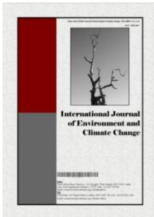

International Journal of Environment and Climate Change

11(5): 34-38, 2021; Article no.IJECC.70215
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Gibberellic Acid (GA_3) on the Yield Attributing Traits during a Cold Period in Rice

D. Shashibhushan[1*], M. Ashish Reddy[1], D. Bhadru[1] and T. Pradeep[1]

[1]Seed Research and Technology Centre, PJTSAU, Hyderabad, 500030, India.

Authors' contributions

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

Article Information

DOI: 10.9734/IJECC/2021/v11i530407
Editor(s):
(1) Dr. Wen-Cheng Liu, National United University, China.
Reviewers:
(1) Asif Bashir Shikari, India.
(2) Elizzandra Marta Martins Gandini, Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/70215

Original Research Article

Received 01 May 2021
Accepted 06 July 2021
Published 08 July 2021

ABSTRACT

Gibberellic acid is an essential growth promoter that aids in the systematic plant growth. Studies on the impact of GA_3 during cold period discovered a positive effect on the growth of rice plants. The current study evaluated the impact of various concentrations of GA_3 on the yielding attributes of rice during cold stress in the rice varities, JGL 18047, BPT 5204, and RNR 15048. All the quantitative traits showed significant variation among the genotypes and treatments. Gibberellins applied at low concentrations during seedling stage (1, 2 or 3 gm/200 m^2 of nursery area) revealed higher quantitative trait values compared to higher concnetartions (5 and 10 gm). Among all the three varities, RNR 15048 was found to be the best variety than the others in terms of yielding triats. Therefore, GA_3 applied at a concentration of 1gm, 2gm or 3gm promotes the rice plant growth during cold periods and results in higher yield. Among these, 2 gm of GA_3 for 200 m^2 of nurcessary area was found to be the best in aiding the crop growth during cold phase.

Keywords: Rice; growth promoter; temperature stress; cold period; quantitative traits.

1. INTRODUCTION

Cold tolerance is one of the major qualities, a rice cultivar is expected to have since the low temperatures have caused significant yield losses in many parts of the world [1]. Low temperatures during the flowering stage cause incomplete panicle exertion, spikelet sterility, and

**Corresponding author: E-mail: danamshashi@gmail.com;*

degeneration of the spikelet resulting in low grain formation [2]. The yield losses of rice are reported to be up to 26% due to extreme cold conditions. For instance, In Australia, rice farmers experienced a loss of 0.5 to 2.5 tons per hectare due to low temperatures during the reproductive stage [3]. Cold stress during the seedling stage affects the overall crop growth and reduces the crop yield. Low temperatures result in reduced germination and stunted seedling growth. The application of suitable growth regulators at optimum concentrations regulates crop growth and increases the yield [4]. Gibberellic acid is one such growth promoter applied on the rice crop during the seedling stage or anthesis stage to mitigate the cold stress in rice [5]. It promotes the time of flowering, impacts the shape of the plant, and helps in plant growth [6]. Various studies had taken place across the globe on the impact of gibberellins on plant growth during cold stress. Grohs et al. [7], revealed that the application of gibberellins acid on rice crop mitigate the cold stress by preventing the formation of reactive oxygen species and lipid peroxidation. The study performed by Das et al. [8] showed that the application of gibberellins on boro rice during cold stress increased the yield by 12.5% over control. It has shown that gibberellins acid is the major cold stress reduction factor in rice, but the concentration to be applied to rice crop plays a crucial role in the mitigation of cold stress [9]. The present study aims at the examination of the impact of various concentrations of GA_3 on the rice crop during cold stress.

2. MATERIALS AND METHODS

The study was carried out at Seed Research and Technology Centre, PJTSAU, Hyderabad during the winter season in a split-plot design with three genotypes as main plot (JGL 18047, BPT 5204, and RNR 15048) and seven treatments of gibberellic acid (GA_3) as subplot (1, 2,3,4,5,10 gm per 200 m^2 of nursery area, and control). The study was conducted in three replications. Sowing of nursery took place at the beginning of winter and gibberellins was applied 15 days after seedling emergence. The minimum temperature ranged between 10 to 20^{o}C and the maximum temperature ranged between 25 to 30^{o}C during the crop growth. The yield attributes such as flag leaf length, flag leaf width, plant height, productive tillers per plant, panicle length, test weight, and grain yield were examined during the study. All the traits were collected on ten plants that were tagged randomly before flowering.

The quantitative data were checked for normality using the Shapiro-Wilk normality testand the heterogeneity test was performed by Levene's test of heterogeneity before analyzing the data with a mixed model. All the quantitative traits were subjected to mixed model analysis by following the Restricted Maximum Likelihood (REML) method with the help of the ASREML package in "R". Anova was performed by Kenward-Roger degrees of freedom approximation method.Marginal means were computed for each treatment and genotype. The pairwise comparison test was performed among the treatments by Tukey's method with the "emmeans ()" function from the package "emmeans" [10]. The model used for mixed model analysis is presented below.

$$Yir = \mu + Gi + Trj + R_k + Gi{*}\ Trj$$

Yir = observed value of the ith genotype of Rth replication

μ = general effect

Gi = effect of the ith genotype

Trj = effect of the jth treatment

R_k = effect of the K_{th} rep

Gi*Trj = Interaction of the genotype and treatment

3. RESULTS

Shapiro-Wilk normality test [11] and Levene's heterogeneity test [12] performed on the quantitative data revealed that all the traits satisfied the condition of normality and heterogeneity. Analysis of variance of the quantitative traits showed that there is a significant difference between all the genotypes and treatments, and the interaction between them is also significant. The variation between the replications was non-significant in all three rice genotypes and seven treatments for all the quantitative traits. The results of ANOVA are presented in Table 1 and each trait is elaborated in the following sections.

Table 1. Analysis of variance results

Source of Variation	Mean sum of squares		F value	
	Genotype	Treatment	Genotype	Treatment
Flag leaf length	14.34	18.3	37.86	1.27
Flag leaf width	0.309	0.162	82.25	6.87
Plant height	1984.29	146.28	136.5	6.29
Productive tillers per plant	139.19	119.7	403.17	207.06
Panicle length	40.201	47.474	48.43	37.252
Test weight	11.90	0.059	175.20	8.55
Grain yield	407221.85	2304914.571	225.512	265.408

Table 2. Mean values of the quantitative traits studied

Gibbelins concentration and rice variety	Flag leaf length (cm)	Flag leaf width (cm)	Plant height (cm)	Productive tillers per plant	Panicle length (cm)	Test weight (cm)	Grain yield (Kg/ha)
1 gm (RNR 15048)	22.57	1.31	95.1	15.4	23.47	1.14	4268
2 gm(RNR 15048)	23.5	1.44	91.97	15.4	21.7	1.23	4905
3 gm(RNR 15048)	21.97	1.35	87.23	14.33	22.07	1.12	4903
4 gm(RNR 15048)	22.5	1.07	91.7	13.67	21.83	1.04	4886
5 gm(RNR 15048)	22.63	1.2	94.33	14.8	20.97	1.13	4096
10 gm(RNR 15048)	21.5	1.22	95.53	11.07	21.27	1.11	3463
Control (RNR 15048)	18.37	1.21	88	10.03	18.33	1.1	4279
1 gm (JGL 18047)	21.6	1.12	78.87	10.53	18.37	2.22	4366
2 gm(JGL 18047)	18.6	1.19	88.1	14.7	20.93	2.15	4619
3 gm(JGL 18047)	20.43	1.16	87.37	13.2	19.87	2.21	4483
4 gm(JGL 18047)	20.27	1.2	78.4	14.2	20.83	2.15	4445
5 gm(JGL 18047)	17.53	1.21	81.16	13.07	21.77	2.12	3458
10 gm(JGL 18047)	21.43	1.17	77.27	12.23	21.73	2.15	3070
Control (JGL 18047)	21.16	0.88	75.43	9.5	17.13	2.02	3836
1 gm (BPT 5204)	19.47	1.17	95.03	15.4	22.03	1.36	3214
2 gm(BPT 5204)	19.13	1.21	92.73	18.53	23.67	1.4	4136
3 gm(BPT 5204)	21.3	1.34	92.3	17.2	23.67	1.33	3872
4 gm(BPT 5204)	21.87	1.33	93.13	16.2	21.1	1.38	3858
5 gm(BPT 5204)	21.87	1.33	93.67	14.53	21.07	1.4	3153
10 gm(BPT 5204)	22.5	1.34	94.03	14.9	20.4	1.42	3016
Control (BPT 5204)	21.07	1.28	94.03	15.47	22.13	1.35	3252
CD Value (Genotype)	0.46	0.08	3.82	0.59	0.915	0.083	196.3
CD Value (Treatment)	0.29	0.02	2.52	0.39	0.064	0.043	119.4

A significant difference was observed between the plant height of control and gibberellins treated rice plants. How ever-increasing or decreasing trend was not observed with the increase in gibberellins concentration. The mean plant height of all the genotypes and treatments together was found to be 88.8 cm where the highest plant height value was recorded in RNR15048 (95.5 cm) rice variety treated with 10 gm of gibberellins acid and the least in the untreated JGL 18047 (75.4 cm) rice variety. The seedling length just before transplanting was found to be increasing with increase in the dosage of GA3.

Productive tillers per plant are one of the major plant traits which determine the yield of the rice variety. In the current study, The average productive tillers of all the varieties and treatments were 14 with BPT 5204 rice variety (18.53 tillers per plant) treated with 2 gm as the top variety and untreated JGL 18047 (9.5 tillers per plant) as the least variety. In most of the genotypes, lower concentrations of gibberellins (1gm to 4gm) produced a larger number of tillers compared to higher concentrations.

Pancile length was significantly varying among the genotypes and treatments. The rice variety, BPT 5204 treated with 2g and 3g of gibberellins, and the untreated rice variety JGL 18047 was observed with the longest (23.67 cm) and shortest (17.13 cm), respectively. Lower concentrations of gibberellins unveiled longer panicles compared to higher concentrations in all the genotypes.

Flag leaf length was found to be highest in control compared to the gibberllins treated plants in JGL 18047 and BPT 5204 whereas it is vice versa in RNR 15048. The mean flag leaf length values of the rice varities RNR 15048, JGL 18047, and BPT 5204 are 21.08, 20.14, and 21.03, respectively.

The average flag leaf width of all the varities and treatments together was observed to be 1.22 cm. RNR 15048 treated with 2g of gibberllic acid had the broadest leaves (1.44 cm) while the untreated JGL18047 had the narrowest leaves (0.88 cm).

The test weight (100 seeds) varied significantly among the varities and treatments. The mean test weight of the experiment was 1.54 gm with a minimum weight of 1.1 gm (untreated RNR 15048) and a maxim weight of 2.22 gm (JGL 18047 treated with 1 gm of gibberllic acid). The mean test of all the treatments of RNR 15048, JGL18047, and BPT 5204 was 1.12 gm, 2.14gm, 1.7gm, respectively.

The mean grain yield of all the treatments together was found to be 3979.9 Kg/h. Highest yield was recorded in RNR 15048 treated with 2gm of gibberlins and the least in BPT 5204 treated with 10g of gibberlins. The average grain yield of RNR 15048, JGL18047, and BPT5204 was recorded as 4400Kg/h, 4043.4Kg/h, 3543 Kg/h, respectively. The mean values of all the quantitative traits are presented in Table 2.

4. DISCUSSION

Cold tolerance is one of the key research area in several crops including rice [13]. Several harmones and growth regulators have been studied against the cold tolerance in rice. The research conducted by Shinkawa et al. [14] revealed that abscisic acid induced freezing tolerence in seedlings of rice. Similarly, the study performed by Mega et al. [15] showed that the sustained low abscisic acid levels increases seedling vigour under cold stress. Das et al. [8] studied the effect of gibberllic acid on boro rice variety and found that GA_3 applied at early tillering stage induced cold tolerance in rice. In the current study, the effect of various concentrations of gibberllic acid on rice seedlings for cold tolerance was studied on three rice varieties.

Considering all the characters studied, low concnetrations, i.e 1gm, 2gm and 3gm are effective in promoting growth in rice compared to high concenrations during cold phase. The gibberllic acid concentration was found to have negative correlation with most of the traits revealing that low concentrations are better than the high concnetrations, and control in protecting the rice plants from cold stress. Ten grams of gibberllic acid was found to have the least impact on the rice plants. Among the three rice genotypes, RNR 15048 and JGL 18047 showed the better performance compared to BPT 5204.

5. CONCLUSION

The current investigation revealed that the application of GA_3 on rice during seedling stage induces cold tolerance and aids in increasing the yield significantly. The concentration of GA_3 to be applied is less than five (1gm, 2gm and 3gm) to get better results. Among these, 2 gm of GA_3 for 200 m^2 of nurcessary promoted the plant growth significantly comparing to others. Among all the three varities RNR 1508 was found to be the best variety than the others in terms of yielding triats.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Lima MGS, Lopes NF, Zimmer PD, Meneghello GE, Mendes CR, Amarante L. Enzyme expression in indica and japonica rice cultivars under saline stress. Acta Sci. Biol. Sci. 2012;34:473–481.
2. Coast O, Murdoch AJ, Ellis RH, Hay FR, Jagadish KSV. Resilience of rice (*Oryza* spp.) pollen germination and tube growth to temperature stress. Plant Cell Environ. 2015;39:26–37.
3. Da Cruz RP, Kothe Milach SC, Federizzi LC. Rice cold tolerance at the reproductive stage in a controlled environment. Scientia Agricola. 2006;63(3):255–261.
4. Biswas AK, Mondal SK. Regulation by kinetin and abcisic acid of correlative senescence in relation to grain maturation, source-sink relationship and yield of rice (*Oryza sativa* L.). Plant Growth Regulation. 1986;4(3):239–245.
5. Cui S, Huang F, Wang J, Ma X, Cheng Y, Liu J. A proteomic analysis of cold stress responses in rice seedlings. Proteomics.

2005;5(12):3162–3172.
6. Mutasa-Göttgens E, Hedden P. Gibberellin as a factor in floral regulatory networks. In Journal of Experimental Botany; 2009.
7. Grohs M, Marchesan E, Roso R, Moraes BS. Atenuação de estresse por baixa temperatura em plântulas de arroz. Pesquisa Agropecuaria Tropical. 2016; 46(2):197–205.
8. Das R, Haloi B, Pathak K. Enhancement of physiological efficiency of boro rice using exogenous gibberellic acid. In Indian J. Plant Physiol. 2011;16(4).
9. Lantzouni O, Alkofer A, Falter-Braun P, Schwechheimer C. Growth-regulating factors interact with dellas and regulate growth in cold stress. Plant Cell. 2020; 32(4):1018–1034.
10. Altendorf K, Isbell T, Wyse DL, Anderson JA. Significant variation for seed oil content, fatty acid profile, and seed weight in natural populations of field pennycress (*Thlaspi arvense* L.). Industrial Crops and Products. 2019;129:261–268.
11. Shapiro SS, Wilk MB. An analysis of variance test for normality (complete samples). Biometrika. 1965;52(3-4): 591.
12. Levene H. In contributions to Probability and Statistics: Essays in Honor of Harold Hotelling. In Contributions to probability and statistics: Essays in … 1960;69(346).
13. De Freitas GM, Thomas J, Liyanage R, Lay JO, Basu S, Ramegowda V, Amaral MN. Do, Benitez LC, Braga EJB, Pereira A. Cold tolerance response mechanisms revealed through comparative analysis of gene and protein expression in multiple rice genotypes. PLoS ONE. 2019;14(6).
14. Shinkawa R, Morishita A, Amikura K, Machida R, Murakawa H, Kuchitsu K, Ishikawa M. Abscisic acid induced freezing tolerance in chilling-sensitive suspension cultures and seedlings of rice. BMC Research Notes. 2013;6(1).
15. Mega R, Meguro-Maoka A, Endo A, Shimosaka E, Murayama S, Nambara E, Seo M, Kanno Y, Abrams SR, Sato Y. Sustained low abscisic acid levels increase seedling vigor under cold stress in rice (*Oryza sativa* L.). Scientific Reports. 2015;5.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/70215