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Nature of Genetic Control of the Length and Number of Elongated Internodes in Deepwater Rice under Non-flooded Condition

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ABSTRAK

Turunan jumlah panjang dan bilangan ruas yang dipanjangkan dalam beberapa jenis padi apungan telah di kaji dalam 7 × 7 dialel (tidak termasuk salingan) melalui prosedur yang tidak memerlukan air yang banyak. Anggaran keupayaan menggabung dan analisis komponen genetik menunjukkan kesan gen berdaya tambah dan tidak berdaya tambah begitu ketara dengan keadaan yang lebih kepada jenis berdaya tambah. Anggaran yang tinggi terhadap kemampuan mewaris selanjutnya menyokong kepentingan kesan gen berdaya tambah. Jalmagna dan IR40905 - 11 - 3 - 1 - 5 - 2 - 21 diputuskan sebagai penggabung terbaik. Walau bagaimanapun benih yang baik tidak selalunya penggabung terbaik. Keketaraan taburan gen menunjukkan wujudnya isimetri gen. Hitung panjang darjah dominan adalah 0.83 bagi kedua-dua jumlah panjang dan bilangan ruas yang dipanjangkan menunjukkan dominan separa.

ABSTRACT

Inheritance of total length and number of elongated internodes in some varities of deepwater rice were studied in a 7 × 7 diallel (excluding reciprocals) by a procedure that does not require flooding. Estimates of combining ability and genetic component analysis showed highly significant additive and non-additive gene effects with preponderance of additive type. The high estimate of narrow sense heritability further supported the importance of additive gene effects. Jalmagna and IR40905-11-3-1-5-2-21 were not always the best combiners. The significance of the gene distribution indicated the presence of gene asymmetry. The average degree of dominance was 8.83 for both total length and number of elongated internodes indicating partial dominance.

Keywords: ***Oryza sativa*** **L., deepwater rice, plant elongation**

INTRODUCTION

Deepwater rice possess the ability to elongate rapidly to keep pace with rising water to as much as 5 - 6 meters. The total elongation during flooding is usually a cumulative effect of three elongating plant components: leaf sheath, leaf blade and internodes. Internode elongation is the most important. Leaf elongation is limited. The length of an elongated internode may vary from 9 - 30cm. However, the number of elongated internodes does not indicate actual elongation capacity (Datta 1982, Hasanuzzaman *et al.* 1975). Lack of suitable screening methods for elongation ability have been considered a major bottleneck in the study of the trait. Available methods are destructive in nature. Experiments conducted at the International Rice Research Institute (IRRI) with elongating and non-elongating rice varieties grown under normal irrigated condition showed developmental-morphological differences between the two types, which can be detected even in the absence of flooding. This suggested that the length and the number of elongated internodes of rice grown under non-flooded condition could be used as traits suitable for genetic studies (Thakur and Hillerislambers 1989; Dwivedi *et al.* 1992). Therefore, the present study was undertaken to determine the nature of genetic control of the length and number of elongated internodes without flooding.

MATERIALS AND METHODS

The materials consisted of seven eco-culturally different rice varieties viz fast elongating tall traditional (Jalmagna), slow elongating tall (IR40905-11-3-1-5-2-21), tall traditional deepwater (NDGR 207), slow elongating modern type (IR11141-6-1-4 and NDGR 150), submergence tolerant, non-elongating, modern type

(BKNFR76106-16-0-1) and submergence sensitive, non-elongating, modern type (IR42). Performance of these parents with respect to the number of elongated internodes and length of internodes under non-flooded condition is shown in Table 1. These were crossed in all possible combinations excluding the reciprocals. The seven parents and their F_1's were grown in a randomized block design with four replications under normal irrigated condition during the wet season of 1991 at IRRI. Each entry consisted of three rows, each with 15 plants. Plant spacing between and within rows was 30 cm. Standard crop management practices were followed. At the time of complete panicle emergence, 10 plants were selected randomly from each replication and main tillers were dissected to record the length and number of elongated internodes. Internodes with more than 6 cm length were considered elongated.

TABLE 1
Average number of elongated internodes and length of internodes of parents used

Parent	Type*	Average	
		Number of elongated internodes	Length of internodes (cm)
NDGR207	1	4	68.1
NDGR150	1	4	67.9
IR11141-6-1-4	1	5	63.5
IR40905-11-3-1-5-2-2-1	1	5	101.5
BKNFR76106-16-0-1	2	3	47.8
IR42	2	3	48.2
	LSD (.05)	0.5	5.0

*1 = elongating, 2 = non-elongating

Analysis of combining ability was carried out according to Griffing (1956) using Model 1, Method 2. The genetic components of variances were computed following Hayman (1954).

RESULTS AND DISCUSSION

General Combining Ability (gca) and Specific Combining Ability (sca) Effects

An analysis of variance demonstrated the presence of highly significant genetic variability within diallel population for total length and number of elongated internodes. The mean square due to gca and sca effects were highly significant indicating the importance of both additive and non-additive types of gene effects in controlling these two traits (Table 2). However, gca variances were higher than sca variances indicating the predominance of additive gene action in the expression of these characters.

TABLE 2
Analysis of variance for combining ability

Character	Mean square[a]		
	gca	sca	error
Length of internodes	1379.467**	123.678	4.954
Number of elongated internodes	3.779**	0.393**	0.085

** Significant 1% level
a Mean squares for gca, sca, and error are based on 6, 21 and 81 degrees of freedom, respectively.

Jalmagna was the best general combiner followed by IR40905-11-3-1-5-2-21 for internode length and number of elongated internodes as these genotypes showed highly significant and positive gca effects for these traits (Table 3). NDGR 207 had positive and highly significant gca effects for length of internodes while having negative and significant effects for number of elongated internodes. The rest of the genotypes were adjudged to be poor general combiners due to significant but negative gca effects. The parents which were good combiners for length of

TABLE 3
Estimates of gca effects in 7 parent F1 diallel for number and length of internodes based on Griffing (1956)

Parent	Length of internodes	Number of Elongated internodes
Jalmagna	22.32**	1.286**
NDGR207	2.54**	-0.187*
NDGR150	-3.52**	-0.492**
IR11141-6-1-4 -	6.80**	-0.048
IR40905-11-3-1-5-2-21	8.43**	0.341**
BKNFR76106-16-0-1	-8.271**	-0.270**
IR42-14.704**	-0.631**	
S.E.(gi)	.679	.09

* Significant at 5%
** Significant at 1%

internodes were also good combiners for number of elongated internodes except for BDGR 207. Thus, the parents particularly Jalmagna and IR40905-11-3-1-5-2-21 are considered good donors for the improvement of length and number of elongated internodes.

Jalmagna/BKNFR76106-16-0-1, NDGR207/NDGR150, NDGR207/IR11141-6-1-4, NDGR207/BKNFR76106-16-0-1, NDGR 150/IR40905-11-3-1-5-2-21, NDGR150/BKNFR76106-16-0-1, IR11141-6-1-4/IR40905-11-3-1-5-2-21, IR40905-11-3-1-5-2-21/BKNFR76106-16-0-1, IR40905-11-3-1-5-2-21/IR42 possessed high and significant sca effects for internode length (Table 4). These best cross combinations involved at least one good general combiner. Of the 21 crosses, four showed negative and significant sca effects. The remaining crosses had either positive or negative but non-significant sca effects. Therefore, it could be concluded that sca effects varied greatly from cross to cross; and that moderate to poor general combiners also produced good combinations. However, low internode length parents showed very high negative general and specific combining ability effects.

The crosses, Jalmagna/IR40905-11-3-1-5-2-21, IR40905-11-3-1-5-2-21/BKNFR76106-16-0-1, NGDR150/BKNFR76106-16-0-1 showed positive and significant sca effects for number of elongated internodes. The first two crosses involved high x high and high x low general combiners. The high and highly significant sca effect of NDGR 150/BKNFR 76106-16-0-1 involving both poor general combiners indicated that poor general combiners may not always produce poor F_1 combinations for number of elongated internodes. The remaining cross combinations showed low magnitude of sca effect, either positive or negative except for Jalmagna/NDGR 207 and Jalmagna/NDGR150 which possessed significant negative sca effects. The presence of non-additive genetic variance or sca effects offer scope for exploiting heterosis in these traits through the development of hybrid rices.

TABLE 4
Estimates of sca effects in 7 parent F_1-diallel for number and length of internodes based on Griffing (1956) (normal irrigated condition)

Cross	Length of internodes	Number of elongated internodes
Jalmagna/NDGR207	-18.186**	-1.653**
Jalmagna/NDGR150	-10.314**	-0.597
Jalmagna/IR1141-6-1-4	1.319	-0.042
Jalmafna/IR40905-11-3-1-5-2-21	1.425	0.569*
Jalmagna/BKNFR76106-16-0-1	11.381**	0.431
Jalmagna/IR42	-3.586	-0.458
NDGR207/NDGR150	4.769*	0.431
NDGR207/IR4040905-11-3-1-5-2-21	-2.142	-0.458
NDGR207/ bknfr76106-6-0-1	8.364**	0.403
NDGR207/IR42	-1.103	0.014
NDGR150/IR11141-6-1-4	-2.525	-0.014
NDGR150/IR40905-11-3-1-5—2-21	10.381**	0.097
NDGR150/BKNFR76106-16-0-1	11.336**	0.708**
NDGR150/IR42	2.769	-0.181
IR11141-6-1-4/IR40905-11-3-1-5-2-21	16.264**	0.403
IR11141-6-1-4/BKNFR76106-16-0-1	-8.031**	-0.236
IR11141-6-1-4/IR42	-2.547	-0.125
IR40905-11-3-1-5-2-21/BKNFR76106-16-0-1	12.175**	0.625*
IR40905-11-3-1-5-2-21/IR42	4.358*	0.236
BKNFR76106-16-0-1/IR42	-9.786**	-0.403
S.E.(S_{ij})	1.977	0.262
S.E. (S_{ij}-S_{ik})	2.937	0.389

*, ** Significant at 5 and 1% respectively.

Genetic component analysis

Tests for the validity of the additive-dominance model for length and number of elongated internodes satisfied their assumptions. The regression coefficients for length of internodes and the number of elongated internodes, b= 8.11 and 3.24 respectively, were signicantly different from zero, but their deviation from unity was not significant indicating the presence of non-allelic interaction (epistasis) at very low intensity. Estimated genetic components of variation and proportional values for these characters are presented in Table 5. The significance of additive effects and three components of dominance (H_1, H_2 and h^2) for length of internodes and two components of dominance (H_1 and H_2) for number of elongated internodes indicated the importance of both additive and dominance genetic effects. This was supported by the importance of gca and sca effects in the combining ability analysis. However, the larger magnitude of D as compared to H_1 revealed the greater importance of additive gene action. This was further substantiated by high narrow sense heritability observed for these traits. The significance of F value suggested the presence of asymmentry in the distribution of genes among parents. This was also corroborated by the ratio estimates of $H_2/4H_1$ for length and the number of elongated internodes (0.171 and 0.159 respectively) whose maximum possible value of .25 is expected under equal frequencies of posi-

TABLE 5
Estimates of genetic components of variation and proportional values for number and length of internodes (normal irrigated condition)

Component	Length of internodes	No. of Elongated internodes
D(Additive effects)		808.113*
2.488*		
	+11.311	+0.255
H(Dominance effects)	555.719*	1.706*
H_1	+77.023	+0.615
H_2	381.078*	1.089*
	+67.868	+0.542
H_2	169.342*	-0.042^{ns}
	+45.583	+0.364
F (Gene distribution)		388.523*
1.556*		
	+76.751	+0.613
E (Environment effects)	4.739^{ns}	0.089^{ns}
	+11.311	+0.090
Proportional values		
$H1/D)^{1/2}$(Average dominance)	0.829	0.828
$H_2/4H_1$ (Gene asymmetry)	0.171	0.159
K_D/K_R^+ (Proportion of dominance and recessive genes in the parents)	1.816	2.213
r between Wr+Vr and Y_r	-0.161	0.579
Heritability narrow sense (%)	74.817	68.182

\+ KD.KR= $[(4DH1)^{1/2}+1/2\ F]/[(4DH1)^{1/2}-1/2\ F]$
* Significant at 5% level
ns Nor significant

tive and negative alleles. This further implies that positive and negative alleles were not present in equal proportion in each parent used. The average degree of dominance $(H_1/D)^{1/2}$ for both length and number of elongated internodes was 0.83 showing partial dominance.

CONCLUSION

Combining ability and genetic components analyes revealed the importance of both additive and non-additive types of gene effects with preponderance of additive and non-additive type for the number and length of internodes. Jalmagna and IR40905-11-3-1-5-2-21 proved to be the best general combiners among the varieties studied for the two traits. They could be used in breeding to develop improved deepwater rices.

The length and number of elongated internodes measured in the absence of flooding could be used to determine the genetic architecture of donors and breeding materials but may not be useful in practical breeding since the procedure is laborious and consuming.

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