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Neeva Mahapatra
Krishi Vigyan Kendra, Orissa University of Agriculture & Technology, Puri, Bhubaneswar, Odisha, India

Correspondence
Neeva Mahapatra
Krishi Vigyan Kendra, Orissa University of Agriculture & Technology, Puri, Bhubaneswar, Odisha, India

Yield and its attributing characters of different rice genotypes to submergence stress

Neeva Mahapatra

Abstract

Submergence is an important constraint which prolongs partial submergence damages of rice plants and reduces grain yield. Due to the heterogeneity in flood-prone ecosystem, many different types of traditional rice varieties are being grown by the farmers. The local landraces adapted to extreme in water availability could be the sources of new gene(s) which would be utilized to improve the adaptability of rice to submergence with high yield. The main goal of this study is to identify new genetic resources tolerant to submergence based on morpho-physiological traits. Field experiment comprising 22 varieties which were completely submerged for 15 days under RBD design was conducted to screen out the submergence tolerant varieties basing upon morpho-physiological characters in the costal ecosystem of Odisha during kharif 2014 in the Adaptive Research Station, Sakhigopal. Nitrogen content of before submergence and during harvesting is the key criteria of yield. Nitrogen uptake during the harvesting is directly proportional to the yield. There are different yield attributing characters like 1000 grain weight, number of panicle per unit land and number of fertile grains/panicle which influence the final yield of the variety. The suitable combination among these varies depending upon the submergence tolerance of the variety. Based on the findings, it was concluded that the grain yield is positively correlated with number of grains/panicle and filled grains/panicle and negatively correlated with sterility percentage which is found incase of Sabita, FR-43B and Jalamagna.

Keywords: rice, submergence, nitrogen uptake, panicle, yield attributing characters

Introduction

Submergence has been identified as the 3rd most important constraints affecting rice production in Eastern India [1]. Rice is the staple food for more than half of the world's population. Nearly 25% of the world's rice is cultivated in the rainfed lowland ecosystem which accounts for only 17% of the global rice supply [2]. Asia accounts for about 90% of the global rice production. India is the second largest rice-growing country after China, with a production of more than 100 million tones. About 29% of India's total rice area (approximately 13 million hectare) is rainfed low land and this area is prone to unscheduled submergence of the rice crop [3, 4]. Submergence affects plant growth and development which ultimately affect seed yield. Seed yield is a complex and polygenic trait which is a final product affected by large numbers of its component characters [5]. According to Mohanty *et al*. (2000) [2] submergence tolerance in rice plants occurs by which certain rice varieties survive submergence of 10 days or more particularly in shallow water for water depth up to 40 cm (as per the classification followed in India) and up to 50 cm (as per the classification followed at the International Rice Research Institute). Flash-floods are highly unpredictable and may occur at any growth stage of the rice crop, which may results in yield loss up to 100% depending on different climatic & agronomic factors [6]. Variability of different genotypes, character associations and seed yield component are very much important aspects for improvement of any character. Adoption of modern rice varieties is less in flood-prone areas and farmers still grow different types of traditional rice varieties due to lack of proper high-yielding variety which can tolerate heterogeneous flooding situations. Traditional rice varieties are lower yield, however, it possess some adaptive traits require for the ecosystem for survival and plant productivity. In this circumstance improvement of germ plasm is likely the best option to withstand submergence and stabilize productivity in these environments. High yielding genotypes coupled with submergence tolerance can increase the productivity under submerged condition. Selection for submergence tolerance is very important. Current understanding of the physiological and biochemical bases of submergence tolerance has made it possible to design efficient phenotypic protocols and has laid the foundation for further genetic and molecular studies. This will subsequently speed up the breeding process. Breeding would be more efficient by focusing on those traits which are linked with submergence tolerance [7]. Hence, the present investigation was carried out to study the importance of studying the variability and character association for genetic improvement of submergence tolerant rice varieties of different agro morphological characters, variability parameters, association between the characters and direct and indirect effects of yield components on seed yield under submergence.

Materials and Methods

Plant culture and Growth condition

The experiment was conducted at the Adaptive Research Station, Sakhigopal, Puri, Orissa, India (19048' N, 85052' E, and 6 m above the mean sea level) to study the effects of submergence on different morpho-physiological characteristics and their association with different yield contributing characters, which would guide breeding strategies for tolerance under submergence.

The experiment was conducted in sandy clay loam soil (pH 6.4, organic C 0.68%, total N 0.01%, avialable P 17.5 kg/ha, and available K 129 kg/ha). The nursery bed was developed for planting of 22 paddy varieties namely Sabita, FR43B, Jalamagna, OR-2331/14, IR 85085 SUB-17 Jayanti Dhana, Jalamani, CR Dhan-500, CR Dhan-401, CR Dhan-505, Mahalaxmi Manika, CR Dhan-1030, OR-142/99, Tanmayee, Urbashi, Salibahana, Rambha, OR/2328/05, Mayurakantha, Bankoi and Kalasira. Required amount of FYM and phosphatic fertilizers were well mixed with the soils of nursery for development of fertility of soil, before date of sowing. Seed treatment of above rice genotypes were done with the help of Carbendazim @ 3g/kg seed and Streptocycline @ 1.5g/kg seed followed by washing with distilled water. Seeds were soaked in this treated water for 24 hrs and subsequently placed on moist gunny bags for sprouting. Sprouted seeds were direct seeded at 1 cm depth in the twenty two varieties were sown in lines with keeping appropriate spacing between the varieties. The irrigation channels were kept surrounding the speed beds. Frequent sprinkler irrigation was given for seed bed initially and after germination management was done in such a manner that the raised seed bed remained moistened without any standing water over its surface for one week. Thereafter standing water was maintained upto 3 cms. For the better growth of seedlings minimum N-fertilizer was given in seed bed. Before 7 days of rooting of seedling granular pesticide was applied in seed bed @ 10 kg/ac in order to avoid the infection of disease and pest after the transplanting. After 21 days of sowing the seedling was up rooted for transplanting. Natural flooding occurs at tillering stage of the rice for continuous 15 days. Data were taken just before and after the harvesting.

Determination methods

Estimation of nitrogen content of different plant parts and grain

Nitrogen content of different plant parts at heading and grain maturity were estimated following the procedure of A.O.A.C.(1970). Exactly 200 mg of powdered plant parts were taken in100 ml Kjeldahl digestion flasks separately about 200 mg of digestion mixture (K_2SO_4 : $CuSO_4$=5:1) and 4 ml of concentrated H_2SO_4 were added. These flasks were kept as such for about one hour and then heated slowly till frothing occurred. To check the frothing, two crystals of sodium thio-sulphate were added to each digestion flask. Then the digestion was continued until the contents of the flask became completely clear blue syrupy liquid without any bubbling. The flask was cooled and content was diluted to 50 ml with distilled water. Then 10 ml of diluted sample extract was transferred into a micro-Kjeldahl distillation unit. The digestion flask was washed twice with little amount of distilled water and all the washing were transferred into the distillation unit. There-after, 10 ml of 40% NaOH was added and distillation was continued for 10 minutes. During distillation, liberated ammonia was absorbed by 10 ml of 4% boric acid present in a 150 ml conical flask containing 2 drops of mixed indicator. After completion of distillation, the distillate was titrated against 0.02 NHCl.

Calculation**:** % N in sample= (Sample titer- Blank titer) x N of HCl x 14 x100 x 5) / Sample weight (g) x 100.

Yield attributing characters

Decrease in the effective panicle number, filled grains/panicle and 1000-seed weight are the major deficiencies caused by the submergence. Randomly 3 hills from each treatment of each varieties were selected; the effective panicle number and high-tillering panicles (sprouting of side stalks from high-node axillary buds of the rice plant's stem under appropriate conditions is reffered to as "high tillering") were counted and the spikes were threshed manually. Filled and chaffy grains were differentiated using the floating method (submerged grains are the filled grains) and recorded. The panicle length, total grains/panicle, total filled grains/panicle and sterility percentage were obtained. The filled grains are dried in the sun and 1000-seed weight were obtained (measurements were performed triplicate for each treatment). The yield was calculated based on the panicle number per 5 m2, grain number per panicle, sterility percentage and 1000-seed weight.

Results and Discussion

Nitrogen uptake (g/m2) by the shoot and different plant parts before and after submergence and at harvest

The photosynthesis activity of leaves depends upon the essential nutrient content of the leaf and stem. In general the nitrogen content of the shoot decreased when the crop was subjected to submergence. The nitrogen content of the shoot ranged from 5.27 g/m2 to 5.52 g/m2 in tolerant varieties whereas the susceptible variety the uptake was lower which ranged from 4.44 g/m2 to 5.13 g/m2. After submergence due to damage of plant parts the uptake of nitrogen was reduced to a tune of 12.43% to 16.13% in tolerant cultivars but in susceptible cultivars it was 17.00% to 19.80% depending upon the genotypes. Due to regeneration capacity of the tolerant cultivar the nitrogen content increased more than susceptible cultivar.

From the data it was revealed that the mean nitrogen uptake by the stem and leaf before the submergence was greater than their mean nitrogen uptake after the submergence. The mean N-uptake was highest in Sabita (5.52 g/m2) followed by FR-43B (5.44 g/m2) whereas the lowest value was recorded in Bankoi (4.44 g/m2) before the submergence. Data recorded after the submergence indicated that higher N-uptake was exhibited by Sabita (4.83 g/m2) and lowest value was shown in Bankoi (3.56 g/m2) with a reduction of 12.48% and 19.80% respectively as compared to before submergence (Table 1).

At harvesting N-uptake was maximum in panicle as compared to other plant parts irrespective of genotypes. The maximum N-uptake was exhibited by Sabita (3.86 g/m2) and lowest in Bankoi (2.81 g/m2). From the C.V. value it was found that there was no wide variation among the varieties as regards to N-uptake by the plant. The correlation indicated that shoot N-uptakeis positively correlated with grain yield. Nitrogen uptake plays a critical role in the rate and duration of dry matter production after flowering [8]. N-uptake in shoot was having quadratic relationship with grain yield whereas N uptake in grain was linearly associated with grain yield [9].

Table 1: Nitrogen uptake by shoot before and after submergence in different rice cultivars

Variety	Nitrogen Uptake (g/m2)		
	BS (75 DAS)	**AS (90 DAS)**	**At Harvest**
Sabita	5.52	4.83 (-12.48%)	3.86 (-30.06%)
FR-43B	5.44	4.75 (-12.65%)	3.44 (-30.23%)
Jalamgna	5.40	4.70 (-12.90%)	3.67 (-31.90%)
OR-2331/14	5.40	4.67 (_13.45%)	3.67 (-31.95%)
IR 85085 SUB-17	5.36	4.63(-13.50%)	3.62(-32.35%)
JayantiDhana	5.34	4.54(-14.80%)	3.60 (-32.55%)
Jalamani	5.35	4.53 (15.15%)	3.60(-32.70%)
CR dhan-500	5.33	4.43 (16.89%)	3.56(-33.15%)
CR dhan-401	5.28	4.42 (16.29%)	3.49(-33.80%)
CR dhan-505	5.27	4.42(-16.13%)	3.48(-33.95%)
Mahalaxmi	5.25	4.40(-16.19%)	3.45(-34.20%)
Manika	5.25	4.40(-16.19%)	3.42(-34.80%)
CR dhan-1030	5.14	4.27(-16.80%)	3.42(-34.90%)
OR-142/99	5.13	4.25(-17.00%)	3.32(-35.16%)
Tanmayee	5.13	4.24(-17.30%)	3.30(-35.53%)
Urbashi	5.10	4.18(-17.88%)	3.28(-35.66%)
Salibahana	5.09	4.17 (17.91%)	3.27(-35.70%)
Rambha	4.97	4.07(-18.10%)	3.17(-36.10%)
OR/2328/05	4.80	3.92(-18.25%)	3.06(-36.25%)
Mayurakantha	4.65	3.77(-18.91%)	2.95(-36.39%)
Kalasira	4.60	3.71(-19.30%)	2.91(-36.54%)
Bankoi	4.44	3.56(-19.80%)	2.81(-36.66%)
Sem C.D 5% C.V	0.06 0.18 2.16	0.07 0.02 2.80	0.30 0.86 15.91

Yield and its attributing characters

Variation in panicle length among the varieties under test due to submergence was presented in the Table-2, which revealed that maximum panicle length was exhibited by IR 85085 Sub-17 (26.80 cm) followed by Sabita (26.68 cm) where as minimum value of th same was shown by OR-142/99 (21.49 cm). Significant difference among the genotypes was not exhibited. It was also noted that the panicle length is positively correlated with the yield, adventitious roots, grains/panicle, percentage of ripened grains (Table-2).

The maximum number of grains/panicle was found in OR-2331/14 (209.5 cm) followed by Mayurakantha (200.17 cm) where as the lowest value of the same was observed in Kalasira (146.50 cm). There was significant difference among the cultivars as regard to number of grains/panicle (Table-2). There was positive correlation with the grain yield.

Among the cultivars the bold grains/panicle was highest in OR-2331/14 (99.80/panicle) which was significant greater than others varieties. On the contrary Banki at significant lower value (52.80/panicle) of the same than other genotypes. It was found that percentage of increase of the bold grains of OR-2331/14 (47.09%) as compared to the Bankoi. The data presented in Table indicated that the bold grains are positively correlated with grain yield. Significantly difference among the varieties as record to filled up grains was noted.

Data presented in Table-2 indicated that the sterility percentage under submerge dcondition, the maximum value wasrecorded from Bankoi (65.00%) whereas the minimum value of the same was exhibited by Sabita (44.30%). From the Table it was revealed that the percentage of sterility is negatively correlated with the yield.

Comparison of 1000 seed weight among the genotypes indicated that highest value was recorded from Jayanti Dhan (27.67g) followed by Kalasira (27.26 g) where as the minimum value of the same was exhibited by CR-1030 (20.50g). From the Table-15it was found that there was positive correlation with grain yield.

The Harvest Index (HI) of the tested cultivars under submerged condition ranged from 23.94 to 32.46. This highest value of Harvest index was shown in FR-43B (32.46) followed by Sabita (32.45) whereas the lowest value of the same was shown in Bankoi (23.94) which was 26.24% % reduction from the former. From the Table-16 it was clear that HI is positively correlated with grain yield, grains/panicle and shoot dry matter at harvest but negatively correlated with 1000 grain weight.

Table 2: Yield And it's Attributing Characters In Response To Submerged Condition Of Rice Varieties

Variety	Panicle Length (cm)	No. Of Grains/ Panicle	No. Of Filled Grains/ Panicle	Sterility (%)	1000 Grain Wt.(g)	Harvest Index (%)	Yield (q/ha)
Sabita	26.68	156.00	86.80	44.3	25.70	32.45	38.43
FR-43B	24.08	162.00	83.00	48.7	24.70	32.46	38.07
Jalamgna	20.56	155.37	80.00	48.5	23.54	31.34	36.72
OR-2331/14	22.91	209.53	99.80	52.3	20.27	30.76	36.60
IR 85085 SUB-17	26.80	179.90	80.00	55.5	20.60	30.37	36.63
Jayanti Dhana	23.61	180.77	78.40	56.6	27.67	29.87	35.40
Jalamani	22.40	154.50	68.00	55.9	26.35	29.55	35.21
CR dhan-500	23.30	159.80	72.50	54.6	26.34	29.36	34.54
CR dhan-401	23.94	164.67	66.80	59.4	24.85	29.20	35.23
CR dhan-505	24.03	161.80	68.70	57.5	25.58	28.89	34.90
Mahalaxmi	24.50	198.47	88.00	55.3	23.57	28.94	34.48
Manika	22.25	191.47	81.00	57.6	20.74	28.39	33.48
CR dhan-1030	25.36	175.27	71.30	59.3	20.50	28.22	33.53
OR-142/99	21.49	179.60	69.20	61.4	20.54	27.90	33.59
Tanmayee	24.20	148.13	62.60	57.7	25.24	27.84	33.57
Urbashi	20.39	165.90	62.00	62.6	20.61	27.53	32.17
Salibahana	23.47	172.10	63.60	63.0	23.33	26.92	31.42
Rambha	25.42	156.87	59.40	62.1	24.50	26.33	31.10
OR/2328/05	21.60	165.47	59.00	64.3	22.18	25.16	29.47
Mayurakantha	22.57	200.17	72.00	64	22.64	24.80	27.13
Kalasira	24.75	146.50	55.00	62.4	27.26	24.31	26.00
Bankoi	22.13	152.07	52.80	65.0	24.73	23.94	26.10
SEM	0.49	1.09	1.02	1.09	0.83	0.10	0.47
C.D 5%	1.41	3.12	2.91	3.10	2.36	0.29	1.35
C.V	3.63	1.11	2.60	3.15	6.05	0.61	2.45

There was variation in grain yield among the different genotypes ranging from 26.00 q/ha in Kalasira to 38.43 q/ha in Sabita under submerged condition. There are different yield attributing characters like 1000 grain weight, number of panicle per unit land and number of fertile grains/panicle which influence the final yield of the variety. The suitable combination among these varies depending upon the submergence tolerance of the variety.

Sabita had the highest productivity (38.43 q/ha) than the others due to the suitable combination among the yield attributing characters like 1000 grain weight, more number of effective tillers/hill and more fertile grains/panicles. The present experiment revealed that the highest number of effective tillers/hill was found in Sabita (7.90/hill) followed by FR-43B (7.87/hill) which indicates the high survival percentage of the cultivars during submergence. There is a greater ability of sink tissues to store sugar. So the number of panicles/hill, effective tillers/hill and 1000 grain weight are regarded as the selection criteria for adequate production of grain yield under submergence [10].

The data revealed in Table-2 shows that the grain yield is positively correlated with number of grains/panicle and filled grains/panicle and negatively correlated with sterility percentage. The above findings regarding the relationship of grain yield with its attributes are in accordance with many workers whose report indicated that the rice yield is positively associated with number of grains/panicle, number of filled grains/panicle and number of effective tillers/hill [11]. So from the present investigation it was concluded that the future research should be based on increasing the number of effective tillers/hill, number of filled grains/hill and dry matter accumulation after the submergence to obtain sustainable yield of rice crop under submergence condition.

Conclusion

Incidences of stagnant flooding will increase in future due to unusual rainfall patterns under the influence of climate change. The present investigation has identified some new submergence tolerant varieties, which can be utilized as donors in rice breeding programme and also for identification of additional genes. From the present investigation it can be concluded that the high N-uptake during harvesting and also higher yield attributing characters results in higher yield incase of Sabita, FR-43B and Jalamagna under submergence condition. Thus they are the most submergence tolerant varieties among all.

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