OUTLOOK FOR HYBRID RICE IN INDIA

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ABSTRACT

Experience gained through commercial exploitation of hybrid vigour in maize, *Sorghum* and pearl millet indicates that heterosis not only results in substantial yield increases but also in stability of performance, particularly under environmental stress. Since there is further scope to exploit the full potentiality of high yielding dwarf varieties under irrigated conditions, commercial hybrids of rice, if developed, may first enable improvement and stabilisation of production levels of upland rices which form a substantial proportion of the total area under this crop.

In the light of the available information the prospects for the development of commercial rice hybrids are examined. While the dominant genes which have been reported to confer resistance to major rice diseases are a distinct advantage, care should be exercised in the choice of male and female parents to maintain the desirable grain quality of the F_1 hybrid. The possibilities of developing a commercial rice hybrid using the cytoplasmic source from the West African rice variety Sakotira-55 and the restorer systems from varieties like Basmati 370 are discussed to provide a hypothetical model in such work. Reference has also been made to the availability of ancillary characters in the rice germ plasm, which would aid development of commercial hybrids.

INTRODUCTION

THE widespread commercial exploitation of hybrid vigour in India is presently confined to *Zea mays* L., *Sorghum bicolor* (L.) Moench and *Pennisetum typhoides* Stapf ex Hubbard. The principal components of our experience with these crops can be summed up as follows: First, heterosis offers scope for making a large jump in yield level. Secondly, hybrid vigour confers a considerable degree of resilience to fluctuations in environment probably through early seedling vigour and has thus proved to be an advantage under dry-farming conditions. For example, hybrid *Sorghum* CSH-1 and hybrid pearl millet, H.B. 1, H.B. 2, H.B. 3 and H.B. 4 have yielded consistently more than the local varieties during seasons characterised by drought and aberrant weather. Thirdly, through an appropriate reconstruction of plant morphology and developmental rhythm and by exploiting additive gene action through suitable population improvement programmes, composites or varieties with as good a yield potential as the hybrids can be developed. Examples of this type are furnished by the Swarna variety of *Sorghum* and the composites of maize, *viz.*, Jawahar, Kisan, Vikram, Ambar and Vijay.[1,2] Fourthly, dependence on a single source of male sterility is fraught with danger if the male sterile parent carries dominant genes for susceptibility to important diseases, *e.g.*, susceptibility to ergot, downy mildew and grain smut in the case of CMS 23 A of *Pennisetum typhoides* or poor grain quality in the case of MS Kafir-60 of grain *Sorghum* which has a chalky endosperm.

SCOPE AND NEED FOR HYBRID RICE

Different estimates have revealed that a 25% gain in yield over the best commercial variety will be necessary for making exploitation of hybrid vigour in a self-pollinated plant an economically viable proposition. Several crosses reveal that this degree of enhanced yield can be attained (Table I). If in rice, hybrid vigour will confer the same degree of buffering against the vagaries of the weather as has been observed in *Sorghum*,[3] research on hybrid rice may certainly be worthwhile in India since out of the 35 million hectares under rice, over 20 million hectares are purely rainfed. On the other hand, in the irrigated and abundant rainfall regions of India the full yield potential of the dwarf varieties is yet to be realised due to inadequacies in water management, agronomic and pest control practices and post-harvest technology. Therefore, even if the yield ceiling can be raised through hybrid rice, it may not be of immediate practical value in such areas. However, if stability in production can be achieved in upland rice, this will be a great contribution to preventing violent fluctuations in foodgrain production in India.

ADVANTAGES AND DISADVANTAGES OF THE RICE PLANT FOR EXPLOITING HETEROSIS

The possibility of ratooning and vegetative propagation[4,5] would make hybrid seed production much less expensive in rice than in crops like wheat. Secondly, dominant genes for resistance to diseases and pests like blast and gall midge are known.[6-8] Thirdly, other desirable characters such as early flowering,[9]

TABLE I

Manifestation of heterosis in some intervarietal crosses in indica *rice*

Cross $P_1 \times P_2$	Height (cm)			Panicle length (cm)			Tillers per plant			Grains per panicle			1000 grain weight		
	P_1	P_2	F_1	P_1	P_2	F_1	P_1	P_2	F_1	P_1	P_2	F_1	P_1	P_2	F_1
DGWG × RS II ..	91·5	128·0	135·8	24·7	26·4	31·5	7	5	14	119	239	277	24·00	24·00	26·50
IARI 5901 × RS II ..	85·5	128·0	136·0	21·7	26·4	28·9	7	5	10	138	239	196	24·50	24·00	27·00
IARI 10560 × RS II ..	100·6	128·0	138·8	23·8	26·4	31·1	7	5	8	133	239	277	22·00	24·00	25·00
IARI 10561 × RS II ..	100·6	128·0	145·3	24·2	26·4	30·7	7	5	8	135	239	329	22·00	24·00	23·50
DGWG × NP 130 ..	94·5	137·6	116·6	24·7	27·5	25·9	7	4	15	119	135	169	24·00	18·50	22·50
IARI 5 01-2 × NP 130	90·6	137·6	127·0	25·8	27·5	27·6	8	4	12	172	135	189	22·00	18·50	21·50
IARI 5980 × NP 130 ..	88·5	137·6	125·0	26·7	27·5	24·0	5	4	18	146	135	139	21·50	18·50	20·50
IARI 599 × NP 130 ..	82·4	137·6	108·0	19·0	27·5	19·2	5	4	10	105	135	92	26·00	18·50	23·00
IARI 10560 × NP 130	100·6	137·6	111·0	23·8	27·5	26·1	7	4	13	133	135	222	22·00	18·50	21·00
IR 8 × RS 1 ..	95·6	126·0	136·5	28·5	27·5	26·1	8	5	36	175	237	290	28·00	24·00	26·60
IR 127 × RS 1 ..	130·00	126·0	163·6	29·0	27·5	28·4	4	5	48	375	237	290	20·00	24·00	18·25
S. 55 × Basmati 370 ..	80·00	151·0	160·6	20·5	29·5	29·6	6	4	46	106	135	215	25·00	19·50	23·55
S. 55 × AC 5636 ..	80·00	135·0	189·0	20·5	28·0	32·2	6	5	55	106	137	329	25·00	20·50	23·75
IR 127 × Basmati 370 ..	130·0	151·0	168·7	29·0	29·5	29·2	4	4	35	375	135	265	20·00	19·50	21·00

seed dormancy[10,11] and dense panicle[12] have been reported as dominant and hence can be incorporated in the hybrid rice without difficulty. Quality considerations influence heavily the price of rice in Indian markets. The F_2

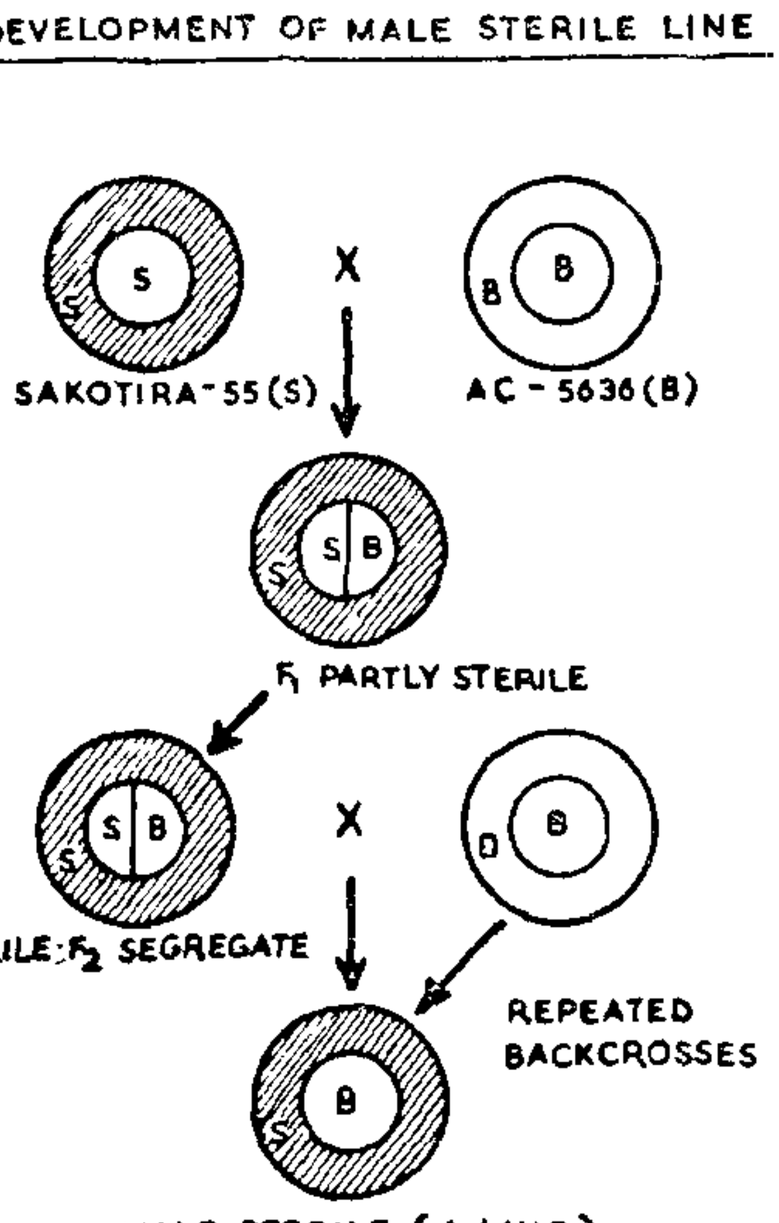

FIG. 1

Note: 1. In case restoration is easily obtained as in the case of *Sorghum* and diverse restorers are available, simultaneous testing for fertility restoration and agronomic desirability can be undertaken.

2. On the other hand if fertility restoration presents difficulties as in case of wheat, development of suitable restorer lines would be an additional step.

grains may show much variability in amylose content and gelatinization temperature and thereby affect the milling and cooking qualities. Hybrid rice may face an adverse price discrimination unless both the parents are carefully chosen so as to yield a quality hybrid.

Prospects for Developing Commercial Hybrids

Given the necessary extent of manifestation of hybrid vigour, the major prerequisites for capitalising on such vigour commercially are : (*a*) a usable form of male sterility, and (*b*) floral characters such as long period of glume opening, protruding stigma, a long period of stigma receptivity, abundant production of pollen and availability of dominant genes for amylose content, gelatinization temperature and resistance to the major pests and diseases. No systematic research programme has so far been undertaken in India to explore the prospects for developing hybrid rice for commercial cultivation. Some of the observations relevant to the initiation of such a programme are summarised below :

Usable Form of Male Sterility.—Sporadic reports of the incidence of male sterility in rice exist beginning from an early record by Ramanujam.[13] Self-sterility has been recorded in *O. barthii* Cheval.[14] The genetic mechanisms underlying such self-sterility are yet to be elucidated. No case of cytoplasmic male sterility and fertility restorer genes has so far been recorded in India.

Recently, different degrees of fertility and sterility have been found at the Indian Agricultural Research Institute in different crosses involving a rice variety from West Africa, Sakotira-55 (*O. sativa*). Some F_1s (*e.g.*, Sakotira-55 × AC 5636) showed over 70% sterility. The reciprocal crosses showed differential fertility. A study on the lines indicated in Fig. 1 has been undertaken to examine whether the sterility arises from any specific interaction between Sakotira cytoplasm and gene(s) of the pollen parent. Environmental stability in the expression of male sterility is another important trait which will be tested. No work has so far been done on the chemical induction of male sterility.

Availability of Other Desirable Genes.—In the Assam rice collections maintained at the Indian Agricultural Research Institute, sufficient variation has been observed for the size of anther and stigma as well as for the duration of glume opening. The large feathery stigma protruding out of spikelet even after anthesis, large anthers bearing abundant pollen and longer period of glume opening are some of the mechanisms favouring cross-pollination. These could be exploited profitably.

Conclusion

It is premature to express definite views on the outlook for hybrid rice in India. Practically, no scientific effort has been expended so far in this field excepting the recording of a few useful traits as indicated in this paper. In the opinion of the authors, hybrid rice will have value in increasing yield and stabilizing production in upland areas provided the response of hybrid rice to fluctuations in rainfall pattern is similar to that observed in *Sorghum* and pearl millet. Before much further work on hybrid rice is done, it is proposed to gather data on the behaviour of several F_1 hybrids under upland conditions.

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