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Cytoplasmic inheritance of variegation in bajara, the pearl millet *(Pennisetum Typhoides Stapf and Hubbard)*

by

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Introduction: In the course of field studies on pearl millet (*Pennisetum typhoides* Stapf and Hubbard) an interesting morphological variation viz., white striping of leaves in some plants was observed. Plants with albinotic stripes with varying intensities were observed in three inbred lines. Similar variegation has been studied in Gramineae in the genus *Zea* (Anderson, 1923; Demerec, 1927), *Sorghum* (Karper, 1934), *Hordeum* (Imai, 1936), *Avena* (Love *et al*, 1936), *Oryza* (Pal *et al* 1941) and *Triticum* (Pao *et al*, 1946). The occurrence and inheritance of variegation in the pearl millet has not been reported so far, though chlorophyll deficiencies as albinos and albino-stripes have been recorded (Krishnaswamy *et al*, 1942). Detailed studies of variegation in pearl millet have been made and presented in this paper.

Previous Work: The discovery of cytoplasmic inheritance in 1909 by Correns (1909) in Mirabilis and by Baur (1909) in Pelargonium evoked considerable interest in different aspects of heredity and the years that followed witnessed a large number of such instances in various crops. In maize, Anderson (1923) and Demerec (1927) have described four cases of cytoplasmically inherited chlorophyll variegation. Karper (1934) has described in detail a case of cytoplasmic inheritance of variegation in sorghum. He has traced striping upto the panicle and has shown evidence that the pattern of striping in the panicle determines the type of progeny. A definite non-randomised occurrence of the white and green spikelets in the panicle has been observed. The white spikelets in the striped area produce white plants only, even when fertilised with pollen from normal green plants and that normal green plants pollinated with pollen from white spikelets produce green plants only. Imai (1936) has recorded in barley an instance of maternal inheritance of yellow and white plastids which arose by the mutation of green plastids through genic action. Love *et al* (1936) in their studies on the variegation of Oats, have observed that the behaviour of chlorophyll deficiency was apparently cytoplasmic in nature. In rice, Pal *et al* (1941) have recorded that variegation is a mendelian recessive to

green and that albinism is transmitted through the mother only Pao *et al* (1946) have noted an instance of material inheritance o yellow-striped plant in wheat. They have recorded that pur breeding, truly variegated lines were not isolated.

Material and methods: Over three hundred pure lines isolatec from varieties of different geographical origin are maintained at th Millets Breeding Station, Coimbatore. Out of them, the stripec plants were noted in the following three inbred lines.

S. No.	Number of inbreds		Place of origin
1.	P. T. 827/2	...	Kottapuli Cumbu, Salem
2.	P. T. 826/4	...	Kullan Cumbu, Salem
3.	M. S. 6356/12	...	A variety of Bajri, Madhya Pradesl

The details of stripes were studied in these lines.

Another set of three inbred lines which were found to be pur for green progenies during five generations of selfing were chosen and were hybridised with the striped plants to study the inheritance o this character. The details of these inbreds are as below :—

S. No.	Number of inbreds		Place of origin
1.	P. T. 820/6	...	Emari sajja, Chittoor
2.	P. T. 829/5	...	Arisi Cumbu, Coimbatore
3.	P. T. 841/9	...	Bajiri, Sind

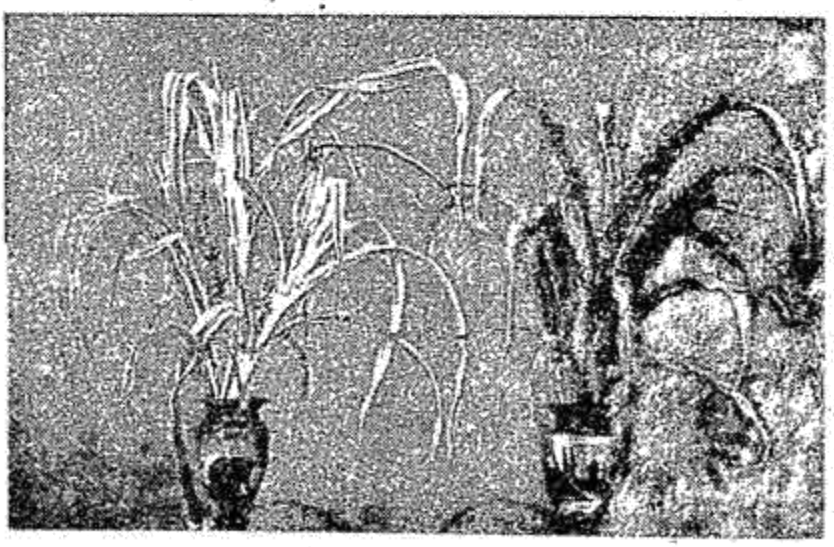

FIG. 1.
A striped and a normal green plant of the pearl millet.

he striped and green plants from the segregating lines were selfed and the behaviour of the progenies were observed. Reciprocal crossess of striped plants with green plants (both homozygous and heterozygous parents) were made and the inheritance of the striping was studied in the F_1 and F_2 generations.

Further, white spikelets of the striped panicle and green spikelets of pure green panicle were hybridised, reciprocally and the behaviour of striping was studied in the subsequent generations.

Transverse section of the striped leaf was taken and the arrangement of chloroplast was also studied.

Experimental data : *Experiment No. 1. Study of the striping charactor.* The striping is marked as white longitudinal lines along the entire leaf blade and sheath also (Photographs). Stripes have been found to occur even in the seedling (first) leaf itself. It is more marked in the later formed leaves where the width of the stripes vary from 0·01 cm. to the entire breadth (4·5 cms) of the leaf. The white stripe takes it origin from each node near the axillary bud and runs along the groove in the internode. On the leaf sheath it takes the route along the margins and finally travels along the leaf blade. In heavily striped plants, the stripes travel up to the panicle along the peduncle and all the spikelets arising from the stripes are completely white. Transverse section of the striped leaf, when examined shows that the white stripe is completely devoid of green plastids, although the cells are packed with colourless bodies.

Regarding tillers many of them were found to be striped, few of them green and still fewer completely white (Table–I).

TABLE I

Striped Plants Sl. No.	Total No. of Tillers.	Nature of Tillers		
		Green	Striped	Albino
1.	5	1	3	1
2.	3	...	3	...
3.	3	1	2	...
4.	4	...	3	1
5.	4	1	3	...
6.	3	...	3	...
7.	3	...	2	1
8.	3	1	2	...
9.	5	...	5	...
10.	2	...	2	...
Total	35	4	28	3

The striped plant shows poor development and a heavily striped plant seldom reaches half the normal height. In such cases the tillers do not produce any panicle. The white stripes continue to remain so and they do not turn green later on. Some of the striped plants expressed definite demarcation between the white and the green patches. This demarcation was seen in the panicle also. Seeds collected from the spikelets marked at the time of flowering as green, striped and albino based on the appearance of the maternal tissue in the spikelets, were sown and the behaviour of the progenies was observed. It was seen that the type of seedlings produced agreed with the expression of the parental tissue. The data are presented in Table–II.

TABLE II

S. No.	Panicle Number	Seeds taken from the type of spikelets	Character of seedlings obtained
1.	P. T. 827/2	(i) 6 green	6 green
		5 striped	one green + 4 striped
		5 white	5 white
2.	P. T. 827/2	(ii) 5 green	5 green
		7 striped	5 striped, one green + one white
		4 white	4 white
3.	„	(iii) 5 green	5 green
		4 striped	4 striped
		4 white	4 white
4.	P. T. 826/4	(i) 6 green	6 green
		5 striped	3 striped, one green + one white
		4 white	4 white
5.	P. T. 826/4	(ii) 5 green	5 green
		6 striped	6 striped
		5 white	5 white

Experiment No. II. During the year the striping was noted, striped and green plants in P. T. 826/4 and P. T. 827/2 were selfed and the segregation noted in the subsequent generations are presented in Table III.

TABLE III.

S. No.	No. of the inbreds	Character of the tiller	Character expressed by the progeny			Total
			Green	Striped	Albino	
1.	P. T. 827/2 a	Green	283	...	...	283
2.	„ 827/2-1	Green	312	...	...	312
3.	„ 826/4-4	Green	359	...	...	359
4.	„ 827/2 b	Green	398	129	10	537
5.	„ 827/2 c	Green	265	79	13	357
6.	„ 826/4 a	Green	122	37	9	168
7.	„ 826/4 b	Green	166	47	2	215
8.	„ 827/2-1	Striped	85	15	29	129
9.	„ 826/4-2	Striped	161	27	24	212
10.	„ 826/4-3	Striped	84	23	17	124
11.	„ 826/4-4	Striped	67	44	14	125
12.	„ 826/4-5	Striped	53	45	11	109
13.	„ 827/2-3	Striped	25	24	4	53
14.	„ 826/4-1	Striped	15	6	5	26
15.	„ 827/2-2	Striped	15	20	2	37
16.	„ 826/4-6	Striped	18	6	...	24
17.	„ 827/2-2	Striped tiller with white panicle	No germination		...	...
18.	„ 826/4-6	do.	No germination		...	...

Experiment No. III. In the following seasons reciprocal crosses between plants with different genotypes were made. In each of the crosses two F_1 plants were selected, selfed and the behaviour of the F_2 populations was studied. The data is presented in Table IV. In each plant that was involved in the crosses, a tiller was always selfed and its progenies were studied to know whether it was homozygous or heterozygous.

TABLE IV.

Cross Nos.	Crosses ♀ Parent	x	♂ Parent	F_1	F_2 Green	Striped	Albino
1.	MS. 6356/1	x	P. T. 827/2	(1) green	101	28	5
	Homozygous green		Heterozygous green	(2) green	236	...	...
2.	P. T. 826/4		P. T. 820/6	(1) green	63	23	...
	Heterozygous striped		Homozygous green	(2) green	38	12	...
3.	Reciprocal of Cross No. 2		...	(1) green	48	18	...
				(2) green	43	13	...
4.	P. T. 841/9	x	P. T. 827/2	(1) green	110	34	4
	Homozygous green		Heterozygous striped	(2) green	37	13	...
5.	Reciprocal of Cross No. 4		...	(1) green	63	20	...
				(2) green	55	13	4

Experiment No. IV. Plants with heavy striping were crossed reciprocally with green plants and the results obtained in the F_1 and F_2 populations are presented in Table V.

TABLE V.

Cross Nos.	Crosses ♀ Parent	x	♂ Parent	F_1	F_2 Green	Striped	Albino
6	P. T. 827/2–4 Plant and panicle striped	x	P. T. 841/9 Homozygous green	1 green 15 striped 4 albino	* % @		
7	Reciprocal of cross Nos. 6			(1) green	112	30	7
				(2) green	99	28	6

TABLE V *(Contd.)*

Cross Nos.	Crosses ♀ Parent	x ♂ Parent	F_2	F_1 Green	Striped	Albino
8	MS. 6356/12–2 Plant and panicle striped	x MS.6356/12–4 Homozygous green	3 green 13 striped 5 albino	* % @		
9	Reciprocal cross No. 8		(1) green (2) green	115 62	31 17	7 5
10	MS. 6356/12–2 Plant and panicle striped	x P. T. 829/5 Homozygous green	3 green 23 striped 17 albino	* % @		
11	Reciprocal of cross No. 10		(1) green (2) green	153 140	46 35	12 12

* These green plants show poor vigour and produce green plants only.

% The segregation of these plants is determined by the extent of striping.

@ These albino plants die after a few days of germination.

Experiment No. V.: In order to study the breeding behaviour of the white plastids the following crosses were made and the progenies studied.

(i) white spikelets in a striped panicle were pollinated with pollen from a pure green plant.

(ii) Similarly a reciprocal cross viz., the green spikelets of the green plant was pollinated with the pollen from the white spikelets.

The data is presented in Table–VI.

TABLE VI

Cross Nos.	Crosses ♀ Parent	♂ Parent	F_1	F_2 Green	Striped	Albino
12	P. T. 827/2 white spikelets only.	x P. T. 820/6 Pure green spikelets.	albinos only	...	...	...
13	Reciprocal of cross No. 12		green	113	47	9

Discussion: The general pattern of the stripe in pearl millet is quite similar for the most part, to that described in Sorghum and Zea Since the emerging leaves from the germinated seeds themselves show the expression of green and white patches, it indicates that the plasmotype of these plastids are determined in the embryonic stage itself. As the striped plants with the normal panicle continuously threw out green, striped and albino progenies similar to the (heterozygous) green plants, it indicates that striping does not breed true to its typo. When the striping extends to the panicles its progenies are green, striped and white in accordance with the location of the parent seed in relation to the presence of the white stripes in the panicle. This indicates that the parental tissue from which the spikelets orginate determines the nature of the progeny.

The behaviour of the selfed progeny of green plants, presented in Table III indicate that the gene for the production of chlorophyll is dominant. When the striped and albino plants are considered as one unit, the ratio between the green progenies and the rest (striped plus albino) approximate to a monogenic segregation. Subsequently these indications were confirmed from the behaviour noted in the F_1 and F_2 progeny of the reciprocal corssess (Table-IV) between homozygous and heterozoygous green planns. Thus it can be reasonably presumed that the albino plants are extreme case of striping.

The difference in the F_1 behaviour of the crosses between the heavily striped and pure green plants (Table V) indicates that the transmission of the striping when the panicles are striped, is purely maternal. This has been again confirmed in the behaviour of the F_1 progeny of the reciprocal crossess between the white and the green spikelets (Table- VI).

Summary: The nature of striping in the pearl millet *Pennisetum typhoides* Stapf and Hubbard) has been described. Striped plants continuously give rise to green, striped and albino plants. when crossed with green plants, the striped plants were found to be a monogenic recessive. The character is carried only through the mother indicating its close affinity with the cytoplasm. In heavily stripped plants the stripe extends to the panicle and the spikelts from the albinotic zone gives rise to albino seedlings. Transverse section of the leaf reveals the white stripe to be completely devoid of chloroplasts.

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