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DETERMINATION OF LODGING CHARACTERS OF SOME BRRI RECOMMENDED RICE VARIETIES AT THREE NITROGEN LEVELS DURING WET SEASON IN BANGLADESH

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Key words: Lodging character, Rice, Nitrogen level, Wet season

Abstract

Lodging characters including morphological, anatomical and physiological features of some BRRI recommended rice varieties at three nitrogen levels were studied. Basal internode elongation with thin internode wall is the most important character for lodging. Moment, culm strength and nature of wrapping of the leaf sheath are also important for lodging. Lower moment, higher culm strength and tightly wrapping of the leaf sheath make a variety tolerant to lodging. These characters are greatly influenced by nitrogen application which is more remarkable for lodging susceptible varieties. Lower nitrogen and higher potassium contents in internode help to decrease the lodging tendency of a variety. Rice anatomy is also important for identifying lodging susceptible and tolerant varieties. Results revealed that lodging susceptible variety like BRRI dhan 32 has bigger and higher number of intercellular space and lower number of vascular bundles in the culm. According to the lodging tendency, it appears that BRRI dhan 32 is a lodging susceptible variety whereas, BRRI dhan 37, BRRI dhan 38, BR 11 and BR 6110 are semi susceptible, semi tolerant and lodging tolerant varieties, respectively.

Introduction

Rice is a staple food in many countries of the world including Bangladesh. It grows in all the three crop-growing seasons of Bangladesh and occupies about 77% of the total cropped area of about 13.9 million hectares. It constitutes about 92% of the total food grains produced annually in the country and provides a sense of food security of the people (Bhuiyan *et al.* 2002). The average rice yield at farmers level is about 2.0 - 2.5 t/ha while the average rice yield at farm/research level is about 4.5 to 5.0 t/ha (BRRI 2001). Several problems are responsible regarding the yield gap in which lodging is one of the major problems associated with low yield at wet season.

Lodging of rice plants is caused mainly by the action of wind and rain. Culm of rice plants becomes weakened under heavy application of nitrogenous fertilizers, deep submergence, sunlight deficiency (Kono 1995). Lodging tends to occur in vigorously growing plants after heading, when ripening progresses and panicles drop. Chang (1964) reported that, lodging, prior to harvest results in appreciable losses in both quality and quantity of rice. He also mentioned that lodging limits the possibility of increasing rice yields through heavy fertilizer application and dense planting. Yoshida (1981) reported that tall varieties fail to yield more in response to increased nitrogen applications mainly because they tend to lodge at high nitrogen levels. Therefore, a study was undertaken to determine the lodging characters of six BRRI varieties at different nitrogen levels.

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Materials and Methods

The study was carried out at the Bangladesh Rice Research Institute (BRRI) experimental farm during T. Aman season (wet season) of 2003. Thirty-day-old-seedlings of four BRRI recommended modern rice varieties - BR 11, BRRI dhan 32, BRRI dhan 37 and BRRI dhan 38 and one BRRI promising line BR 6110 were transplanted in micro plot (1 m^2) replicated 3 times. Three levels of nitrogen, namely 0, 60 and 120 kg N/ha were used. Combination of varieties and nitrogen levels were arranged in Randomized Complete Block Design. Twenty × 20 cm spacing were maintained and two seedlings were transplanted in each hill. Twenty five hills were accommodated in each micro plot. Other fertilizers such as TSP, MP and gypsum except urea were applied as basal dose. Normal cultural practices and plant protection measures were taken as and when necessary.

Plants of three hills were collected from each plot at heading to milk stage when the rice plant is more vulnerable to lodging. At first, three median tillers were selected from each selected hill and data were collected from these selected individual tillers. The final data represent the average value of three selected median tillers from each plot. Internode length from basal to 8th internode, internode thickness and total internode length at different nitrogen level for each variety were measured by using scale and slide calipers. Culm strength was measured by lodging meter. Wrapping score was done by visual observation. Moment was computed by multiplying internode length with internode weight.

For measuring the culm strength, the selected plant slanted into 45° by artificial pressure created by lodging meter. This pressure was counted as culm strength. Lodging co-efficient was computed by the formula of Seco (1960).

Data were subjected to analysis of variance and the means were compared by DMRT (Gomez and Gomez 1984).

Results and Discussion

Internode elongation: There was no significant difference in internode elongation among the varieties up to 3rd internode, but differed significantly from the 4th internode onward. The longest internode was found in between 4th and 8th in BRRI dhan 32 and the shortest internode was found in BR 11 and the latter was identical to BR 6110 (Fig 1). At high nitrogen level, elongation of basal internode specially 4th and 5th internodes was maximum in BRRI dhan32 than those of other varieties. Fig. 2 showed the effect of nitrogen on internode elongation. Among the varieties there were no significant difference between the 0 and 60 kg N/ha except in BRRI dhan 32, where the length of internode increased significantly up to 60 kg N/ha and no significant difference was found between 60 and 120 kg N/ha. Yoshida (1981) found positive response of nitrogen fertilizer and reported that elongation of the lower internodes caused by heavy nitrogen application, which are essential for high yield, make the plant more susceptible to lodging.

Internode thickness: Internode thickness is one of the most important characters of a rice variety for lodging resistance. Results obtained showed that the thickness of internode gradually decreased with the increase in internode number except 2nd internode in BR 11 (Fig. 3). However, beginning from the 1st internode, thickness of internode was highest in BR 6110,

which was followed by BR 11 and BRRI dhan 38. The lowest internode thickness was found in BRRI dhan 32. Varieties having thin basal internode are vulnerable to lodging. Remarkable effect of nitrogen on internode thickness was found in BRRI dhan 32 and BRRI dhan 37. The thickness of internode wall decreased with the increase of nitrogen fertilizer (Fig. 4). Internode of BRRI dhan 32 and BRRI dhan 37 become thinner than those of other varieties at high amount of nitrogen fertilizer. It might be due to the increase in outer diameter of culm accompanied by a larger increment in inner diameter when high level of nitrogen fertilizer were added, resulting in thinner culm, smaller culm areas. As a result, plants are lodged at high level of nitrogen fertilizer. Chang (1964) found similar results and reported that the culm become thin and slenderness ratio becomes large at high nitrogen level.

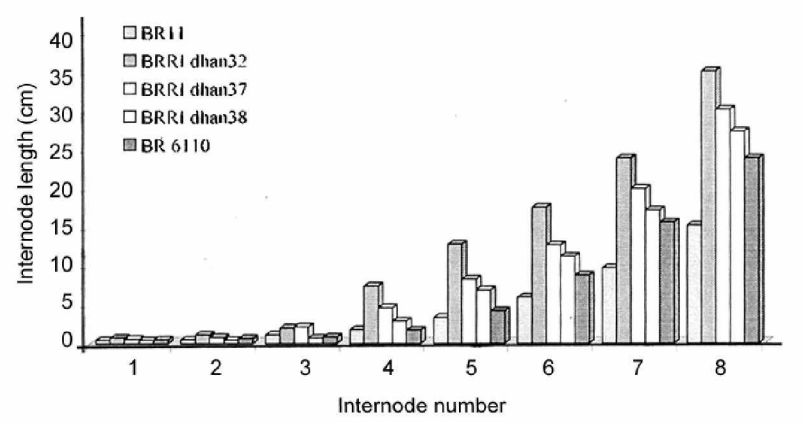


Fig. 1. Internode length of eight basal internodes of five BR varieties/lines.

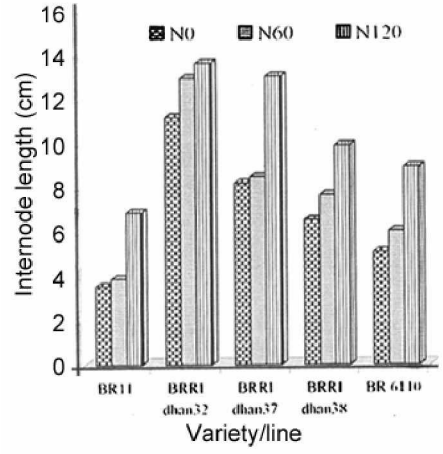


Fig. 2. Internode length of five BR varieties/ lines at different nitrogen levels.

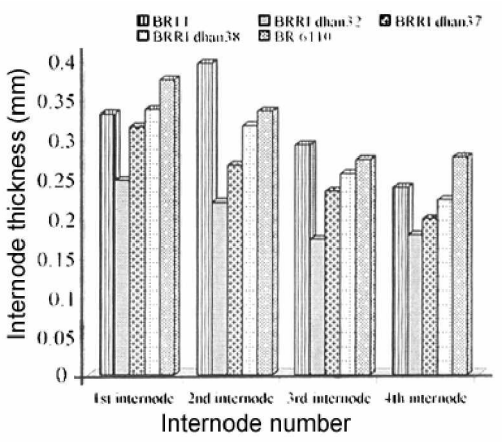


Fig. 3. Internode thickness of five BR varieties/ lines.

Moment: Moment is the product of internode length and internode weight of a plant. The higher the moment the more is the potentiality of a variety to lodge. The moment value of BR 11 was the lowest among the varieties in all the nitrogen levels and BRRI dhan 32 and BRRI dhan

37 produced higher moment irrespective of different nitrogen levels. In a variety, moment value was affected by nitrogen application (Fig. 5). The result showed that with the increase of added nitrogen, moment of all varieties gradually increased. The highest moment was found in BRRI dhan 37 at 120 kg N/ha level which was statistically similar to BRRI dhan 32 and the lowest value was found in BR11 at 0 kg N/ha. It might be due to the increase in elongation of internode at higher nitrogen level.

Culm strength: Culm strength is an inherent character. Generally when a plant has more culm strength it has more resistance to lodging. Results obtained showed that culm strength gradually decreased with the increase of nitrogen fertilizer in all the varieties. The highest culm strength was found in BR 11 and the lowest value of culm strength was found in BRRI dhan32 at different nitrogen level (Fig. 6). It might be due to increase in internode length and decrease in culm thickness at high nitrogen level, which is more evident for BRRI dhan32 and BRRI dhan37. According to the culm strength, BRRI dhan 32 lodged completely at maturity stage followed by BRRI dhan 37 and BRRI dhan 38 and, BR 11 and BR 6110 did not lodge.

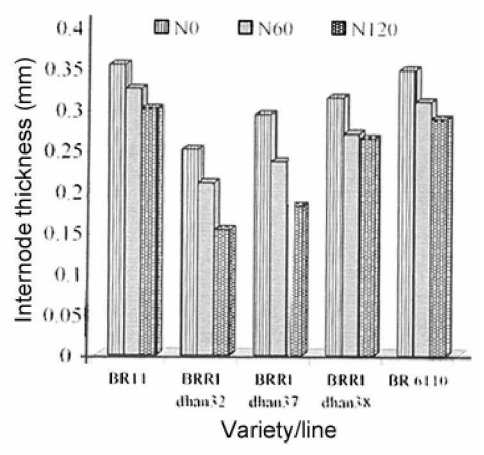


Fig. 4. Internode thickness of five BR varieties/ lines.

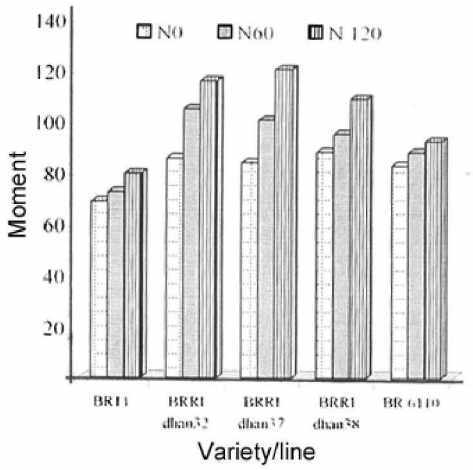
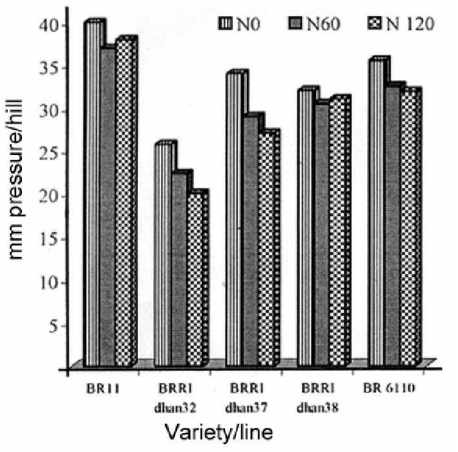


Fig. 3. Moment of 5 BR varieties/lines.



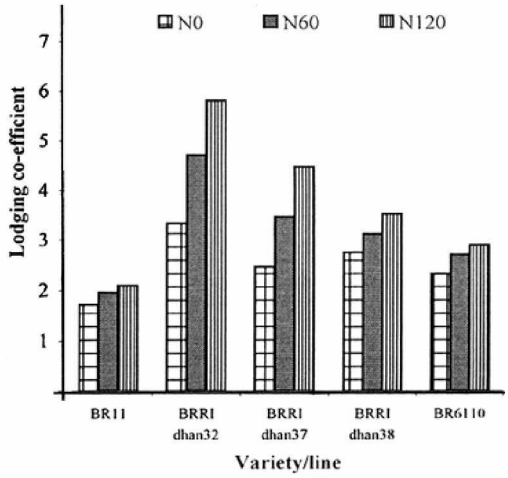


Fig. 6. Culm strength of five BR varieties/lines at different nitrogen levels.

Fig. 7. Lodging co-efficient of five varieties at different nitrogen levels.

Leaf angle: Leaf angle is associated with the efficient utilization of solar energy, erect leaves favouring the deep penetration of light with a minimum of mutual shading even at high leaf area index values. Results showed that BRRI dhan32 had the highest leaf angle and BR6110 had the lowest angle (Table 1). Leaf angle of all the varieties had significant response to added nitrogen. Leaf angle increased significantly up to 60 kg N/ha except in BRRI dhan 38 and BR 6110 and, then significant results were not found at 120 kg N/ha level (Table 1). At high nitrogen levels, vigorous plant growth occurred, leaves become long and droopy and which was more evident in BRRI dhan32. These droopy leaves collect more raindrops overloading the culm and thereby rice plants lodge. Similar results were found by Yoshida (1981).

Table 1. Leaf angle of first three leaves of five BR varieties/lines at different nitrogen levels.

Variety/Line	Leaf angle (degree)		
	0 kg/ha	60 kg/ha	120 kg/ha
BR 11	20.33 dB	22.56 dA	23.78 dA
BRRI dhan 32	46.22 aB	51.11 aA	51.89 aA
BRRI dhan 37	30.67 bB	33.56 bA	34.11 bA
BRRI dhan 38	23.78 cB	25.22 cB	31.89 cA
BR 6110	19.00 dB	19.89 eB	22.89 dA
CV (%) = 6.6	LSD (005) =1.889		

Means followed by same letters in a vertical column do not differ at 5% level.
Capital letter = Difference among nitrogen levels and small letter = Varietal difference.

Wrapping score: Culm is covered by leaf sheath. The culm strength depends on the tightness of wrapping freshness and turgor of sheath. Leaf sheath wrapping vary among the varieties. Variety having high score of wrapping is resistant to lodging. Result showed that 1st and 2nd leaf

Table 2. Wrapping score of five varieties/lines at different nitrogen levels.

Variety/line	N fertilizer dose (kg/ha)	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	Total wrapping score
BR 11	0	9	9	9	7	5	3	42
	60	9	9	7	5	5	1	36
	120	9	9	7	5	5	1	36
BRRI dhan 32	0	9	9	7	5	1	1	32
	60	9	9	7	5	1	1	32
	120	9	7	5	3	I	1	26
BRRI dhan 37	0	9	9	7	5	5	1	36
	60	9	9	7	5	5	1	36
	120	9	9	7	5	5	1	36
BARI dhan 38	0	9	9	7	7	5	1	38
	60	9	9	7	5	3	1	34
	120	9	9	7	5	1	1	32
BR 6110	0	9.	9	7	5	5	3	38
	60	9	9	7	5	3	1	34

120 9 . 9 7 5 3 1 34

1 = Non or slightly wrapping. 3 = < 50 % partial wrapped. 5 = > 50% partial wrapped. 7 = Full wrapping. 9 = Over wrapping.

sheath wrapping at the basal portion of all the varieties was similar except in BRRI dhan32 at 120 kg N/ha level. Total score of wrapping was the highest in BR 11 and the lowest in BRRI dhan 32 (Table 2). It might be due to genetic make up of a variety.

Lodging co-efficient: Lodging co-efficient is the ratio of moment and culm strength. Generally the higher the lodging co-efficient the more is the potentiality of a variety to lodge. Irrespective of the different nitrogen levels, BRRI dhan 32 had higher lodging co-efficient followed by BRRI dhan 37 and the lowest was found in BR 11 (Fig. 7). Lodging co-efficient increased with the increase of fertilizer application rate. It was more applicable in case of lodging susceptible varieties like BRRI dhan 32 and BRRI dhan 37.

Nitrogen content of internode: There was no significant difference in nitrogen content among the varieties up to 3rd internode and the significant difference were found from the 4th internode and onward. In 4th to 6th internode, higher amount of nitrogen content was found in BRRI dhan 32 and BRRI dhan 37 and, lower amount of nitrogen content was found in BRll, which was similar to BRRI dhan 38, and BR 6110 (Table 3). Table 4 showed that BRRI dhan 32 had the highest nitrogen content among the varieties even at 0 kg nitrogen level. Nitrogen content of increased with the increase of nitrogen fertilizer all the four varieties. It is known that lodging susceptible varieties generally have the high nitrogen content in internodes. High nitrogen content stimulates the elongation of internode length and reduces the internode thickness.

Table 3. Nitrogen content in basal six internodes of five BR varieties/lines.

Variety/line	N content (%)					
	1st internode	2nd internode	3rd internode	4th internode	5th internode	6th internode
BR 11	0.65 A	0.60A	0.62 A	0.46 B	0.39 B	0.43 B
BRRI dhan 32	0.82 A	0.73 A	0.70 A	0.74 A	0.79 A	0.74 A
BRRI dhan 37	0.81 A	0.87 A	0.65 A	0.79 A	0.67 A	0.74 A
BRRI dhan 38	0.77 A	0.71 A	0.60 A	0.35 B	0.39 B	0.45 B
BR 6110	0.70 A	0.66 A	0.57 A	0.45 B	0.39 B	0.46 B
CV (%) = 4.7			LSD (005) = 0.276			

Means followed by same letters in a vertical column do not differ at 5% level.

Potassium content of internode: The highest amount of potassium content was found in BR 11 among the varieties at 120 Kg N/ha, which was statistically similar to BR 6110. The lowest amount of potassium content was found in BRRI dhan 37. Different nitrogen levels remarkably influenced potassium content of internode. The potassium content of BRRI dhan 37 decreased with the increase of nitrogen fertilizer application, but not in other varieties (Table 4). The culm's mechanical strength is increased by potassium applications, which increase its thickness (Noguchi 1940) and maintain high turgor pressure in the cells (Kono and Takahashi 1961 b).

Anatomical feature: A single layer epidermis with moderately thick cuticle was found in all the varieties except in BRRI dhan 32 (Fig. 8). Vascular bundles were broadly arranged in two rows, the outer small and the inner large. BRRI dhan 32 had comparatively lower number of vascular bundles than those of the other varieties. No lacunae within the culm were found in BR 11. However, BRRI dhan 32 exhibited very wide lacunae in the culm resulting in very low culm strength. Chang (1964) reported that lodging-resistant varieties generally have higher number of vascular bundles in the culm and a high percentage of outer vascular bundles are fused with the sclerenchyma and compact parenchyma cells in the culm and fewer or smaller lacunae within the culm.

Table 4. Nitrogen and potassium content of five BR varieties/lines at different nitrogen levels.

Variety/Line	N content (%)			K contents (%)		
	0 Kg/ha	60 Kg/ha	120 Kg/ha	0 Kg/ha	60 Kg/ha	120 Kg/ha
BR 11	0.472 bA	0.584 aA	0.684 aA	1.057 a A	0.967 ab A	0.930 ab A
BRRI dhan 32	0.660 aB	0.693 aB	0.857 aA	0.943 a A	0.723 b A	0.733 c A
BRRI dhan 37	0.598 bB	0.742 aA	0.908 aA	0.997 a A	0.777 b B	0.720 c B
BRRI dhan 38	0.42 I bA	0.569 aA	0.646 aa	1.087 a A	1.0 lOa A	0.807 bc B
BR 6110	0.495 bA	0.506 aA	0.693 aA	1.070 a A	0.967 ab A	0.943 ab A
CV (%) = 4.7	LSD (0.05) = 0.195			CV (%) = 12.4		LSD (0.05) = 0.20

Means followed by same letters in a vertical column do not differ at 5% level.
Capital letter = Difference among nitrogen levels and small letter = Varietal difference.

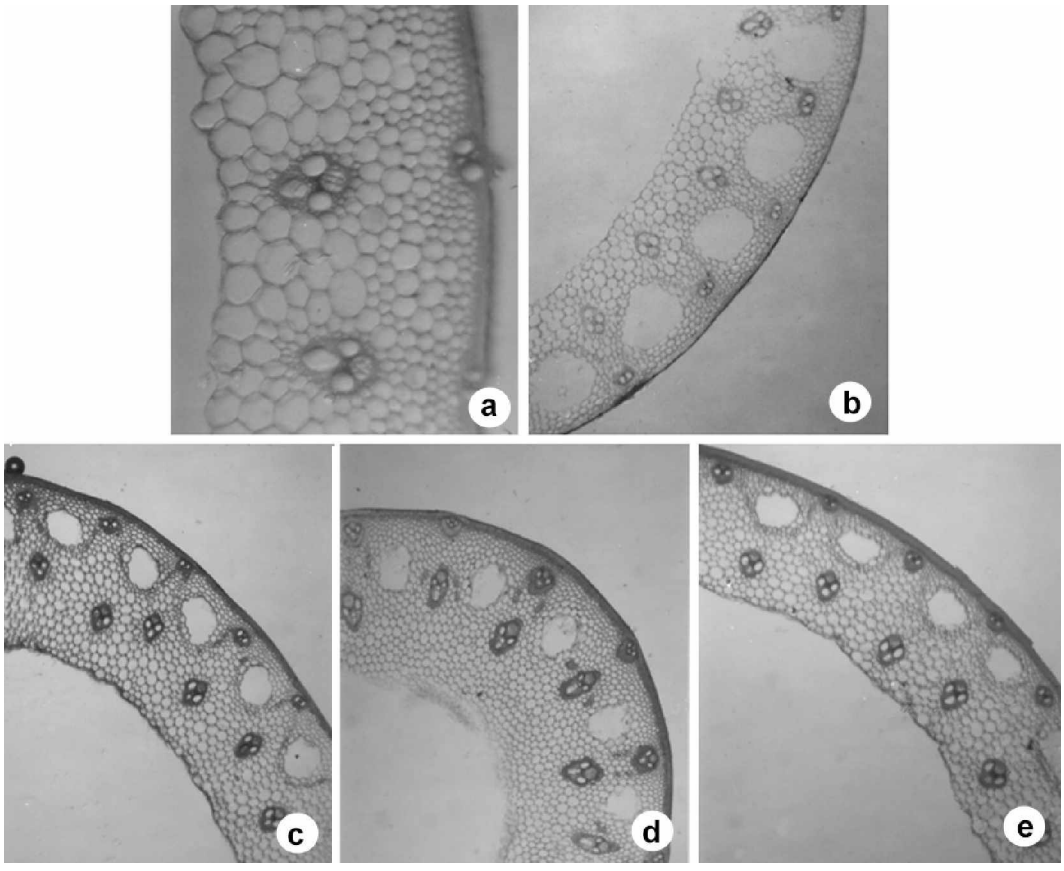


Fig. 8. Transverse section of five BR varieties/line. (a) BR 11, (b) BRRI dhan 32, (c) BRRI dhan 37, (d) BRRI dhan 38 and (e) BR 6110.

Thus the results obtained during this investigation and also by others show that:

* Internode thickness, moment, nature of leaf sheath wrapping, nitrogen content and anatomy of the lower internode are most important characters to identify the lodging susceptible or tolerant varieties in rice.
* BR 11 and BR 6110 have been found to be lodging tolerant varieties, BRRI dhan 38 is a semi tolerant variety, BRRI dhan 37 is a semi susceptible variety and BRRI dhan 32 is a lodging susceptible variety in T. Aman season grown in Bangladesh.
* Higher nitrogen increased the lodging problem, heavy nitrogen should not be used in case of lodging susceptible variety like BRRI dhan 32.

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