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Introduction: focusing on breeding for durable disease resistance of the Andean highland food crops

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The Andean region

The Andes forms a long chain of mountains of over 7,000 km long that range form Southern Venezuela to the South of Chile. The crops discussed in this issue are grown at altitudes ranging from 1,500 m to over 4,000 m in a very heterogeneous environment, characterised by large differences in rainfall, humidity and temperature. Also the latitude and direction of the slopes have significant effects on the amount and distribution of rainfall. Farmers have great experiences and skills in adapting their farming systems to these specific conditions. In the Andean region the majority of the farmers can be classified as low input small-holders, typical for marginal areas.

Breeding for a heterogeneous environment

In heterogeneous environments combined with small-holder farming systems genotype × environment × farming interactions play a major role. Cultivars have to be adapted to both the local physical environment (climate, soil, topography and biotic stresses) and the socio-economic environment (preferences of the users, preferences of the markets, technological facilities). In such situations conventional and centralized plant breeding programmes are typically not successful (Morris and Bellon, Euphytica 2004, 136:21–34.). As an alternative, a decentralized way of breeding will be more appropriate. The Preduza approach encompasses such a decentralized way of breeding.

Local cultivars

In the Andean zone the many indigenous crops such as maize, quinoa, potato, common bean, and crops that were introduced centuries ago, such as barley, wheat and faba bean, are still typically being grown as local cultivars (landraces). Local cultivars are propagated by the farmers and have become adapted to the vagaries of the local climate, the marginal growing conditions and the agronomic systems applied by the farmers. These cultivars usually represent a large variation both within and between cultivars. The total variation in all landraces of the indigenous crops is often very wide, representing a rich agro-biodiversity.

The genetic variation in local cultivars resulted from the balance between forces enlarging the genetic variation within cultivars (out-crossing between and within cultivars followed by segre-

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gation, mutation, inadvertent mixing) and forces restricting the genetic variation (natural selection and selection carried out by the farmers). These local cultivars form an excellent basis for the development of improved cultivars as they are already adapted to the local region and the requirements of the farmers and as they still contain a wide genetic variation.

In this special issue, Ochoa et al., Silva et al., Gabriel et al. and Ochoa et al. present the results of their surveys for disease resistances in local cultivars in common bean, maize, potato and wheat respectively, illustrating the degree of genetic variation still present in these crops.

Durable resistance

Johnson (Phytopathology 1981, 71:567–568) defined durable resistance as resistance that remains effective while being extensively used in agriculture for a long period in an environment conducive to the disease. Such resistance, if introduced in the local cultivars, would be an important improvement for the small-holder. Unfortunately many resistances introduced in modern cultivars appeared not durable. These non-durable resistances occur widespread, function usually against fungi and bacteria with a narrow host range, are controlled by single genes (monogenic) and are associated with a hypersensitive reaction. These resistance genes interact in a gene-for-gene way with avirulence genes in the pathogen to give an incompatible reaction. In contrast, durable resistance against specialized fungi and bacteria is often quantitative, based on the additive effects of some to several genes, and is not associated with the hypersensitive reaction. This quantitative resistance is often widespread in the crop species. An exception is durable resistance against viruses that is often monogenic and associated with a hypersensitive response.

Quantitative resistance is discussed in this issue in common bean (Ochoa et al.), maize (Silva et al., Vásquez and Mora), potato (Gabriel et al.) and barley (Sandoval-Islas et al.). The ineffectiveness of race-specific resistance, based on major genes, is shown in common bean (Ochoa et al.) and wheat (Ochoa et al.). In barley a considerable effect of quantitative resistance on yield loss reduction is reported by Ochoa and Parlevliet.

Participatory plant breeding

The farmers in the Andean regions usually consume their own agricultural food products. In order to breed cultivars that fit in these local farming systems, participatory plant breeding (PPB) is crucial (Ceccarelli et al. Euphytica 2001, 122:521–536; Joshi et al. Euphytica 2001, 122:589–597: Smith et al. Euphytica 2001, 122:551–565; Witcombe et al. Euphytica 2003, 130:413–422).

The involvement of farmers in plant breeding programmes is not a fixed process but should be adjusted to the local social-economic conditions. Witcombe et al. (Experimental Agric. 1996, 32:445–460) distinguish participatory variety selection (PVS) and participatory plant breeding (PPB). In PVS farmers select from sets of existing cultivars or advanced materials, while in PPB farmers already participate in the selection of segregating material that may be far from ready for practical usage. PPB is very demanding for both the farmer and the breeder. ‘‘Preduza’’ believes that there is not much added value by the involvement of farmers in early breeding cycles and therefore advocates that selection in early generations can be better done by the breeder. This is much more cost effective and, giving the limited resources, PVS could be implemented in six widely different crops in three Andean countries.

In this issue Danial et al. report their experiences with PVS in various crops, McElhinny et al. report about their experiences in quinoa in two communities in Ecuador and Almekinders et al. discuss seed production in relation to participatory plant breeding.

Seed production

In marginal farming systems the production of the seed for the next planting is usually done by farmers themselves, who withhold part of the harvested seed for the next cropping season. This is a relatively cheap method, but has drawbacks as often undesired outcrossing occurs and the quality of the seeds may be quite low. Almekinders et al. and Duijndam et al. report in this issue about such informal seed productions systems. Alternatively, basic seed may be produced by the breeding institute. Such formal seed production is more expensive but may better guarantee the identity and health of the improved cultivars, a topic discussed by Parlevliet.

Preduza: a generic approach for marginal farming systems

The papers in this issue demonstrate clearly that all crops mentioned above represent a large reservoir of genetic variation, that can be well explored and exploited by breeders in good cooperation with farmers. This illustrates that the Preduza approach is independent of the crops and specific traits and of the local farming systems used. Therefore, the Preduza approach reflects a very efficient system of participatory breeding for marginal farmers that can be exploited for any crop and at any location. This special issue may be a good help for those who are involved in similar programmes aiming at improving the living conditions of rural communities by breeding.