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Effects of anti Gibberellic and Ethylene Substances for Submergence Tolerance in Rice (*Oryza Sativa* L.)

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Abstract

10 days old rice seedlings of three rice genotypes viz. FR13A, Mahananda and Swarna were sprayed with 10µMolar/Lt solution of gibberellic acid (GA_3) retardant paclobutrazol and stress hormone abscisic acid (ABA), gibberellic acid (GA_3) and ethylene inhibitor substances like STS solution of concentration 0.02Molar, 20µMolar, 0.6 mili Molar; 10 µMolar $CoCl_2$ and 240ppm $AgNO_3$ solution on the leaves prior to two days of submergence under drum and pot screening method in each separate set up in three replications. Gibberellin and ethylene inhibitors reduce the stem elongation and increases survival% after complete four days full submergence. The important genetic variability components viz. CV, GCV, PCV, h%, GA and GA% of mean were estimated for different agro morphological characters after treatment effect. Manipulation of gibberellic acid and ethylene action are very important for breeding submergence tolerance in rice. Less difference of GCV and PCV along with high heritability and genetic gain of the characters indicate that they are controlled by additive genes and selection based on the characters will be effective for breeding submergence tolerance in rice.

Key words: Submergence, gibberellic acid and ethylene inhibitor, drum and pot screening, survival% and genetic variability parameters.

Introduction

Rice production in India is an important aspect of the national economy. Rice is the world's single most important food crops and primary food source for one third of the world population. Within the country, rice occupies 1/3 of the total cropped area, contributes about 40 to 43% of total food grain production and continues to play a key role in the national food and livelihood security system. However, productivity of rice is only 2.54 tones/ha of milled rice as against the global average productivity of 3.28 tones/ha[1]. At the current rate of population growth (1.98%) Indian population is expected to touch 1.63 billion by 2050. Of these about 52% will be the urban population. Per capita demand for food has been estimated to be about 140Kg cereal/year or about 384g/day. Considering that about 60% of the cereal requirement will be rice, it may be estimated that rice requirement will be 230 g/day or 84 kg/year/person. This would transform into requirement of about 136 million tones of rice for an expected population of 162 million by the year 2050 for consumption purpose alone. Among the 42 biotic and abiotic stresses affecting rice production, submergence has been identified as the 3rd most important constraint for higher productivity in Eastern India because it sometimes resulted in near total yield loss[2]. Suitable germplasm as well as management technologies are therefore needed to enhance and stabilize rice productivity in the submerged areas[3-6]. Submergence intolerant cultivars usually showed increased levels of seedling death during submergence. Ethylene increased the responsiveness of the inter node tissue to gibberellic acid by causing a reduction in the levels of abscisic acid, because abscisic acid is a potent antagonist of gibberellic acid. Ethylene produced during submergence triggers reduction of seedling survival. Potent inhibitors of ethylene action in plants are silver nitrate ($AgNO_3$), silver thiosulfate (STS) and cobalt chloride ($CoCl_2$) etc. There is a good negative correlation between per cent survival and elongation growth of genotypes during complete submergence. When elongation growths during submergence is reduced by application of gibberellins biosynthesis inhibitors and ethylene inhibitors as foliar spray prior to submergence, per cent survival increases by many folds. In rice, elongation growth of internodes during submergence is mediated by the ratio of gibberellins and abscisic acid[7] and enhancement of gibberellins activity by ethylene[8]. Application of exogenous gibberellins and ethylene biosynthesis inhibitors will enhances the submergence tolerance by reducing the stem elongation. Work presented here focuses on how survival of established rice seedlings along with other agro morphological characters is affected by the successful manipulation of elongation growth during submergence by laboratory drum and pot screening method for three rice varieties viz. FR13A, Mahananda and Swarna. This is achieved using the growth regulator gibberellin (GA_3), gibberellins biosynthesis inhibitor paclobutrazol and abscisic acid (ABA) with different concentration to reduce growth during submergence[9]; potent ethylene action inhibitors silver nitrate viz. $AgNO_3$, silver thiosulfate (STS) and $CoCl_2$[10-14]. The estimates of various genetic variability parameters guide the selection of the treatments effect for submergence breeding.

Material and Methods

Drum and Pot Screening: The experiment was conducted during 2013-2014 at glass house at Dept. of Genetics and Plant Breeding, Calcutta University with FR13A as tolerant check along with other two varieties Mahananda and Swarna which includes Swarna as susceptible check. 15 germinated seed of different rice entries were sown in 3 replication in pot (height 17 cm, diameter 18.5 cm) filled with soil. The soil was filled up to the 13 cm pot height. 10 days old seedlings were transferred into 100 cm long drum with 49 cm diameter and submerged with 95 cm depth of tank water. The water depth was maintained 95 cm throughout the experiment. Seedling length, plant population were recorded before submergence. To resist the entry of sunlight the drums were covered with lid. After 4 days of submergence the pots were taken from the drum and plant height, plant population were recorded. Survival% was recorded after submergence[15].

Treatments of seedlings: 10 days old rice seedlings of three rice genotypes viz. FR13A, Mahananda and Swarna were sprayed with 10µMolar/Lt solution of gibberellic Acid (GA_3), gibberellic Acid (GA_3) retardant paclobutrazol and stress hormone abscisic acid (ABA) and ethylene inhibitors substances like STS solution of concentration 0.02Molar, 20µMolar, 0.6 mili Molar; 10 µMolar $CoCl_2$ and 240ppm $AgNO_3$ solution on the leaves prior to two days of submergence, in each separate set up with three replications. Plant height and plant population were recorded before submergence. The treated 10 days old seedlings were transferred to drum (same procedure as normal drum and pot screening) filled with 95 cm water. After 4 days the pots were taken from the drum and plant height, plant population were recorded. Survival score was done after submergence. Comparison of effects of treatment on tolerance was done with reference to control condition.

Statistical analysis: Plant from each entry was measured for calculating different traits and the mean data was utilized for calculation. The calculation was done by 3x9 factorial RBD with three varieties and nine treatments in three replication. The component characters were estimated are plant height before and after submergence, elongation% and survival%. The experimental design was calculated by the method suggested by Gomez and Gomez[16].

Results and Discussion

Table 1 represents the effects of growth regulators on plant height (cm) before submergence. It was seen from the table that there was less significant differences of plant height mean treatment effects before submergence. The mean effect of 10µMolar/Lt ABA, paclobutrazol, and gibberellic acid, 0.02Molar STS, 20µMolar STS, 0.6 mili Molar STS, 10 µMolar $CoCl_2$ and 240ppm $AgNO_3$ solution was 21.67 cm, 23.83 cm, 22.80cm, 25.32 cm, 28.10 cm, 24.83 cm, 26.16 cm and 29.50 cm respectively. The mean height of stem before submergence for FR13A, Mahananda and Swarna was 24.20, 30.04 and 21.61 cm respectively.

Table-2 represents the effects of growth regulators on plant height (cm) after submergence. 10µMolar/Lt ABA, 0.02Molar STS, 0.6 mili Molar STS and 240ppm $AgNO_3$ has significantly reduces plant height over the control in submergence tolerant check variety FR13A. The growth regulator like ABA and paclobutrazol has greatly reduces the plant height over the control. Treatment like ABA, paclobutrazol, silver thiosulfate solution and silver nitrate solution has significantly reduces the plant height over the control. The mean height of stem after submergence for FR13A, Mahananda and Swarna was 26.69, 32.62 and 24.69 cm respectively.

Table-3 represents the effects of various treatments on elongation %**.** Six treatments like 10µMolar/Lt ABA, 10µMolar/Lt paclobutrazol, 0.02 Molar STS, 20µMolar STS, 0.6 mili Molar STS and 240 ppm $AgNO_3$ significantly reduce the elongation% over the control. It was seen from the table that gibberellic acid is one of the most significant substances along with ethylene is fully responsible for elongation under the submergence stress. Treatment like 240 ppm $AgNO_3$ which is a anti ethylene substance has showed highest elongation reduction with the value of 7.04 and other anti ethylene substance like 0.02 Molar STS and 20µMolar STS has significant role in elongation reduction. The average elongation% of stem after submergence for FR13A, Mahananda and Swarna was 7.37, 9.05 and 14.59% respectively.

Table-1
Effects of Growth Regulators on Plant Height (Cm) Before Submergence

Variety/ Treatment	Control	10µ Molar/Lt Abscisic acid	10µ Molar/Lt Paclobutrazol	10µ Molar/Lt Gibberelic Acid	0.02Molar Silver thio sulfate	20µMolar Silver thio sulfate	0.6 m Molar Silver thio sulfate	10 µMolar $CoCl_2$	240ppm $AgNO_3$	Mean
FR 13 A	25.00	24.00	26.50	23.07	22.97	24.80	21.50	25.47	24.5	24.20
Mahananda	26.00	24.00	26.00	25.33	31.00	35.00	32.00	32.00	39.00	30.04
Swarna	25.00	17.00	19.00	20.00	22.00	24.50	21.00	21.00	25.00	21.61
Mean	25.33	21.67	23.83	22.80	25.32	28.10	24.83	26.16	29.50	Interaction (VXT)
CD at 5%	Variety				Treatment					
	0.12				0.36					1.07
Note: µMolar/Lt = micro molar/liter; mMolar= mili molar; ppm= parts per million										

Table-4 represents the effects of various treatments on survival %. Except 10µMolar/Lt Gibberellic acid all other treatments has significant role for greater survival value for all the varieties. Except gibberellic acid all other treatments has greatly increased survival % of the susceptible variety Swarna. Anti ethylene and anti gibberellic substances has played great role to increase survival % under submergence condition. 10µMolar/Lt gibberellic acid even showed the poor survival rate even in the tolerant check variety FR13A. The average survival % for FR13A, Mahananda and Swarna was 69.44, 67.88 and 46.33% respectively.

Table-5 represents the genetic variability study of different characters for treatment effects. Less difference of GCV and PCV and high heritability coupled with high genetic gain of the characters indicates that they are controlled by additive genes and selection based on the characters will be effective for breeding submergence tolerance[17].

Table-2
Effects of Growth Regulators on Plant Height (Cm) After Submergence

Variety/ Treatment	Control	10µMolar/Lt Abscisic acid	10µMolar/Lt Paclobutrazol	10µMolar/Lt Gibberelic Acid	0.02Molar Silver thio sulfate	20µ Molar Silver thio sulfate	0.6 m Molar Silver thio sulfate	10 µMolar $CoCl_2$	240ppm $AgNO_3$	Mean
FR 13 A	26.50	25.00	29.00	28.40	26.00	27.00	24.00	28.00	26.33	26.69
Mahananda	30.00	26.00	27.60	31.00	33.00	37.50	34.50	33.00	41.00	32.62
Swarna	28.00	20.00	22.50	23.20	24.00	27.50	23.00	26.00	28.00	24.69
Mean	28.17	23.67	26.37	27.53	27.67	30.67	27.17	29.00	31.78	Interaction (VXT)
CD at 5%	Variety				Treatment					
	0.13				0.40					1.19
Note: µMolar/Lt = micro molar/liter; mMolar= mili molar; ppm= parts per million										

Table-3
Effects of Growth Regulators on Elongation % for Submergence Tolerance in Rice

Variety/ Treatment	Control	10µMolar/Lt Abscisic acid	10µMolar/Lt Paclobutrazol	10µMolar/Lt Gibberelic Acid	0.02Molar Silver thio sulfate	20µMolar Silver thio sulfate	0.6 m Molar Silver thio sulfate	10 µMolar $CoCl_2$	240ppm $AgNO_3$	Mean
FR 13 A	6.00	4.19	5.48	18.31	8.31	8.00	4.35	7.70	4.00	7.37
Mahananda	15.13	8.11	6.05	22.51	6.48	7.11	7.80	3.11	5.11	9.05
Swarna	13.00	17.62	18.41	16.00	9.03	12.08	9.51	23.70	12.00	14.59
Mean	11.38	9.97	9.98	18.94	7.94	9.07	7.22	11.50	7.04	Interaction (VXT)
CD at 5%	Variety				Treatment					
	0.12				0.35					1.06
Note: µMolar/Lt = micro molar/liter; mMolar= mili molar; ppm= parts per million										

Table-4
Effects of Growth Regulators on Survival % for Submergence Tolerance in Rice

Variety/ Treatment	Control	10µMolar/Lt Abscisic acid	10µMolar/Lt Paclobutrazol	10µMolar/Lt Gibberelic Acid	0.02Molar Silver thio sulfate	20µMolar Silver thio sulfate	0.6 m Molar Silver thio sulfate	10 µMolar $CoCl_2$	240ppm $AgNO_3$	Mean
FR 13 A	80.00	98.00	84.00	10.00	70.00	72.00	68.00	69.00	74.00	69.44
Mahananda	60.00	84.00	81.00	20.00	80.00	70.00	73.00	69.00	74.00	67.88
Swarna	20.00	50.00	60.00	10.00	65.00	45.00	52.00	50.00	65.00	46.33
Mean	53.33	77.33	75.00	13.33	71.67	62.33	64.33	62.67	71.00	Interaction (VXT)
CD at 5%	Variety				Treatment					
	0.17				0.52					1.56
Note: µMolar/Lt = micro molar/liter; mMolar= mili molar; ppm= parts per million										

Table-5
Estimate of different genetic parameters of variability, heritability and genetic advance of different traits after treatment

Characters	Co efficient of variation (CV)	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability (h %)	Genetic advance (GA)	Genetic advance of mean (GAM)
Plant height before submergence	0.94	18.8	18.9	99.1	168.8	666.41
Plant height after submergence	0.73	17.52	17.56	99.4	155.9	550.31
Elongation%	0.94	25.64	26.67	92.38	7.8	74.28
Survival%	5.69	18.7	18.8	98.9	170.5	279.51

Conclusion

It may say that anti gibberellic and anti ethylene substances which are acts as growth retardants has a beneficial effect on overall survival% of the paddy genotypes in submergence condition. Gibberellins action inhibitors like paclobutrazol and ABA plays crucial role for increasing survival by reducing stem elongation. Ethylene inhibitors like silver thiosulfate and silver nitrate solution plays the important role by reducing the stem elongation and increasing the survival by manifolds in susceptible variety. These action followed by high heritability and genetic gain suggests the control of additive genes.

References

1. Food and Agriculture Organization of The United Nations, Rome, The State of Food Insecurity in the World Addressing food insecurity in protracted crises, **(2010)**

2. Hossain M. and Laborte A., Differential growth in rice production in eastern India: agro ecological and socio-economic constraints*,* Physiology of Stress Tolerance of Rice, NDUAT and IRRI, Los Banos, The Philippines, 221–239, (**1996**)

3. Ella E.S., Kawano N., Yamauchi Y., Tanaka K. and Ismail A.M., Blocking ethylene perception enhances flooding tolerance in rice seedlings, *Funct. Plant Biol*., **30**, 813–819 (**2003**)

4. Setter T.L. and Laureles E.V., The beneficial effect of reduced elongation growth on submergence tolerance of rice*, J. Exp. Bot*, **47**, 1551–1559 **(1996)**

5. Ramakrishnayya G., Setter T.L., Sarkar R.K., Krishnan P. and Ravi I., Influence of P application to floodwater on oxygen concentrations and survival of rice during complete submergence, *Exp. Agric*., **35**, 167–180 **(1999)**

6. Das K.K., Sarkar R.K. and Ismail A.M., Elongation ability and non-structural carbohydrate levels in relation to submergence tolerance in rice, *Plant Sci*., **168**, 131–136 **(2005)**

7. Susanne H.B. and Hans K., On the Role of Abscisic Acid and Gibberellin in the Regulation of Growth in Rice, *Plant Physiol.,* **99**, 1156-1161 **(1992)**

8. Raskin I and Kende H., Role of Gibberellin in the Growth Response of Submerged Deep Water Rice, *Plant Physiol*., **76,** 947-950 **(1984)**

9. Syahputra B.S.A., Sinniah U.R., Rastan S.O.S. and Ismail M.R., Changes in Gibberellic Acid (GA_3) Content in *Oryza sativa* Due to Paclobutrazol Treatment, *J.Food Pharm.Sci*., **1**, 14-17 **(2012)**

10. Elmo M.B.J., A Potent Inhibitor of Ethylene Action in Plants, *Plant Physiol.,* **58**, 268-271 **(1976)**

11. George L.S., Richard M.B., Michael S.R. and Linda L.D., Efficacies of Commercial Anti-ethylene Products for Fresh Cut Flowers, *Hort Technology.,* 199-202 **(1993)**

12. Adaucto B.P., Effect of inhibitors of ethylene biosynthesis and signal transduction pathway on the multiplication of *in vitro*-grown Hancorina speciosa, *Plant Cell, Tissue and Organ Culture.,* **66**, 1-7 **(2001)**

13. Alberto G., Lucas J.J.L., Stefan T.P., Frans J.M.H. and Luciana P., Ethylene Production is Associated with Germination but not Seed Dormancy in Red Rice, *Annals of Botany*., **99**, 735-745, (**2007**)

14. Tiwari A.K., Srivastva R.M., Kumar V., Yadav L.B., and Mishra S.K.**,** Senescence indicator's of cymbidium flowers as affected by anti-ethylene pulsing, *Prog. Agric,* **10** 246-251, (**2010)**

15. Standard Evaluation System for Rice (SES)., *International Rice Research Institute (IRRI)*, **November**, **(2002)**

16. Gomez K.A and Gomez A.A., Statistical procedures for agricultural research, *John Wiley and Sons, Inc. Publishers, Canada*., 2nd edn, (**1984**)

17. Khan A.S., Imran M. and Ashfaq M., Estimation of genetic variability and correlation for grain yield components in rice (*Oryza sativa* L.), *American-Eurasian J. Agric. and Environ. Sci.,* **6(5)**, 585-590 (**2009**)