Original Research Article

Screening of Rice Hybrids for Cold Tolerance at Seedling and Vegetative Stage Under Low Temperatures

Abstract:

Low temperature is one of the most important abiotic constrains in rice cultivation. Rice plant growth and development are affected by cold stress from germination to reproductive stages. Development of 48 hybrids involving twelve restorer lines and four CMS lines by using line x tester mating design. Evaluation of 69 rice genotypes including checks based on leaf score (SES, IRRI, 2013), root length, shoot length, fresh weight, dry weight, and SPAD analysis at seedling stage as well as leaf score, number of tillers, seedling growth and establishment at vegetative stage. Results indicated that the hybrids IR72081 A x JGL 11118, IR72081 A x JGL 21071, IR80559A × JGL 29662, IR80559A × KNM 110, IR80559A × SN 470, IR58025A × JGL 29662 identified as cold tolerant genotypes. This study aimed to identify cold tolerant genotypes under low temperatures at seedling and vegetative stage. Screening for cold tolerance during early growth stages potentially be an effective way of assessing cold tolerance in breeding programmes.

Keywords: cold tolerance**,** leaf score, root length, shoot length, SPAD analysis

1. Introduction:

Rice (*Oryza sativa* L.) is one of the most important food crops in the world. For more than half of the world's population, it is a staple food crop. Rice is a member of the Gramineae (grass) family. It belongs to the Oryza genus, which contains more than 20 species, only two of which, *Oryza sativa* and *Oryza glaberrima*, are cultivated globally. Rice is an angiosperm that is monocotyledonous. It is a diploid with 24 chromosomes that may be recognised using cytogenetic methods.

In the northern and central Telangana areas, rice is the most important crop to be grown in all year round. Rice sowings are confined to a few months per year, despite the availability of adequate irrigation systems, because the main reason for the restriction is cold stress.

When sowings are delayed in the Kharif crop, which often happens due to late canal water release or a delay in monsoon rains, the reproductive phase of the crop coincides with low temperatures in November and December, resulting in poor seed set and yields. In addition, throughout the winter, minimum temperatures frequently fall below 10°C, resulting in poor seedling growth in the rabi crop. Low temperature stress can manifest itself at any stage of growth, including germination, seedling, vegetative, reproductive, and grain maturity, in addition to the two critical stages.

Low temperature stress impacts seed germination during the early stages of rice growth, inhibiting seedling establishment and eventually leading to non-uniform crop maturation. Cold temperatures affect rice at all phonological phases, as well as grain production and yield. In the vegetative stage, low temperatures can delay growth and impair seedling vigour. low number of seedlings, reduced tillering, increased plant mortality, lengthened the growth period, and caused panicle sterility, resulting in poorer grain output and yield. From germination to reproductive phases, cold can be detrimental, leading in lower crop yields in most circumstances (Cruz et al. 2013). As a result, cold-tolerant plants can grow faster than cold-sensitive plants in low temperatures (Cabello et al. 2014). With this background present investigation was planned with objective to identify cold tolerant genotypes under low temperatures at seedling and vegetative stage.

2. Materials and methods:

2.1 Study site:

The experiment was conducted at the Regional Agricultural Research Station farm, Jagitial during 2021-2022. Three sowings staggered by seven to ten days interval. A total of 69 rice genotypes (48 Hybrids, 12 testers and 4 CMS lines) were selected along with resistant and susceptible checks as experimental material (Table.1).

2.2 Method of collection

In *Rabi* 2021-2022, evaluation of hybrids, parents and along with checks against cold stress through SPAD (Soil Plant Analysis Development) analysis, root length, shoot length, fresh weight, dry weight, leaf score (1-9) (SES IRRI,2013) at seedling and vegetative stage (Table .2&.3). The mean values and scoring of the genotypes given below (Table.4)

Deviation for SPAD analysis=

$$\frac{Normal\ conditions\ (30DAS) - cold\ stress\ conditions(15DAS)}{Normal\ conditions(30DAS)} \text{ x } 100$$

In the past five years, temperatures were at their optimum level but now the weather conditions are very low during October – January (fig.1). Due to minimum temperatures often results in poor germination, seedling mortality, leaf chlorosis, stunted growth, reduced tillering at seedling and vegetative stage. After transplanting of seedlings, there will be transplanting shock. This may occur and take some time for recovery. But, due to cold stress, there will be chances of getting more time for recovery of the seedlings.

3. Results and Discussion:

Cold tolerance was linked to physiological indicators such as root length, shoot length, and their fresh weight, dry weight as well as SES scoring and SPAD reading. These characteristics were chosen because they were the most effective in distinguishing cold tolerance from cold resistance genotypes at the seedling and vegetative stage. Because the rice crop grown during the rabi/boro season is affected by cold stress during the nursery stage is a better knowledge of the mechanism of cold tolerance at the seedling stage is critical. The findings revealed that, at the seedling stage, the genotypes IR72081A x JGL11118, IR72081A x KNM 110, IR80559A × JGL 29662, IR80559A × KNM 110, IR80559A × NSR 64, IR80559A × WGL 14, IR80559A × SN 470, IR58025A × JGL 11118, IR58025A × JGL 29662, IR58025A × KNM 110, IR58025A × NSR 64, IR58025A × WGL 23985, JGL18264-1A × WGL 23985 and JGL 24423 having score 1(Highly tolerant) and IR72081A × IR 72, JGL 11470 and JGL 1798 having score 7 (Sensitive). (Fig. 2) (Table.2)

Based on chlorophyll content through SPAD analysis, the hybrids IR72081A × JGL 11118, IR72081A × JGL 21071, IR80559 A × JGL 29662, IR58025A × JGL 29662, IR72081 A × JGL 29662, IR72081 A × KNM 110, IR80559 A × SN 470 shows less deviation which indicates tolerant genotypes. While more deviation showed in IR72081 A × IR 72 and JGL18264-1A × SN S33 which are sensitive to cold stress. (Table.4)

For root length, the crosses IR72081A × JGL 11118, IR72081A × JGL 21071, IR80559A × KNM 110, IR80559A × WGL 23985, IR58025A × JGL 11118, IR58025A × KNM 110 and check JGL 24423 (fig.3) (Table.2) and for shoot development, the crosses IR80559A × JGL 29662, IR80559A × IRTON 270, IR80559A × SN 470, IR58025A × JGL 11118, JGL 18264-1A × SN 470 exhibit tolerance. (Fig.4) (Table.4)

At the vegetative stage, due to cold stress, the colour of leaf and seedling establishment is quite different. Among the genotypes, 15 were tolerant, 52 were moderately tolerant and 5 were sensitive (Fig.4) (Table.4)

During Rabi, rice productivity decreases on around 20 lakh acres in the northern Telangana zone because the temperatures fall below 10^{o}C. The development of high-yielding, cold-tolerant cultivars is the most efficient way to overcome the problem of low-temperature stress. Cold tolerance in the seedling, booting, and flowering stages was linked to those in the germination stage, whereas cold tolerance in the seedling stage was linked to those in the booting stage. Similar results were reported by Fallah and Elyasi (2010), Satya *et al*. (2010) Donoso Ñanculao *et al*. (2013), Sahu *et al*. (2014), Priyanka *et al*. (2015), Kumari and Jaiswal (2017), Rahul *et al*. (2017), Rahul *et al*. (2018), lone *et al*. (2018), Doan Cong Dien and Takeo Yamakawa (2019), Rathod *et al*. (2020), Rativa *et al*. (2020) and Sumayya *et al*. (2020).

Conclusion:

The genotypes that come under score 1-3 are considered as tolerant. Among the genotypes, the crosses IR72081A x JGL 11118, IR72081A x JGL 21071, IR80559A × JGL 29662, IR80559A × KNM 110, IR80559A × KNM 110, IR80559A × SN 470 exhibit highly cold tolerance, therefore these genotypes were good for rabi crop and IR72081A × IR 72, JGL18264-1A × SN S33 exhibit susceptible to cold by comparing with parents and checks. The maximum shoot length was observed in the genotype IR80559A × JGL 29662 as well as fresh weight and it was considered a cold-tolerant genotype. The genotype IR72081A × IR 72 found to be susceptible to all the parameters; therefore it is not recommended for rabi paddy.

4. Further Research:

Developing and identifying cold- tolerant genotypes. In Northern Telangana, temperature falls below 10^{o}C but the optimum temperature of the rice is 12^{o}C. So, the farmers are facing this problem. In this way, it is useful to develop cold-tolerant genotypes.

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Table 1. Genotypes used as experimental material in this study

S.No	Genotype	S.No	Genotype
1.	IR72081 A × JGL 11118	36	IR58025A × SN 470
2.	IR72081 A × JGL 21071	37	JGL 18264-1A × JGL 11118
3.	IR72081 A × JGL 29662	38	JGL 18264-1A × JGL 21071
4.	IR72081 A × KNM 11O	39	JGL 18264-1 A × JGL 29662
5.	IR72081 A × NSR 64	40	JGL 18264-1A × KNM 110
6.	IR72081 A × NSR103	41	JGL 18264-1A × NSR 64
7.	IR72081 A × IRTON 270	42	JGL 18264-1A × NSR 103
8.	IR72081 A × IR 72	43	JGL 18264-1A × IRTON 270
9.	IR72081 A × WGL 14	44	JGL 18264-1A × IR 72
10.	IR72081 A × WGL 23985	45	JGL 18264-1A × WGL 14
11.	IR72081 A × SN 233	46	JGL 18264-1A × WGL 23985
12.	IR72081 A × SN 470	47	JGL 18264-1A × SN S33
13.	IR80559 A × JGL 11118	48	JGL 18264-1A × SN 470
14.	IR80559 A × JGL 21071	49	IR72081B
15.	IR80559 A × JGL 29662	50	IR80559B
16.	IR80559 A × KNM 110	51	IR58025B
17.	IR80559 A × NSR 64	52	JGL 18264-1B
18.	IR80559 A × NSR 103	53	JGL 11118
19.	IR80559 A × IRTON 270	54	JGL 21071
20.	IR80559 A × IR 72	55	JGL 29662
21.	IR80559 A × WGL 14	56	KNM 110
22.	IR80559 A × WGL 23985	57	NSR 64
23.	IR80559 A × SN 233	58	NSR 103
24.	IR80559 A × SN 470	59	IRTON 270
25.	IR58025 A × JGL 11118	60	IR 72
26.	IR58025 A × JGL 21071	61	WGL 14
27.	IR58025 A × JGL 29662	62	WGL 23985
28.	IR58025 A × KNM 110	63	SN 233
29.	IR58025A × NSR 64	64	SN 470

30.	IR58025A × NSR 103	65	JGL 24423 (Tolerant check)
31.	IR58025A × IRTON 270	66	Tellahamsa (Tolerant check)
32.	IR58025A × IR 72	67	US – 312
33.	IR58025A × WGL 14	68	JGL 11470 (Susceptible check)
34.	IR58025A × WGL 23985	69	JGL 1798 (Susceptible check)
35.	IR58025A × SN 233		

Table 2. Leaf scoring (1-9) (SES IRRI, 2013) at seedling stage.

Score	Observations	Tolerance
1	Seedlings dark green	Highly tolerant
3	Seedlings light green	Tolerant
5	Seedlings yellow	Moderately tolerant
7	Seedlings brown	Sensitive
9	Seedling dead	Highly sensitive

Table 3. Leaf scoring (1-9) (SES IRRI, 2013) at vegetative stage.

Score	Observations	Tolerance
1-3	All leaves normal color	Tolerant
4-6	Pale green leaves	Moderately tolerant
7-9	Yellowing of leaves and stunted growth	Sensitive

Table 4. The mean values and scoring of rice genotypes at seedling /vegetative stage under low temperature

		Before transplanting								After transplanting
S.no.	**Genotype**	**Score (Seedling stage) 20DAS**	**SPAD reading (mm) 15DAS**	**SPAD reading (mm) 30DAS**	**Deviation (%)**	**Root length (cm)**	**Shoot length (cm)**	**Fresh weight (g)**	**Dry weight (g)**	**Score (Vegetative stage) 15DAP**
	Hybrids									
1.	IR72081 A × JGL 11118	1	26.14	27.12	3.61	12.8	20.75	0.74	0.23	3
2.	IR72081 A × JGL 21071	3	25.76	26.74	3.66	13	20.25	1.17	0.30	5
3.	IR72081 A × JGL 29662	3	23.18	24.78	6.45	9.25	18.55	0.86	0.25	4
4.	IR72081 A × KNM 11O	1	21.48	22.88	6.11	7.2	17.15	0.76	0.17	3
5.	IR72081 A × NSR 64	3	18.16	24.28	25.20	8.35	18.2	0.79	0.19	5
6.	IR72081 A × NSR103	3	18.64	25.1	25.73	8.55	17	0.88	0.20	6

7.	IR72081 A × IRTON 270	3	22.26	25.36	12.22	8.35	14.25	0.99	0.28	4
8.	IR72081 A × IR 72	7	12.84	23	44.17	8.55	15.4	0.61	0.14	7
9.	IR72081 A × WGL 14	5	18.06	24.44	26.10	9.35	17.95	0.88	0.21	3
10.	IR72081 A × WGL 23985	3	15.72	23.3	32.53	8.35	16.75	0.71	0.20	5
11.	IR72081 A × SN 233	3	15.78	26.98	41.51	6.65	18.45	1.04	0.34	5
12.	IR72081 A × SN 470	3	20.36	25.02	18.62	11.95	18.25	1.09	0.43	3
13.	IR80559 A × JGL 11118	3	24.44	28.94	15.54	10.5	19.2	1.01	0.42	3
14.	IR80559 A × JGL 21071	3	23	26.06	11.74	8.05	21.05	0.76	0.27	3
15.	IR80559 A × JGL 29662	1	24.1	25.22	4.04	8	24.05	1.36	0.42	3
16.	IR80559 A × KNM 110	1	22.56	3.67	12.21	13.55	21	0.67	0.35	3
17.	IR80559 A × NSR 64	1	21.32	23.38	8.81	9.7	20.05	0.63	0.27	5

18.	IR80559 A × NSR 103	3	22.04	27.26	19.14	8.75	19.1	0.63	0.27	5
19.	IR80559 A × IRTON 270	3	22.42	25.02	10.39	5.55	23.05	1.42	0.39	5
20.	IR80559 A × IR 72	3	19.76	25.12	21.33	11.1	20.85	1.25	0.42	3
21.	IR80559 A × WGL 14	1	19.54	24.68	20.8	6.1	21.95	1.17	0.30	5
22.	IR80559 A × WGL 23985	3	19.82	24.88	20.33	13.15	19.95	1.47	0.41	4
23.	IR80559 A × SN 233	5	17.98	24.48	26.55	5.35	18.7	0.86	0.36	5
24.	IR80559 A × SN 470	1	23.82	25.16	5.32	9.8	23.3	1.47	0.54	3
25.	IR58025A × JGL 11118	1	19.86	27.62	28.09	12.55	21.85	1.25	0.36	5
26.	IR58025A × JGL 21071	3	18.14	26.56	31.70	7.95	20.45	1.33	0.39	5
27.	IR58025A × JGL 29662	1	23.88	24.9	4.09	11.7	20.65	1.55	0.34	5
28.	IR58025A × KNM 110	1	17.2	25.7	33.07	12.55	20.9	1.29	0.40	5

29.	IR58025A × NSR 64	1	17.42	25.8	31.63	8.95	14.55	1.17	0.21	3
30.	IR58025A × NSR 103	3	15.92	19.32	17.59	11.9	20.15	1.24	0.32	5
31.	IR58025A × IRTON 270	3	15.12	24.26	37.67	8.25	21.9	1.56	0.42	5
32.	IR58025A × IR 72	3	16.24	18.2	10.76	8.15	16.6	0.82	0.36	5
33.	IR58025A × WGL 14	3	16.04	24.16	33.60	7.3	18.4	0.88	0.22	4
34.	IR58025A × WGL 23985	1	17.16	22.84	24.86	8.75	16.9	0.73	0.20	4
35.	IR58025A × SN 233	3	20.66	25.8	19.92	9.35	17.9	0.80	0.19	3
36.	IR58025A × SN 470	3	18.08	23.64	23.51	9.3	18	0.64	0.25	5
37.	JGL18264-1A× JGL 11118	3	18.04	22.88	21.15	7.3	18.95	0.63	0.18	5
38.	JGL18264-1A × JGL 21071	5	17.4	20.4	14.70	5.85	16.8	0.43	0.15	5
39.	JGL18264-1A × JGL 29662	3	17.86	19.72	9.43	8.35	19.05	0.82	0.32	5

40.	JGL18264-1A × KNM 110	5	12.3	18.46	33.36	6.5	15.05	0.97	0.30	4
41.	JGL18264-1A × NSR 64	5	14.9	22.14	32.70	8.9	17.65	0.78	0.20	5
42.	JGL18264-1A × NSR 103	3	11.23	25.74	56.37	7.25	14.5	0.15	0.07	5
43.	JGL18264-1A × IRTON 270	5	17.96	22.82	21.29	9	18.7	1.08	0.42	5
44.	JGL18264-1A × IR 72	3	15.2	25.04	39.29	6.9	18.7	0.65	0.26	5
45.	JGL18264-1A × WGL 14	3	15.86	22.32	28.94	9.5	21.25	1.23	0.33	5
46.	JGL18264-1A × WGL 23985	1	17.18	23.06	25.49	8.3	19.3	0.67	0.43	5
47.	JGL18264-1A × SN S33	5	12.7	22.64	43.90	9.4	20.1	0.81	0.38	7
48.	JGL18264-1A × SN 470	5	15.02	23.08	34.92	9.55	22.35	1.48	0.42	5

	Lines									
49.	IR72081B	5	16.22	23.78	31.79	6.15	13.8	0.33	0.11	5
50.	IR80559B	5	12.96	19	31.78	5.65	12.8	0.25	0.07	5
51.	IR58025B	5	13.12	20.96	37.40	4.7	13.35	0.26	0.15	5
52.	JGL 18264-1B	5	14.9	19.8	24.74	2.7	10.95	0.07	0.20	7
	Testers									
53.	JGL 11118	3	19.4	19.54	0.07	5.3	14.75	0.42	0.19	6
54.	JGL 21071	3	17.62	22.5	21.6	3.75	14.55	0.60	0.25	5
55.	JGL 29662	3	16.32	22.54	27.59	5.8	15.25	0.45	0.16	5
56.	KNM 110	3	17.38	17.56	1.02	6.5	12.6	0.34	0.09	6
57.	NSR 64	3	18.3	21.08	13.18	2.15	15.5	0.28	0.18	5
58.	NSR 103	5	16.48	19.08	13.62	2.3	11.75	0.61	0.25	5
59.	IRTON 270	5	15.62	20.5	23.80	11.3	14.85	0.77	0.25	5
60.	IR 72	5	16.86	19.04	11.44	2.05	12.35	0.61	0.23	5

61.	WGL 14	5	17.1	17.56	2.61	5.95	16	0.75	0.20	6
62.	WGL 23985	5	17.52	20.78	15.68	4.35	14.55	0.55	0.24	5
63.	SN 233	5	17.42	17.56	0.79	6.1	10.95	0.52	0.23	5
64.	SN 470	3	18.42	18.08	1.88	6.05	14.45	0.44	0.19	5
	Checks									
65.	JGL 24423(Tolerant check)	1	17.24	22.68	23.98	12.95	20.11	0.66	0.19	3
66.	Tellahmsa(Tolerant check)	3	21.48	23.7	9.36	5.15	17.75	0.40	0.15	3
67.	US – 312	3	17.2	20.42	15.76	5.55	17.5	0.40	0.07	5
68.	JGL 11470(Susceptible check)	7	13.58	17.08	20.49	3.05	11.45	0.13	0.07	7
69.	JGL 1798(Susceptible check)	7	13.02	17.7	26.44	3.65	11.35	0.13	0.05	7

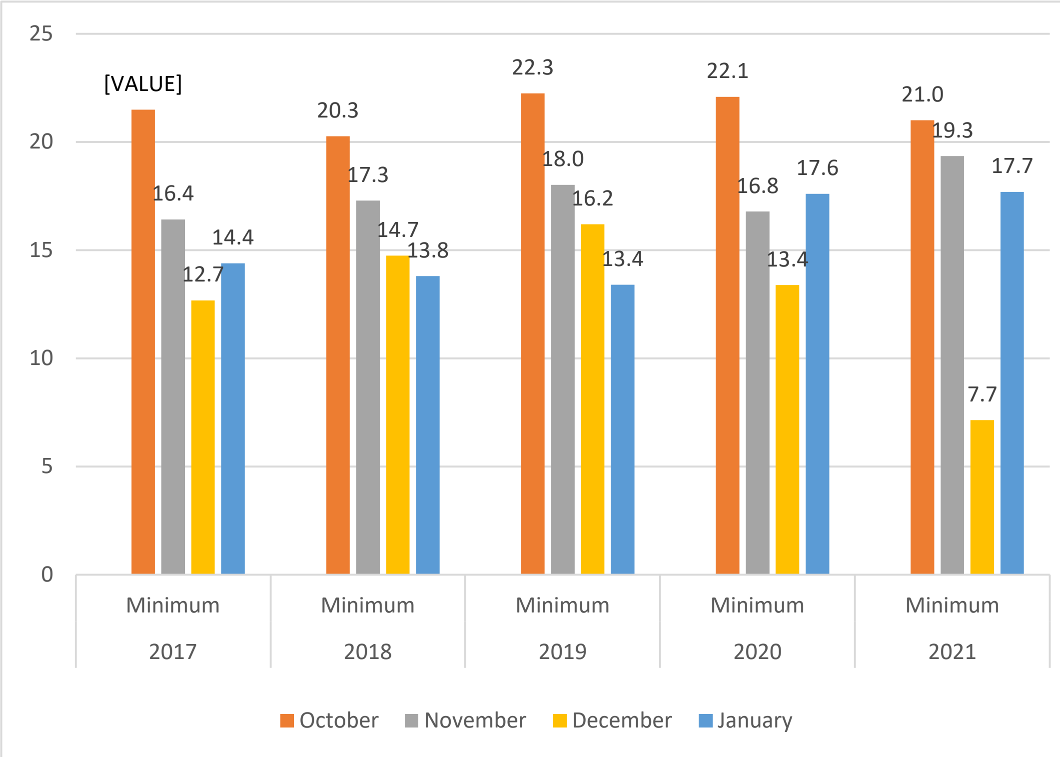


Fig.1. Average weather status from 2017 -2021

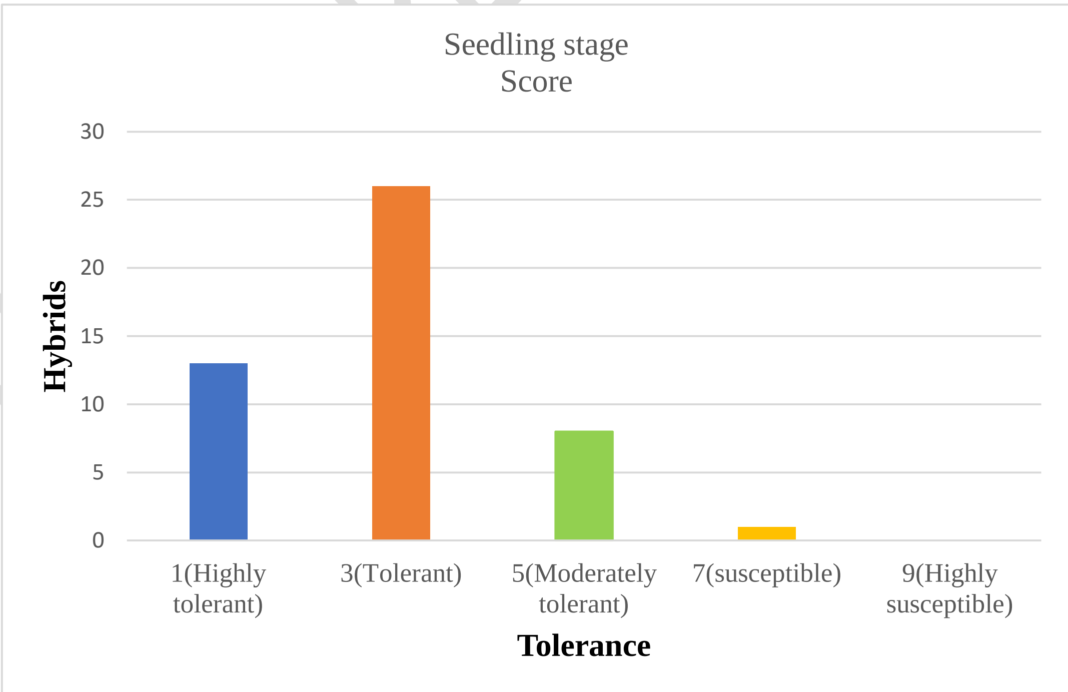
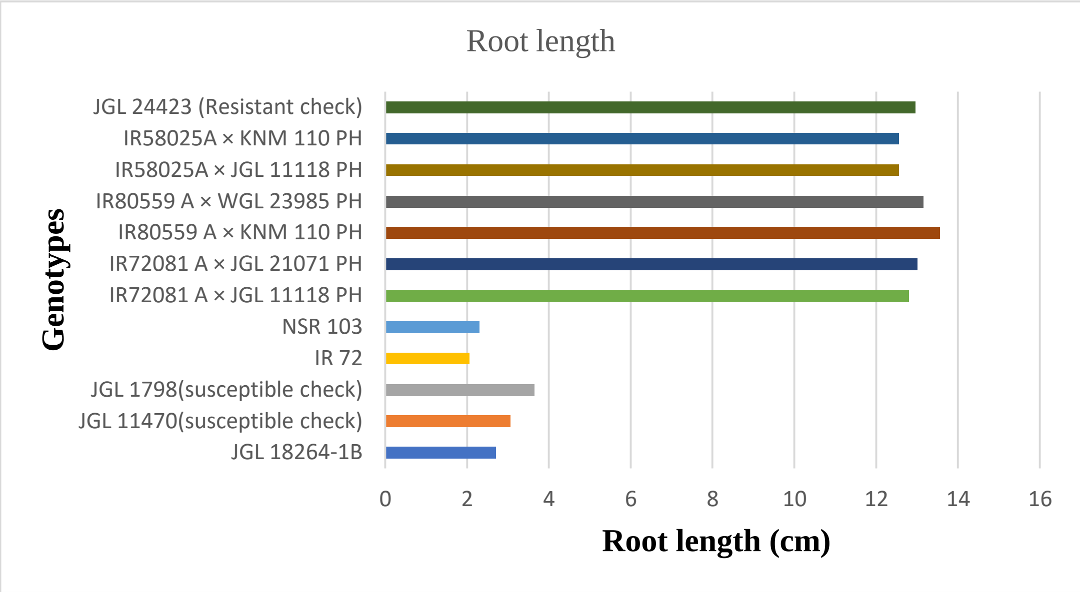
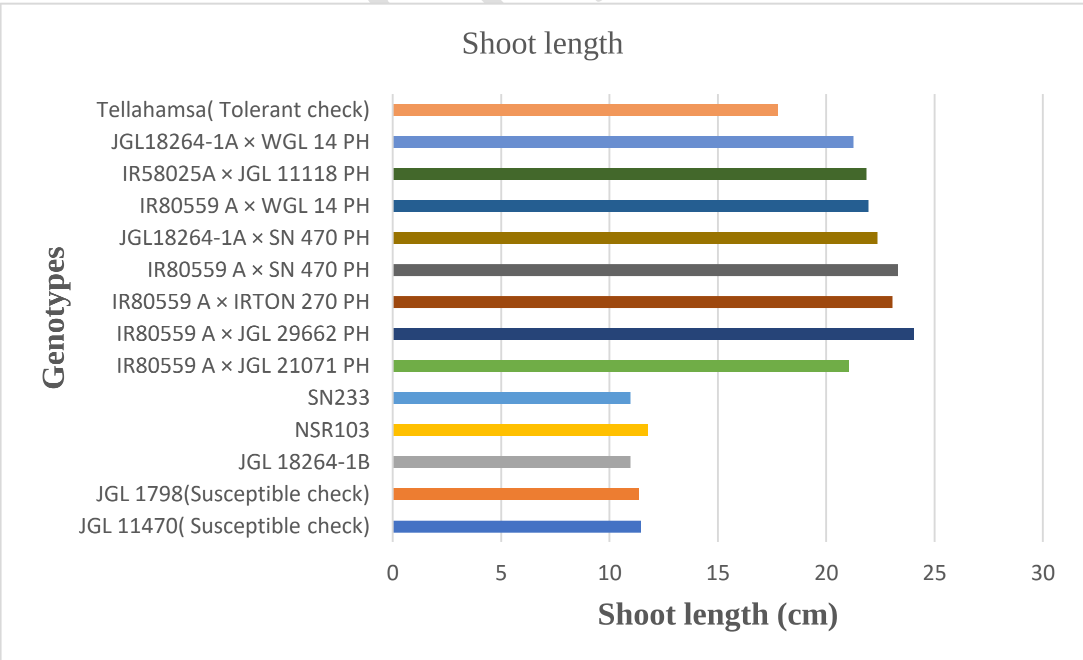


Fig.2. Frequency distribution of Hybrids and their tolerance at seedling stage



PH: Promising hybrids

Fig.3. Frequency distribution of genotypes and root length



PH: Promising hybrid

Fig.4. Frequency distribution of genotypes and shoot length

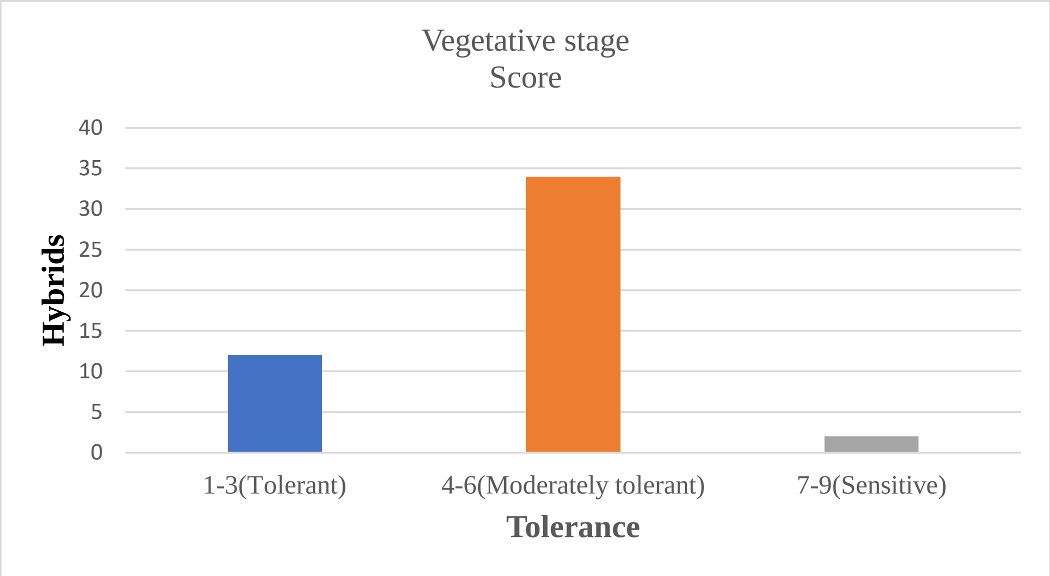


Fig.5. Frequency distribution of Hybrids and their tolerance at vegetative stage