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DROUGHT RESPONSE INDICES FOR IDENTIFICATION OF DROUGHT TOLERANT GENOTYPES IN RAINFED UPLAND RICE (*Oryza sativa* L.)

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Abstract: Identification of suitable rice genotypes for rainfed condition is one of priority research area therefore, in order to quantify the drought tolerance genotypes, the rate of water response and contribution of yield components due to water availability of upland rice with different drought tolerance/resistant indices obtained from the yield data under rainfed upland and irrigated sets of experiment were examined with 17 IET cultures consisting 6 AVT-VE-DS, 10 IVT-VE-DS and 1 check variety Anjali. The crop received 464.6mm rainfall in 18 rainy days during vegetative phase and 108.8mm rainfall in only 3 rainy days between flowering to maturity stage. During this phase crop exposed to 2 distinct prolonged dry period (>10 days). Drought tolerance indices were varied significantly indicating genotypic variability. Different drought indices probably measure similar aspect of drought tolerance/resistance. The stress tolerance index (SIT), mean productivity Index (MPI), geometric mean productivity (GMP) and yield index (YI) were superior in genotype IET-23380, IET-24065 and IET-24068 indicating that they can be used as alternative for each other to select drought tolerant genotypes with high yield performance in both stress and non-stress conditions. The stress susceptibility index (SSI), tolerance (TOL), and yield stability index (YSI) were superior in the genotype IET-22743 closely followed by IET-24061 and IET-24062 indicated that SSI, TOL and YSI can be used to screen drought resistant and suitable genotypes under two reproductive stage drought condition.
Keywords: Stress tolerance index, Geometric mean productivity, Mean productivity index.

INTRODUCTION

The scarcity of water will increase in the next two decades in many regions of the world. This will have significant social and economic repercussion. Rice production heavily depends on water availability while, drought is one of the most important constraint adversely affecting the yield in rainfed upland cultivation. India has witnessed severe drought in the year 2002, 2009 and 2012 which caused reduction of yield (21.5 in 2002 and 10.02 in 2009) million tons (Manjappa and Shailaja 2014). The timing of drought, early season, mid-season or terminal stage, has a major influence on how much yield loss occurs (Fischer *et al.* 2003).

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Variability of drought and yield attributing characters are prerequisite for the identification of drought tolerant high yielding genotypes. Rice is particularly sensitive to drought stress during reproductive growth, even under moderate drought stress (Hsiao 1982 , O'Toole 1982). In rice, moderate stress can be broadly characterized by a 31 to 64% loss in grain yield as compared with non-stress conditions (Kumar *et al.* 2008). The ability of crop cultivars to perform reasonably well in drought-stressed environments is paramount for stability of production. The relative yield performance of genotypes in drought-stressed and non-stressed environments can be used as an indicator to identify drought-resistant varieties for drought-prone environments. Several drought indices have been suggested on the basis of a mathematical relationship between yield under drought conditions and non-stressed conditions. These indices are based on either drought resistance or drought susceptibility of genotypes (Raman *et al.* 2012). Therefore, in order to quantify the drought tolerance in rice genotypes and contribution of yield components due to water availability of upland rice with different drought tolerance/resistant indices obtained from the yield data under rainfed upland stressed and irrigated non stressed condition experiments.

MATERIAL AND METHODS

17 IET rice genotypes consisting 6 AVT-VE-DS, 10 IVT-VE-DS and 1 check variety Anjali were tested under both rainfed and irrigated conditions at the instructional farm of JNKVV, College of Agriculture Rewa MP. The experiment was laid out in RBD with three replication in silty clay loam soil during kharif season on 2nd July 2013-14. Direct seeding was done in rainfed set of experiment while, transplanting was done in irrigated set on same dates. The irrigated experiment was considered to be a favorable condition so that plots were watered at planting, tillering, heading, flowering and grain filling stages. Nitrogen and phosphorus Potash fertilizers were appliedat the rate of 100:60:40 Kg/ha. Half dose of nitrogen + full doses of phosphorus Potash fertilizers at the time of sowing and remaining half dose of nitrogen in two equal doses at the time of tillering and panicle initiation stages of crop growth were applied. The total dry weight and grain yield were measured by harvesting per m^2 of each plot at crop maturity. The grain yield data were recorded for each genotypes at both environment (non stress-irrigated and drought stress) and were subjected to calculate drought selection indices. The drought tolerance/ resistance indices were calculated using the following formulas:

(1) Stress tolerance index, $\text{STI} = \frac{(Ys)(Yp)}{(Yp)2}$ (Fernandez, 1992)

(2) Mean productivity Index, MPI= $\frac{Ys+Yp}{2}$ (Hossain *et al.* (1990)

(3) Geometric mean productivity, GMP= $\sqrt{(Ys)\ (Yp)}$ (Ramirez and Kelly (1998)

(4) Yield index, YI = $\frac{Ys}{\overline{Ys}}$ (Gavuzzi *et al.* 1997)

(5) Stress susceptibility index, SSI = $\frac{1-Ys/\,Yp}{1-\overline{Ys}/\overline{Yp}}$ (Fischer and Maurer 1978)

(6) Stress tolerance, TOL = $Yp - \quad Ys$ (Rosielle and Hamblin 1981)

(7) Yield stability index, YSI = $\frac{Ys}{Yp}$ (Bouslama and Schapaugh 1984)

in which *Ys* denote the mean yield of genotype under stress and *Yp* the mean yield of genotype under non-stress (irrigated) conditions.

RESULT AND DISCUSSION

Weather condition

The crop received a total of 573.4 mm in 21 rainy days (Fig.1). During vegetative period the crop received 464.6 mm rain in 18 rainy days and the crop was not exposed to any dry spells during this period. Between flowering and maturity the crop receive 108.8 mm rain with only 3 rainy days. The crop during reproductive growth was exposed to 2 distinct prolonged dry periods of (>10 days).

Drought Indices

Different drought indices probably measure similar aspect of drought tolerance / resistance. Results obtained on mean yields of all genotypes evaluated under stress and non-stress (irrigated) conditions illustrated in fig.2, fig.3, fig.4, fig.5, fig.6, fig.7, fig.8. and Table1.

Stress tolerance index (STI)

Stress tolerance index (STI) varied significantly and genotype with high values indicated the tolerance to drought condition. Genotypes IET-23380 followed by IET-24065 and IET-24068 with high STI values indicating the tolerance towards the moisture stress while, genotype IET-24064, IET-24067 and IET-24071 has > 100 values showing susceptiblity to drought (Fig.2).

Mean productivity index (MPI)

The genotypes with high values of MPI is more desirable index. Significant variability was also found among the genotypes in mean productivity index (MPI) and genotype IET-23380, IET-24065, IET-24068 and IET-24070 with high MPI values(<350) indicating tolreance (Fig.3).

Geometric mean productivity (GMP)

Geometric mean productivity (GMP) is more desirable index during while judging the genptypes for drought tolerance and genotype IET-23380, IET-24065 and IET-24068 showing higher values as in case of STI and MPI cross testing the genotypes suitable for drought condition. Similarly lower values of GMP was noted in the genotypes IET-24064, ITE-24067 and IET-24071 showing susceptiblity to drought and all other genotypes were intermediate (Fig.4).

Tolerance (TOL)

The genotypes with low values of this index (TOL) are more stable in two different conditions and suitable for the screening of breeding materials for drought tolerance. Significant variability were found amongst the genotypes for tolerance (TOL) and rice genotypes IET-22743, IET-24061 and IET-23383 exhibited the lower TOL values and Genotypes IET-24070, IET-24064 and IET-24063 higher TOL values indicating nonsuitability for the drought conditions while all other genotypes were intermediate (Fig.5). Similar results were recorded by several workers for Selections based on these indices (Pantuwan *et al*. 2002, Ouk *et al.* 2006 and Sio-Se Mardeh *et al*. 2006).

Stress susceptibility index (SSI)

Ys and Yp are the mean yield of genotypes under stress and non stress conditions and the genotypes with SSI < 1 are more resistant to drought conditions. Result indicated that the genotype IET-22743 had the lowest SSI followed by IET-24061, IET-24062 and IET-23383 exhibited resistance to drought while, genotypes IET-24061 followed by IET-24064, IET-24063 and IET-24069 exhibited susceptibility and all other genotypes were intermediate in nature (Fig.6).

Yield Stability Index (YSI)

The genotypes with high YSI values can be regarded as stable genotypes under stress and non stress conditions. Significant differences were found amongst the genotypes for YSI and and as in case of SSI the genotype IET-22743 had the highest YSI followed by IET-24061, IET-24062 and IET-23383 exhibited stability to stress while, genotypes IET-24070 followed by IET-24064 and IET-24063 had lower values exhibited unstability under stress and all other genotypes were intermediate in nature (Fig.7). Similar findings on these indices were carried out by many authors (Garrity and O'Toole 1995, Pantuwan *et al*. 2002 , Ouk *et al*. 2006, Sio-Se Mardeh *et al*. 2006 , Kumar *et al*. 2008 and Raman *et al*. 2012).

Yield Index (YI)

The genotypewith high values of Yield index (YI) found suitable for drought condition. The genotype had >1 value considered tolerant while, the genotypes having <1 value denoted as susceptible one. The genotypes IET-23380, IET-24065 and IET-24068 showing higher values as in case of STI and MPI and GMP cross testing the genotypes suitable for drought condition. Similarly lower values of YI was noted in the genotypes IET-24064, ITE-24069 and IET-24070 exhibited susceptiblity to drought and all other genotypes were intermediate (Fig.8).

CONCLUSION

Study indicated that selection based on drought indices will result in the identification of genotypes with significantly higher performance under moderate to severe drought on the cost of slightly lower yield under normal irrigated condition. Among 17 genotypes, the combination of seven drought indices and deviation identified IET-23380, IET- 24065 and IET-24068 as three promising high-yielding drought-tolerant genotypes as the stress tolerance index (SIT), mean productivity Index (MPI), geometric mean productivity (GMP) and yield index (YI) were superior indicating that they can be used as alternative for each other to select drought tolerant genotypes with high yield performance in both stress and non-stress conditions. The stress susceptibility index (SSI), tolerance (TOL), and yield stability index (YSI) were superior in the genotype IET-22743 closely followed by IET-24061 and IET-24062 indicated that SSI, TOL and YSI can be used to screen drought resistant and suitable genotypes under two reproductive stage drought condition.

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Tables and Figures

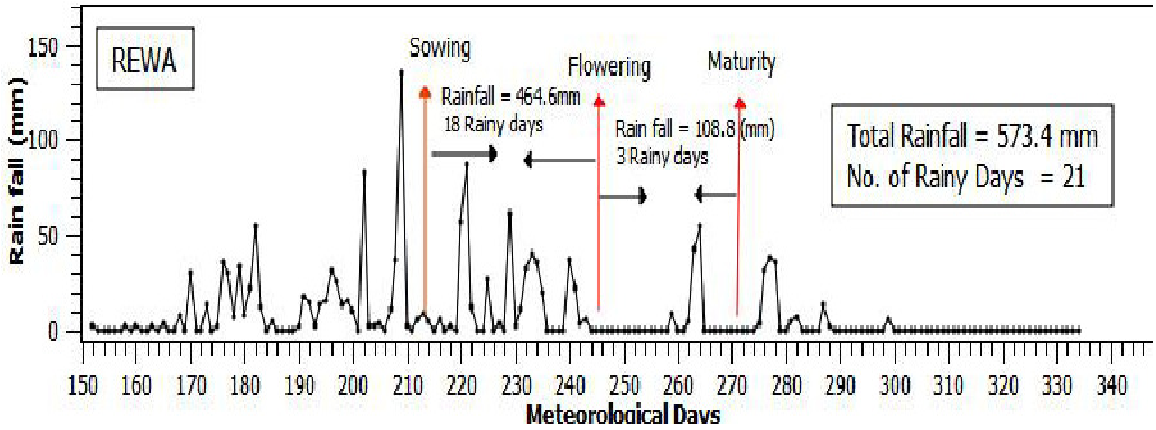

Figure 1. Rainfall distribution and number of rainy days during pre and post flowering crop growth period.

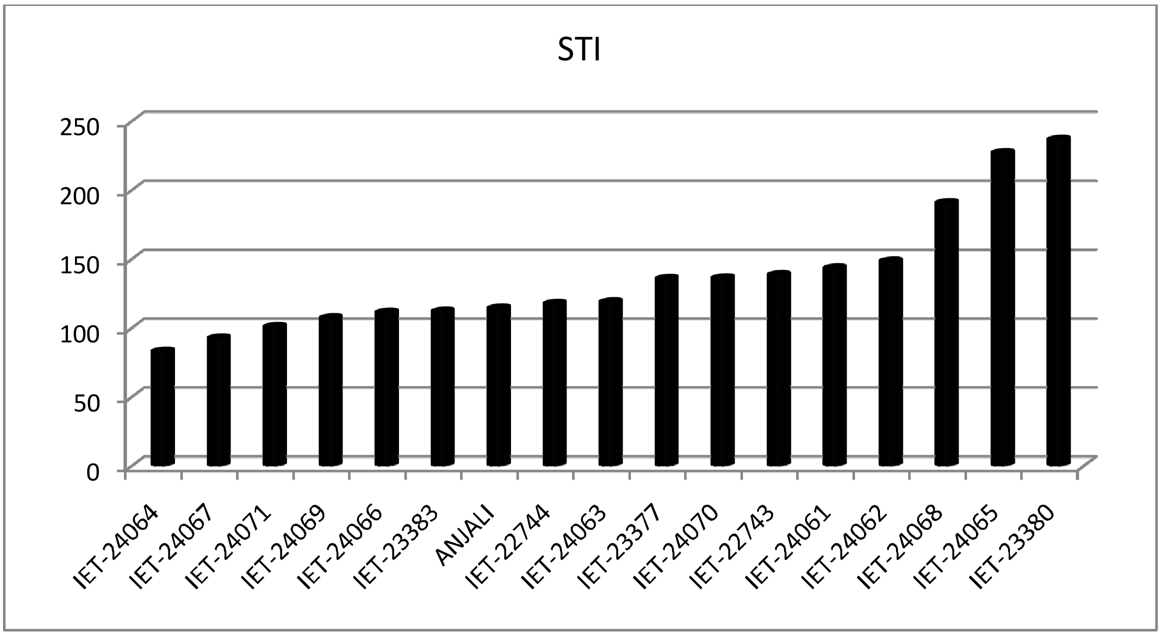

Figure 2. Variability of stress tolerance index (STI) of different rice genotypes as a function of non stress and drought stress upland condition

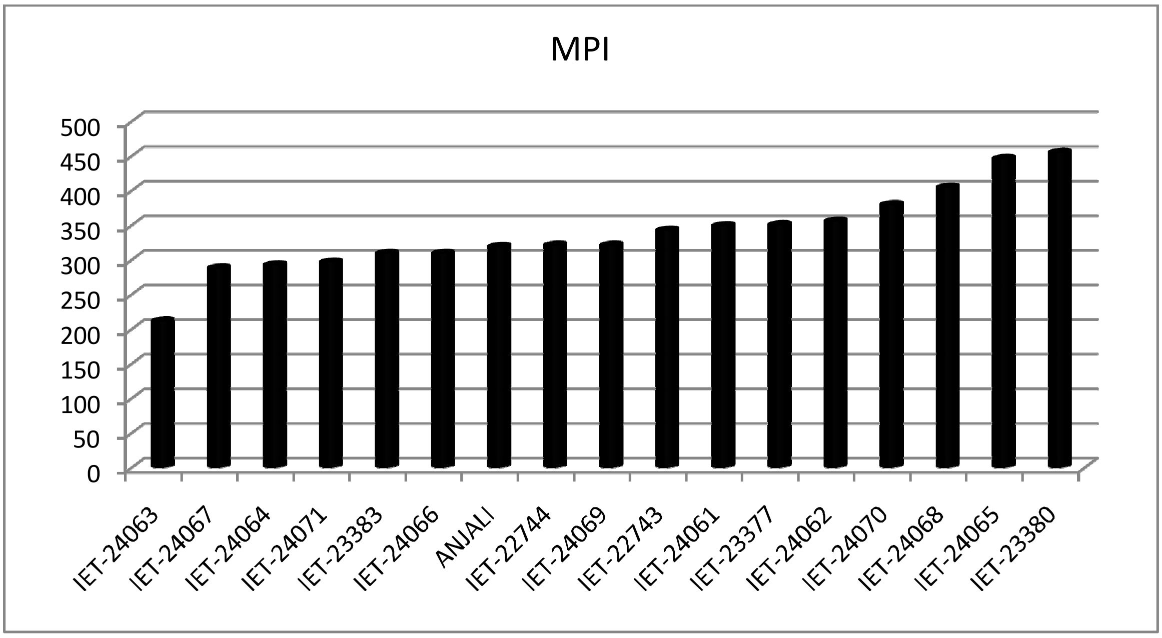

Figure 3. Variability of mean productivity index (MPI) of different rice genotypes as a function of non stress and drought stress upland condition.

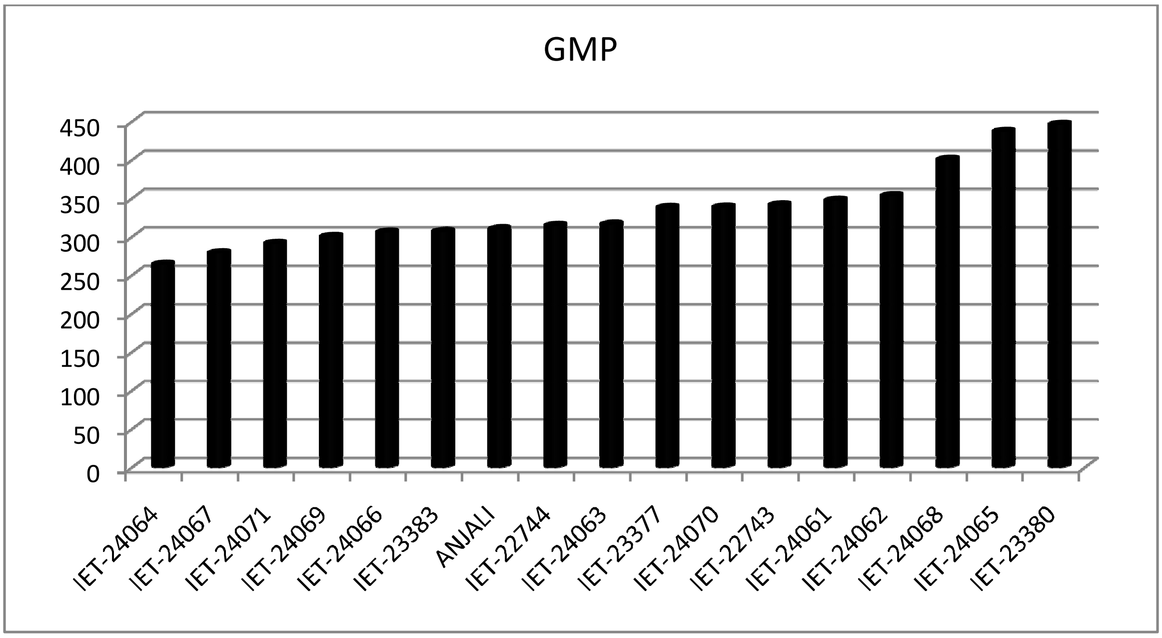

Figure 4. Variability of Geometric mean productivity (GMP) of different rice genotypes as a function of non stress and drought stress upland condition.

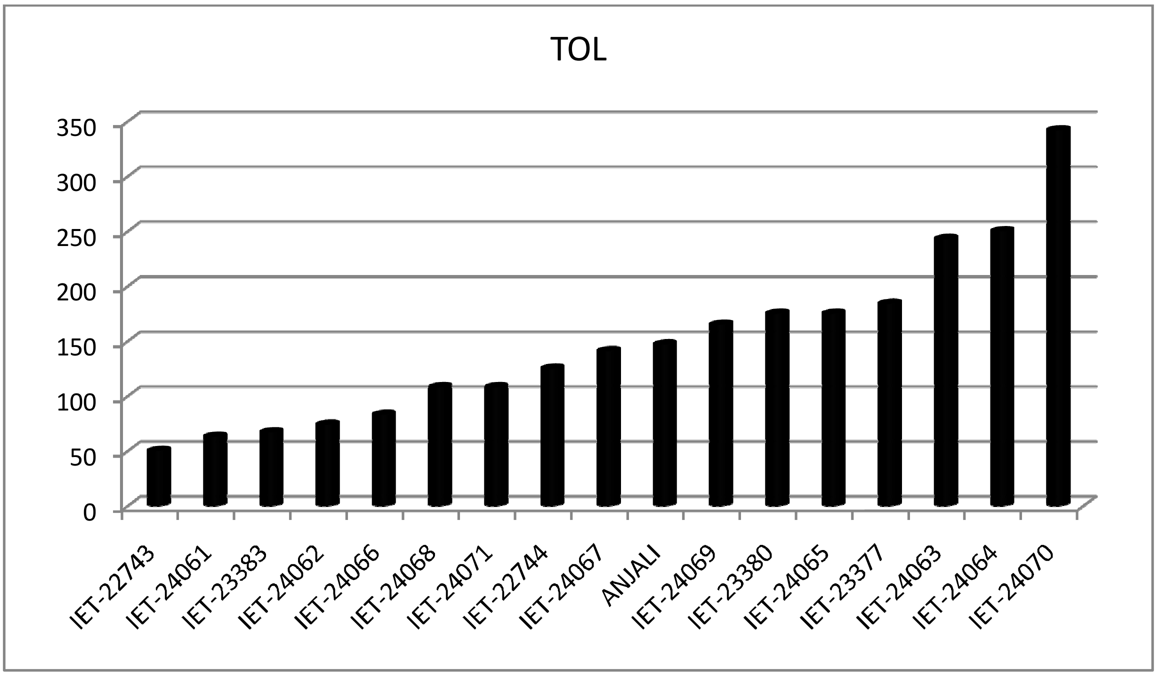

Figure 5. Variability of stress tolerance (TOL) of different rice genotypes as a function of non stress and drought stress upland condition

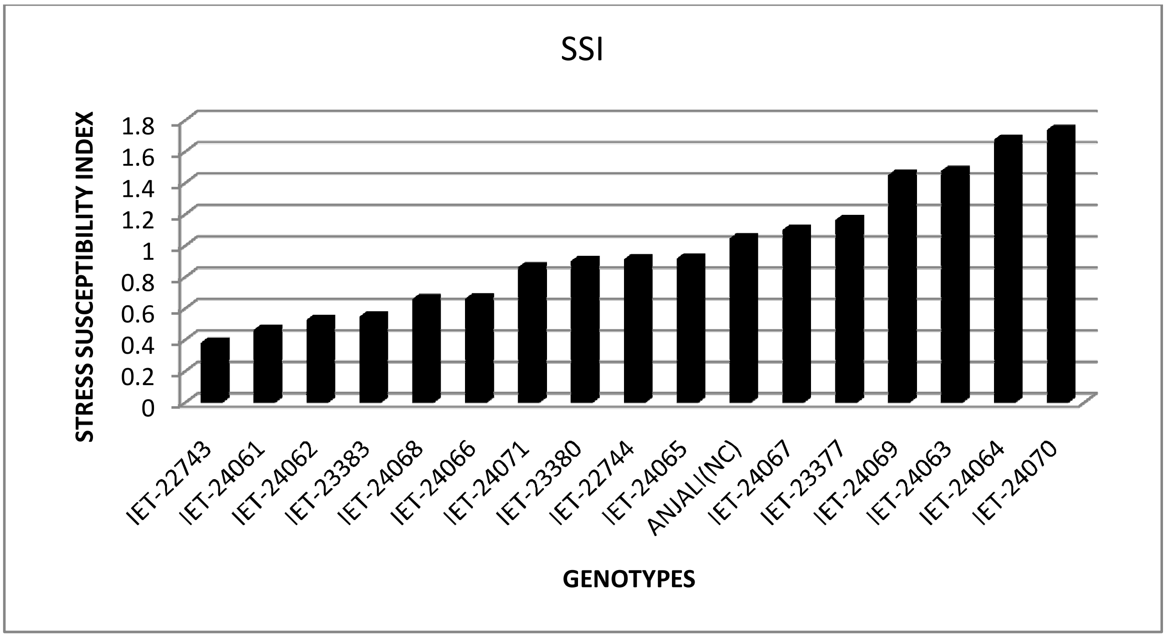

Figure 6. Variability of stress susceptibility index (SSI) of different rice genotypes as a function of non stress and drought stress upland condition

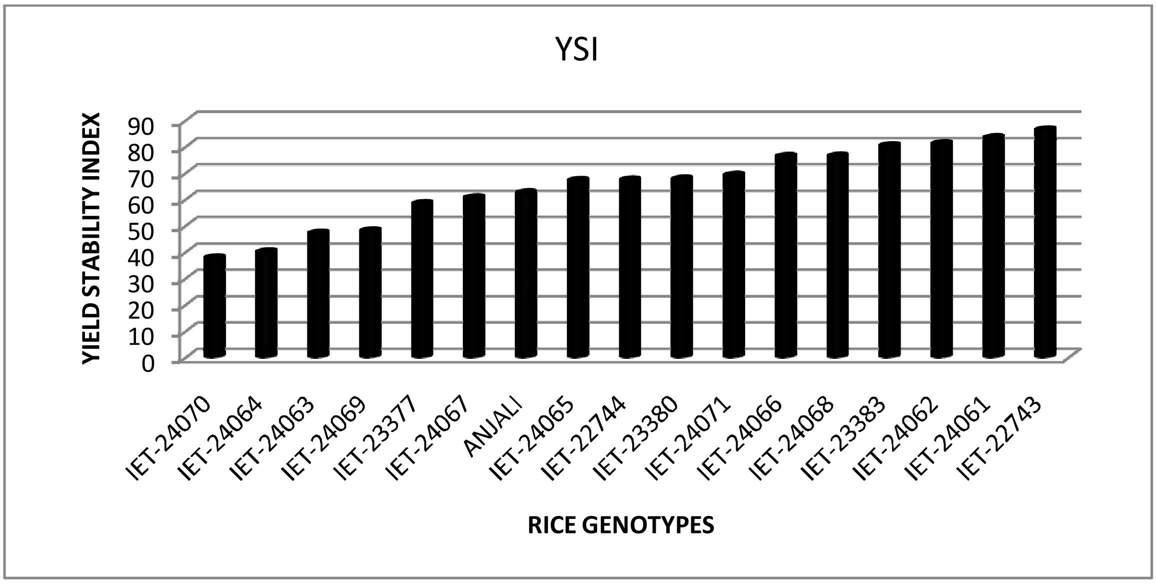

Figure 7. Variability of yield stability index (YSI) of different rice genotypes as a function of non stress and drought stress upland condition

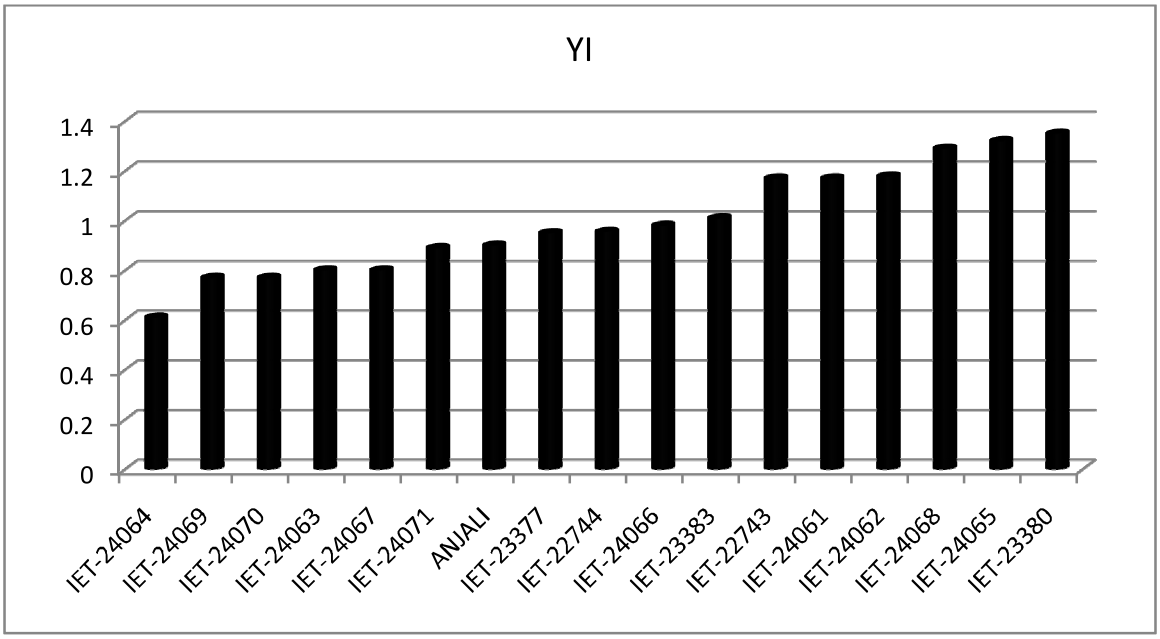

Figure 8. Variability of yield index (YI) of different rice genotypes as a function of non stress and drought stress upland condition

Table 1. Mean comparison of drought tolerance indices and grain yield of rice genotypes under both non stress (Y*ns* -irrigated) and drought stress(Y*s*) condition

Genotypes	Y*ns*	Y*s*	STI	MPI	GMP	TOL	SSI	YSI	YI
IET-22743	367	317	138.32	342	341.08	50	0.381	0.86	1.17
IET-22744	383	258	117.49	320.5	314.34	125	0.912	0.67	0.95
IET-23377	442	258	135.58	350	337.69	184	1.163	0.58	0.95
IET-23380	542	367	236.51	454.5	445.99	175	0.902	0.67	1.35
IET-23383	342	275	111.82	308.5	306.67	67	0.547	0.8	1.01
IET-24061	380	317	143.22	348.5	347.07	63	0.463	0.83	1.17
IET-24062	392	318	148.21	355	353.06	74	0.527	0.81	1.17
IET-24063	460	217	118.68	211	315.94	243	1.476	0.47	0.81
IET-24064	417	167	82.81	292	263.89	250	1.675	0.4	0.61
IET-24065	533	358	226.87	445.5	436.82	175	0.917	0.67	1.32
IET-24066	350	267	111.11	308.5	305.69	83	0.662	0.76	0.98
IET-24067	358	217	92.36	287.5	278.72	141	1.1	0.6	0.8
IET-24068	458	350	190.6	404	400.37	108	0.659	0.76	1.29
IET-24069	433	208	107.08	320.5	300.1	165	1.451	0.48	0.77
IET-24070	550	208	136.02	379	338.23	342	1.737	0.37	0.77
IET-24071	350	242	100.71	296	291.03	108	0.862	0.69	0.89
ANJALI	392	245	114.19	318.5	309.9	147	1.047	0.62	0.91
Mean	420.52	269.94	135.97	337.73	334.5	147.05	0.969	0.649	0.995
CD(P<0.05)	35.8	19.3	10.2	27.7	27.3	11.3	0.22	0.19	0.23