Drought Stress and Variability Assessment among Indica Rice Lines at Early Growth Stage

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Introduction

- Rice feeds nearly half of the world's population. More than 90% of the total rice in the world is produced and consumed in Asia [1].
- Cultivated rice (*Oryza sativa* L.) in Asia can be categorized into two groups: indica and japonica subspecies, but indica species are the most widely grown in Asian countries.
- Rice production is threatened by several abiotic stresses, of which drought stress is the most devastating abiotic stress [2].
- Drought stress is mainly caused by successive increased water shortage and uneven distribution of rainfall [3].
- Rice is generally considered as sensitive to drought, which greatly affects its growth and development, particularly at seedling stage, resulting in reduced canopy growth and thus lower yield [4].
- Therefore, it is very important to study drought stress effects at early seedling stage in order to avoid yield losses. Also, developing screening methodology to identify lines with greater tolerance will be beneficial for future breeding programs.

Hypothesis and Objectives

- We hypothesized that the selected lines will show high variability for drought stress tolerance during seedling stage.
- The objectives were to assess the phenotypic variability and the phenotypic effect of drought stress among the 75 rice lines at seedling stage.
- To screen and categories the selected rice lines for drought stress into different groups, based on root and shoot morpho-physiological parameters.

Materials and Methods

- Location: Rodney Foil Plant Science Research facility MSU
- PVC plastic pots (15.2 cm diameter and 30.5 cm height)
- Soil medium consisting of 3:1 sand: loam (clay), 500 g of gravel
- Eight seeds/pot, but thinned to one plant per pot 10 days after emergence
- Randomized complete block design with 4 replications
- 75 rice lines obtained from IRRI
- Optimum water and nutrient conditions in sunlit
- Irrigated three times a day with standard Hoagland's nutrient solution

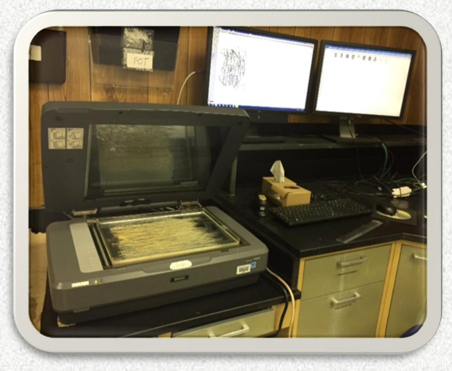



Treatments:

- Treatments were imposed 1 week after emergence
- Control (100%) and drought with 50% soil moisture
- Maintained for 20 days
- Harvested at 30 days

Measurements

- **Soot Parameters:**
  - ✓ Plant height (PH)
  - ✓ Total number of tillers (TL)
  - ✓ Leaf numbers on main tiller
  - ✓ Above ground biomass
  - ✓ Leaf Area (LA)
  - ✓ Leaf dry weight
  - ✓ Stem dry weight
  - ✓ Leaf chlorophyll content
- **Root Parameters:**
  - ✓ Cumulative root length (RCL)
  - ✓ Root surface area (RSA)
  - ✓ Average root diameter(RAD)
  - ✓ Root volume (RV)
  - ✓ Number of roots (RN)
  - ✓ Number of tips (RNT)
  - ✓ Number of forks (RNF)
  - ✓ Longest Root length (LRL)


Results and Discussion

Table 1. Analysis of variance (ANOVA) of rice growth and development aspects as affected by treatment variables.

Source	PH	TN	LA	LW	SW	TD	SPAD	FO	FM	FVFM
Drought (D)	***	***	***	***	***	***	***	NS	NS	NS
Lines (L)	***	NS	***	***	***	***	***	**	**	*
D*L	NS	NS	**	NS	NS	NS	NS	NS	NS	NS

Source	RW	LRL	RL	RSA	RAD	RV	RT	RF	RC
Drought (D)	***	NS	NS	NS	***	NS	*	NS	**
Lines (L)	***	***	***	***	***	***	**	***	***
D*L	NS	NS	NS	NS	NS	NS	NS	NS	NS

*The significance levels *** and ** represent P< 0.001 and 0.01, respectively, while NS is non significant.*

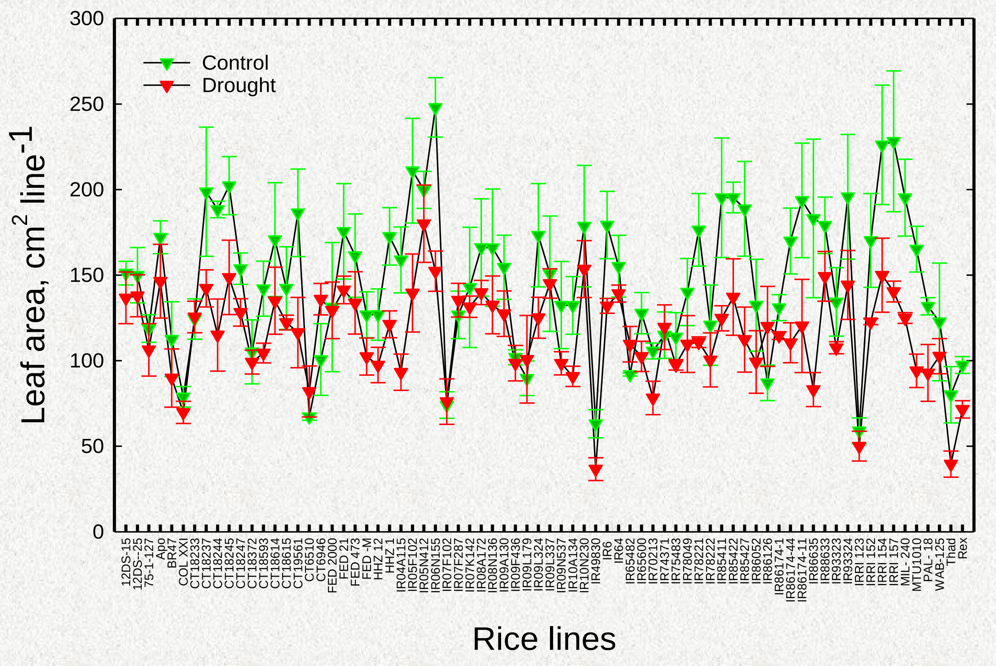


Fig. 1. Drought stress effects on leaf area measured 30 days after planting.

- Leaf area decreased significantly at drought stress for all the lines. However, there were no significant differences in the leaf area among the lines for the same treatment (Fig. 1).
- Similarly, there was no significant interaction between the lines and the drought for all the morphological parameters except for leaf area.

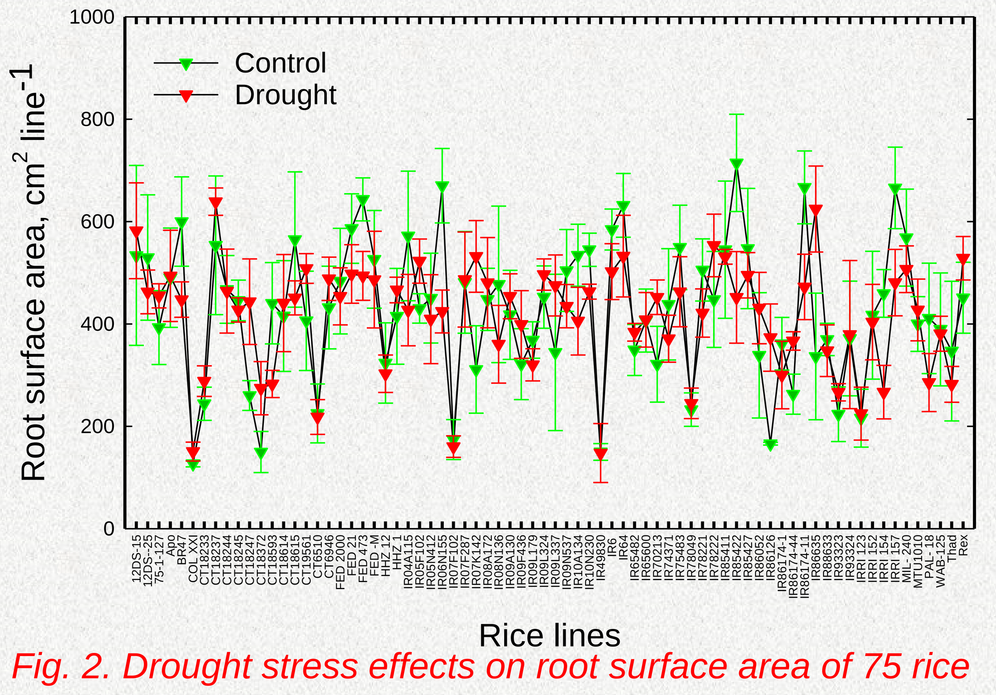


Fig. 2. Drought stress effects on root surface area of 75 rice lines measured 30 days after planting.

- Some of the root parameters like root weight (RW) and average root diameter (RAD) were found highly significant both because of drought stress and the lines but had no significant interactions.
- Other root parameters like root length (RL), surface area (RSA) and root volume were not significantly different between the treatments.

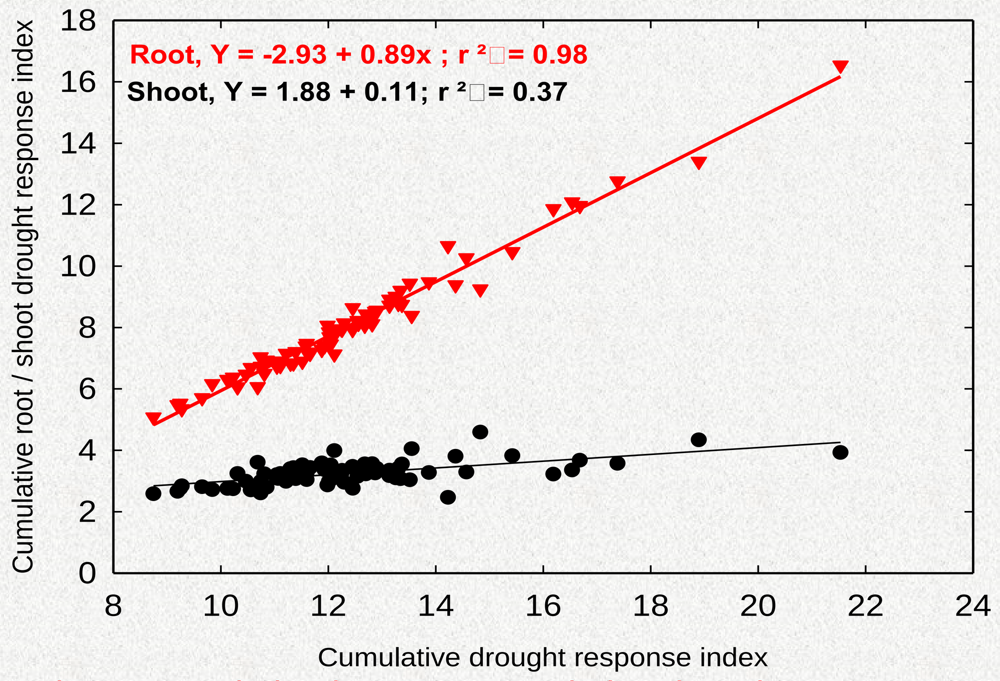


Fig. 3. Correlation between cumulative drought response index and cumulative root or shoot drought response index.

- The correlation of root parameters with cumulative drought response index was found much higher (**r^2 = 0.98**) than with the correlation between the shoots parameters with drought index (**r^2 = 0.37**)
- It indicates that the root parameters are more important than the shoot parameters in screening for drought tolerant cultivars.

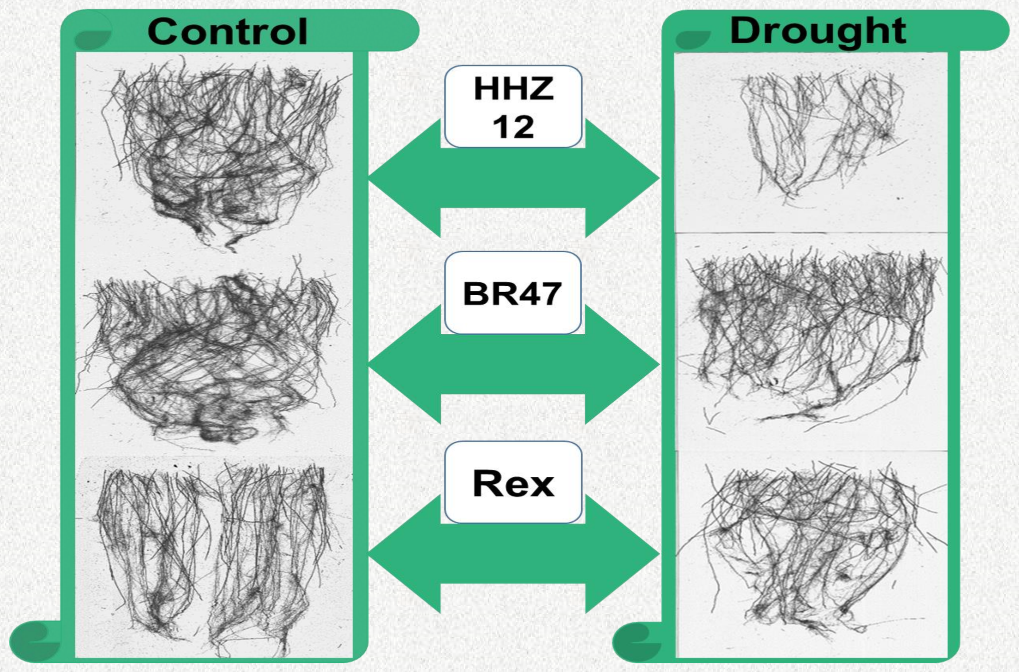


Fig. 4. Pictorial representation of root systems under control and drought stressed treatments for select rice lines.

- **Fig. 4.** Shows is a comparison of the root growth and development of the same rice lines under control and drought stress conditions.
- Drought stress has affected the root growth and development of rice lines and has turned the highly vigorous, compact and deep root system into a less vigorous, loose and shallow root system.

Classification for drought stress

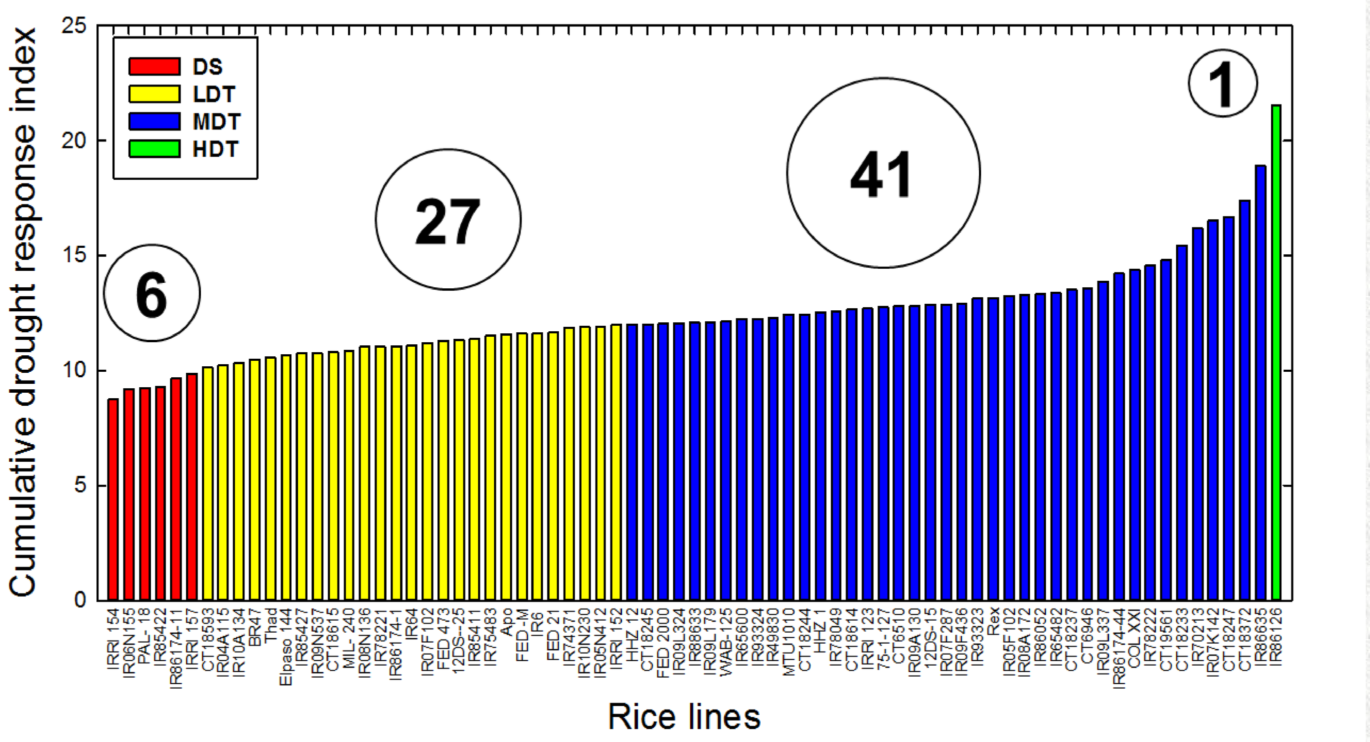


Fig. 5. Categorization of rice lines into different groups based on cumulative drought response indices.

- The cumulative drought response indices and their standard deviations were used to classify the 75 rice lines into 4 different categories (Fig. 5)
- **Drought susceptible (DS):** Out of the total 75 line six lines were classified as drought susceptible. These lines couldn't develop an extensive root system and probably were unable to uptake and hold water and nutrients for a longer period of time.
- **Low Drought Tolerant (LDT):** 27 cultivars were classified as low drought tolerant lines.
- **Moderate Drought Tolerant (MDT):** More than half (54.6%) of the total lines were classified as moderately drought tolerant.
- **High Drought Tolerant (HDT):** Only one lines (IR86126-104-B-B) was classified as highly drought tolerant, having significantly higher values for almost all the root and shoot parameters.

Summary and Conclusions

- The selected rice lines showed a huge variability for all the morphological parameters, but physiological parameters were not significantly affected by drought stress.
- Shoot parameters were affected more than the root parameters. Leaf area was observed as highly significant and most critical among all the shoot parameters.
- Drought stress affected both root and shoot parameters but response to drought stress was more effectively explained by the root parameters than the shoot parameters.
- The stronger, vigorous and extensive the root system, the higher the drought tolerance of a line and vice versa.
- Most of the lines (54.6%) were found moderately tolerant to drought stress.
- The highest and the least drought tolerance was found in the rice lines "IR86126-104-B-B" and "IRRI 154 " respectively.
- The wide range of variability in morphological parameters and the broad chain of response to drought stress makes research on drought stress desirable, especially for breeding purposes in order to produce drought tolerant cultivars/hybrids for drought-prone environments.

References

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