

**Table of contents**

Table of contents	iii
List of abbreviations	vii
Chapter I	
General introduction	1
1.1 Background	1
1.2 Pearl millet in Sudan	2
1.3 General challenges in pearl millet breeding	2
1.4 Pearl millet genetic diversity	3
1.5 Molecular marker technology	4
1.6 Pattern of genotype by environment interaction	5
1.7 Nutrition deficiency and biofortification	7
1.8 Research objectives	8
1.9 References	9
Chapter II	
Characterization of Sudanese pearl millet germplasm for agro-morphological traits and grain nutritional values	15
2.1 Abstract	15
2.2 Introduction	16
2.3 Materials and Methods	17
2.3.1 Field trials	17
2.3.2 Data collected	18
2.3.2.1 Agro-morphological traits	18
2.3.2.2 Nutritional traits	18
2.3.3 Statistical analysis	19
2.4 Results	20
2.4.1 Agro-morphological diversity	20
2.4.2 Variability in grain mineral nutrient contents	20
2.4.3 Frequency distributions	20
2.4.4 Coefficients of correlation	20
2.4.5 Variation among high-nutrient accessions	23
2.4.6 Geographic differentiation	24



2.4.7	Cluster analysis	25	
2.5	Discussion	27	
2.5.1	Extent of pearl millet agro-morphological diversity in Sudan compared to other studies	27	
2.5.2	Variability of Sudanese pearl millets for grain nutrient content compared with other studies	27	
2.5.3	Exploitation of trait relations in pearl millet improvement	30	
2.5.4	Geographic differentiation of pearl millet in Sudan	31	
2.5.5	Prospects for using the observed genetic diversity in pearl millet breeding	31	
2.6	Conclusions	32	
2.7	References	32	
Chapter III			
Genetic diversity of Sudanese pearl millet (<i>Pennisetum glaucum</i> (L.) R. Br.) landraces as revealed by SSR markers, and relationship between genetic and agro-morphological diversity.....			39
3.1	Abstract	39	
3.2	Introduction	40	
3.3	Materials and Methods	41	
3.3.1	Plant materials	41	
3.3.2	Genomic DNA extraction	42	
3.3.3	Genotyping by SSR markers	42	
3.3.4	Analysis of diversity	42	
3.3.5	Analysis of molecular variance and population structure	43	
3.3.6	Molecular and morphological diversity relationship	44	
3.4	Results	44	
3.4.1	Overall genetic diversity	44	
3.4.2	Regional genetic diversity	44	
3.4.3	AMOVA and genetic structure of the Sudanese pearl millets	46	
3.4.4	Principal component and phylogeny analyses	48	
3.5	Discussion	49	
3.5.1	Genetic diversity of pearl millet in Sudan	49	
3.5.2	Regional genetic diversity	51	



3.5.3	Implications of the diversity observed in pearl millet breeding	52	
3.6	Conclusions	54	
3.7	References	55	
Chapter IV			
Patterns of pearl millet genotype-by-environment interaction for yield performance and grain iron (Fe) and zinc (Zn) concentrations in Sudan			61
4.1	Abstract	61	
4.2	Introduction	62	
4.3	Materials and Methods	63	
4.3.1	Field evaluation and nutritional analysis	63	
4.3.2	Data analysis	65	
4.3.2.1	Location-wise and combined analysis across environments	65	
4.3.2.2	Relevance of environmental factors explaining G×E interaction	66	
4.3.2.3	Analysis of G×E interaction patterns and yield stability	67	
4.3.2.4	Parametric and nonparametric stability parameters	67	
4.4	Results	68	
4.4.1	Environmental means and variance components	68	
4.4.2	Correlations between grain yield and other traits within the different environments	69	
4.4.3	Environmental characteristics underlying G×E interaction	69	
4.4.4	Analysis of variance for AMMI	71	
4.4.5	Genotypic stability analysis based on AMMI	72	
4.4.6	Mega-environment and successful genotypes identification using GGE biplots ..	73	
4.4.7	Univariate stability measurement	75	
4.4.8	Rank correlations among estimated stability parameters	75	
4.4.9	Relationship between agro-morphological traits and yield stability parameters	77	
4.5	Discussion	77	
4.5.1	Opportunity to select for specific adaptation to irrigated environments in Sudan	77	
4.5.2	Need to select for yield stability in rainfed environments of Sudan	78	
4.5.3	Prospects for combining yield performance with high grain mineral concentrations	81	
4.5.4	Association among the yield stability parameters	81	



4.6	Conclusions	82
4.7	References	82
Chapter V		
	General discussion	87
5.1	Phenotypic diversity in pearl millet landraces	87
5.2	Variability of pearl millet's grain nutrient content	88
5.3	Genetic diversity and population structure	90
5.4	Pattern of genotype by environment interaction	91
5.5	General conclusion	92
5.6	References	94
6	Summary	99
7	Zusammenfassung	102
8	Appendices	107
9	Acknowledgements	123
10	Curriculum vitae	125
11	Erklärung	126