CHAPTER

# 2 DOMESTICATION AND GERMPLASM CONSERVATION

## 2.1. DOMESTICATION

***Domestication** is the process of bringing wild species under human management.* The present-day cultivated plants have been derived from wild weedy species. Therefore, the first step in the development of cultivated plants was their domestication, which began ~10,000 years ago when man began agriculture. The first domesticated plants were cereals, legumes and other species used for their fruits or roots. Most of the crops were domesticated by the prehistoric man. Knowingly or unknowingly he must have selected for the characteristics that made the plants more suited to his needs. It is reasonable to assume that characters like seed shattering and dormancy were rapidly eliminated. Under domestication, the crop species have changed considerably as compared to the wild species from which they originated. The changes, brought about by selection by man as well as nature, are often so great that the crops are classified as distinct species. As a result, in many cases, the parental wild species of the cultivated plants are not definitely known. The domesticated species were selected for characteristics entirely different from those for which the wild species were selected in nature. Therefore, the two groups of plants developed in two different, often opposite, directions.

Domestication of wild species is still being done and is likely to continue for a long t in the future. This is because the human needs are likely to change with time. Consequen the wild species of little importance today may assume great significance tomorrow. Thi particularly true for microorganisms producing antibiotics, involved in nitrogen fixation, producing other compounds of industrial or medical interest; forest trees producing tim and other commercial products; medicinal plants; and plants fulfilling specific needs. notable case of recent domestication is that of several members of Euphorbiaceae produc latex. The latex of these plants may be commercially used for the extraction of petrole products, including petrol and diesel. A large scale cultivation of these plants is being done USA and Japan. The Department of Science and Technology, Government of India, h initiated a project for cultivation of jojoba (*Simmondsia* sp.) in the arid zones of Rajasth Gujarat, Maharashtra and Uttar Pradesh. Seeds of jojoba contain oil, which is comparable sperm whale oil and is highly suitable as an industrial lubricant. The plants producing late are gopher plant (*Hevea* sp.), milkweed (*Euphorbia lathyrus*), etc. They are hardy dese plants and their latex compares favourably with petroleum crude, and is being used for the extraction of petroleum products. As a result, fields of these plants are often called ***living o fields***. Kala jeera (*Bunium persicum*), a perennial spice, was domesticated during 1990s i Himachal Pradesh; it is being cultivated as an orchard crop.

### 2.1.1. Selection under Domestication

When different genotypes present in a population reproduce at different rates, it is calle ***selection***. A ***population*** may be simply defined as the group of individuals, which mate or ca mate freely with each other. Thus a population consists of individuals of a single species growing in the same locality. Selection is grouped into two types, (1) natural and (2) artificial on the basis of the agency responsible for it.

**2.1.1.1. Natural Selection.** The selection that occurs due to natural forces like climate soil, biological factors (*e.g.*, diseases, insect pests, etc.) and other factors of the environmen is called ***natural selection***. It occurs in natural populations, *i.e.*, wild forms and wild species and determines the course of their evolution. Generally, all the genotypes of the populatio reproduce, plants become more adapted to the prevailing environment and the populatio retains considerable genetic variability.

In 1962, Nichlson proposed that natural selection may be seen to operate through two mechanisms, *viz.*, (1) environmental selection and (2) competition. ***Environmental selectio*** acts against all such genotypes that are unable to cope with the environmental stresses. As a result, the population consists, ultimately, of only those genotypes that are capable of surviving the prevalent environmental stresses and are also able to reproduce. ***Natural selection through competition*** occurs in crop populations where a plant takes up more water, nutrients or light than another at the expense of the other. Therefore, the more successful is a plant in exploiting resources, the greater will be its potential to be represented in the succeeding generations and it will be selected through competition.

**2.1.1.2. Artificial Selection.** In contrast, ***artificial selection*** is carried out by man. This type of selection is confined to domesticated species. It allows only the selected plants to reproduce, ordinarily makes plants more useful to man and generally leads to a marke decline in genetic variability in the selected progenies/populations. Usually plants become less adapted to the natural environment, and they have to be grown under carefully managed conditions. *Our present-day crops are the products of continued artificial selection.*

## 2.1.2. Types of Selection

Selection is grouped into the following three types depending mainly on the type of phenotypic class favoured by it : (1) directional selection, (2) stabilizing selection and (3) disruptive selection. In plant breeding situations, selection is almost always directional aiming to achieve the maximal expression of targeted characters. In nature, however, selection would be either directional, stabilizing or disruptive depending on the state of evolution of the population. While a population is adapting to new environmental conditions (either in a new area where it has been introduced, or in the same region in which the environment has undergone a change), there will be directional selection to increase the fitness of the species. Once the population has become adapted, directional selection will be succeeded by stabilizing and disruptive selections.

**2.1.2.1. Directional Selection.** When individuals having the extreme phenotype for a trait or a group of traits are selected for, it is called ***directional selection***. Directional selection usually selects for such gene combinations that produce a fully balanced phenotype; such a phenotype results in the maximum yield under artificial selection, and in the maximum fitness under the natural selection. Once such gene combinations are established, these co-adapted gene complexes are protected from further changes by genetic linkage, and sometimes also by a change in the mode of reproduction, *e.g.*, from cross-pollination to self-pollination. In case of cross-pollinated species, directional selection achieves the correct 'heterozygous balance', while in self-pollinators it establishes the correct 'homozygous balance.'

*In cross-pollinated populations, directional selection will favour alleles showing dominance in the appropriate direction, and genes showing 'desirable' epistatic interactions will also be selected for. As a result, characters subjected to prolonged directional selection will show high directional dominance and/or epistasis.*

**2.1.2.2. Stabilizing Selection.** When selection favours the intermediate phenotype and acts against the extreme phenotypes, it is termed as ***stabilizing selection.*** In nature, it follows directional selection, and strives to maintain the co-adapted gene complexes generated by the latter. It may be pointed out that for such characters that directly affect fitness, *e.g.*, viability and fertility, selection will always be directional. Therefore, stabilizing selection occurs only for those traits that do not affect fitness directly. The stabilizing selection favours those genotypes whose phenotypic expression clusters around the population mean. In such characters, therefore, the 'maximal' expression is not the 'optimal' expression, *e.g.*, flowering time in many crop species.

*Stabilizing selection disfavours dominance; if dominance is present, it is bidirectional (some alleles show dominance in one direction, while some other show dominance in the opposite direction). Similarly, epistasis is also selected against. Thus stabilizing selection accumulates alleles showing additive gene action.*

**2.1.2.3. Disruptive Selection.** This type of selection succeeds directional selection in such natural populations that are subjected to distinct ecological niches that may be spatial, temporal (seasonal or long-term cycles) or functional (*e.g.*, males and females of species) i nature. In each 'ecological niche' a different 'phenotypic optima' is selected for so that t population ultimately consists of two or more recognizable forms; such a selection is calle *disruptive selection.* The consequences of such a selection depend mainly on the followi two factors : (1) whether the different optimal phenotypes are independent of or depende on, each other for their maintenance or function, and (2) the rate of gene flow between the For example, the male and female forms of a single species are completely interdependent function, *i.e.*, reproduction, and show 100% gene exchange. At the other extreme, a specie may occupy a habitat that is fragmented into two or more independent niches. In each niche different phenotypic optima is selected for. In such cases, if the selection pressure is hig enough and continued long enough, genetic barriers to crossing may arise leading to the genetic separation of these forms, and eventually to their evolution as distinct species.

Disruptive selection maintains polymorphism in a population. Further, it shows such features as frequency-dependence (*e.g.*, less frequent alleles being more favoured), density-dependence, cyclical nature, etc.; a discussion of these aspects is beyond the scope of this book. *Since disruptive selection is 'directional' in nature within each 'ecological niche' of the habitat, it favours dominance and epistasis. In addition, it often leads to the establishment of integrated 'supergenes', e.g., in case of male and female forms of a species.* A ***'supergene'*** is a set of closely linked genes that together lead to the development of a specific optimal phenotype, *e.g.*, a male or female form.

### 2.1.3. Changes in Plant Species under Domestication

The precise sequence of events during the evolution of crop plants under domestication is not known. Presumably in the initial stages, considerable genetic variability existed in each domesticated species. This variability was acted upon by both natural and artificial selections. It may be expected that man always tried to pick out the plant types, which better suited his needs. He would obviously have selected for larger fruits and seeds. Our record of planned and systematic selection goes only as far back as middle of the nineteenth century. Before this period, selection efforts were obviously unfocussed and primitive. But judging from the results, *i.e.*, the differentiation of crops from their wild prototypes, the then completely unscientific man was not a bad plant breeder at all. The domesticated species have undergone several important changes as a consequence of his efforts.

Domestication of crops is believed to have occurred independently in the following at least six regions : (*i*) Mesoamerica, (*ii*) the Southern Andes (including the eastern piedmonts), (*iii*) the Near East, (*iv*) Africa (probably the Sahel and the Ethiopian highlands), (*v*) South East Asia, and (*vi*) China. In spite of the geographical diversity of these centres, a remarkably similar set of traits seems to have been selected in widely different crops; these traits are called ***domestication syndrome traits*** (Table 2.1). The changes in crop traits under domestication have resulted from selection of spontaneous mutations. Almost all the characteristics of plant species have been affected under domestication. The characters that show more distinct changes are those that have been objects of selection and are still plant breeding objectives in many cultivated species. Some of the important changes that have occurred under domestication are briefly listed below.