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Inheritance of Lodging Character in Rice

by

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Synopsis: The results obtained from a study of the inheritance of lodging in crosses involving two improved Madras strains TKM. 6 and Co. 29 with type 265 from Java and type 2236 from Australia are reported. "Lodging" was dominant over "non-lodging" in F_1 and the segregation in the F_2 indicated monogenic inheritance of this character, which was in confirmity with the previous finding of Ramiah. The results of this study will enable the rice breeders to evolve suitable breeding techniques for the evolution of non-lodging paddy strains.

Introduction: Lodging of straw is a phenomenon met with in rice especially so with many *indica* varieties. Most of the improved short duration strains of paddy, released by the State department of Agriculture, get badly lodged when the crop is supplied with optimum or slightly higher doses of nitrogenous manures. Depending upon the stage of the crop at which lodging occurs as well as its intensity, the loss of grain in rice has been estimated to vary from 18 to 60 percent (Subbiah Pillai and Parasuram 1956). Breeding for non-lodging varieties of rice has been engaging the attention of the rice breeders of the State for the past 30 years. Realising the importance, the Food and Agricultural Organization of the UNESCO has undertaken a Co-ordinated project viz., the *japonica* x *indica* hybridization project in 1950–'51 for the evolution of non-lodging and heavy yielding paddy strains and suitable for the different South East Asian Countries. Except for the work of Ramiah and Dharmalingam (1934) no inheritance studies on the 'lodging' of rice appears to have been done. A study was therefore made on this aspect and the results obtained are presented in this paper.

Review of Literature: Biffen and Engledow (1926) recorded a great diversity of straw types among the progenies of intervarietal crosses of *Triticum vulgare*. Nilson Ehle (1923) in wheat and Berg (1926) in oats have reported transgressive segregation in straw stiffness (Ramanujam 1950). Howard and Howard (1912) found enough evidence for distinct segregation for straw strength in a wheat hybrid. Waldron (1926) found the F_1s of crosses between Marquish and Kota wheats to be intermediate between the parents in straw strength. Kilduft (1930) studying two Kota wheat crosses

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found straw strength to be influenced by multiple factors with transgressive segregation in the direction of the weaker parent. Torrie (1936) studying the F_3 population of two wheat crosses concluded that polymeric factors might possibly control the lodging character. Goulden and Neatby (1929) and Goulden and Elder (1926) found that weak straw and resistance to Stem rust in wheat were genetically linked. Clark *et al* (1928) have reported genetic association between awnedness and tendency to lodge. Boyce (1948) studying a varietal cross in *Triticum vulgare* found the character for strong straw to be partially dominant and might be governed by one to many genes. In Corn, Hayes and Maclelland (1928) reported that the F_1 plants had a lodging index near the mean of the two inbred parents and concluded that in Corn, angle of lodging and pulling resistance to be heritable and possibly controlled by many factors. Jenkins and Gerhard (Hall 1934) reported a lazy gene that was responsible for lodging in Corn. Ramiah and Dharmalingam (1934) reported lodging in rice to be dominant, being governed by a single gene *Ld*. Coleman and Strokes (1958)found in a sorghum cross erect stalk was inherited as a single dominant (EE) to the weak stalk (ee).

Material and Methods: (i) *Materials:* Two high yielding, short duration strains, with lodging habit viz., TKM. 6 and Co. 29, released by the Madras Agricultural Department were taken for the study. From a personnel survey of the records of about 950 short duration rice varieties maintained in the 'germ plasm' bank at the Paddy Breeding Station, Coimbatore, two non-lodging types viz., T. 265 (Java) and T. 2236 (Australia) were selected as non-lodging parents.

The important characteristics of the four types are as follows:

Particulars	TKM. 6	Co. 29	T. 265	T. 2236
1. Place of origin	Strains released by the Madras Agricultural Department		Java	Australia
2. Duration in days	110	115	120	120
3. Height (in centimeters)	122·5	130·0	140·0	135·0
4. Productive tillers per plant (Mean)	9·1	8·9	4·4	4·1
5. Straw character	Lodging with one or two culms breaking at the first or second internodes or both above ground level even before the plants get matured with the least disturbance.		Very stiff and thick straw and tends to remain erect even after ripening.	

(ii) *Methods:* (a) *Hybridization:* The seeds of the four parents collected from selfed single plants were first treated with Agrosan to control any seed borne fungus and then they were soaked in water and drained the next day. Then on the third day, the sprouted seeds were sown in nursery beds ($2' \times 1\frac{1}{2}'$) manured with green leaf at the rate of 10,000 lb. per acre. The seedlings were transplanted on the 25th day after sowing. The spacing adopted was 2' between rows and one foot between plants so as to facilitate hybridization work. Single seedlings were planted for each hole. After studying the plants for the parental characters, ten plants were marked for use as the pollen and ovule parents. Hybridization was effected as per the method described by Ramiah (1953). On the 30th day, when the hybrid seeds would have completely matured, they were collected, sun-dried and preserved in a glass bottle till the sowing time.

(b) *Raising of F_1:* The F_1 seeds which were kept in bottles separately were sown in the seed pans along with their respective parents. Separate seed pans were used for each cross and their parents. The seedlings were pulled out carefully on the 25th day after sowing and were transplanted in lines, one foot between rows and plants, with single seedling per hole. The field was not manured to avoid the interference of high fertility on the lodging behaviour of the material under study. The seeds from each F_1 as well as the parents were collected separately and preserved.

(c) *Raising of F_2:* The seeds of F_2 families along with their parents were sown in nursery beds ($4' \times 4'$) and were transplanted. The field trials were laid out in a replicated randomised design in strips of $3' \times 20'$ size with a spacing of 6" in the row and 12" betwen rows with single seedling per hole.

(d) *Method of observation:* In the case of F_1 hybrids, since the number of plants were limited, all the available plants were studied, while in the parents, 25 plants selected at random were taken as a minimum number. In the case of F_2 population all the available plants were taken into consideration in each family for recording the lodging nature of the straw. The date of flowering for each plant was marked so as to facilitate easy observation of lodging character subsequently. All those plants which stood erect even after the grains have reached complete maturity were taken as non-lodged and the rest as lodged. The angle of lodging was not taken into consideration since the lodging in most plants were beyond 30° from the vertical on the 30th day after flowering. Since there was segregation for duration in the F_2 population, lodging observations were made frequently viz., once in two days.

Experimental results: (i) *Hybridization:* The two lodging strains were used as the ovule parent and the non-lodging types as the pollen parent. The details of the crosses effected are furnished below:

Nature of cross	No. of crosses effected	No. of hybrid seeds obtained	No. of F_1 hybrids studied	F_2 Studied	
				No. of Families	No. of Plants
TKM. 6×T. 265	74	6	4	2	810
Co. 29×T. 265	49	4	2	2	764
TKM. 6×T. 2236	75	8	5	2	686
Co. 13×T. 2236	29	5	3	2	712

(ii) *Behaviour of F_1:* A considerable amount of hybrid vigour was noticed in all the F_1 plants particularly in height and number of productive tillers. The flowering dates were nearer the early maturing parents. In these F_1 hybrids, most of the tillers in each F_1 plant lodged, indicating the dominant nature of the 'lodging' character.

(iii) *F_2 results:* Segregation was observed for lodging habit and the details of the phenotypic segregations in individual crosses are furnished below:

1. TKM. 6×T. 265. (Pooled data from two families)

Family	Phenotype		Total
	Lodging	Erect	
1	302	76	378
2	316	116	432
Total	618	192	810

X^2 and probability of the above cross

Sl. No.	Phenotype	Population Observed	Population Expected on 3:1 ratio	Deviation + or −	$\frac{d^2}{e}$	χ^2
1.	Lodging	618	607·5	+ 10·5	0·1815	
2.	Erect	192	202·5	− 10·5	0·5444	0·7259

There was clear cut segregation for lodging and non-lodging, the former being dominant. The probability level was between 30 to 50% and thus accorded well with expectations on the basis of monogenic segregation.

2. Co. 29 × T. 256. (Pooled data from two families)

Family	Phenotype		Total
	Lodging	Erect	
1	271	103	374
2	283	107	390
Total	554	210	764

X^2 and probability of the above cross

S. No.	Phenotype	Population Observed	Population Expected on 3 : 1 ratio	Deviation + or −	$\frac{d^2}{e}$	X^2
1.	Lodging	554	573	− 19	0·4531	
2.	Erect	210	191	+ 19	1·3665	1·8196
	Total	764	764			

In this cross also, monogenic segregation has been obtained, the probability level being 10 to 20%.

3. TKM.6 × T.2236. (Pooled data from two families)

Family	Phenotype		Total
	Lodging	Erect	
1	250	84	334
2	258	94	352
Total	508	178	686

X_2 and probability of the above cross

S. No.	Phenotype	Population Observed	Population Expected on 3 : 1 ratio	Deviation + or −	$\frac{d^2}{e}$	X^2
1.	Lodging	508	514·5	+ 6·5	0·0820	
2.	Erect	178	171·5	− 6·5	0·2463	0·3283
	Total	686	686·0			

The data presented in the above table accords well with 3 : 1 segregation with a probability level of 50 to 70%.

4. Co. 29 × T. 2236 (Polled data from two families)

Family	Phenotype		Total
	Lodging	Erect	
1	268	82	350
2	272	90	362
Total	540	172	712

X^2 and probability of the above cross

S. No.	Phenotype	Population Observed	Population Expected on 3 : 1 ratio	Deviation + or −	$\frac{d^2}{e}$	χ^2
1.	Lodging	540	534	+ 6	0·0674	
2.	Erect	172	178	− 6	0·2022	0·2696
	Total	712	712			

In this cross also, expectations on the basis of monogenic segregation have been realised.

Discussion: Lodging in rice as in the case of other cereals is known to be controlled both by hereditary and environmental factors. Based on genetical studies, Ramiah and Dharmalingam (*loc cit.*) concluded that a single factor controlled lodging which was inherited in a dominant fashion. The gene symbol *Ld.* was assigned for this character by Kadam and Ramiah (Ramiah 1953). It is interesting to note that unlike in the case of wheat, oats and corn, where lodging is known to be governed by multiple factors, lodging in rice is controlled by a single gene. Ramiah and Dharmalingam (*loc cit.*) used the Burmese types as the non-lodging parent in their inheritance studies and apart from this record, there appears to be no further study regarding the inheritance of lodging in rice, in recent years.

The results obtained in the present study involving TKM. 6 and Co. 29, two improved strains released by the Madras State Department of Agriculture which are known to be lodging types, in their crosses with non-lodging parent types from Java (T. 265) and Australia (T. 2236), are therefore considered important. The inheritance of lodging habit has been found to be controlled by a single dominant gene in the crosses studied now, based on the segregations for this character observed in the F_2. It would, therefore be possible to isolate a non-lodging selection from the derivatives of the above crosses either by further line breeding or by adopting a judicious back crossing programme, if necessary. Bhide (1960) has obtained good results in isolating non-lodging barley types by adopting a back-crossing

programme. The results of this study likewise will enable the rice breeders to evolve suitable breeding techniques for the evolution of non-lodging paddy strains.

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