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HYBRID INVIABILITY AND WEAKNESS IN CERTAIN *INDICA* RICE CROSSES*

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The barriers preventing growth and /or reprodudtion of F_1 hybrids are the most widespread among those which seperate plant species. These may be manifested at any stage from the commencement of growth of the hybrid zygote to the maturation of the segregating genotypes in the F_2 generation. During the course of studies on intra-racial *(indica x indica)* hybrid sterility in 0. *sativa* L., an instance of a reproductive barrier in the form of hybrid inviability and weakness was detected in populations of the crosses of PTB 7 with PTB 10 and CO 29- Morphological characteristics, degree of pollen and spikelet sterility and the breeding behaviour of the F_1 and F_2 populations of these crosses are reported in this paper.

Materials and Methods

F_1 plants numbering 41 obtained from crosses of PTB 7 with PTB 10 and Co 29, including the reciprocals, were sown in wet nursery during the mam season, 1970. The plants were afterwards transferred to pots as the hybrid plants were very weak and slow growing. Twelve plants perished before reaching maturity. Hybrid plants were supported as they were weak and lanky and special care was given for their maintenance. Plants of the three parents were also grown along with the hybrids. Selfing was done in 15 of the surviving F_1 plants of the crosses involving PTB 7 and a total number of 59 seeds were obtained from all the four crosses. Out of these, 56 plants were obtained for studies in the F_2 generation. Observations on flowering and fertility were taken from a total number of 42 F_2 plants which came to maturity.

Results and Discussions

The frequency of weak and inviabie plants and percentage of pollen and spikelet sterility of four crosses involving PTB7 and two crosses between PTB 10 and CQ29 are furnished in Table 1. The number of normal plants, weak and inviabie plants, per cent germination in the selfed progenies of the hybrids, flowering duration and the percentage of sterility are given in Table 2. In both generations

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varying percentages of plants in each hybrid combination were inviable or weak. However, plants from crosses of PTB 10 and CO 29 were fully normal in both F_1 and F_2. The growth of seedlings of crosses involving PTB 7 was normal only up to the 4-5 leaf-stage beyond which 29% of the plants were inviable in F_1 and 14.3% in the F_2. The F_1 populations were all either weak or inviable and the percentage of these plants in the F_2 represented 53.6 per cent of the total. The plants showed slow growth and were characterised by poor root development, less tillering, late flowering and by the production of very short panicles with fewer spikelets (Plate 1). Oka (1957) found F_1 lethality in certain of the continental varieties including PTB 7 and PTB 10. Some plants, however, developed to maturity. Reciprocal crosses showed no differences and the tetraploids Of some of the surviving F_1s also were lethal. F_1 inviability and weakness were also reported by Chu *et al.* (1969) and Chu and Oka (1970) in some of the interspecific hybrids on Oryza studied by them.

It is evident from Table 2 that the frequency of weak and inviable plants (13) was more than that of normal plants (9) in the F_2 populations of PTB 10 and almost equal (16 and 17 respectively) in the F_2 of PTB 7 and CO 29. Both sets of populations showed a fit to a ratio of 9 weak/inviable plants to 7 normal plants. Kostyuchenko (1936) observed lethality of F_1 plants, some of the plants matured to produce seeds which in F_2 segregated in a 9:7 ratio of nonviable to viable plants in crosses of spring wheat. Caldwell and Compton (1943) and Heyne *et al.* (1943) also suggested the operation of complementary dominant genes for hybrid inviability and weakness in certain hybrids of winter wheat. Oka (1957) obtained a 1:1 ratio for weak to normal plants in the back cross progenies of four crosses of continental varieties and suggested that the condition of lethality was due to the action of complementary lethal genes. In the present investigation since hybrid weakness was manifested in segregating populations in definite proportions and since there were no reciprocal differences in F_1s, a similar genie basis can be attributed to this abnormal behaviour It can also be suggested that PTB 7 possessed one dominant lethal gene and the two varieties PTB 10 and CO 29 had in common another dominant lethal gene which in interaction with the one in PTB 7 resulted in hybrid inviability or weakness. All the three varieties orginated in areas near fo each other in South India; PTB 7 and PTB 10 are pure line selections from native varieties grown for many years in two different localities in Kerala and CO 29 is of hybrid origin in the Tamil Nadu. It might be assumed that these varieties in the course of evolution under diverse agroclimatic conditions have developed genes which interacted to produce lethality and or inviability in their progenies.

It was also observed that the F_2 progenies in all the four combinations showed varying extent of pollen and spikelet sterility as well as segregation for flowering duration ranging from early to late flowering. Six of the progenies

Table 1

Frequency of weak, inviable and normai plants, mean flowering duration and percentage of sterility in the F_1s and parentvarieties

Variety/Hybrid	Percentage of		No. of plants			Mean flowering	% Mean sterility	
	Seed set	Germination	Normal	Weak	Inviable	duration (days)	Pollen sterility	Spikelet sterility
PTB 7	—	—	5	—	—	80	9.3	7.5
PTB 10	—	—	5	—	—	77	4.7	6.2
CO 29	—	—	5	—	—	83	5.5	4,7
PTB 7 x CO 29	34.2	69.0	—	13	5	134	30.6	70.5
CO 29 x PTB 7	16.3	81.2	—	6	2	130	39.4	76.3
PTB 7 x PTB 10	27.2	75.7	—	4	3	135	40.7	88.8
PTB 10 x PTB 7	18.0	93.4	—	6	2	129	33.7	81.7
PTB 10 x CO 29	30.0	92.9	13	—	—	74	11.3	6.2
CO 29 x PTB 10	21.6	90.5	11	—	—	76	8.0	5.6

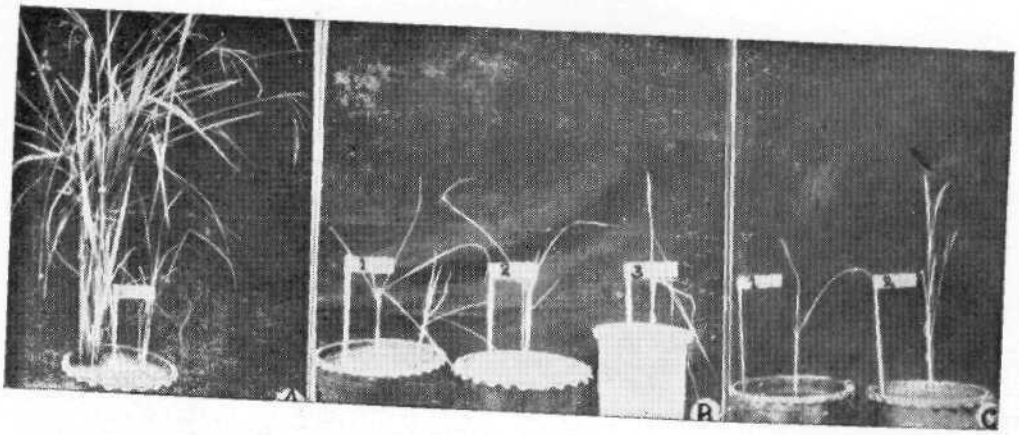

Fig 1 A One weak plant (PTB 7 x PTB 10) and one normal plant (selfed) of PTB 7.

B Weak F_1 Plants of;

1 PTB 10 x PTB 7
2 PTB 7 x PTB 10
3 PTB 7 x Co 29

C Weak F_1 plants of:

1 Co 29 x PTB 7
2 PTB 7 x PTB 10

Table 2

Data on germination, flowering and sterilily in F_2 populations of PTB 7, PTB 10 and CO 29 and parents.

Hybrid/Variety	No. of F_2 seeds.	% of germination	No. of mature plants	No. of hybrid plants Normal	Weak	Inviable	Range in flowering duration(days) in parents & F_2 progenies.	% of sterility X^2 (range). Pollen sterility	Spikelet Sterility	(9:7)
PTB 7	—	94.0	5	5	—	—	85	6.4	3.8	—
PTB 10	—	98,0	5	5	—	—	80	5.6	6.7	—
CO 29	—	100.0	5	5	—	—	89	6.0	5.2	—
F_2 PTB 7 x CO 29	23	91.3	21	11	9	1	81-152	12.6-70.8	13.6-62.1	0.32
F_2 CO 29 x PTB 7	15	80.3	12	6	4	2	73-155	1.2-60.0	6,8-82.4)	N.S
F_2 PTB 7 x PTB 10	15	67.7	10	3	5	2	88-160	7.4-82,1	4.7-64.5	2.7
PTB 10 x PTB 7	16	81.4	13	6	4	2	70-146	14.3-58.2	10.2–78.0	N.S

were non-flowering even after 180 days since sowing. F_1 plants were uniformly late-flowering and showed medium to high pollen and spikelet sterility (Table I). However, the frequency of occurrence of inviable plants in the F_1 and F_2 populations was comparatively low being 20 ahd 14,3 per cent respectively. A considerably higher rate of survival of weak F_1 plants and F_2 progenies and seed development even in progenies derived from highly sterile F_1s indicated a genie basis for the existence of an incompletely developed reproductive isolation through hybrid inviability and weakness similar to that reported by Chu *et al.* (1963) and supplemented by hybrid sterility. This finding is in conformity with the reports of Vickery (1964) who noticed a partial combination of crossing barriers, F_1 weakness and F_1 sterility in *Mimulus* sp.

Summary

The existence of a partial reproductive isolation in the form of hybrid inviability and weakness supplemented by hybrid sterility was evident in four crosses of PTB 7 with PTB 10 and CO 29. F_1 plants were inviable or weak and were characterised by stunted growth, less tillering, late flowering and high spikelet sterility. Selfed progenies of weak F_1 plants showed segregation for weak and inviable and normal plants in definite ratios. However, hybrids between PTB 10 and CO 29 were normal. The lethality and weakness of plants in F_1 and later generations were found to be determined by the action of a pair of complementary dominant lethal genes, one of which was present in PTB 7 and the other present commonly in both PTB 10 and CO 29.

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സംഗ്രഹം

പി ടി ബി 7 എന്ന നെല്ലിനം പി ടി ബി 10, സിഒ 29 എന്നിവയുമായി സംയോ ജിച്ചുണ്ടാകുന്ന സങ്കരങ്ങളിൽ വിത്ത് ffi ുളക്കാതിരിക്കുകയോ അഥവാ ffljg^jru നശിച്ചുപോ കുന്നതായോ rare തല്പെകി raft തൈകളുടെവള്ച്ച മുരടിച്ച് ശോഷിച്ച കതിരുകളോടുകൂടിയ ചെറിയ ചെടികൾ ഉണ്ടാകുന്നതായോ കണ്ടു. ഇത്തരം ചെടികളുടെ രണ്ടാം തലമുറയിൽ വള ർച്ച മുരടിച്ച അഥവാttii§<9a3ny(in ചെടികളും നല്ല ചെടികളും 9;7 എന്ന അനുപാതത്തിൽ ഉണ്ടായി. ഒരു ജോഡി പൂരകജീനുകളുടെ പ്രവർത്തനഫലമായിട്ടാണ് ഇത്തരത്തിൽ ഉള്ള പ്രത്യേകത ഉണ്ടായതെന്ന് അനുമാനിക്കാം.

References

Caldwell R. M. and Compton L. E. 1943. Complementary lethal genes in wheat causing a progressive lethal necrosis of seedlings. *J. Hered.* 34, 67-70.

Chu, Y. E. and Oka, H. I. 1970. The genetic basis of crossing barriers between *Oryza perennis* sub sp, *barthii* and its related taxa. *Evolution* 24, 135-144.

Chu, Y. E. Morishima H. and Oka H. I, 1959, Reproductive barriers distributed in cultivated rice species and their wild relatives. *Jap. J. Genet,* 44, 207-223.

Hoyne, E. G., Niebe G. A. and Painter R, H. 1943. Complementary genes in wheat causing death of F_1 plants. *J. Hered.* **34**, 243-245.

Kostyuchenko, I, A. 1936. The premature perishing of the hybrids in wheat cresses. *Bull. Appl. Bot. Leningrad. Ser. A* 19, 127-137.

Oka, H. I. 1957. Phylogenetic differentiation of cultivated rice. XV Complementary lethal genes in rice. *Jap. J.Genet.* 283-87.

Vickery, R. K. 1964. Barriers to gene exchange between members of *Mimulus guttatus* complex. *Evolution,* 18, 52-59.

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