

Studies on internode and certain other characters in relation to cytoplasmic-genetic male sterile lines in rice

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Abstract. Twenty two cytoplasmic-genetic male sterile lines and their isogenic maintainers were investigated for five plant characters (viz. Plant height, internode, flowering duration, panicle length and panicle exertion) to understand the influence of male sterile cytoplasm on these characters in rice. All the cytoplasmic-genetic male sterile lines showed delayed flowering, shorter plant height, reduced first and second internode, poorer panicle exertion and delayed senescence than their respective maintainers indicating the influence of male sterile cytoplasm on these characters. However, there was no difference in internode number between the cytoplasmic-genetic male sterile and maintainer lines. The first internode of the cytoplasmic-genetic male sterile lines were significantly shorter and the percentage contribution of the first internode to the culm length was relatively less than their maintainer lines. The reduced first internode and its low contribution to the culm length were inferred to be responsible for reduced plant height, poorer panicle exertion and delayed flowering of the cytoplasmic-genetic male sterile lines. The significant and positive association between the length of successive pair of internodes indicated the simultaneous development of those internodes at a time.

Key words: Cytoplasmic-genetic male sterile line; Flowering duration; Internode; Maintainer lines; Male sterile cytoplasm; Panicle exertion; Plant height.

Introduction

The effects of sterility-inducing cytoplasm on morphological traits has been studied in certain crops like tobacco (Clayton, 1950), maize (Grogan and Sarvela, 1964; Grogan *et al.*, 1971) and sorghum (Lenz and Atkins, 1981). Such studies are essential for the development of usable form of cytoplasmic-genetic male sterile lines that would have less undesirable effect on other plant parts. The information on the influence of male sterile cytoplasm on various plant traits are not available in rice so far. Hence, the present investigation was designed for the first time to study the influence of male sterile cytoplasm on the number and length of internode and other related characters such

as plant height, flowering duration, panicle exertion and delayed senescence in cytoplasmic-genetic male sterile lines of rice. The information obtained from this study and the interrelationship among these characters are described here.

Materials and Methods

Twenty two cytoplasmic-genetic male sterile (CMS) lines originated from five different sources (V 20A, Zhenshan 97A, V 41A, Er-Jiu-Nan 1A, IR 46826A, IR 46827A, IR 46828A, IR 46829A, IR 46830A, IR 46831A, IR 48483A, IR 54752A, IR 54753A, IR 54754A, IR 54756A, IR 54757A, IR 54758A, Madhu A of wild abortive source, Yar-Ai-Zhao A of Gambiaca source, Pankhari 203A of T.N.1 source, Wu 10A of Chinsurah Boro II source and MS 577A of *Oryza sativa* f. *spontanea* source) were developed through repeated

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backcrossing to their respective maintainers (recurring male parents) at various research Centres. These CMS lines along with their isogenic maintainers were grown during 1987 wet season at Central Rice Research Institute (CRRI), Cuttack. Twenty five days old seedlings were transplanted in the field with a spacing of 20 x 15 cm² in a randomized block design in two rows with two replications each. Observations on plant height, flowering duration, panicle length, panicle exertion, number and length of internodes were recorded for ten plants at random from each of the CMS lines and its isogenic maintainer in each replication.

Correlation coefficients between pairs of characters were estimated (Aljibouri *et al.*, 1958). The total length of all the developed internodes was termed as culm length. The topmost internode below the panicle base was taken as first internode while the bottommost internode was termed as basal internode.

Results

Based on the plant height and number of internodes all the CMS lines and their maintainers were classified into three groups. Fourteen CMS lines, V 20 A, Zhenshan 97A, V 41A, Er-Jiu-Nan 1A, IR 46826A, IR 46828A, IR 46829A, IR 46830A, IR 46831A, IR 48483A, IR 54756A, Yar-Ai-Zhao A, Wu 10A and MS 577A and their maintainers were included in group 1 and had five internodes each. The second group consisted of four CMS lines viz. IR 46827A, IR 54754A, IR 54757A and Madhu A and their maintainers having six internodes each. The rest of the four CMS lines IR 54752A, IR 54753A, IR 54758A and Pankhari 203A and their maintainers with seven internodes each formed the third group. In each group the CMS lines were significantly shorter than their maintainer lines. The increased plant height in CMS lines in group 2 and group 3 was found to be associated with the increase in number of internodes in both CMS and their maintainer lines (Table 1). However, no difference in number of internodes was recorded between any of the CMS and its maintainer line. The gradual reduction in the length of the internodes from first internode to the basal internode (from top to bottom of the plant) was seen in both CMS and maintainer lines. The length of the two top (1st and 2nd) and two middle (3rd and 4th internode) could be measured with relatively small errors as compared to the rest of the internodes. A large vari-

ation was observed for the 1st internode length while it was less for the lowermost internodes (5th, 6th and 7th) in both CMS and maintainer lines in all groups (Table 1). The first two internodes in CMS lines were relatively shorter than their respective maintainer lines in all the groups. However, the length of the 1st internode in the CMS lines in all the three groups was significantly shorter than that of their maintainer lines (Table 1). The length of other internodes in both CMS and their maintainer lines were found to be almost same in all groups. The percentage contribution of 1st and 2nd internode length to the total internode length (culm length) was relatively more than the other internodes. However, the percentage contribution of the 1st internode to the culm length in CMS lines was less than their maintainer lines while it was more for the rest of the internodes in all the groups (Table 1). It was also observed that the maintainer lines were flowered earlier than that of their CMS lines in all the groups. However, this difference in flowering duration was not found to be significant (Table 1).

Almost all the CMS lines showed poor panicle exertion except Pankhari 203A and Wu 10A where panicle exertion was 100%. In the maintainers the panicles were completely exerted under normal condition of crop growth. The difference in panicle exertion between the CMS and maintainer lines was found to be significant in all the groups. However, no difference in panicle length between these two lines was observed in any of the three groups (Table 1).

Correlation coefficients were worked out for both CMS and their maintainer lines only for group 1. These were not estimated for group 2 and group 3 because of the small population. It was found that plant height was significantly and positively correlated with that of the length of first two internodes and panicle exertion in both CMS and maintainer lines (Table 2).

Significant positive correlations were obtained between the length of 2nd and 3rd internodes in CMS lines and between 1st and 2nd internodes in maintainer lines. Further it was seen that the length of 1st internode was positively and significantly correlated with the panicle exertion in maintainer lines. Significant and positive correlations were also obtained for 3rd internode with 4th and 5th and 4th internode with 5th in both the CMS and maintainer lines (Table 2).

Table 1. Mean internode length, plant height and other related characters of CMS (A) and maintainer (B) lines

Characters		Group 1			Group 2			Group 3		
		Mean (cm)	A-B (cm)	PCI ^a to culm length	Mean (cm)	A-B (cm)	PCI ^a to culm length	Mean (cm)	A-B (cm)	PCI ^a to culm length
Pl. ht. (cm)	A	53.4±2.0	-10.5**	—	70.0±3.1	-12.0*	—	90.0±5.6	-19.3*	—
	B	63.9±2.0	—	—	82.0±2.1	—	—	109.3±6.8	—	—
1st. Int. (cm)	A	16.2±0.7	- 8.9**	45.6	19.7±0.4	-10.6**	41.3	26.3±2.1	-12.2*	39.5
	B	25.1±0.8	—	54.8	30.3±1.5	—	50.3	38.5±2.5	—	47.1
2nd Int. (cm)	A	11.3±0.7	- 1.9	31.8	12.6±1.0	- 1.8	26.2	17.5±2.8	- 2.8	26.3
	B	13.2±0.6	—	28.8	14.4±0.9	—	24.0	20.3±2.9	—	24.8
3rd Int. (cm)	A	4.9±0.5	+ 0.2	13.7	7.9±0.8	- 0.1	16.6	11.6±1.2	+ 0.3	17.5
	B	4.7±0.5	—	10.2	8.0±0.8	—	13.3	11.3±1.1	—	13.9
4th Int. (cm)	A	2.2±0.2	+ 0.3	6.2	4.1±0.7	- 0.2	8.6	6.1±0.3	- 0.5	9.1
	B	1.9±0.2	—	4.2	4.3±0.5	—	7.2	6.6±0.9	—	8.0
5th Int. (cm)	A	1.1±0.2	+ 0.2	2.8	2.5±0.5	0.0	5.3	3.0±0.4	- 0.2	4.6
	B	0.9±0.1	—	2.0	2.5±0.4	—	4.1	3.2±0.4	—	3.9
6th Int. (cm)	A	—	—	—	0.8±0.2	+ 0.1	1.7	1.4±0.2	+ 0.1	2.0
	B	—	—	—	0.7±0.1	—	1.2	1.3±0.2	—	1.5
7th Int. (cm)	A	—	—	—	—	—	—	0.7±0.1	+ 0.1	1.1
	B	—	—	—	—	—	—	0.6±0.1	—	0.7
Flow. dur. (days)	A	78.1±2.7	+ 2.4	—	93.3±5.4	+ 3.5	—	103.8±2.5	+ 2.0	—
	B	75.7±2.9	—	—	89.8±5.0	—	—	101.8±2.5	—	—
Pan. len. (cm)	A	17.9±0.9	- 0.2	—	22.5±1.2	+ 0.6	—	25.8±7.3	- 1.8	—
	B	18.1±0.6	—	—	21.9±1.9	—	—	27.6±1.4	—	—
Pan. exs. (cm)	A	12.6±0.9	- 5.5*	—	16.0±1.4	- 5.9*	—	19.3±2.6	- 8.3*	—
	B	18.1±0.6	—	—	21.9±1.9	—	—	27.6±1.4	—	—
Pan. exs. (%)	A	70.4±3.6	-28.9**	—	70.9±3.6	-29.1**	—	74.4±8.7	-25.6*	—
	B	100	—	—	100	—	—	100	—	—

^aPercentage contribution of each internode.

*Significant at 5%; **Significant at 1%.

Discussion

Cytoplasmic-genetic male sterile (CMS) lines in rice have been reported to have reduced plant height and poorer panicle exertion as compared to their isogenic maintainer lines (Shinjo, 1975; Zhu, 1979; Wan, 1980; Lu *et al.*, 1980 and Virmani and Wan, 1986). In the present investigation, the CMS lines were also observed to have reduced plant height and poorer panicle exertion besides delayed senescence as compared to their maintainers (Table 1). The slight

reduction in plant height in CMS lines would be of advantage as the panicles of CMS lines during flowering would be at a lower level than those of maintainer lines so as to increase the rate of outcrossing during anthesis through better dispersal of pollen grains and thereby increasing rate of seed set in seed multiplication plots.

Eventhough the CMS lines were significantly shorter than their isogenic maintainers, there was no difference with respect to the number of internodes between them (Table 1). The significant reduction in plant height and poorer panicle exertion of the CMS

Table 2. Correlation coefficient between plant height of different internodes, flowering duration and panicle exertion in CMS (above diagonal) and maintainer lines (below diagonal) of group 1

Characters	Plant height	1st Internode	2nd Internode	3rd Internode	4th Internode	5th Internode	Flowering duration	Panicle exertion
Plant height	—	0.6688**	0.8366**	0.5154	0.4987	0.3152	0.3899	0.6378**
1st Internode	0.7821**	—	0.5011	0.1578	0.1286	-0.0562	0.2647	0.2898
2nd Internode	0.7980**	0.5668*	—	0.5475*	0.2610	0.0574	0.4238	0.3904
3rd Internode	0.4341	-0.0902	0.3363	—	0.7390**	0.6398*	0.3479	0.0991
4th Internode	0.5192	0.1028	0.1709	0.7516**	—	0.8757**	0.0689	0.1640
5th Internode	0.4413	0.0727	0.1766	0.6173*	0.8391**	—	0.3672	0.2284
Flowering duration	0.2762	0.2477	0.1804	0.1482	0.1732	0.4113	—	0.1928
Panicle exertion	0.7806**	0.6482*	0.5317	0.0179	0.2149	0.1205	0.0823	—

* Significant at 5%; ** Significant at 1%.

lines might be mostly due to the significant reduction in 1st internode in all the groups. The relatively shorter 2nd internode might also be responsible for the reduced plant height and poorer panicle exertion in the CMS lines. This was further substantiated from the significant and positive association of plant height with 1st and 2nd internode and with panicle exertion in both the CMS and maintainer lines (Table 2). This indicated the role of upper internodes in determining plant height.

In Barley, the increase in length of the first internode and decrease in length of the basal internode was reported to be a common feature in early-heading mutants (Gustafsson *et al.*, 1960). In rice, short culm early mutants were reported to be associated with elongated upper internode with relatively large share to the culm length (Futsuhara *et al.*, 1967; Morishima and Oka, 1968; Kawai and Narahari, 1971). Tsai and Oka (1968) reported that the gene responsible for earliness in rice has its primary effect on promoting flower-initiation and subsequently suppress the fifth internode and accelerates the elongation of the panicle and upper internodes. These reports suggested that the elongated upper internodes with relatively large contribution to the culm length might be associated with earliness while the shorter upper internodes having low contribution to the culm length might be associated with lateness in barley and rice. The present investigation indicated a significant reduction in first internode length and its low contribution to the culm length in CMS lines as compared to their maintainer lines. The length of all other internodes in CMS lines was almost equal

to that of their maintainer lines. The relative contribution of the middle and basal internodes to the culm length in CMS lines was more than that of their maintainer lines while it was less for the uppermost or first internode in the CMS lines. These findings indicated that the significant reduction in first internode length and its small share or low contribution to the culm length in CMS lines might be responsible for their reduced plant height and delayed flowering resulting in poorer panicle exertion and delayed senescence. Conversely, the maintainer lines were taller, flowered early and had fully exerted panicles as they had longer or elongated first internode with larger share contributing to the culm length. Very short internode just below the panicle neck was reported to result in low panicle exertion (Xu and Li, 1986).

The above results indicated the influence of male sterile cytoplasm on reduced plant height, shorter 1st and 2nd internodes, delayed flowering, poorer panicle exertion and delayed senescence. However, it did not show any influence on the number of internodes. A significant positive correlation was seen amongst the internode length mostly between pairs of two adjacent internodes in both CMS and maintainer lines which indicated the simultaneous development of successive internodes at a time. Such findings were also reported in a few short culm mutants of rice variety Norin No. 22 (Kawai and Narahari, 1971).

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水稻節間及其他性狀與細胞質雄不稔性品系之關係

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以 22 種細胞質雄不稔性之水稻品系，及其同源維持系間，就株高、節間、花期、穗長及穗突出情況等性狀加以比較研究，以便了解雄性不稔植株之細胞質對以上各性狀之影響。在與其同源維持系相較下，所有細胞質雄不稔性品系均有花期延遲、株高矮、第一與第二節間變短，花穗突出不良以及老化延遲現象，顯示這些性狀與雄不稔性之細胞質有關。然而，細胞質雄不稔性品系與其同源維持系之間，在節間數目上並無不同，但由於雄不稔性品系第一節間明顯地較短，第一節間在稻稈長度上所佔比率也相對地減少，這些現象可能是造成植株較矮、花穗突出不良，以及開花較慢的原因。相續節間長度之明顯正相關情形，顯示這些節間可能發育於同一時期。