THE TOLERANCE OF SEVERAL GENOTYPES OF UPLAND RICE TO SHADING AT DIFFERENT GROWTH STAGES

Toleransi Beberapa Genotip Padi Gogo terhadap Naungan pada Fase Pertumbuhan Berbeda

Muhammad Kamal
Staf Pengajar Jurusan Budidaya Pertanian Fakultas Pertanian Universitas Lampung

ABSTRAK

Keberhasilan pengembangan padi gogo sebagai tanaman sela pada areal perkebunan tanaman karet sangat tergantung pada tingkat toleransinya terhadap naungan. Metode penyaringan yang cepat dan akurat sangat membantu dalam penyediaan padi gogo toleran naungan dalam jumlah banyak. Dua set penelitian telah dilakukan untuk mengevaluasi apakah toleransi padi gogo terhadap naungan selama fase vegetatif memiliki konsistensi dengan naungan selama masa pertumbuhan tanaman (fase vegetatif dan reproduktif). Perlakuan pada penelitian 1 dan 2 disusun secara faktorial dalam rancangan acak kelompok dengan tiga ulangan. Faktor pertama berupa naungan dengan menggunakan paranet hitam dua taraf yaitu 0% dan 50%, sedangkan faktor kedua berupa genotip padi gogo yang meliputi Jatiluhur, B9048C, TB177-E, Batutegi, Kalimutu, dan Limboto. Naungan diberikan selama fase pertumbuhan vegetatif dan selama masa pertumbuhan tanaman (fase vegetatif dan reproduktif). Hasil percobaan menunjukkan bahwa genotip Jatiluhur, B9048C, TB177E dan Batutegi secara konsisten menunjukkan hasil lebih tinggi daripada genotip Kalimutu dan Limboto baik pada naungan selama fase vegetatif dan naungan selama masa pertumbuhan tanaman. Padi gogo yang toleran terhadap naungan selama fase vegetatif juga menunjukkan toleransi terhadap naungan selama masa pertumbuhan tanaman (fase vegetatif dan reproduktif).

Keywords: Reproductive, shading, tolerance, upland rice, vegetative, yield

INTRODUCTION

The need for rice in Indonesia is continously increasing, and mostly depending on wet land rice. However, the area of productive land used as paddy field tends to decrease every year due to land conversion to nonagricultural practices. Thus, the development of upland rice plays important role in maintaining national rice production. Because of the huge area of plantation land, the development of upland rice has been directed as an intercrop on rubber plantation land. Boerhendy (2004) indicated that Indonesia has about 3.3 millions hectare of rubber plantaion.

One of the main problems in the develoment of upland rice on rubber plantation land is shading caused by rubber crop canopy (Kamal *et al*. 2004). Thus, the use of upland rice genotypes tolerant to shading is highly required for cultivating upland rice as intercrop. Screening of upland rice genotypes tolerant to ruibber crop canopy can be done by using paranet. Kamal (2004) reported that the use of black paranet with 50 % shading is efective enough to screen upland rice genotypes tolerant to shading under 3-year old rubber crops.

Previous studies indicated that the genotypes of upland rice tolerant to shading showed better agronomic performances such as greater number of leaves, tillers and spickelets (Kamal *et al*. 2002, Laut *et al*. 1998). Other studies indicated that the tolerance of upland rice to shading is associated with stomatal conductivity, low light compensation pointhigh nitrate reductase and Rubisco activities (Chozin *et al*. 2000, Kamal 2005). In simple way, crop tolerance to sahding can be evaluated by coimparing between crop growth and yield under normal and shading condition. The more tolerant to shading, the less difference in growth and yield under those two conditions (Sulistyono *et al*. 1998).

Although many studiers have been conducted to evaluate the effect of shading on growth and yield of upland rice, spesific information on relative response of upland rice to shading vegetative stage and full growth period is little available. Up to now, screening for upland rice tolerant is done by imposing shade condition during vegetative and reproductive stages, so screening period takes long time. In fact, rice plant response to shading depends on growth stages (Yoshida 1981). Thus, it is possible to screen rice tolerance to shading based on rice growth stages by using paranet.

The objective of this study was to evaluate whether shading tolerance of upland rice during vegetative stage is consistent with that under full growth period. This information is useful in shortening the screening period of upland rice tolerant to shading.

METHODS

Two sets of experiments were conducted at the expereimental station of Lampung University, Bandar Lampung, in 2004.

Six genotypes of upland rice including Jatiluhur, B9048C-TB-4-B-2, TB-177-E, Batutegi, Kalimutu and Limboto were used. The fertilizers used were Urea, TSP and KCl. The treatments consisting of shade and upland rice genotypes in experiment 1 and 2 were arranged in a Randomized Block Design with three replications. The first factor was shade consisting of two levels, 0 and 50%, while the second factor was upland rice genotypes. Shading condition was made of black paranet as used before (Kamal *et al.* 2002, Kamal 2004). In experiment 1, the shading treatment was imposed during vegetative stage, while in experiment 2, the shading was imposed during vegetative and reproductive stages. The treatment of 50% shade was done by putting the rice plants under the small house made of black paranet.

Before planting, rice seeds were treated by fungicide and soaked in water for 24 hours. Then, rice seeds were planted in polybags each of which contained 10 kg of air-dry soil. The five genotypes of upland rice were planted in polybags and put under 0 and 50% shade The rate of fertilizer application was 12.0, 15.0, and 4.25 g/polybag for Urea, TSP and KCl respectively. TSP and KCl were applied before planting by mixing the fertilizers with a half part of soil in each polybag, while Urea was apllied twice, that is, a half dosage at planting time and the other half dosage at 40 days after planting. Two weeks after emergence the rice plants were thinned to 2 plants /polybag. Throught the experiment, rice plants were watered regularly to avoid water stress. Pest and disease were controlled by using pesticides.

The observation was done on growth variables including the number of leaves and tillers, while the observation of yield components included the number of panicles, seed number/panicle, panicle length, weight of 100 seeds, seed number/plant, and green yield/plant. The number of leaves and tillers was determined at the vegetative stage of rice (55 days after emergence), while yield components were determined after harvesting. All data were subjected to analysis of variance (ANOVA). The difference between mean values was determined by LSD test at P=0.05. Data were analyzed by Proc. GLM and Proc. Corr. (SAS Inst., Raleigh, NC, USA).

RESULTS AND DISCUSSION

Vegetative Growth

The treatment of shading imposed during vegetative stages and during the whole growth stages (vegetative and reproductive stages) significantly reduced the number of leaves and tillers of upland rice (Table 1). There is similarity between the effect of shading duirng vegetative stage and during the whole growth stage although the effect of shading during the whole stage is much more pronounced than that during vegetative stages. This is mainly due to the difference in the length of light deficit since light is very determinant factor on rice growth through photosynthesis. The treatment of shading during the whole growth stage automaticallly resulted in more length of light deficit compared to shading during vegetative growth stage. As reported before (Yoshida 1981, Sharma 1999), the number of leaves and tillers of rice plants is highly dependent on light intensity, and low light intensity caused by shading could reduce the number of leaves and tillers. Kamal (2005) indicated that shading with 50%-paranet significantly reduced the number of tillers of upland rice, and slowed down the emergence of tillers since the formation of tillers in rice depends on assimilate availability (Tunner & Jund 1993, Hanada 1995). The number of tillers is highly correlated with rice yield, thus the reduction of tiller number significantly decreased rice yield.

Compared to all upland rice genotypes (Table 1), Jatiluhur indicated the highest number of leaves and tillers, while Kalimutu resulted in the lowest number of leaves and tillers. This is consistent with the previous study (Laut *et al.* 1998) indicating that Jatiluhur is tolerant to shading while Kalimutu and Limboto are intolerant. Based on agronomic performance, Kamal *et al.* (2002) reported that the upland rice tolerant to shading possed greater number of leaves and tillers.

Yield Components and Seed Yield

Upland rice yield components differently responded to shading. The effect of shading on panicle number and seed number per panicle did not depend on upland rice genotypes, while the effect of shading on seed number and seed size depended on rice genotypes (Table 3). The effect of the 50%-shade on panicle number is significant at any stage of shading although it is more pronounced during the whole growth stages than at the vegetative stages. The effect of the 50%-shade during vegetative stage on seed number/panicle was not significant, while the effect of the 50%-shade during the whole growth stage is significant (Table 2). This means that panicle number is more sensitive to shading than seed number/panicle. As explained before, panicle number was mostly determined by tiller number. Since the availability of assimilate is indespensable to tiller growth, photosynthesis is utmost important in panicle growth and development which in turn, determine rice yield (Hendrix 1995, Ishii 1995).

Based on the number of panicles (Table 2), Jatiluhur is the most superior, while Kalimutu and Limboto are the lowest ones. As presented in Table 3, the shading tolerant genotypes (Jatiluhur, B9048C, TB-177-E and Batutegi) consistently indicated more seed number under the 50%-shade during vegetative and the whole growth stages. On the average, in this case, the

Table 1. Effect of shading at different stages of upland rice genotypes on the number of leaves and tillers

Treatment	Shading period			
	Vegetative stage		Vegetative and reproductive stage	
	Lef number (no./pot)	Tiller number (no./pot)	Leaf number (no./pot)	Tiller number (no./pot)
Shade Level				
0 % (open)	97.9 a	25.1 a	95.7 a	23.6 a
50% (shade)	39.4 b	16.5 b	36.5 b	10.3 b
Rice Genotypes				
Jatiluhur	93.2 a	29.0 a	91.2 a	25.3 a
B9048C	62.2 bd	21.2 b	76.8 ab	20.6 ab
TB-177-E	71.8 ad	24.8 ac	80.7 a	22.6 a
Batutegi	48.9 bc	12.5 c	53.7 b	18.7 ab
Kalimutu	41.8 c	17.2 bc	58.8 b	13.4 b
Limboto	57.2 bc	23.3 ab	55.3 b	18.4 ab

The numbers followed by the same letters at the same column and treatments are not significant (LSD test at P=0.05).

Table 2. Effect of shading at different stages of upland rice genotypes on panicle number and seed number/panicle

Treatment	Shading period			
	Vegetative stage		Vegetative and reproductive Stage	
	Panicle number (no./pot)	Seed number/ panicle (no./pot)	Panicle number (no./pot)	Seed number/ panicle (no./pot)
Shade Level				
0 % (open)	21.2 a	182.6a	19.4 a	125.8 a
50% (shade)	14.6 b	178.2a	12.3 b	102.4 b
Rice Genotypes				
Jatiluhur	24.1 a	212.7 b	21.0 a	150.1 a
B9048C	17.9 bc	179.3 bc	16.2 b	104.0 b
TB-177-E	21.6 ab	187.6 bc	17.8 b	137.8 a
Batutegi	12.5 d	343.1 a	15.5 bc	97.9 b
Kalimutu	15.2 dc	83.1 d	10.8 b	110.7 c
Limboto	21.3 b	128.0 cd	12.2 c	107.7 bc

The numbers followed by the same letters at the same column and treatments are not significant (LSD test at P=0.05).

Table 3. Effect of shading at different stages on seed number, seed size (weight of 100 seeds) and seed yield of different upland rice genotypes

Treatment		Shading period					
		Vegetative stage			Vegetative and reproductive stage		
Sahde Level	Rice Genotypes	Seed number (no./pot)	Weight of 100 seeds (g)	Seed yield (g/pot)	Seed number (no./pot)	Weight of 100 seeds (g)	Seed yield (g/pot)
0 % (open)	Jatiluhur	4402.3a	2.1 a	92.9 a	2439.8a	2.0 a	58.9 a
	B9048C	2390.1b	2.5 ab	59.3 be	1975.5a	3.0 b	60.1 a
	TB-177-E	6348.2d	2.1 a	135.2 c	3058.9b	2.0 a	70.4 a
	Batutegi	2310.6b	2.9 b	67.4 be	2136.2ab	2.8 b	59.8 a
	Kalimutu	1621.2b	3.7 c	59.9 be	1817.3a	3.0 b	63.2 a
	Limboto	2548.4bc	2.8 bd	71.3 bd	1774.5a	3.0 b	55.6 a
50% (shade)	Jatiluhur	4002.5ac	2.2 ad	88.1 d	1647.5ac	2.0 a	36.3 b
	B9048C	2161.3b	2.6 abd	56.0 e	1400.3ac	3.0 b	37.7 b
	TB-177-E	1264.8b	2.9 b	37.7 f	1158.4ac	3.1 b	36.9 bc
	Batutegi	2770.3bc	2.2 ad	61.5 e	1677.5ac	2.0 a	35.2 bc
	Kalimutu	819.6b	3.6 c	29.7 f	719.9c	3.0 b	20.4 c
	Limboto	1081.2b	2.5 abd	27.0 f	901.0cd	3.0 b	23.5 c

The numbers followed by the same letters at the same column and treatments are not significant (LSD test at P=0.05).

reduction of seed number under the 50%-shade during vegetative stages was 33% and 54% for tolerant and intolerant upland rice genotypes, respectively. On the other side, the reduction of seed number under the 50%-shade during the whole growth stages was 40% and 54%, respectively. This means that there is similarity between shading during vegetative stages and during the whole growth stages (vegetative and reproductive stages) in reducing the seed number of upland rice although the reduction ius much more greater on the 50%-shade during the whole growth stages.

Shading also influenced upland rice seed yield. The 50%-shade with paranet significantly reduced the seed yield of upland rice although it depended on upland rice genotypes (Table 3). The pattern of seed yield reduction under shading during vegetative stages is almost the same as at the whole growth stages. The reduction of seed yield under the 50%-shade duirng vegetative stages was 31% and 56% for tolerant and intolerant upland rice genotypes, respectively. Under the 50%-shade during the whole growth stages, the reduction of seed yield was 41% and 63%

Table 4. Coeficient of correlation between vegetative growth and yield components of upland rice as affected by shading at vegetative stage

	Leaf number	Tiller number	Panicle number	Seed per panicle	Seed number	Seed size	Seed yield
Leaf number	1.000	0.952***	0.742**	0.211	0.635**	0.232	0.862**
Tiller number		1.000	0.832**	0.126	0.716**	0.261	0.815**
Panicle number			1.000	0.123	0.728**	-0.157	0.721**
Seed per panicle				1.000	0.523*	-0.113	0.617**
Seed size					1.000	-0.203	0.886**
Seed number						1.000	0.201
Seed yield							1.000

** and *** indicate significant correlation at P=0.01 and P=0.001, respectively.

Table 5. Coeficient of correlation between vegetative growth and yield components of upland rice as affected by shading at the whole growth stage (vegetative and reproductive stages)

	Leaf number	Tiller number	Panicle number	Seed per panicle	Seed number	Seed size	Seed yield
Leaf number	1.000	0.968***	0.780**	0.196	0.675**	0.320	0.824**
Tiller number		1.000	0.763**	0.092	0.603**	0.331	0.766**
Panicle number			1.000	0.117	0.795**	-0.266	0.654**
Seed per panicle				1.000	0.681*	-0.051	0.662**
Seed size					1.000	-0.214	0.873**
Seed number						1.000	0.279
Seed yield							1.000

** and *** indicate significant correlation at P=0.01 and P=0.001, respectively.

for tolerant and intolerant upland rice genotypes, respectively. According to Levit (1980), yield is one of the best indicator for the tolerance capability of the plants to environment stress. Sulistyono *et al.* (1998) indicated that the more tolerant to shading, the less difference in rice seed yield between shading and normal conditions. Thus, based on seed yield, the upland rice genotypes producing high seed yield under the 50%-shade during vegetative stages also resulted in high yield under the 50%-shade duirng the whole growth stages (vegetative and reproductive stages). It seems the upland rice genotypes tolerant to shading duirng vegetative stages is tolerant shading during the whole growth stages. Thus, screening the upland rice genotypes tolertant to shading during vegetative stages could shorten the screening period as required before (the whole growth stages).

The result of correlation analysis also indicated similar pattern of correlation between vegetative growth and yield component variables. Seed yield was strongly correlated with the number of leaves, tillers, panicles and seeds (Table 4 and 5). This substantiated the above results. Under the 50%-shade during vegetative stages, seed yield was correlated with the number of tillers (r=0.815**), panicles (r=0.721**) and seeds (r=0.886**). Under the 50%-shade during the whole growth stages, seed yield was also highly correlated with the number of tillers (r=0.776**), panicles (r=0.654**) and seeds (r=0.873**). In other words, such variables as the number of tillers, panicles and seeds are important rice yield determinants under shading during vegetative stages and during the whole growth stages.

CONCLUSION

The upland rice genotypes of Jatiluhur, B9048C, TB177E and Batutegi is most likely more tolerant than Kalimutu and Limboto under the 50%-shade during vegetative stages and during the whole growth (vegetative and reproductive) stages. The upland rice genotypes producing high yield under shading during vegetative stages alsso resulted in high yield under shading during the whole growth stages. Under shading during vegetative stages and during the growth stages, rice seed yield was highly correlated with the number of tillers, panicles and seeds. It seems there is consistency in the tolerance of upland rice to shading during vegetative stages and during the whole growth stages. Thus, the upland rice genotypes tolerant to shading during vegetative stages would be tolerant to shading during the whole growth stages.

REFERENCES

Boerhendhy, I. 2004. Penggunaan bahan tanam unggul untuk mendukung pembangunan perkebunan karet rakyat. Pros. Simposium Nas. dan Konggres Peragi VIII. Bandar Lampung, 8-10 Juli 2003, Perhimpunan Agronomi Indonesia (Peragi), Bandar Lampung.

Chozin, M.A., D. Sopandie, S. Sastrosumarjo & Suwarno. 2000. Physiology and genetic of upland rice adaptability to shade. University Research for Graduate Education. Directorate General of Higher Education. Ministry of Education, Jakarta.

Hanada, K. 1995. Differentiation and development of tillers buds. *In* T. Matsuo, K. Kumazawa, R. Ishii, K. Ishihara & H. Hirata (Eds), pp. 61-65. Science of the Rice Plants. Vol.2. Food and Agric. Plic. Res. Center, Tokyo.

Hendrix, J.E. 1995. Production-related assimilate transport and partitioning. *In* M. Pessarakli (ed.) p.421-448. Handbook of Plant Crop Physiology. Marcel Dekker Inc., New York.

Ishii, R. 1995. Roles of photosynthesis and respration in the yield-determining process. *In* T. Matsuo, K. Kumazawa, R. Ishii, K. Ishihara & H. Hirata (eds), p. 691-696. Science of the Rice Plants. Vol.2. Food and Agric. Plic. Res. Center, Tokyo.

Kamal, M., K. Setiawan, M.S. Hadi & A. Karyanto. 2002. Agronomic performance of upland rice planted under shading conditions. International Seminar. Int. Soc. Southeast Asian Agric.Sci. (ISSAS). Tokyo, Japan.

Kamal, M., K. Setiawan, M.S. Hadi & A. Karyanto. 2004. Analysis of flag leaf characters and yield components of upland rice planted under shading caused by rubber crop canopy. J. agrista 8(2):127-133.

Kamal, M. 2004. Penggunaan paranet untuk menyaring padi gogo toleran naungan. Jurnal Penelitian Pertanian Terapan, Vol. IVa (2):137-143.

Kamal, M. 2005. Vegetative growth, stomatal conductance and nitrate content of upland rice grown under different shading conditions. J. Agrista 9(1): 57-65.

Laut, B.S., N. Soverda, A. Ete, D. Anggorowati, T. Juhaeti & Sahardi. 1998. Adaptasi padi gogo terhadap naungan: Penyaringan naungan buatan. Pros. Sem. Peningkatan Produksi Padi Nasional. 9-10 Desember 1998. Bandar Lampung,

Levit, J. 1972. Response of Plants to Environmental Stress. Academic Press, New york.

Sharma, A.R. & D.P. Singh. 1999. Rice. *In* D.L. Smith & C. Hamel (Eds) pp.357-385. Crop Yield Physiology and Processes. Springer-Verlag Berlin Hedelberg, New York.

Sulistiyono, E., D. Sopandie, M.A. Chozin, & Suwarno. 1998. Adaptasi tanaman padi gogo terhadap naungan.: Pendekatan morfologi dan fisiologi. Pros. Sem. Peningkatan Produksi Padi Nasional, 9-10 Desember 1998, Bandar Lampung

Tunner, F.T & M.F. Jund. 1993. Rice ratoon crop yield linked to main crop stem carbohydrates. Crop Sci. 33:150-153.

Yoshida, S. 1981. Fundamentals of Rice Science. International Rice Research Institute. Los Banos, Philippines.