SHORTENING THE BREEDING-CYCLE 1)

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ABSTRACT

Shortening the breeding-cycle is a reduction of the time which is needed for growing one generation from seed to seed. The physiological processes involved in shortening the breeding-cycles in five different groups of plants are briefly discussed, and summarized in the scheme on p. 9.

1. INTRODUCTION

Every breeding deals with generative propagation and usually with repeated generative propagation. By definition a breeding-cycle is the period from seed to seed. It is merely another word for "generation", but a word with more physiological background which I thought appropriate for a discussion in this section. As a rule, a breeding-program involves several breeding-cycles. Consequently, the length of one cycle is quite often the limiting factor in fulfilling a breeding-project in a reasonable lapse of time. Reducing the duration of one cycle may be a great help to the breeder.

In short cycle plants like summer annuals there is no great difficulty, although shortening the breeding-cycle is also desirable in this case. The same holds true for the winter annuals which are sown in the fall and harvested before the next fall. Biennials normally take twice as long as annuals and a reduction of the breeding-cycle is already highly desirable. But the main difficulties are met with in the perennials, both herbaceous and woody, for instance most flower bulbs and fruit trees respectively. In these plants a breeding-cycle may last very long, because it may take several years before a seedling forms its first flowers. And the possibility of carrying out a rational breeding-program, involving for instance a back-cross scheme, depends entirely on the possibility of shortening the breeding-cycle.

The scope of the present paper is to review briefly the principles of this problem. We can approach it from two different angles: from groups of related plants and from processes of the physiology of development. I shall start with a discussion of groups of related plants in the above order: annuals, biennials, perennials, however slightly more differentiated. It will turn out that the difficulties increase as we proceed in the given order. Next, a brief summary of the physiological problems involved will be given.

1) Lecture in the section Physiology of Eucarpia, Gembloux, Belgium, 4th July 1961.
2. SHORTENING THE BREEDING-CYCLE IN DIFFERENT GROUPS OF PLANTS

2.1. Summer annuals, non cold requiring, day neutral

Our first group comprises the non cold requiring and day neutral summer annuals, like for instance most peas and beans, and tomatoes. In these plants the seed germination usually does not offer serious difficulties. Hard shells may occur which can be overcome by mechanical means (red clover) or by chemicals like concentrated acids (tropical legumes). Also, seed dormancy may occur which can be broken by low temperature, but this dormancy seldom lasts long.

An unsolved, though rather academic problem is whether there is a juvenile phase for flowering, defined as a period from seed germination during which the plant is not apt to form flower buds. The situation in peanuts, where the seed contains floral primordia (3), is highly exceptional and usually a period of vegetative growth is necessary before flower bud formation can take place. I come back to the juvenile phase in discussing the biennials.

For a rapid development to the generative condition adequate growing circumstances are required and these are not always identical with the best growing circumstances for rapid vegetative growth. The rapid flowering of mustard with deficiency of nitrogen is well known (5). In general, temperature and light are extremely important factors and the successful growing of tomatoes in winter is one of the best examples of what can be reached by regulating temperature and light in their mutual interaction (8). Gibberellins may speed up the growth and the flowering. I obtained an extremely dwarfed neutronic pea mutant which in the field does not reach the flowering stage, but which after treatment with gibberellin elongates its stem appreciably and flowers normally (9).

The induction of flowering by grafting, like potatoes on tomatoes, is a very special technique and does not seem to have a wide application in other plants.

By regulating the growth factors, the raising of at least two generations in one year seldom meets with serious difficulties in the summer annuals. A relatively easy method is the growing of a generation in our winter in the other hemisphere.

2.2. Summer annuals, non cold requiring, but requiring a certain day length

A separate group of plants is composed of the non cold requiring summer annuals which, however, require a certain day length. These are mainly the short day plants, like Kalanchoë, and the long day plants, like the summer cereals.

As far as a juvenile phase for flower induction exists, it is usually rather short and the necessary day length treatments can start early. For the rest we may meet the same difficulties as in the former group. A rather interesting case is the chinese aster, Callistephus, which for an extreme shortening of the breeding-cycle needs a combination of short day and long day treatments. Floral induction takes place most rapidly in long days, but floral development in short days. By a proper adjustment of these two treatments two breeding-cycles can be reached in one year (2).

Several instances are known of flowering in the non-inductive day length after appropriate grafting, but this does not mean much saving in time.