The sea beet of the Po delta

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Introduction

The sea beet, classified *Beta vulgaris* L. subsp. *maritima* L. Arcang. by Lange *et al*. (1999), is quite common along the Adriatic coast of the Po delta (Barstch 1999). The species, considered to be the progenitor of cultivated beets (McGrath *et al.* 1999), is characterized by a remarkable genetic and phenotypic variability. Its adaptive ability allows it to grow even on salty soils and in conditions of limited availability of water. This genetic variability may be an adaptive response to environmental stresses (Hanson and Wyse 1982). Besides being a source of genetic resistance to sugar beet diseases such as cercospora and rhizomania, the sea beet is also arousing great interest as possible source of resistance to abiotic stress (Luterbacher and Smith 1998).

Resistance to cercospora leaf spot and to rhizomania

Hybridization between sugar beet and sea beet is easy due to their genetic affinity (Hjerdin *et al*. 1994). Experiments in transferring useful traits to the cultivated varieties began toward the end of the 19th century in different countries, but only the work carried out by Munerati brought significant results (Munerati *et al.* 1913).

In the summer of 1909, this author collected seed on the right bank of the Po di Levante river (Fig. 1), close to its mouth at the Adriatic sea (Munerati 1946).

Mass selections from the plants sown in cultivated soil were followed by several cycles of inbreeding with the objective of fixing the biennial trait. Using predominantly biennial lines, he began to cross it with sugar beet, continuing by a number of backcrossings to eliminate the negative traits of the wild parentage (fangy and fibrous root, tendency to bolting, etc.). Munerati does not mention the specific programme to improve the resistance to cercospora leaf spot (CLS), to which even the sea beet of the Po delta is normally susceptible. Around 1925, he selected genotypes able to reduce or delay the development of the fungus on the leaves. Some lines were forwarded to the breeders working for the US Department of Agriculture (Coons *et al*. 1955).

Further selections improved bolting resistance and after ten years it was possible to release the line R 581, which was considered to show the first substantial progress against the disease (Coons *et al*. 1975). The line was distributed to public and private breeding stations, and was used directly for a number of commercial varieties classified as CLS-resistant.

Presently, the increased effort of the breeding companies has produced several improvements in sugar yield and bolting resistance, which only a few years ago were the main disadvantages of the resistant varieties. With the recent breeding progress, the sugar yield of these varieties is today similar to that of the varieties susceptible to CLS (Skaracis and Biancardi 2000). Even with the protection given by genetic resistance and fungicide, the control of the disease is not complete (Stevanato *et al.* 2002), and a lot of breeding activity is still necessary, especially to reduce the use of fungicides on the crop.

The origin of rhizomania resistance, recently reviewed by Biancardi *et al.* (2002), is probably to be sought in Italian CLS-resistant materials derived from the above-mentioned crosses with sea beet. The authors confirm the hypothesis of the common origin of the supposed qualitative (monogenic) rhizomania resistances well known as "Rizor type" and "Holly type". The Italian sea beet genotypes, from which CLS resistance was obtained, probably also provided the quantitative (multigenic) resistance to rhizomania shown by the multigerm variety 'Alba P'. Other authors confirmed the presence of rhizomania-resistant genes in sea beet biotypes collected in many parts of the world (Whitney 1989).

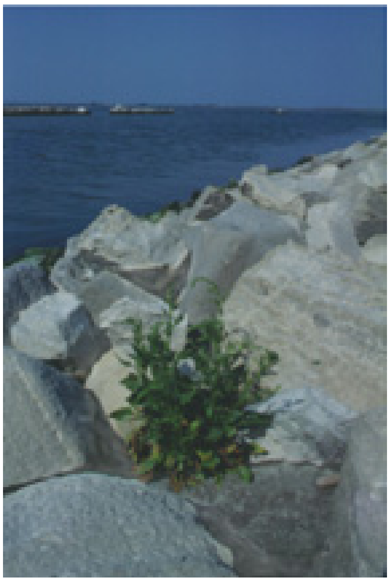

Fig. 1. Sea beet habitat (Porto Levante).

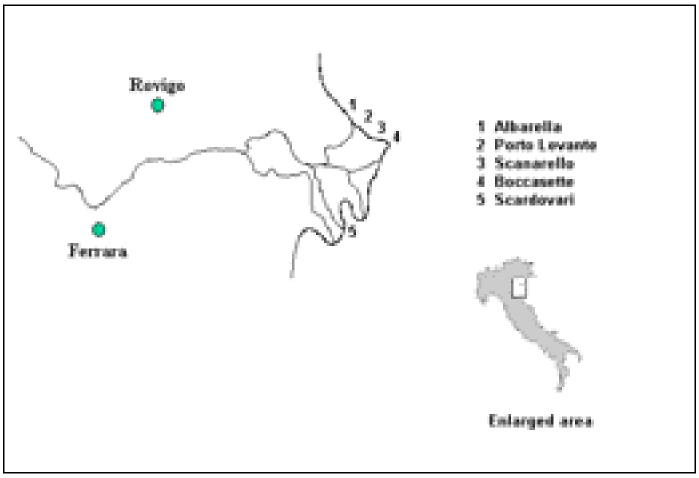

Fig. 2. Sea beet populations of the Po delta.

Distribution and description of sea beet populations

In recent years, the distribution of sea beet populations along the Po delta coastline has been examined with the objective of studying the genetic variability of the different populations and to evaluate the possible presence of hybrids with cultivated beets (Bartsch *et al.* 2002). Five principal sites were located (Fig. 2).

The coastline from the Venice lagoon to the southern part of the Po delta appeared the most densely populated. This is probably due to the relatively high presence of undisturbed natural habitats (Stevanato *et al.* 2001). Representative samples of seed were collected from each population and stored in controlled conditions. The seed is available for breeding purposes and for research centres involved in protection of genetic resources.

Sea beets were identified in some restricted areas in the northern part of the Po delta. Only in few places between the mouths of the Po di Levante and Po di Maestra can the populations be considered sufficiently protected from foreign pollination because of the distance from the sugar beet fields. Great variability in the form of the seed stalk, number of flowers per flower cluster, shape of leaves and roots, etc., was immediately observed. The plant prefers the banks very close to the seawater, which is certainly important for the dispersion of the species. Some plants grow without any apparent ill effects, with the fibrous roots partially submerged. Probably due to the lack of competitive ability, the sea beet seems to suffer from the presence of weeds (Graminaceae), which grow partially uncontrolled along the banks. The seed collected at different times reached the maximum germination of 20% in the harvest made on 20th July (Biancardi and De Biaggi 1979).

Germplasm evaluation and conservation

During the months of July and August 2000, the previously located populations of wild beets were sampled. The aim of the investigation was to study the genetic traits of the different populations and identify possible crosses with cultivated beets. Two or three young leaves were sampled from each plant. The DNA was extracted from each leaf using the methods of Doyle and Doyle (1987) and analyzed using the AFLP technique (Bartsch *et al.* 2002).

In order to determine the extent of genetic variation of the morphophysiological characters involved in the mechanisms of response to water and nutritional stress, the parameters "root length" and "sulfate uptake rate" were measured after water/nutritional stress in 30-day-old sea beet seedlings grown in hydroponics. The objective of this research was to study the mechanisms of adaptation to water/nutritional stress with the aim of identifying the morphological and physiological markers useful for the selection of genotypes tolerant to abiotic stresses (Saccomani *et al.* 2002).

The wild populations must be catalogued and conserved in order to avoid genetic erosion and the risks of gene flow from cultivated to wild beet. Gene flow is possible in the current situation, but it would be more worrying if transgenic varieties were to be grown. As is known, transgenic varieties of sugar beet resistant to herbicides, nematodes and rhizomania are currently under advanced field experimentation (Wenzel 1998). Several researchers pointed out the risk of gene flow caused by the transfer of transgenes from the commercial seed breeding centres in Emilia-Romagna and Veneto to the Adriatic coastal areas. The diffusion of transgenes carried by pollen within the wild populations would probably confer a selective advantage on the hybrids, and therefore it could modify the genetic structure of the populations themselves (Bartsch *et al.* 1999).

The ISCI-Sezione di Rovigo has begun collaboration with the Po Delta Regional Park in order to preserve the natural populations of sea beet. Owing to the decreasing number of plants in the main area concerned (Barstch *et al.* 2002), the cultivation of plots located in more isolated sites was initiated. The aims of such activity can be summarized as follows: i) identification of the different populations of sea beet and recording of their geographical coordinates; ii) evaluation of the dimensions and phenotypic variability of each population and monitoring of the numeric variation over time; iii) collection and conservation of the seed of populations under genetic erosion. The inspections will permit a complete mapping of the localities and characterization of the factors that determine genetic erosion. The long-term storage of the seed will allow the conservation of the various populations and, if necessary, the restoration of their numbers.

Conclusions

The sea beet of the Po delta is of great interest as a source of genetic resistance useful for the cultivated varieties. Because of the land reclamation works and the expansion of the tourist facilities, the number of plants of sea beet is declining in various localities. The main populations were mapped and AFLP analysis of the genetic structure has been performed. In order to preserve this resource, it is necessary to analyze the biodiversity in order to determine the genetic structure of each population. This should allow the detection of any possible future modifications caused by gene flow. It is also necessary to reconsider the policy of *in situ* conservation of sea beet germplasm in this area.

References

Bartsch, D., M. Lehnen, J. Clegg, M. Pohl-Orf, I. Schupan and N.C. Ellstrand. 1999. Impact of gene flow from cultivated beet on genetic diversity of wild seed beet populations. Molecular Ecology 8:1733-1741.

Bartsch, D., P. Stevanato, M. Lehnen, A. Mainolfi, T. Mücher, A. Moschella, S. Driessen, G. Mandolino, A. Hoffmann, M. De Biaggi, U. Wehres and E. Biancardi. 2002. Biodiversity of sea beet in northern Italy. Pp. 171-180 *in* Proceedings of the 65th International Institute for Beet Research (IIRB) Congress, 13-14 February 2002, Brussels, Belgium.

Biancardi, E. and M. De Biaggi. 1979. *Beta maritima* L. in the Po Delta. Pp. 181-185 *in* Atti Convegno in Commemorazione di Ottavio Munerati, 5-6 October 1979, Rovigo, Italy.

Biancardi, E., R.T. Lewellen, M. De Biaggi, A.W. Erichsen and P. Stevanato. 2002. The origin of rizomania resistance in sugar beet. Euphytica 127:383-397.

Coons, G.H., F.V. Owen and D. Steward. 1955. Improvement of the sugar beet in United States. Advances in Agronomy 7:89-139.

Coons, G.H. 1975. Interspecific hybrids between *Beta vulgaris* L. and the wild species of *Beta*. J. of the American Society of Sugar Beet Technologist 18:281-306.

Doyle, J. and J.L. Doyle. 1987. Genomic plant DNA preparation from fresh tissue – CTAB method. Phytochem. Bull. 19:11-15.

Hanson, A.D. and R. Wyse. 1982. Biosynthesis, translocation and accumulation of betaine in sugar beet and its progenitors in relation to salinity. Plant Physiology 70:1191-1198.

Hjerdin, A., T. Sall, N.O. Nilsson, C.H. Bornman and C. Hallden. 1994. Genetic variation among wild and cultivated beets of the Section *Beta* as revealed by RFLP analysis. J. of Sugar Beet Research 31:59-67.

Lange, W., W. A. Brandenburg and T.S.M. De Bock. 1999. Taxonomy and cultonomy of beet (*Beta vulgaris* L.). Botanical J. of the Linnean Society 130:81-96.

Luterbacher, M. and J. Smith. 1998. Improving disease resistance and drought tolerance in sugar beet using wild *Beta* germplasm. British Sugar Review 66:26-29.

McGrath, J.M., C.A. Derrico and Y. Yu. 1999. Genetic diversity in selected, historical US sugarbeet germplasm and *Beta vulgaris* ssp. *maritima*. Theoretical and Applied Genetics 98:968-976.

Munerati, O., T. Mezzadroli and V. Zapparoli. 1913. Osservazioni sulla *Beta maritima* L. nel triennio 1910-1912 [Three-year observations on *Beta maritima* L. 1910-1912]. Le Stazioni Sperimentali Agrarie Italiane 46(6):347-371.

Munerati, O. 1946. Il problema della barbabietola [The beet problem]. Pp. 3-29 *in* Convegno per la Ripresa Economico-Agraria del Polesine, 14-17 April 1946, Venezia.

Saccomani, M., P. Stevanato, M. Cagnin and E. Biancardi. 2002. Genetic variation of sulfate uptake in sugar beet. Pp. 255-260 *in* Proceedings of the 65th International Institute for Beet Research (IIRB) Congress, 13-14 February 2002, Brussels, Belgium.

Skaracis, G.N. and E. Biancardi. 2000. Breeding for cercospora resistance in sugar beet. Pp. 177-195 *in Cercospora beticola* Sacc. Biology, agronomic influence and control measures in sugar beet (M.J.C. Asher, B. Holtschulte, M.R. Molard, F. Rosso, G. Steinrücken and R. Beckers, eds). Advances in Sugar Beet Research Series 2. International Institutefor Beet Research (IIRB), Brussels.

Stevanato, P., M. De Biaggi, G. N. Skaracis, M. Colombo, G. Mandolino and E. Biancardi. 2001. The sea beet of the Adriatic coast as source of resistance for sugar beet. Sugar Tech 3:77-82.

Stevanato, P., E. Biancardi, R. Telloli, M. De Biaggi and M. Colombo. 2002. Effetti della cercosporiosi sulla qualità estrattiva della barbabietola da zucchero [Effects of cercosporosa leaf spot on the processing quality of sugar beet]. Agroindustria 2:132-138.

Wenzel, G. 1998. Isolation genes and their transfer into crop plants. Pp. 139-149 *in* Proceedings of the 61st International Institute for Beet Research (IIRB) Congress, 11-12 February 1998, Brussels, Belgium.

Whitney, E.D. 1989. Identification, distribution and testing for resistance to rhizomania in *Beta maritima*. Plant disease 73:287-290.