International Journal of Agricultural Technology 2019 Vol. 15(5):769-778
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Comparison of root system and stomata in nine upland rice varieties

Raumjit, N.[*], Siwadon, S., Sukanya, S. and Thirayut, W.

Department of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Pince of Chumphorn Campus Chumphorn Province, Tambon Chum Kho, Amphur Pathiu, Chumphorn Province, 86160, Thailand.

Raumjit, N., Siwadon, S. Sukanya, S. and Thirayut, W. (2019). Comparison of root system and stomata in nine upland rice varieties. International Journal of Agricultural Technology 15(5):769-778.

Abstract The root system and stomata of upland rice have important implications for both nutrient uptake and drought tolerant. The drought is one of the most known limiting factors of crop cultivation during rainy season which is caused from the climatic change. The root system and stomata in nine upland rice varieties:- Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm was reported. Result found that root system and stomata were associated with drought tolerance of upland rice. Among the nine upland rice varieties, Pukaotong variety had the moderate plant height, root length, root thickness number root and number stomata. On the other hand, Pukaotong variety had the lowest length of long cell and high yield per plant, indicating the high drought tolerance ability.

Keywords: Local upland rice, Root, Drought tolerant

Introduction

Upland rice (*Oryza sativa* L.) is grown on rain-fed and naturally well-drained soils having undulated topography (Fageria, 2001). In Thailand, planting of upland rice had the highest in the northern and in the southern (Raumjit and Thirayut, 2015). The upland rice can be categorized into three groups: indica, japonica and javanica subspecies (Chang, 1976). In the northern part of Thailand is grown japonica subspecies, while the southern part of Thailand grows indica subspecies. About 40 % of upland rice in the southern part of Thailand is produced by small–scale farmers for household consumption or for sale in local markets (Raumjit and Thirayut, 2013).

However, one of the major problems of upland rice production in southern Thailand is the drought during rainy season which is caused from the climatic change. It affects to rice growth and reduces grain yield and quality (Nokkoul and Wichitparp, 2013). Drought condition is a serious problem for

[*] **Corresponding Author**: Raumjit, N..; **Email**: knraumjit@gmail.com

rice production in many regions of the world. Drough can occur at any stage of the rice crop in a year in rainfed areas (Padmini *et al.,* 2017). Drought condition occurred during vegetative have reduced leaf formation, tillering, and the development of panicles per plant. At reproductive stage, droughts have reduced the number of grains per panicle, which was reduced to 60% and grain weight (Pantuwana *et al.,* 2002). When drought occurred during grain filling, the percentage of filled grains decreased to 40% and individual grain mass decreased by 20% (Boonjung and Fukai, 1996).

Certain upland rice varieties are significantly a source of genetic that can be used development of drought stress tolerance varieties. The use of upland rice tolerant varieties is on the most promised strategy to minimize the effect of water deficit on growth and productivity, because upland rice had strong root system; root length and root thickness density. Furthermore, the root characteristics are considered to be major factors affecting plant response to water stress. Root system had an important role under drought conditions (Sharp and Da vis, 1985). Stomatal density thus plays an important role in determining transpiration rate (Jones, 1998). Stomata with the lower density shows the higher resistant to the drought (Lestari, 2006). The distributions of root system and number stomata are an important indicator of the potential of water uptake and hydration of upland rice. This study to determine the association between root system and stomata and drought tolerant and yielding in the nine upland rice varieties. Bcause nine varieties of upland rice: Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm, they are popular varieties grown in southern Thailand.

Materials and Methods

Nine varieties of upland rice: Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm were grown in 12-inch plastic pots at King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Chumphon Province, Thailand in 2015 growing season. It locates at the south of Thailand, which situates at Latitude 10º 00' 30.05" N Longitude 99º 25' 45" E Altitude 17.84 m above the sea level. The study used Randomized Randomized Complete Block design (RCB) with three replications and nine treatments.

Rice cultivation was done by filling the soil into plastic pots with 7 kilograms per pot. Seeds of nine upland rice varieties were sown into plastic pots (20 plastic pots per variety). The plants were thinned to 1 plant per pot after 14 days after seedling emergence. Fertilizer 15-15-15 was applied at a rate

of 1 g. per pot at 14, 25, and 50 days after seedling emergence. Watering 3 times per week (1 liter per pot per time). Weeds were eliminated by hand twice at the age of 20 and 40 days after the seeds germinated. The collected data were plant high, days to harvesting of the grain, number of plants per tiller, number of panicles per tiller, panicle length, number perfect grains per panicle, empty grain per panicle and yields per tiller (reduced moisture content (hot air oven) at 43 degrees Celsius for 48 hours). Intact roots along with soil were pulled out from the plastic pots and washed carefully to remove the soil. Root length was calculated and recorded from the shoot base to the tip of the longest roots. Root thickness was measured at 2 cm from the shoot base. Number of roots per tiller was calculating recorded the number of roots per tiller.

For the stomata, matured leaf of third leaf from the top was collected from the pots the food reserve accumulation stage and fixed in FAA solution (Sarwar and Ali, 2002). Preparations of epidermal layers were made by scraping of the mature leaf samples (for detail see Sarwar and Ali, 2002). Stomatal features on the leaf epidermis i.e., number, length and breadth of stomatal apparatus were studied and measured 40x magnifications of a compound microscope. All data were analyzed using the analysis of variance and means separated by Duncan's Multiple Range Test (DMRT) at the 5% level of significance.

Results

The results in Table 1 showed that Samduen had the highest plant height (109.73 cm) compare with varieties of other group (Table 1), no significantly different from those of Pukaotong, Samduen, Lebnok, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm had the plant height of 104.00, 101.60, 100.27, 99.93, 99.00, 97.73 and 96.80 cm, respectively. However, semi-dwart upland rice variety Nangdam showed the lowest plant hight (84.7 cm.). The Dawk Pa-yawm variety had the highest harvesting age of 132 days, which was significantly different from those of Pukaotong, Samdune Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang were harvesting age of 118, 104, 123, 121, 124, 121, 121, and 124 days, respectively. The numbers of plant per tiller were not statistically different among the varieties ranged from 10 to 13 plants per tiller. On the other hand, Lebnok had the highest plants per tiller and Nangdam had the lowest plants per tiller compare to other. For number panicles per tiller, Samduen and Nangdam varieties had the lowest of number panicles per tiller of 8 panicles per tiller, which were statistically different Pukaotong, Lebnok, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties. The mean values of panicles per tiller of 10

panicles per tiller. The Pukaotong, Samduen, Lebnok, Dokkam, Nangkruan, Lebmuenang and Dawk Pa-yawm varieties had panicle length ranged from 24.93 to 30.00 cm., which were statistically different from those of Nangchuan was the panicle length of 24.07 cm.

Table 1. Plant height, harvesting age of grains**,** number plants per tiller, number panicle per tiller and panicle length of Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties

Varieties	Plant height (cm)	harvesting age of grains(days)	No.plant per tiller	No.panicle per tiller	Panicle length (cm)
Pukaotong	104.00[a1/]	118.00 d	12.00	10.00a	24.93ab
Samduen	109.73[a]	104.00 e	12.00	8.00b	30.00a
Lebnok	99.00[a]	123.00 bc	13.00	10.00a	27.27ab
Nangdum	84.27[b]	121.00 c	10.00	8.00b	30.00a
Dokkam	96.80[ab]	124.00 b	11.00	10.00a	30.00a
Nangkruan	101.60[a]	121.00 bc	11.00	10.00a	27.20ab
Nangchuan	97.73[a]	121.00 bc	12.00	9.00ab	24.07b
Lebmuenang	99.93[a]	124.00 b	12.00	10.00a	25.73ab
Dawk Pa-yawm	100.27[a]	132.00 a	12.00	10.00a	27.80ab
F-Test	*	*	ns	*	*
C.V.(%)	7.45	1.13	11.82	12.86	10.01

1/: ns = non – significant, * Means not followed by the same letter are significantly different at the 5% level of probability as determined by DMRT.

The Pukaotong variety had hight the perfect grains per panicle of 97.00 seed, which was not significantly different from those the Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan and Lebmuenang varieties ranged from 62.00 to 86.00 grains. All eight varieties have statistically different from those of Dawk Pa-yawm had the lowest perfect grains per panicle of 56.00 grains. The empty grains per panicle, Dawk Pa-yawm variety had hight the empty grains per panicle of 72.00 grains, which was not significantly different from those of Pukaotong, Samduen, Lebnok, Nangdam, Nangkruan, Nangchuan, Lebmuenang varieties, which were the empty grains per panicle ranged from 47.00 to 67.00 grains. The Dokkam variety had lower the empty grains per panicle of 30.00 grains. All the varieties have not significantly different in the yields per plant, which were the yields per plant ranged from 161.77 to 225.06 g. per plant. However, Pukaotong had the highest yields per plant and Dawk Pa-yawm had the lowest plants per tiller compare with varieties of other group (Table 2).

Table 2. number perfect grains per panicle, empty grains per panicle, yields per plant, root length, root thickness and number roots per tiller of Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties

Varieties	No. perfect grains per panicle (grains)	Empty grains per panicle (grains)	Yields per plant (g)	Root length (cm)	root thickness (mm.)	No. roots per tiller (root)
Pukaotong	97.00[a1/]	54.00 [ab]	225.06	47.80[a1/]	1.63[ab]	216.00[ab]
Samduen	86.00[b]	47.00 [ab]	168.11	45.00[ab]	1.67[ab]	232.00[a]
Lebnok	82.00[b]	56.00 [a]	199.90	45.00[ab]	1.47[b]	191.00[b]
Nangdum	66.00[cd]	56.00 [a]	164.72	40.00[b]	1.53[ab]	192.00[b]
Dokkam	86.00[b]	30.00 [b]	197.19	52.00[a]	1.73[a]	196.00[b]
Nangkruan	67.00[c]	57.00 [a]	189.92	48.73 [a]	1.47[b]	222.00[ab]
Nangchuan	65.00[dc]	59.00 [a]	178.84	47.40 [ab]	1.57[ab]	235.00[a]
Lebmuenang	62.00[dc]	67.00 [a]	172.84	54.00[a]	1.53[ab]	218.00[a]
Dawk Pa-yawm	56.00[d]	72.00 [a]	161.77	54.00[a]	1.60[ab]	216.00[ab]
F-Test	*	*	ns	*	*	*
C.V.(%)	26.90	24.53	24.63	10.10	7.65	8.22

1/: ns = non – significant, * Means not followed by the same letter are significantly different at the 5% level of probability as determined by DMRT.

The Lebmuenang and Dawk Pa-yawm varieties had the highest the root length of 54.00 cm., which were not significantly different from those of Pukaotong, Samduen, Lebnok, Dokkam, Nangkruan and Nangchuan varieties were the root length ranged from 45 to 52 cm. but, which were significantly different from those of Nangdum variety with was the lowest root length of 40.00 cm. (Figure 1) The Dokkam variety had the hightes the root thickness of 1.73 cm. which was not significantly different from those of Pukaotong, Samduen, Nangdam, Dokkam, Nangchuan, Lebmuenang and Dawk Pa-yawm were the root thickness ranged from 1.53 to 1.67 cm. but, which were significantly different from those of Lebnok and Nangkruan varieties were the root thickness of 1.47 cm. The Nangchuan variety had the highest the number of roots per tiller of 235 roots which were not significantly different from Pukaotong, Samduen, Nangkruan, Lebmuenang and Dawk Pa-yawm varieties were the number roots per tiller ranged from 216 to 232 roots. These have significantly different from those of Lebnok, Nangdam and Dokkam, which were number roots per tiller of 191, 192 and 196 roots, respectively (Figure 2).

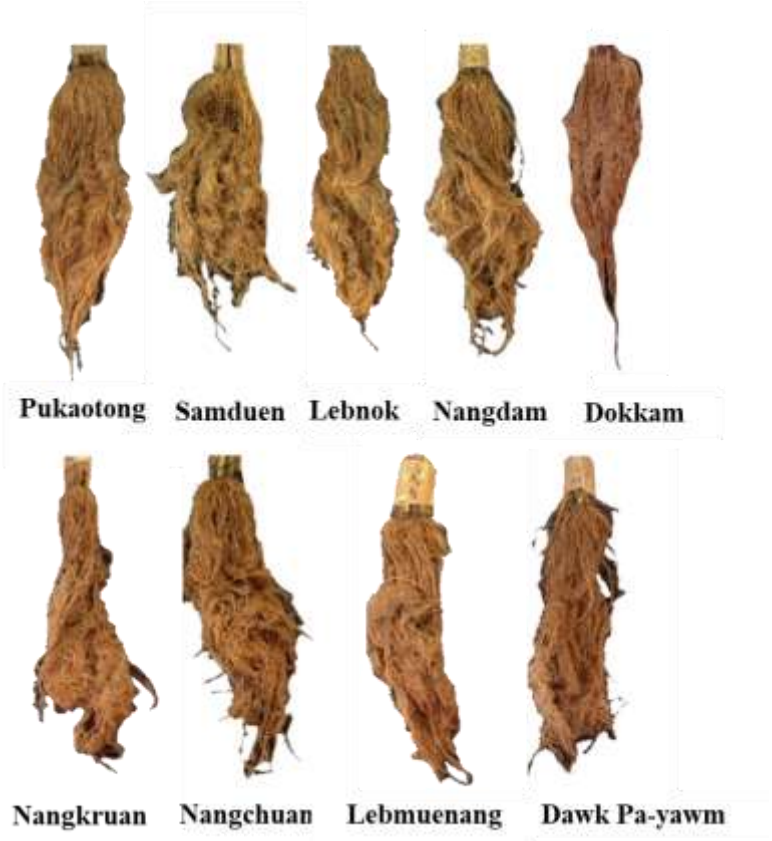

Figure 1. Root of upland rice: Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties before drying

The Samduen variety had the lowest number of stomata of 22.05 units per 0.0625 square millimeters, which was not significantly different from those Pukaotong, Nangdam, Dokkam and Nangkruan had the number stomata of 26.55, 25.40, 26.40 and 25.95 units per 0.0625 square millimeters, respectively. They were significantly different from those of Lebnok, Nangchuan, Lebmuenang and Dawk Pa-yawm had the number stomata of 32.75, 30.15, 35.70 and 35.90 units per 0.0625 square millimeters, respectively (Figure 3). Size of stomata, Dokkam had the lower lenght of 15.38 μm, which was not significantly different from those Pukaotong, Lebnok, Nangdam and Dawk Pa-yawm had the lenght of stomata ranged from 16.13 to 17.25 μm but, they were significantly different from Samduen, Nangkruan, Nangchuan and Lebmuenang had the lenght of stomata ranged from 17.63 to 18.38 μm. All varieties had the width of stomata ranged from 4.88 to 5.13 μm, which were not significantly

different amoung the varieties. The Pukaotong variety had the lowest width of stomata compare with varieties of other group. Size of long cell, all the upland rice had the length of long cell were statistically different. The Pukaotong variety had the lowest length of long cell of 55.75 μm compare with varieties of other group. On the other hand, Nangchuan had the highest length of long cell of 96.25 μm followed by Lebnok, Lebmuenang, Nangkruan, Dokkam, Nangdam, Dawk Pa-yawm and Samduen. All varieties had the width of long cell ranged from 13.25 to 16.13 μm, which were not significantly different amoung the varieties (Table 3).

Figure 2. Root of upland rice: Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties after drying

Figure 3. Stomata of upland rice: Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties

Table 3. Number stomata, stomata size and Long cell size of Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm varieties

Varieties	No. of stomata (count/0.0625mm2)	Stomata size (µm)		Long cell size (µm)	
		Length	Width	Length	Width
Pukaotong	26.55 bc1/	16.13 bc	4.88	55.75 e	14.00
Samduen	22.05 c	18.25 ab	5.00	69.25 d	14.00
Lebnok	32.75 ab	16.88 bc	5.00	88.38 ab	14.75
Nangdum	25.40 bc	17.25 abc	5.00	79.25 bcd	13.25
Dokkam	26.40 bc	15.38 c	5.00	80.50 bc	14.25
Nangkruan	25.95 bc	18.38 a	5.00	84.88 bc	13.50
Nangchuan	30.15 ab	18.00 ab	5.00	96.25 a	16.13
Lebmuenang	35.70 a	17.63 ab	5.13	85.63 abc	15.25
Dawk Pa-yawm	35.90 a	17.25 abc	5.00	75.00 cd	14.75
F-Test	*	*	ns	*	ns
C.V.(%)	16.67	7.58	3.42	8.84	8.00

1/: ns = non – significant, * Means not followed by the same letter are significantly different at the 5% level of probability as determined by DMRT.

Discussion

The experiment comparison of root system and stomata in nine upland rice varieties sow in plastic pots; Pukaotong, Samduen, Lebnok, Nangdam, Dokkam, Nangkruan, Nangchuan, Lebmuenang and Dawk Pa-yawm were sow in plastic pots. The studies focused on the root systems and stomata for drought tolerance. Most drought resistant upland varieties remained highly positive correlated to roots thicknesses (Biswas *et al.,* 2018) stomatal density and stomatal size being related to drought resistance (Xu and Zhou, 2008; Lestari, 2006). Our analysis indicated that Nangdam variety had the lower plant hight, root length, number plant per tiller and panicle per tiller, moderate root thickness, number stomata and long cell. On the other hand, Lebmuenang and Dawk Pa-yawm varieties had the highest root length, number plant per tiller and panicle per tiller and number stomata with moderate plant hight, root thickness and stomata size and had lower yield per plant. (Table 1, 2 and 3). These collected data did not support the observation of Yoshida *et al*., (1982). They had reported that a plant with few and early tillers tend to have a deep root system. High tillering ability may be an undesirable character for drought tolerance (Biswas *et al*., 2018).

The Dokkam variety had the highest root thickness with lower number root, length of stomata and empty grains per panicle. However, Dokkam variety had lower yields per plant when compared to Pukaotong variety (Table 1, 2 and 3). These collected data did not support this observation of Biswas *et al*., (2018). The had reported that moderate plant height with thicker root could be considered as drought resistant variety. On the other hand, Pukaotong variety had moderate plant hight, root length, root thickness, number root, number stomata and stomata size with lower length of long cell but highest in the number perfect grains per panicle and yield per plant (Table 1, 2 and 3). On the other hand, Samduen had lowest number stomata and had highest plant hight with moderate root length, root thickness, number root and number stomata but lower in the number perfect grains per panicle and yield per plant (Table 1, 2 and 3). From our research data we can say that moderate plant height, root length, root thickness, number root, number stomata and stomata size and lower length of long cell can be considered as drought tolerant varieties.

Acknowledgement

The author would like to offer particular thanks Assoc. Prof. Dr. Withya Buajarern, critically revised the article.

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(Received: 29 May 2019, accepted: 31 August 2019)