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A Novel Study of Pure Line Theory and Applied Genetical Modification of Mass

Srikanth G. A., Peddisetti Roshini., Bhavana, G.V. Sirisha P.S. and Sindhu N.S.
Assistant Professor, Department of Plant Physiology, Sampoorna International Institute of Agricultural Science and Horticultural Technology, Belekere, Channapatna, Karnataka

SUMMARY

Pure line theory and the genotype/phenotype distinction in the early twentieth century, one of the most important pioneering contributions to genetics and Mendelian plant breeding. The majority of historians have already determined that pure line theory had little direct impact on breeding methods. Instead, pure line theory structured breeding programmes and eliminated extrinsic heritable factors, resulting in more orderly breeding. This gradual shift explains how and why today's giant multi-national seed firms arose; pure lines encouraged standardisation and economies of scale.

INTRODUCTION

It is the earliest method of selection. Man has always practiced mass selection consciously or unconciously from the time of domestication. In its most basic form mass selection consists of selecting individuals on the basis of phenotypic superiority and mixing the seeds for using as planting material for next season.

Procedure for evolving variety by mass selection

First year : Large number of phenotypically similar plants having desirable characters are selected. The number may vary from few hundred to few thousand. The seeds from the selected plants are composited to raise the next generation.

Second year: composited seed planted in a preliminary field trial along with standard checks. The variety from which the selection was made should also be included as check. Phenotypic characterlistics of the variety are critically examined and evaluated.

Third to sixth year : The variety is evaluated in coordinated yield trials at several locations.\ It is evaluated in an initial evaluation (IET) trial for one year. If found superior it is promoted to main yield trials for 2 or 3 years.

Seventh year : if the variety is proved superior in main yield trials it is multiplied and released after giving a suitable name.

Modification of mass selection

Mass selection is used for improving a local variety. Large number of plants are selected (I year) and individual plant progenies are raised (II year). Inferior, segregating progenies are reflected. Uniform, superior rows are selected and the seed is bulked. Preliminary yield trials are conducted in third year. Fourth to seventh year multilocation tests are conducted and seed is multiplied in eight year and distributed in ninth year. Many other modifications also are followed depending on the availability of time and purpose for which it is used.

Merits of Mass selection:

- Can be practiced both in self and cross pollinated crops
- The varieties developed through mass selection are more widely adopted than pure lines.
- It retains considerable variability and hence further improvement is possible in future by selection
- Helps in preservation of land races
- Useful for purification of pureline varieties
- Improvement of characters governed by few genes with high heritability is possible.
- Less time consuming and less expensive.

Demerits of mass selection

- Varieties are not uniform
- Since no progeny test is done, the genotype of the selected plant is not known
- Since selection is based on phenotype and no control over pollination the improvement brought about is not permanent. Hence, the process of mass selection has to be repeated not and then.

- Characters which are governed by large number of genes with low heritability can not be improved.
- It cannot create any new genotype but utilizes existing genetic variability.

Achievements

Mass selection must have been used by pre historic man to develop present day cultivated cross from their wild parents. It was also used extensively before pureline selection came into existence.

Cotton : Dharwad American Cotton
Groundnut : TMV-1 & TMV-2
Bajra : pusa moti, Baja puri, Jamnagar gaint, AF3

Johannsen's Pure Line Theory

The pure line theory

A pureline is a progeny of a single homozygous plant of a self-pollinated species. All the plants of a pureline have the same genotype. The phenotypic differences within a pureline is due to environment. Therefore variation within a pureline is not heritable. Hence selection in a pureline is not effective. The concept of pureline was proposed by Johannsen in 1903 on the basis of his studies with princess variety of beans (*Phaseolus vulgaris*). From a commercial seed lot he selected seeds of different sizes and grew them separately. The progenies differed in seed size. Progenies from larger seeds produced larger seeds than those obtained from smaller seeds. This clearly showed that the variation in seed size in the commercial seed lot of princess variety had a genetic base. As a result selection for seed size was effective. Johannsen further studied 19 lines, each line was a progeny of a single seed from the original lot. He discovered that each line showed a characteristic mean seed weight, ranging from 640mg in Line No 1 to 350 mg in line No 19. The seed size within a line showed some variation, which was much smaller than that in the original commercial seed lot. Johannsen postulated that the original seed lot was a mixture of pure lines. Thus each of the 19 lines represented a pure line, and the variation in seed size within each of the pure lines had no genetic basis and was entirely due to environment.

Genetic Basis Of Pure Line

Self pollination increases homozygosity with a corresponding decrease in heterozygosity. The effect of homozygosity and heterozygosity may be illustrated by taking an individual heterozygous for (Aa) a single gene as follows

No of generations of selfing	Frequency %			Frequency %	
	AA	Aa	aa	Homo-zygosity	Hetero-zygosity
1	0	100	0	0	100
2	25	50	25	50	50
3	37.5	25	37.5	75	25
4	43.75	12.5	43.75	87.5	12.5
5	46.875	6.25	46.875	93.73	6.25
6	48.437	3.125	48.437	96.874	3.125
7	49.218	1.562	49.218	98.436	1.562
8	49.608	0.781	49.608	99.216	0.781
9	49.803	0.39	49.803	99.606	0.39

Proportion of completely homozygous plants in the population
$[(2m - 1) / 2m]n$
m = No. of generations of self pollination
n = No. of genes segregating

Suppose an individual heterozygous for a single gene (Aa) and the successive generations derived from it are subjected to self-pollination. Every generation of self -pollination will reduce the frequency of heterozygote Aa to 50 per cent of that in the previous generation. There is a corresponding increase in the frequency of the two homozygotes AA and aa. As a result, after 10 generations of selfing, virtually all the plants in the population would be homozygous, *i.e.,* AA and a. On the other hand, the frequency of heterozygote Aa would be only 0.097 per cent, which is negligible. It is assumed here that the three genotypes AA, Aa and aa have equal survival. If there is unequal survival, it may increase or decrease the rate at which homozygosity is achieved. If A is favoured, the rate of increase in homozygosity would be lower than expected. But if A is selected against, homozygosity would increase at a faster rate than expected.

Pureline selection

Pureline selection has been the most commonly used method of improvement of self pollinated crops. Almost all the present day varieties of self pollinated crops are purelines. Pureline selection has several applications in improvement of self pollinated crops. It is used to improve.

1. Local varieties
2. Old pureline varieties and
3. Introduced varieties

General procedure for evolving a variety by pureline selection

The pure line selection has three steps.

1. Selection of individual plants from a local variety or some other mixed population.
2. Visual evaluation of individual plant progenies and Yield trials

Selection

First year : A large number of plants (200-3000) which are superior than the rest are selected from a local variety or mixed population and harvested separately (in some cases individual heads or stems may be selected). The number of plants to be selected depends upon the breeder's discretion but should be as large as possible in view of the available time, land, funds, labour etc. It is advisable to select for easily observable characters such as flowering, maturity, disease resistance, plant height etc.

Evaluation :

Second year: Progenies of individual plants selected in 1st year are grown separately with proper spacing (plant to row or head to row). The progenies are evaluated by taking elaborate date on visual characters such as plant height, duration, grain type, ear characters besides yield. The number of progenies should be reduced as much as possible. Disease epiphytotics may be created to test the progenies for disease resistance, poor, weak, diseased, insect attacked and segregating progenies are rejected. The superior progenies are harvested separately. If necessary the process may be repeated for one or more years.

Yield trials :

Third year : The selected progenies, now called as cultures are grown in replicated trial for critical evaluation of yield etc. The best local variety is used as a check and should be grown at regular intervals, after every 15 or 20 cultures for comparision. This is known as preliminary yield trial. Superior cultures based on observable characters and yield are selected. The number is drastically reduced.

Fourth & Fifth years : The superior cultures are tested against the local checks in yield trials. Observations are recorded on many characters like diseases resistance, days to flower, days to maturity, height of the plant ear characters, test weight and yield. The data is subjected to statistical analysis to identify really superior cultures.

If necessary the trials may be extended for one more year or season. Inferior culture are rejected and a few (4-5) promising cultures are selected.

Sixth, Seventh and Eighth years: The promising cultures selected are evaluated at several locations along with strains or cultures of other breeders and local checks. One or two promising cultures are selected.

Ninth year: The best progeny identified earlier is multiplied, named and released as a variety for official release of any variety (approval from the variety releasing committee of the state or central is necessary).

Advantage of pureline selection

- The purelines are extremely uniform since all the plants in the variety will have the same genotype.
- Attractive and liked by the farmers and consumers.
- Purelines are stable and long test for many years.
- Due to its extreme uniformity the variety can be easily identified in seed certification programmes.

Limitations or disadvantages of pureline selection

- New genotypes are not created by pureline selection
- Improvement is limited to the isolation of the best genotype present in population. No more improvement is possible after isolation of the best available genotype in the population.
- Selection of purelines require great skill and familiarity with the crop.
- Difficult to detect small differences that exist between cultures
- The breeder has to devote more time
- Pure lines have limited adaptability hence can be recommended for cultivation in limited area only.

CONCLUSION

In reality, the industry only embraced the pure line in part. Furthermore, assertions that violated the logic of the pure line were not only accepted, but validated and legitimised by the agricultural geneticists linked with NIAB. The storey of how and why the plant breeding industry changed is still being written.

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