Iron Toxicity Tolerance of Improved Rice Varieties in the Low Country Wet Zone of Sri Lanka

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Abstract

In order to evaluate the impact of iron rich adverse soil on the improved rice varieties of Sri Lanka, a field experiment was carried out, in two seasons of 2012/13 *Maha* and 2012 *Yala*. Thirty seven improved rice varieties were tested in this study. Extractable soil iron (Fe) level of tested locations varied from 245ppm to 326ppm during the evaluation period. Design of the experiment was an augmented method with two replicates for each entry and rice plant reactions for Fe toxicity were evaluated by using the IRRI standard evaluation system. Among the tested rice varieties, two varieties (*Bw* 267-3, *Bw* 367) performed as highly Fe tolerant varieties and twelve varieties (*Bw* 451, Bg 360, Bg 406, Bw 364, At 354, Bg 358, Bw 363, Bg 379-2, Bg 359, Bg 454, Bg 250, Bg 96-741) were recorded to have field level of tolerance. Twenty rice varieties were moderately tolerant (Bg305, *Bg* 357, *Bg* 403, *Bw* 361, *Bg* 94-1, *Bg* 3-5, *At* 308, *Ld* 408, *Bw* 452, *Bw* 453, *Bw* 351, *At* 307, *At* 303, *Ld* 365, *At* 362, *Bg* 38, *Bg* 300, *Bg* 745, *Bg* 450, *Ld* 368) and three rice varieties (*Bw* 272-6b, *Bg* 407 and *At* 303) were highly susceptible. Variations of rice varietal reactions were observed during the stress period where highly tolerant varieties grew normally without leaf bronzing symptoms, tolerant cultivars remained green until later stage of plant growth (88 days) while moderately tolerant varieties developed leaf bronzing symptoms at least once in the growth period especially at panicle initiation and susceptible varieties had prominent leaf bronzing symptoms throughout the evaluation period.

Key words: Rice, Iron toxicity, Rice varieties,

Introduction

Iron toxic paddy fields of low country wet zone of Sri Lanka belong to different agro ecological zones defined as WL_{1a}, WL_{1b}, WL_{2a}, WL_{2b}, and WL_3. The ferrous iron toxicity in the gleyic paddy soils is reported to reduce the rice yield and toxicity is triggered by multiple nutritional deficiencies, anaerobic conditions, and low pH and by high level of Fe in the soil. The Department of Agriculture (DOA), Sri Lanka has released more than sixty improved rice varieties up to 2012 and recommended them for different agricultural practices in Wet, Dry and Intermediate zones based on the rice varietal characteristics. Some of the rice varieties were recommended as more suitable for the locations having specific conditions namely Fe toxicity, salinity, bog soil, and sandy soils. Regional Rice Research and Development Centre (RRRDC), Bombuwela is developing iron tolerant rice varieties mainly for LCWZ of Sri Lanka in specific selected locations (Kivlawatta, Polgahamulla).

Rice varieties differ widely in Fe toxicity stress tolerance, and tolerant genotypes are utilized to improve rice cultivars with enhanced Fe (ii) toxicity tolerance. The breeding efforts are facilitated by better understanding of efficient screening methodology of iron toxicity. In order to evaluate the impact of iron rich soil on growth of improved rice varieties of Sri Lanka, a field experiment was carried out in the wet zone under rain fed conditions during two seasons of 2012/13 *Maha* and 2012 *Yala*. The experiment was conducted at RRRDC, Bombuwela, under the purview of NARP research program of developing rice varieties for abiotic stresses. In the past years, several views have been discussed to explain mechanism of excessive uptake of Fe(ii) and special attention was paid to low pH and high concentration of the Fe(ii) in the soil (Ponnmperuma 1977). Rice plants absorb iron as Fe (ii) and are transported to leaves through xylem. Under anaerobic soil conditions, Fe (iii) is converted to Fe (ii)

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and rice plants absorb them excessively and causing damage to plant by oxidative injuries. Characteristic Leaf bronzing symptoms in susceptible rice varieties grown under iron rich soil are caused by precipitation and deposition of ferric compound in the appoplast . Critical ferrous levels range between 30 and several thousand ppm (Moomann and Van Bremen, 1978).

Materials and Methods

The experiment was conducted by the Rice Research & Development Centre (RRRDC), Bombuwela, Sri Lanka, in a location of low land paddy field adjacent to a upland. Inbred seeds of popular improved rice varieties (37) were used and the design of the experiment was an augmented method with two replicates for each entry. The rice variety Bw 267-3 and rice variety Bw 272-6b were used as tolerant and susceptible check varieties, respectively. The field evaluations were conducted in two seasons of 2012 *Yala* and 2012/13 *Maha.* Dry sowing of rice seeds in rows was done and evaluations were done at two weeks interval up to twelve weeks using standard evaluation system for rice iron toxicity tolerance (SES) published by the International Rice Research Institute (IRRI) guidelines and observed general growth condition in relation to standard resistant (Bw 267-3) and susceptible (Bw 272 6b) check varieties (Manual for rice stress evaluations IRRI, 1997).

Iron toxicity	
Scoring	**Tolerance Level**
1	Growth and tillering nearly normal
2	Growth and tillering nearly normal,redish brown spots on tips of older leaves
3	Growth and tillering nearly normal,older leaves reddish brown
5	Growth and tillering retarded,many leaves discoloured
7	Growth and tillering ceases,most leaves dead
9	All plants dead or dying

Based on the observations made and using the SES evaluation criteria considered in scoring and grouping them into highly tolerant, tolerant, moderate and susceptible varieties and conclusions were not made for the rice varieties that had observations only in one season. The DOA recommended agricultural practices were applied when necessary and only the basal fertilizer (Urea) was applied at the rate of 3.5g/m^2. In 2012 *Yala* season, 38 rice varieties were tested and soil samples were collected *to* analyze soil characteristics. In 2012/13 *Maha* season *36* test entries were evaluated. Physico-chemical characteristics of soil samples were tested and weather records were obtained from the Meteorology Unit of the Agronomy Division of RRRDC, Bombuwela.

Results and Discussion

Soil Characterization

Extractable iron (Fe) content ranged from 245 ppm to 326 ppm, while soil pH fluctuated from 4.8 to 6.32. Available phosphorus content ranged from 8.63 ppm to 11.29 ppm. Soil K content had a range from 26 ppm to 32 ppm and the soil was sandy loam in nature.

Climatic data

Recorded total rain fall in the 2012 *Yala* was 826.6 mm (May to July) and the average day temperature was 30.2 °C , while in 2012/13 *Maha* (November to February) total rain fall was recorded as 710 mm and the mean day temperature was 30.8 °C.

Highly tolerant varieties

Plant growth is nearly normal during the evaluation period and bronzing leaf symptoms were absent in highly tolerant varieties (Bw 267-3, Bw 367).

Tolerant varieties

Rice varieties of Bw 451, Bg 360, Bg 406, Bw 364, At 354, Bg 358, Bw 363, Bg 379-2, Bg 359, Bg 454, Bg 250,

Table 1. Iron toxicity tolerance levels of rice varieties in 2012 Yala season

Treatment	Reaction to iron toxicity (2012 *Yala*)			
	Average scoring (R1)	Average scoring (R2)	Tolerance level	Special attributes
Bw 267-3	1	1	HT	3.5 months
Bw 272-6b	7	9	S	3 months
Bw 367	1	1	HT	3.5 months
Bw 361	5	1	MR	3.5 months
Bw 379-2	1	3	T	4.5 months
Bw 359	1	3	T	3.5 months
Bg 450	3	5	MR	4.5 months
Bg 745	3	5	MR	Photoperiod sensitive 5-6 months
Bg 403	3	5	MR	4 months
Bg 357	3	5	MR	3.5 month
Bg 305	3	5	MR	3 months
Bg 300	3	5	MR	3 months
Bw 363	1	3	T	3.5 month
Bg 38	3	5	MR	Photoperiod sensitive 5-6 months
At 362	5	5	MR	3.5 month
Ld 365	5	5	MR	3.5 month, Recommended for LCWZ cultivation
At 303	5	3	MR	3 months
Bg 407	7	5	S	Photoperiod sensitive,4 months
Bg 358	1	3	T	3.5 months
At 307	3	5	MR	3 months
Bw 364	3	3	T	3.5 months
Bw 351	3	5	MR	3.5 months

Table 2. Iron toxicity tolerance levels of rice varieties in 2012/13 Maha season

Treatment	Reaction to iron toxicity (2012/13Maha)			
	Average scoring (R1)	Average scoring (R2)	Tolerance level	Special attributes
At 354	-	-	N.A	3.5 month, Salinity tolerant
Bg 96-741	-	-	N.A	4-4.5 months
Bw 267-3	1	1	HR	3.5 months
Bw 272-6b	7	9	S	3 months
Bw 367	1	1	HR	3.5 months
Bw 361	5	3	MR	3.5 months
Bw 379-2	1	2	T	4.5 months
Bw 359	1	3	T	3.5 months
Bg 450	3	5	MR	4.5 months
Bg 745	3	5	MR	Photoperiod sensitive 5-6 months
Bg 403	3	5	MR	4 months
Bg 357	3	5	MR	3.5 month
Bg 305	3	5	MR	3 months
Bg 300	3	5	MR	3 months
Bw 363	1	3	T	3.5 month
Bg 38	3	5	MR	Photoperiod sensitive 5-6months
At 362	5	5	MR	3.5 month
Ld 365	5	5	MR	3.5month, Recommended for LCWZ cultivation
At 303	5	3	MR	3 months
Bg 407	7	5	S	Photoperiod sensitive,4 months
Bg 358	1	3	T	3.5 months
At 307	3	5	MR	3 months
Bw 364	2	3	T	3.5 months
Bw 351	3	5	MR	3.5 months
Bw 453	5	5	MR	4-4.5 months

S-Susceptible, MR- Moderately tolerant, T-Tolerant, HR=highly tolerant N.A –Not available

R1- Replicate 1 R2- Replicate 2

Table 3 Variation of rice varietal reactions for iron toxicity

Toxicity Tolerant levels	Symptoms	Varieties
Tolerant	Reddish brown spots on tips of older leaves	Bg379-2,Bg359,Bw363,Bg 358,Bw 364,Bg 454,Bg 360,Bg 250, Bw 451,
Moderately tolerant	Growth and tillering retarded, many leaves discolored	Bw 361,Bg 450, Bg 745,Bg 403,Bg 305,Bg 300, Bg 38,At 362,Ld365,At307,Bw351, Bw452,Bw453,Ld408,Bg3-5,Bg 94-1,
Susœptible	Growth and tillering ceases, most leaves dead	Bw 272-6b,Bg 407,At 303
Highly tolerant varieties	Growth and tillering nearly normal	Bw 267-3, Bw367

Bg 96-741 showed field level tolerance for soil Fe toxicity present in the evaluation periods. There was slight leaf yellowing observed during tillering phase and before flowering, even though it last only for a short period. Leaf yellowing symptoms recovered when plants get matured. Bronzing leaf symptoms were not developed.

Susceptible varieties

Rice varieties Bw 272-6b, Bg 407 and At 303 are recorded as highly susceptible varieties. Bronzing leaves were prominent from seedling stage to maturity. Plant growth was retarded with poor seed setting or panicles were almost absent in both seasons.

Moderately tolerant varieties

Twenty rice varieties (20) were less tolerant (Bg 305, Bg 357, Bg 403, Bw 361, Bg 94-1, Bg 3-5, At 308, Ld 408, Bw 452, Bw 453, Bw 351, At 307, At 303, Ld 365, At 362, Bg 38, Bg 300, Bg 745, Bg 450, Ld 368) as they had bronzing symptoms in mature leaves, at least in one of the main growth stages of rice plant, but they were not prominent as in susceptible rice plants. Moderate tolerant rice varieties had fertile panicles with fertile seeds but plant growth retarded relative to tolerant check variety of Bw 267-3.

Locally improved tested rice varieties recorded a range of genetic variation from susceptible to highly tolerant for Fe toxicity stress in LCWZ of Sri Lanka. The rice varieties Bw 267-3, Bw 367 are valuable genetic sources for iron toxicity tolerance. Tolerant and moderately tolerant rice varieties are less affected but show leaf symptoms under peak rainy periods of LCWZ of Sri Lanka.

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