Generation Challenge Programme

CULTIVATING PLANT DIVERSITY FOR THE RESOURCE POOR

Characterization of drought stress environments for maize and upland rice in central Brazil

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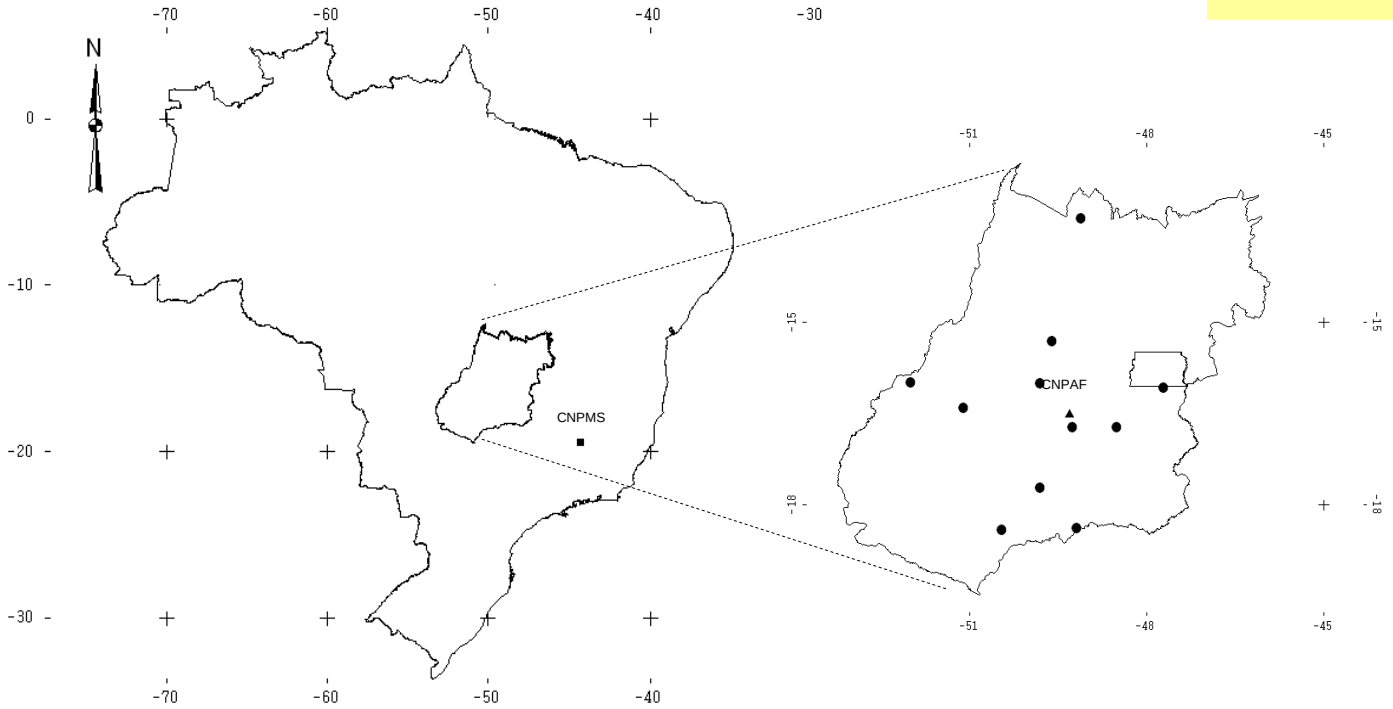
CIRAD

Embrapa Arroz e Feijão

CSIRO

Introduction

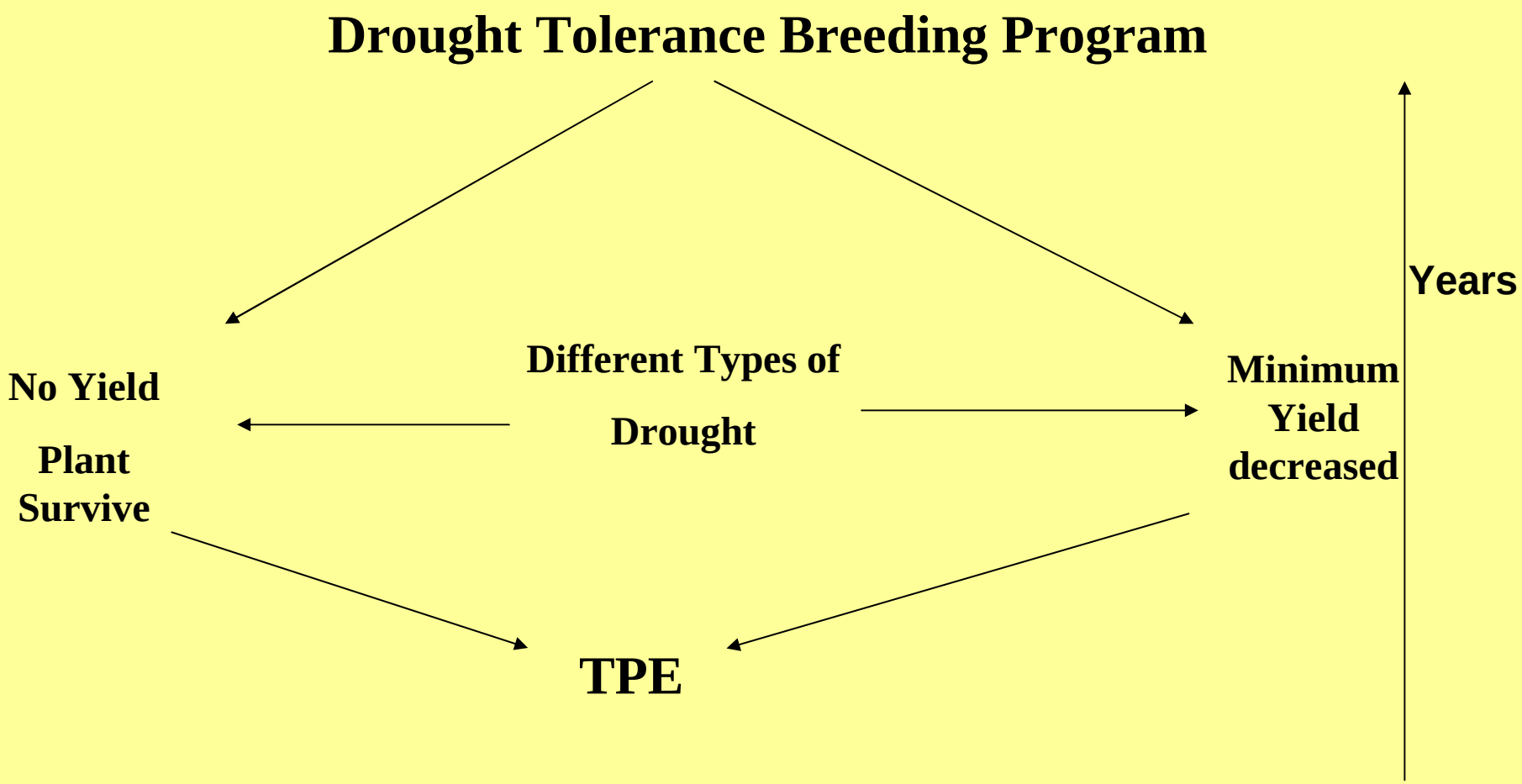
- **Region of Study:**



Introduction

- **Importance of region:**
  - **Maize:**
    - **As First Crop:**
      - **Production: 3,043,396 ton (36,293,153 ton);**
      - **Harvested Area: 551,340 ha (9,230,356 ha);**
      - **Yield: 5,520 kg/ha (3,932 kg/ha).**
    - **As Second Crop:**
      - **Production: 3,043,396 ton (4,612,913 ton);**
      - **Harvested Area: 273,320 ha (4,556,588 ha);**
      - **Yield: 3.890 kg/ha (3,344 kg/ha).**
  - **Upland Rice:**
      - **Production: 246,411 ton (11,077,200 ton);**
      - **Harvested Area: 117,900 ha (2,901,312 ha);**
      - **Yield: 2,090 kg/ha (3,818 kg/ha).**

Introduction

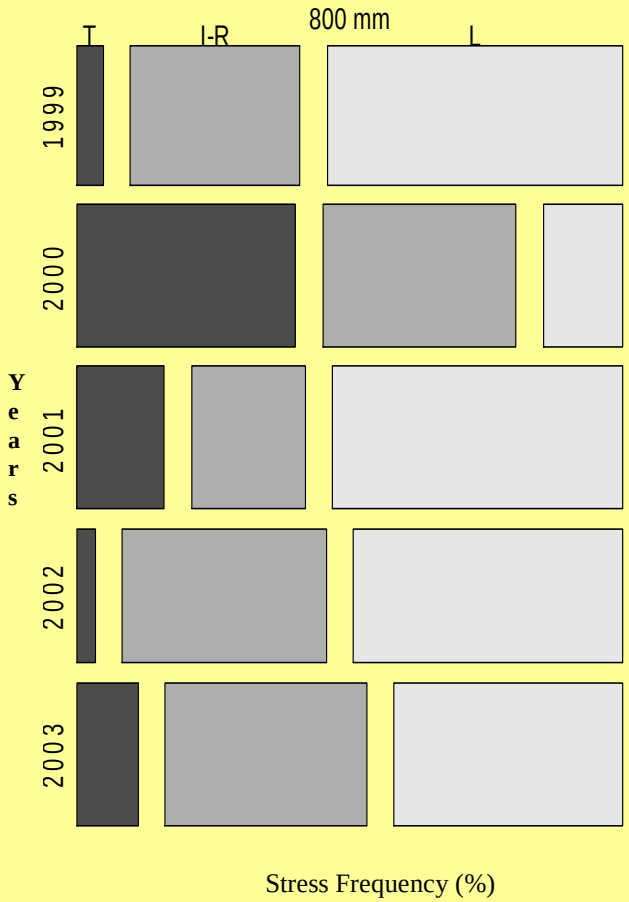


- **Focus on the Drought Tolerance Breeding Program**

Introduction

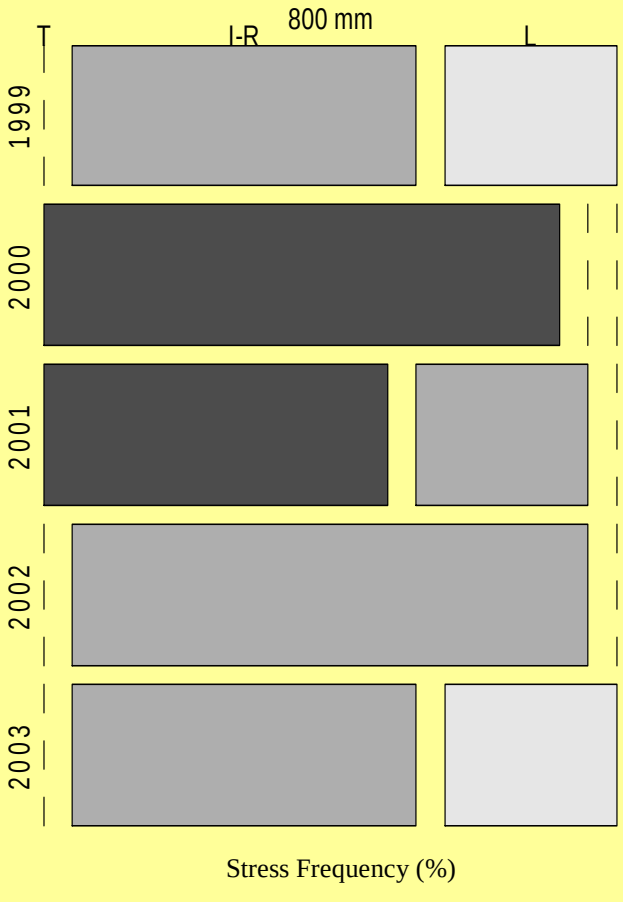
Site

TPE



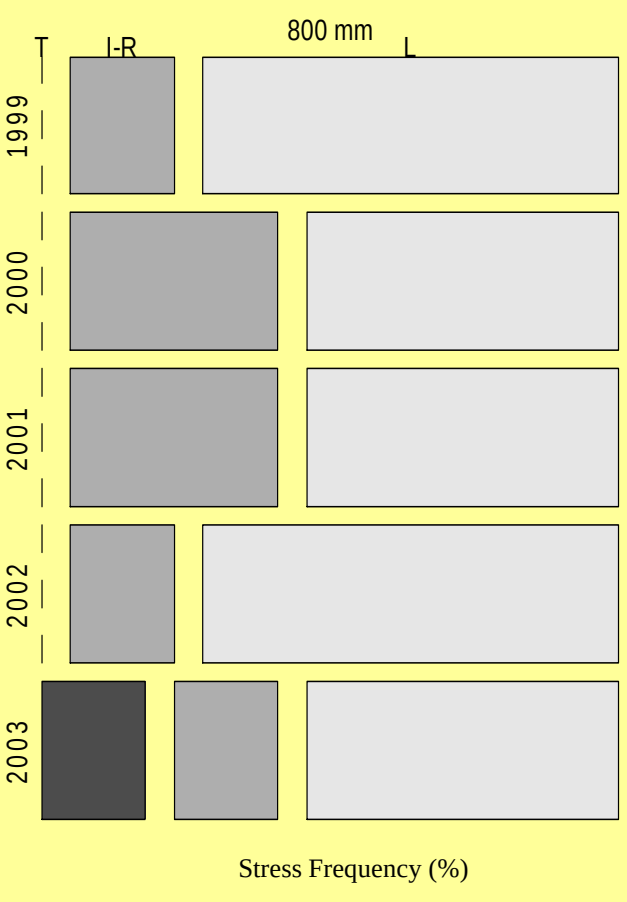
Site

PLANALTINA



Site

STO ANTÔNIO DE GOIÁS



Objective

- **determine the geographical and inter-annual variation of seasonal drought patterns for upland rice and maize (as first and second crop);**
- **evaluate how well the current environmental screens for upland rice and maize fit the TPE for these crops;**
- **provide, as a case study, strategies that may help improving the efficiency of these breeding programs;**

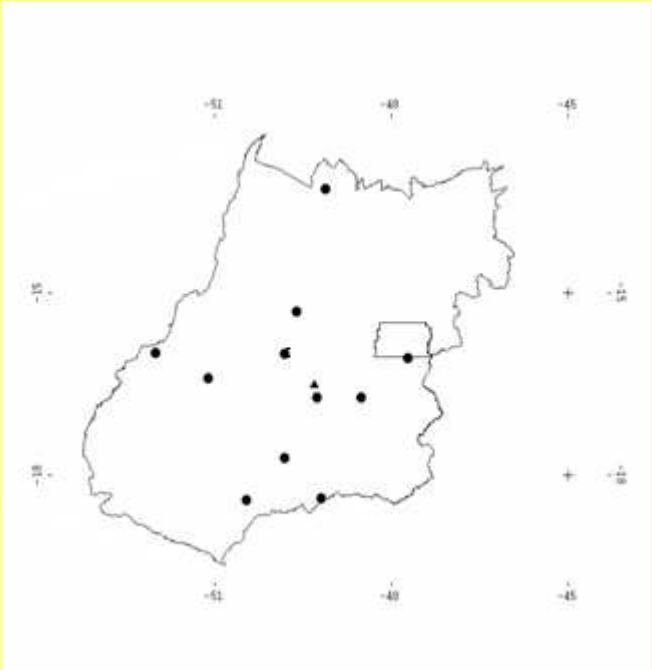
METHODOLOGY

- **It was used Ecotrop Plataform (Rice06 and Maize06 models);**
  - **02 reference genotypes for upland rice (short and medium cycle);**
  - **01 reference genotype for maize (medium cycle);**
- **Characteristics of Crop Model Management:**
  - **Soil depth – 0.4 and 0.8 m (0.5 and 1.0 m);**
  - **Begin of simulation – 01-July;**
  - **Allowed water to accumulate;**
  - **Plant crop on given date –** (germination only if FTSW in the top soil layer was 0.7 or higher)
- **Coefficient of stress**
  - **Ratio of water supply/demand**
  - **Repeated simulations for range of dates**

METHODOLOGY

- 12 Sites;
- Five Planting Dates;
- Windows Planting:
  - Rice short cycle – from 01/11 to 31/12;
  - Rice Medium cycle – from 15/10 to 31/12;
  - Maize 1 crop – from 15/10 to 31/12;
  - Maize 2 crop – from 20/01 to 01/3.

Site	Latitude	Longitude	Altitude (m)	N° of years
Aragarças	-16.00	-52.00	310	6
CNPAF	-16.50	-49.30	741	22
Ceres	-15.33	-49.60	739	6
Goiânia	-16.73	-49.25	749	6
Iporá	-16.41	-51.11	688	6
Itaberai	-16.01	-49.78	1001	6
Itumbiara	-18.40	-49.18	449	6
Planaltina	-16.08	-47.70	1007	6
Porangatu	-13.30	-41.11	391	6
Quirinópolis	-18.43	-50.40	633	6
Vianópolis	-16.80	-48.48	1110	6
Vicentinópolis	-17.70	-49.78	648	6



METHODOLOGY

Soil data

Genetic coefficient

Weather data

Management

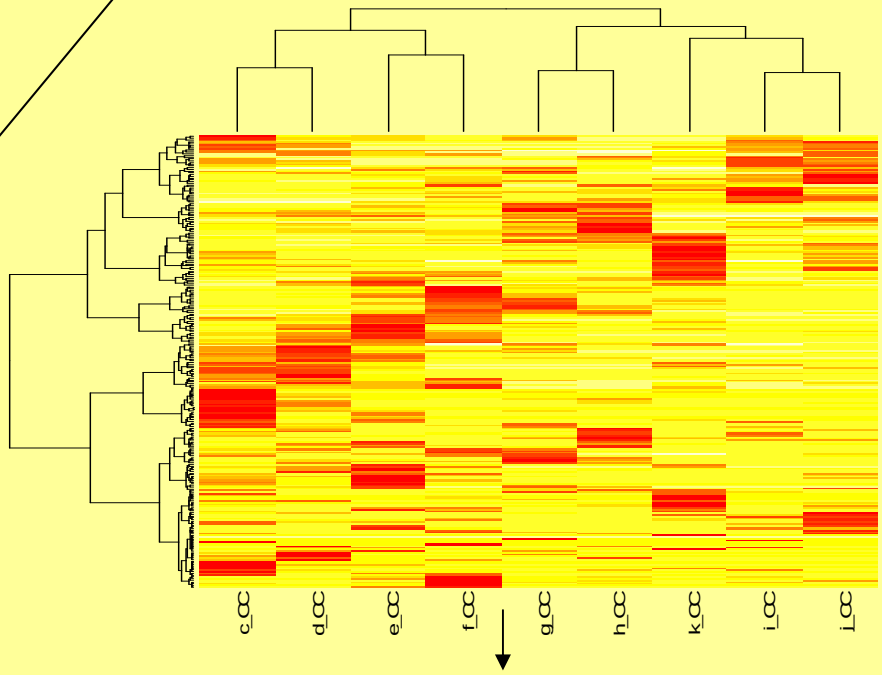
Crop model

Daily Stress Index

Stress Index 100 DD

Filter → Crop Failure

Cluster Analyse



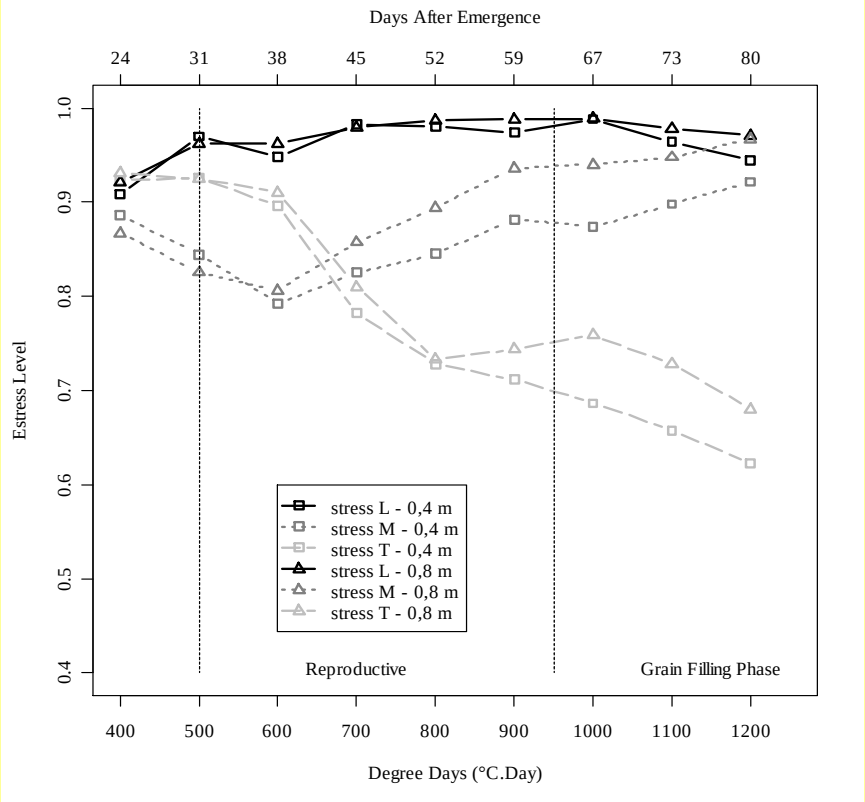
Description of TPE

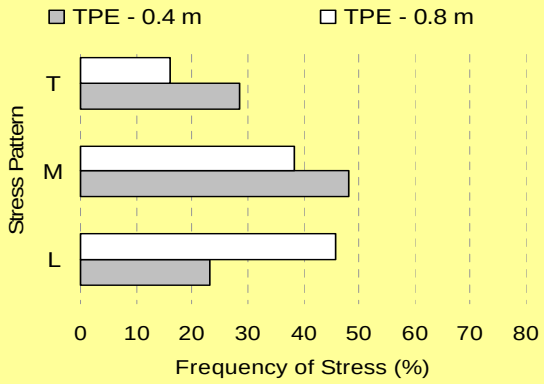
Frequency of Stress Patterns

	row.names	c_CC	d_CC	e_CC	f_CC	g_CC	h_CC	i_CC
1	cnpaf-Rice-400-nov-01-1983	1	1	1	0.82	0.91	0.99	0.98
2	cnpaf-Rice-400-nov-01-1984	1	0.94	0.99	1	0.77	0.91	1
3	cnpaf-Rice-400-nov-01-1985	0.79	0.88	0.6	0.68	1	1	1
4	cnpaf-Rice-400-nov-01-1986	0.55	0.56	0.74	0.96	0.97	1	0.7
5	cnpaf-Rice-400-nov-01-1987	0.96	1	1	1	1	0.96	0.99
6	cnpaf-Rice-400-nov-01-1988	0.97	1	1	1	1	0.76	1
7	cnpaf-Rice-400-nov-01-1989	0.81	1	1	1	1	1	0.98
8	cnpaf-Rice-400-nov-01-1990	0.55	0.85	0.85	0.94	0.77	1	0.82
9	cnpaf-Rice-400-nov-01-1991	0.72	0.93	0.98	1	0.82	1	0.89
10	cnpaf-Rice-400-nov-01-1992	1	1	1	0.88	0.73	0.75	0.81
11	cnpaf-Rice-400-nov-01-1993	0.68	0.94	0.98	1	1	1	1

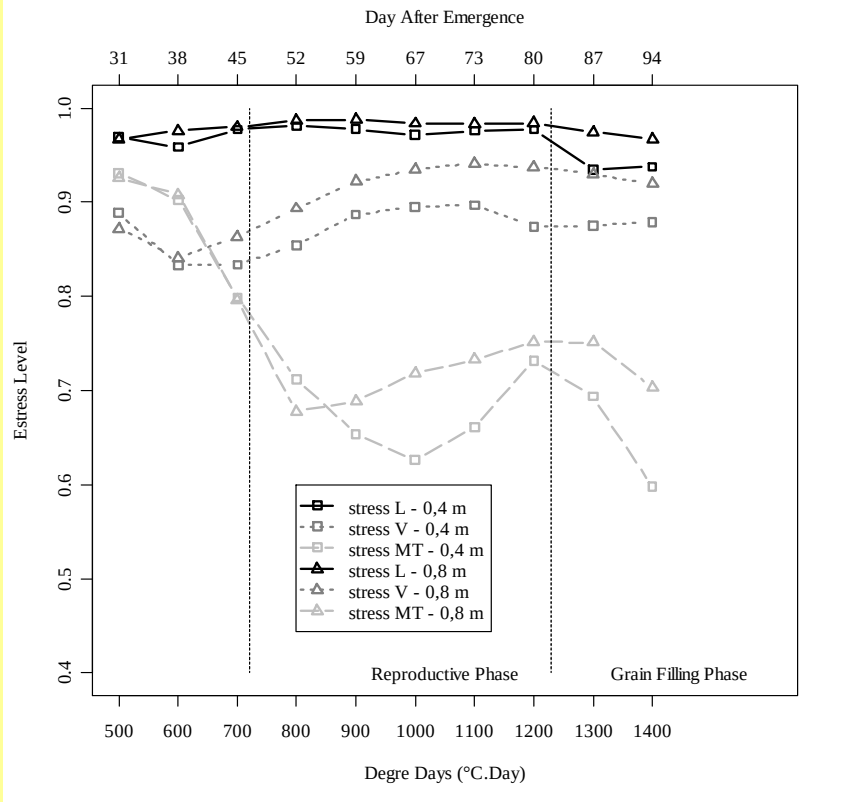
Results: Rice Stress Pattern

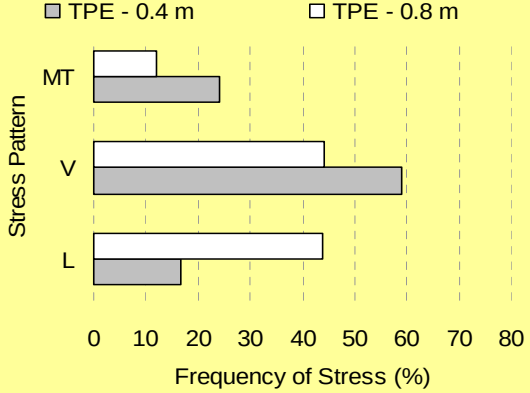
Stress Pattern Short Rice





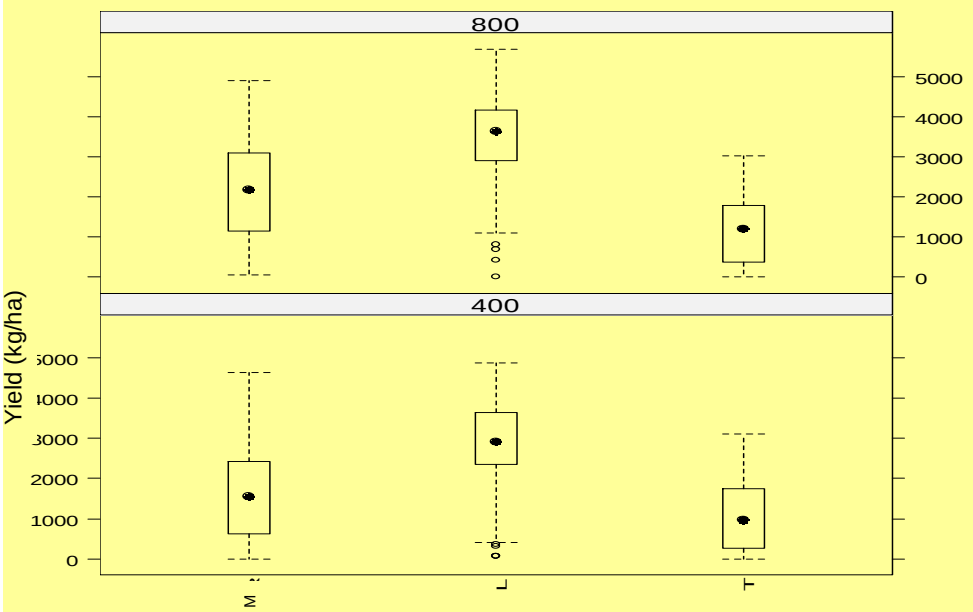
Stress Pattern Medium Rice

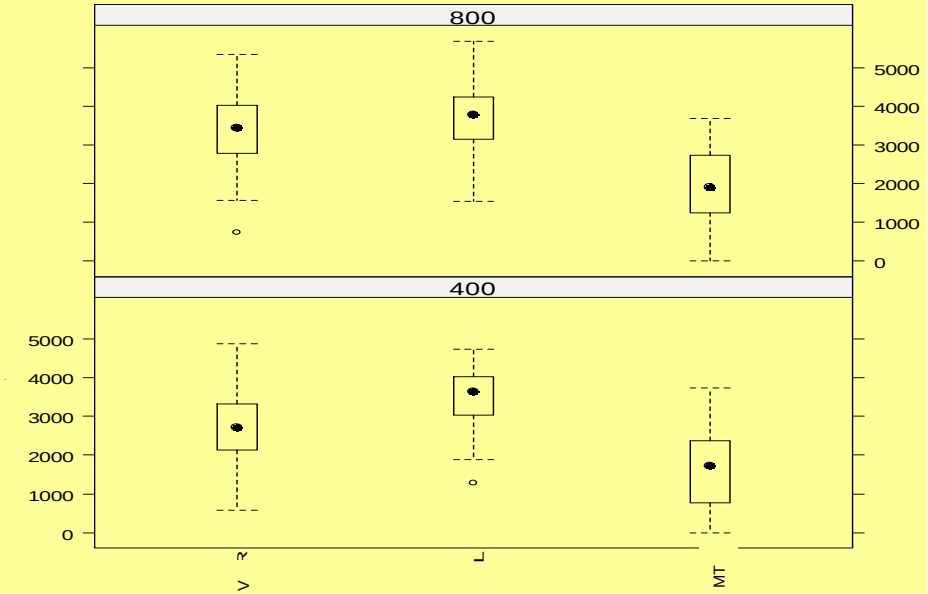




Results: Rice Stress Pattern

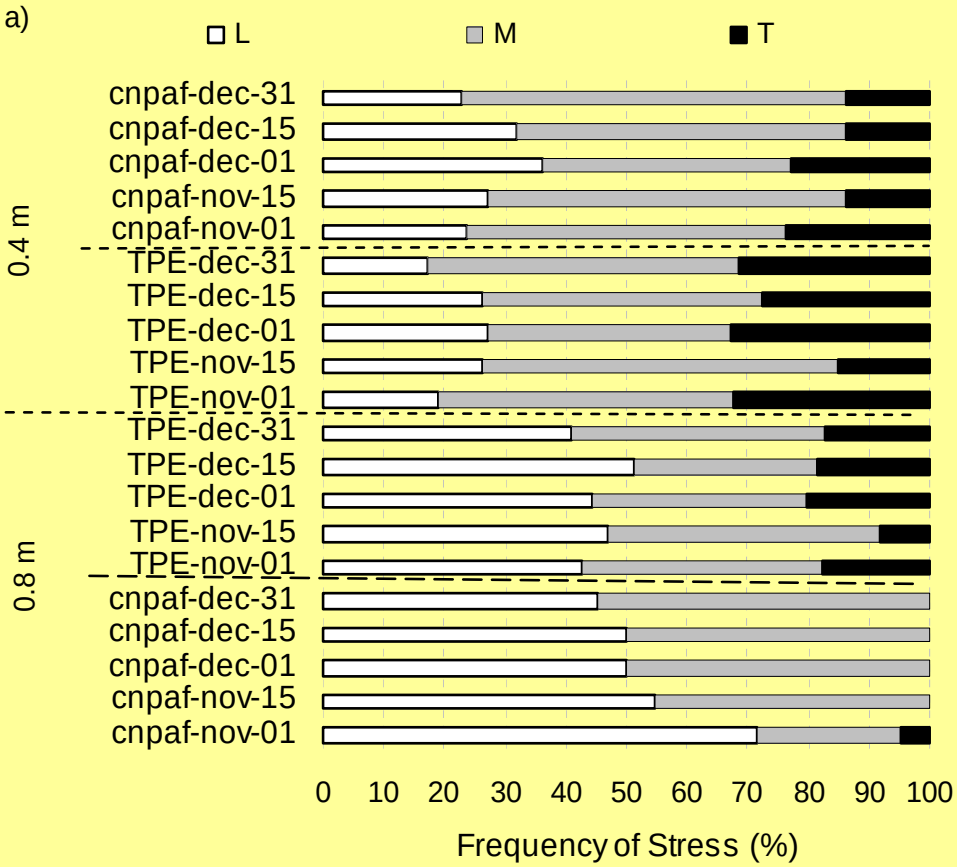
Soil Depth	Variable	Short Rice TPE				Medium Rice TPE			
		Stress Type				Stress Type			
		L	M	T	Average	L	V	MT	Average
Deep (0.8m)	*GYpot (kg.ha^{-1})	3937	4120	4217	4051	2950	2885	2860	2911
	**sd (kg/ha)	718	622	542		483	485	498	
	***GYatt (kg/ha)	3718	3378	1982	3311	2853	2597	1402	2566
	sd (kg/ha)	785	834	942		535	720	914	
	****RWSI (%)	6	18	53	18	3	10	51	12
	Stress Frequency (%)	46	38	16		44	44	12	
Shallow (0.4m)	GYpot (kg/ha)	3927	4027	4270	4074	2976	2873	2956	2935
	sd (kg/ha)	677	668	590		407	493	514	
	GYatt (kg/ha)	3516	2742	1634	2599	2683	2086	1018	1929
	sd (kg/ha)	728	869	944		560	773	737	
	RWSI (%)	10	32	62	36	10	27	66	33
	Stress Frequency (%)	23	48	29		17	59	24	



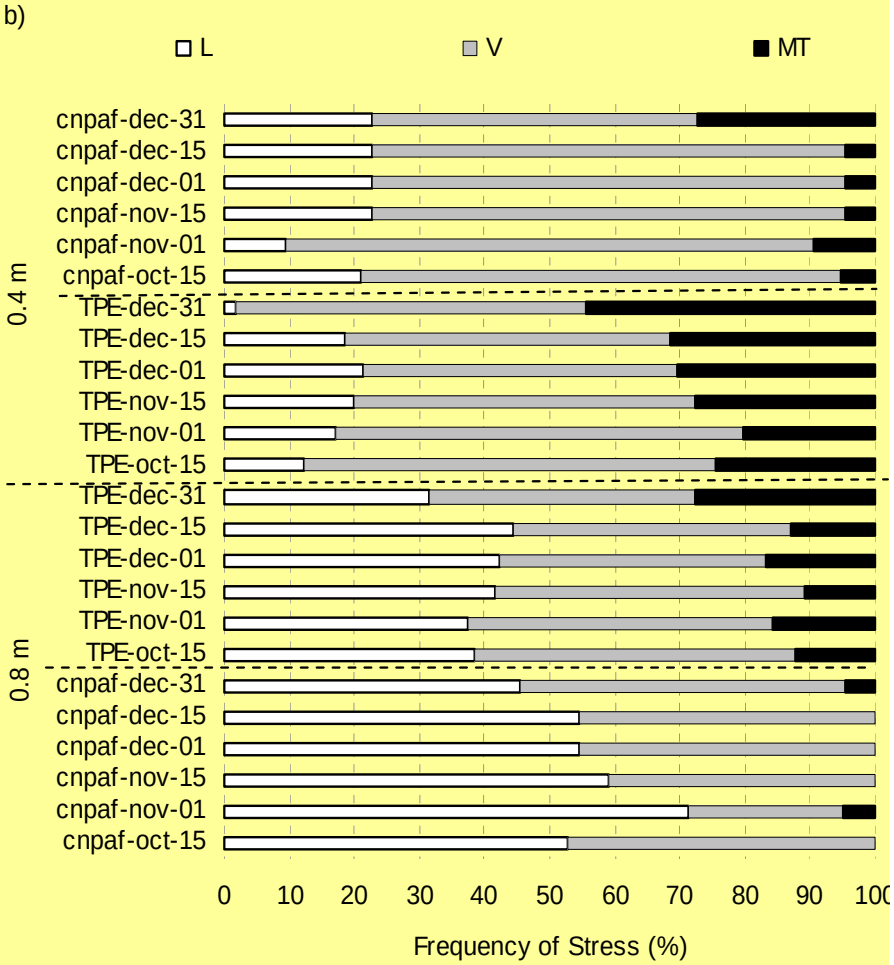


Results: Rice Stress Pattern

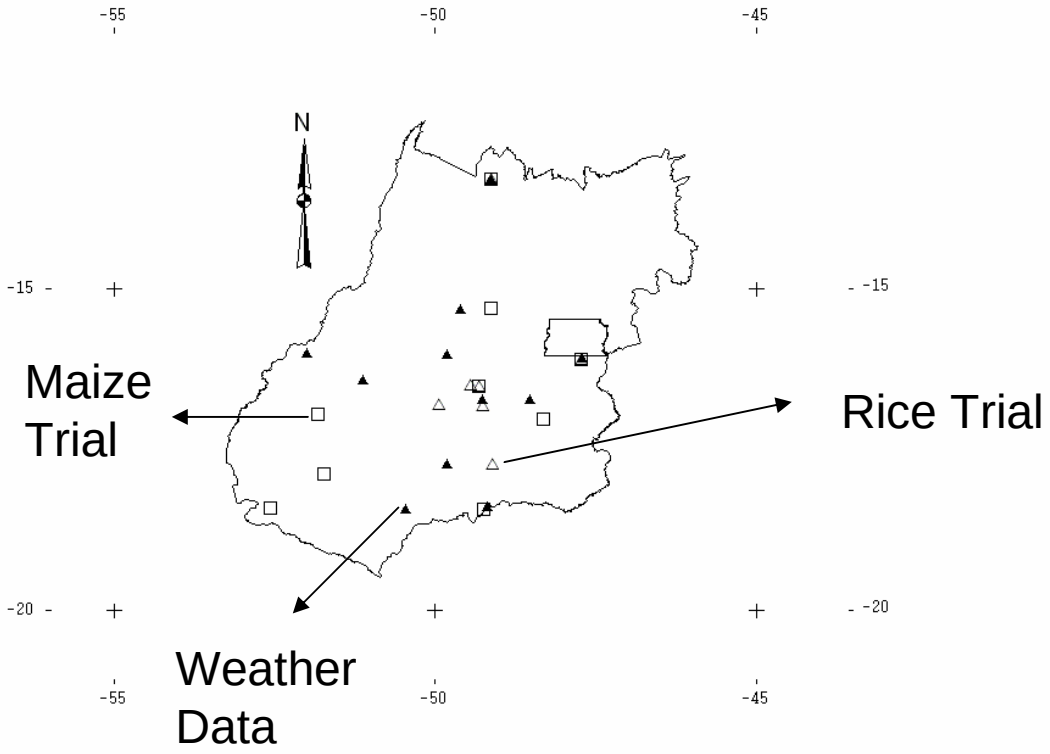
Short Rice Frequency Stress Pattern



Medium Rice Frequency Stress Pattern

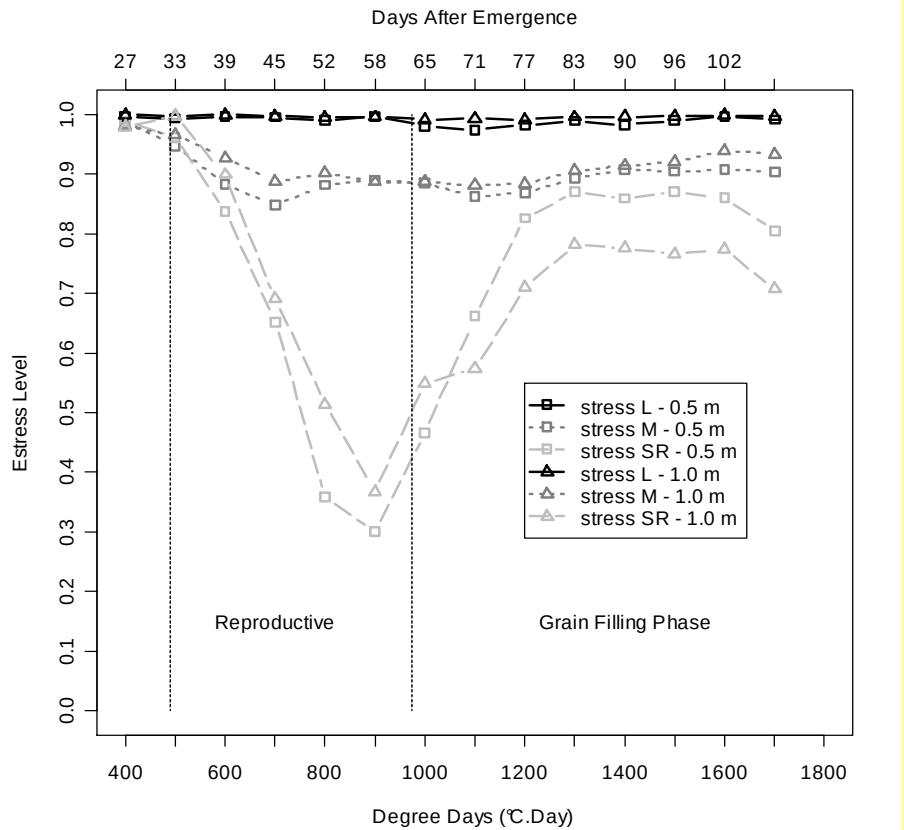


Results: Rice Summary

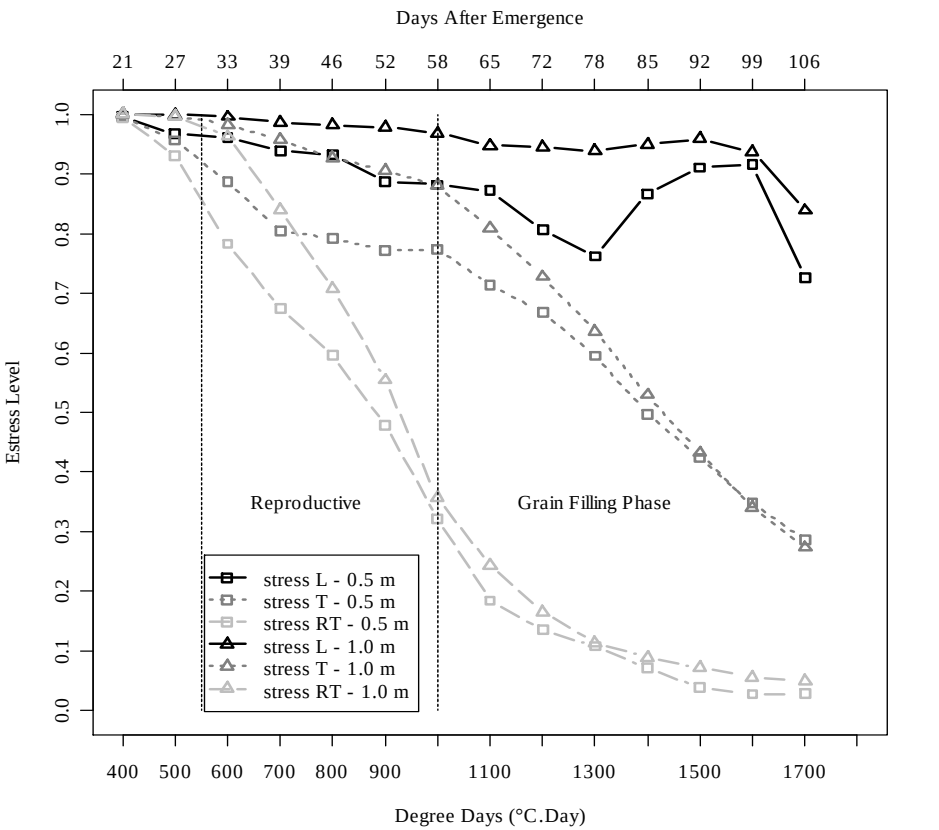


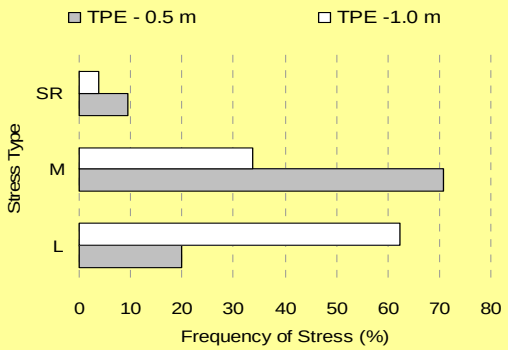
Results: Maize Stress Pattern

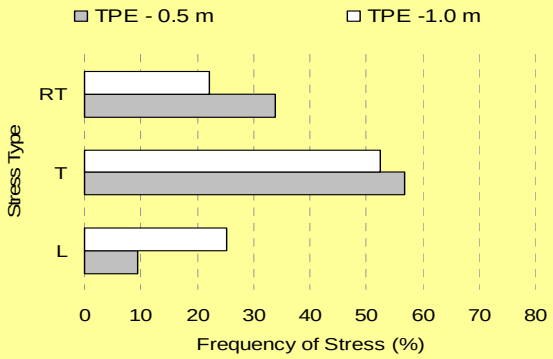
Stress Pattern Maize 1 Crop



Stress Pattern Maize 2 Crop

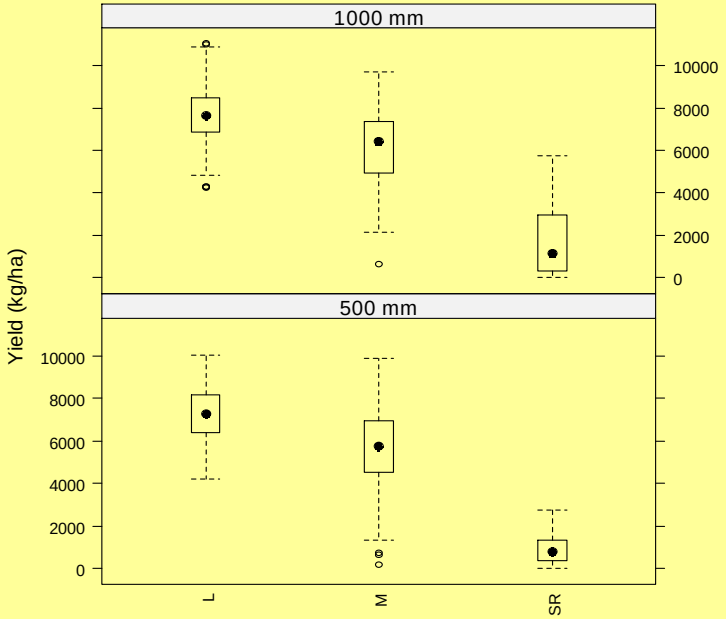


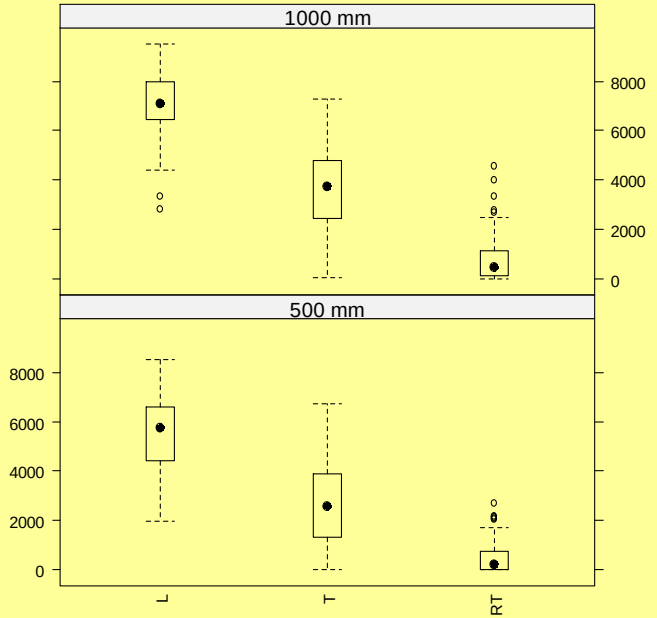




Results: Maize Stress Pattern

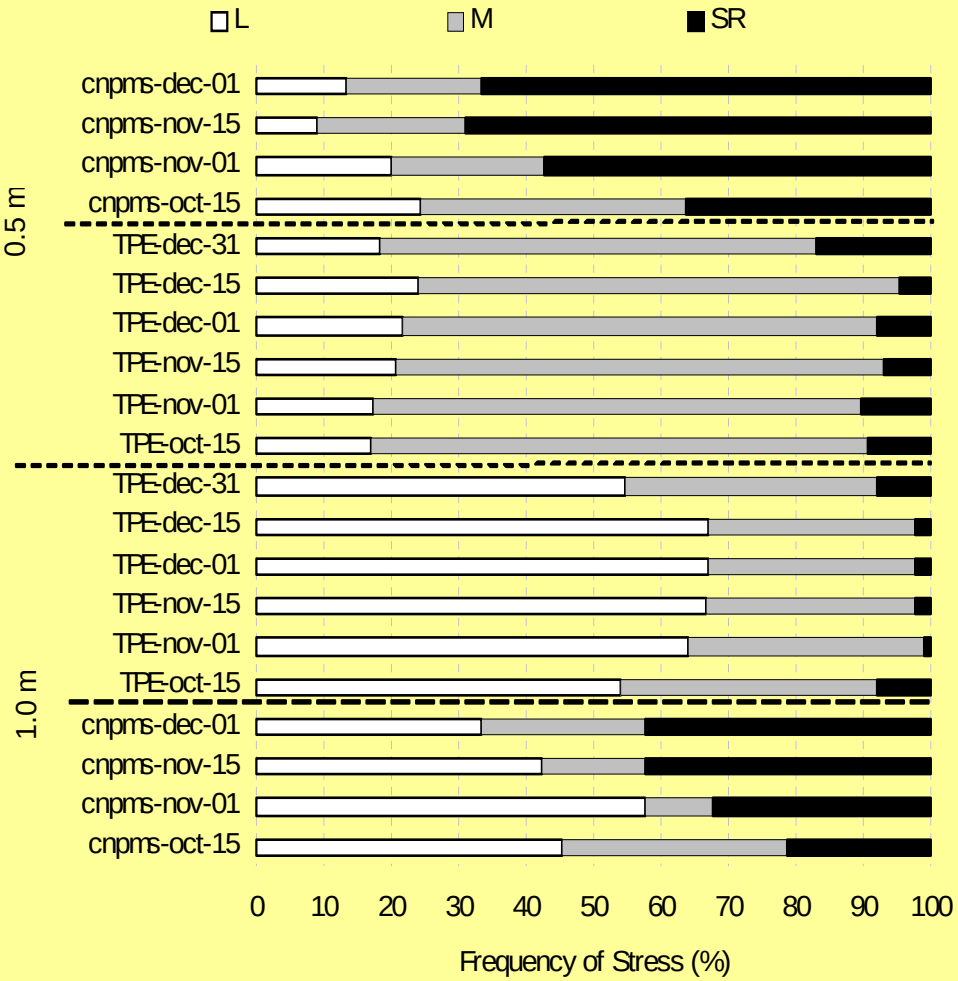
Soil Depth	Variable	Maize First Crop TPE Stress Type L	M	SR	Average	Maize Second Crop TPE Stress Type L	T	RT	Average
Deep 1.0m (maize)	*GYpot (kg.ha^{-1})	7725	8117	8978	7908	8065	8342	8923	8317
	**sd (kg/ha)	1246	1211	1001		799	980	1205	
	***GYatt (kg/ha)	7638	6161	1739	6900	7141	3639	786	3850
	sd (kg/ha)	1219	1797	1642		1199	1582	906	
	****RWSI (%)	1	24	81	12	11	56	91	52
	Stress Frequency (%)	62	34	4		25	52	22	
Shallow 0.5m (maize)	GYpot (kg/ha)	7430	7964	8480	7904	7983	8244	8781	8398
	sd (kg/ha)	1272	1238	1023		966	918	1133	
	GYatt (kg/ha)	7271	5661	945	5559	5547	2630	463	2214
	sd (kg/ha)	1218	1754	781		1634	1574	575	
	RWSI (%)	2	29	89	29	31	68	95	73
	Stress Frequency (%)	20	71	9		11	55	34	



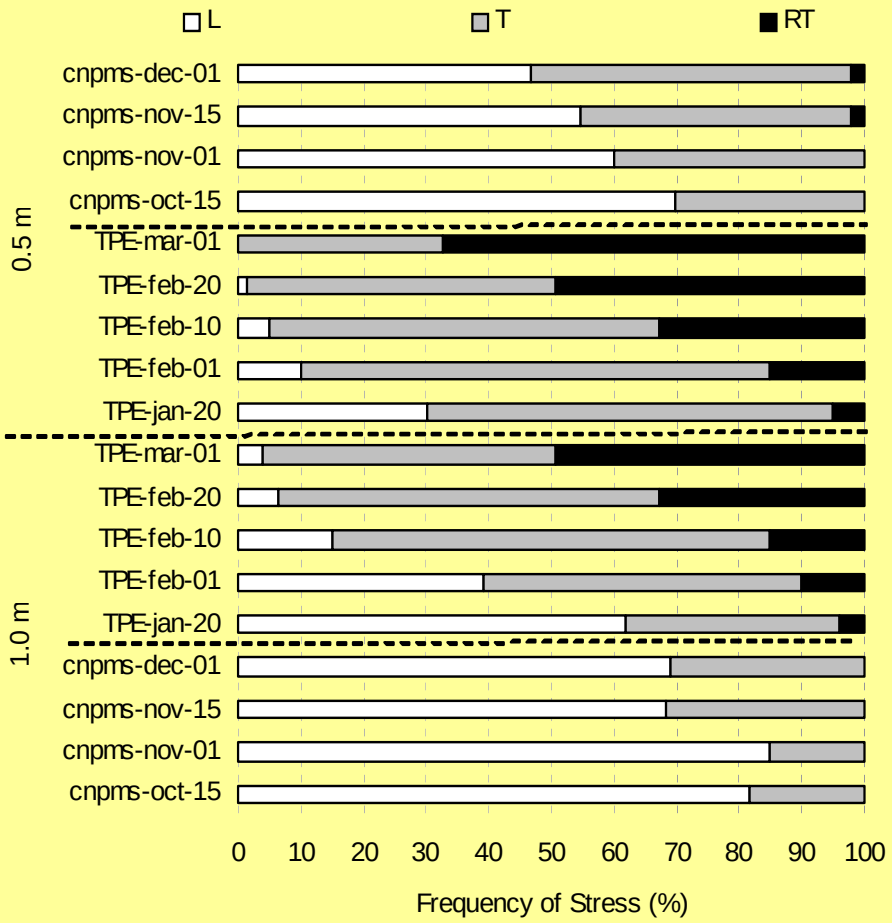


Results: Maize Stress Pattern

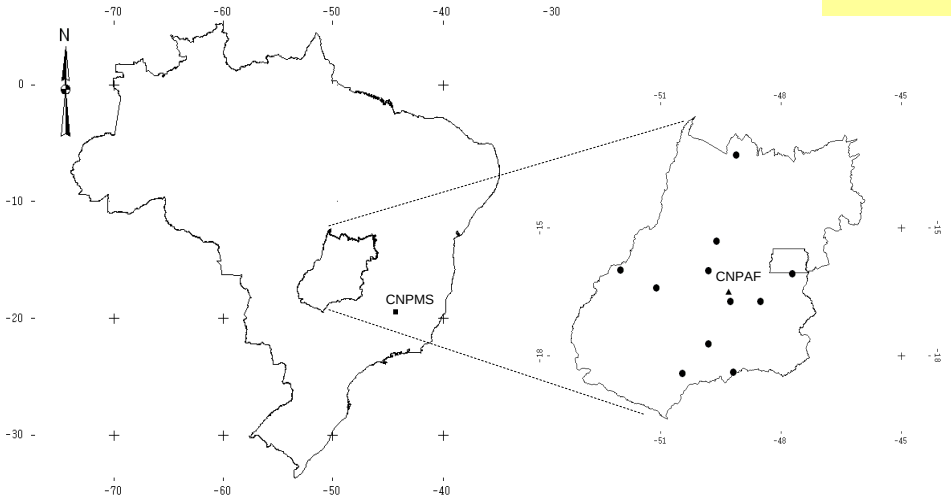
Maize 1 Crop Frequency Stress Pattern

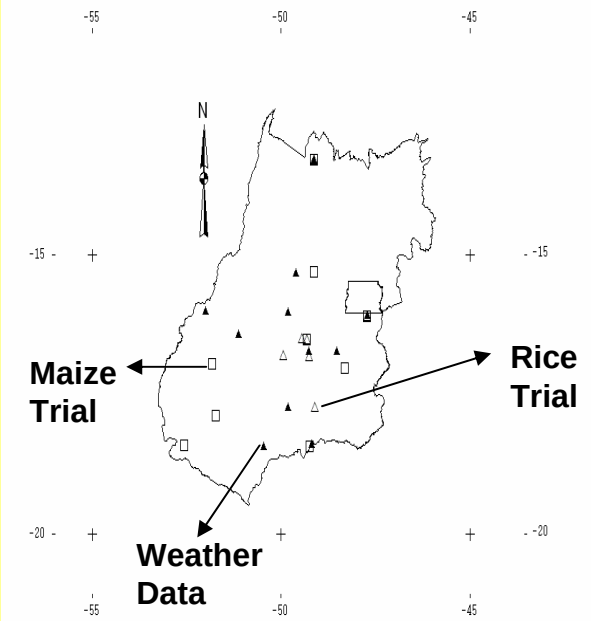


Maize 2 Crop Frequency Stress Pattern



Results : Maize Summary





Conclusion

- for upland rice, with no physical restrictions on root development, the stress level does not limit breeding for potential yield;
- for maize as first crop, with no physical restrictions on root development, the stress level also does not limit breeding for potential yield;
- for maize as second crop, the breeding target should be “escape” (developing of earlier-season cultivars) and/or development of a drought breeding program specific for terminal stress.

Heinemann et al. (2007) Characterization of drought stress environments for upland rice and maize in central Brazil. **Euphytica**, DOI 10.1007/s10681-007-9579-z.