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Experimental strategy for the improvement of Brassica crops.

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The breeding procedures that were employed so far in the Brassica group of crops were based on the traditional approach like identifying good single cross combinations and evolving variety derivatives in advanced generations by pedigree breeding. This resulted in varieties which had two genotypes incorporated at the most.

The area and production of rapeseed and mustard in 1969-70 were 3.1 million hectares and 485 kg/ha only. The highest yields per hectare recorded in All India Coordinated Oil seeds Project during 1971-72 were 956, 1817, 1256 and 2225 kgs for brown sarson yellow sarson, toria and rai respectively. The respective average yields remained at 720, 874, 1011 and 1744 kgs. It would be seen, therefore, that a lot of scope exists to tone up the yield levels by reorienting the existing breeding procedures.

The modern concepts of plant breeding mainly rest on the formulation of procedures to bring in divergent, productive and competing genotypes into a composite variety or population. Such procedures are adopted even in self-pollinated crops like wheat and barleywith some modifications. They have paid rich dividends in cross-pollinated crops especially in maize.

Brassica campestris :

Brassica campestris var. brown sarson, though classified as a cross-pollinated crop, has some associated problems. There are self-incompatible and self-compatible types and also those of intermediate ranges of self-incompatibility. On selfing, self-incompatible types do not set seed; however bud-pollination overcomes this difficulty. Emasculation is needed in order to effect crosses between self-compatible types. This crop is entomophilous, and as such the success of the genotypic mixing under isolation depends on the amount of bee activity. Hence genotypic inter-mixtures cannot as readily be obtained even in self-incompatible types as could be obtained in maize under isolation.

As would be found in any cross-pollinated crop, inbreeding does have an adverse effect in this crop as well, though the degree of inbreeding depression depends on the genotypes used to a certain extent. Thus the maintenance of varietal purity becomes a problem; more so that of maintaining the identity of the parents of a synthetic variety, for example.

Careful considerations of the breeding problems involved in this crop would immediately suggest that it would be worthwhile to breed composite populations in order to bring about significant yield improvement. The pilot experiments conducted in the biometrical genetics unit do provide some methods of compositing productive populations in a reasonably short period.

It has been found in several crop plants that a careful planning of a multiple cross programme would help in associating a group of genotypes in a single productive composite population (MacKey, 1963; Jensen, 1970). It was found that a fruitful choice of parents of multiple-crosses can be made on the general and specific combining ability effects of single crosses assessed at F1 level. Basic work conducted on three-way crosses in brown sarson and three- and four-way crosses in triticale at the biometrical genetics unit had shown that the following choices would be preferred in that order; selecting those singlecrosses (F1) as multiple cross parents (i) in which the g.c.a. effects of the parents are in opposite directions, the total acting in the desirable direction, the s.c.a. effects being non-significant. (ii) in which the g.c.a. effects are in the same desirable direction with non-significant s.c.a. effects and (iii) in which the sum of the g.c.a. and s.c.a. effects is in the desirable direction, the g.c.a. effects are in opposite direction and the s.c.a. effect is small though significant.

Similar criteria can also be applied to choose the top-most three- or four-way crosses at their F1 level. It would be necessary to effect the choice on the basis of a few key-characters related to yield in order to achive the required improvement at population level.

A possible short-term approach for population improvement in brown sarson is diagramatically outlined in Fig.1. The scheme is based on the following broad concepts :

(A) Creation of an effective gene pool (on the basis of reinforcing general combining ability effects) as a reservoir of additive genetic variance.

(B) Release of a number of desirable and coadapting recombinants through transgressive segregation and break-up of undesirable linkages by intermating in segregating generations and

(C) Composition, through modified mass selection, of productive élite gene pools, from which a number of productive composites can be derived and a portion of which can be used to initiate a parallel programme x starting from step (A).

We would now deal with each of the steps in detail:

(A) An initial single-cross hybrid programme of the size of 200 crosses is carried out. These crosses may form a diallel set or a line x tester set or fit into a known design allowing the estimation and testing of general and specific combining ability effects and variances. For example, a half diallel involving 20 parents or a line x tester mating involving 20 female and 10 male parents would suffice for a start. It would be very essential to include parents genetically diverse for a number of yield attributes and also belonging to different geographical, ecological or agro-climate regions.

One-half of the single cross seed material is used to grow the F1 and evaluate the g.c.a. and s.c.a. effects. on this basis, a minimum of 20 F1's are selected as outlined earlier. If more than 20 F1's are available for selection (which may be so in many cases), sets of 20 F1's can be made to run parallel programmes.

These 20 F1's will now be crossed in direct and reciprocal combinations with at leat 10 varieties or lines which are agronomically good and possess desirable yield atrributes to make up 200 three-way crosses. These are once more tested for their combining ability and sets of 15 top-most three-way crosses were selected as before, to run parallel programmes. Confining our attention to one such set, the seeds of the 15 selected single-cross x variety combinations and their corresponding variety x single-cross reciprocals are mixed in equal quantity to form the source gene pool. Thus two tests of combining ability are involved to form the source genepool, one at single cross and the other at the three-way cross level.

As observed earlier, the formation of this source gene pool should be based on at least the two most important yield components, number of primary and of secondary branches per plant in addition to the single plant yield.

(B) The progeny pool from the source pool is obtained through mass inter-crossing. Plants raised from the source gene pool were taken at random as females and after emasculation, pollinated with the mixed pollen from a number of other plants from the same pool, in isolation. Seeds of as many such crosses as physically feasible are mixed to get the composite F2 seed material. The F2 is grown similarly and a cycle of similar inter-crossing repeated. Three such cycles in all (refer to Fig.1), would be enough to complete the formation of necessary recombinants.

It is necessary to use the seeds of inter-crosses on.. to produce the progeny generation in each cycle. In case it is decided to use only self incompatible types, the inter-crosses can be allowed to be made in isolation avoiding hand-crossing . Because of the entomophilous nature of pollination, the time involved to obtain a good shuffle of genes may be more depending upon a number of factors. Thus it would seem worth the effort if the parental seeds are obtained by hand-crossing. Another advantage in hand-crossing would be the possiblity of including ev even self-compatible and intermediate types in the source gene pool which would make it more effective because of the diversity among these types.

(C) Mass selection is now carried out at plant level to identify elite gene pools to form productive composites. Since a good degree of homogeneity would have been obtained at the end of the setp (B), it would not be necessary to eliminate a large proportion of plants by mass selection at this stage. On the other hand, elite gene pools of various potentials can be formed.

In this connection, it will be of utility to base selection on the three key characters, primary branches, secondary branches and yield. Since primaries and secondaries are correlated between themselves and with yield also, a choice favouring a large number of branches and high yield will be preferred at plant level. If, in addition, the choice stipulates that the number of secondary branches should be less than twice t the number of primary branches (the lower the better), a desirable compact plant frame can also be automatically selected for. Variations of these criteria can lead to the formation of different productive groups. It is worth-noting that intermating between these groups can form further productive groups.

The mass selection at plant level is now carried out once m more within individual groups, using similar criteria mentioned above.

Each of these groups has now attained the status of productive composite populations and can go for initial yield evaluation trials.

Yield and Oil Content

Contrary to the existing opinion, that a negative correlation among seed size, yield and oil content exist in brown sarson, Swedish reports affirm simultaneous improvement for yield and oil content (Olsson, 1960; Appleqvist and Ohlson, 1972). This would therefore enable one to effect selection for high oil content at the step (C). Therefore while effecting mass selection the character, oil content should be included right from the beginning of the step (C). Quick screening for oil content by NMR Spectrometer should be very helpful in this regard.

Brown sarson is affected only by aphids in India, which can effectively be controlled by spraying parathion or malathion.

Flexibility and Organisation of the Programme.

Flexibility: The programme of population improvement can admit of some flexibilities at stage A. For example, if, at any time of the execution of the programme, genetically diverse material or extoic germ plasm become available which are worth trying into the source pool, they can be introduced at the three-way crossing programme by crossing them with the already chosen single crosses. This would mean it would be necessary to retain one half of the seeds of source pool for such eventualities

This programme should be taken up both for brown sarson and toria varieties of Brassica campestris separately.

Initial studies of inter-varietal crosses among brown and yellow sason and toria revealed that recombinants incorporati the good attributes of the parental varieties can be isolated (Rathinam, 1974). Hence it is worth constructing source gene pool with inter-varietal crosses and running parallel programmes of population improvement.

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Organisation: Few centres of the Coordinated Project should be identified and individual workers made responsible for the necessary crossing programmes. It is necessary that a good amount of crossed seeds is collected to allow for F1 testing at single and thee-way crosses level. The assembled seed material can be grown at two locations, Delhi and Kanpur to even out environmental fluctuations. The data can be analysed at Delhi Centre and the selection of crosses to generate source pool be made. The whole process of analysis including selection can be easily programmed on a computer.

After the source pool is assembled, the three cycles of inter-crossing can again be easily carried out by dividing the work among the same centres which made the crosses. After every cycle of intercrossing, the crossed seeds should be pooled from all centres, mixed thoroughly and again distributed for the next cycle of intercrossing. This process would work smoothly unless a vast amount of location interaction is operating Apriori however, there is no strong reason to presume the operation of undesirable interactions. When stage C is reached, the homogeneous material can be grown in one location, Delhi and composites developed.

Thus it would be seen four seasons are required for stage A, three for B and two for C; the time period can be cut if an off-season crop can be raised in a suitable location.

Brassica juncea:

Brassica juncea being a strictly self-pollinated crop, breeding procedures should be directed at developing superior variety derivatives.

The programme given for Brassica campestris can be modified to suit the needs of this crop. Such a programme is outlined in Fig.2. The steps are self-explanatory. It would be noted that the source pool would consist of superior single three-way combinations (Single cross x variety and corresponding variety x single cross pooled) identified on the character means and combining ability components. Each such selected combination will undergo inter-crossing within. The inter-crossed seeds will be grown and the second cycle of inter-crossing will be made. The crossed material will be raised and mass selection (for number of primary and secondary branches and single plant yield) at plant level will be made as described earlier. Three cycles of such selection should be able to produce a derivative ready for testing in an initial evaluation trial.

The source pool can start with five superior three-way combinations and the 10 inter-crosses among them. Thus 15 derivatives would be available at the end of the programme for comparative evaluation.

If the source pool contains more number of superior combinations, parallel programmes can be run. The workload can, as described earlier, be arranged to be shared by a few centres.

Similar flexibility and organisational features as in Brassica campestris can also be introduced in this programme.

In conclusion, one would observe that the success of the programmes would depend on the success of constructing an effective gene pool. No doubt material from different genetic and geographical sources should be included. It would be ideal to identify genetically resistant sources of aphids and plug them into the source gene pool. For this purpose, simultaneous programmes to identify aphid resistant genotypes would be worth-initiating.

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Fig 1. Programme to derive composite populations in *B. campestris*

Fig 2. Programme to derive varieties in *B. juncea*