PLANT BREEDING: THE STATE OF THE ART

N.W. Simmonds

Edinburgh School of Agriculture
West Mains Road
Edinburgh EH9 3JG
Scotland

INTRODUCTION

The readership of this book is a varied one. Some will know a great deal about plant breeding but little about genetic engineering; others will have reciprocal knowledge. Yet there is clearly an area of overlap of interests which it is the object of the book to explore. I am honored by having been invited to discuss plant breeding in an introductory way, to help to set the stage, so to speak, for the more detailed discussions to follow. In doing so, I am conscious that I must concentrate upon the wider issues of plant breeding, not the details, and that I cannot evade the responsibility of stating some kind of view as to the probable place of genetic engineering. My treatment is inevitably broad and I have taken the view that a little provocation here and there will not be amiss. With this approach in mind I shall first outline the general character of plant breeding (with apologies to the professionals in the audience who know it all already) and then enumerate what I take to be the principal problem areas of the subject, the areas in which we really need much more hard thinking, calculation and experiment.

Recent general works on plant breeding, including crop-by-crop outlines, include references 17, 18, 28, 35, 36, and 39.

GENERAL FEATURES OF PLANT BREEDING

Plant breeding has, I suggest, the following main features.

(1) It is a science-based technology directed towards economic objectives. It is nothing if not economically successful and it has long since passed the stage of being an "art".
(2) Genetics is basic to rational plant breeding but the technology appeals to numerous other sciences as well, with agricultural science, chemistry and plant pathology being perhaps especially prominent. Biometry is crucial to plant breeding because it lies at the heart of all selection and trials problems. Biometrical genetics, in the narrow sense, however, has had little practical effect. Often enough plant breeders do first what biometrical geneticists (and plant physiologists) later interpret. In only one crop I suspect (maize, 20) has formal biometrical genetics reached a level at which it influences breeding plans at the practical level.

(3) Plant breeding can also be thought of as applied evolutionary science. The breeder generates new genotypes of superior adaptation to environments which may be static or, perhaps more often, changing and he does so by manipulating gene frequencies in populations. The genetic variation is polygenic rather than oligogenic and the improved genotype requires a subtle balance (so far unanalyzable) of characters. All the components of neo-Darwinian micro-evolution are plainly identifiable: generation of variation, recombination, selection and isolation of the products. The plant breeder, it seems, is not only a technologist, but also an evolutionist.

(4) Plant breeding is but one component of crops research. The other, of course, is agronomy or crop husbandry research. The universal experience of crop yields in technologically-based agricultures of the past 50 years is that, with hesitations, they have gone steadily upwards. For this, both improved environments (E or husbandry effects) and improved genotypes (G or plant breeding effects) are generally agreed to have been responsible, in roughly equal measure. The interaction (GE) component has, I believe, been historically more important than is generally acknowledged (37) and I shall suggest later that it is deserving of more study. At all events, G, E and GE effects are the essential outcomes of crops research and plant breeders are responsible for something like half the achievement.

(5) Whatever the crop, the general pattern of plant breeding is a cyclical system of generationwise assortative mating (GAM): the best products of one cycle become the parents of the next (Fig. 1). The system is not closed, however, because there is (or should be) a steady trickle of new genetic material entering it from outside sources. There are, of course, endless complications of detail due to biological differences between crops and socio-economic requirements: wheat and sugarcane breeding programs, say, bear little superficial resemblance to each other. But the fundamental cyclical GAM pattern is common to both.