Japanese Journal of Gastroenterology and Hepatology

Preliminary Report

ISSN: 2435-1210 | Volume 10

Growth, Yield Responses and Water Use Efficiency Under Water Deficit Stress of Rice Plant

Phomvongsa B[1*], Phonesavanh K[1], Souttaphanh K[1], Linthasone T[2] and Sihathep K[3]

[1]Department of Agronomy, Faculty of Agriculture and Forestry, Champasak University, Vietnam

[2]Science Division, Faculty of Agriculture and Forestry, Champasak University, Vietnam

[3]Rice research academic, Phongnam Rice Research Center, Vietnam

[*]Corresponding author:

Bounsuan Phomvongsa,
Department of Agronomy, Faculty of Agriculture and Forestry, Champasak University, Laos, Vietnam

Received: 02 Jan 2024
Accepted: 17 Jan 2024
Published: 25 Jan 2024
J Short Name: JJGH

Keywords:

Water deficit stress; Growth; Yield; Water use efficiency; Rice plant

Citation:

Phomvongsa P. Growth, Yield Responses and Water Use Efficiency Under Water Deficit Stress of Rice Plant. J Gastro Hepato. 2024; V10(7): 1-6

1. Abstract

The experiment was conducted in dry season in 2021-2022 in Laboratory in cement block of the nursery experiment, faculty of agriculture. Ubon ratchathani University, to investigate the impact of water deficit stress under alternate wetting and drying (AWD) practices on growth and yield responds of rice. The experiment planning was factorial in CRD with 2 factors as follows: factor 1. water managements 4 levels which are: 1. Continuously flooding at 5 cm (CF) and water deficit stress at 15; 25 and 35 cm respectively. And factor 2. Varieties which are: local glutinous rice by Lee nok variety and modern glutinous rice by RD22 variety. The experiment consisted in 4 replications. The results showed that, the CF increase plant height better compared to AWD. The tillering was found highest with AWD 25. The yield components and yield of rice plant was found AWD 25 and Leenok variety were most optimized increased the panicle per hill, panicle length, total grain per panicle, filled grain per panicle, 1,000 grain weigh and grain yield of rice plant and AWD 25 highest water use efficiency on rice yield is 0.67 kg m^{-3}.

2. Introduction

Rice (Oryza sativa L.) is the best source of carbohydrates and proteins and has been considered by the World Food and Agriculture Organization (FAO) as a cereal for safe food for the world's population. It is well known that the global rice production is increasing to meet the food for the increasing population as well. It is estimated that the global rice production must reach 430 million tons by the year 2030 and within the year 2050 the rice production must reach 455 million tons (Araujo et al., 2013). Especially in Asia and area about 90% of the rice production was in that region (Ito et al. 2007). However, rice production has been affected by periodic and non-seasonal rainfall. This is a consequence of climate change and the global warming crisis, it will have serious and challenging effects on rice production for farmers in Southeast Asia. This affects the stability of world food production (Rodrigues et al., 2019). The drought caused the rice plants to cause water deficit stress (WDS). Water saving or low water farming is the choice and solution for farmers around the world. and is an important issue that leading organizations and agricultural countries are increasingly paying attention to tackling and vigorously changing water use behavior in farming amid drought impacted by climate brush shifts. which makes many farmers production areas suffer from drought and nonseasonal rains. But traditional practice has continuously flooded (CF) there is quite a lot of water. While alternate wetting and drying (AWD) technology results in high significantly savings water. It is a technology that changes the behavior of farmers in the midst of water scarcity. Which can save more than half of water with compared to CF (Takayoshi et al., 2016). Therefore, AWD it is a water saving technology that responds to

farmers in the midst of such a critically now and in the future.

While, AWD can affect physiological responses such as the creation of hydrocarbons or sugars (Zhang et al., 2012), affect the source and sink and other translocation for utilization that occur within the rice plant (Carrijo et al., 2018), affect grow below and above of rice plant. The characteristics that are important yield components of glutinous rice such as tillering, plant height, panicle number, panicle length, filled and unfilled grain, grain number and grain weight and yield. The biological yield such as straw yield and harvest index. Therefore, the objective of this study was to assess the positive and negative effects of water deficit stress on the growth and yield response of rice plant.

3. Research Method

This experiment was conducted in dry season in 2021-2022 in laboratory in cement block of the nursery experiment was factorial in CRD with 2 factors as follows factor 1. water managements 4 levels which are 1. Continuously flooding at 5 cm (CF) and water deficit stress at 15; 25 and 35 cm respectively, factor 2. Varieties which are local glutinous rice by Leenok variety and modern glutinous rice by RD22 variety, the experiment consisted in 4 replications.

3.1. Transplanting

The seedling age with 21 days and were planted in straight rows, which were 1-2 cm depth and 25 x 25 cm spacing was used and transplanting 1 seedling per hill and total 6 hills per cement block.

3.2. Water Managements

The 15 after planting date (DAT) the water level in the experimental plot was maintained about 5 cm water depth, after that water level was controlled until the maximum growth or panicle initiation stage (PIs) of rice. After that maintaining the water level to a depth of 5 cm as usual every plot until the dough grain stage.

3.3. Growth Data Collection

Plant height (cm) was measuring from the base in the soil surface to the top and tillers number were collected at the age of rice 60 DAT

3.4 Yield and Yield Components

The panicle number per hill, panicle length, total grain per panicle, filled and unfilled grain per panicle, 1,000 grain weight, straw yield, grain yield, harvest index

1) Grain $\frac{\text{Grain yield (g)}}{\frac{(100-\text{MC})}{(100-14)} \times \frac{(a)g}{1,000g} \times \frac{10,000m^2}{(b)m^2}}$ (1)

2) HI = $\frac{\text{Grain yield (kg)}}{\text{Grain yield (g)} + \text{Biology yield (g)}}$ (2)

3) Water use efficiency (WUE) = $\frac{\text{Grain yield (kg)}}{\text{Water use } (m^3)}$ (3)

4. Data Analyzed

This study was planned using factorial in CRD in laboratory with 4 replications, the mean of the experimental results was analyzed by analysis of variance (ANOVA) and the LSD mean difference at the level of variance 95% confidence (Gomez and Gomez, 1983) using the Statistrix 0.8 program.

5. Results

This research was conducted in sandy loam conditions, pH 6.45 and organic matter 0.42 % and soil texture is sandy loam. Which is consistent with the results of Taparat and Soontorn, (2016) found that in Esaan region, especially the soil depth of 0-30 cm in Si Kai Subdistrict, Warinchamrap District, Ubon Ratchathani Province, which is in the region of research is sandy laom approximately 64.7-74.8, 13-18.8 and 12.2-16.2% for sand, silt and clay respectively.

5.1. Plant Growth

(1) Plant height

The plant height at the 60 DAT was found high significantly at 0.01 probability level, which the highest plant height was found with AWD 15 and AWD 25 is 88.36 and 89.65 cm, compared to AWD 35 lowest height is 86.15 cm and found that RD 22 best height is 92.23 cm, while the Leenok lowest height is 84.25 cm, the RD 22 and CF AWD 15 and AWD 25 was highest is 93.40 93.73 and 92.95 cm respectively. While the Leenok and CF AWD 15 and AWD 35 lowest height is 83.33 83.85 and 83.48 cm respectively.

(2) Total tillers

The plant tillers per hill at the 30 DAT was found high significantly at 0.01 probability level, which the highest tillers per hill with AWD 25 is 7.44 tillers, while the AWD 15 was lowest is 5.98 tillers. The Leenok highest tillers per hill is 6.80 tillers, while the RD 22 was lowest is 5.84 tillers. The Leenok and AWD 25 was highest tillers per hill is 8.80 tillers, while the RD 22 and AWD 35 was lowest is 5.19 tillers.

The plant tillers at the 45 DAT was found high significantly at 0.01 probability level, which the highest with AWD 15 and AWD 25 is 14.59 and 16.39 tillers, while the CF and AWD 35 was lowest is 12.54 and 10.67 tillers. The Leenok highest tillers is 14.81 tillers, while the RD 22 was lowest is 12.28 tillers. The Leenok and AWD 25 was highest is 20.95 tillers, while the RD 22 and AWD 35 was lowest is 9.58 tillers.

The plant tillers at the 60 DAT was found significant at 0.05 probability level, which the highest tillers were found with AWD 25 is 23.85 tillers, while the CF was lowest is 19.85 tillers. The Leenok highest tillers is 23.53 tillers, while the RD 22 was lowest is 20.04 tillers. The Leenok and AWD 25 was highest is 28.62 tillers, while the RD 22 and AWD 25 and AWD 35 was lowest is 19.08 and 19.24 tillers respectively.

5.2. Yield and Yield Components

(1) Panicle per hill

The panicle per hill was high significantly at 0.01 probability level, which the highest was found with AWD 25 is 28.27 panicles. While the AWD 35; AWD 15 and CF respectively was lowest is 21.61; 21.81 and 23.78 panicles. The Leenok was highest is 27.21, while the RD 22 was lowest is 20.53 and the Leenok with AWD 25 was highest is 33.70, while the RD 22 with AWD 35 was lowest is 18.69 panicles.

(2) Panicle length

The panicle length was high significantly at 0.01 probability level, which the highest was found with CF; AWD 15 and AWD 25 is 28.13; 28.13 and 27.50 cm. While the AWD 35 was lowest is 25.75 cm. The Leenok was highest is 29.38 cm, while the RD 22 was lowest is 25.38 cm. While the Leenok with CF AWD 15 and AWD 25 was highest is 30.25; 30.50 and 29.75 cm, while the RD 22 with AWD 35 was lowest is 24.50 cm.

(3) Total grain per panicle

The grain number per panicle was high significantly at 0.01 probability level, which the highest grain number was found with CF; AWD 15 and AWD 25 is 175.13; 175.50 and 183.13 grains respectively, while the AWD 35 was lowest is 131.88. The Leenok was highest is 172.38, while the RD 22 lowest is 160.44. While the Leenok with AWD 25 was highest is 194.00, while the both varieties and AWD 35 was lowest is 123.50 and 140.25 grains for the Leenok and RD 22 respectively.

(4) Filled and unfilled grain per panicle

The filled grain per panicle was high significantly at 0.01 probability level, which the highest filled grain was found with AWD 25 is 89.88%, while the AWD 35 was lowest is 79.13%. The Leenk was highest filled grain is 87.13%, while the RD 22 was lowest is 84.94%. The varieties and water in each level was not significant.

(5) 1,000 grain weight

The grain weight was high significantly at 0.01 probability level, which the highest was found with CF; AWD 15 and AWD 25 is 20.36; 20.48 and 20.55 g respectively, While the AWD 35 was lowest is 19.14 g. Which the Leenok was highest found 20.41 g, while the RD 22 was lowest is 19.85 g. The rice varieties and water in each level was not significant.

(6) Grain yield

The yield was high significantly at 0.01 probability level, which the highest was found with CF; AWD 15 and AWD 25 is 1284; 1271 and 1311 kg rai^{-1} respectively, While the AWD 35 was lowest is 942 kg rai^{-1}. Which the Leenok was highest found 1,227 kg rai^{-1}, while the RD 22 was lowest is 1,177 kg rai^{-1}. The rice varieties and water managements in each level was not significant.

(7) Straw yield

The straw yield was high significantly at 0.01 probability level, which the highest was found with AWD 25 is 967 kg rai^{-1}. While the CF AWD 15 and AWD 35 was lowest is 844; 818 and 816 kg rai^{-1} respectively. Which the Leenok was highest found 956 kg rai^{-1}, while the RD 22 was lowest is 767 kg rai^{-1}. The rice varieties and water managements in each level was not significant.

(8) Harvest index

The harvest index was high significantly at 0.01 probability level, which the highest was found with CF and AWD 15 is 0.53 too respectively. While the AWD 35 was lowest is 0.46. Which the RD 22 was highest found 0.53, while the Leenok was lowest is 0.48. The rice varieties and each level water were not significant.

(9) Water consumption (m^3 ha^{-1})

The water used of rice plants grown under CF and AWD conditions was found high significantly at 0.01 probability level, which the highest found with CF is 13,650 m^3 ha^{-1}. While AWD 35 was the lowest water used is 7,850 m^3 ha^{-1}, the water use of rice varieties and water management were not significant.

(10) Water use efficiency (kg m^{-3})

The water uses efficiency of rice plants grown under conditions that received CF and AWD was found high significantly at 0.01 probability level, which the highest being found with AWD 25 highest water use efficiency on rice yield is 0.67 kg m^{-3}, while CF's lowest water use efficiency with 0.44 kg m^{-3}. The water use efficiency of rice varieties and water management was not significant.

6. Discussion

The water is an indispensable and essential factor for growth and yield of rice plants. Although, rice is not an aquatic plant. But the rice plant can be born and growth in both flooding conditions and in suitability soil moisture. Which the water deficit (WD) causing high water deficit stress (WDS) in rice plants and effects on growth (Zhang et al., 2012; Yu et at., 2015; Carrijo et al., 2018), as well as yield and other yield components of rice plants (Yoshida, 1981). While, moderate AWD 25 the dehydration of the rice roots was not severe and not very stressfully. Therefore, it does not greatly affect the growth of the rice plant, which is not useful for the production of rice plants. Thus, which does not damage yield and yield components of rice plants (Rahman and Bulbul, 2014; Majeed et al., 2017). This will cause severe damage to yield of rice plants (Farooq et al., 2009). Although, the CF causes better physiological growth and causing higher plant height (Table 1), will make many of the yield components higher, such as panicle length, number of grains per panicle, grain weight and grain yield of rice plant. Thus, the rice plant can create sufficient nutrients for growth, tillering and is suitable for creating important yield components such as panicle per hill, panicle length, total grain per panicle, filled and unfilled grain, 1,000 grain weight and grain yield as well as the optimized biological yield and harvest index of the rice plant (Table 2). Which the highest being found with AWD 25 highest water use efficiency on rice yield is 0.67 kg m^{-3}, while CF's lowest water use efficiency with 0.44 kg m^{-3}.

Table 1: Plant height (cm) and tiller (tiller) in each growth stage of rice under intermittent and continuous watering conditions

Water managements	Age (30 DAT)		Age (45 DAT)		Age (60 DAT)	
	Height	Tillers	Height	Tillers	Height	Tillers
A (Water managements)						
CF	45.16 a	6.45 b	80.59 a	12.54 b	88.36 ab	19.85 b
AWD 15	42.84 b	5.98 c	79.21 b	14.59 a	88.79 a	22.27 ab
AWD 25	36.49 c	7.44 a	73.80 c	16.39 a	89.65 a	23.85 a
AWD 35	35.58 c	5.39 d	72.99 c	10.67 b	86.15 b	21.16 ab
B (Varieties)						
Leenok	39.35 b	6.80 a	70.64 b	14.81 a	84.25 b	23.53 a
RD22	40.68 a	5.84 b	82.66 a	12.28 b	92.23 a	20.04 b
A x B						
Variety 1 (Leenok)						
CF	43.03 b	6.46 b	78.80 d	11.21 cd	83.33 c	19.46 bcd
AWD 15	42.90 b	6.33 b	74.48 e	15.35 b	83.85 c	22.96 bc
AWD 25	36.15 c	8.80 a	64.83 f	20.95 a	86.35 bc	28.62 a
AWD 35	35.33 c	5.59 cd	64.45 f	11.75 cd	83.48 c	23.08 b
Variety 2 (RD22)						
CF	47.30 a	6.44 b	82.38 bc	13.87 bc	93.40 a	20.25 bcd
AWD 15	42.78 b	5.63 cd	83.95 a	13.83 bc	93.73 a	21.59 bcd
AWD 25	36.83 c	6.08 bc	82.78 ab	11.83 cd	92.95 a	19.08 d
AWD 35	35.83 c	5.19 d	81.53 c	9.58 d	88.83 b	19.24 cd
F-Test A	**	**	**	**	**	*
B	**	**	**	**	*	**
A x B	**	**	**	**	**	**
CV (%)	3.34	6.45	1.05	13.85	2.83	11.9

* = significant at 5% level, ** = high significantly at 1% level.

Table 2: Yield and yield components of rice under intermittent and continuous watering conditions

Factors	Panicle hill^{-1}	Panicle length	Grain panicle^{-1}	Filled Panicle^{-1}	1,000 grain	Yield
	(panicle)	(cm)	(grain)	(%)	(g)	(Kg ha^{-1})
A (Water managements)						
CF	21.61 b	28.13 a	175.13 a	87.50 b	20.36 a	8,025 a
AWD 15	21.81 b	28.13 a	175.50 a	87.63 b	20.48 a	7,944 a
AWD 25	28.27 a	27.50 a	183.13 a	89.88 a	20.55 a	8,194 a
AWD 35	23.78 b	25.75 b	131.88 b	79.13 c	19.14 b	5,888 b
B (Varieties)						
Linok	27.21 a	29.38 a	172.38 a	87.13 a	20.41 a	7,668 a
RD22	20.53 b	25.38 b	160.44 b	84.94 b	19.85 b	7,356 b
A x B						
Variety 1 (Linok)						
CF	22.51 cd	30.25 a	185.00 abc	88.75	20.57	8,175
AWD 15	23.75 c	30.50 a	187.00 ab	88.5	20.83	8,175
AWD 25	33.70 a	29.75 a	194.00 a	91.5	20.86	8,487
AWD 35	28.88 b	27.00 b	123.50 d	79.75	19.38	5,837

Variety 2 (RD22)						
CF	20.70 cde	26.00 c	165.25 c	86.25	20.15	7,875
AWD 15	19.88 de	25.75 c	164.00 c	86.75	20.13	7,718
AWD 25	22.85 cd	25.25 cd	172.25 bc	88.25	20.24	7,906
AWD 35	18.69 e	24.50 d	140.25 d	78.5	18.91	5,937
F-Test A	**	**	**	**	**	**
B	**	**	*	**	**	**
A x B	**	**	*	ns	ns	ns
CV (%)	10.12	2.22	8.63	1.03	1.17	4.06

* = significant at 5% level, ** = high significantly at 1% level, ns = not significant.

7. Conclusion

The rice planting by AWD to the growth and yield response of rice. Results showed that. Although CF will increase the height of the rice plant better compared to AWD. However, the CF AWD 15 and AWD 25 were not significant. The tillering was found highest with the AWD 25. If groundwater critical conditions are reduced to AWD 15 are water well and less impact on growth and yield. Even when groundwater was reduced to AWD 25, the rice roots began to absorb less water. While at the AWD 35 the water deficit stress of the roots severely affected the growths and yield of rice. The yield components and yield of rice it was AWD 25 the optimized increased the panicle per hill, panicle length, total grain per panicle, filled grain per panicle, 1,000 grain weigh and grain yield of rice plant. Thus, the yield and yield components of rice were AWD 25 and Leenok variety were optimized for panicle per hill, panicle length, total grain per panicle, filled grain per panicle, 1,000 grain weigh and grain yield of rice and AWD 25 highest water use efficiency on rice yield is 0.67 kg m^{-3}.

References

1. Araújo. Response of traditional upland rice varieties to inoculation with selected diazotrophic bacteria isolated from rice cropped at the Northeast region of Brazil", Applied Soil Ecology. 2013; 64(3): 49-55.
2. Carrijo DR, Akbar A, Reis AFB, Gaudin ACM, Parikh SJ, Green PG, et al., Impacts of variable soil drying in alternate wetting and drying rice systems on yields. Grain arsenic concentration and soil moisture dynamics. Field Crops Research, 2018; 222: 101-110.
3. Farooq M, Wahid A, Kobayashi N, Fujita ASMAB. Plant drought stress: effects, mechanisms and management. Agronomy for Sustainable Development. 2009; 29: 185-212.
4. Gomez K, Gomez A. Statistical Procedures for Agricultural Research, 2nd edited. Los Banos, Laguna, Philippines: International Rice Research Institute, p1983; p. 690.
5. Ito S, Abdullah A, Kobayashi H, Matsumura I. World Rice Demand towards 2050: Impact of decreasing Demand of per Capita Rice Consumption for China and India, 2007; 18.
6. Ishihara K, Saito H. Relationship between leaf water potential and photosynthesis in rice plants. Faculty of Agriculture, Tokyo University of Agriculture and Technology, Saiwaicho, Fuchu, Tokyo, 183 Japan, pp. 1983; 6.
7. Majeed A, Saleem M, Jalil S, Abbas SH, Hayat A. Water saving rice production using alternate wetting and drying technique in rice based cropping system in sindh, Pakistan. Science Technology and Development, 2017; 36: 30-35.
8. Munns R, James RA. Screening methods for salinity tolerance: a case study with tetraploid wheat, Plant and Soil. 2003; 253, 201-218.
9. Rahman MR, Bulbul SH. Effect of alternate wetting and drying (AWD) irrigation for boro rice cultivation in Bangladesh. Agriculture, Forestry and Fisheries, 2014; 3, 86-92.
10. Ramegowda V, Basu S, Krishnan A, Pereira A. Rice growth under drought kinase is required for drought tolerance and grain yield under normal and drought stress conditions. Plant Physiology, 2014; 166, 1634–45.
11. Rodrigues J, Inzé D, Nelissen H, Saibo NJM. Source–sink regulation in crops under water deficit. Trends in Plant Science, 2019; 24, 10-1016.
12. Takayoshi Y, Tuan LM, Kazunori M. Alternate wetting and drying (AWD) Irrigation technology uptake in rice paddies of the mekong delta and yokoyama shigeki. Asian and African Area Studies, 2016; 15: 234-56.
13. Taparat SO, Soontorn K. Properties and Carbon and Nutrient Storage Potential of Forest Soils in a Highland Community Forest, Chiang Mai Province, Science and Technology, 2016; 18: 39-51.
14. Xu Q, Ma Z, Tingbo L, Meng B, Wang Z, Niu J. Effects of water stress on fluorescence parameters and photosynthetic characteristics of drip irrigation in rice. Water, 2020; 12: 1-19.
15. Yang J, Zhou Q, Zhang J. Moderate wetting and drying increases rice yielding and reduces water use, grain arsenic level, and methane emission. Science Direct, 2017; 51-158.
16. Yoshida S. Fundamentals of Rice Crop Science. International Rice Research Institute, Los Banos, Philippines, 1981; pp. 277.
17. Yu SM, Lo SF, Ho THD. Source–sink communication: regulated by hormone, nutrient and stress cross signaling. Plant Science, 2015; 20(12): 844-57.
18. Zhang Y, Tang Q, Peng S, Xing D, Qin J, Laza RC. Water use efficiency and physiological response of rice cultivars under alternate wetting and drying conditions. The Scientific World Journal, 2012; 10: 1-10.
19. Zhu X, Lu Y, Wang Q, Chu P, Miao W, Wang H, La H. A new method for evaluating the drought tolerance of upland rice cultivars. Science Direct, 2017; 10: 488-498.

20. Zhu MD, Zhang M, Gao DJ, Zhou K, Tang SJ, Zhou B, et al., Rice OsHSFA3 gene improves drought tolerance by modulating polyamine biosynthesis depending on abscisic acid and ROS levels. Molecular Science, 2020; 21: 1857.