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Geographical Diversity and its Influence on Rice Yield

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ABSTRACT

Experiments were conducted at two different geographical locations, the Asian Institute of Technology, Thailand and the Cereal Institute, Thessaloniki, Greece to compare tillering and yield of locally recommended rice varieties. Rice varieties RD23 and KDML105 of Thailand gave the same number of tillers at harvest and delayed planting (September 14) showed higher number of tillers/hill compared to early planting though there were no significant variations of panicles/m2 observed among different planting dates. The variety RD23 resulted in significantly higher grain yield (3.7 t/ha) compared to KDML105 (2.9 t/ha). The variety KDML105 showed higher 1000-grain weight (26.3 g) with longer duration (125 days) and lower HI (0.27) compared with RD23. Planting up to August 14 resulted in higher grain yield and 1000-grain weight, but delayed planting showed lower yield as well as grain weight. The indica type rice variety Olympiada showed significantly higher number of tillers/hill (19.8) at harvest compared with other japonica-typed varieties. The variety Maratelli resulted in lowest grain yield (5.7 t/ha). Indica typed variety showed higher panicles/m2 (319) with higher HI (0.57) but less 1000-grain weight (24.0 g) compared with other japonica typed varieties. Tropical rice showed lower grain yield, HI and maturity duration compared with temperate rice.

Key words: geographical variations, rice, tiller, yield

INTRODUCTION

There is a 'hunger belt' in the world, located between 30 °N latitude and 30 °S latitude, centering around the equator. There are about 2.7 billion people living in the hunger belt; 60% of them suffer from mal-nutrition and 20% are starving. It is possible to improve the area through increasing the rice production in the hunger belt (Matsushima, 1980).

Rice has a wide physiological adaptability and is grown successfully in tropics, subtropics and temperate region. It requires a fairly high temperature, ranging from 20 to 40 °C. The optimum temperature appears to be about 30°C for the daytime maxima and 20°C for the nighttime maxima (Sreenivasan, 1985). Remarkable diversity exists in rice because of its long history of cultivation and selection under diverse climatic, edaphic and biotic environments; frequently in geographically separated areas. Most of the world's rice is grown in the tropics and the extreme latitude in which it is grown is in temperate region. Yoshida (1981) reported that rice can be grown between 53 °N to 35 °S latitude, below sea level to elevations above 2,000 m, and in upland conditions to 5 m water depth.

There are 111 rice-growing countries in the world of which three countries produce an average yield of 6 t/ha or more, 17 countries produce 4 t/ha

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or more, 78 countries produce 3 t/ha or less of which 57 countries produce 2 t/ha or less and 13 countries produce less than 1 t/ha. Temperate countries produce higher yield compared with tropical areas where the average rice paddy yield of Europe was 5.1 t/ha and that of Asia was 4.0 t/ha (Anon, 2000). Productivity of rice does not only vary between one country to another, but also within the same country based on the different agro-ecological zones and production system used. The maximum potential yield of modern rice varieties are about 13 t/ha in tropical environments and 15 t/ha in temperate regions as reported by Tran (1997).

An attempt was therefore undertaken to compare the tillering and yield parameters of some locally recommended rice varieties under two geographically diverse locations.

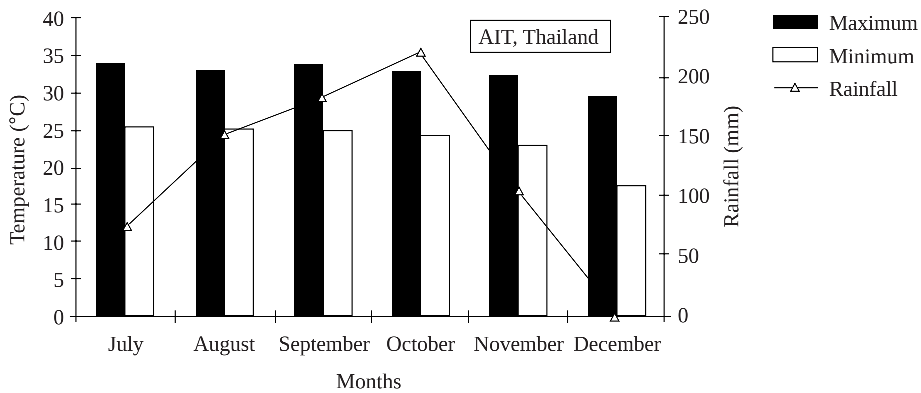
MATERIALS AND METHODS

Two experiments were conducted with rice (*Oryza sativa* L.) of which Experiment 1 was done at Asian Institute of Technology, Thailand (14°04' N latitude and 100 °37' E longitude, 2 m altitude) and Experiment 2 was conducted at experimental station of the Cereal Institute in Kalochori, Thessaloniki, Greece (40°33' N latitude and 23°00' E longitude, 0 m altitude). The weather data of the study areas were presented in Figure 1. Experiment 1 was conducted during July to December, 1999 in an acid sulfate soil (Rangsit Series) with heavy clay (65%) in texture, pH 4.3, organic carbon 1.32%, total nitrogen 0.18%, total phosphorus 0.049%, total potassium 0.69% and bulk density 1.17 g/cc. The experiment was laid out in a split plot design having varieties as the main plot and planting dates as the sub plot with three replications. There were two varieties (KDML105 – photoperiod-sensitive and RD23 - photoperiod-insensitive) and five planting dates (July 15, July 30, August 14, August 30 and September 14). The unit plot size was 4 m × 3 m. Thirty-day old nursery seedlings were transplanted with 25 cm × 25 cm spacing having three seedlings/hill. At final land preparation, basal fertilizer which consisted of 30% of the N (75 kg/ha), P at the rate of 30 kg/ha and K at the rate of 16.6 kg/ha was applied and incorporated to the soil. The remaining N was top-dressed in two equal splits at active tillering and before panicle initiation.

Experiment 2 was conducted during May to October, 2000. The condition of the soil was silty loam (Aquic Xerotluvents) with a pH of 7.5 and 1.6% organic matter. Randomized complete block design was used with four replications. There were seven different locally recommended rice varieties viz. Olympiada, Selenio, San Andrea, Senia, Roxani, Ariete and Maratelli used in the experiment. The studied varieties came from Greece (Olympiada and Roxani), Italy (Ariete, Maratelli, San Andrea and Seleni) and Spain (Senia). All the varieties were japonica type except Olympiada, which was indica type. The planting of seeds in pots was done on May 4, 2000, while the transplanting of the seedlings on the field as recommendation (l/hill) at June 12, 2000. The spacing was maintained as 25 cm × 25 cm. The field was fertilized with 75 kg N/ha (in three installments), 17 kg P/ha and 31 kg K/ha that was applied by hand broadcasting. The first 25 kg/ha of N and the whole amount of phosphorus and potassium were applied before transplanting. The second application of N (30 kg/ha) was done at the early beginning of tillering stage and the third one (20 kg/ha) was done before panicle initiation.

Both experiments were kept free from weeds by hand weeding. The water level was maintained at about 10 cm (in depth) throughout the growth period, except 15 days before harvesting. Tiller numbers were counted at 15 and 45 days after transplanting (DAT) and at harvest from pre selected hills and finally averaged as their number/hill. Only those tillers having three or more leaves were considered for counting. Grain yield was determined from inner rows leaving boarders and adjusted to 14% moisture content. Grain moisture content was measured with a digital moister tester. Analysis of Variance (ANOVA) was done for the data using

(a)



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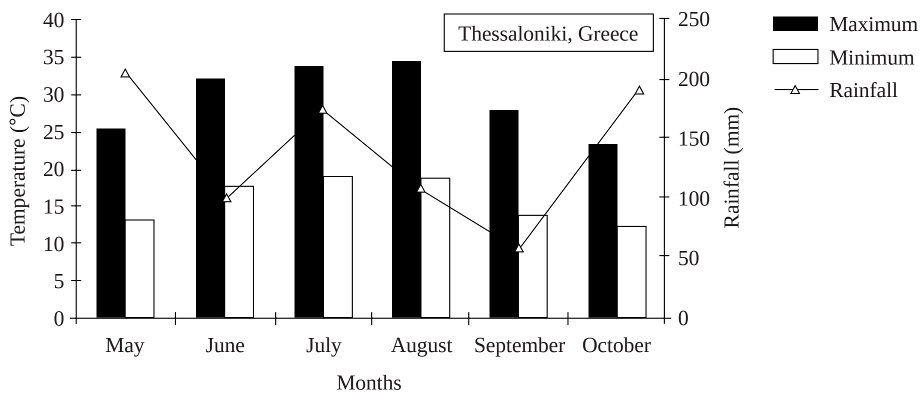


Figure 1 Weather condition of (a) AIT, Thailand and (b) Thessaloniki, Greece during study period.

IRRISTAT statistical package. Treatment means were separated using Fisher's protected Least Significant Difference (LSD) test (P = 0.05) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Tiller production

Experiment 1

At 15 DAT, the tiller number was significantly influenced by planting dates, but the same as varieties. Delayed planting showed higher tiller production compared with early planting. September 14 planting produced 16 tillers/hill that was same as August 30 planting (13 tillers/hill) and July 15 planting gave the lowest number (7) of tillers/hill. At 45 DAT, varieties and planting dates did not show any significant variations in tiller production. At harvest, though the variety RD23 showed 23% higher number of tillers compared with KDML105, they were statistically similar. For planting dates, September 14 planting gave significantly highest number of tillers (19 tillers/hill) compared with other planting dates (Table 1).

Experiment 2

The indica type rice variety Olympiada

showed significantly highest number of tillers/hill at 15 and 45 DAT as well as at harvest. Among the japonica type varieties, Selenio and Roxani produced higher number of tillers/hill (Table 2).

Above results showed that irrespective of variety, there were 27.5 tillers/hill found in tropical climate at 45 DAT (planting 3 seedlings/hill) whereas it was only 11.6 in temperate climate (planting single seedling/hill). The tiller mortality rate at harvest was 47% in tropical climate and only 5% in temperate climate. Though higher mortality rates, tropical rice varieties gave 32% higher number of tillers/hill at harvest compared to temperate rice. Tiller mortality takes place towards the maturity due to several reasons like nutrients, light, temperature, plant density and cultivar (Wu *et al*., 1998).

Growth duration, yield attributes and yield

Experiment 1

The variety and planting date as well as their interactions were found significant for flowering

Table 1 Tillering pattern of transplanted rice at Asian Institute of Technology, Thailand.

Treatment	Tiller production, no./hill			
	15 DAT	30 DAT	45 DAT	At harvest
Variety				
KDML105	10	20	23	13
RD23	12	26	32	16
LSD 0.05	ns	ns	ns	ns
Planting date				
July 15	7	15	26	14
July 30	9	22	28	13
August 14	11	27	27	13
August 30	13	24	27	16
September 14	16	28	29	19
LSD 0.05	2.9	5.7	ns	3.1

Table 2 Tillering pattern of transplanted rice at Thessaloniki, Greece.

Treatment	Tiller production, no./hill			
	15 DAT	30 DAT	45 DAT	At harvest
Olympiada	6	19	20	20
Selenio	6	15	14	12
San Andrea	4	8	8	8
Senia	5	12	12	9
Roxani	3	10	12	12
Ariete	3	8	8	9
Maratelli	2	7	7	7
LSD 0.05	0.9	1.6	1.7	1.9

and maturity dates. July 15 planting of photosensitive variety KDML105 needed significantly longer maturity duration (150 days) and the lowest duration (107 days) for the same variety planted on September. The maturity duration for the other variety RD23 ranges between 119 to 123 days. The duration of the vegetative phase increases greatly when the photoperiod sensitive varieties are subjected to photoperiods longer than the critical daylength. On the other hand, duration of the vegetative phase in weakly or non photoperiodic sensitive varieties does not increase much even if the varieties are subjected to long photoperiods (Anon., 1970). Therefore changes observed with different planting dates for KDML105 variety could be attributed to its photoperiod sensitivity. Planting date and variety had no influence on effective number of panicles/m^2. The variety KDML105 showed higher grain weight but lower HI compared with RD23. Delayed planting of both the varieties resulted in lower grain weight (Table 3). The higher grain weight of early planting might be due to the distribution of a greater portion of assimilates into developing panicles. Early planting and the variety KDML105 revealed higher grain weight than late planting and variety RD23 as reported by Biswas (2001).

The variety and planting date as well as their interaction showed significant influence on grain yield. The highest yield (4.9 t/ha) was given by July 15 planting of RD23 and the lowest yield (2.0 t/ha) from KDML105 planted on September (Figure 2a). The superior grain yield of RD23 than KDML105 was reported by Biswas and Salokhe (2001). The lower number of tillers per hill of KDML105 might be responsible for its lower grain yield.

Experiment 2

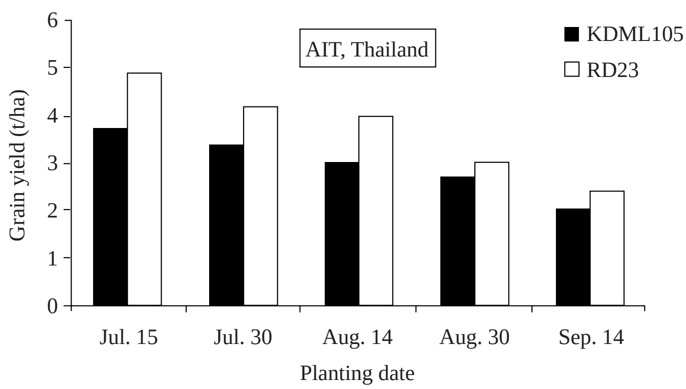
The variety Roxani and Olympiada needed longer duration compared with other varieties. The maturity duration of all the tested varieties of temperate climate in Greece were higher than the varieties planted on the tropical climate in Thailand. Approximately 30 days were needed to mature in tropical climate but it was about 60 days in temperate climate irrespective of their types. Tanaka and Vergara (1967) reported temperature

Table 3 Growing period, panicles/m^2, 1000-grain weight and harvest index of transplanted rice at AIT, Thailand.

Treatment	Flowering date	Maturity date	Panicles /m^2	1000-grain weight, g	Harvest index
Variety					
KDML105	97	125	201	26.3	0.27
RD23	91	121	234	24.4	0.42
LSD 0.05	0.8	1.7	ns	1.48	0.04
Planting date					
July 15	108	136	201	26.6	0.36
July 30	100	129	209	26.2	0.34
August 14	91	120	205	25.9	0.36
August 30	86	117	238	23.5	0.34
September 14	85	114	233	24.5	0.34
LSD 0.05	1.7	0.9	ns	1.15	ns

as an important factor that dominates for about 30 days from flowering to maturity in the tropics but for 65 days in temperate regions. The variety Olympiada (indica type) gave significantly higher panicle numbers/m^2 (319) and Maratelli, the lowest (118/m^2). The varieties Roxani and San Andrea resulted in heavier weights, whereas the 1000-grain weight of Olympiada was lowest (24.0 g). The higher grain weight of japonica type varieties over indica type was reported by Ntanos and Koutroubas (2000). The HI of Ariete and Olympiada were significantly higher and on the other hand lowest HI was revealed in Roxani and Maratelli (Table 4). The indica type variety Olympiada gave the highest grain yield (9.1 t/ha) and the lowest yield by Maratelli of japonica type variety (5.7 t/ha). Tran (1997) reported that because of the more favorable climatic conditions, such as long day-length, high solar radiation and low night temperature in the temperate regions and Mediterranean climate zones, rice yield is usually superior to that of rice grown in humid tropical regions. There were no variations of grain yield observed among japonica type varieties (Figure 2b).

(a)



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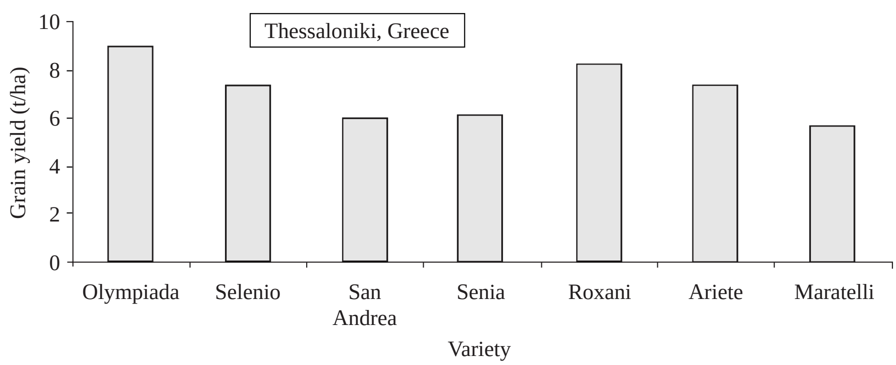

Figure 2 Grain yield of rice at (a) AIT, Thailand and (b) Thessaloniki, Greece.

Table 4 Growing period, panicles/m2, 1000-grain weight and harvest index of transplanted rice at Thessaloniki, Greece.

Treatment	Flowering date	Maturity date	Panicles $/m^2$	1000-grain weight, g	Harvest index
Olympiada	104	162	319	24.0	0.57
Selenio	91	146	189	28.0	0.54
San Andrea	91	146	122	39.2	0.50
Senia	94	151	144	36.0	0.51
Roxani	103	164	189	40.0	0.46
Ariete	94	149	150	35.0	0.57
Maratelli	92	147	118	34.0	0.45
LSD 0.05	-	-	30.4	0.70	0.01

CONCLUSION

Understanding the various components of grain yield and how to improve them will help in increasing rice production by raising the current yield level. Above results showed that rice grain yield in temperate region was much more higher compared to tropical region. Temperate rice had the advantage of longer maturity duration that was almost double than tropical rice. Grain weight of japonica rice was higher than tested indica rice. The HI of temperate rice was also higher compared to tropical rice. Maturity duration, tiller mortality rate, grain weight and harvest index were the important parameters those reflected on the better performance of rice in temperate region than tropical region.

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