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Effect of Moisture Regimes on Yield and Yield Attributes of Rice Cultivars under Aerobic Condition in Summer Season

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ABSTRACT

A field experiment was conducted at Regional Research Station, Gayeshpur of Bidhan Chandra Krishi Viswavidyalaya, West Bengal to study the "Effect of moisture regimes on the rice cultivars under aerobic condition in summer season during 2012 and 2013". The farm is located at 22˚ 57' N latitude, 88˚ 20' E longitude and at an elevation of 9.75 m above sea level. The experiment was conducted on sandy clay loam soil. The experiment was laid in split plot design replicated thrice. The treatments consisted of four irrigation regimes in main plots viz. I_1: Scheduling of irrigation at 60-70 % field capacity (FC) throughout the season, I_2: Scheduling of irrigation at 80-90 % FC throughout the season, I_3: Scheduling of irrigation at 60-70 % FC at vegetative stage and at 80-90 % FC at reproductive stage and I_4: Control. (maintaining at 100% FC) and three varieties in sub plots viz.V_1: Satabdi, V_2: Khitish and V_3: IR 36. The results revealed that yield attributes viz., number of panicles per m² (234.91), panicle length (24.81 cm), number of grains per panicle (135.91), grain yield (3.2 t ha^{-1}), straw yield (5.3 t ha^{-1}) and harvest index (37.77 %) were significantly higher values under maintaining crop at 100 % field capacity than remaining treatments. Amongst the varieties, Khitish recorded significantly higher yield attributes viz. panicle length (25.35 cm), number of grains per panicle (135.55), test weight (22.71 g/1000 seed), grain yield (2892.62 kg ha^{-1}), and harvest index (37.56%) than Satabdi and IR 36.

Keywords Aerobic rice, Irrigation regimes, Rice varieties, Summer season.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of about 3.5 billion people and demand is expected to continue to grow as population increases (GRiSP 2013). Half the world's population subsists wholly or partially on rice whereas 90 % of the world's rice crop is grown and consumed in Asia. Rice is the most important crop in

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India and extensively grown as food crop. The (Annual report 2020-21) rice area in India 43.66 million ha with rice production of 118.87 million tonnes and yield of 2.722 t ha^{-1}.

Further, rice crop is the greatest water user amongst of the crops, consuming about 80 % of the total irrigated fresh water resources in Asia (Wu *et al.* 2017). Irrigated lowland rice usually has standing water for most of the growing season. But traditional lowland rice with continuous flooding has relatively high water inputs (Orasen *et al*. 2019) and its sustainability is threatened by increasing water shortages. The production of lowland rice, a squandering user of water, is being threatened by this increasing water scarcity. Rice production and food security largely depend on the irrigated lowland rice system, whose sustainability is threatened by fresh water scarcity, water pollution and competition for water use (Silalertruksa *et al*. 2017). To safeguard the food industry and conserve water, an alternate system of growing rice with less water is essentially required.

Aerobic rice is a concept of growing rice where high yielding rice varieties grown in non-puddled aerobic soil under supplementary irrigation. Aerobic rice genotypes can reduce water requirement for rice production by over 44 % compared to lowland rice, by avoiding water use for seed bed and land preparation and by reducing percolation, seepage and evaporation losses, with grain yield potential of 6 mt ha^{-1} (Bouman *et al*. 2005) which is significantly higher than traditional upland cultivars.

Keeping these facts in view, a comprehensive study was therefore carried out in which three rice cultivars were evaluated under four different soil moisture regimes in summer season under aerobic condition.

MATERIALS AND METHODS

The field experiment on summer aerobic rice was conducted in the dry (boro) seasons of 2012 and 2013 at Regional Research Station, Gayeshpur of Bidhan Chandra Krishi Viswavidyalaya. The station is located in a sub-tropical region at 22˚ 57' N latitude, 88˚ 20' E longitude and at an elevation of 9.75 m above sea level. The soil of the experimental field is sandy clay loam in texture and the depth of the soil is shallow to medium. The experiment was laid in split plot design replicated thrice. The treatments consisted of four irrigation regimes in main plots viz., I_1: Scheduling of irrigation at 60-70 % field capacity (FC) throughout the season, I_2: Scheduling of irrigation at 80-90 % FC throughout the season, I_3: Scheduling of irrigation at 60-70 % FC at vegetative stage and at 80-90 % FC at reproductive stage and I_4: Control. (maintaining at 100% FC) and three varieties in sub plots viz., V_1: Satabdi, V_2: Khitish and V_3: IR 36. The field experiment was undertaken with four levels of the irrigation regimes wherein the treatments were imposed 15 days after sowing and upto 15 days before harvesting in the main plots and three rice varieties in the sub plots. Proper care was taken for crop management in all the experimental plots starting from land preparation and continued up to harvesting operation. Recommended dose of fertilizers was applied to the experimental field i.e., 120 – 60 – 60 of N-P-K kg ha^{-1}. One meter row length in each plot was earmarked for recording different biometrical observations and destructive samplings. The experimental data recorded on various parameters were analyzed statistically following the analysis of variance procedure described by (Gomez and Gomez 1984). Critical difference for examining treatmental means for their significance was calculated at 5% level of probability.

RESULTS AND DISCUSSION

Data on number of panicles per m^2, panicle length (cm), number of grains per panicle and test weight (g/1000 seed) of aerobic rice as influenced by irrigation regimes and varieties.

Number of panicles per m^2

Cogitation of the data in Table 1 revealed that number of panicles per m^2 was significantly influenced by irrigation regimes. Aerobic rice under I_4 treatment (228.60) recorded significantly higher panicle number per m^2 than I_1 (181.33), I_2 (203.03) and I_3 (193.60) during 2012. Significantly lowest panicle number per m^2 was recorded under I_1 (181.33) than under other irrigation regimes. Similarly, in 2013 I_4 treatment (241.24) recorded significantly higher panicle number

Table1. Number of panicles per m², panicle length (cm) of aerobic rice as influenced by irrigation regimes and varieties during 2012, 2013 and pooled data.

Treatments	No. of panicles (m)			Panicle length(cm)		
	2012	2013	Pooled	2012	2013	Pooled
Irrigation regimes						
I_1	181.33	196.06	188.70	21.03	21.16	21.10
I_2	203.03	217.21	210.12	23.13	23.91	23.52
I_3	193.60	223.93	208.76	23.06	23.16	23.11
I_4	228.60	241.24	234.91	24.63	25.00	24.81
SEm±	1.59	3.53	1.53	0.36	0.29	0.20
CD at 5%	5.50	12.19	5.30	1.24	1.00	0.71
Varieties						
V_1	224.53	240.04	232.28	21.15	21.50	21.33
V_2	170.20	190.30	180.25	25.04	25.66	25.35
V_3	210.20	228.50	219.35	22.69	22.76	22.72
SEm±	3.62	3.65	3.18	0.37	0.27	0.25
CD at 5%	10.86	10.96	9.53	1.10	0.82	0.75

per m^2 than I_1 (196.06), I_2 (217.21) and I_3 (223.93). Significantly lowest panicle number per m^2 was recorded in I_1 (196.06) than under other irrigation regimes. From the pooled data, it can be revealed that I_4 treatment (234.91) recorded significantly higher panicle number per m^2 than I_1 (188.70), I_2 (210.12) and I_3 (208.76). Significantly lowest panicle number per m^2 was recorded in I_1 (188.70) than panicle number per m^2 under other irrigation regimes. The increase in the panicle number per m^2 under I_4 treatment was mainly attributed to the more water supply and the similar findings was reported by (Ramana *et al.* 2013).

From the Table 1 it can be stated that varieties also significantly influenced the panicle number per m^2. Among the varieties, Satabdi (224.53) recorded significantly higher panicle number per m^2 than Khitish (170.20) and V3 (IR-36) (210.20) during 2012. Significantly lowest panicle number recorded in Khitish (170.20) than panicle number per m^2 in Satabdi and V3 (IR-36). During 2013, Satabdi (240.04) recorded significantly higher panicle number per m^2 than Khitish (190.30) and V3 (IR-36) (228.50). Significantly lowest panicle number recorded in Khitish (190.30) than panicle number per m^2 in Satabdi and V3 (IR-36). From the pooled data of 2012 and 2013, it can be concluded that Satabdi (232.28) recorded significantly higher panicle number per m^2 than Khitish (180.25) and V3 (IR-36) (219.35). Significantly lowest panicle number recorded in Khitish (180.25) than panicle number per m^2 in Satabdi and V3 (IR-36). Interaction effect of irrigation regimes and varieties on panicle number per m^2 was found non-significant.

Panicle length (cm)

Perusal of the data in Table 1 revealed that panicle length was significantly influenced by irrigation regimes. Among the irrigation regimes, I_4 treatment (24.63 cm) recorded significantly higher panicle length than I_1 (21.03 cm), I_2 (23.13 cm) and I_3 (23.06 cm) during 2012. Aerobic rice under I_1 (21.03 cm) treatment recorded significantly lower panicle length than other treatments. However, aerobic rice under I_2 (23.13 cm) and I_3 (23.06 cm) treatments are on par with each other in panicle length. Similarly, during 2013, I_4 treatment (25.00 cm) recorded significantly higher panicle length than I_1 (21.16 cm), I_2 (23.91 cm) and I_3 (23.16 cm). Aerobic rice under I_1 (21.16 cm) treatment recorded significantly lower panicle length than other treatments. However, aerobic rice under I_2 (23.91 cm) and I_3 (23.16 cm) treatments are on par with each other in panicle length. Pooled data of 2012 and 2013 reveals that, I_4 treatment (24.81cm) recorded significantly higher panicle length than I_1 (21.10 cm) I_2 (23.52 cm) and I_3 (23.11 cm). Aerobic rice under I_1 (21.10 cm) treatment recorded significantly lower panicle length than other treatments. However, aerobic rice under I_2 (23.52 cm) and I_3 (23.11 cm) treatments are on par with each other in panicle length. The increase in the panicle length under I_4 treatment might be attributed to the increase in soil moisture availability. But the findings are on contrary to the findings of (Nguyen *et al.* 2009).

Perusal of the data in Table 1 revealed that panicle length was significantly influenced by different varieties. Khitish (25.04 cm) recorded significantly higher panicle length than Satabdi (21.15 cm) and IR-36 (22.69 cm) during 2012. Significantly lower panicle length was recorded in Satabdi (21.15 cm). Similarly, during 2013, Khitish (25.66 cm) recorded significantly higher panicle length than Satabdi (21.50 cm) and IR-36 (22.76 cm). Significantly lower panicle length was recorded in Satabdi (21.50 cm). Pooled data, revealed that Khitish (25.35 cm) recorded significantly higher panicle length than Satabdi (21.33

cm) and IR-36 (22.72 cm). Significantly lower panicle length was recorded in Satabdi (21.33 cm). Interaction effect of irrigation regimes and varieties on panicle length was found non-significant.

Number of grains per panicle

Perusal of the data in Table 2 revealed that number of grains per panicle was significantly influenced by irrigation regimes I_4 treatment (134.67) recorded significantly higher number of grains per panicle than I_1 (101.03), I_2 (120.83) and I_3 (115.73) during 2012. However, significantly lowest number of grains per panicle was recorded at I_1 treatment (101.03) than rest of irrigation treatments. However, number of grains per panicle under I_2 (120.83) treatment was on par with that under I_3 (115.73) treatment. Similarly, during 2013 I_4 treatment (137.17) recorded significantly higher number of grains per panicle than I_1 (106.47), I_2 (120.20) and I_3 (118.80). However, significantly lowest number of grains per panicle was recorded at I_1 treatment (106.47) than rest of irrigation treatments. However, number of grains per panicle under I_2 (120.20) treatment was on par with that under I_3 (118.80) treatment. Pooled data revealed that, I_4 treatment (135.91) recorded significantly higher number of grains per panicle than I_1 (103.75), I_2 (120.51) and I_3 (117.26). However, significantly lowest number of grains per panicle was recorded at I_1 treatment (103.75) than rest of irrigation treatments. However, number of grains per panicle under I_2 (120.51) treatment was on par with that under I_3 (117.26) treatment. The increase in the number of grains per panicle under I_4 treatment was mainly due to more water supply than remaining treatments. This finding was supported by findings of (Belder *et al*. 2005).

Table 2. Number of grains per panicle and test weight (g/1000 seed) of aerobic rice as influenced by irrigation regimes and varieties during 2012, 2013 and pooled data.

Treatments	No. of grains per panicle			Test weight (g/100. seed)		
	2012	2013	Pooled	2012	2013	Pooled
Irrigation regimes						
I_1	101.03	106.47	103.75	20.19	20.63	20.41
I_2	120.83	120.20	120.51	20.55	20.53	20.54
I_3	115.73	118.80	117.26	20.54	20.78	20.66
I_4	134.67	137.17	135.91	20.67	20.35	20.51
SEm±	2.23	2.02	1.58	0.15	0.10	0.06
CD at 5%	7.73	6.97	5.45	N.S.	N.S.	N.S.
Varieties						
V_1	99.45	104.23	101.83	17.84	17.61	17.27
V_2	134.25	136.85	135.55	22.58	22.86	22.71
V_3	120.50	120.90	120.70	21.06	21.25	21.15
SEm±	1.52	1.60	1.03	0.14	0.11	0.10
CD at 5%	4.58	4.80	3.11	0.45	0.34	0.31

Perusal of the data in Table 2 revealed that number of grains per panicle was significantly influenced by different varieties. Khitish (134.25) recorded significantly higher number of grains per panicle than Satabdi (99.45) and IR 36 (120.50) during 2012. However, significantly lowest number of grains per panicle was recorded in Satabdi (99.45). Similarly during 2013, Khitish (136.85) recorded significantly higher number of grains per panicle than Satabdi (104.23) and IR 36 (120.90). However, significantly lowest number of grains per panicle was recorded in Satabdi (104.23). Pooled data clearly revealed that Khitish (135.55) recorded significantly higher number of grains per panicle than Satabdi (101.83) and IR 36 (120.70). However, significantly lowest number of grains per panicle was recorded in Satabdi (101.83). The interaction effect of irrigation regimes and varieties was found non significant on the number of grains per panicle of aerobic rice. The variation in number of grains per panicle may be attributed to the genetic varietal character of the rice varieties.

Test weight (g/1000 seed)

Perusal of the data in Table 2 revealed that, the influence of irrigation regimes on that the test weight of aerobic rice is non significant during 2012 and 2013. The similar findings were reported by (Samui *et al*. 1979).

From the both years of experimentation i.e. 2012 and 2013 as well as pooled data, it was observed that, among the varieties Khitish (22.58 g/1000 seed) recorded significantly higher test weight than Satabdi (17.84 g/1000 seed) and IR 36 (21.06 g/1000 seed) during 2012. Further, Satabdi (17.84 g/1000 seed) recorded with significantly lowest test weight than other varieties. Similar trend observed in 2013 that Khitish (22.86 g/1000 seed) registered significantly higher test weight than Satabdi (17.61 g/1000 seed) and IR 36 (21.25 g/1000 seed). Further, Satabdi (17.61 g/1000 seed) recorded with significantly lowest test weight than other varieties. From the pooled data, it was clearly noticed that significantly higher value of test weight was recorded in Khitish (22.71 g/1000 seed) than Satabdi (17.27g/1000 seed) and IR 36 (21.15 g/1000 seed). Besides, Satabdi (17.27 g/1000 seed) registered significantly lowest values of test weight than remaining two varieties. The interaction effect of irrigation regimes and varieties was found non significant on the test weight of aerobic rice.

Grain yield

Perusal of the data in Table 3. revealed that grain yield of aerobic rice was significantly influenced by the irrigation regimes. Grain yield of aerobic rice under I_4 treatment (3177 kg ha^{-1}) was significantly higher than grain yield under I_1 (2215 kg ha^{-1}), I_2 (2707 kg ha^{-1}) and I_3 (2671 kg ha^{-1}) during 2012. However, I_1 (2215 kg ha^{-1}) recorded significantly lowest grain yield than under rest of irrigation regimes. The decrease in the grain yield under I_1 treatment was due to drought stress. Thus drought stress decreases the rate of photosynthesis and severe drought stress also inhibits the photosynthesis of plants by causing changes in chlorophyll content, by affecting chlorophyll components and by damaging the photosynthetic apparatus. This opinion was in similarity with (Kawamitsu 2000). Further, it was noticed that grain yields under I_2 (2707 kg ha^{-1}) and I_3 (2671 kg ha^{-1}) was on par with each other. Similarly in 2013, I_4 (3258 kg ha^{-1}) recorded significantly higher grain yield than I_1 (2174 kg ha^{-1}), I_2 (2705 kg ha^{-1}) and I_3 (2588 kg ha^{-1}). Significantly lowest grain yield was recorded at I_1 (2174 kg ha^{-1}) as compared to rest of the irrigation regimes. Further, it was noticed that grain yields under I_2 (2705 kg ha^{-1}) and I_3 (2588 kg ha^{-1}) was on par with each other. Pooled data of 2012 and 2013 recorded that significantly higher grain yield was recorded under I_4 (3217 kg ha^{-1}) than I_1 (2194 kg ha^{-1}), I_2 (2704 kg ha^{-1}) and I_3 (2630 kg ha^{-1}). Significantly lowest grain yield was recorded under I_1 (2194 kg ha^{-1}) than at other irrigation regimes. Further, it was noticed that grain yields under I_2 (2706 kg ha^{-1}) and I_3 (2630 kg ha^{-1}) was on par with each other. The higher yield under I_4 treatment than remaining treatments was mainly attributed to more availability of moisture in the root zone due to near field capacity conditions. The findings were in coincidence with the findings of (Nguyen *et al*. 2009) and (Brajagopal *et al*. 2020).

Varietal performance recorded significant difference in grain yield. It was recorded that significantly higher grain yield was recorded Khitish (2866 kg ha^{-1}) than Satabdi (2478 kg ha^{-1}) and IR 36 (2733 kg ha^{-1}) during 2012. However, significantly lowest grain yield was recorded in Satabdi (2478 kg ha^{-1}) than other two varieties. Similarly during 2013, it was recorded that significantly higher grain yield was recorded Khitish (2919 kg ha^{-1}) than Satabdi (2465 kg ha^{-1}) and IR 36 (2660 kg ha^{-1}). However, significantly lowest grain yield was recorded in Satabdi (2465 kg ha^{-1}) than other two varieties. From the pooled data, it

Table 3. Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) of aerobic rice as influenced by irrigation regimes and varieties during 2012, 2013 and pooled data.

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Mean
Irrigation regimes									
I_1	2215	2174	2194	4248	4129	4188	34.26	34.47	34.37
I_2	2707	2705	2706	4678	4689	4684	36.64	36.58	36.61
I_3	2671	2588	2630	4603	4399	4501	36.69	37.02	36.85
I_4	3177	3257	3217	5269	5324	5297	37.61	37.93	37.77
SEm±	46.98	33.31	27.55	88.87	152.01	69.29			
CD at 5%	162.15	117.95	95.08	306.74	NS	239.17			
Varieties									
V_1	2478	2465	2471	4541	4387	4464	35.21	35.81	35.51
V_2	2866	2919	2893	4778	4806	4792	37.41	37.71	37.56
V_3	2733	2660	2696	4779	4714	4746	36.28	35.98	36.13
SEm±	36.57	47.19	29.31	75.02	128.97	54.03			
CD at 5%	109.67	141.49	87.91	NS	NS	NS			

was recorded that significantly higher grain yield was recorded Khitish (2893 kg ha^{-1}) than Satabdi (2471 kg ha^{-1}) and IR 36 (2696 kg ha^{-1}). However, significantly lowest grain yield was recorded in Satabdi (2471 kg ha^{-1}) than other two varieties. The increase in the grain yield in Khitish was mainly due to significantly higher panicle length, more number of grains per panicle and test weight (1000 grain weight) than IR 36 and Satabdi. The interaction effect of irrigation regimes and varieties was found non significant on the grain yield of aerobic rice.

Straw yield

Perusal of the data from Table 3 revealed that straw yield of aerobic rice was significantly influenced by the irrigation regimes. From the 2012 data, it was registered that significantly higher straw yield of aerobic rice at I_4 treatment (5269 kg ha^{-1}) than I_1 (4248 kg ha^{-1}), I_2 (4678 kg ha^{-1}) and I_3 (4603 kg ha^{-1}). However, I_1 (4248 kg ha^{-1}) recorded significantly lowest straw yield than at other irrigation regimes. Further, it was noticed that straw yields at I_2 (4678 kg ha^{-1}) and I_3 (4603 kg ha^{-1}) was on par with each other. On contrary in 2013, no significant difference in straw yield was recorded due to the influence of irrigation regimes. Neverthless, pooled data of 2012 and 2013 recorded that significantly higher straw yield was recorded at I_4 (5297 kg ha^{-1}) than I_1 (4188 kg ha^{-1}), I_2 (4684 kg ha^{-1}) and I_3 (4501 kg ha^{-1}). Significantly lowest straw yield was recorded at I_1 (4188 kg ha^{-1}) than at other irrigation regimes. Further, it was noticed that straw yields at I_2 (4684 kg ha^{-1}) and I_3 (4501 kg ha^{-1}) was on par with each other. The higher straw yield due to more water supply under I_4 treatment was similar with the findings of (Brajagopal *et al*. 2020).

During 2012 and 2013, it was recorded that effect of varieties on straw yield was found non significant. The interaction effect of irrigation regimes and varieties was found non significant on the straw yield of aerobic rice.

Harvest index

The harvest index data calculated based on grain yield and straw yield of aerobic rice explained that highest HI was recorded at I_4 treatment (37.61 %) followed by I_3 (36.69 %), I_2 (36.64%) and I_1 (34.26%) during 2012. Similarly in 2013, highest HI was registered at I_4 treatment (37.93 %) followed by I_3 (37.02%), I_2 (36.58 %) and I_1 (34.37 %). Mean data of 2012 and 2013, revealed that highest HI was recorded at I_4 treatment (37.77 %) followed by I_3 (36.85 %), I_2 (36.61%) and I_1 (34.37%). Findings were in conformity with the findings of (Peng *et al*.2006).

Under aerobic condition, rice variety Khitish (37.41%) recorded highest HI followed by IR 36 (36.28 %) and Satabdi (35.21 %) during 2012 and similarly in 2013, rice variety Khitish (37.71%) recorded highest HI followed by IR 36 (35.98 %) and Satabdi (35.81 %). Likewise, pooled data recorded that Khitish (37.56%) recorded highest HI followed by IR 36 (36.13 %) and Satabdi (35.51 %).

CONCLUSION

Yield attributes of rice viz., number of panicles per m^2, panicle length, number of grains per panicle and yield of aerobic rice was significantly influenced by the irrigation regimes but the influence of irrigation regimes on test weight (1000 seed weight) of aerobic rice was non significant.

It was found that aerobic rice under I_4 (maintaining at 100% FC) treatment recorded higher number of panicles per m^2 (234.91), panicle length (24.81 cm), number of grains per panicle (135.91), grain yield (3217.33 kg ha^{-1}), straw yield (5296.61 kg ha^{-1}) and harvest index (37.77 %) than that of under I_1 (scheduling of irrigation at 60-70 % FC throughout the season), I_2 (scheduling of irrigation at 80-90 % FC throughout the season) and I_3 (scheduling of irrigation at 60- 70 % FC at vegetative stage and at 80-90 % FC at reproductive stage).

From the pooled data, Khitish variety registered higher growth attributes viz. plant height at harvest (100.87 cm), drymatter accumulation at harvest (796.78 g m^{-2}), leaf area index at flowering (4.11) and number of tillers per m^2 (212.82), yield attributes viz. number of panicles per m^2 (180.25), panicle length (25.35), number of grains per panicle (135.55), 1000 seed weight (22.71g), grain yield (2892.62 kg ha^{-1}), straw yield (4791.69 kg ha^{-1}) and harvest index (37.56%) than that of Satabdi and IR 36.

REFERENCES

Annual report (2020-21) Department of Agriculture and Farmers welfare, Ministry of Agriculture and Farmers welfare, Government of India, pp 5.

Belder P, Bouman BAM, Spiertz JHJ, Peng S, Castaneda AR, Visperas RM (2005) Crop performance, nitrogen and water use in flooded and aerobic rice. *Pl Soil* 273(1-2): 167-182.

Bouman BAM, Peng S, Castaneda AR, Visperas RM (2005) Yield and water use of irrigated tropical aerobic rice system. *Agricult Water Manag* 74: 87- 105.

Brajagopal M, Kalipada P, Narayan CS (2020) Response of aerobic rice to irrigation regimes and method of zinc application on growth and yield during summer season in lateritic soil. *Res Crops* 21 (1): 1-9.

Gomez KA, Gomez AA (1984) Statistical procedure for Agriculture Research. 2nd edn. John Willey and Sons, New York, pp 680.

GRiSP (Global Rice Science Partnership) (2013) Rice Almanac, 4th edn. Int Rice Res Institute, Los Banos, Philippines , pp 283.

Kawamitsu Y (2000) Photosynthesis during desiccation in an intertidal alga and a land plant. *Pl Cell Physiol* 41(3): 344-353.

Nguyen HT, Fischer KS, Fukai S (2009) Physiological responses to various water saving systems in rice. *Field Crops Res* 112: 189-198.

Orasen G, De Nisi P, Lucchini G, Abruzzese A, Pesenti M, Maghrebi M, Kumar A, Nocito FF, Baldoni E, Morgutti S, Negrini N, Valè G, Sacchi GA (2019) Continuous flooding or alternate wetting and drying differently affect the accumulation of health-promoting phytochemicals and minerals in rice brown grain. *Agronomy* 9(10): 628.

Peng S, Bouman BAM, Visperas RM, Castaneda AR, Nie L, Park H (2006) Comparison between aerobic and flooded rice in the tropics: Agronomic performance in an eight-season experiment. *Field Crops Res* 96: 252- 259.

Ramana KV, Murthy, Reddy DS (2013) Effect of irrigation and weed management practices on nutrient uptake and economics of production of aerobic rice. *J Agric Veterinary Sci* 3: 15-21.

Samui RC, Maiti BK, Jana PK (1979) Effect of N on pre-*kharif* direct seeded rice. *Ind J Agron* 24 (1): 77-80.

Silalertruksa T, Gheewala SH, Mungkung R, Nilsalab P, Lecksiwilai N, Sawaengsak W (2017) Implications of water use and water scarcity footprint for sustainable rice cultivation. *Sustainability* 9(12): 2283.

Wu XH, Wang W, Yin CM, Hou HJ, Xie KJ, Xie XL (2017) Water consumption, grain yield, and water productivity in response to field water management in double rice systems in China. *PLoS One* 7 (12): 12.