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SCREENING OF RICE GENOTYPES FOR VEGETATIVE STAGE DROUGHT CONDITION

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ABSTRACT

Drought is expected to become more frequent and severe due to climate change, which would probably put more and more severe constraints on rice production globally. Due to the delayed arrival of monsoon rains or the long intervals between first showers, vegetative-stage drought has recently become a significant factor in lowering the production of rice. The vegetative stage is critical determinant of the growth and maturation of rice. Thus, choosing rice cultivars that confer drought resistance from different cultivars with contrasting drought tolerance at the vegetative stages will bring new insights for the breeding of rice. For that, field experiment was conducted at rain-out shelter, IGKV, Raipur (C.G.) for the screening of rice genotypes with check IR-20, IR-64, Swarna, MTU-1010 (susceptible), RRF-105 and RRF-127(tolerant) for different vegetative stage drought traits *i.e.* seedling height (cm), leaf length (cm), leaf width (cm), leaf area (cm^2), chlorophyll content (g/cm^2), leaf rolling, leaf drying and relative leaf water content (%). In our experiment, sathka and korma appears to be tolerant whereas some of the genotypes *i.e.* MTU-1001, RKM-1, RIL 63-28, RIL 98-45, RIL 101-46, Banka (B:1279 II), Bako (B:2483), Hiran Bako (H:358), Kanthi Bako (K:685), Banko (B:1314), Banko (B:1614), Budhiya Banko (B:221) and Budhiya Banko (B:578) be have moderately tolerate with SES leaf rolling, drying score, chlorophyll, relative leaf water content to vegetative phase drought stress condition.

Key words : Drought, Rice, Tolerant, Vegetative stage.

Introduction

Rice is the staple food in Asia, and the current climate scenario threatens its production. An estimated 26% increase in rice production is needed by 2035 to feed the growing population (Seck *et al.*, 2012). Climate change is predicted to increase the frequency and severity of drought, which will likely result in increasingly serious constraints on rice production worldwide. In rainfed locations, early-season drought occurs in most areas, affecting the timely transplanting of seedlings and the growth of direct-seeded rice. The predominant rice-growing areas in the regions are often threatened by severe water deficit, partly due to low-input irrigation systems. In addition, emerging water shortages resulting from economic development and urbanization are leading to rationing of water in regions where irrigated lowland rice has traditionally been grown, and these production systems are also becoming water-limited. The impact of drought on plants is complex and influenced by environmental conditions. The vegetative stage is critical determinant of the growth and maturation of rice. Therefore, selecting rice cultivars that confer drought resistance from different cultivars with contrasting drought tolerance at the vegetative stages will bring new insights for the breeding of rice. In India, the leading rice producing states are West Bengal, Uttar Pradesh, Punjab, Odisha, Andhra Pradesh, Bihar and Chhattisgarh (Pathak *et al.*, 2020). About 54% of India's total rice land is rainfed, with the majority being in the North East, North India, Central-Western India, and Eastern India, with some also found in other areas.

Due to the delayed arrival of monsoon rains or the long intervals between first showers, vegetative-stage drought has recently become a significant factor in lowering the production of rice in shallow rainfed areas (Bunnag and Pongthai, 2013). In recent years, the frequency and severity of vegetative stage drought stress have increased in the shallow rainfed regions of South and Southeast Asia, especially in East India. Vegetative-stage drought stress decreases global rice production by 21–50.6% due to plant growth reductions of up to 70% (Lum *et al.*, 2014; Petrozza *et al.*, 2014; Zhang *et al.*, 2018). Furthermore, emerging changes in climate patterns, especially erratic rainfall and temperature fluctuations, will exacerbate drought frequency and duration in the years ahead (Lesk *et al.*, 2016). The rapidly changing climate, declining land resource availability, increased food demands, and increased biotic and abiotic stresses threaten global food security (Gwynn-Jones *et al.*, 2018).

Superior physiological and growth responses under vegetative stage drought stress can be early indicators for selecting drought-tolerant genotypes. However, some screening studies have selected rice genotypes suitable for drought-prone areas. To date, there are many drought-tolerant rice cultivars available for rice farmers to combat the effects of drought stress. Therefore, we aimed to complement ongoing work on improving the drought tolerance of rice by characterizing vegetative-stage drought response traits in a set of germplasm lines.

We undertook a vegetative-stage drought experiment using to dissect the physiological basis of superior lines previously identified for drought tolerance under field conditions, and identify promising drought-tolerant lines compared to check and parental lines for advancing the varietal release pipeline and thus contributing to sustainable future strategies for rice production.

Materials and Methods

86 rice genotypes including IR-20, IR-64, Swarna, MTU-1010, RRF-105 and RRF-127 were used in this study. Field experiments were conducted at the research cum instructional farm, rain-out shelter, Indira Gandhi Krishi Vishwavidyalaya at the Raipur in 2023. The experiments were conducted in 2.5m rows. Water was drained 40 days after seed sowing. The experiments were laid out in a randomized complete block design in which each treatment was replicated two times. The seedling height (cm), leaf length (cm), leaf width (cm), leaf area (cm^2), chlorophyll content (g/cm^2), leaf rolling, leaf drying and relative leaf water content (%) were measured after 50 days of sowing of the drought-stress treatment.

The data for seedling height were obtained by measuring the seedling from the basal to the youngest tip of the leaf shoot. The leaf length was measured by measuring the leaf from the base to leaf tip. The leaf width was measured by measuring the leaf in fully expanded condition. Chlorophyll content was measured by SPAD-502 Plus meter. It was also suggested as a reliable parameter in screening germplasm for drought tolerance (Li *et al.*, 2006). The mean SPAD reading is equivalent to chlorophyll content in g/cm^2 (Teng *et al.*, 2004).

The degree of leaf rolling of plant under drought stress was determined based on a standard chart presented by Standard Evaluation System for Rice (SES) by IRRI, Philippines. A visual score was assigned to indicate the degree of leaf rolling found on the sample leaf using a scale ranging from 0 to 9, with 0 indicating the healthy leaf and 9 indicating a leaves tightly rolling (V-shape). The leaf drying was also observed through a visual score from 0 to 9, with 0 indicating no symptoms of leaf drying and 9 indicating fully dried leaf.

The relative leaf water contents were also measured based on the method described by Turner (1981). The relative leaf water content was determined in the fully expanded leaf. The fresh weights of the sample leaves were recorded and the leaves were immersed in distilled water in a Petri dish. After 2-4 h, the leaves were removed, the surface water was blotted off, and the turgid weight was recorded. The samples were then dried in an oven at 70°C to constant weight. The relative leaf water content was calculated using the following formula:

$$\text{RLWC (\%)} = [(FW-DW) / (TW-DW)] \times 100$$

Where, FW is the fresh weight, DW is the dry weight and TW is the turgid weight.

Results and Discussion

Leaf rolling

Leaf rolling is considered the first symptoms of the stress conditions reaction (Mohamed *et al.*, 2021). The results showed that in the vegetative phase, the lines were divided into distinct group on the basis of visual score from 1 to 9. The results observed that there were variations in the level of rolling in these lines. 72 lines are reported 5 or less than 5 score which means they showed the tolerant to drought in vegetative phase and 14 lines showed 7 or 9 score for leaf rolling which depicted that this lines susceptible to vegetative stage drought condition (Fig. 1). This is a different genetic response in each line causing differences in scores due to leaf rolling.

Leaf drying

For leaf drying score, 72 lines are reported 5 or less than 5 score, which means they showed the tolerant to

Table 1 : Data of some important traits related to vegetative stage drought in rice.

S. no.	Genotypes	Accession No.	Seedling height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Chlorophyll (g/cm^2)	RLWC (%)	Leaf rolling	Leaf drying
1	RIL 3-1	RIL 3-1	26.00	17.50	0.33	5.80	21.9	50.00	5	3
2	RIL 7-2	RIL 7-2	25.00	18.83	0.40	7.45	24.1	49.66	5	3
3	RIL12-3	RIL12-3	24.67	17.83	0.60	10.72	29.5	78.23	3	3
4	RIL 13-4	RIL 13-4	28.00	19.17	0.40	7.70	23.8	40.87	7	7
5	RIL 15-5	RIL 15-5	30.33	20.00	0.50	9.97	24.5	70.80	3	3
6	RIL 16-6	RIL 16-6	26.17	18.67	0.60	11.20	23.8	63.89	5	3
7	RIL 18-7	RIL 18-7	30.33	20.67	0.50	10.32	22.6	77.84	3	3
8	RIL 23-8	RIL 23-8	25.67	18.17	0.50	9.08	25.5	33.33	7	7
9	RIL29-9	RIL29-9	27.67	20.33	0.80	16.30	24.5	70.35	3	3
10	RIL 32-10	RIL 32-10	29.33	19.17	0.70	13.43	29.4	79.33	3	3
11	RIL 33-11	RIL 33-11	27.83	18.50	0.40	7.55	16.1	70.12	3	3
12	RIL 34-12	RIL 34-12	29.33	20.83	0.40	8.33	28.2	44.70	7	7
13	RIL 37-13	RIL 37-13	38.83	26.33	0.48	12.72	26	48.88	7	7
14	RIL 39-15	RIL 39-15	27.17	19.83	0.60	12.03	22.5	65.85	5	5
15	RIL 41-16	RIL 41-16	26.67	19.50	0.60	11.73	19.2	75.14	3	3
16	RIL 42-17	RIL 42-17	26.33	19.50	0.80	15.53	28.1	75.47	3	3
17	RIL 43-18	RIL 43-18	27.00	20.00	0.60	12.03	24.4	72.78	3	3
18	RIL 44-19	RIL 44-19	22.83	17.67	0.50	8.97	28	58.33	5	5
19	RIL45-20	RIL45-20	22.67	17.00	0.60	10.17	24.9	49.69	7	7
20	RIL 48-21	RIL 48-21	22.67	17.33	0.60	10.43	24	57.36	5	5
21	RIL 49-22	RIL 49-22	24.00	17.17	0.50	8.62	23.1	73.13	3	3
22	RIL 50-23	RIL 50-23	22.67	22.00	0.50	10.93	21	42.55	7	7
23	RIL 54-24	RIL 54-24	26.50	20.50	0.53	11.00	21.5	72.00	3	3
24	RIL 57-25	RIL 57-25	28.50	22.17	0.43	9.63	20.2	28.64	7	7
25	RIL 60-26	RIL 60-26	25.33	22.00	0.40	9.17	20.5	77.93	3	3
26	RIL 61-27	RIL 61-27	24.67	19.83	0.50	9.93	24.5	66.67	5	3
27	RIL 63-28	RIL 63-28	23.67	17.67	0.50	8.80	19.5	80.13	3	3
28	RIL 64-29	RIL 64-29	25.67	18.33	0.60	10.93	22.7	41.20	7	7
29	RIL 65-30	RIL 65-30	23.67	18.83	0.50	9.42	23.1	55.70	5	3
30	RIL 66-31	RIL 66-31	29.67	21.67	0.60	12.97	28.9	64.56	5	3
31	RIL 67-32	RIL 67-32	26.00	18.67	0.70	13.08	31.8	64.98	5	3
32	RIL 68-33	RIL 68-33	29.00	21.67	0.70	15.17	31	67.04	5	5
33	RIL 73-34	RIL 73-34	25.00	18.83	0.70	13.18	20.6	64.17	5	3
34	RIL 74-35	RIL 74-35	27.67	20.33	0.50	10.25	24.2	72.12	3	3
35	RIL 80-36	RIL 80-36	24.83	18.33	0.60	10.90	21.4	79.51	3	3
36	RIL 81-37	RIL 81-37	23.33	17.00	0.60	10.27	26.2	62.29	5	3

Table 1 continued...

Table 1 continued...

37	RIL 84-38	RIL 84-38	26.00	18.67	0.60	11.20	27.8	70.22	3	3
38	RIL 85-39	RIL 85-39	30.33	22.50	0.60	13.60	27.2	69.14	5	3
39	RIL 86-40	RIL 86-40	27.33	21.00	0.60	12.53	28.9	67.70	5	3
40	RIL 88-41	RIL 88-41	27.67	20.67	0.70	14.53	26.8	68.75	5	3
41	RIL 89-42	RIL 89-42	25.00	17.50	0.60	10.53	25.3	62.86	5	3
42	RIL 91-43	RIL 91-43	26.67	19.83	0.60	11.83	32.3	69.40	5	3
43	RIL 95-44	RIL 95-44	30.00	24.17	0.70	17.07	28.2	78.84	3	3
44	RIL 98-45	RIL 98-45	38.33	25.00	0.63	15.83	24.7	83.74	3	3
45	RIL 101-46	RIL 101-46	28.17	21.17	0.60	12.75	32.2	82.40	3	3
46	RIL 102-47	RIL 102-47	28.00	20.33	0.70	14.23	30.2	59.66	5	5
47	RIL 121-48	RIL 121-48	27.00	19.17	0.90	17.25	40.1	64.38	5	5
48	RIL 123-49	RIL 123-49	44.33	31.00	0.80	24.83	28.8	57.14	5	5
49	RIL 125-50	RIL 125-50	30.00	22.17	0.70	15.52	36.4	73.14	3	3
50	BANGLA	B : 58 (A)	51.33	34.67	0.60	20.87	26.1	44.89	7	7
51	CHHOTE BANGALA	C : 490	59.33	40.00	0.80	32.10	34.8	76.67	3	3
52	BANKA	B : 1279 II	35.00	25.33	0.60	15.40	32.9	91.04	3	3
53	BAKO	B : 1851	26.50	16.83	0.70	11.77	31.2	77.88	3	3
54	BAKO	B : 2483	33.00	21.33	0.50	10.67	30	89.62	3	3
55	BAKO	B : 2842	47.00	31.67	0.43	13.67	29.9	63.77	5	3
56	HIRAN	H : 358 BAKO	40.33	27.00	0.50	13.47	28.9	81.93	3	3
57	KANTH BAKO	K : 1904	39.67	28.67	0.33	9.50	27.3	75.63	3	3
58	KANTHI BAKO	K : 685	39.00	27.00	0.40	10.80	27.4	83.06	3	3
59	PATAR BAKO	P : 842	29.33	22.67	0.37	8.30	30.2	41.55	7	7
60	PATAR BAKO	P : 843	32.67	23.67	0.43	10.23	27.4	69.47	5	3
61	BANKO	B : 1063 I	27.33	21.33	0.30	6.40	28.8	43.33	7	7
62	BANKO	B : 1181	21.50	16.00	0.33	5.37	31.2	60.42	5	3
63	BANKO	B : 1314	28.17	23.17	0.60	13.92	33.2	87.38	3	3
64	BANKO	B : 1614	29.67	23.00	0.60	13.67	35.9	89.35	3	3
65	BANKO	B : 1750	34.67	24.67	0.33	8.17	33.8	70.62	3	3
66	BANKO	B : 2849	32.33	22.50	0.63	14.33	24.8	76.89	3	3
67	BUDHIYA BANKO	B : 221	41.00	30.67	0.60	18.33	26.4	83.04	3	3
68	BUDHIYA BANKO	B : 349 II	41.00	30.33	0.53	16.20	32.2	69.38	5	3
69	BUDHIYA BANKO	B : 578	34.33	22.67	0.70	15.87	38.4	88.89	3	3

Table 1 continued...

Table 1 continued...

70	Mahamaya		21.67	17.00	0.63	10.80	25.9	78.20	5	3
71	Swarna		20.67	16.00	0.57	9.10	35.7	75.60	9	9
72	IR-20		31.67	22.67	0.53	12.07	32.6	76.50	9	9
73	IR-64		30.67	22.67	0.70	15.93	33.3	64.25	9	9
74	MTU-1010		32.00	22.33	0.77	17.13	35	72.63	5	3
75	MTU-1001		42.33	31.00	0.77	23.83	32.5	89.43	3	3
76	RRF-105		33.33	22.67	0.73	16.67	30.4	86.64	1	1
77	RRF-127		43.67	31.33	0.83	26.20	35.2	76.10	1	1
78	Karanga		31.67	25.00	0.90	22.50	27.5	84.93	3	3
79	Ramshree		45.67	30.33	0.83	25.20	32.3	78.18	3	3
80	Karela		24.33	18.00	0.60	10.77	22.6	79.43	3	3
81	Sathka		43.67	28.00	0.37	10.23	33	93.30	2	3
82	Korma		28.17	19.33	0.43	8.37	25.4	97.48	2	3
83	Baisoor		18.33	14.00	0.43	6.07	21.3	71.94	3	3
84	NPT-12		33.33	23.33	0.43	10.10	27.5	61.16	5	3
85	RKM-1		39.33	28.33	0.33	9.47	30.6	85.26	3	3
86	Banspatri		28.33	20.17	0.67	13.48	33.2	73.76	3	3

drought in vegetative phase and 14 lines showed 7 or 9 score for leaf drying that depicted that this lines susceptible to vegetative stage drought condition (Fig. 2).

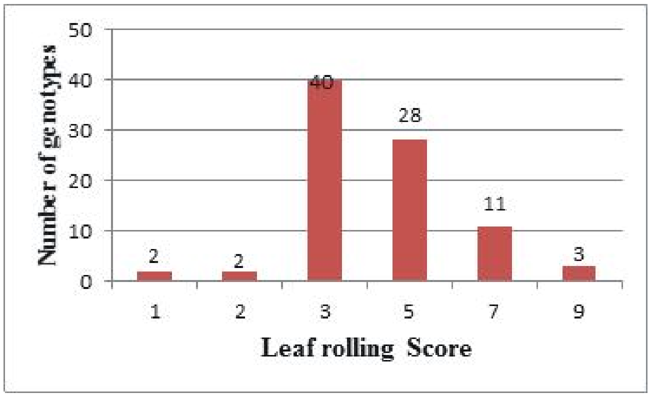

Fig. 1 : Graphical representation of leaf rolling score (According o SES for Rice, IRRI).

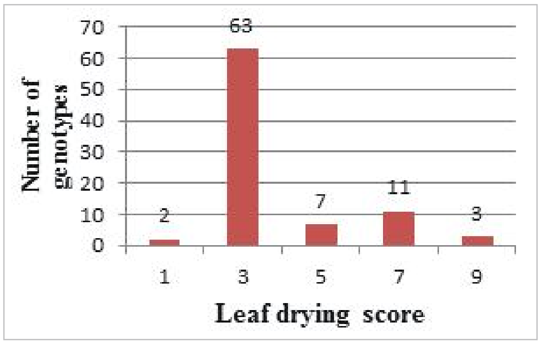

Fig. 2 : Graphical representation of leaf drying score (According o SES for Rice, IRRI).

Chlorophyll content

Photosynthesis is the primary assimilation process determines the growth of crop plants and affects various traits of plant productivity. One important component in this process is photosynthetic pigment contains chlorophyll and carotenoids. High levels of chlorophyll are associated with drought stress tolerance. In general, an increasing in the level of drought stress leads to a decrease in chlorophyll levels. The SPAD-502Plus determines the relative amount of chlorophyll present by measuring the absorbance of the leaf in two wavelength regions. It can be seen that chlorophyll has absorbance peaks in the blue (400-500 nm) and red (600-700 nm) regions, with no absorbance in the near-infrared region. The high SPAD value is depicted high chlorophyll content. Based on the data, 29 lines showed more than 30 SPAD value with the highest value 40.1 g/cme^2 in drought stress condition, while 57 lines showed less than 30 SPAD value with the lowest chlorophyll content was showed by 16.1 g/cm^2 (RIL 33-11) (Table 1).

Seedling height (cm)

Seedling height varies from 18.33 cm to 59.33 cm (Table 1) depicted that there is a large variation in seedling height in drought stress condition. On an average reduction in seedling height was reported in the most of the studied rice cultivars under vegetative stage drought stress (Kumar *et al.*, 2008 and Mohamed *et al.*, 2021).

Leaf length (cm), width (cm) and leaf area (cm^2)

Leaf length and width ranges from 14.00 cm to 40.00 cm and 0.30 to 0.90 cm, respectively in fully expanded condition. Leaf area varies from 5.37 cm^2 to 32.10 cm^2 (Table 1). Leaf area is important functional factor for photosynthesis, as simulation and transpiration along rice plant life (Mohamed *et al*., 2021). The reduction in leaf area is a common drought avoidance mechanism (Abdallah *et al*., 2010 and Ghazy, 2017). Water stress causes losses in tissues, which reduces turgor pressure in the cell, thereby, inhibiting enlargement and division of cells causing reduction of plant growth, stem elongation and leaf expansion.

Relative leaf water content (%)

The relative water content (RWCs) of plant leaves is a character that closely related to the size of cells and proper for providing a reflection of the water supply equilibrium for the metabolic processes on leaves and transpiration (Pandey and Shukla, 2015). Cultivars that are able to regulate higher RLWCs are considered as drought-tolerant cultivars because of its ability to balance internal water conditions. RLWC varies from 97.48 % to 28.64%. RWC in rice leaves decreased as the level of soil moisture decreased and this may be due relative low root ability to absorb water from the soil drought stress conditions, which is reflected in reduction of plant growth. These results also, were proclaimed by Zheng *et al*. (2005), Sibounheuang *et al*. (2006) and Zulkarnain *et al*. (2009).

Conclusion

In our study, sathka and korma appears to be tolerant to the vegetative stage drought with SES rolling and drying score ‘1’ and ‘2’ at the end of the stress period where as some of the genotypes *i.e.* MTU-1001, RKM-1, RIL 63-28, RIL 98-45, RIL 101-46, Banka (B:1279 II), Bako (B: 2483), Hiran Bako (H: 358), Kanthi Bako (K: 685), Banko (B: 1314), Banko (B: 1614), Budhiya Banko (B: 221) and Budhiya Banko (B: 578) behave moderately tolerate with SES leaf rolling and drying score ‘3’ to vegetative phase drought stress condition. The identified genotypes also had high RLWC (>80%) compared to susceptible genotypes like IR 20, IR 64 and MTU 1010 (Kumar *et al*., 2014). Drought score is used to measure the tolerance toward drought stress condition and reflects the extent of correlation of the plant tissue dehydration with its RLWC (Cabuslay *et al*., 1999; 2002). The ability of plant with low leaf rolling and drying score in addition to high relative leaf water content are an important selection criterion for selecting drought tolerant genotypes.

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