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Evolution of Inbreeding Depression Consanguineous Related to Procedure for Development of Inbred Lines

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SUMMARY

Inbreeding depression, or the reduced survival and fertility of related individuals' offspring, occurs in wild animal and plant populations as well as in humans, demonstrating that natural populations have genetic heterogeneity in fitness attributes. Because intercrossing inbred strains boosts yield (heterosis), which is crucial in crop breeding, inbreeding depression is significant in the evolution of outcrossing mating systems. The genetic basis of these effects has been contested since the early twentieth century. Inbreeding depression and heterosis are now thought to be mostly caused by the presence of recessive harmful mutations in populations, according to traditional genetic studies and new molecular evolutionary techniques.

INTRODUCTION

A systematic observations on effect of inbreeding started during 17thcentury when inbreeding became a common practice in cattlebreeding.In 1876, Darwin published his book on cross and self fertilization in vegetable kingdom. He concluded that progeny obtained from self fertilization were weaker than those obtained from out crossing.Darwin also reported the results from his experiments on self and cross fertilizationin maize for the first time.East (1908) and Shull (1909) independently showed the effect of inbreeding depression while working maize. Subsequently scientists reported inbreeding depression in other cropplants.It has become clear that in cross pollinated crops and in asexually propagated species inbreeding has harmful effect which are severe.

Effects of inbreeding: Inbreeding is accompanied with a reduction in vigour and reproductive capacity i.e. fertility. There is a general reduction in the size of various plant parts and in yield. In many species, harmful recessive alleles appear after selfing; plants or lines carrying them usually do not survive. The different effects of inbreeding are :

- **Appearance of Lethal and Sublethal Alleles** : IB results in appearance of lethal; sublethal and subvital characters. Eg : Chlorophyll deficiencies, rootless seedlings, flower deformities – They do not survive, they lost inpopulation.
- **Reduction in vigour** : General reduction in vigour size of various plantparts.
- **Reduction in Reproductive ability** : Reproductive ability of population decreases rapidly.Manylinesreproducepurelythattheycannotbemaintained.
- **Separation of the population into distinct lines** : population rapidly separates into distinct lines i.e. due to increase in homozygosity. This leads to random fixation of alleles in different lines. Therefore lines differ in genotype and phenotype. It leads to increase in the variance of thepopulation. **Increase in homozygosity** : Each lines becomes homozygous. Therefore, variation within a line decreases rapidly. After 7-8 generations of selfing the line becomes more than99%homozygous.Thesearetheinbreds.Thesehavetobemaintainedbyselfing.
- **Reduction in yield** : IB leads to loss in yield. The inbreds that survive and maintained have much less yield than the open pollinated variety from which they have been developed.

Degrees of inbreeding depression

Inbreeding depression may range from very high to very low or it may even be absent.
The ID is grouped into 4 categories.

High inbreeding depression : Eg : alfalfa and carrot show very high ID. A large proportion of plants produced by selfing show lethal characteristics and do notsurvive.

Moderate inbreeding depression : Eg : Maize, Jowar and Bajra etc. showmoderateID. Many lethal and sublethal types appear in the selfed progeny, but a substant ial proportion of the population can be maintained under self-pollination.

Low inbreeding depression : Eg : Onion, many Cucurbits, Rye and Sunflower etc. show a small degree of ID. A small proportion of the plants show lethal or subvital characteristics. The loss in vigour and fertility is small ; rarely a line cannot be maintained due to poorfertility.
Lack of inbreeding depression : The self-pollinated species do not show ID, although they do show heterosis. It is because these species reproduce by self-fertilizationandasaresult,havedevelopedhomozygousbalance.

Procedure for development of inbred lines and their evaluation
Development of inbred lines: Inbred lines are developed by continues self fertilization of a cross-pollinated species. Inbreeding of an OPV leads to many deficiencies like loss of vigour, reduction plant height, plants become susceptible to lodging, insects and pests andmany other undesirable characters appear. After each selfing desirable plants are selected and self pollinated or sib pollinated. Usually it takes 6-7 generations to attain near homozygosity. An inbred line can be maintained by selfing or sibbing. The purpose of inbreeding is to fix the desirable characters in homozygous condition in order to maintain them without any geneticchange.
Evaluation of inbred lines: After an inbred line is developed, it is crossed with other inbreds and its productiveness in single and double cross combination is evaluated. The ability or an inbred to transmit desirable performance to its hybrid progenies is referred as its combiningability.GCA : The average performance of an inbred line in a series of crosses with other inbred lines is known asGCA.SCA : The excessive performance of a cross over and above the excepted performance basedon GCA of the parents is known as specific combining ability. Thus GCA is the characteristic of parents and SCA is characteristic of crosses or hybrids.

The inbreds are evaluated in following way.
Phenotypic evaluation: It is based on phenotypic performance of inbreds themselves. It is effective for characters, which are highly heritable i.e. high GCA. Poorly performing inbreds are rejected. The performance of inbreds is tested in replicated yield trials and the inbreds showing poor performance arediscarded.
Top Cross test: The inbreds, which are selected on phenotypic evaluation, are crossed to a tester with wide genetic eg. An OPV, a synthetic variety or a double cross. A simple way of producing top cross seed in maize is to plant alternate rows of the tester and the inbred line and the inbred line has to be detasselled. The seed from the inbreds is harvested and it represents the top cross seed. The performance of top cross progeny is evaluated in replicated yieldtrainspreferablyoverlocationsandyears.Basedonthetopcrosstestabout50%ofthe inbred are eliminated. This reduces the number of inbreds to manageable size for next step. Top cross performance provides the reliable estimate ofGCA.
Single cross evaluation: Out standing single cross combinations can be identified only by testing the performance of single cross. The remaining inbred lines after top cross test are generally crossed in diallel or line x tester mating design to test for SCA. A single cross plants are completely heterozygous and homogenous and they are uniform. A superior single cross regains the vigour and productivity that was lost during inbreeding and can be more vigorous and productive than the original open pollinated variety. production of single cross seed is commerciallyfeasible.

Exploitation of Heterosis for modification in inbreeds clones
When F_1generation from a cross between two or more purelines, inbreds, clones or other genetically dissimilar populations / lines is used for commercial cultivation, it is called **hybridsvarieties**.
Shull scheme could not be exploited commercially because of the following reasons :

- Superiorinbredswerenotavailableinthosedays.
- Since the female parent was an inbred the amount of hybrid seed produced per acre was low (30-40% of the open pollinated varieties). Therefore, the hybrid seed was moreexpensive.
- The male parent was also was an inbred so there is poor pollen availability. Therefore, more area has to be maintained under male parent. Hence hybrid seed production became moreexpensive.
- The hybrid seed was often poorly developed as it was produced by an inbred and had arelativelypoorgermination.Soitneedshigherseedrate.

Prediction of the Performance of Double Cross Hybrids

In a double cross hybrid, four inbred parents are involved. Theoretically, the potential of the double cross will be the function of the inbreeding value of these four parental inbreds. Therefore, based on the procedure of testing of the breeding value of inbreds, the performance of a double cross hybrid can be predicted through any of the four methods indicatedbyJenkins(1934).Startingwiththesimplestprocedurethesemethods are:

- Top-cross testing (one cross per inbred) to know the breeding value to each of the four inbreds (total 4 top-crosses per doublecross).
- Mean of the four non-parental single crosses involved in (AXB) X (CXD) double cross, viz., (AXC), (AXD), (BXC) and (BXD) (total 4 non-parental single crosses per doublecross).
- Average yield performance of all possible six crosses [n(n-1)/2], namely AXB, AXC, AXD, BXC, BXD and CXD (total six crosses per doublecross).
- Average progeny-performance of each inbred can be de termined by the mean performance of each inbred in all possible single crosses where it occurs (n-1 crosses per inbred).

CONCLUSION

Interpopulation outcrossing can have either favourable (heterosis) or negative (outbreeding depression) impacts, but inbreeding is frequently linked with fitness reduction (inbreeding depression). Depending on the focal population (especially its effective size) and the attribute researched, these phenomena may occur with varying intensities within a metapopulation. At this size, however, nothing is known about interpopulation variance. Within a metapopulation of the hermaphroditic snail Physa acuta, we investigate the effects of inbreeding depression, heterosis, and outbreeding depression on life-history features throughout the course of a full life cycle. We show that at this scale, all three phenomena can co-occur, even if they are not necessarily manifested on the same features. Local populations exhibit a wide range of inbreeding depression, heterosis, and outbreeding depression. We show that, as predicted by theory, tiny and isolated populations have more outcrossing heterosis than large, open populations. These findings highlight the need for an integrated theory that accounts for both deleterious mutations and genetic incompatibilities within metapopulations, as well as the variability of the focal population, in order to fully comprehend the genetic consequences of inbreeding and outbreeding at this scale.

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