Phenotypic and QTL Analysis of the BT Population in Ghana

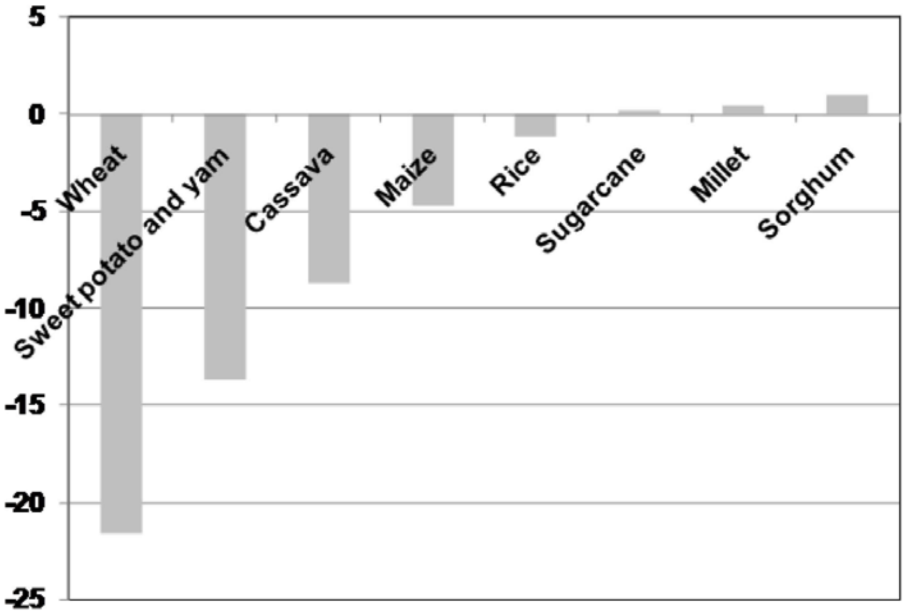
17th Sweetpotato Breeders'meeting June 7th, 2018

Obaiya Utoblo, Daniel Akansake, Isaac Dorgbetor, John Saaka, Jolien Swanckaert, Edward Carey, Dorcus Gemenet

Supervisor :Dr.E.Carey

How does drought affect sweetpotato?

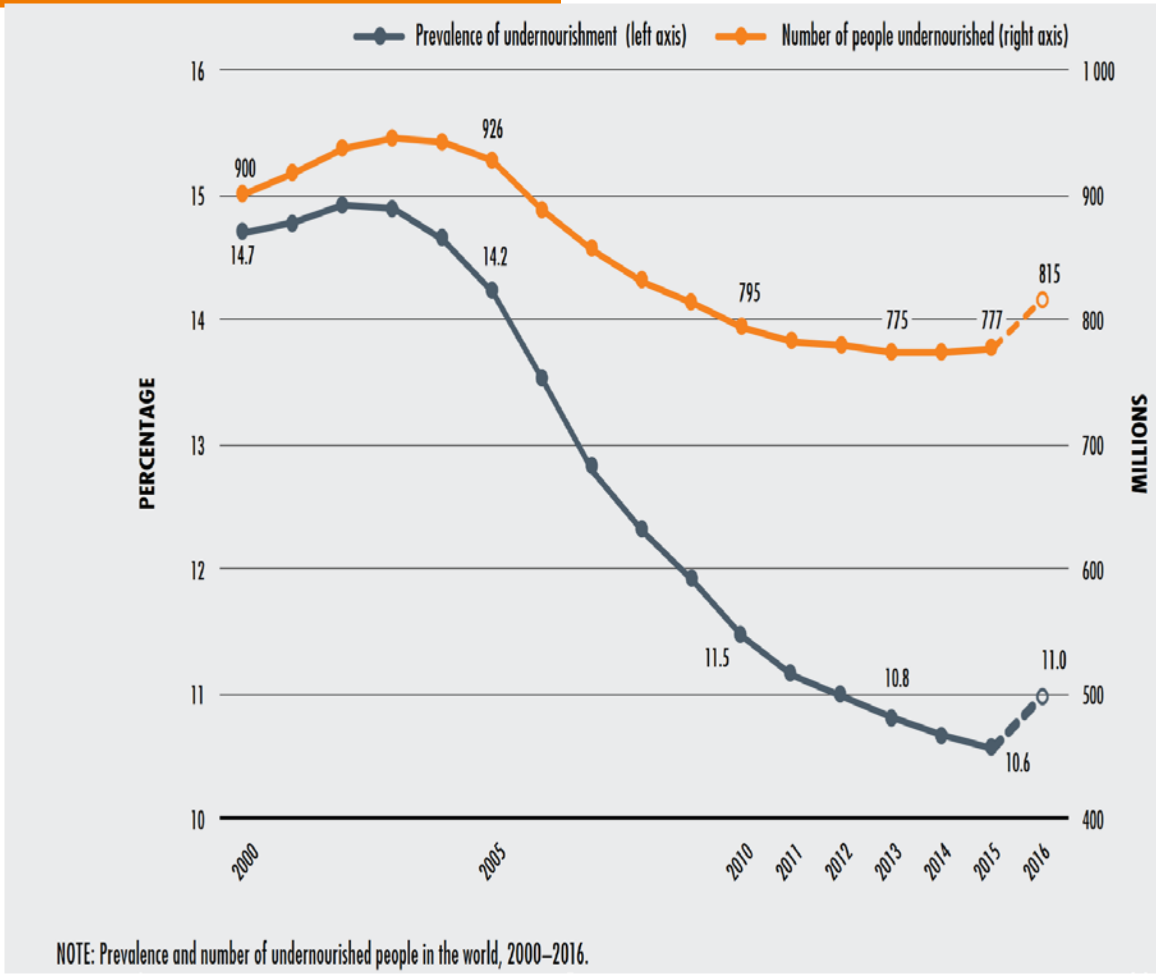
- Decrease in growth, lower biomass (Gajanayake *et al*,2014)
- Pencil roots, no capacity to store carbohydrates (Lewthwaite and Triggs 2009).
- Yield loss (50-80%) depending on the timing, duration, and intensity of water (Solis Phd thesis, Lewthwaite and Triggs 2012).



Yield changes by crop as a result of climate change, 2050, SSA (percent change)
Source: (Ringler *et al*,2010)

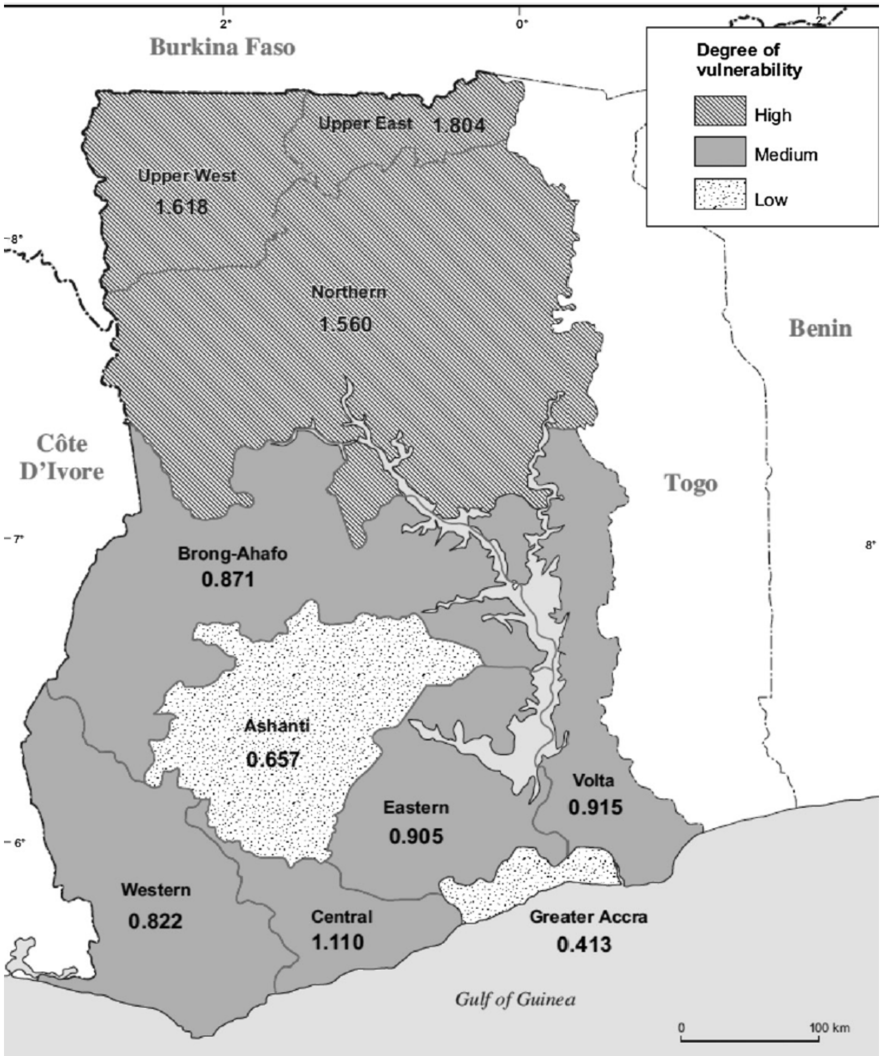
Reduced yield means:

- Less food
- Increase in food prices
- Food insecurity
- SSA-highest Prevalence of Under-nourishment (PoU)



Source: FAO state of food insecurity ,2017

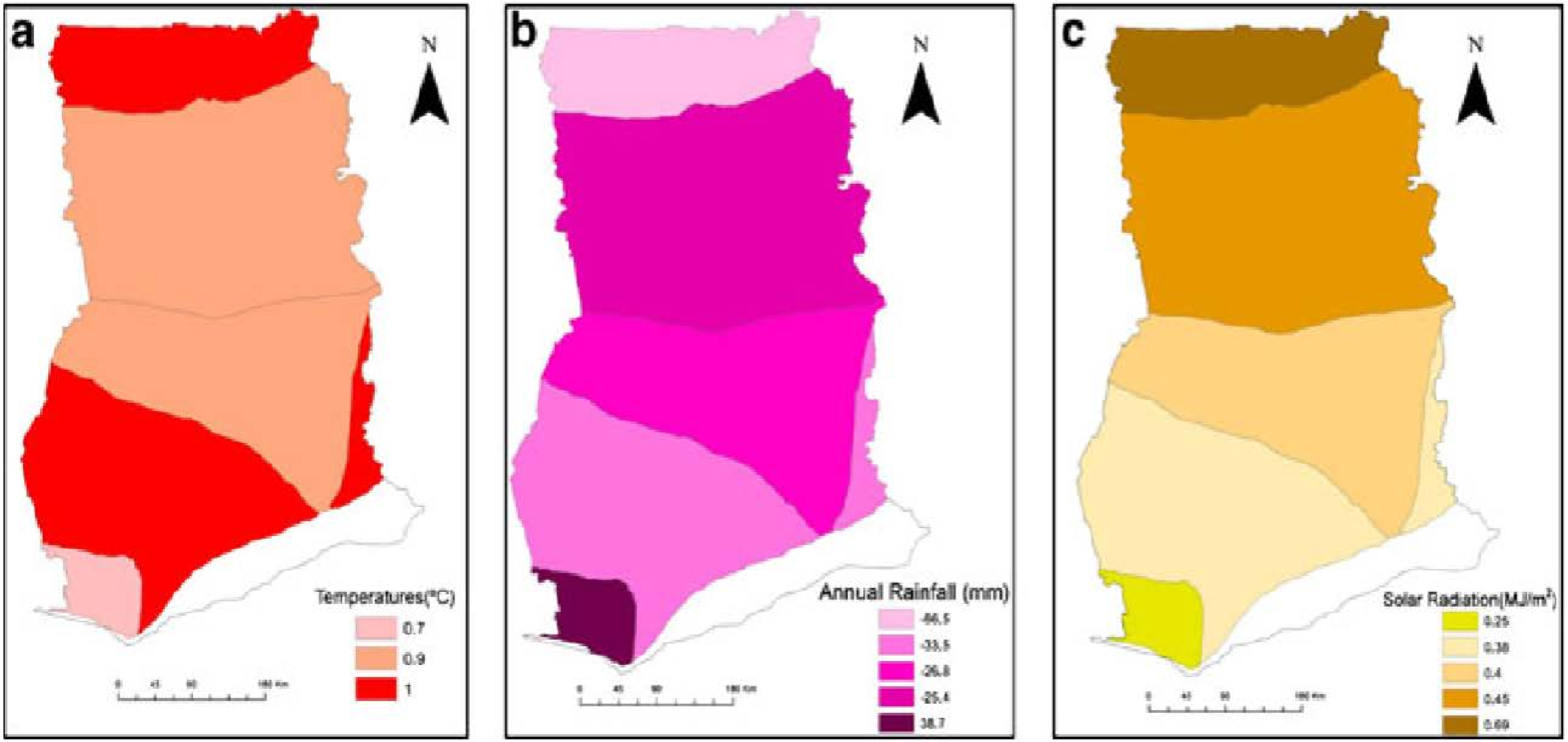
Drought situation in Ghana



Drought vulnerability indices of the various regions in Ghana. Source:Antwi-Agyei *et al*,2012

- Increased temperature, decreased rainfall(20%) and runoff (30%) over the past 40 years (Asante 2004)
- North of Ghana, most threatened region in terms of water scarcity and drought
- A major drought from 1981–1983

Predicted climatic variability for Ghana by 2020



a. Predicted increases in daily mean temperatures; **b.** Predicted changes in annual rainfall **c.** Predicted increase in solar radiation. Armah *et al*,2011

Phd study objectives

Evaluation of the effect of drought on sweetpotato in Ghana using the Beauregard x Tanzania (BT) mapping population

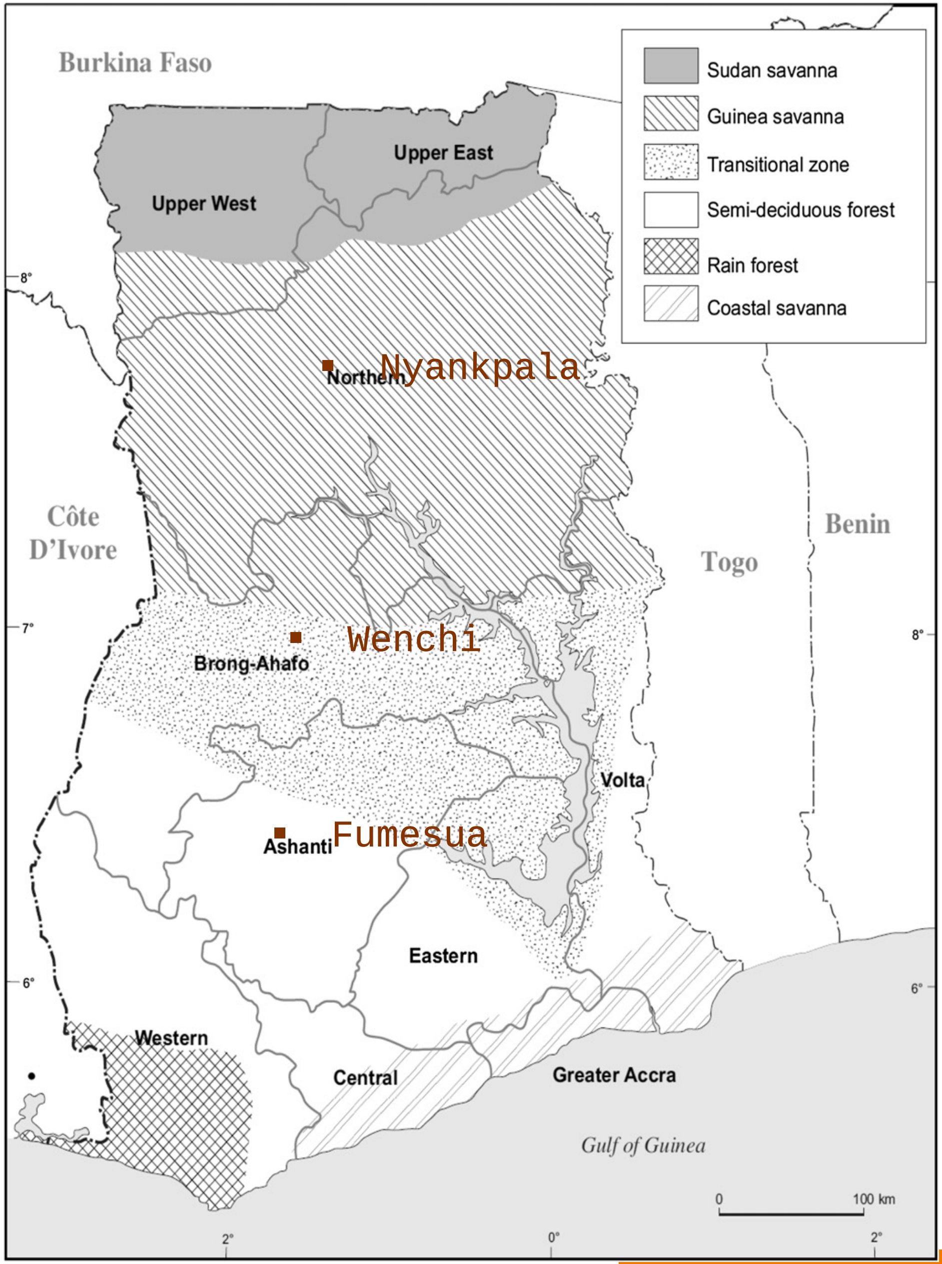
- Estimation of the effect of drought on sweetpotato grown in the field under drought conditions in Ghana
- Mapping of Quantitative Trait Loci for drought tolerance using the BxT mapping population in Ghana
- Evaluation of the effect of drought on the early above ground parts and root system architecture (RSA) of sweetpotato in the screenhouse in Ghana
- Evaluation of the effect of drought on quality traits of sweetpotato grown under drought conditions in Ghana

Objective 1: Estimation of the effect of drought on sweetpotato grown in the field under drought conditions in Ghana

Sub-objectives:

- Estimation of quantitative genetic parameters under drought and irrigated conditions
- Estimation of drought tolerance indices for genotypes
- Identification of drought tolerant genotypes for subsequent experiments

Field experiments conducted



Rainfed conditions

- Fumesua 2016 (246 genotypes)
- Nyankpala 2016 (247 genotypes)

- Irrigation

Nyanpkala 2017 (270 genotypes)
Wenchi 2017 (270 genotypes)
Nyankpala 2018 (260 genotypes)

- Drought

Nyankpala 2017 (270 genotypes)
Wenchi 2017 (270 genotypes)
Nyankpala 2018 (260 genotypes)

Environmental conditions of locations used and data collected

	Nyankpala		Wenchi
	2017	2018	2018
ECRN-100 Precipitation (mm)	2.40	17.85	53.72
VP-3 Humidity (RH)	0.46	0.50	0.71
VP-3 Temp (°C)	29.66	27.55	26.15
PYR Solar Radiation (W/m²)	229.65	209.54	216.12
Irrigation Avg soil Moisture(m³/m³ VWC)	0.20	0.21	0.07
Drought Avg soil Moisture(m³/m³ VWC)	0.12	0.16	0.04

Data collected Using Fieldbook app:

- Agronomic traits (Spbase) nocr,noncr, vw, rytha, fytha, biom, hi
- Physiological: canopy temperature, chlorophyll content, LAI
- Morphological: stem girth, number of nodes, vine length




Data analysis

Mixed model ,lme4 and predictmeans packages of Rstudio version R-3.3.1,

For single site analysis, genotypes, blocks within replications as random

For combined analysis :205 genotypes common to all 6 environments (drought and irrigation) were selected

R package corrplot for correlation

Beauregard **Tanzania**

Genotypes under irrigation

Genotypes under Drought

Root yield (rytha) means, coefficient of genetic variation, repeatability and genetic correlation between drought and irrigated environments

location	Treatment	μ	CV_g	w^2	r_g	RYR
Nyanpkala 2017	Irrigation	3.60	60.58	0.57	0.65	74.28
	Drought	0.93	71.18	0.44		
Wenchi 2017	Irrigation	2.11	97.62	0.46	0.64	10.50
	Drought	1.89	101.41	0.52		
Nyanpkala 2018	Irrigation	7.86	42.58	0.48	0.62	62.06
	Drought	2.98	21.96	0.38		
	μIrrigation		66.93	0.51		
	μDrought		64.85	0.45		

Variance components , Best Linear Unbiased Predictor means(μ), broad sense heritability (h^2),repeatability(w^2), Relative Yield Reduction(RYR),Genetic correlation (r_g) for combined analysis within treatment for root yield(rytha), foliage yield(fytha), biomass(biom) and harvest index(hi)

Random term	rytha		fytha		biom		hi	
	irrigation	drought	irrigation	drought	irrigation	drought	irrigation	drought
G	1.66**	0.24*	1.72***	0.97*	5.84***	1.34*	56.90***	53.60***
G X E	5.16**	1.77**	7.47***	7.67**	18.47***	13.05***	20.34***	98.38***
Mean	4.68	1.96	6.61	4.87	11.26	6.80	38.30	35.24
H^2	0.47	0.28	0.63	0.42	0.73	0.39	0.74	0.72
CV_g	27.533	25.10	19.83	20.20	21.45	17.00	19.70	20.78
RYR%	58.17		26.38		39.64		8.00	
$r_{g\ irr\ vs\ drgt}$	0.68		0.29		0.61		0.72	

Variance components, Best Linear Unbiased Predictor means(μ), broad sense heritability (h^2),repeatability(w^2), Relative Yield Reduction(RYR) and Genetic correlation (r_g) for combined analysis across treatment for traits

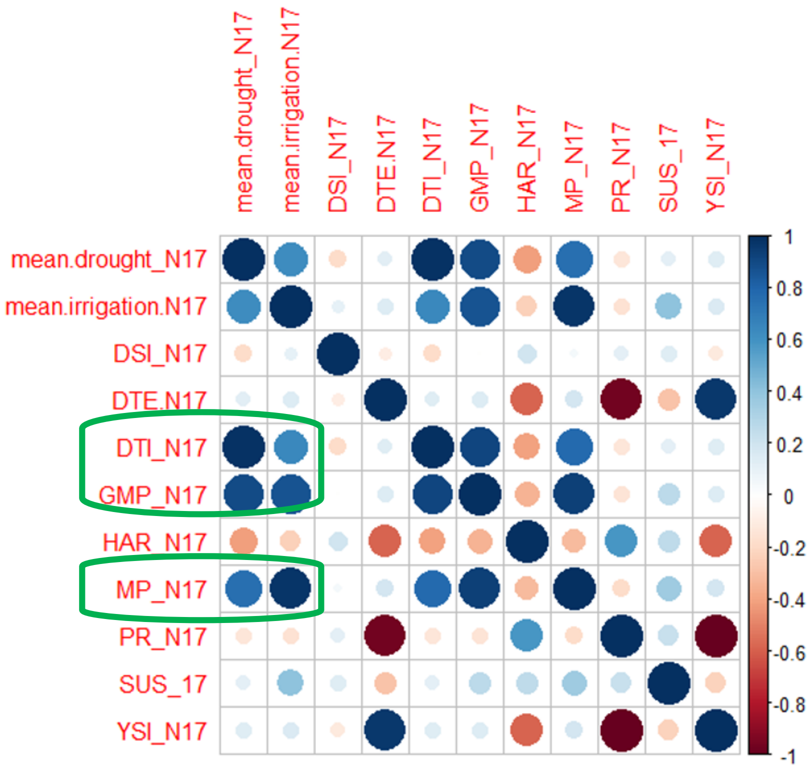
Random term	rytha	fytha	Biom	Hi
G	1.41***	2.72 ***	6.17***	76.21****
G X E	0.72 **	1.24 **	2.98***	5.62 ***
G x T	0.00	0.000	0.00	0.00
G x T x E	2.93***	8.37***	13.08 ***	68.77***
Mean(μ)	2.34	3.30	5.63	19.14
h^2	0.56	0.52	0.56	0.70

Estimation of drought tolerance indices for genotypes

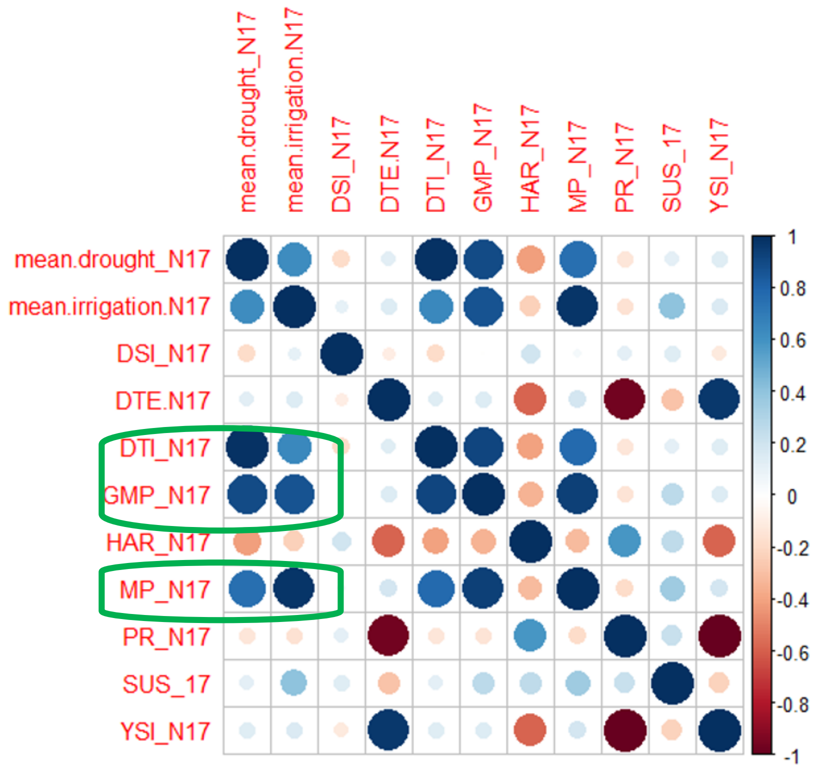
Drought tolerance indices used:

- (DII)= 1 - mean Ys/mean Yp, Fisher and Maurer (1978)
- (DSI)=(1 - Ys/ Yp)/DII ,Fisher and Maurer (1978)
- (DTE)=(Ys/ Yp) x 100 Fischer and Wood (1981)
- (PR)=[(Yp - Ys)/Yp] x 100
- (GMP)=sqrt(Yp)*(Ys)(Fernandez,1992)
- (DTI)=(Yp)* (Ys)/sqrt(mean Yp) (Fernandez,1992)
- (MP)=(Yp + Ys)/2 (Rosielle and Hamblin,1981)
- (SUS)=(Yp - Ys) (Hossain *et al*,1990)
- (YSI)=Ys/ Yp (Bouslama and Schapaugh,1984)

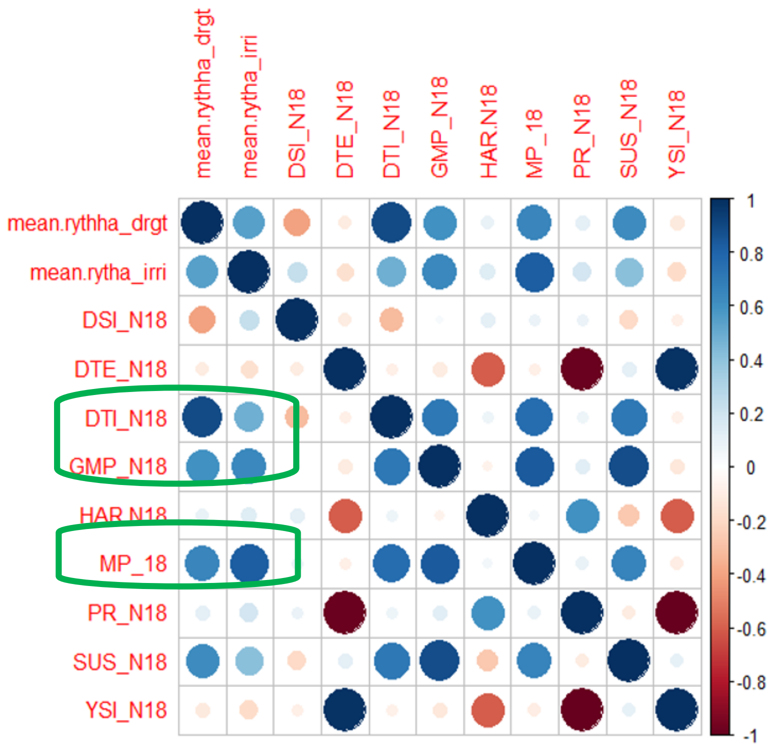
Correlation between drought tolerance indices and rytha under drought and irrigated conditions per environment



Nyanpkala 2017



Wenchi 2017



Nyanpkala 2018

Top 5 genotypes selected	
Nyanpkala 2017	Wenchi 2017
CIP105269.127	CIP105269.127
CIP113641.252	CIP113641.280
CIP113641.61	CIP113641.108
CIP113641.431	CIP113641.252
CIP113641.308	CIP113641.307
Bottom 5 genotypes selected	
CIP105269.119	CIP105269.111
CIP105269.142	CIP105269.119
CIP105269.154	CIP105269.142
CIP105269.163	CIP105269.80
CIP105269.66	CIP105269.82

DT indices vs mean for selection under drought

Genotype	Index selection
CIP113641.280	31.17
CIP105269.127	28.94
CIP113641.244	24.23
CIP105269.186	23.43
CIP113641.308	23.32
CIP113641.183	23.05
CIP105269.104	20.60
CIP113641.108	19.47
CIP105269.43	19.29

Genotype	µ rytha_ drought
CIP113641.280	7.6389
CIP105269.127	6.6985
CIP113641.244	5.3935
CIP105269.43	4.8009
CIP105269.104	4.4769
CIP113641.183	4.3611
CIP105269.186	4.3287
CIP113641.308	4.287
CIP113641.113	4.0972

Summary

- General reduction in mean rytha, fytha, biomass and hi under drought conditions

- Of all traits studied, rytha had the highest relative yield reduction, the most reduction in mean yield

- Moderate genetic correlations between drought and irrigation, selection for genotypes for drought conditions should be done under drought

- Drought Tolerant indices GMP, MP and DTI were suitable for identification of genotypes with the high yield under both drought and irrigation environments , not much different when mean rytha is used

Objective 2: Mapping of Quantitative Trait Loci for yield related traits under drought and irrigated conditions in Ghana

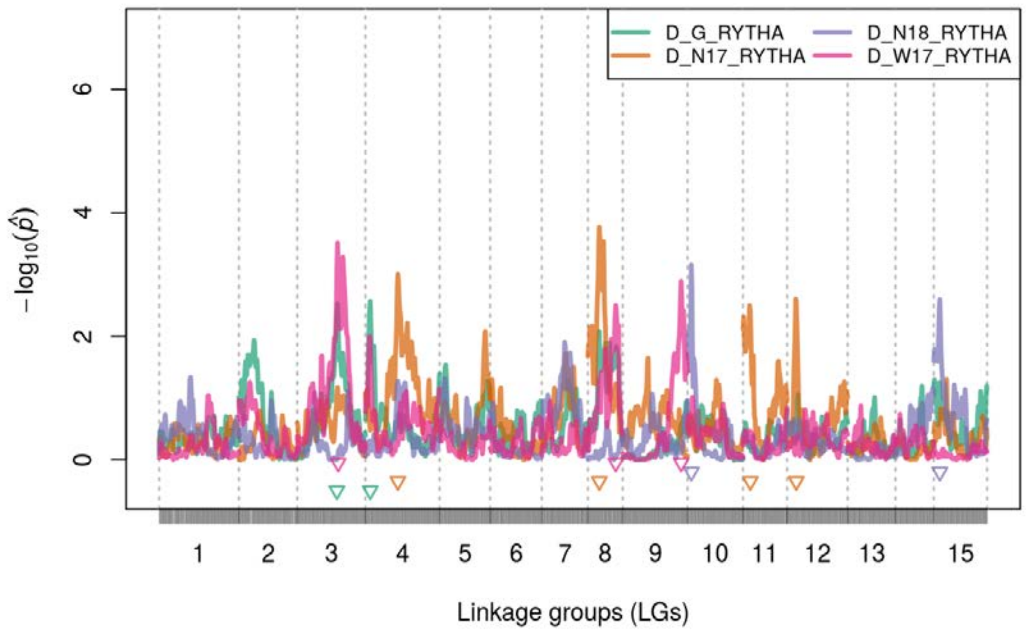
in collaboration with NCSU

Specific objectives:

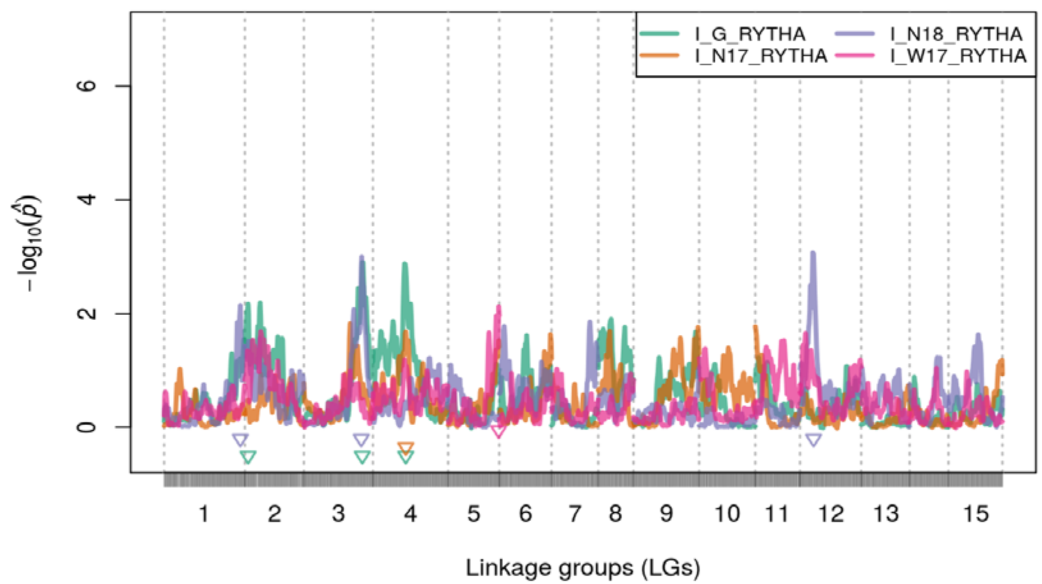
- Identification of genomic regions responsible for rytha, fytha and hi under drought and irrigated conditions

- Identification of genomic regions which are repeatable across environments

D


D_G_RYTHA
D_N18_RYTHA
D_N17_RYTHA
D_W17_RYTHA
−log10(p̂)
0
2
4
6
1
2
3
4
5
6
7
8
9
10
11
12
13
15
Linkage groups (LGs)

I


I_G_RYTHA
I_N18_RYTHA
I_N17_RYTHA
I_W17_RYTHA
−log10(p̂)
0
2
4
6
1
2
3
4
5
6
7
8
9
10
11
12
13
15
Linkage groups (LGs)

Summary of QTLs under drought and irrigation

Trait	S/N	LG	Position	P-value	H2
D_G_RYTHA (29.37%)	1	3	198.03	0.003	0.16
	2	4	24.38	0.003	0.14
D_G_FYTHA (14.73%)	1	11	156.32	0.0007	0.15
D_G_HI (44.90%)	1	4	18.17	0.0002	0.18
	2	5	234.58	0.0004	0.15
	3	13	9.35	0.001	0.12
D_N17_RYTHA (50.11%)	1	4	162.13	0.0005	0.12
	2	8	57.04	0.0001	0.12
	3	11	36.42	0.003	0.15
	4	12	45.37	0.001	0.12
D_N18_RYTHA (23.85%)	1	10	18.85	0.0007	0.12
	2	15	30.19	0.001	0.12
D_W17_RYTHA (39.16%)	1	3	204.59	0.0003	0.13
	2	8	138.87	0.003	0.13
	3	9	291.38	0.001	0.13

Trait	S/N	LG	Position	P-value	H2
I_G_RYTHA (42.19%)	1	2	15.9	0.003	0.09
	2	3	288.02	0.0009	0.18
	3	4	162.13	0.0007	0.15
I_G_FYTHA (46.20%)	1	4	198.08	0.0004	0.19
	2	7	81.82	0.006	0.12
	3	11	213.8	0.003	0.15
I_G_HI (17.91%)	1	1	105.12	0.0006	0.18
I_N17_RYTHA (12.11%)	1	4	162.13	0.011	0.12
I_N18_RYTHA (47.16%)	1	1	375.62		0.16
	2	3	282.86		0.11
	3	12	67.07		0.2
I_W17_RYTHA (9.16%)	1	5	249.18	0.011	0.09

Summary

205 genotypes used may be too few for QTL mapping in SP

Wenchi shared QTL with combined environment under drought for rytha

Nyanpkala 2017 and 2018 shared QTL with the combined environment under irrigation for rytha

Objective 3:Evaluation of the effect of drought on the early above ground parts and root system architecture (RSA) of sweetpotato in the screenhouse in Ghana

- Evaluate the effect of drought on early RSA traits in selected genotypes of the B xT mapping population
- Evaluate the effect of drought on morphological and physiological traits in selected genotypes
- Determine the relationship between RSA traits and yield from different locations and across locations

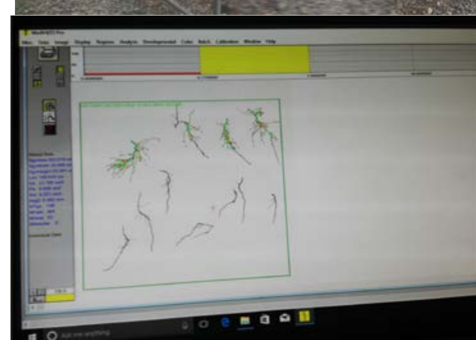
Data collected:

Physiological

Morphological

Root traits






Objective 4: Evaluation of the effect of drought on quality traits of sweetpotato grown under drought conditions in Ghana

- Roots collected from irrigated and drought field experiments were processed

- Quality traits analyzed - NIRS

Next steps….

Data analysis:

QTL analysis for fytha and hi for single environments and combined environments

Morphological and physiological traits for Nyanpkala 2017 and 2018 experiments

Morphological , physiological and RSA traits from screen house experiments

Quality data from drought and irrigated field experiments to be co-authored with Victor Amankwaah

Timeline

JUNE
Development of manuscript for objective 1 and thesis writing

July
Data analysis for screen house experiments (RSA)
Development of manuscript objective2

August
Data analysis for screen house experiment (Morpho and physio traits)
thesis writing

September
Data analysis for morphological and physiological traits from field,
Thesis writing

October
Data analysis for quality traits, manuscript development, thesis writing

November
Thesis writing

December
thesis writing and submission

January 2019
Manuscript development

Acknowledgement

NC STATE UNIVERSITY

CIP
INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

WACCI
WEST AFRICA CENTRE FOR CROP IMPROVEMENT