Natural Response of Rice Seedlings under Cold Conditions

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Authors’ contributions
This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice (Oryza sativa L., Poaceae) is the primary source of food for billions of people throughout the world and around 90% of the cultivated area under rice is in Asia. Rice is the majorly grown during both seasons and in Rabi season the seedlings are raised in exposure to the cold months and hence, cold tolerant rice varieties are the prerequisite for rice cultivation. Among the districts of Telangana, Nizamabad, records the lowest mean minimum temperature ranging from 11-16°C over past ten years. The main aim of the study was to identify cold tolerant genotypes. The experiment was conducted to evaluate 35 genotypes of rice for cold tolerance under field conditions. Sprouted seeds of these genotypes were sown in nursery during Rabi 2017-18. The germination percentage was recorded at 15 days after sowing (DAS) and 30 DAS, scoring for cold was done and chlorophyll content through SPAD meter were taken. Akshaydhan and Krishna Hamsa were least affected by cold and scored 1 considering them as cold tolerant and can be used as donors in crossing programs.

Keywords: Cold tolerance; germination percentage; rice; seedling stage.

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1. INTRODUCTION

Rice is more sensitive to cold stress than other cereal crops due to its origin in tropical and subtropical regions. Of all the rice species cultivated Asian rice (Oryza sativa L.) is more sensitive to prolonged low temperatures. Optimum temperature range for rice germination lies between 20–35°C and temperature of 10°C is cited as minimum critical value below which rice does not germinate [1]. Exposure of rice seedlings to low temperature results in poor germination, seedling mortality, leaf chlorosis or withering, reduced tillering, delayed inflorescences development and spikelet sterility [2,3]. Low temperature is a major climatic problem for rice growing in 25 countries [4]. Breeding of rice cultivars with improved cold tolerance is largely focused on the seedling and reproductive developmental stages which have the most significant impact on yield [5].

Among the districts of Telangana, Nizamabad is one of the major rice producing districts with an area of 86,923 hectares and productivity of 6012 kg ha⁻¹. This district is most affected by cold temperatures during Rabi season. Mostly temperatures fall below 13°C from second fortnight of November to December second fort night coinciding with nursery growing period. Farmers of this district mostly prefer to sow nurseries during this period to curtail water scarcity problem during reproductive period of crop. But prevailing low temperatures during this period affect germination and growth causing yellowing and withering of seedlings due to which farmers are transplanting overaged seedlings which is finally affecting yield of crop. Over the past 10 years the average minimum temperature ranged from 11-16°C during seedling stage. Hence there is need to identify the rice varieties which can withstand low temperature at seedling stage. Visual assessment following direct exposure to low temperatures is the most common method of evaluating cold tolerance in rice seedlings [6]. Hence, the experiment was planned to identify cold tolerant genotypes, which can be further used as donors in breeding program.

2. MATERIALS AND METHODS

A total of 35 Rice genotypes (Table 1) consisting of released varieties and pre-release cultures were grown during Rabi 2017-18 at Regional Sugarcane and Rice Research Station (RS & RRS), Rudrur, Nizamabad, Telangana, India. Nursery seed bed was prepared and sprouted genotypes were sown on 27th November to expose the seedlings to low temperature. The germination percentage was recorded at 15 days after sowing (DAS) and 30 DAS. The maximum and minimum temperatures and relative humidity during this period were recorded. Chlorophyll content through SPAD meter was recorded at 15 DAS and 30 DAS was taken to assess leaf chlorophyll concentration. Scoring for cold tolerance was done before uprooting the seedlings for transplanting at 15 DAS and 30 DAS, according to the Standard Evaluation System for Rice [7]. The scale for seedling cold tolerance ranged from 1-9.

3. RESULTS AND DISCUSSION

The focus of the experiment was to screen the rice genotypes which can tolerate cold temperatures at seedling stage. The last ten years weather parameters during the period cold occurrence i.e., last week of November to January first week had been taking into consideration which shows the average of minimum temperature ranged from 14.0°C (2007) to 14.7°C (2017), mean of maximum temperature ranged from 30.7°C (2007) to 24.2°C (2017) and Relative humidity ranged from 78.5% (2007) to 73.5% (2017) as shown in Fig. 1. Percentage of seedlings in the nursery were recorded at 15 DAS, the variety Akshaydhan (92.0%) recorded highest germination percentage followed by Krishna Hamsa (87.0%), WGL 915 (87.0%) and JGL 11727 (86.0%). IR 64 (21.0%) recorded lowest germination percentage Table 2. Reduction in seedling number in the nursery is due to low temperatures during seedling stage.

The minimum and maximum temperatures and relative humidity in present study varied from the date of sowing in nursery bed to 30DAS as represented in Fig. 2. At 15 DAS, the maximum mean temperature was 29.6°C and the minimum temperature was 15.0°C. After 30 DAS, the temperature came down to 24.4°C and 13°C with decrease in the temperature seedling mortality was observed in all the genotypes. Lowest reduction in seedling number was recorded in Akshaydhan (3%) and Krishna Hamsa (5%). Whereas IR 64, Triguna and NDR 359 showed highest reduction in seedling number as shown in Fig. 3. In order to enhance and ensure uniform establishment of rice seedlings in the early season, cold tolerance during this time is vital [8].
Table 1. Details of genotypes

| S. no. | Genotype   | Parentage                                                                 | Remarks          |
|--------|------------|---------------------------------------------------------------------------|------------------|
| 1      | Bhadrakali | Phalguni / IR 36                                                          | Released variety |
| 2      | Prasanna   | IRAT 8 / N 22                                                             | Released variety |
| 3      | Triguna    | Swarnadhan / RP 1579-38                                                   | Released variety |
| 4      | Rajendra   | IJ 52 / T(N)1                                                             | Released variety |
| 5      | Aditya     | M 63-83 / Cauvery                                                         | Released variety |
| 6      | Mashuri    | Taichung 65/mayang ebos 60080/2                                           | Released variety |
| 7      | MTU 1010   | Krishnaveni/IR64                                                          | Released variety |
| 8      | MTU 1001   | MTU 5249 x MTU 7014                                                        | Released variety |
| 9      | MTU 1075   | MTU 2716/MTU 1010                                                         | Released variety |
| 10     | Suraksha   | Sasyasree / MR 1523                                                       | Released variety |
| 11     | Krishna Hamsa | Rasi / Fine Gora                                        | Released variety |
| 12     | JGL 24423  | (MTU 1010 x NLR 34449) x MTU 1010                                        | Pre-release variety |
| 13     | JGL 18222  | JGKL 3855/JGL 7046                                                        | Released variety |
| 14     | Sampada    | Vijaya / C 14-8                                                           | Released variety |
| 15     | Erramallelu | BC 5-55 / W 12708                                                         | Released variety |
| 16     | Indursamba | BPT 5204 x Surekha                                                         | Released variety |
| 17     | Jaldhidhan 6 | Dular Mutant/ Nagina 22 mutant                                       | Released variety |
| 18     | KNM 118    | MTU 1010 / JGL 13595                                                        | Released variety |
| 19     | IR 64      | Derived from traditional rice varieties                                    | Released variety |
| 20     | JGL 1798   | BPT 5204 / Kavya                                                          | Released variety |
| 21     | Dhanrasi   | C-11-A-41                                                                 | Released variety |
| 22     | NDR 359    | BG-90-2-4 / 08677                                                         | Released variety |
| 23     | CSR 36     | CSR 13/Panvel-. 2/ IR-36                                                  | Released variety |
| 24     | JGL 21002  | MTU 1010/ JGL11727                                                        | Released variety |
| 25     | Jarava     | B 32 Sel 4/ O.rufipogon 4/B 29-6                                          | Released variety |
| 26     | WGL 915    | SN 22R x IRBBN 39                                                        | Pre-release variety |
| 27     | JGL 11727  | JGL420 / MTU1010                                                          | Released variety |
| 28     | Varalu     | WGL 20471 / CR 544-1-2                                                   | Released variety |
| 29     | JGL 11470  | JGL 418 / Gedongbetan                                                    | Released variety |
| 30     | WGL 44     | BPT 5204 / ARC 5984 // Kavya / BPT 5204                                   | Released variety |
| 31     | Krishna    | Chandan / BPT 5204                                                       | Released variety |
| 32     | JGL 18047  | MTU 1010 / JGL 13595                                                        | Released variety |
| 33     | Akshaydhan | BR 827-35/ SC 109-2-2                                                     | Released variety |
| 34     | Ravi       | M 63-83 / / RP 79-5 / Rikotu Norin 21                                       | Released variety |
| 35     | Naveen     | Sattari X Jaya                                                            | Released variety |

Fig. 1. Average weather parameters over past ten years at RS & RRS, Rudrur
The t-test results showed that there is significant difference in the mean number of seedling percentage at 15 DAS and 30 DAS as shown in Table 2.

Scoring for cold tolerance under field conditions and chlorophyll content through SPAD meter readings were taken at 15 DAS and 30 DAS. Score of 1 and 3 is given to genotypes with dark green and light green seedlings respectively. They are supposed to be cold tolerant [7]; score of 5 and 7 for yellow and brown seedlings respectively and 9 for dead seedlings as shown in Table 3. Akshaydhan and Krishna Hamsa scored 3 with a chlorophyll content ranging from 32.3-28.6. These two genotypes can be considered as cold tolerant and can be used as donors for cold tolerance in breeding programs. Any variety to ideally fit for cold conditions must have tolerance at seedling stage [9].

Massardo et al. [10] reported evaluation of rice seed germination rate and new plant traits under more than one temperature treatments are

Table 2. Number of seedlings (%) at 15 DAS and 30 DAS

| Genotypes      | Seedling % @ 15 DAS | Seedling % @ 30 DAS | % change in seedling over 15 DAS |
|----------------|---------------------|---------------------|---------------------------------|
| Sampada        | 77                  | 59                  | 23                              |
| MTU 1010       | 83                  | 71                  | 11                              |
| Erramallelu    | 79                  | 57                  | 28                              |
| Jarava         | 79                  | 53                  | 33                              |
| Suraksha       | 80                  | 62                  | 22**                            |
| JGL 11470      | 80                  | 64                  | 20                              |
| JGL 18047      | 81                  | 68                  | 16                              |
| JGL 21002      | 82                  | 67                  | 18                              |
| IR 64          | 21                  | 7                   | 67**                            |
| Prasanna       | 81                  | 58                  | 28                              |
| Aditya         | 80                  | 68                  | 15**                            |
| MTU 1001       | 83                  | 70                  | 16**                            |
| JGL 18222      | 81                  | 64                  | 21**                            |
| Triguna        | 37                  | 13                  | 65**                            |
| NDR 359        | 42                  | 25                  | 40                              |
| Bhadrakali     | 84                  | 72                  | 14                              |
| JGL 24423      | 84                  | 70                  | 16                              |
| WGL 44         | 84                  | 76                  | 10                              |
| JGL 11727      | 86                  | 73                  | 15**                            |
| Krishna hamsa  | 87                  | 82                  | 6                               |
| WGL 915        | 87                  | 79                  | 9                               |
| Naveen         | 68                  | 47                  | 31**                            |
| KNM 118        | 70                  | 58                  | 17                              |
| Ravi           | 71                  | 47                  | 34                              |
| Akshaydhan     | 92                  | 89                  | 3                               |
| CSR 36         | 56                  | 34                  | 39                              |
| MTU 1075       | 77                  | 63                  | 18                              |
| Indursamba     | 74                  | 62                  | 16**                            |
| Dhanrasi       | 59                  | 31                  | 47**                            |
| Jaldhidhan 6   | 67                  | 46                  | 31**                            |
| Krishna        | 68                  | 42                  | 38                              |
| Rajendra       | 74                  | 52                  | 30                              |
| JGL 1798       | 82                  | 67                  | 18                              |
| Mashuri        | 75                  | 61                  | 19                              |
| Varalu         | 76                  | 64                  | 16                              |

**1% level of significance
Fig. 2. Average weather parameters from date of sowing to 30 DAS at RS & RRS, Rudrur

Fig. 3. Number of seedlings (%) at 15 DAS and 30 DAS

Table 3. Scoring of genotypes and recording SPAD readings

| Scores (SES scale, IRRI 2002) | Genotypes                                                                 | Range of SPAD meter readings |
|-------------------------------|---------------------------------------------------------------------------|------------------------------|
| 1                             | ----                                                                      |                              |
| 3                             | Akshaydhan and Krishna Hamsa                                             | 32.3 – 28.6                  |
| 5                             | Bhadra kali, Varalu, JGL 21002 Prasanna, Naveen, JGL 18047, Ravi, Mashuri, WGL 915, WGL 44, JGL 24423, RDR 763 and MTU 1010 | 25.7 – 14.1                  |
| 7                             | CSR 36, MTU 1001, MTU 1075, Aditya, Suraksha, JGL 1798, JGL 18222, JGL 11727, NDR 359, Dhanrasi, Krishna and KNM 118 | 12.4-6.4                    |
| 9                             | Triguna, Jarava, Sampada, Rajendra, MTU 1156, Erramallelu, IR 64 and Jaldhidhan 6 | 4.0 – 1.8                   |

necessary to distinguish cold tolerant genotypes from cold susceptible genotypes. Changrong et al. [11] reported that the seeds from the few varieties could germinate quickly at low temperature but, the seedling growth was severely delayed by low temperature stress. They also reported that cold tolerance at germination and seedling stage were correlated.

4. CONCLUSION

Among 35 genotypes under study, two genotypes Akshaydhan and Krishna Hamsa had high seedling germination and low seedling mortality with tolerance to cold conditions. These genotypes can be used as donors in
crossing programme to develop cold tolerant varieties.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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