Exploitation of heterosis for raising productivity in sesame

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Abstract

Sesame (*Sesamum indicum* L.) is an ancient indigenous oil crop of India with the highest area, production and export in the world. Sesame seeds are excellent food, they are nutritious, edible oil, providing good health care as biomedicine, all in one. Nevertheless, the productivity of this very high value crop is low in India as compared to other countries. Exploitation of hybrid vigor is a means for increasing productivity as in many other crops. The Indian Council of Agricultural Research launched a network project to exploit hybrid vigour for raising productivity of sesame at eight Centres of All India Coordinated Research Project. Two thousand six hundred twenty five germplasm lines were studied and 3834 crosses involving 1550 diverse parents, identified as donors for important economic traits, were made at different centres to study heterosis and combining ability using diallel, half diallel and line x tester designs. Simultaneously studies were also undertaken to identify an effective hybrid seed production technique and develop CMS/GMS sources.

One thousand six hundred thirty six hybrids were evaluated in replicated and un-replicated trials at different locations. Observed standard heterosis ranged from 9.5 to 327% for seed yield. Capsules/ plant, plant height and branches/plant exhibited high to medium and seed weight and days to maturity low heterosis. Large-scale multiplication of 26 promising hybrids involving parents with high general and specific combining ability was done to evaluate their performance in multi-location coordinated trials. Seven experimental hybrids, AHY.Til-5, AHY.Til-12, RTH-1, AHYT-13, RHT-3, TKG-HY-5 and TKG-HY-4, identified with superior in seed yield 31.0 to 54.3% and in oil yield 13.0 to 48.0%over TKG-22, the national check variety.

The most effective economic and viable for hybrid seed production system involved emasculation and pollination simultaneously in the same morning between 7 to 11am. The cost of manually produced hybrid seed ranged from Rs.350/kg at Tikamgarh to Rs.1000/kg at Jagtial depending mostly upon labour cost. Wider spacing of 45 x 10 cm was significantly superior to realize high yields of hybrids over 30 x 10 cm spacing. Stable CMS lines with 99.0% pollen sterility were developed through interspecific hybridization between *S. malabaricum x S. indicum* and back crossing with *indicum* types.

Media summary

Productivity of sesame is low in India. For raising productivity, sesame hybrids are being developed. Out of 1636, seven experimental hybrids exhibited exploitable heterosis in multi-location trials.

Key Words

Sesame, high-value, productivity, exploitable heterosis, sustain, yellow-revolution.

Introduction

Sesame (*Sesamum indicum* L.) is one of the most ancient oil crops in India. The crop is cultivated in almost all parts of the country in all the seasons of the year. Sesame is called as the ‘queen’ of oilseeds in view of its oil and protein are of very high quality, and it has tremendous potential for export. India accounts for the lion’s share of 39% area, 27% production and 40 % export of sesame in the world. The crop, by virtue of its short duration, fits well into wide ranges of sequences and inter cropping systems. Nevertheless, the productivity of sesame in India is very low (421 kg/ha) in comparison with some other countries like China (705 kg/ha), Japan (700 kg/ha), Korea (635 kg/ha) and Thailand (575 kg/ha). There

is an urgent need to augment the productivity levels. Unlike China, the hybrid technology, so far, remained an untapped resource for raising sesame productivity in India. The development of commercial hybrids could improve the productivity and thereby the production to a level of exportable surplus of sesame in the country. The Indian Council of Agricultural Research launched an ad-hoc network project "exploitation of hybrid vigour" to boost ongoing efforts for sesame improvement in India.

The hybrid technology has already proved its unparallel potential even in several self-pollinated crops like cotton, rice and sesame. China has exploit heterosis in sesame at commercial level for the first time, with two hand-emasculated hybrids, having a yield potential of 3000 kg/ha. These released for general cultivation. The corn hybrid programme of USA, cotton hybrid programme of India and rice hybrid programme of China have been, among others, the most successful and forerunners in this technology to pave the way of major break-through in productivity.

Methods

Under the hybrid network project, 3834 crosses involving 1550 diverse parents were made at eight Centres (Tikamgarh, Mandor, Jalgaon, Vridhachalam, Dharwad, Bhubaneshwar, Amreli and Jagtial) of All India Coordinated Research Project (AICRP) to study heterosis and combining ability using half diallel, diallel and line x tester designs with ultimate objective of developing hybrid(s) in sesame. One thousand six hundred thirty six hybrids were evaluated in replicated and un-replicated station trials at different locations in sesame growing states of India. Fully-fledged Initial Hybrid Trial (IHT) and Advance Hybrid Trial (AHT) were formulated to further confirm the performance of the promising crosses at multi-locations in a plot size of 4 x 3.6 m. Twenty-six experimental hybrids found promising in station trials, were evaluated in IHT and AHT during 2001-03 for standard heterosis over the national check variety, TKG-22. Different procedures of hand emasculation and pollination were followed to develop effective and economic technique for manual hybrid seed production. Inter specific hybridization between *S. malabaricum* x *S. indicum* and back crossing with *indicum* types was followed to develop CMS lines.

Results

Studies on the extent of heterosis in sesame at different locations indicated a wide range of standard positive heterosis from 9.5 to 327% for seed yield in 655 out of 1636 cross combinations. The important heterotic combinations with over 100 % standard heterosis included RT-127 x IS-100 b, RMT-68 x EC-362397, RT-127 x EC-362452, RT-127 x ES-81-1-84, RMT-68 x IS-100 b, RMT-68 x NIC-8413, RT-103 x EC-370939, RMT-68 x EC-370939, RMT-124 x DORS 6 A, RT-103 x TNAU-65, RMT-124 x ES-81, RMT-124 x EC-362452, RT-103 x IS 100 b, RT-46 x EC-362397, RT-127 x EC-370939, RT-103 x NIC-8413, RT-127 x ES-14-2-84, RT-46 x RNAU-63, ACV-1 x TMV-6, BS-490 x VS-9516, DORS-102 x TMV-6, SI-3015 x TMV-3, SI-72 x SVPR-1, SI-1818 x CO-1, SI-3192 x CO-1, YLM-40 x TMV-6, SI-106 x TMV-3, Annamalai-1 x TMV-3, Annamalai-1 x SVPR-1 and Gowri x SVPR-1. The single location data in the all India Coordinated Trials indicated significant superiority of a few hybrids ranging from 31% to 54% over the best check local variety. Three hybrids, namely AHY Til-12, RTH-1 and AHY.Til-5 also registered a superiority of 23.4 to 27.5% in seed yield over the national check when pooled over 6 locations in Zone I, representing arid and semi arid ecosystem. The hybrid, AHY Til-12 also maintained a superiority of 20% in seed yield against the national check over the zones at national level and RTH 1 recorded a 22% superiority in oil yield over the check. Seven experimental hybrids AHY.Til-5, AHY.Til-12, RTH-1, AHYT-13, RHT-3, TKG-HY-5 and TKG-HY-4 exhibited superiority of 31.0 to 44.3% in seed yield and 13.0 to 48.0% in oil yield over TKG-22, the national check variety intended to be replaced. However a large gap existed in the heterosis reported in the experimental hybrids at a single or two locations and their average performance in multi-location trials on large plots indicating high genotype x environment interaction.

Earlier Recelli and Mazzani (1969) reported mean yield of 510 F, hybrids to be 66 % higher than that of the parents. Some of the hybrids however produced several times more yield than the parents. Delgado (1972) produced several high yielding hybrids among shattering and non-shattering types, of which six hybrids out yielded the best parents by 200-275%. Murty (1975) found on an average, 33% heterosis for seed yield and number of capsule per plant. Dixit (1976) studied six F_1s and found the best hybrid 77 % superior to better parent in yield. Yermanos and Kotecha (1978) and Kotecha and Yermanos (1979)

reported in a diallel set of 8 x 8 parents, the heterosis over better parents ranging from 28.0 to 238% for seed yield. Osman (1980) studied heterosis in eleven hybrids between a male sterile parent of tropical origin and eleven fertile parents from both temperate and tropical zones and found F_1s to be significantly superior to their better parents for plant height, oil content and seed yield with a mean of 51% higher yield in F_1s. High heterosis to the extent of 328% for seed yield was reported by Singh *et al*. (1983). Krishnaswamy *et al.* (1985) reported heterosis in seed yield of sesame ranging from 50 to 325% and hetero-beltiosis from 50 to 263%.

Manual seed production

Sesame has the advantage of epipetatious flowers and thus easy emasculation and pollination, high number of seeds (40-50) produced per flower, low seed rate (2.0-2.5 kg /ha) and high seed multiplication ratio (1:300), for manual hybrid seed production. At Vridhachalam, an average of 2500 flowers were prepared from 440-plants/40 m2/day. Male flowers collected from 10 m2 were found optimum to pollinate 2500 flowers in varieties Co.1 and SVPR-1 as pollen and ovule parents, respectively. The effective flowering period extended up to 15-20 days. The estimated production of hybrid seed was 2.5 to 3 kg/40 m2 with the cost of about Rs. 200/- per kg seed. The estimated cost of hybrid seed produced by hand emasculation and pollination at Jalgaon involving crosses Tapi x HT-24, ATPT-85-6 x Tapi and Tapi x CST-785 worked out to be Rs. 1218/- per kg seed. The cost of hybrid seed was found to be Rs. 500/- per kg through massive hybridization technique at Tikamgarh. Emasculation and pollination simultaneously in the same morning between seven to eleven am was found most effective, economic and viable for hybrid seed production. Seed production per unit area was higher in 4 rows of female to one row of male and when 4 female flowers were pollinated with one male flower.

Cytoplasmic male sterility

Commercial production of hybrid seed of sesame utilizing CMS system would be more desirable. The work on the development of CMS lines through inter-specific hybridization using *Sesamum malabaricum* x *S. indicum* types was undertaken at Vridhachalam Centre of AICRP. Through backcross breeding, the genes of *S. indicum* types have been successfully transferred into the sterile cytoplasm of *S. malabaricum,* a wild species of Indian origin. The indicum type plants with 95% pollen sterility have been developed. Similar work is in progress at Mandor and Jalgaon Centres of the Project.

Constraints

Low variability in available germplasm; inadequate research and development support; lack of required national/regional collaboration and poor exchange of information and materials, restrict the rate of development of hybrids.

Conclusion

Commercially exploitable heterosis ranging from 34 to 54 % existed in seven out of 26 experimental hybrids under multi-location testing in large plots. Thus the reproductive system in sesame is amenable for manual hybrid seed production. However, seed cost also high ranging from Rs. 350 to Rs. 1000 /kg seed depending upon the labour wages. CMS lines with 99% pollen sterility have been developed through back crossing of *S. malabaricum* x *S. indicum*. Commercial hybrids may not be plausible till stable of CMS system is developed. Testing/evaluation of hybrids in multi-location trials for better expression of heterosis and to increase the flow of germplasm to actual users and to share experiences with international cooperation with China, USA, Israel and Korea. In addition there is a need for a public sector collaboration to draw strength from each other with greater involvement of private sector to promote research and development.

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