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Research Article

Water Stress on Germinating Paddy Seeds

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Abstract

This study evaluated variations in water stress on the germination of three famous rice varieties (*Oryza sativa* L.) amongst farmers in Thailand. The research was designed by a randomised complete block (RCBD) with four different treatments of moisture in the plant material which included (1) 80% humidified for proper planting condition (control), (2) 60% moisture (3) Moisture level of 40%, and (4) moisture content of 10%. Rice seeds have been soaked in water for 48 hours before planting. The moisture content of the planting equipment was monitored during the experiment. The experiment measured physical growth, including germination rate, stem height, root length and chemical growth, chlorophyll content of rice plants. The findings showed that all rice varieties were tending, to grow in the same direction. The germination rate of all rice varieties depends on the water content of the vegetable material. They all grow into 80% moisture, followed by 60% and 40%, respectively. However, 10% moisture did not germinate for all varieties. Riceberry rice showed better growth than other rice from a physical perspective. Medium height 13.56 cm, root length 4.76 cm, high chlorophyll content 2.0 mg/g. The second highest germination rate was Pathumthani 1 when KDML 105 had the lowest germination rate. Moisture or water retention of less than 40% is unsuitable for rice cultivation.

Keywords: *Germination, Global warming, Humidity, Drought, Rice.*

Introduction

Global warming increases the likelihood of intense daytime and nighttime heat by contributing to the intensity of heat waves. The hot weather also promotes evaporation of water. It is responsible for the most severe droughts [National Academy of Sciences, 2019]. Global warming is impressive when it comes to the magnitude and frequency of droughts. Certain regions do not receive precipitation or low precipitation during the rainy season. It's warmer than the global average temperature in many areas, with more warming above land and oceans. In humans, 20-40% of the world's population survives with a mean air temperature 1.5^{o}C higher than the pre-industrial temperature for at least one season [International Panel of Climate Change, Special report]. In Thailand, Thailand's meteorological department reported that Thailand has an average temperature of 1.1^{o}C higher than normal, the highest average temperature in 69 years (1951-2019). Although the quantity of precipitation in 1998, 2010, 2015 and 2016 was affected by ENSO. Especially in 1998, 2016 and 2015, when the violent phenomenon El Nino happened. Thailand experienced significantly lower precipitation in 2019, down 14% from normal. Consequently, rainfall and moisture are not conducive to rice cultivation. There are generally two rice fields: the wet season and the second dry rice field. The dry season can only be used in the irrigation area. However, some producers grow rice throughout the year, which does not consider the water supply.

Most Thai farmers prefer to grow rice transplants or wet seedlings. Farmers are turning to dry seeding in areas where there is

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little water supply. They naturally allow rice to germinate during drought until rain or irrigation water becomes available. Therefore, rice planted in dryland areas cannot grow. As a result, farmers are losing investment and revenue and creating investment liabilities.

Water is required for the process of absorbing germinating minerals and controlling the temperature in the plant. The water inhibitor is the first seed germination process, leading to gas exchange and enzymatic activation. Resulting in digesting foods that accumulate in the endosperm, such as starch, proteins, fats, as energy leading to complete germination [Martins, A.R. *et al*., 2012]. Consequently, water quality, content and level are important for this process. Lack of moisture or insufficient moisture may prevent plant seeds from germinating, are unhealthy, are not ready for growth or maturity, and are not ready for production. Yield was not as desirable because of inadequate relative humidity for seed germination and growth [Thai Meteorological Department, 2020]. Additionally, reduced water content is a salinity factor that influences seed germination, physiological, biochemical, and molecular changes [Ibrahim, E. A, 2016]. Rising air temperatures in the growing area destroy rice crop biomass and reduce grain yield [Smakgahn, K. *et al*., 2015]. The reduction in rice yields because of rising night temperatures is associated with global warming [Peng, S. *et al*., 2004]. Rice crops cultivated in drought-warmed areas cause more damage to grain quality than those affected on both sides [Abdul Rahma, S.M. *et al*., 2019]. This condition will have significant implications for the agriculture industry and farmers. It influences farmers' incomes as production drops [Thai Meteorological Department, 2020]. The aim of this research was to study the impact of moisture stress on the germination of rice seeds. The experiment was carried out in the laboratory with the three most popular rice strains in Thailand. The results of the study should enable farmers to take decisions on how to prepare plantations and how to grow rice.

Material and Methods

The experiment employed three varieties of rice, including Thai jasmine rice (Khoa Dawk Mali 105; KDML 105), Pathumthani 1, and Riceberry rice or purplish black rice. Rice KDML 105 or Thai jasmine rice is non-sticky rice classified as photosensitive rice. The mature rice plant is approximately 140 cm high, with long and narrow green leaves. The rice seed is delicate. The cooked rice grain is soft and smells like pandan leaves. This rice can be grown in drought tolerant uplands, modulated, acidic and saline soils [Farm Channel Thailand, 2020]. Pathumthani 1 or Ham Pathum rice is flavored and does not respond to the photoperiod. This variety of rice can grow at the same time in wet and dry seasons. The growing season is 113-126 days following transplantation and 104-114 days for the dry seeding method. It's dormant for 3-4 weeks. This rice measures about 104-133 cm high, with straight and green leaves with bristles. Grain quality is similar to that for jasmine rice (KDML 105). The cooked grain is smooth and sticky, with a gentle fragrance. Pathumthani 1 rice tolerates brown and white grasshoppers and resists burns and diseases of dry margins [Farm Channel Thailand, 2020]. Riceberry rice is the cross between KDML 105 rice and Homnin rice. Riceberry rice is insensitive to the photoperiod, non-stick rice, dark purple grain, sticky and scented during cooking. Rice Riceberry is a fine grain, dark violet when ripe, and brown rice has a unique flavor. The cooked rice grain is dark violet glossy like the berry, soft texture, and has a good taste. This special purple rice can be grown throughout the year, harvested at maturity for 130 days, and has produced an average yield compared to other rice varieties in Thailand [Rice family Thailand, 2021].

The experiment was carried out in the laboratory, seeding in the plastic tray, and using tower paper as planting material. The experiment was designed as a randomized complete block (RCBD), consisting of four treatments, three repeats for each as follows: 1). Control treatment: Planting equipment 80% wet, 2). Planting equipment was

moistened at 60%, 3). The planting material was 40% moisture and 4) the planting material was 10% moisture and there was no extra water on the second day after seeding.

Rice seeds are prepared from three varieties by selecting healthy seeds, free of contamination, with a high percentage of germination and free of diseases and pests. Soak the rice seeds in clean water for 48 hours and put them in a very moist glass pan. Keep at room temperature of 25°C throughout the experience. Plant about 50 seeds in a plastic tray with used tower tissue paper stacked in 5 layers as planting material. Moisture control, according to the specified treatment and plant growth observed over a 21-day period.

Observing the Growth of Rice

Germination is seen in days 7, 14 and 21 after seeding. Measure the length of the roots, the height of the plants, the fresh and dry weight of the roots and the fresh and dry plants at the surface (stems). The aboveground biomass of the plant was measured from the base of the plant adjacent to the root to the end of the final green leaf at the top. The length of the root was measured from the root, attach at the end of the longest root. Plant samples were collected 21 days after germination, fresh weight was recorded, then dried at 60°C for 24 hours at a record dry weight [Mansuriwong, P. *et al*., 2015].

Analysis of Chlorophyll Concentration

Total chlorophyll in rice plant was analyzed using a methodology outlined in Arnon, (1949). Using 2 grams of rice leaves collected 21 days after germination, finely mixed, then added 0.1 g of CaCO3 (s) and extracted with 80% acetone solution. The solution sample was shaken for 2 minutes and then set aside to separate the supernatant and sediment for 20 minutes. Then transfer into a stirrer and agitate until the substance is smooth. Finally, the sample was determined using the spectrophotometer at wavelengths of 642.5 and 660.0 nm [Arnon, D.I, 1949].

Data Analysis

The data were analyzed using the statistical package for the social sciences (SPSS) program for variance, ANOVA, compared the mean by the LSD (Least Significant Difference) method at a 95% confidence level.

Results and Discussion

The Seed Germination Percentage

The seed germination percentage is calculated using the total number of sprouted seeds in relation to the total number of rice seeds initiated for each experiment. The sprout was counted when the roots or shoots reached at least 1 mm [Mansuriwong, P. *et al*., 2015].

Germinating rate (%) = (Total number of sprouts x 100) /Total number of seeds.

A total percentage of seed germination based on moisture is given in Figure 1 and details include:

With 80% humidity, Riceberry rice has the largest number of germinated rice seeds, 127. Followed by KDML 105 rice, 106 shoots, and 86 of Pathumthani 1 rice least germinated rice seeds. The germination rate was calculated based on the number of germinated rice seeds. The findings show that recovery rice was 84.66%, KDML 105 70.66%, and Pathumthani 1 57.33%.

With 60% humidity, Riceberry rice also has the largest number of sprouted rice seeds as a control treatment, 117, followed by KDML 105 rice, which germinated 106. The smallest germinated rice seed of Pathumthani 1 with 85 regular germinating rice seeds. Riceberry rice had a germinated percent of 78.00%, KDML 105 rice was 56.66% and Pathumthani 1 rice was 51.33%. Germination rates for rice seeds were 7.8%, 0.94% and 1.16% lower than this control treatment for Riceberry rice, KDML 105 rice and Pathumthani 1 rice, respectively.

At 40% moisture, the largest number of germinated seeds was obtained from Riceberry rice, which was 91 germinated seeds. The second highest number of germinated seeds was KDML 105 rice, of which 61 germinated, and Pathumthani 1 rice had the smallest number of 46 sprouts. The germination percentage of rice seed was 60.66, 40.66, and 30.66 for Riceberry, KDML 105, and

Pathumthani 1 rice, respectively. Riceberry rice, KDML 105 rice and Pathumthani 1 rice have a germination rate of 22.23%, 28.24% and 40.27%, respectively, below the control (80% moisture). In addition, seed germination of all varieties was lower than that of the use of 60% moisture of 29.0%, 85.71%, and 66.66% for Riceberry, KDML 105, and Pathumthani 1 rice, respectively.

The result showed that the rice seeds of all rice varieties do not germinate under moisture conditions of 10%. Therefore, the percentage of seeds germinating in this condition could not be calculated. With high moisture, the sprouting rate was higher than with lower moisture. As a matter of fact, the humidity is at the heart of the germination process. It helps circulate the food accumulated in the seed, and a variety of chemical reactions required adequate moisture [Siringarm, K, 2015]. Rice in general has a high germination rate and extremely high moisture conditions. For example, areas that were flooded during the year [Teerawaril, S, 2008]. But in dry areas, the farmer can plant rice in low humidity conditions of about 60% and 40%. However, the germination rate varies depending on the moisture obtained and the yield will be reduced under conditions of low moisture.

The Development of Rice Plants

Note the height of the plant measurement from the top of the root to the end of the last. Germinated rice had the highest average size on day 21 after planting for all varieties of rice. Seedlings under 80% moisture reached the maximum height, 11.05 cm of KDML 105 rice and 11.43 cm for Pathumthani 1 rice, and 13.56 cm for Riceberry rice. The height variance of the stems in the highest scattered Pathumthani 1 rice was 48.7% due to the relative board difference in stem height in the same experiment, followed by Riceberry rice (45.5%) and KDML 105 (37.2%), respectively. Riceberry rice can thrive, with the highest average stem size. Riceberry also observed the smallest variation in stem height. These can be due to genetically modified rice varieties of Homnin rice and KDML 105 rice to account for development in an inappropriate cultivation environment [Phonsen, W, 2017]. But no germination in 10% moisture content. These findings concluded that the moisture conditions of the veneer material were positively correlated with the height of the germinated rice.

Measurement of the length of the root of the part attached to the roots at the tip of the longest root. Root length for all four treatments was statistically significant ($p \leq 0.05$). High moisture conditions improve root germination than low moisture conditions. Root length in 80% of moisture conditions produced the fastest growth, followed by 60% and 40% of moisture conditions, respectively. But not less moisture germination conditions; 10%. Regarding the results, 80% of the humidity considering the length of the longest root, which KDML 105 rice was 3.83 cm. Pathumthani 1 rice was 4.66 cm, while Riceberry rice was 4.76 cm.

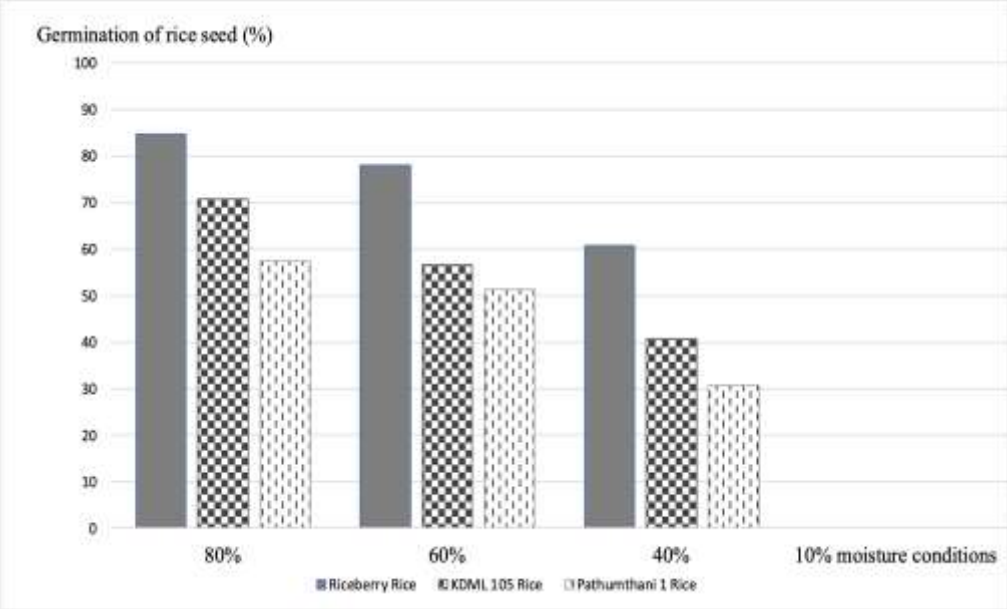

Figure 1: Comparison of germination of rice seeds (%) Riceberry, KDML 105, and Pathumthani 1 rice seeds at 21 days after sowing under different moisture conditions

KDML 105 is the second fastest growing rice because it is drought tolerant. They can be cultivated under conditions of exhausted moisture [Lianchamrean, W, 2002], but the growth rate of seedlings is about 30% lower than that of Riceberry rice under the same conditions. The results showed that Pathumthani 1 rice had the lowest growth rate because it has a long dormant period and requires high moisture to grow. It is not suitable for growing in winter or in dry areas with no irrigation [Department of Agriculture, 2000]. Results of root height and length are presented in Tables 1 and 2.

Table-1: Height statistics of germinated rice in 7, 14, and 21 days after sowing of KDML 105, Pathumthani 1, and Riceberry rice

Moisture conditions (%)	**Plant height (cm)**								
	KDML 105 rice			**Pathumthani 1 rice**			**Riceberry rice**		
	7 days	14 days	21 days	7 days	14 days	21 days	7 days	14 days	21 days
40%	0.77^{a}	3.93^{a}	4.83^{a}	0.03^{a}	3.67^{a}	4.63^{a}	0.63^{a}	5.20^{a}	7.50^{a}
60%	1.03^{a}	4.90^{b}	6.40^{b}	0.83^{b}	5.30^{b}	5.10^{ab}	2.07^{b}	6.20^{b}	9.90^{b}
80%	2.40^{b}	5.43^{b}	7.03^{c}	0.90^{b}	5.67^{b}	6.43^{b}	3.43^{c}	7.43^{c}	11.13^{c}
F-test	*	*	*	*	*	*	*	NS	*
CV (%)	37.2			48.7			45.8		

Values in a column followed by a common letter are not significantly different at the 5% level by DMRT **: significantly different (p≤ 0.01), ns: not significantly different

Table-2: Comparison of germinated rice root length 7, 14 and 21 days after seeding KDML 105, Pathumthani 1 and Riceberry rice

Moisture conditions (%)	**Root length (cm)**								
	KDML 105 rice			**Pathumthani 1 rice**			**Riceberry rice**		
	7 days	14 days	21 days	7 days	14 days	21 days	7 days	14 days	21 days
40%	0.30^{a}	0.43^{a}	1.90^{a}	0.27^{a}	0.53^{a}	2.23^{a}	0.43^{a}	0.83^{a}	2.67^{a}
60%	0.53^{b}	0.53^{b}	2.17^{b}	0.73^{b}	0.53^{a}	3.57^{b}	1.17^{b}	1.67^{b}	3.70^{ab}
80%	0.73^{c}	0.70^{b}	2.83^{c}	0.67^{ab}	1.40^{b}	4.67^{b}	1.37^{b}	2.03^{b}	4.07^{b}

F-test	*	*	*	NS	*	*	*	NS	*
CV (%)	38.9			24.3			28.2		

Values in a column followed by a common letter are not significantly different at the 5% level by DMRT **: significantly different (p≤ 0.01), ns: not significantly different.

Chlorophyll Content

Chlorophyll accumulation in rice seedlings 21 days after germination indicates a positive relationship with moisture conditions. The results suggest that germination conditions at 80% rice moisture were more chlorophyll-rich than others. Under these conditions, KDML105 rice accumulated 1.18 mg/g. Pathumthani 1 accumulated 1.19 mg/g, while Riceberry accumulated more than 2 mg/g. Low moisture content affects plant photosynthesis because the color content of the leaves diminishes with dehydration [Chaum, S. *et al*., 2009]. Chlorophyll levels in rice below 60% and 40% moisture decreased by 26.67% and 33.33%, respectively, compared to normal conditions (80%). As a result, Pathumthani 1 was the most sensitive rice variety to moisture conditions (Figure 2). Stunted plants or yellow leaves, brown leaves, often observed in 40% of wet conditions. This is because the moisture was not suitable for the process of silicone absorption by the rice plant, which is an essential complement to rice growth.

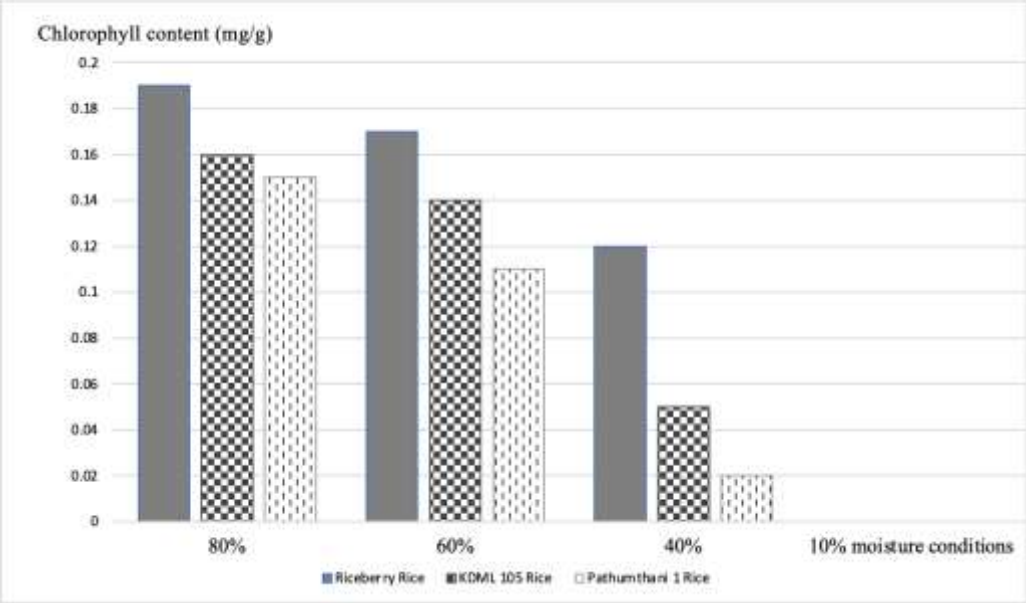

Figure 2: Comparison of chlorophyll levels (mg/g) of Riceberry rice, KDML 105 rice, and Pathumthani 1 rice at 21 days after sowing under different moisture conditions

Conclusion

The findings indicated that moisture conditions in plant material affected rice germination, rice growth and botanical chemistry. The 80% moisture experiment found the greatest germination rate, followed by 60% and 40%. It was not found that the sprouted rice was under 10 percent moisture. Stunted plants or yellow leaves, brown leaves, frequent in 40% of moisture handling conditions. Rice paddies do not grow in 10%.

Moisture due to very poor planting conditions. This is because humidity conditions are unsuitable for germination and growth. The results show that high moisture conditions produced the most fertile rice plants in terms of physical properties and chlorophyll accumulation in rice plants. The results suggest that rice seeding with low moisture content reduces plant growth and may not be healthy for the next stage of growth. The results of the study can be used to inform farmers' decision-making when preparing seeds or planting rice. It is also used to consider crop timing selection to prevent investment loss. This

study was conducted in a lab and used non-soil, planting equipment to account for moisture only, without considering soil nutrients or fertility. Therefore, studying crop cultivation in rice fields or in real areas is an interesting study to continue.

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