THE TEA QUARTERLY

VOLUME XXV. DECEMBER, 1954 PART IV.

VEGETATIVE PROPAGATION AND CLONAL SEED PRODUCTION

G. B. Portsmouth

The question is often asked why the Tea Research Institute does not favour the development of improved strains of seed for planting purposes, but prefers to concentrate entirely on vegetative propagation. The answer is unfortunately by no means simple and, for its proper understanding, some knowledge of the elementary principle of genetics is required.

However, at the outset of this article, it may be as well to point out that Dr. Wight, who is in charge of the breeding work at Tocklai, insists on a clear distinction being made between vegetative and generative clones. Vegetative clones are those used solely for the multiplication of planting material by means of cuttings. Generative clones, on the other hand, are plants which are crossed sexually to produce clonal seed.

Selection and assessment of the characteristics of a vegetative clone is a comparatively straight-forward business, which requires no knowledge of the genetic make up of the plant. Furthermore, under Ceylon conditions, it is a process which is assured of a reasonable degree of success after only a few years. The development of high yielding high quality clones, such as 2024, to a stage at which fairly wide-spread distribution is possible, in the period elapsing since the start of selection work at the Tea Research Institute in 1937, furnishes all the proof necessary for this assertion.

The selection of generative clones, however, is a much more difficult business since it requires an understanding of genetics such as is only likely to be possessed by a specialist plant breeder. Furthermore two selected parents are required to produce each batch of clonal seed, while the assessment of the characteristics of the progeny is much slower than in the case of a vegetative clone. As a consequence it is not surprising that very little in the way of high class clonal seed development has resulted from over twenty years of work at Tocklai.

In fact the difficulties and length of time involved in the development of improved clonal seed with tree crops are so great that this method of improving the standard of planting material has been almost entirely discarded. R. J. Garner, the world famous authority on propagation, in the introduction to the 'Imperial Bureau of Horticulture and Plantation Crops' Technical Communication No. 14, dealing with propagation by cuttings and layers, states:—

> 'In an orderly world the unpredictable variability of seedling plants will not much longer be tolerated. The use of clonal scion varieties is recognised as essential and recent work with fruit tree rootstocks and with 'strains' of small fruits and other subjects grown on their own roots has made clear the

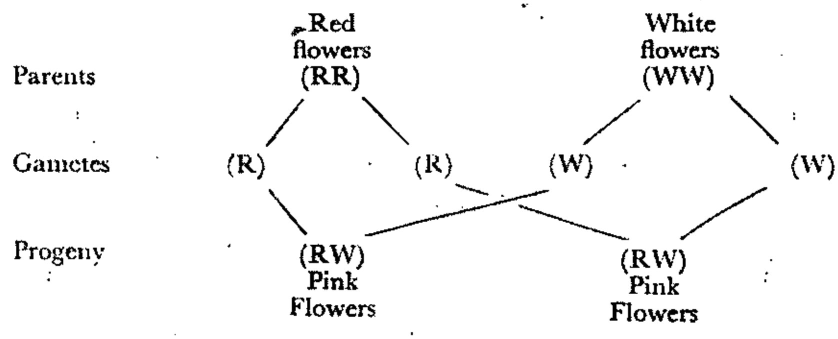
advantages to be gained by the use of selected varieties propagated vegetatively. In years to come it seems likely that we shall insist on having all our woody and many of our herbaceous plants vegetatively propagated including perhaps forest trees and hedge plants'.

Now what are these difficulties which render the production of improved clonal seed such a remote possibility that its successful achievement can be disregarded for all practical purposes. Apart from the fact that the tea bush is sterile to its own pollen, thus rendering breeding work more complicated, the principal difficulty is concerned with the nature of the hereditary mechanisms involved in the concept called 'vigour'. All high yielding, strong growing vegetative clones almost certainly possess vigour in this genetic sense and it is therefore essential that plants produced from clonal seed must also possess vigour if they are to be able to compete on level terms with the better vegetative clones. Unfortunately, it is just this production of vigour which turns out to be one of the most difficult tasks in plant breeding.

In plants all the individual characteristics displayed by any particular species or variety are controlled by certain entities known as genes. Thus in tea we may have separate genes for flower colour, leaf colour, leaf shape, leaf hairiness, type of root development, resistance to blister blight, etc., etc. These genes are present in all cell nuclei, where they are located in bodies known as chromosomes, so called from the readiness with which they can be stained by certain dyes. Each chromosome carries a large number of different genes and, as the tea plant possesses a total of some 30 chromosomes, it is obvious what a vast number of different genetic characters may be involved.

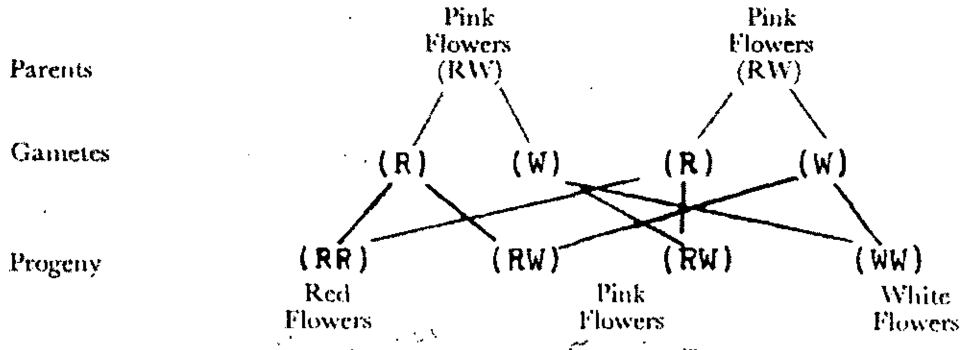
However, in the nucleus of the ordinary vegetative or diploid cell the chromosomes are organised in pairs, each individual of a pair carrying a set of genes controlling the same characters. Thus, if we consider a character such as flower colour, there will be a gene for flower colour in each chromosome of the pair. These two genes may either be the same or different, with the result that different flower colours are possible, depending on the particular genetic constitution of the individual concerned.

When sexual division takes place one chromosome of each pair goes to a different gamete, with the consequence that a new distribution of genes takes place. A simple example will illustrate best what actually happens. The flower *Mirabilis jalapa* has both a red and a white flowered variety. When these are crossed the resulting progeny have pink flowers. Let the gene for red flowers be R, and that for white flowers W. Then the distribution of genes during the process of crossing can be shown diagramatically as under:—



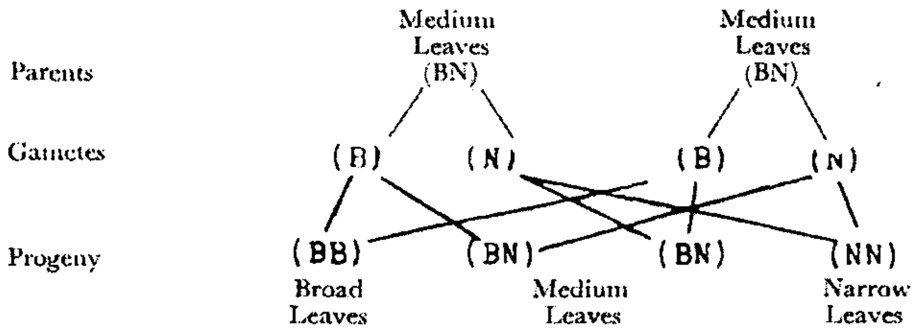
In this case it is evident that when both genes of the pair are the same we get either a red or a white flower, but when they are dissimilar we get pink flowers.

Now let us see what happens when two pink flowered plants are crossed:—



The progeny now contains different coloured plants in the proportion of 1 red, 2 pink and 1 white.

So much for one pair of genes. Suppose now we consider another pair controlling leaf shape. Let the gene for broad leaves be B and that for narrow leaves N, and let plants containing both B and N have medium leaves. Then, provided that they are carried in a different pair of chromosomes from those carrying R and W, these genes will also segregate entirely independantly as under:—



The actual distribution of both sets of genes and the characters to be expected in the progeny can be determined by combining the distributions of both R and W and B and N in a table as under:—

	RR	RW	RW	WW
BB	RR BB	RW BB	RW BB	WW BB
BN	RR BN	RW BN	RW BN	WW BN
BN	RR BN	RW BN	RW BN	WW BN
NN	RR NN	RW NN	RW NN	WW NN

This gives the following proportional expectation of different types of plants in the progeny:—

1	RR	BB	—	Red flowers, broad leaves
2	RW	BB	—	Pink flowers, broad leaves
1	WW	BB	—	White flowers, broad leaves
2	RR	BN	—	Red flowers, medium leaves
4	RW	BN	—	Pink flowers, medium leaves
2	WW	BN	—	White flowers, medium leaves
1	RR	NN	—	Red flowers, narrow leaves
2	RW	NN	—	Pink flowers, narrow leaves
1	WW	NN	—	White flowers, narrow leaves

Thus when only 2 pairs of genes segregate independantly it is possible to get as many as 9 different types of plants in the progeny of a cross. With 3 pairs of genes there is a possibility of 27 different types of progeny and with n different pairs of genes the number will be 3^n.

The 15 pairs of chromosomes in tea would permit of 15 pairs of genes segregating entirely independantly. This could give rise to 3^{15} or 387, 420, 489 different kinds of plant. It is obvious therefore that all the many variations of jat etc. met with in the field are readily explicable on a hereditary basis.

Before returning to the subject of vigour two other genetical terms need to be introduced. These are:—

Homozygous.—Applied to one particular character, this means that the plant contains a pair of similar genes such as RR or WW.

Heterozygous.—Applied to one particular character, this means that the plant contains a pair of dissimilar genes such as RW or BN.

A brief definition of vigour is now possible, namely that maximum vigour is generally associated with maximum heterozygosity. Thus, in the example given above, maximum vigour is likely to be exhibited by the pink flowered, medium leaved plants carrying the dissimilar pairs of genes RW and BN. On the other hand the pure homozygous plants RR BB, RR NN, WW BB and WW NN are likely to be the least vigorous.

Now the fact that our best vegetative clones almost certainly possess a high degree of vigour also implies that their genetic make up is highly heterozygous. Accordingly, when two such plants are used as parents and crossed, the distribution of genes in the resulting seed will follow the lines given in the tabular example. Here it is important to note that only 4 out of 16, or $\frac{1}{4}$ of the progeny will be completely heterozygous for 2 characters and hence retain the vigour of their parents. However, many more than 2 characters are likely to be associated with vigour. In general the proportion of progeny having the same degree of heterozygosity, and hence vigour, is $(\frac{1}{2})^n$, where n is the number of characters or pairs of genes involved. Thus, even if only 5 pairs of genes are concerned with vigour, only 1 in 32 of the plants in the progeny will possess the same amount of vigour as their parents.

The very small proportion of desirable progeny that may be expected when vegetative clones are crossed thus provides an explanation of the unsuitability of this type of material for clonal seed production.

However, the production of improved clonal seed is still a feasible proposition, provided that the potential parents are correctly chosen. If we look back at our first example it will be seen that when a homozygous red flowered plant is crossed with a homozygous white flowered plant the progeny consists entirely of heterozygous pink flowered plants. Hence what is required is that our two clonal seed parents should both be highly homozygous, but carrying dissimilar genes. When crossed such plants must produce highly heterozygous offspring, which should display the required vigour.

However, this is not the whole story, since besides vigour our clonal seed must also exhibit other desirable characters such as good manufacturing quality. Accordingly in choosing our prospective parents it is essential to ensure that these desired characters are already present in one or both of them.

Unfortunately, owing to their lack of vigour, our required highly homozygous parents are likely to be rather poor specimens without any marked distinguishing features. In fact such plants are likely to be amongst those discarded in the seedling nursery and never planted out. Suitable parents are accordingly difficult to find. Furthermore, there is little chance of assessing their potentialities except by carrying out a laborious series of trial crosses, growing the progeny to bearing and then taking comparative yield and quality tests. Such a prospect is indeed formidable and any breeding programme may take very many years with little or no success except for the unexpected lucky chance.

Surely then it is far better to concentrate on the assured prospects of short term improvement offered by vegetative clones rather than to fritter away time and energy waiting for a lucky chance to provide us with two or more satisfactory generative clones.