A Brief Look at Polyploidy

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A Brief Look at Polyploidy - Paul Gripp (reprinted from the AOS Journal)
One of the main features of orchids as a hobby is the wide range of interest that makes it a challenging, intriguing, and ever-searching endeavour. The study of plant genetics in reference to orchids is one of these fascinating sidelines.

Now, orchid genetics can be a very involved, technical subject, but for those of us interested in merely a working knowledge to help us in our estimate of expectations, there are a few basic facts which we should understand in order to be intelligent cultivators of this particular plant family. Perhaps the most basic study that we, as orchid growers, should understand is that area dealing with chromosome numbers (or, levels of ploidy). Plants carry, in their anatomical make-up, a certain number of genetic carriers (chromosomes) which determine the characteristics of the plants and their future progeny.

An interesting fact about chromosomes is that, besides carrying the individual genes that determine specific characteristics, the degree of influence of an individual set of chromosomes is greatly modified by the number of sets (or level of ploidy) of the particular individual. Hence, the terms diploid (2n), triploid (3n), tetraploid (4n), pentaploid (5n), etc., refer to the number of sets or level of ploidy. Those in which the multiple is greater than the normal or diploid level are referred to collectively as polyploids. In trying to
understand this, we should keep in mind that although plants of these various genetic groups do have certain specific characteristics, their main significance in breeding and heredity is their degree of influence in determining the characteristics of progeny. It is also true that the nature and significance of ploidy varies greatly among the various genera. In certain genera the rules of ploidy are fairly simple, with not too many exceptions. In other genera, however, the rules are very much complicated by uneven chromosome numbers and ability to breed among even very irregular chromosome patterns.

Generally speaking, the rules for the genus Cymbidium are fairly simple and well worked out, and they serve as a good example on which to learn. Breeding in cymbidiums turns out to be a blending process influenced by the various traits of both parents and weighed in quantity by their particular level of ploidy.

Diploids (2n): - Most typical, normal, naturally occurring wild types are of a diploid level of ploidy. The diploid level is the standard in nature, even though mutations and resultant abnormal strains commonly occur. Diploids are characterized by typically good, natural vigour. Diploids have many good features that are important in the most modern hybrids, and often it is their agreeable complimentary compatibility that makes a good match when used with other levels of polyploids, particularly the tetraploids.

Good Cymbidium diploids are certainly of great importance. Because of the fact that many of the most famous polyploids in cymbidiums have been brought about by much inbreeding, there are some poor growth characteristics that have carried along, and it is often the free-growing habit of the diploid that influences the progeny into being good, free performers. Cymbidium diploids are also characterized by often having more flowers per spike than many of the more popular tetraploids. Together with this, popularity in the tetraploid line has centred around the full-shaped white tetraploid. In order to get other colours, we must draw from the diploid colour genes.

Cymbidium Fanfare 'Sierra Spring', AM/AOS

Cymbidium Fanfare 'St. Francis',

AM/AOS (1965)

An example of a diploid (2n) flower.

An example of a tetraploid (4n) flower

Tetraploids (4n): - Tetraploids originally occurred by freak happenings, the plants' cellular structure changing in such a way as to possess twice the normal number of chromosomes in their make-up. Though tetraploids are often characterised by slower growth and heavier texture, the significance to the naked eye may or may not be apparent. It is also questionable to say that tetraploids are always necessarily associated with desirable features, such as good form and other characteristics we look for. Their main significance lies in their breeding influence. Because of their doubled chromosome number, they assert double the influence that a normal diploid would. Thus, the tetraploid has led to the finest advances in orchid breeding. This is because certain plants of good quality have been discovered to be tetraploids and they have been used in breeding to exert the advantage of their added breeding influence.

Triploids (3n): - Triploids normally are the resultant progeny from the mating of a tetraploid with a diploid. These comprise the great bulk of present-day cymbidiums. They are distinguished by uniform good growing characteristics and freeness of performance. Their visual traits, of course, vary from the extremes of one parent to the other and combinations of both, with their typical average lying about one-third from the tetraploid parent and two-thirds from the diploid. The ideal is to find those few plants from a particular cross which exhibit the good features of both parents, and in these exceptional cases we find our improvements. We usually find that triploid cymbidliums are sterile and will not produce seed. There are, however, some exceptions which give rise to other categories of polyploidy.

Pentaploids (5n): - A still higher realm of polyploidy is sometimes found in orchid plants, and this is the pentaploid. a type having five sets of chromosomes in the vegetative cell. Pentaploids have proven to be fairly useful breeders, although because of the mechanics of chromosomes, uniform growth and quality usually are not obtained and some of the resultant seedlings may be more difficult to grow and bloom. Many of our most famous plants, however, have pentaploid parents in their backgrounds.

Aneuploids: - Hybridizers are continually trying to do the unusual: therefore, there is an emphasis on abnormal types which has led to the development of a goodly number of orchid plants with uneven chromosome numbers. These are termed aneuploids.

Aneuploids are usually derived from uneven and rather unstable crossings, when parents of semi-incompatible chromosome numbers are used. The seedlings of such aneuploid crosses are usually most irregular and will vary greatly as individuals from their brothers in almost every aspect - from exact chromosome number to flower and growth patterns. This irregularity is brought about because their individual chromosome numbers are not exact multiples of the typical base number of the parent plants. Because some of these may be close to that of tetraploids, sometimes these aneuploids will act as breeders, but their performance can only be proven by giving them a try to see the results. There are many fine plants among the aneuploids, and although their implications in breeding are definitely hit and miss, it assuredly makes for interest and speculation.

With these various levels of ploidy available for hybridizing, there are a variety of possible combinations and it is possible to anticipate some generalities about the resulting progeny. It is with these thoughts in mind that hybridizers propose hopeful crossings.

<u>Diploid X Diploid</u>: - In the early days when all or most cultivated plants were diploids, a knowledge of other types was lacking. Flowers were mated with little regard to genotype, and most of these happened to be diploids. Even though more advanced types of combinations have come about, certain hybridizers have worked hard in the diploid line and fantastic progress has been obtained. The results, although different from those obtained with polyploids, have shown characteristics that, while not necessarily comparable, have been equally spectacular. The use of diploid crosses in cymbidiums at present are:

- to gain more desirable forms of coloured types, which are more intense in diploids than other classes;
- to provide a new assortment of genes for use as potential breeding with
- tetraploids;
- to create early bloomers; and
- to make miniature cymbidiums.

<u>Diploid X Tetraploid</u>: - The breeding method which has proven most satisfactory, with the largest and most prominent mass producers of seedlings for uniform high-quality progeny, has been the mating of the tetraploid of good form with the free and prolific diploid. The result is the triploid strain. There seems to be no doubt that for uniform high quality of shape, habit, and pleasing colour, this seems to be one of the most satisfactory of genetic combinations. Because of the fact that the tetraploid parent influences twice as much as the diploid parent, its characteristics of form and colour are more nearly approached. As new tetraploids of different types are brought into use, we will be able to greatly broaden our spectrum of hopefulness.

<u>Tetraploid X Tetraploid</u>: - An even more recent trend in breeding is the tetraploid-with-tetraploid mating. These have produced outstanding blooms. In addition, the resulting progeny are tetraploids, so this type of breeding has given rise to entire strains of tetraploid plants. Because there were only a few tetraploids in the beginning, there was much tetraploid inbreeding, with consequent undesirable characteristics perpetuated in the progeny. Some of the more inbred tetraploid types, even though characterized by excellent flower quality, have poor growing and blooming habits and are difficult plants to handle. Care must be used in selecting and mating tetraploids to guard against such bad features.

Triploid, Pentaploid and Aneuploid Matings: - When triploids, pentaploids and aneuploids are used in mating with their like or the more normal diploid or tetraploid, a wide number of combinations can occur. Because these "offbeat" types produce gametes (pollen and egg) that are often incomplete or uneven, crosses with them are characterised by irregularity and unevenness, if they take at all. Because they are lacking certain genes, many plants do not perform normally. Over the years, however, certain plants in the aneuploid or uneven polyploid levels (triploids, pentaploids, etc.) have become known as good parents as a result of the success of their progeny. Sometimes outstanding plants are obtained from these matings, but usually the resulting aneuploid plants are irregular growers and often the seeds are few. For commercial establishments who grow large blocks of seedlings, this type of breeding is not practical. "Off-beat" breeding offers tremendous interest for the hobbyist, however. The hobbyist can't use many plants, and if he drops all his pods for the year, he has lost nothing. This opens up an infinite vista for attempts where the high percentage of failures will keep the hobby in line. The value to this type of breeding is that occasionally very fine varieties arise, and secondly, often the progeny that do arise are strange aneuploids themselves and sometimes breedable.

The subject of ploidy has many interesting facets, each of which can be magnified into a particular situation in a specific genus or group of plants. Cymbidiums have been used as a passing example because they are not only well worked out but simple in example. In some other genera things can be far more complicated. Although there are many

variations and exceptions in the behaviour of living things, most of these differences can be explained by subsequent modifications and rearrangements which do not change the underlying principles. The ways of Mother Nature sometimes appear confused and complicated, but in reality, they are orderly and pleasant, and these phenomena are brought forth most finely in our study of the orchids.

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