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Research Article

Temperature Effect on Yield and Yield Components of Different Rice Cultivars in Flowering Stage

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In order to study the effect of cold stress in flowering stage on yield and yield components of different rice cultivars, an experiment was performed as split plot factorial based on completely randomized design (CRD) in greenhouse of deputy of rice research institute of Iran (Amol) in 2010, in three repetitions. Treatment included 5 varieties as main factors that included cultivars of shirudi, fajr, local tarom, hybrid, and line 843. Two levels of temperatures T_1 (13°C, stress temperature) and T_2 (32°C, normal temperature, control) along with flowering stage were selected as two subfactors. Three seedlings were planted in each plot. The cold stress was done in flowering stage with holding pots at 13°C for 15 days. Results showed that low temperature had significant effect in level of 1 percent on all characters, such as the number of panicles, the length of panicle, and the number of full, empty, and total grains; as a result, yield had caused significant reduction. Interaction between temperature and varieties showed that most tolerant variety in relation to temperature stress along with least percentage yield (19%) is shirudi variety and the most sensitive one with most percentage of yield decrease (29%) was local tarom variety.

1. Introduction

Rice (*Oryza sativa*) is a monocot crop. It is a cereal grain and the most widely consumed staple food for a large part of the world's human population, especially in Asia. After maize (corn), it has the second-highest worldwide production, according to data from 2010. Rice can be grown in different environments depending upon water availability and temperature conditions [1]. Cold stress is a common problem in rice cultivation and affects global production as a crucial factor [2]. Rice is a cold-sensitive plant that originated from tropical or subtropical zones. When low temperature occurs during the reproductive stages, it can cause serious yield and yield components losses [3]. The optimum temperature for rice cultivation is between 25°C and 35°C, and in temperate regions, rice growth is impressed by limited period that favors its growth [4].

Exposure to cold temperature affects all phonological stages of rice and lower grain production and yield, too. Low temperature in vegetative stage can cause slow growth and reduce seedling vigor [5] low number of seedlings, reduce tillering [6] increase plant mortality [3, 7, 8] increase the growth period [9] and in reproductive stage, it can cause to produc panicle sterility and lower grain production and yield [6].

Critical stages for cold damage include germination, booting, flowering, and filling stages [10]. Since the most sensitive stage for cold harm is the flowering stage, which occurs 10–12 days prior to heading, our objective of this study is to evaluate the effect of cold stress on yield and yield components in flowering stages and identify the Iranian current rice crop resistant and sensitive cultivars.

2. Materials and Methods

The experiment was performed as split plot factorial based on completely randomized design (CRD) in Greenhouse of Deputy of Rice Research Institute of Iran (Amol) in 2010, in three repetitions. This treatment included 5 varieties

Table 1: Sources of variations of yield and yield components.

S.O.V	df	Panicle number/hill (cm)	Panicle length/hill (cm)	Full grain number/hill	Empty grain number/hill	Total grain/hill	Yield (gm/hill)
Cultivar factor	4	106.8**	19.89**	112.82**	151494.7**	156662**	215.8**
Error A	10	29	71.15	1426.76	13948.7	17314.8	581.2
Growth stage factor	4	18.77**	11.29**	4269.82**	27148.8**	2851.3**	251.2**
Temperature factor	1	181.5**	95.36**	117264**	18627.6**	574370**	357.2**
Growth stage × temperature interaction	4	31.86**	11.13**	3235.15**	56684.02**	1091.2**	53.16**
Variety × growth stage interaction	16	84.98**	9.94**	2822.8**	279182.9**	2720.7**	120.8**
Cultivar × temperature interaction	4	7.41	3.28**	6637.30**	126981.2**	5494.1**	85.12**
Cultivar × temperature × growth stage interaction	16	139.2**	8.17**	5812.32**	733214.2**	4543.7**	53.72**
Error B	90	2.27	7.2	10.47	5.9	11.29	7.8
CV	—	20.2	13.4	14.2	15.2	16.8	11.2

Ns: nonsignificant, * and ** significant in probability levels of 5% and 1%, respectively.

Table 2: Effect of cultivar on yield and yield components across temperature.

Cultivar	Panicle number/hill (cm)	Panicle length/hill (cm)	Full grain number/hill	Empty grain number/hill	Total grain/hill	Yield (gm/hill)
Shirudi	5.93^ab	19.32^ab	317.83^a	50.80^b	366.24^a	80.63^a
Fajr	5.64^ab	20.48^a	182.29^c	57.73^b	212.71^c	73.73^b
Tarom	3.61^c	20.5^a	147.20^d	80.56^a	196.63^d	69.72^d
Line 843	4.93^b	20.78^a	252.5^b	52.93^b	310.30^b	72.46^c
Hybrid	4.93^b	18.96^b	160.77^c	49^c	226.37^c	71.95^c

Distinct letters in the row indicate significant differences according to Tukey's test ($P \leq 0.01$).

as main factor that include cultivars of shirudi, fajr, local tarom, hybrid, and line 843. Two levels of temperatures T_1 (13°C, stress temperature) and T_2 (32°C, normal temperature, control) along with flowering stage were selected as two subfactors. Three seedlings were planted in each plot. The cold stress was done in flowering stage with holding pots at 13°C for 15 days. 13°C temperature treatment was adjusted with cooler installation and relative humidity was maintained constantly between 70 and 80 percent by wetting bottomless sack of greenhouse. The normal temperature of 32°C was adjusted by split cooler installation and temperature setting thermostat and relative humidity was maintained between 80 and 85 percent.

The number of panicles in a hill was obtained with counting panicles in a hill. In order to measure the length of panicle (cm), all panicles of hill were measured from the location of the panicle nodes to the panicle head with a ruler and then average values were recorded. Then, all grains of panicles were separated and the number of full and empty grains was counted and with the sum of them, the total number of seeds was obtained. By weighting the full and healthy grains of panicles, yield in hill was evaluated. All statics were performed with SAS program (Version 6.2) and MSTAT-C (Version 2.1). The mean comparisons were performed by the Duncan multiple range test in significance level of 1 percent.

3. Results and Discussion

As shown in Table 1, cultivar, growth stage, and temperature effects and their interactions on all treatments, such as the number of panicles, the length of panicle, the number of full, empty, total grains, and yield, were significant in level of 1 percent (Table 1).

As shown in Table 2, the maximum number of panicles was obtained in shirudi and fajr cultivars, respectively (5.93 and 5.64), and the minimum one was related to local tarom (3.61). The maximum amount of the length of panicle was obtained in line 843, local tarom, and fajr cultivars, respectively (20.78, 50.5, and 20.48) and the minimum one was related to hybrid cultivar (18.96). The maximum number of full grains was achieved in shirudi cultivar (317.83) and the minimum of it was obtained in tarom cultivar (182.29). The maximum and minimum numbers of empty grains were related to tarom and hybrid cultivars, respectively (80.56, 49). The maximum and minimum numbers of total grains were related to shirudi and tarom cultivars, respectively (366.24, 196.63). The shirudi and tarom cultivars were obtained by maximum and minimum yield, respectively (80.63, 69.72), gr per hill (Table 2).

As shown in Table 3, the temperature had significant effect on all treatments, so that the maximum value of each trait was obtained in normal temperature (T_2) and the minimum one was related to stress temperature (T_1).

Table 3: Temperature effect on yield and yield components across varieties.

Temperature	Panicle number/hill (cm)	Panicle length/hill (cm)	Full grain number/hill	Empty grain number/hill	Total grain/hill	Yield (gm/hill)
T_2	6.2[a]	20.7[a]	246.4[a]	24.0[b]	323.3[a]	100.65[a]
T_1	4.0[b]	19.2[b]	175.9[b]	72.92[a]	199.5[b]	75.80[b]

Distinct letters in the row indicate significant differences according to Tukey's test ($P \leq 0.01$).
T_2: 32°C, T_1: 13°C.

Table 4: Interactive effects between cultivar and temperature on yield and yield components.

Treatment	Panicle number/hill (cm)	Panicle length/hill (cm)	Full grain number/hill	Empty grain number/hill	Total grain/hill	Yield (gm/hill)
V_1T_2	5.80[abc]	20.55[a]	376.21[a]	115.1[a]	452.07[a]	25.4[a]
V_1T_1	4.06[a]	18.09[a]	263.33[c]	46[e]	286.13[d]	20.4[f]
V_2T_2	6.43[abc]	19/67[a]	183.25[e]	36.5[f]	220.0[f]	24.8[b]
V_2T_1	4.80[abcd]	18.20[a]	181.26[ef]	23.73[g]	204.93[g]	18.2[h]
V_3T_2	7.07[ab]	21.25[a]	226.0[d]	82.92[c]	338.33[b]	22.5[d]
V_3T_1	4.33[bcd]	19.80[a]	38.40[h]	24.93[g]	114.4[i]	15.8[j]
V_4T_2	7.2[a]	21.70[a]	282[b]	103.33[b]	385.66[c]	22.2[c]
V_4T_1	4.66[abcd]	19.85[a]	282[b]	103.33[b]	385.66[c]	17/4[h]
V_5T_2	4.8[abcd]	20.90[a]	177.66[f]	64.80[d]	235.93[e]	22.1[e]
V_5T_1	2.4[d]	20.06[a]	143.56[g]	13.20[h]	157.33[h]	16.5[i]

Distinct letters in the row indicate significant differences according to Tukey's test ($P \leq 0.01$).
V_1: shirudi, V_2: fajr, V_3: local tarom, V_4: line 843, and V_5: hybrid cultivars.
T_2: 32°C, T_1: 13°C.

The interactions effects table for cultivar in temperature (Table 4) shows that shirudi cultivar achieved the lowest reduction percent number of panicles (20%) and it was the most resistant cultivar and hybrid cultivar obtained the highest one (50%) and was a susceptible cultivar.

All experimental characteristics had not had significant difference for reduction of panicle length. Shirudi obtained the lowest reduction percent for number of full, empty, total grains and yield, respectively (5%, 6%, 7%, and 19%), and local tarom achieved the most reduction percent for them, respectively (83%, 73%, 66%, and 29%), and for yield (29%) and it was the most susceptible cultivars (Table 4).

4. Conclusions

Low temperature had significant effect in level of 1 percent on all treatments; the number of panicles, the length of panicle, the number of full, empty, total grains, and yield had caused significant reduction in them. The interaction temperature with varieties shows that most tolerant variety in relation to temperature stress along with least percentage yield (19%) is shirudi variety and the most sensitive one with most percentage of yield decrease (29%) is local tarom variety.

Cold stress at reproductive stage has had inappropriate effects on the yield of rice in Australia, China, and Korea since 2000 [2, 4, 6, 10–14]. Low temperature in the range of 15–19°C during the reproductive stage impairs microspore development and causes the production of sterile pollen grains, resulting in poor grain filling and high spikelet sterility [10] and reducing spikelet fertility and affecting grain quality [13]. Several methods have been proposed to reduce the threat of low temperature, including substitution of cold-sensitive cultivars with cold tolerant ones, setting of sowing time, and selection of varieties with a growth duration permitting elusion of peak stress periods are some of the adaptive measures that will help in the reduction of adverse effects of low temperature.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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