

# Evaluating Performance of Sixteen Upland Rice Genotypes under Field Conditions for Further Breeding Process

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Received: December 25, 2017

Accepted: January 25, 2018

Online Published: February 15, 2018

doi:10.5539/jas.v10n3p144

URL: <https://doi.org/10.5539/jas.v10n3p144>

## Abstract

Rice is second most consumed cereal after wheat and it is considered as staple food in Thailand and most of the ASEAN countries. Analyzing yield performance of upland rice genotypes under field conditions is a key step in rice crop breeding program for improved rice production and ensuring food security. The objective of this research was to conduct a yield trial to assess performance of sixteen Thai upland rice genotypes under field conditions for further breeding process. Data from field trial that was conducted in 2016 in field research area of Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Thailand was used in this assessment. Randomized complete block design (RCBD) with three replications was used to layout the experiment in field. Soil was analyzed upto 50 cm soil depth for its fertility and nutrient status to check the fertilizer requirements before planting. Soil moisture contents were recorded using PR2/6 probe. Observed moisture contents indicated that there was 60-70% water available to all genotypes based on field capacity (FC). Results indicated that genotypes, Hawm Mali Doi, Jao Khao Pichit, Jao Daeng, Sahn Deuan and Ma-led-nai-fai were shorter in plant height while genotypes Ma-led-nai-fai, Goo Meung Lung, Jao Daeng, Dawk Pa-yawm and Hawm Jet Ban had higher number of tillers m<sup>-2</sup>. Genotypes Ma-led-nai-fai, Goo Meung Lung, Jao Daeng, Dawk Pa-yawm and Hawm Jet Ban had higher number of panicles m<sup>-2</sup>. Genotypes Jao Daeng, Ma-led-nai-fai, Sahn Deuan, Hawm Mali Doi and Jao Khao Pichit were early flowering and maturity considering as early maturity genotypes. Genotypes Goo Meung Lung, Hawm Mali Doi, Jao Khao Pichit, Jao Daeng and Mai Tahk had higher 1000 GW while genotypes Dawk Kham, Dawk Kha, Hawm Jet Ban, Dawk Pa-yawm and Bow Leb Nahag were superior in grain yield response. Performance of genotypes indicated that these genotypes can be used for further breeding process for acquiring desired traits.

**Keywords:** upland rice, yield assessment, soil moisture contents

## 1. Introduction

Rice (*Oryza sativa* L.) is commonly used cereal as a staple food after wheat for a significant part of human population. Upland rice contributes around 4% in total rice production in the world. Upland rice contributes about 10% of the total rice area in Thailand which is grown in northern and southern parts of country (Nokkoul et al., 2011). The upland rice system prevails in dry lands without irrigation as well as puddling. These environments mostly suffer from various abiotic stresses accompanied with improbable rainfalls. In upland rice areas, environmental conditions are erratic ranging from humid to sub-humid. Soil and topography of these locations are moderately fertile to remarkably infertile and smoothly to sharp sloppy respectively. Rice farming in these rain fed areas is risk-prone.

Global warming increases the drought occurrence (Farooq et al., 2009) which results in global water scarcity. Upland areas mostly suffer from sporadic occasions of abiotic stresses like droughts and floods thus lowering the production efficiency of these areas. In future prediction of climate change, it is estimated that the water shortfall is going to be more severe (Wassmann et al., 2009), and Bates et al. (2008) stated that the concentration and frequency of drought will be increased. Drought occurrence obstructs the rice performance. Rice growth period in rain-fed areas are prone to dry spells occurring anytime which leads to drought of different concentration yet rice is considered highly sensitive when drought occurring at reproductive stages (O'Toole, 1982; Venuprasad et al., 2007) as floral development is badly effected under water stress. Most of the physiological and biochemical processes are slowed down in drought stress conditions. Upland rice without puddling is cultivated in rainy

season in southern Thailand. Rainy season lasts from May to October and the upland rice planted in months of May to July is at reproductive stage at the end of rainy season. Due to less rainfall and occurrence of drought in the end of rainy season critically affects the rice yield. Heat is another factor during the growth period which increase the crop damage along with drought. Upland rice is potential source of genetic traits for rice breeding program and its performance is declining every year due to abiotic stresses. Therefore it becomes important to screen the upland rice genotypes having capability to tolerate drought and heat stresses especially at reproductive stages. Number of these abiotic stresses including drought and heat need to combat by screening and developing improved genotypes. Breeding upland rice for drought tolerance and heat to avoid the abiotic stresses is one of the important factor to increase the efficiency of rice production. Selection and development of the drought tolerant upland rice genotypes is important in southern Thailand as the local genotypes has the potential of higher productivity in stress conditions. Keeping in view the problems associated with upland rice production there was a need to assess the performance of upland rice genotypes for different agronomic traits under field conditions to use the suitable genotypes for further breeding process. Therefore, we selected sixteen Thai upland rice genotypes commonly grown in southern of Thailand for evaluating their response for agronomic traits including their growth duration and different yield attributes.

## 2. Material and Methods

### 2.1 Soil Analysis

Soil analysis involved collection of input data on soil characteristics upto 0-50 cm on soil class, texture, field capacity, electrical conductivity, organic carbon, organic matter, soil texture, pH of soil in water, cation exchange capacity, organic carbon, total nitrogen, phosphorus, potassium, calcium sodium and zinc, which was performed at Central laboratory, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Thailand. Physical and chemical properties of soil are detailed in Table 1.

Table 1. Soil physical and chemical properties upto 50 cm soil depth

Soil Properties	Units	Values at Soil Layer Depths (cm)			Method/Equipment	References/Model
		0-15	15-30	30-50		
		Sandy Loam	Sandy Clay Loam	Sandy Clay		
Texture	% Sand	70.56	63.75	55.52	Hydrometer method	Bouyoucos,1936; Day, 1965
	% Silt	11.86	10.48	8.28		
	% Clay	17.58	25.77	36.20		
Field capacity	%	33.60	38.52	46.42	Gravimetric method	Cassel & Nielsen, 1986
Electrical conductivity	$\mu\text{S cm}^{-1}$	43.4	45.6	58.6	EC meter	Seven Easy EC Meter (Mettler Toledo)
Soil pH	Slightly Acidic	4.92	5.22	5.13	pH meter	Seven Easy (Mettler Toledo) 8603
Organic carbon	%	0.67	0.48	0.42	Walkley & Black's method	Walkley & Black, 1934
Organic matter	%	1.15	0.82	0.72		
Cation exchange capacity	meq/100 g soil	3.59	4.42	5.27	Exchangeable cation extraction method	Ross, 2009
Total N	%	0.07	0.06	0.05	Kjeldahl method	Kjeldahl,1883
Available P	%	52.21	27.24	15.53	Bray no. II	Bray,1945
Potassium	$\text{mg kg}^{-1}$	101.30	100.74	100.76	Exchangeable cation extraction	Thomas, 1982; Levinson, 1969
Calcium	$\text{mg kg}^{-1}$	380.15	569.14	606.80	Exchangeable cation extraction	Thomas, 1982; Levinson, 1969
Sodium	$\text{mg kg}^{-1}$	7.03	9.94	12.70	DTPA extraction method	Lindsay & Norvell, 1978
Zinc	$\text{mg kg}^{-1}$	3.31	2.37	1.09	DTPA extraction method	Lindsay & Norvell, 1978

### 2.2 Experimental Details

Sixteen Thai upland rice genotypes including, Jao Khao Pichit, Jao Daeng, Sahn Deuan, Dawk Kham, Dawk Kha Hawm Jet Ban, Khao Sai, Khao Ruang, Nual Hawm, Ma-led-nai-fai, Dawk Pa-yawm, Goo Meung Lung, Hua Bon, Bow Leb Nahag and Mai Tahk were used in this study. Experiment for yield assessment under field conditions was conducted in field research area of Faculty of Natural Resources, Prince of Songkla University,

Hat Yai, Thailand, using RCBD with three replications. Plant population was maintained at 13 plants  $m^{-2}$  by keeping 30 cm row to row and 25 cm plant to plant distance and sowing was performed by direct seeding method. Optimum amount of fertilizer at rate of 75 kg N, 45 kg P and 45 kg  $K^+$   $ha^{-1}$  was applied in three splits. Irrigation was applied using sprinklers when plants were observed under wilting and rainfall was also received by plants during growing season. Soil moisture contents were recorded by using PR2/6 probe (Delta-T Devices) upto 100 cm at 0-10, 10-20, 20-30, 30-40, 40-60 and 60-100 cm soil depths. Three PR2/6 probes were installed in each replication of experiment and moisture contents were recorded on weekly basis.

### 2.3 Data Collection and Analysis

Data collection and calculation of yield parameters was done by destructive method (Soler et al., 2013) and large area sample plus subsample approach, as a way to minimize work load and to minimize sample variability. The principle proposed includes taking a large sample (about 1  $m^2$  land area) for land-area dependent biomass to reduce the coefficient of variation (CV), and then taking a small subsample (1 to 3 plants) for plant internal traits having low CV's. Three plant were selected for subsample from which plants parts were separated into leaves, stems and panicles. Samples were dried in oven at 70 °C for various durations depending upon the plant part until no change in weight was observed. Obtained data was analyzed ( $P < 0.05$  and  $P < 0.01$ ) using statistical software R-2.14.0 to test the significance of results and mean comparison.

## 3. Results and Discussion

### 3.1 Weather Conditions

Data relating to daily maximum (Tmax.) and minimum (Tmin.) air temperature and average daily rainfall was obtained from Kho Hong agro-meteorology station located about five kilometres to experimental site. Mean Tmax., Tmin. and average daily rainfall during season were 42.0, 24.8 °C and 5.8  $mm\ day^{-1}$  respectively (Figure 1). Primary atmospheric variables that impact on crop growth are solar radiation, air temperature, humidity, and precipitation. Optimum temperature required for rice growth ranged from 25 °C to 35 °C (Yoshida, 1978) while temperature prevailed during the growth period was higher than optimum range which indicated that temperature had influence on crop growth and development. Less rainfall occurred during the growth period which caused a stress to all genotypes at different growth stages.

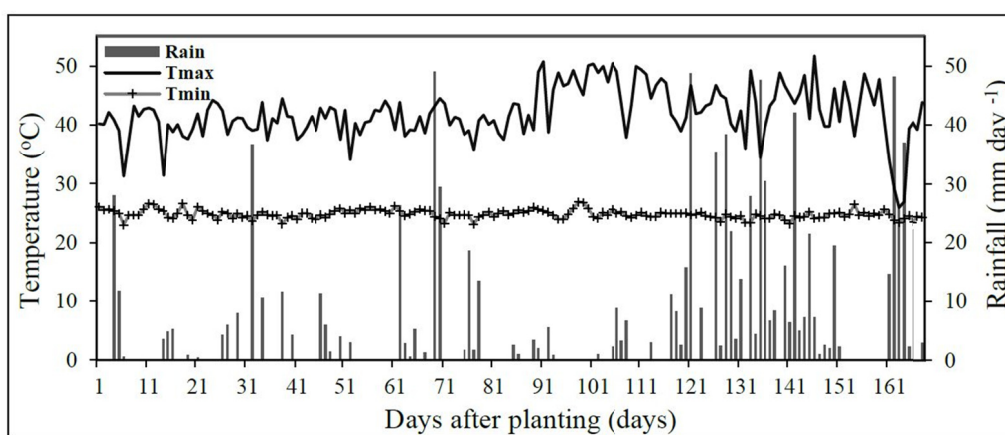


Figure 1. Mean daily maximum and minimum temperature and rainfall occurred during experiment

### 3.2 Soil Moisture Contents

Soil moisture contents recorded during the season were lower than the full crop requirement of 100% FC. Soil moisture contents ranged between 15.8 to 23.4% of FC for 0-10 cm (Figure 2 [a]), 16.0 to 23.3% of FC for 10-20 cm (Figure 2 [b]), 18.3 to 24.8% of FC for 20-30 cm (Figure 2 [c]), 14.0 to 20.8% of FC for 30-40 cm (Figure 2 [d]), 20.7 to 27.9% of FC for 40-60 cm (Figure 2 [e]) and 34.1 to 41.7% of FC for 60-100 cm (Figure 2 [f]) respectively. Overall all genotypes had 70% water availability of full crop requirement which indicated that all genotypes had a moderate water stress during its growth especially near flowering period. Rainfall was also less during the flowering period of most of genotypes (Figure 1). In upper soil layers upto 30 cm, FC was near to 70% and it was decreased to 60% under deeper soil layers upto 60 cm while it was increased to 80% under 60-100 cm soil layer (Figure 2). Although rice have deeper root length but its ability to extract water from deep soil

layers is relatively low which makes rice more vulnerable to water stress. Kondo et al. (1999) stated that root pattern of rice varies from other crops. Turner et al. (2001) and Subbarao et al. (1995) described that root characteristics like length, Density, depth and biomass significantly contribute towards water economy. Deeper and thicker roots efficiently extracted water from deeper layers (Kavar et al., 2008). Rainfall occurrence and moisture contents in different soil layers indicated a high variation in soil water availability to plants and it showed that all genotypes had a moderate stress during the growth.

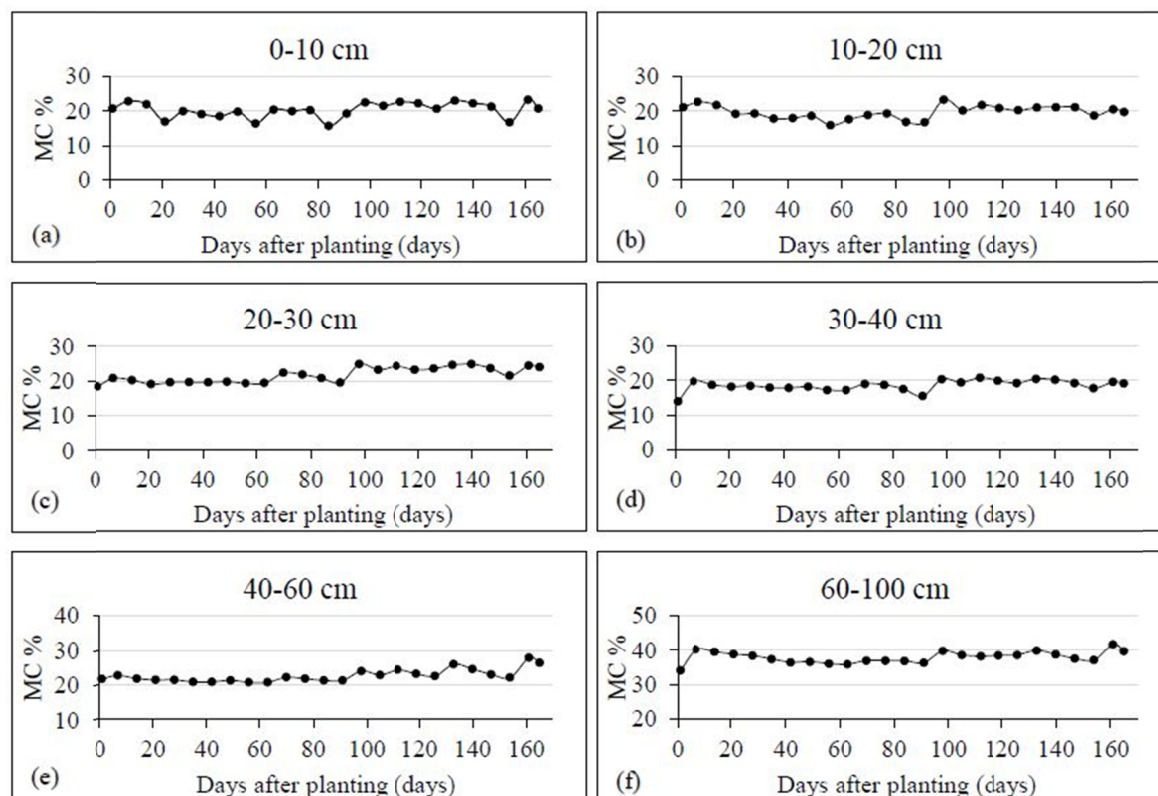


Figure 2. Soil moisture contents at each soil depth upto 100 cm

### 3.3 Genotypic Performance

Results from analysis of variance indicated that there was a highly significant difference for plant height, number of tillers and panicles, days to flowering and maturity and one thousand grain weight and a significant difference for grain yield and biomass between all genotypes (Table 2). In comparison of means of agronomic traits of upland rice genotypes (Table 3), mean values ranged between 102 to 140 days and 120 to 161 days for days to flowering and maturity respectively. Mean values ranged between 98 to 181 cm, 116 to 266 tillers and 106 to 191 panicles for PH, number of tillers and panicles respectively. For GY, 1000 GW and biomass, mean values ranged from 1608.30 to 3994.70 kg ha<sup>-1</sup>, 24 to 26.67 g and 3435.70 to 6968.70 kg ha<sup>-1</sup> respectively. Genotypes, Hawm Mali Doi, Jao Khao Pichit, Jao Daeng, Sahm Deuan and Ma-led-nai-fai were shorter in plant height while genotypes Ma-led-nai-fai, Goo Meung Lung, Jao Daeng, Dawk Pa-yawm and Hawm Jet Ban had higher number of tillers m<sup>-2</sup>. Dwarfness is required in rice crop breeding to avoid lodging losses. Shorter genotypes could be used for acquiring traits for shorter plant height in rice breeding. Genotypes Ma-led-nai-fai, Goo Meung Lung, Jao Daeng, Dawk Pa-yawm and Hawm Jet Ban had higher number of panicles m<sup>-2</sup>. Genotypes Jao Daeng, Ma-led-nai-fai, Sahm Deuan, Hawm Mali Doi and Jao Khao Pichit were early flowering and maturity considering as early maturity genotypes while genotypes Goo Meung Lung, Nual Hawm, Mai Tahk, Khao Ruang and Hua Bon were late flowering and maturity considering as late maturity genotypes. Genotypes Goo Meung Lung, Hawm Mali Doi, Jao Khao Pichit, Jao Daeng and Mai Tahk had higher 1000 GW while genotypes Hawm Jet Ban, Dawk Kham, Dawk Kha, Dawk Pa-yawm and Bow Leb Nahag were superior in grain yield response. Genotypes Mai Tahk, Goo Meung Lung, Dawk Kham, Hawm Jet Ban and Bow Leb Nahag produced maximum biomass (Table 3). Different

agronomic parameters including days to flowering and maturity, number of tillers and panicles, 1000 GW and GY have been focused to be accounting for screening genotypes in rice breeding (Yang et al., 2001; Venuprasad et al., 2008 & Wang et al., 2010). Results showed that different genotypes could be considered for acquiring required traits in rice crop breeding program. For example early maturity genotypes should be considered for early maturing to escape drought stress which can be benefited in rice breeding for drought.

Table 2. Mean square of analysis of variance of agronomic traits of sixteen upland rice genotypes

SOV	df	PH	NT	NP	DF	DM	GY	1000 GW	Biomass
Replication	2	118.69	4575.15	6108.08	17.31	14.14	3903198	1.52	4420490
Treatment	15	1063.20**	4150.44**	1840.35**	543.25**	554.26**	1667649*	39.65**	3785735*
Error	30	98.82	1040.17	986.95	28.24	13.39	795138	2.98	2205423
CV %		7.18	21.77	23.31	4.35	2.55	31.23	6.02	29.69

Note. SOV = Source of variation, df = degree of freedom, PH = Plant height, NT = Number of tillers, NP = Number of panicles, DF = Days to flowering, DM = Days to maturity, GY = Grain yield, 1000 GW = one thousand grain weight, \*\* = Highly significant, \* Significant.

Table 3. Mean of agronomic traits of sixteen upland rice genotypes

Genotype	PH (cm)	NT (no. m <sup>-2</sup> )	NP (no. m <sup>-2</sup> )	DF (days)	DM (days)	GY (kg ha <sup>-1</sup> )	1000 GW (g)	Biomass (kg ha <sup>-1</sup> )
Hawm Mali Doi	118	148	135	105	124	1805.20	34.67	3559.20
Jao Khao Pichit	129	143	131	105	127	1608.30	32.67	3569.50
Jao Daeng	115	179	164	102	120	1977.60	32.00	3435.70
Sahm Deuan	131	125	120	103	126	2156.30	27.00	3440.20
Dawk Kham	146	125	115	128	152	3994.70	26.00	5486.80
Dawk Kha	151	116	115	127	151	3671.90	27.00	5746.40
Hawm Jet Ban	141	149	142	126	150	3490.20	28.33	5764.20
Khao Sai	137	141	129	128	151	2879.40	26.33	4779.40
Khao Ruang	155	122	112	131	152	3079.20	28.00	5710.00
Nual Hawm	152	118	106	134	151	2563.10	28.67	4483.40
Ma-led-nai-fai	98	266	191	103	124	1996.90	24.00	4812.40
Dawk Pa-yawm	141	155	143	129	151	3514.90	25.33	5428.90
Goo Meung Lung	181	183	179	140	161	3355.60	36.67	6656.70
Hua Bon	139	127	116	131	150	2889.90	26.00	4429.10
Bow Leb Nahag	134	147	141	130	151	3365.00	26.00	5750.50
Mai Tahk	146	127	118	133	152	3339.40	31.00	6968.70
Mean	138	148	135	122	143	2855.5	28.72	5001.30
LSD 0.05	16.57	53.78	52.38	8.86	6.10	1532.80	2.88	2476.40
LSD 0.01	22.32	72.41	70.54	11.93	8.21	2063.90	3.88	3334.50

Note. PH = Plant height, NT = Number of tillers, NP = Number of panicles, DF = Days to flowering, DM = Days to maturity, GY = Grain yield, 1000 GW = one thousand grain weight, LSD = Least significant difference.

#### 4. Conclusion

In conclusion, genotypes Ma-led-nai-fai, Goo Meung Lung, Jao Daeng, Dawk Pa-yawm and Hawm Jet Ban had higher number of panicles m<sup>-2</sup>, genotypes Goo Meung Lung, Hawm Mali Doi, Jao Khao Pichit, Jao Daeng and Mai Tahk had higher 1000 GW while genotypes Dawk Kham, Dawk Kha, Hawm Jet Ban, Dawk Pa-yawm and Bow Leb Nahag were superior in grain yield response. These genotypes can be considered as high yielding genotypes. Genotypes Jao Daeng, Ma-led-nai-fai, Sahm Deuan, Hawm Mali Doi and Jao Khao Pichit were early flowering and maturity considering as early maturity genotypes while genotypes Goo Meung Lung, Nual Hawm, Mai Tahk, Khao Ruang and Hua Bon were late flowering and maturity considering as late maturity genotypes. Early maturity genotypes can be further used for breeding for drought and heat escaping. Authors, suggest for

further experimentation for all of these genotypes under diverse range of soil and weather conditions for improved evaluation.

### Acknowledgements

Research was supported by the Higher Education Research Promotion and the Thailand's Education Hub for Southern Region of ASEAN Countries Project Office of the Higher Education Commission. The authors acknowledge Graduate School and Faculty of Natural Resources, Prince of Songkla University, Hat Yai Campus for financial support.

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