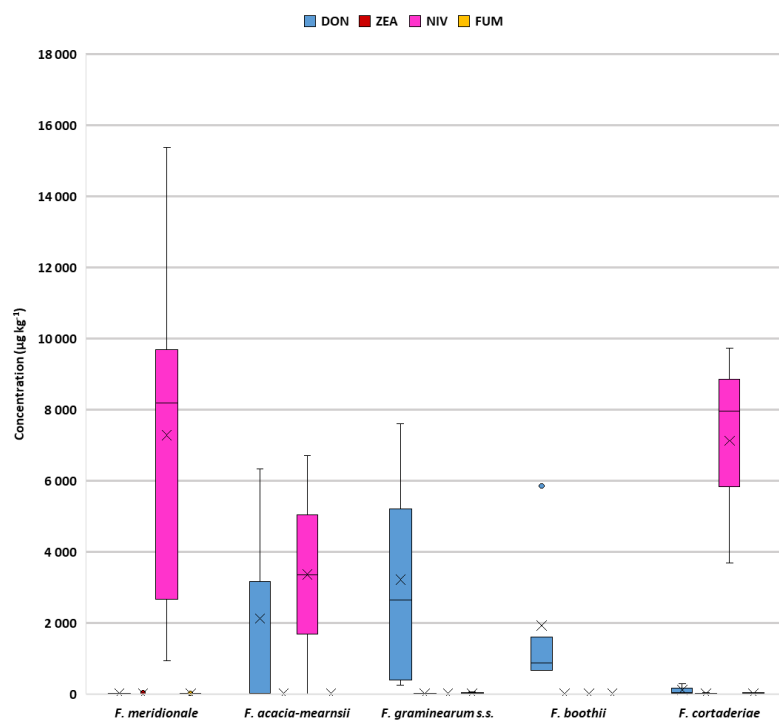


Figure 5. The distribution of mycotoxin accumulation in sorghum grain for deoxynivalenol (DON), nivalenol (NIV), zearalenone (ZEA) and fumonisins (FUM) is shown resulting from inoculation with five *Fusarium graminearum* species complex species.

Table 4. The disease severity and mycotoxin contamination of maize grain inoculated with species within the *Fusarium graminearum* species complex under field conditions during the 2024/25 season.

TREATMENT	SPECIES	DISEASE SEVERITY %	DON	NIV	ZEA
M0100	<i>F. boothii</i>	21.3 a-c	36 329.4 ab	0.0 b	3 659.0 a-c
M22-01	<i>F. meridionale</i>	22.5 a-c	293.0 de	4 235.3 a	666.0 a-c
M22-02	<i>F. boothii</i>	21.3 a-c	73 830.8 a	0.0 b	7 271.3 a
M22-05	<i>F. acacia-mearnsii</i>	5.0 a-d	72 885.1 ab	32.5 b	1 891 a-c
M22-21	<i>F. meridionale</i>	13.8 a-d	7 374.5 a-d	4 541.8 a	1 261.3 a-c
M22-22	<i>F. graminearum s.s.</i>	0.0 d	0.0 e	0.0 b	169.5 a-c
NATURAL	-	0.0 d	0.0 e	0.0 b	0.0 bc
S23-02	<i>F. meridionale</i>	21.3 a-c	283.5 c-e	2105.0 a	2 003.7 a-c
S23-03	<i>F. graminearum s.s.</i>	27.5 a-c	50 018.5 ab	50.8 b	4 272.8 ab
S23-04	<i>F. meridionale</i>	6.3 a-d	171.5 de	702.0 a	261.8 a-c
S23-15	<i>F. boothii</i>	17.5 a-d	50 799.7 ab	0.0 b	6 481.0 a
SG23-01	<i>F. graminearum s.s.</i>	27.5 a-c	103 798.0 a	0.0 b	860.7 a-c
SG23-02	<i>F. cortaderiae</i>	33.8 a	717.0 b-e	5 347.8 a	6 296.1 a-c
SG23-03	<i>F. cortaderiae</i>	8.8 a-d	0.0 e	1 077.8 a	2 763.8 a-c
SG23-04	<i>F. acacia-mearnsii</i>	32.5 ab	233.4 de	5 853.3 a	633.4 a-c
SG23-05	<i>F. acacia-mearnsii</i>	15.0 a-d	0.0 e	1 977.3 a	1 523 a-c
W2-922	<i>F. graminearum s.s.</i>	2.5 b-d	848.0 de	0.0 b	0.0 c
W22-08	<i>F. graminearum s.s.</i>	0.0 d	3 846.8 a-d	0.0 b	435.9 a-c
W22-11	<i>F. boothii</i>	25.0 a-c	53 781.9 ab	0.0 b	4 191.8 ab
W22-15	<i>F. boothii</i>	16.3 a-d	31 825.2 a-c	0.0 b	2 725.6 a-c
W22-21	<i>F. graminearum s.s.</i>	25.0 ab	47 789.0 a	0.0 b	865.8 a-c
WATER	-	1.3 cd	0.0 e	0.0 b	0.0 bc

DON – deoxynivalenol; NIV - nivalenol and ZEA - zearalenone given in $\mu\text{g kg}^{-1}$.

Disease severity%: 0-10 scale. 0=0%; 1=1-10%; 2=11-20%;3=21-30% ... 10=91-100%.

Mean represents the average of 4 (n=4) replications of 4 independent experimental units per treatment.

The limit of quantification of DON was $100 \mu\text{g kg}^{-1}$, $20 \mu\text{g kg}^{-1}$ for ZEA and NIV.

ND – not detected; BDL – below the detectable level. Values below detectable limits included for statistical analyses.

Table 5. Mean disease severity, percentage Fusarium-damaged kernels and mycotoxins deoxynivalenol and nivalenol content in wheat grain inoculated with various species within the *Fusarium graminearum* species complex in the 2023 season.

CULTIVAR	DISEASE SEVERITY %			FDK %			DON			NIV		
	SST0147	SST806	SST8155	SST0147	SST806	SST8155	SST0147	SST806	SST8155	SST0147	SST806	SST8155
TREATMENT												
M22-01	29.2 c-e	37.5 a	41.7 ab	26.7 b-d	36.7 a-c	38.67 a	28.3 cd	12.8 ef	10.7 b-d	36 349.3 ab	25 207.5ab	11 410.9 a
M22-02	41.7 a-d	54.2 a	54.2 ab	36.7 ab	31.3 a-c	37.33 a	2 555.8 a-c	1 356.1 a-c	691.1 ab	0.0 d	0.0 c	0.0 b
M22-04	9.2 de	45.8 a	37.5 ab	21.3 cd	28.7 a-c	39.33 a	36.4 cd	6.2 ef	32.7 b-d	25 455.7 a-d	12 904.1 ab	15 990.6 a
M22-05	75.0 a	68.8 a	83.3 a	50.7 a	44.0 ab	49.33 a	19 809.8 a	7 303.8 a	5 081.3 a	2 223.6 a-c	0.0 c	0.0 b
M22-09	20.8 de	66.7 a	45.8 ab	27.3 b-d	31.3 a-c	39.33 a	18.1 d	54.8 d-f	5.7 b-d	21 700.1 a-c	14 357.3 ab	7 881.2 a
M22-22	41.7 a-d	20.8 a	41.7 ab	30.7 bc	28.0 a-c	42.67 a	5 566.9 ab	1 218.1 a-d	550.3 a-d	652.9 cd	0.0 c	0.0 b
M22-23	37.5 c-e	75.0 a	45.8 ab	30.7 bc	45.3 a	42.00 a	3 184.1 a-d	2 861.8 ab	470.4 a-d	0.0 d	0.0 c	0.0 b
M22-24	9.2 de	33.3 a	50.0 ab	25.3 b-d	22.7 c	42.00 a	40.3 b-d	30.9 d-f	8.7 b-d	0.0 d	0.0 c	0.0 b
M22-35	13.3 de	41.7 a	50.0 ab	28.0 b-d	24.7 bc	36.00 a	234.2 a-d	255.7 b-e	83.9 a-d	0.0 d	0.0 c	0.0 b
M9	58.3 a-c	50.0 a	66.7 ab	26.7 b-d	37.3 a-c	38.67 a	1 521.8 a-d	868.9 a-d	502.7 a-c	0.0 d	0.0 c	0.0 b
S23-01	5.8 de	33.3 a	45.8 ab	20.7 cd	32.7 a-c	39.33 a	80.9 a-d	61.5 c-f	101.9 a-d	2 328.1 b-d	9 376.7 b	7 114.6 a
S23-02	9.2 de	50.0 a	25.0 b	22.7 b-d	29.3 a-c	43.33 a	114.6 a-d	17.7 ef	48.4 b-d	0.0 d	0.0 c	0.0 b
S23-03	13.3 de	41.7 a	37.5 ab	24.7 b-d	30.7 a-c	36.00 a	7.7 d	89.3 c-f	9.8 b-d	0.0 d	0.0 c	0.0 b
SG23-01	25.0 c-e	70.8 a	58.3 ab	32.7 bc	38.7 a-c	40.00 a	14.7 cd	100.1 c-f	4.0 d	52 581.5 a	27 620.7 a	10 424.9 a
SG23-02	13.5 de	41.7 a	45.8 ab	22.0 cd	31.3 a-c	42.00 a	103.0 cd	18.9 ef	36.1 b-d	575.6 cd	0.0 c	0.0 b
SG23-03	2.5 e	16.7 a	29.2 b	22.7 b-d	26.0 a-c	39.33 a	90.2 b-d	277.9 b-e	128.5 a-d	0.0 d	0.0 c	0.0 b
WATER	66.7 ab	63.3 a	51.7 ab	14.8 d	24.4 bc	7.30 b	8.3 d	4.3 f	18.1 cd	-	-	-

FDK% - percentage of Fusarium-damaged kernels; DON – deoxynivalenol; NIV – nivalenol ($\mu\text{g kg}^{-1}$).

The percentage of wheat heads covered with visual symptoms, PFDK or mycotoxins as determined by the mean of three trial replicates.

Means followed by the same alphabetical letter in each column are not significantly different according to the Tukey significant test ($p = > 0.05$).

The limit of quantification of DON was $100 \mu\text{g kg}^{-1}$, $20 \mu\text{g kg}^{-1}$ for ZEA and NIV.

ND – not detected; BDL – below the detectable level. Values below detectable limits included for statistical analyses.

Table 6. Mean disease severity, percentage Fusarium-damaged kernels and mycotoxins deoxynivalenol and nivalenol content in wheat grain inoculated with various species within the *Fusarium graminearum* species complex during the 2024 production season.

CULTIVAR TREATMENT	SPECIES ID	DISEASE SEVERITY %		FDK %		DON		NIV	
		SST0147	SST087	SST0147	SST087	SST0147	SST087	SST0147	SST087
M22-02	<i>F. boothii</i>	1.9 de	0.0 c	30.0 b-e	32.7 a-c	0.0 d	40.6 cd	0.0 c	0.0 c
M22-04	<i>F. meridionale</i>	2.5 c-e	1.3 c	23.2 e	27.6 bc	5.6 cd	60.7 b-d	1 425.0 ab	591.7 ab
M22-05	<i>F. acacia-mearnsii</i>	2.5 c-e	0.0 c	36.0 a-d	24.5 bc	3 644.5 a	65.6 cd	0.0 c	0.0 c
M22-08	<i>F. meridionale</i>	2.5 c-e	0.0 c	30.5 b-e	32.0 a-c	112.2 cd	0.0 d	1 925.8 ab	0.0 c
M22-22	<i>F. graminearum s.s.</i>	22.5 ab	1.3 c	40.5 ab	18.5 c	1 943.1 a	186.4 a-d	0.0 c	142.7 bc
S23-01	<i>F. meridionale</i>	50.0 a	18.8 a	44.0 a	44.6 a	4 236.3 a	3 956.8 a	0.0 c	0.0 c
S23-02	<i>F. meridionale</i>	2.5 c-e	1.3 c	23.0 e	27.0 bc	361.1 a-c	53.3 b-d	909.5 ab	1 369.6 ab
S23-03	<i>F. graminearum s.s.</i>	11.3 b-e	2.5 bc	29.0 b-e	31.4 a-c	2 098.4 a	1 220.1 ab	0.0 c	0.0 c
S23-04	<i>F. acacia-mearnsii</i>	2.5 c-e	0.0 c	31.5 b-e	24.5 bc	108.9 b-d	39.7 cd	74.7 c	0.0 c
SG23-01	<i>F. graminearum s.s.</i>	46.9 a	10.0 ab	38.7 a-c	40.0 ab	0.0 d	3 643.2 a	0.0 c	0.0 c
SG23-02	<i>F. cortaderiae</i>	1.3 e	0.6 c	27.5 c-e	33.0 a-c	8.4 cd	9.9 cd	460.1 b	739.3 a-c
SG23-03	<i>F. cortaderiae</i>	13.1 a-d	0.6 c	33.5 a-e	30.5 a-c	0.0 d	0.0 d	1 824.8 ab	1 061.9 a
SG23-05	<i>F. acacia-mearnsii</i>	7.5 b-e	1.9 bc	30.5 b-e	31.0 a-c	66.0 cd	4.4 cd	3 689.9 a	3 315.1 a
SG23-08	<i>F. acacia-mearnsii</i>	5.0 b-e	3.8 bc	31.5 b-e	29.0 a-c	24.0 b-d	4.2 cd	2 691.9 ab	1 630.8 a-c
W22-02	<i>F. graminearum s.s.</i>	12.5 a-c	0.6 c	25.0 de	19.6 c	4 358.3 a	211.4 b-d	0.0 c	0.0 c
W22-11	<i>F. boothii</i>	2.5 c-e	2.5 bc	25.4 de	29.2 a-c	569.7 ab	305.7 a-c	0.0 c	0.0 c

FDK% - percentage of Fusarium-damaged kernels; DON – deoxynivalenol; NIV – nivalenol ($\mu\text{g kg}^{-1}$).

The percentage of wheat heads covered with visual symptoms, PFDK or mycotoxins as determined by the mean of three trial replicates.

Means followed by the same alphabetical letter in each column are not significantly different according to the Tukey significant test ($p > 0.05$).

The limit of quantification of DON was $100 \mu\text{g kg}^{-1}$, $20 \mu\text{g kg}^{-1}$ for ZEA and NIV.

ND – not detected; BDL – below the detectable level. Values below detectable limits included for statistical analyses.

6. Discussion (provide a detailed discussion of project outcomes in terms of the original hypothesis, results obtained, existing knowledge, and impact on the maize industry)

The results of the study showed the extent of mycotoxin contamination by FGSC on maize as well as rotation crops. Multi-mycotoxin contamination was observed over a two-year period with DON and ZEA being the amount frequently detected and abundant mycotoxins measured in maize, wheat and sorghum.

Significant differences in disease severity and mycotoxin contamination of maize, wheat and sorghum grain by individual isolates of FGSC were observed. The isolates most pathogenic and toxigenic to maize were representatives of *F. cortaderiae* that exhibited the highest disease severity and second highest NIV and ZEA contamination while the greatest ZEA and DON contamination was due to *F. boothii* and the greatest NIV contamination of maize grain was produced by *F. acacia-mearnsii*. The results of the study demonstrate the pathogenic potential of various FGSC species to cause Gibberella ear rot and produce high levels of mycotoxins in maize grain under high disease pressure. Boutigny et al. (2011) found *F. boothii* to be the predominant FGSC species associated with South African maize while Beukes et al. (2017) also determined the ability of various FGSC species from wheat and sorghum to cause GER and produce mycotoxins in maize, although *F. boothii* was found to be the most aggressive FGSC species on maize ears. The pathogenicity and mycotoxin deposition by *F. cortaderiae* and *F. acacia-mearnsii* was interesting as these species have not been isolated from maize grain before. They are, however, prolific on sorghum and could pose a significant threat to producers who grow maize close to or in rotation with each other.

Fusarium acacia-mearnsii was the only species to cause significantly more disease on sorghum grain when compared to other FGSC species. The NIV and ZEA contamination of sorghum grain was very low with *F. boothii* and *F. graminearum* s.s. isolates producing the highest concentration of these mycotoxins. These results were underwhelming considering the aggressive ability of *F. cortaderiae* to produce NIV and ZEA in maize grain but did not produce significant quantities in sorghum, despite being evaluated in the same trial under the same production conditions. The sorghum cultivars used in this study have not previously been evaluated for response to FGSC species and may be limiting the extent of mycotoxin accumulation. tolerant of infection by these pathogens. This is supported by the higher mycotoxin contamination measured in sorghum when evaluated in the tunnel trial using a different cultivar. However, the environmental conditions of tunnel vs. field could also be responsible for this difference, as the field trial experienced less humidity and higher UV. Although mycotoxin contamination of sorghum grain was low, physical damage/loss of kernels was apparent and could cause severe crop losses for producers.

In this study, significant differences in disease parameters and mycotoxin contamination of wheat grain by individual isolates of FGSC were observed across two years of evaluation. *Fusarium acacia-mearnsii* was the most aggressive FGSC species on newly developed wheat cultivars SST0147 and SST8155 while *F. graminearum* s.s. was the most aggressive on SST806, an older cultivar. A previous study found *F. boothii* to have the highest disease severity of FHB, *F. graminearum* s.s. to produce the highest DON and *F. acacia-mearnsii* to produce the highest NIV in wheat (Beukes et al. 2017). With regards to NIV in this study, Sg23-01 (*F. graminearum* s.s.) was dominant in SST0147 and SST806, while *F. meridionale* was dominant in SST8155. Although, *F. graminearum* s.s. cannot produce NIV, thus it must have been contaminated with another NIV producer. Two isolates from maize that aren't very abundant on wheat in South Africa have shown high pathogenicity. This is a concern for producers who grow wheat near or in rotation with maize. The analysis did not return significant ZEA readings

although all the species tested were prominent ZEA producers in the maize trial. ZEA is a more environmentally sensitive compound, that requires high moisture and late harvest to accumulate significantly (Moraes *et al.* 2023). Yu *et al.* (2022) also points out that ZEA detection in wheat may be low because of masked ZEA (α -ZOL, β -ZOL, zearalenone-4/14/16-glucoside and zearalenone-4/14-sulfate) incidence not being searched for.

Data for FGSC species on soybean in South Africa is limited, and although we can be sure FGSC does occur, updated identification and pathogenicity tests are necessary. From the greenhouse trial, mycotoxin accumulation in soybean was low. This was likely because the inoculation for pod blight was not successful. Although, Chiotta *et al.* (2016) found successful FGSC pathogenicity on pods and the seeds within and attributed it to the FGSC being able to take advantage of damaged pod tissue. The mycotoxins detected here may have been from slight residual pathogen infection or from systemic infection originating with the seed. Nonetheless, DON and NIV were present but contrasting to Chiotta *et al.* (2016), where they did not detect NIV from NIV-producing FGSC species. ZEA is often not detected in soybean; a reason for this is the stark difference in chemical composition of soybean to other cereals, including a much higher protein content (El-Shemy 2013). Alternatively, to sorghum and maize, there does not appear to be the same species-specific mycotoxin profile; *F. meridionale* produced DON along with NIV and *F. boothii* and *F. graminearum* s.s. produced NIV along with DON, and neither produced ZEA.

7. Scientific Outputs *(give full references and indicate poster or oral presentation for conference contributions)*

Scientific papers:	A manuscript is currently being finalised for submission to South African Journal of Plant and Soil entitled “<i>Fusarium graminearum</i> species complex associated with wheat and maize grain produced in rotation in South Africa”. A second manuscript is also in preparation for Plant Pathology entitled “Cross-pathogenicity of species within the <i>Fusarium graminearum</i> species complex obtained from different field crops produced in South Africa.”
Technical reports:	4 MT progress reports, 3 WCDA progress reports
Articles in industry magazines:	Van Coller, G.J. and Rose, L.J. 2023. Drie maal skade as <i>Fusarium</i> toeslaan (Deel 1). GraanSA, 31 Augustus 2023. https://sagrainmag.co.za/2023/08/31/drie-maal-skade-as-fusarium-toeslaan/ Van Coller, G.J. and Rose, L.J. 2023. <i>Fusarium</i>-aarskroei: Beter beheer deur oesreste te verminder (Deel 2). GraanSA, 06 November 2023. https://sagrainmag.co.za/2023/11/06/fusarium-aarskroei-beter-beheer-deur-oesreste-te-verminder/ Van Coller, G.J. and Rose, L.J. 2023. <i>Fusarium</i>-aarskroei: Kultivarweerstand en swamdoders ’n wenspan (Deel 3). GraanSA, 13 Desember 2023. https://sagrainmag.co.za/2023/12/13/fusarium-aarskroei-kultivarweerstand-en-swamdoders-n-wenspan/

Conference contributions:	Kirsty Potgieter, Lindy Rose, Gert van Coller and Altus Viljoen. 2026. Cross-pathogenicity of species within the <i>Fusarium graminearum</i> species complex obtained from different field crops produced in South Africa. 54th Southern African Plant Pathology Congress. Umhlanga, 18-22 January 2026. (Oral). Rose, L.J., Janse van Rensburg, B. and Viljoen, A. 2025. Safeguarding and future-proofing South African grains against mycotoxins. National Grain Research Program Annual Research Day, Northwest University, 18-20 March 2025. (Oral). Rose, L.J. Van Coller, G.J., Janse van Rensburg, B., Potgieter, K. and Viljoen, A. 2025. Managing mycotoxins in South African grain: ‘‘A continuously moving target’’. Gordon Research Conferences Meeting of Mycotoxins and Phycotoxins, Stonehill College in Easton, Massachusetts United States, 15-20 June 2025. (Invited speaker). Rose, L.J., Van Coller, G.J., Shaikh, A., Flett, B.C., Janse van Rensburg, B. and Viljoen, A. 2025. Sustainable mycotoxin management: Leveraging plant resistance knowledge. 7th International Conference of Mycotoxicology and Food Security, Hangzhou, China, 17-20 November 2025. (Invited speaker). KH Potgieter, Dr B Janse van Rensburg, Dr G Van Coller and Dr LJ Rose. 2024. <i>Fusarium graminearum</i> species complex associated with maize and wheat grain. 53rd Southern African Plant Pathology Congress. Golden Gate Park, 21-25 January 2024. (Poster presentation). L. J. Rose. 2024. Sustainable plant health – what does it look like and how can we achieve it? 15th Congress of the South African Plant Breeders Association, Monte Bello Estate Bloemfontein, Free State, 11 – 13 March. (Keynote address)
Human capacity development:	1 Final year BScAgric student graduated in 2023. 1 MSc student graduated with distinction in 2025.
Technology transfer:	N/A
Other outputs (Procedures, Methods, Databases, etc):	Culture collection of <i>Fusarium graminearum</i> species complex species from maize, wheat, sorghum and soybean including all metadata with GPS coordinates and information on production practises. Methods for the disease response assessment of soybean and sorghum under greenhouse conditions. Method for rating response to disease on soybean and sorghum.

8. Personnel / Management / Risk factors that influenced progress and lessons learned *(if applicable)*

The project afforded the interaction with many researchers and industry persons from different institutions and companies that really provided sound advice and guidance on the execution of the project. Due to the nature of the project, it was particularly enriching to interact with researchers working on the other host crops including Dr Lisa Rothmann (UFS) and researchers at Fort Hare University, Eastern Cape.

9. Conclusions and Comments you wish to share with the Trust

I would like to thank the MT for this project funding (for the maize portion of this project) and for the opportunity to connect with researchers on other cereal and oilseed crops to complement and help provide comprehensive information on this pathogen group on its host crops. Thanks to the WCDA and NRF for funding the wheat portion of the research and to Dr Rothmann for support with the sorghum and soybean section (samples and/or cultures with information) of the project.

10 Signatures of Project Leader and Authorized Manager



Lindy Joy Rose
Names

Stellenbosch
Place

30 June 2026
Date