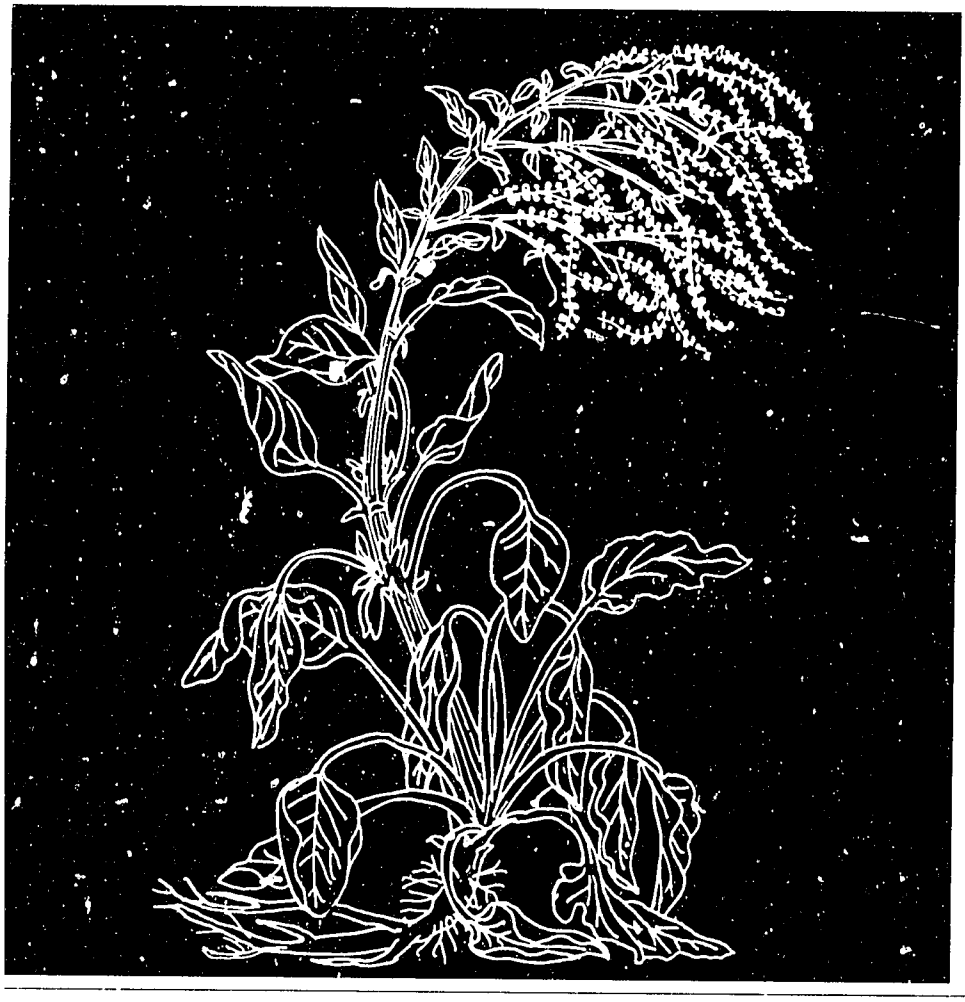
INTERNATIONAL CROP NETWORK SERIES. 11

International *Beta* genetic resources network

- PN-ABU-002

A report on the 3rd
International *Beta* Genetic Resources Workshop
and **World *Beta* Network Conference**
held at the North Dakota State University, Fargo, USA, 4-6 August 1993



International Plant Genetic Resources Institute
IPGRI

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IPGRI

The International Board for Plant Genetic Resources (IBPGR), established in 1974, was transformed in 1993 into a new organization, the International Plant Genetic Resources Institute (IPGRI). IPGRI is an autonomous, international, scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). The basic function of IPGRI is to promote and coordinate, at international level, collection, conservation, documentation, evaluation and use of germplasm, thereby contributing to raising the standard of living and welfare of people throughout the world. With its establishment, IPGRI has presented a new strategic plan that outlines four major objectives. These are: the Institute will assist countries (particularly in the developing world) in assessing and meeting their conservation needs for plant genetic resources, and in strengthening their links to users; it will build international collaboration in the conservation and use of plant genetic resources, mainly through the encouragement of networks based on crop and geographical criteria; it will work to develop and promote improved strategies and technologies for conservation of plant genetic resources; and IPGRI will provide a service to inform the world's genetic resources community of both practical and scientific developments in the field. Financial support for the core programme is provided by the governments of Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, India, Italy, Japan, the Netherlands, Norway, the Russian Federation, Spain, Sweden, Switzerland, the UK, the USA; and the United Nations Development Programme and the World Bank.

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Preface

The World Beta Network (WBN) was founded in 1989 on the initiative of the IBPGR to test the network concept approved by IBPGR's Programme Committee in 1988. The objective of crop specific networks is to improve international collaboration between curators of collections, researchers and users of germplasm, thus enabling maximum use of the often-limited funds for conservation and utilization, through task-sharing. Beet is one of the most important cash crops of the industrialized countries. From the beginning, therefore, IBPGR's strategy aimed at the development of a highly self-sustaining network with only partial financial support from them.

International cooperation on beet genetic resources started in 1987 with a workshop attended by eleven experts from six countries and at which the European Database for Beta was introduced; at that time, 13 institutions had already contributed passport data to the database. This workshop, held at Wageningen in the Netherlands, was fully financed through the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR). The participants decided then to develop a revised IBPGR descriptor list for Beta. It was published in 1991.

In 1989, a further workshop, largely funded by IBPGR, was also held at Wageningen. A total of 33 experts from 20 different countries attended the meeting. The number of institutions contributing to the International Database for *Beta* (IDBB) had increased to 18. For the first time, representatives from breeding companies participated. Lectures on biosystematics, seed dormancy and, in particular, the introduction of the pre-breeding concept of N. O. Bosemark, can be considered as highlights of this 1989 meeting. The lecture on pre-breeding has resulted in ongoing discussion on how plant breeders can improve their use of *Beta* germplasm collections.

A further conference at Braunschweig (FRG) in 1991, was attended by 35 participants from 17 countries. This time, breeding companies partly funded the meeting thus enabling the invitation of key speakers and the participation of experts from eastern European countries. By then the number of holdings documented by the IDBB had increased by two, to a total of 20. The programme of the 1991 workshop consisted of two parts: a working session and lectures on scientific aspects of beet genetic resources. At that meeting, emphasis was given to an inventory of the germplasm activities in Asian, Mediterranean, East European and Northwest European countries. Expansion of the scientific session facilitated the meeting of scientists working on biosystematic aspects of the genus *Beta*. Improved communication between germplasm collectors, curators, researchers and commercial breeders has strengthened the links within the group.

Since the response to the lecture session had been very encouraging, even more time was given to scientists to present their research projects and results at the Fargo meeting in 1993. Many different subjects ranging from conventional breeding to genome analysis and genetic engineering, were covered. With 75 participants from 15 countries, this meeting was the largest to date. The conference was funded by IBPGR and companies associated with the Beet Sugar Development Foundation. In 1993 the number of accessions described by the passport table of the IDBB had increased to a total of 9168 accessions which seeds are stored decentrally at 24 locations all over the world. The successful US *Beta* germplasm conservation and evaluation programme was of particular interest to the participants. The view was expressed by some participants, that none of the other international scientific organizations would cover beet breeding research (from the acquisition of germplasm to sophisticated analyses of the genetic structure of the *Beta* genome) in such a comprehensive way as does the WBN. It seems that the WBN, therefore, established as the IBPGR's model for international cooperation, has accomplished one of its major goals: the development of a voluntary association of crop-specific experts based on the principles of common interest, mutual support and benefit.

World *Beta* Network Coordinating Committee

D. L. Doney
B. V. Ford-Lloyd
H. M. Srivastava
L. Frese - Secretary

Local arrangements committee

J. J. Kern - Co-Chair, American Crystal Sugar Co.
J. D. Eide - Co-Chair, USDA/ARS
J. Bergman - Hilleshog Mono-Hy Inc.
W. M. Bugbee - USDA/ARS
L. G. Campbell - USDA/ARS
D. L. Doney - USDA/ARS
G. A. Smith - USDA/ARS
C. Talley - Betaseed, Inc.
C. A. Wozniak - USDA/ARS

Contributing organizations

USDA-ARS
Beet Sugar Development Foundation (BSDF)
International Board of Plant Genetic Resources (IBPGR)
North Dakota State University (NDSU)

Reports

Welcoming addresses and introductions

On 4 August, 1993, Dr. G. A. Smith, Research Leader at the USDA/ARS and Dr. D. C. Zimmermann, Centre Director of the USDA/ARS, welcomed the participants and briefly reviewed the major objectives and past activities of the WBN. Dr. H. R. Lund, Dean of the North Dakota State University, explained the organization, size, function and research objectives of the University and described the history of the region and its agricultural and industrial potential. The assembly was welcomed on behalf of the Beet Sugar Development Foundation (BSDF) by its Executive Vice-President, T. K. Schwartz. All key speakers expressed their commitment to arranging an agreeable meeting and said that they would be prepared to help as and when necessary.

The following day, Dr. S. Padulosi welcomed the participants, on behalf of IBPGR, and briefly outlined the new structure, objectives and goals of the International Plant Genetic Resources Institute (IPGRI), which is expected to replace IBPGR by 1994. IPGRI will continue to promote networking activities on crops as a major way of successfully channeling efforts in various parts of the world towards the safeguarding and better use of Plant Genetic Resources.

On 6 August, 1993, Dr. H. Shands, Assistant Deputy Administrator for Genetic Resources of the US Department of Agriculture, was introduced to the participants by the General Chairman of the WBN meeting, Dr. D. Doney. In his welcome address, Dr. Shands emphasized the need of having germplasm available for continuous plant variety improvement and consequently food supply security. He mentioned the great potential of biotechnology for crop improvement. In that context, the controversies within FAO over ownership of genetic resources were clearly addressed. Dr. Shands said that the openness of exchange of germplasm and information held by the US genetic resources system will be continued and that the US are open to any kind of cooperation on genetic resources. He advised the participants to counteract any attempt to restrict the exchange of germplasm and information within the WBN.

Tours

On 5 August, the participants had the opportunity to visit the Northern Crop Science Laboratory and the USDA/ARS fields. The demonstration of a taxonomically and geographically comprehensive wild beet collection met with considerable interest. On 6 August, participants were invited to visit the American Crystal Sugar Co. research and beet storage facilities as well as to a large sugarbeet farm close to Fargo.

Report on the third meeting of the World *Beta* Network

North Dakota State University, Fargo, (USA), 4-6 August, 1993

Papers and posters session: a summary

Pre-breeding

After the welcoming speeches were delivered on 4 August, the General Chairman, Dr. Doney, introduced Dr. J. J. Kern as the chairman of the pre-breeding section. The first speaker, Dr. Smith, pointed out that a clear definition for the term 'pre-breeding' is lacking and suggested defining it as 'any manipulation leading to domestication'. The effects of selection pressure on changes in gene frequency were subsequently discussed in the context of the theory of population genetics.

Thereafter, Dr. J. R. Stander described the problems of utilization of exotic germplasm from the viewpoint of a commercial breeder. He pointed out that the sugarbeet culture in the US today is not at risk because of genetic vulnerability and that progress in the field of resistance breeding still can be achieved within the sugarbeet breeding genepool. Broadening the genetic basis of this genepool, by introgression of new cytoplasmic and nuclear genes, would be advisable as a precautionary measure to prevent epidemics. He favored a pre-breeding concept such as that outlined by Dr. N. O. Bosemark during the 1989 WBN meeting and stated that such work should be conducted by public institutions.

Introgression of seabeet accessions into sugarbeet material, was the subject of the report delivered by Dr. Doney. Root yield as well as sugar content improvements had been achieved through repeated cycles of mass selection for root shape and bolting resistance.

Dr. R. T. Lewellen described the development of BNYVV-tolerant synthetics from crosses between sugarbeet lines with a range of B. vulgaris ssp. maritima populations. The selection programme resulted in synthetics which, when grown under mild to severe disease pressure, had higher root and sugar yields than did the sugarbeet parental line. It was noted that during selection for Erysiphe betae resistance within offsprings derived from a cross 'vulgaris' x 'French maritima from the Loire delta', the susceptibility to cyst nematode was reduced by chance.

Dr. J. C. Theuer reported on the use of exotic germplasm for the development of globe- or conical-shaped sugarbeets with the goal to reduce tare, to ease mechanical harvest and to improve processing economy. Thereafter, Dr. W. Lange reported on the Dutch pre-breeding programme using North Atlantic wild beet germplasm as a source of partial resistance against the cyst nematodes, H. schachtii. Depending on the breeding material, the number of cysts was reduced to 15-40% of the susceptible control variety. Also, some of the material shows full resistance to H. trifolii.

Dr. L. G. Campbell presented encouraging results of a screening and pre-breeding programme for root rot resistance. It can be considered as a model for (comparatively inexpensive) pre-breeding work which, ultimately, benefits commercial sugarbeet breeders as well as growers. The continuity of this programme is safeguarded by public funds.

The Indian sugarbeet breeding programme was explained by Dr. H. M. Srivastava. He outlined the specific germplasm qualities for sugarbeet culture in the Asian region. They included high temperature tolerance and Sclerotium root rot resistance. Owing to great ecogeographic diversity, it is possible to test breeding material and genebank accessions for resistance to a great variety of disease agents under natural disease conditions. He gave a comprehensive overview of breeding activities and achievements.

Dr. L. Dalke explained the Polish breeding programme which aims at the introgression of new male-sterile cytoplasm from B. vulgaris ssp. maritima into sugarbeet material.

Dr. A. Kuhk outlined the recurrent selection programme for sugarbeet population improvement at Kiev. Until the 1970s monogerm open-pollinated varieties were used in the former USSR. Today, there is a need to broaden the genetic basis of the breeding genepool through introgression of old multigerm open-pollinated varieties.

Posters

In the afternoon, posters on research programmes dealing with biosystematic aspects, evaluation, breeding and germplasm collection, were presented. Parallel to the poster session, the Database of the Germplasm Resources Information Network for personal computers (pcGRIN), as well as parts of the International Database for *Beta* (IDBB), were demonstrated. Since the pcGRIN software is freely available and is user-friendly, the pcGRIN database generated considerable interest.

Gene transfer

Dr. J. W. Saunders chaired the session. Dr. P. Steen presented results of the herbicide resistance programme of the Maribo breeding company. The degree of herbicide resistance of transformed sugarbeets was shown to vary considerably, depending on the insertion site of the gene. Transgenic lines must be considered as raw material requiring improvement through selection as is the case for any other genetic resource.

Dr. C. Jung reported on a research programme aimed at the identification and cloning of monogenic resistance to the cyst nematode (*H. schachtii*) and its insertion into the sugarbeet genome.

The use of mildly and highly repeated sequences for the analyses of phylogenetic trees was outlined by Dr. A. Berville. Thereafter Dr. C. H. Bornman described the results of RFLP analyses in a set of wild beet accessions as well as sugarbeet- and fodderbeet breeding lines. The sugarbeet breeding lines showed a considerable amount of variation, comparable with the level detected among the wild beet accessions. With one exception, cluster-forming among the wild beet accessions agreed with the classical taxonomic system. Dr. R. Hall then gave an overview of investigations aimed at the transfer, into sugarbeet, of new cytoplasmic sources by means of protoplast fusion. He presented a clear report on the fusion protocol for wild *B. vulgaris* and sugarbeet. Dr. Wozniak described the use of ß-glucuronidase as a marker for the improvement of the DNA transfer techniques in sugarbeet. Transformed tobacco and tomato plants containing the IPT gene start to produce cytokinin upon insect attack. This reduces the plant damage and retards insect development. It was stated by Dr. A. Smigocki that this environmentally-safe pest control system could also benefit sugarbeet production. Dr. W. Lange discussed major results of the PhD thesis of J. Letschert and presented arguments for the use of a revised classification system of *Beta* section *Beta*.

All scientific papers will be published in the Journal of the American Society of Sugarbeet Technologists (ASSBT). The abstracts of papers and posters are attached to this report as Appendix 3.

Review of network activities

Beta *Coordinating Committee (BCC)*

Dr. L. Frese reported that, whereas at the first WBN meeting it was recommended that the BCC (established in 1989 as a central link between all members), should meet at least once per year, it soon proved that the necessary travel expenses could not be covered by the very limited WBN funds. Therefore, on the initiative of Dr. Doney

(member of the BCC from 1991-1993), on 12 August, 1992 a telephonic conference took place between the BCC members. Though the parties called from distant countries (USA, UK, Germany and India), only minor technical difficulties occurred. Prior to the conference call, the agenda had been sent by mail to the BCC members to allow for a more efficient discussion. The minutes of this conference were distributed to the WBN members for their information and to allow for interaction with the committee. In total, three conference calls were organized, each costing about US$ 270.00.

Progress report of the International Database for Beta

Background

In September 1991, the Dutch-German *Beta* Genetic Resources Programme was transferred from the CPRO-DLO Centre for Genetic Resources at Wageningen (the Netherlands) to the Institute of Crop Science (FAL) at Braunschweig (Germany). During the winter 1991/92, the genetic resources information system of the Braunschweig Genetic Resources Centre (BGRC) changed from the outdated hierarchical database program, FIDAS, to the relational ORACLE Version 6.0 program package. After the main genebank management system had started to run under the new program the IDBB was converted from ORACLE version 5.0 to version 6.0 with the consequent loss of some of its user-friendliness (the user menus and security levels) and gain of other features such as the SQLREPORT facilities. The MAPVIEW program package used for mapping of data selected from the IDBB was re-established in the updated system.

General structure of the IDBB

The IDBB uses two-dimensional tables with columns (fields) and rows (records). Currently, the information system consists of a number of main tables (PASSPORT, PARALLEL, SEEDS, EVAL, REG_INF and COORDINATION) and a number of help tables (ADDRESS, COUNTRY, END_USE, O_TYPE, SAM_CAT, SAM_STAT, GERM_METH and LOCAT) which are used to decode the address codes, etc., used by the main tables. The tables were created to register different categories of information.

- The PASSPORT table gives a general description of the botanical type of material, its origin and storage location.
- The SEEDS table can provide information on the seed availability.
- The purpose of the EVAL table was to give a rough overview on the availability of evaluation results at the genebank at which the seed sample is stored.
- The REG_INF table can provide users with advice on handling of the germplasm in the future.
- The COORDINATION table was created as a tool for managing seed increase and evaluation activities within the framework of the WBN/HRB collaborative programme.

A detailed description of most of the tables was given by Frese and van Hintum (1989). This section will therefore only deal with the objective and elements of the new IDBB structures, namely the tables EVAL, LOCAT, REG_INF and COORDINATION.

The table EVAL was created to store metadata on evaluation data. It contains:

IDBBNR the unique registration number assigned to an accession by the table PASSPORT
D_ADDR the address code of the institution donating the information
U_DATE this date is generated by the system, when an IDBB number is entered into the table EVAL, and
19 different fields for storing evaluation metadata, for instance:
ROOTY stores whether or not the accession was evaluated on root yield.

The fields for storing evaluation metadata are one-character number fields and simply store a '1' when the IDBB receives the information that a specific IDBB number had been evaluated for a particular character. A fictitious example of how this IDBB table could be applied for user's information is given in Table 1. Column 'MSTER', for instance, shows that all four genebanks have screened the material on presence or absence of male-sterile plants. Sugarbeet researchers in the USA determined the genetic variant of the male-sterile cytoplasm and tested IDBBnr. 5678 for presence or absence of O-types. IDBBnr. 7001 was screened for *Rhizoctonia*- and BNYVV-susceptibility by the Chinese counterparts, as was IDBBnr. 7338 by the Russian genebank. Users interested in germplasm with a chance of having O-type traits and BNYVV resistance should address their seed requests to the Chinese *Beta* collection and to the US genebank but not to the others. Advantages of this system would be:

- The data received from the decentralized collections could be compiled readily by the IDBB, since it would not be necessary to manage heterogeneous information.
- There would be no need for users to address requests to many national holdings hoping that a few could provide the required information and material.
- Better-defined requests for material help genebanks to reduce unnecessary expenditure of seeds.

Table 1: Mediation of evaluation data and germplasm through the IDBB

IDBBnr.	Donomr.	Donor address	Sp.	Ssp.	Oc.	Descriptors				
						MSTER	CYTMS	OTYPE	BNYVV	RHIZO
7001	49	001CHN	vul	vul	CHN	1			1	1
5678	P1504197	BARCPI	vul	mar	ITA	1	1	1		1
3001	869790	NEDBEG	lom		TUR	1			1	
7338	0042	VIR	vul	cic	DEU	1		1	1	

The EVAL table would benefit mainly those users who do not know how to find the germplasm they require. If a user is aware of a national screening programme s/he would, of course, address requests directly to the national holding.

Users are not always experienced in handling exotic germplasm. The objective of the table REG_INF was to compile exact information on seed-increase procedures at different locations, for each accession. Biennial Swiss chard, originally collected in the south of China, may for instance express a pure annual generation cycle in the north of China. If this information is transmitted by the Chinese counterpart to the IDBB, based on the information stored in REG_INF, future users of the same accession can treat the material properly in their seed increase and screening projects.

The table REG_INF has the fields:

IDBBNR	see above
PADDR	the address of the institution donating seed production data
U_DATE	as in table EVAL above
ANNUA	annuality type
VERNA	vernalization requirements in days
SHATT	degree of seed shattering
LOCCO	location code, stores the code of the seed production location
PLOID	ploidy level of the accession
FSTAR	flowering start as defined by the IBPGR Descriptors for *Beta*, and
GINHI	gives data on presence or absence of seed dormancy or seed hardiness.

The table LOCAT is used to store the most essential climatic data of the seed production locations and to link this information with reference codes. It consists of the fields:

LOCCO	location code used by REG_INF in field LOCCO
U_DATE	as in table EVAL above
LONGI and LAT	the geographic coordinates of the location
ALT	the altitude of the location, and 24 additional fields such as:
TAJAN	the temperature average, in January, of the locations, and
RAJAN	the average rainfall in January.

The table COORDINATION was created with the purpose to better organize the cooperation between the WBN and International Institute for Sugarbeet Research (IIRB) in the field of seed multiplication and evaluation. The support offered by the IIRB is rather specific. Some of the members accept annual wild types for seed increase while others prefer to handle biennial material only. For field screening on *Cercospora beticola* resistance, biennial forms must be provided while annual forms can be sent to collaborators conducting screening under more controlled conditions. Seed yield of annual forms is returned to Braunschweig at the end of the same season whereas the seed increase of cultivated forms or *Corollinae* species sometimes requires more than two years. A part of the seed samples for the IIRB evaluation programme is donated by genebanks of the network. The donors expect, in turn, to receive the evaluation results through the IDBB. To keep track of all activities, a table with the following elements was created:

IDBBNR	refers to the accession registered by the PASSPORT table
ACCNR	shows the content of D_PNR from table PASSPORT and shows the accession number as registered by the institution donating the passport information (=D_ADDR) to the IDBB
S_NAME	gives the botanical description of accession as in table PASSPORT
SS_NAME	gives the botanical description of accession as in table PASSPORT
G_ADDR	shows the content of field D_ADDR (address code of the institution donating the information to the IDBB) in the PASSPORT table
R_DATE	contains the date the sample was received from G_ADDR
R_WEIGHT	gives the seed weight of the sample received from G_ADDR
D_DATE	is the date the sample was dispatched from Braunschweig to:
I_ADDR	the institution increasing the sample
B_DATE	stores the date the IDBB received back the seed yield for distribution to evaluators
B_WEIGHT	stores data on total seed weight received from I_ADDR
EX_DATE	shows the date when remnant seeds were consumed or discarded from the temporary working collection held at Braunschweig.

A second part of the table is used to follow up the evaluation activities:

BNYVV	stores the address of the evaluator on Rizomania resistance
QB_USED	stores data on the quantity of seeds sent to the evaluator
DB_DATE	indicates when the subsample was dispatched to the evaluator
IB_BACK	shows when the evaluation results were sent back from the evaluator to IDBB
GIB_SEND	shows the date when the data were transferred to G_ADDR.

Identical structures were created for *Cercospora beticola* and virus yellows and can be extended to other characters as the need arises. REMARK stores any other relevant free-format information.

Updates since the last WBN meeting in 1991

New sets of passport data were sent to the IDBB from Bulgaria (address code SADOPR), China (001CHN), Germany/the Netherlands (NEDBEG), India (IISRLK), Iran (SBSI), the United Kingdom (BIRDPB) and the USA (BARCPI). Greece (GGB) and the former Czechoslovakia (PRAGGR) provided completed data sets for updating the IDBB. The increase in number of accessions registered by the most relevant tables, i.e. PASSPORT and SEEDS , is shown in Figure 1.

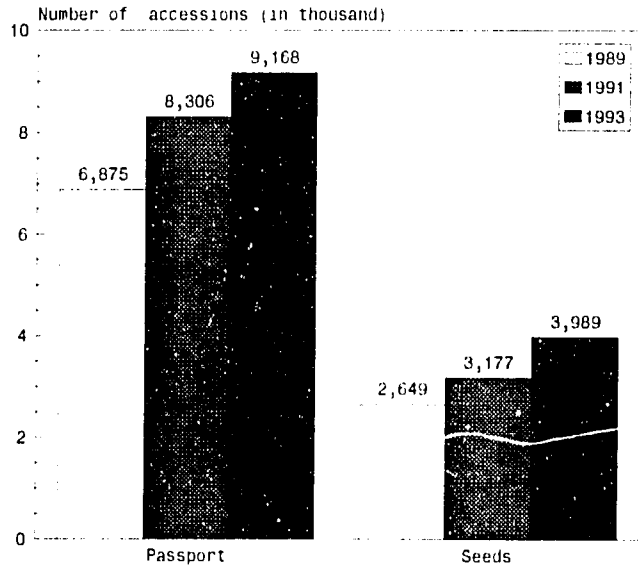


Figure 1: Comparison of the IDBB table content in 1989, 1991 and 1993

Analysis of information

Between 1991 and 1993, passport data of five additional *Beta* holdings were received and registered by the IDBB. Altogether, the database consists of 25 data sets from 21 countries ranging from the Far East to Europe and the USA. There are very small static collections; small to medium sized collections showing steady increase in number of accessions; and large, highly-diverse, growing collections. To date, the IDBB has documented in its PASSPORT table information on 9168 accessions of which 682 are no longer available because of elimination of duplicates or loss of material (Table 2).

As a result of collection activities and germplasm exchange within the network, the number of accessions held by Asian countries amounts to 283 samples. Genebanks in the Mediterranean region currently preserve 1278 accessions. In the eastern European countries 1661 accessions are stored. Due to the political changes and the reorganization of their economies, parts of these germplasm seed stocks appear to be highly endangered.

Table 2: Number of accessions per *Beta* holding and sample category

Donor of information	Donor country	Sample category						Total
		MOS	SDS	SDA	PRD	NOG	NOC	
001CHN	P.R. of China	71			6			77
002JAP	Japan	32						32
AARI	Turkey	296			1			297
AISBRC	Ireland	13			2			15
BARCPI	USA	1772			160	16	2	1950
BIRDPB	UK	488			217	6	346	1057
NVRS	UK	36			42		1	79
BLOBAI	Poland	38			8	50		96
CNRIDG	Italy	88	40		2			130
DYOSAP	France	8			37			45
INRALR	France	14						14
GGB	Greece	679			61			741
IISRLK	India	99	2		30		1	132
MERRVP	Belgium	41			31	54		126
NEDBEG	Germany/Netherlands	1139	360	290	145	41	335	2310
ZIGUK	Germany	191			58	1		250
NGB	Sweden	19			8	2		29
NYONRA	Switzerland	59			10			69
OLORBI	Czech Republic	102			85	1		188
PRAGGR	Czech Republic	66			33	78		177
SADOPR	Bulgaria	117	117		12	9		255
SBSI	Islamic Rep. of Iran	42			1			43
TAPRCA	Hungary	69			22	19		110
VIR	Russian Federation	364			376	95		835
ZARAEE	Spain				1	110		111
Total by sample category		5843	519	290	1348	482	686	9168

Abbreviations used in Table 2

MOS = most original accession, in active collection;
SDS = security duplicate sample, not in active collection;
PRD = probable duplicate, in active collection;
NOG = not within genebank responsibility;
NOC = no longer in the collection.

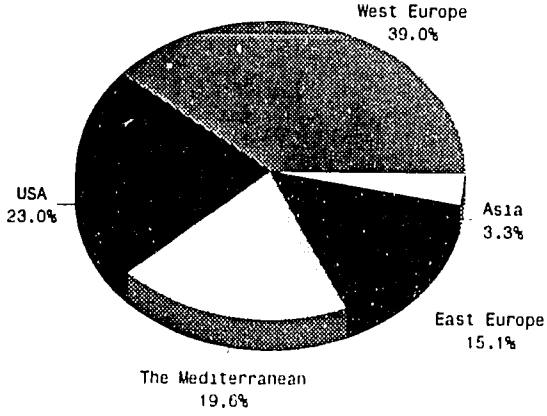
Abbreviations continued

Code	Addresses of *Beta* holdings (summarized)
001CHN	The Institute of Sugarbeet of the CAAS, Hulan County, Heilongjiang Province.
002JAP	Hokkaido National Agricultural Experiment Station, Sapporo, Japan.
AARI	The Directorate Plant Genetic Resources Research Institute, AARI, Menemen 35661 Izmir.
AISBRC	The Agricultural Institute, Sugar Beet Research Centre, Tipperary.
BARCPI	Beltsville Agricultural Research Centre, Beltsville, Maryland 20705.
BIRDPB	Department of Plant Biology, University of Birmingham, Birmingham B15 2TT.
BLOBAI	Plant Breeding and Acclimatization Institute, Blonie.
CNRIDG	Istituto del Germoplasma, Consiglio Nazionale delle Ricerche, Bari.
DYOSAP	Station de Génétique et d'Amélioration des Plantes de Dijon, INRA, Dijon.
GGB	Greek Gene Bank, North Greek Agricultural Research Centre, Thessaloniki.
IISRLK	Indian Institute of Sugarcane Research, Lucknow.
INRALR	Station d'Amélioration des Plantes, Domaine de la Motte-au-Vicomte, INRA, Le Rheu.
MERRVP	Rijksproefstation voor Plantenveredeling, Merelbeke.
NEDBEG	Dutch German Cooperation on Beet Genetic Resources, CPRO-DLO CGN/BGRC, Wageningen/Braunschweig, the Netherlands/Germany.
NGB	Nordic Gene Bank, Alnarp.
NVRS	National Vegetable Research Station, Wellesbourne, Warwick CV35 9EF, United Kingdom.
NYONRA	Station Fédérale de Recherches Agronomiques de Changins, Nyon.
OLORBI	Research and Breeding Institute of Vegetable Crops, Holice, Olomouc.
PRAGGR	Research Inst. of Plant Production, Div. of Genetics and Plant Breeding Methods, Genebank, Praha 6.
SADOPR	Institute of Plant Introduction and Genetic Resources, Sadovo, Plovdiv.
SBSI	Sugar Beet Seed Institute, Karadj, Islamic Republic of Iran.
TAPRCA	Research Centre for Agrobotany I.P.P.Q., Tapioszele, Hungary.
VIR	N. I. Vavilov All-Union Institute of Plant Industry, St. Petersburg.
ZARAEE	Estacion Experimental "Aula Dei" (Aula Dei Experimental Station), Zaragoza.
ZIGUK	Institut für Pflanzengenetik und Kulturpflanzenforschung (IPK), Gatersleben.

The largest part of the world holding has been collected by western and northwestern European countries (3312 samples) and the USA (1948) (Figure 2).

The fraction of 'most original samples' (MOS) has steadily decreased from 74.4% in 1989 to 63.7% in 1993. This decrease can be explained by elimination of duplicates and loss of unique material in the Birmingham (BIRDPB) and the German/Dutch (NEDBEG) collections. The percentage of security duplicates (SDS and SDA) has increased slightly in that time, from 7.2% to 8.9% (Figure 3). As already noted in the

1991 report, these ciphers do not take account of the national security duplicate storage systems in the USA, Turkey, and the Russian Federation. Since the information on security duplication at the national level is not yet documented in the IDBB, the actual percentage of security duplicates within the World *Beta* holding is possibly higher.



Basis: 8432 accessions, i.e. total number of accessions minus sample category NOC

Figure 2: Regional distribution of *Beta* holdings

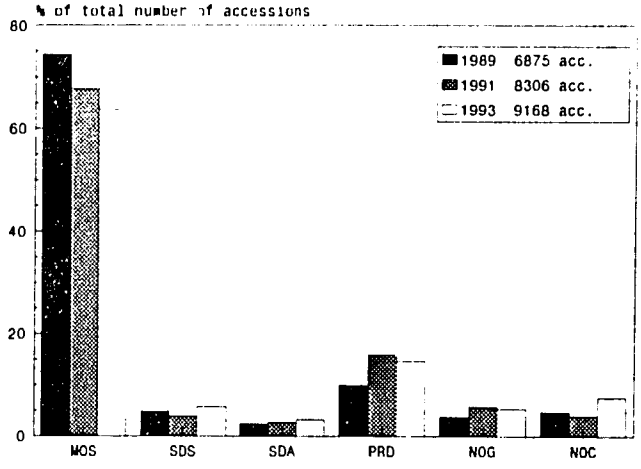


Figure 3 Change of frequency of sample categories

Table 3 shows the number of MOS of wild and cultivated beets stored at selected institutions of the WBN. The geographic origin of MOS of the various botanic groups is presented in Table 4. The column 'Total' in Table 3, was used to summarize the number of MOS by major taxonomic groups (Figure 4). Between 1989 and 1993, the relative quantity of germplasm accessions per major taxonomic group slightly decreased in the groups of section *Beta* wild species (BWI), cultivated germplasm (BCU) and section *Procumbentes*. This indicates a loss of unique material. It stresses the need for more systematic security duplication as well as a seed regeneration emergency programme (see also Figure 3, classes MOS and NOC).

Table 3: Number of most original accessions by botanic name and holding *

BOTANIC NAME	AARI	BARCPI	BIRDPB	GGB	NEDBEG	PRAGGR	TAPRCA	001CHN	VIR	002JAP	IISRLK	SADOPR	Others	Total
Section BETA														
B. sp. unknown	9	6	9		20	1			3				11	59
B. vulgaris	91	480	52		53	12				22	1	109	52	1094
ssp. *maritima*	20	439	108	222	165	6			6		4		54	1217
var. maritima				415	10									10
var. macrocarpa		9	3		37						3		1	65
var. atriplicifolia		7	2	12	2				1				2	14
var. trojana	16		1	1										18
ssp. *adanensis*	8		10	2	5									25
ssp. *orientalis*		1	2		2				3		1		2	11
ssp. *patula*		4	1		3	1							1	10
ssp. *cicla*	37	25	15		57			27	11				13	185
var. cicla				1		18	23				3		11	56
var. flavescens		6	2		7						1		46	62
ssp. *vulgaris*		3	66	1	52				15		1		15	153
var. conditiva		6	31		72	63	24		75				31	302
var. crassa			18		100	10	23		108			2	68	323
var. altissima		663	36		175	38	22	44	141		81	1	31	1232
Section COROLLINAE														
B. corollifora	9	8	5		93	1			3				2	118
B. macrorhiza	1	12	6		42	1					1		2	65
B. lomatogona	59	24	24		106	3					1	2	10	229
B. intermedia	41	8	5		208				1					263
B. trigyna	5	17	25		33	6					2	2	2	92
Section NANAE														
B. nana		1	1	27	22									51
Section PROCUMBENTES														
B. procumbens	16	29		7	2								2	56
B. patellaris		28	23		35	1				10		1	1	99
B. webbiana		9	13	5									1	28
Total by holding	296	1772	488	679	1330	168	69	71	364	32	99	117	358	5843

* For explanation of address codes see Table 2

Table 4: Number of most original accessions by botanic name and country of origin

BOTANIC NAME	TUR	CYP	ISR	GRC	ITA	ESP	FRA	GBR	NLD	SUN	CHN	IRN	JPN	Others	Unknown	Total
Section BETA																
B. sp. unknown	24				6	5		1	1			1		6	14	58
B. vulgaris	217	7	1	213	46	43	5			15	5	60	89	265	128	1094
ssp. *maritima*	35	45	60	251	238	50	184	151	6	1		5		140	51	1207
var. maritima				1	1		1							1	6	10
var. macrocarpa		3	4	2	25									17	14	65
var. atriplicifolia						5								2	7	14
var. trojana	18															18
ssp. *adanensis*	15	2		8												25
ssp. *orientalis*					1									5	5	11
ssp.*patula*														10		10
ssp. *cicla*	46			2	19	33	2		3	4	27			29	20	185
var. cicla	3				11	1	7	1	1	1	3			22	6	56
var. flavescens																
ssp. *vulgaris*	44			14			3		2	14		15	1	34	26	153
var. conditiva	6			1	12		11	28	28	68	2			110	36	302
var. crassa	1			1	6	2	15	5	44	37				175	43	329
var. altissima	17			4	1	1	23	82	23	82	60		4	446	489	1232
Section COROLLINAE																
B. corolliflora	89									10				2	17	118
B. macrorhiza	28									20				4	13	65
B. lomatogona	178									8		6		2	35	229
B. intermedia	252													1	10	263
B. trigyna	32						1			10				4	45	92
Section NANAE																
B. nana				51												51
Section PROCUMBENTES																
B. procumbens						30								1	25	56
B. patellaris						48								7	44	99
B. webbiana						14									14	28
Total by country of origin	1005	63	67	548	373	232	252	268	108	270	98	87	94	1310	1065	5483

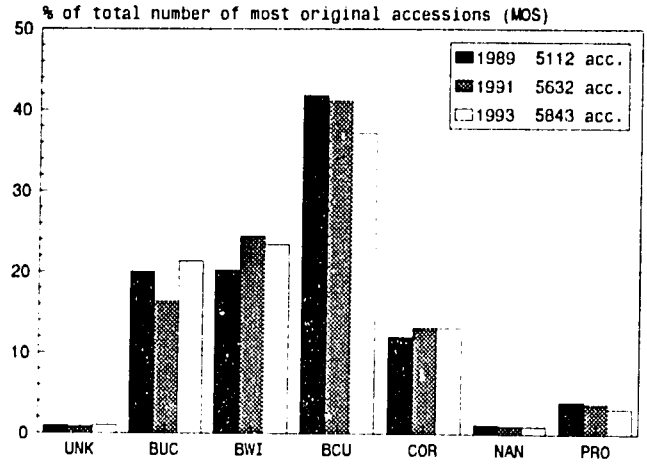
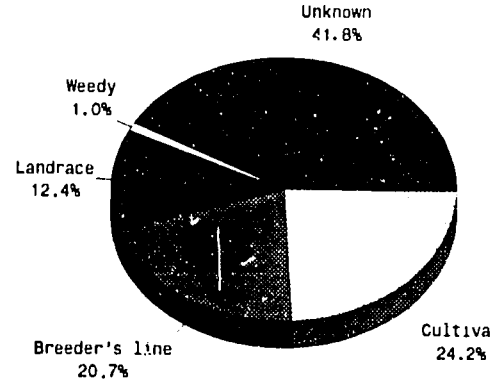


Figure 4: Change in frequency of most original accession in major germplasm groups

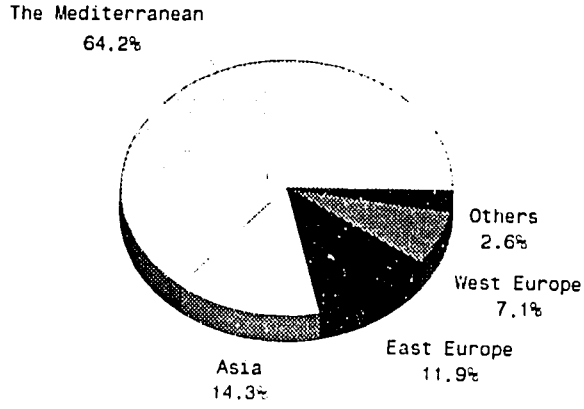
In the past few years, much emphasis has been given to the collection of wild beets with the objective of closing geographic gaps. Landraces of beets, and in particular the widely distributed Swiss chard types, may contain genetic traits as interesting as those of the wild progenitors. Of 2250 MOS of cultivated beets (ssp. *cicla*, ssp. *vulgaris* var. *conditiva*, var. *crassa* and var. *altissima*), 12.4% belong to the group of landraces (Figure 5).



Basis: 2617 accessions of cultivated germplasm

Figure 5: Composition of the world holding of most original samples of cultivated beets

About two-thirds of the landraces have been collected in the Mediterranean region, mainly in Greece, Turkey and Spain (Figure 6).



Basis: 543 accessions of most original samples of landraces

Figure 6: Geographic origin of landraces by regions

Because of collecting trips in Iran and China, the percentage of material from Asian countries is steadily growing but this vast area is still far from having been comprehensively sampled. The depiction of collection sites of landraces in Figures 7, 8 & 9 is based on the number of MOS of which the IDBB has recorded the geographic coordinates of the collection site, i.e. 396 entries. The figures clearly show large geographic gaps within the world holding of *Beta* landraces. These gaps occur particularly within the cultivar groups fodderbeet and root vegetable.

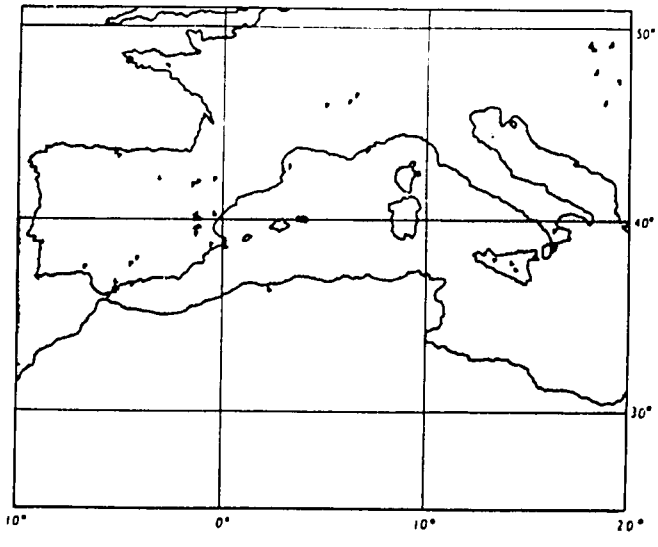


Figure 7. Distribution of most original samples of landraces between 10°W and 20°E

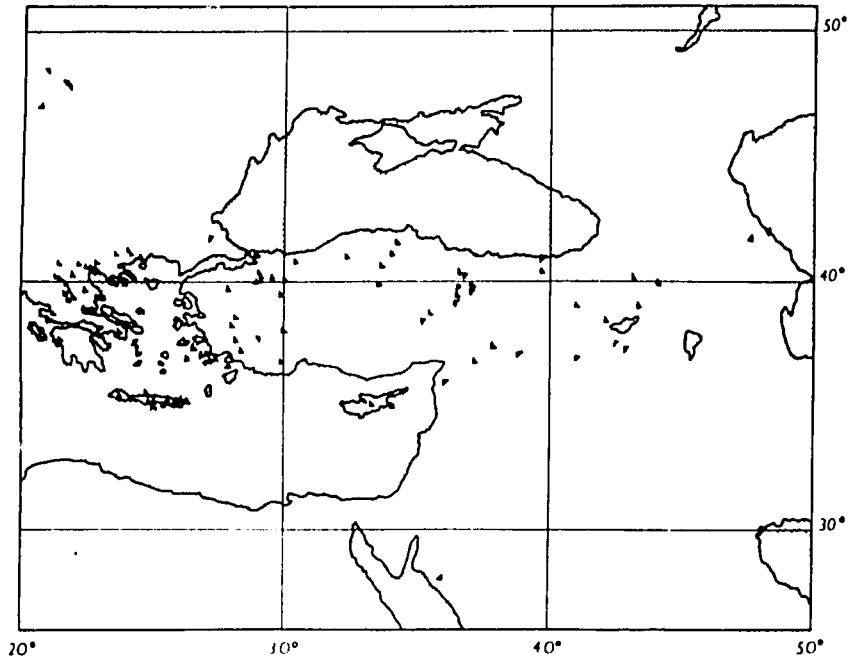


Figure 8. Distribution of most original samples of landraces between 20° E and 50° E

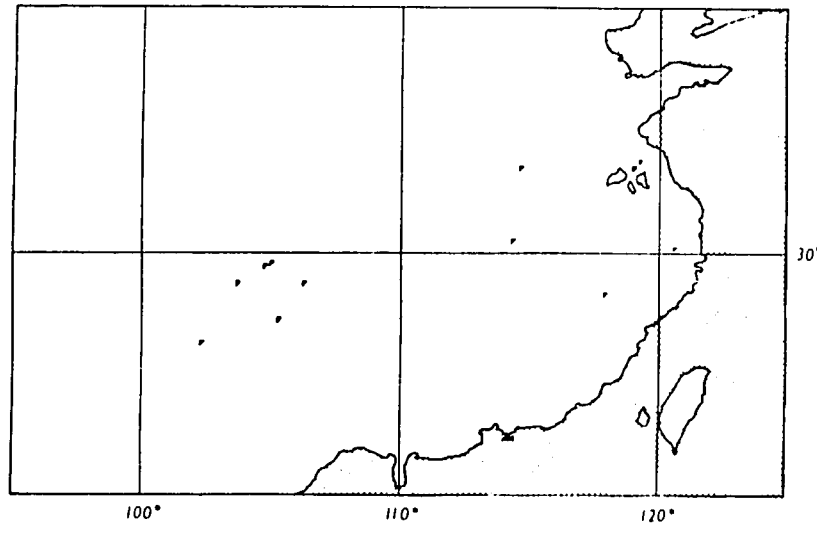


Figure 9. Distribution of most original samples of landraces between 95° E and 125° E

Cooperative evaluation programme proposal

Lack of information on economically interesting characters of genebank accessions is one of the major reasons for under-utilization of germplasm collections. During the past years, several attempts were made to establish, essentially in Europe, an evaluation and pre-breeding programme. Since an attempt to get public funding through the European Commission failed, the Breeding and Genetics Study Group of the IIRB has offered more support to the WBN in the field of seed increase and evaluation. A summary of the support offer is presented in Table 5.

Table 5. Participants and type of support offered by IIRB members and others

Participant	Country	Seed increase	Screening on resistance to		
			Cercospora beticola	Rhizomania	Virus Yellows
ISIROV	Italy		100*	50*	
HOLBSM	Denmark	10-12	10-12	10-12	
SPSBOL	Italy		15		
AGRALO	Italy	4-5	5	5	5
NICSBS	Great Britain	1			25*
VDHAVR	The Netherlands	3	20	20	10
HELLEN	Greece	20	10	10	
DIECKM	Germany	10	10		
KLEINW	Germany	10-15	50	50	
SES	Belgium	10*	5	5	
STRUBE	Germany		20*	20*	
DESPRE	France	2		20*	20*
IISRLK†	India	10			
Total		80-88	245-247	190-192	60

* Biennial types are excepted, only.

† IISRLK is prepared to screen 50 accessions for resistance to *Sclerotium* and Rhizoctonia and high-temperature tolerance

IDBB address codes:

ISIROV	Istituto Sperimentale per le Colture Industriali
HOLBSM	Maribo Breeding Company
SPSBOL	Societa Produttori Sementi
AGRALO	Agra Societa del Seme
NICSBS	Lion Seeds
VDAHVR	van der Have Breeding Company
HELLEN	Hellenic Sugar Industry
KLEINW	Kleinwanzlebener Saatzucht AG
SES	SES Europe
STRUBE	Strube Saatzucht
DESPRE	Florimond Desprez Breeding Company
IISRLK	Indian Institute for Sugar Cane Research

The IDBB has assumed responsibility for the coordination necessary for the cooperation between the IIRB and the WBN. Seed samples are acquired through the IDBB from various national holdings and channeled, according to the specific wishes and facilities, to cooperating IIRB members. Genebanks sent requested samples to the

IDBB in 1992. These samples are stored as a temporary working collection at Braunschweig until they can be passed on to IIRB members for seed multiplication. In general, the seed producer (e.g. DIECKM) uses a subsample of the seed yield for evaluation of a single disease character. Surplus seed is returned to the IDBB for further distribution to other evaluation locations (ISIROV, NICSBS, etc.) where seed-increase facilities are limited. Evaluation data will be sent back to the IDBB for forwarding to the original donors of the accessions.

The number of seed increases per year is less than the number of evaluations offered. To allow for full use of the evaluation capacity, genebanks have been asked to donate their surplus seed yield of the annual seed increase programmes to the IDBB. This would help to reduce the gap between increase and evaluation capacities, which is currently a bottleneck for screening.

An overview of the current state of the programme is presented in Figure 10. It shows that the new IDBB table 'COORDINATION' has registered 368 accessions, of which a part was distributed, from 1989 onwards, to plant breeders and research institutes for the purposes of seed increase or screening for disease resistance.

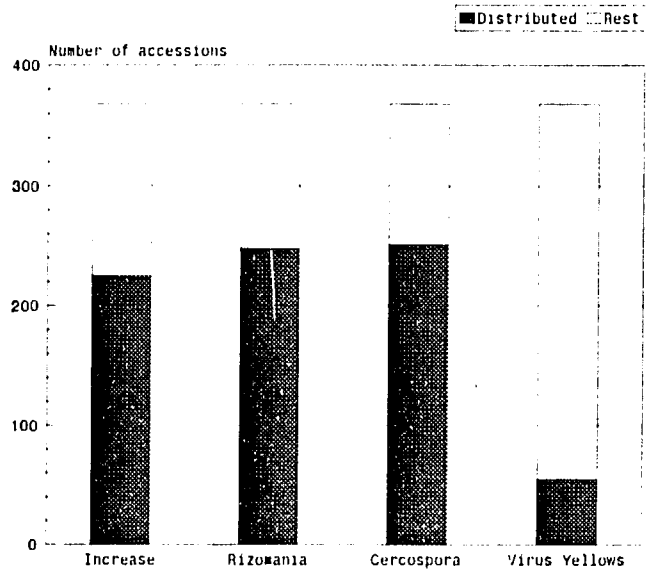


Figure 10. Status of the evaluation programme as documented by the IDBB

Collections since the previous meeting

Egypt

The purpose of a visit, from 18 June to 3 July, 1992, by scientists from the USA was to conduct a collection expedition for wild beets in Egypt and to review the sugarbeet breeding and seed production programmes in Egypt. The budget for transportation to and from Egypt was provided by USDA-ARS, Sugarbeet Research Unit, Fargo, ND, while the travel and accommodation within Egypt, was financed by the Egyptian Ministry of Agriculture. The collection team consisted of Devon L. Doney, (Team

Leader) Research Geneticist, USDA-ARS and Osama Badawy, Sugarbeet Geneticist, Alexandria, Egypt; Ahmed Hassan assisted in the Alexandria and Matruh areas and Mhouhemd Shehatta in the Matruh area, Sakka Research Station. Collections were made at selected locations scattered throughout the Delta area, west to Matruh in the Fayyum area of Middle Egypt, and in the Luxor area of Upper Egypt. A more intensive collection effort was made in the area around Alexandria. A total of 26 locations were sampled. Wild beets appear to be distributed throughout the Delta. Samples taken to the USA were deposited in the *Beta* collection at Ames, Iowa (NC-7 Plant Introduction Station). These accessions will be increased under controlled isolation conditions at Logan, Utah, (USA) during the summer of 1993. Fifteen samples stored at the Sugar Crops Research Institute, A.R.C. were planted at the Nubarin Research Station on 14th November, 1992 to gain data on field emergence, leaf shape, root weight and seed characters. During the collection mission, variation in plant characters was observed. Some accessions appeared to be somewhat domesticated wild beet populations for use as a leaf vegetable. They are more sparsely distributed in the Fayyum and Luxor areas where farmers were found collecting and growing wild beets as a green vegetable. In these areas, the farmers are serving as a means of preserving the wild *Beta* germplasm. However, their actions may have exerted selection pressure for leaf types. The success of this expedition relied heavily on the ability of the Egyptian collector to communicate with local farmers; most of them were very helpful and interested.

A review was made of the sugarbeet breeding and seed production programmes. Satisfactory progress was observed and recommendations made.

In addition to the above activities, lectures on the "Origin, distribution, preservation and utilization of *Beta* germplasm" and "Physiology of root yield and sugar content" were presented at the Sugar Crops Institute at Giza and at Alexandria, respectively.

The locations sampled represent most of the reported wild-beet habitats in Egypt. Some areas were not sampled due to time limitations. Future collection efforts are not recommended until some evaluations can be conducted to determine whether or not sufficient genetic diversity has been sampled.

The Caucasus area

East Anatolia/Armenia is regarded as the center of diversity for *Beta* section *Corollinae*. Early reports of Russian scientists indicated the existence of *B. macrorhiza* in Daghestan. As early as 1977, the beet taxonomist K. Buttler assumed the existence of a second genepool of *B. macrorhiza* in the east Caucasus. However, the distribution and frequency of *B. macrorhiza* in east Caucasus has never been explored carefully and, due to a lack of appropriate research material, Buttler's hypothesis has never been verified. Since original, well-described material of the eastern part of the *Corollinae* distribution area was totally lacking in the world holding, it was decided to organize collecting missions in that area devoting special attention to wild beets and beet landraces, as well as wild lettuce. The missions were implemented within the framework of a Dutch/German/Russian cooperation programme on genetic resources. In 1990, Dr. G. Seiler from the USDA/ARS University Station (Fargo) joined the team.

In 1990 and 1991, a total of 131 accessions of various crops were collected. Among these were 21 *Beta* samples. In Armenia (1991) far fewer beet samples were collected than could be expected to occur in an area known from the literature to be a part of the center of diversity of *Corollinae* and the home of specific landraces. Due to political unrest, not all regions were accessible at that time. The major reasons for difficulty in finding *Beta* germplasm, however, appeared to be due to genetic erosion through overgrazing and the existence of large fields with a concomitant lack of hedges where *Corollinae* species could shelter. In 1991, *B. macrorhiza* was very difficult to trace during a one-day trip in Daghestan. The following year, during excursions of 2-3 days to mountainous areas, *B. macrorhiza* was found growing at ruderal sites such as roadsides

or wet slopes with gravel, rubble and open vegetation. This time eight *B. macrorhiza* populations were sampled. The results of both expeditions are summarized in Figure 11.

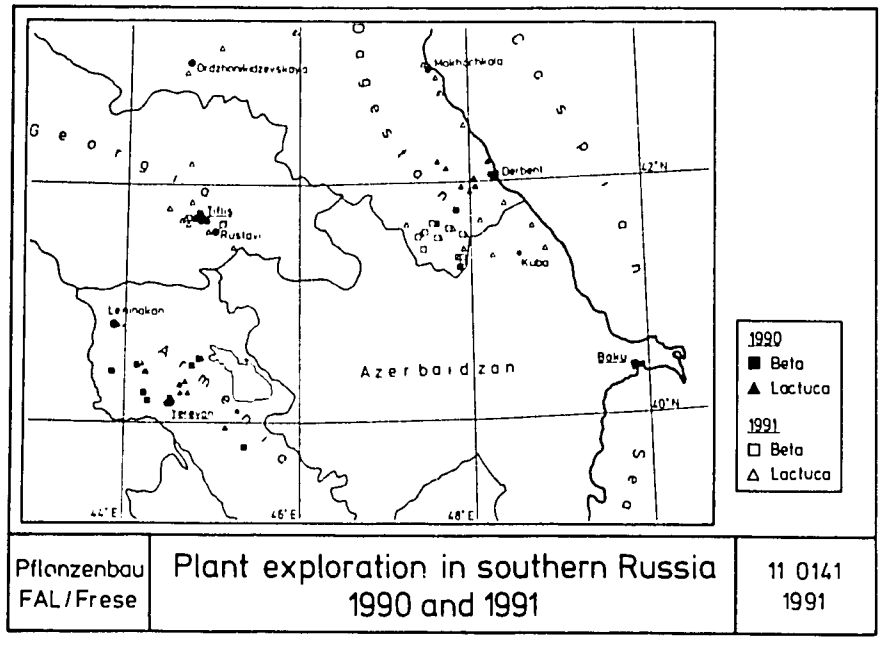


Figure 11. Collection sites and type of germplasm collected in the Caucasus area in 1990 and 1991

In 1992 the material was sown, for seed increase, at the Institute for Crop Science. Leaves of the Caucasian material were sent, together with Turkish accessions, to the Institute of Applied Genetics of the University of Hannover for isozyme analyses. Mrs. Reamon-Büttner investigated the material and found differences in the isozyme pattern between the Caucasian and Turkish material. This finding supports the hypothesis on the existence of two different genepools of *B. macrorhiza*.

Iran

On behalf of M. Nasser Arjmand (Sugar Beet Seed Institute), Dr. H. M. Srivastava presented the report on collecting activities in Iran. The former started a collection of native beet germplasm in May 1991. Latest collections were made in October 1992. A total of 42 accessions (30 landraces, five inland *B. vulgaris* ssp. *maritima* and seven *B. lomatogona*) originating from very different geographic areas, have been documented. In general, the material is bulk-sampled but sometimes single plants were also collected. The plant explorations will be continued. An important constraint for collection missions seems to be manpower and, to a minor extent, natural events such as flooding, in some areas (Hormozgan and West Azerbaidjan). Overgrazing of pastures where beets are growing indicates that this unique germplasm is at risk. The SBSI has no problems with respect to funding of travel expenses. However, to allow for the exploration of more remote areas, the SBSI would need specific support (funding of a 4-wheel-drive car). The SBSI again expressed the willingness to cooperate in regeneration and evaluation. A subsample of some accessions has already been included as security duplicates in the seed store of the Institute for Crop Science at Braunschweig. After seed increase, this material will be evaluated by IIRB members.

Morocco and Spain

A detailed presentation of the results of the Japanese collection mission in Morocco and Spain (1990) was given in the Second WBN report, (1991). When, at this meeting, Dr. H. M. Srivastava expressed concern about the often small number of plants sampled per population, M. Sadiki (Morocco) volunteered to re-collect material on request.

China

Prof. Sun Yi-Chu gave an overview of the status and activities relating to germplasm collection in China between 1990 and 1993. In total, 27 accessions of Swiss chard types with different morphological characteristics have been collected within a region almost as large as the Mediterranean basin. Samples were found growing in villages as cultivated or weedy material. Accessions behaving as biennials in the area of origin often expressed an annual life cycle at the Institute of Sugar Beet (Hulan county) in the north of China. The collection missions are time-consuming and costly. Since funds for travelling only come from the Institute, Prof. Sun Yi-Chu has to proceed in small affordable steps.

The Chinese Swiss chard collection is unique. Subsamples of some of these accessions have been sent to Braunschweig for security duplication. After seed increase, this material will also be fed into the IIRB evaluation programme. Prof. Sun Yi-Chu said that he would continue to explore, conserve, evaluate and duplicate Chinese beet germplasm. The full report on the Chinese germplasm activities is presented as Appendix 4.

Turkey

Dr. A. Tan described the geobotanical features of Turkey and then focused on the distribution of wild beets. Between 1991 and 1992 the following regions were visited:

- Aegean region (Izmir, Manisa, Kütahya)
- Central Anatolia (Karaman, Sivas)
- West Black Sea region (Kastamonu, Sinop, Amasya).

In total, 26 populations were found; 18 seed accessions and 12 herbarium specimens were collected. The species encountered were *B. maritima* (inland and *maritime* types), *B. macrorhiza*, *B. lomatogona* complex (*B. lomatogona*, *B. intermedia*, *B. trigyna*) and *B. corolliflora*.

Beta section *Beta* was found in the following habitats:
- maritime cliffs (sea level to 20 m)
- in vegetable gardens or along the road sides (a few cases as annual weeds).

Beta section *Corollinae* was encountered in habitats such as:
- wheat-field borders
- graveyards
- vegetable-garden borders
- borders of irrigated sugarbeet fields
- humid valleys
- woody and herbaceous perennial vegetation.

Population sizes varied for both sections (from 2-3 plants to at least 100 plants). The diversity varied depending on the species. In *Beta* section *Beta* the phenotypic variability between and within populations was remarkable with respect to both life cycle duration (annual to perennial) and morphology, i.e. growth habit (erect to prostrate), size and shape of fruits and degree of multigermicity.

Variation within *B. macrorhiza* populations was observed, indicating the existence of a different type of *B. macrorhiza*. Dr. Tan said that she is interested in

investigating the relationship between *B. oliosa* and *B. macrorhiza*. *B. corolliflora* showed less phenotypic variability. Within the *B. lomatogona* complex, the phenotypic variability appeared to be related to the collection site. Populations growing in dry fields showed *lomatogona* habit (monogerm fruits, few bigerm and trigerms) while populations growing along fences and hedges in woody perennial vegetation, expressed mostly the *trigyna* habit (triple seeded fruits, few single or four seeded fruits). The collection trips will be continued in the Aegean region in 1993 and will cover areas which have not been sampled previously.

Greece

On behalf of Dr. H. Cortessi (independent collaborator, Greek Genebank, Thessaloniki), Dr. Doney reported on the results of the past collecting activities in Greece. The text of the Greek contribution, entitled '*Beta* germplasm in Greece' and prepared by Dr. Cortessi, N. Stavropoulos and A. Zamanis (all of the same address) is given below.

Current status

Beta germplasm holdings in Greece were collected from seven Mediterranean countries and consist of nine species and various natural crosses between species within section *Beta*. The collection can be considered as quite representative of the Mediterranean area. The overall distribution of *Beta* germplasm in Greece presented in Figures 12 - 16, is based on information recorded during collecting expeditions between 1979 and 1985. Each species is marked with a different sign (circles or column), whose size corresponds to the number of collected samples in each province. This number appears also in most diagrams next to the indicator marks. As is apparent from Figure 12, the regions of Epirus, Thraki, and most of the Aegean islands were not explored. Examination of the distribution of collected *B. vulgaris* ssp. *maritima* (Figure 13) reveals a higher frequency of populations around two centres, i.e. in the central-western part of Greece and the Ionian islands and in the eastern Aegean islands. The distribution of *B. vulgaris* (Figure 14) appears to be more homogeneous all over Greece. Figure 15 presents the distribution of natural hybrids between *B. vulgaris* ssp. *maritima* and *B. vulgaris*. It seems that in the two above-mentioned centres of higher *B. vulgaris* ssp. *maritima* abundance, there is also a higher gene flow between these species. Figure 16 shows the limited number of explorations for *B. nana* in four, high, mountainous areas. This species is reported by botanists to exist in many other mountainous areas of Greece. Finally, Figure 17 presents the accessions of *Beta* collected in Algeria, Tunisia, Cyprus, Syria, Israel and Sicily.

Future activities

Germplasm is collected and preserved for use by current and future breeders. Filling some gaps in the GGB's collection could help to safeguard useful genes for future use in breeding programmes. Future plans include collecting landraces growing at high altitudes in Greece because such primitive forms may have a great potential as sources of bolting resistance.

Properties of *B. nana* are more or less unknown to breeders because very limited material is available. Collection, multiplication *in situ* and examination of growing conditions and characteristics would provide useful information on the species.

Because irrigation is costly and water not always accessible, there is interest in evaluating for drought resistance. *Cercospora beticola* infestation is favored by irrigation and excessive soil nitrogen can be brought to the plant in this way.

Plants of *B. vulgaris* ssp. *maritima* collected in sandy soils next to or at beaches are probably a good source for salt tolerance. Valuable evaluations of *Cercospora beticola* and Rhizomania resistance, are being carried out.

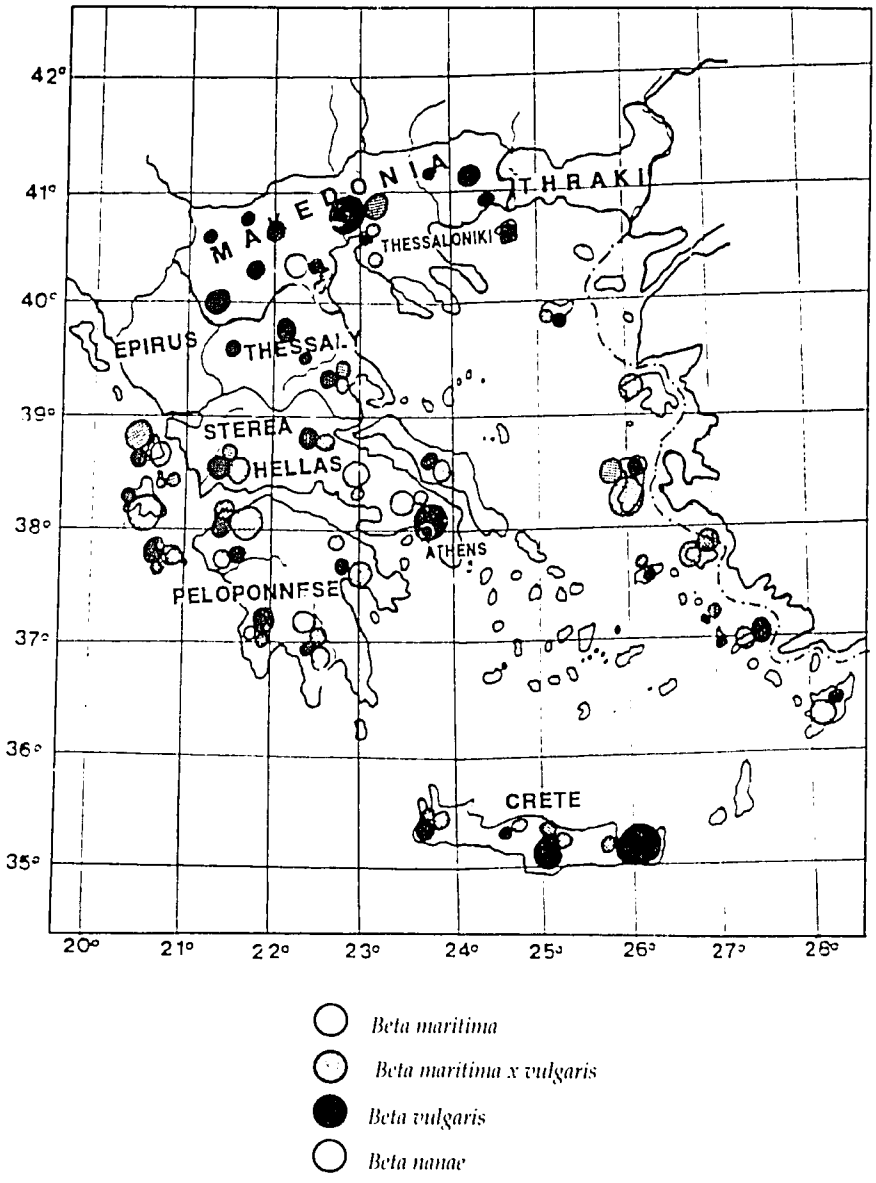


Figure 12 Distribution of *Beta* species in Greece

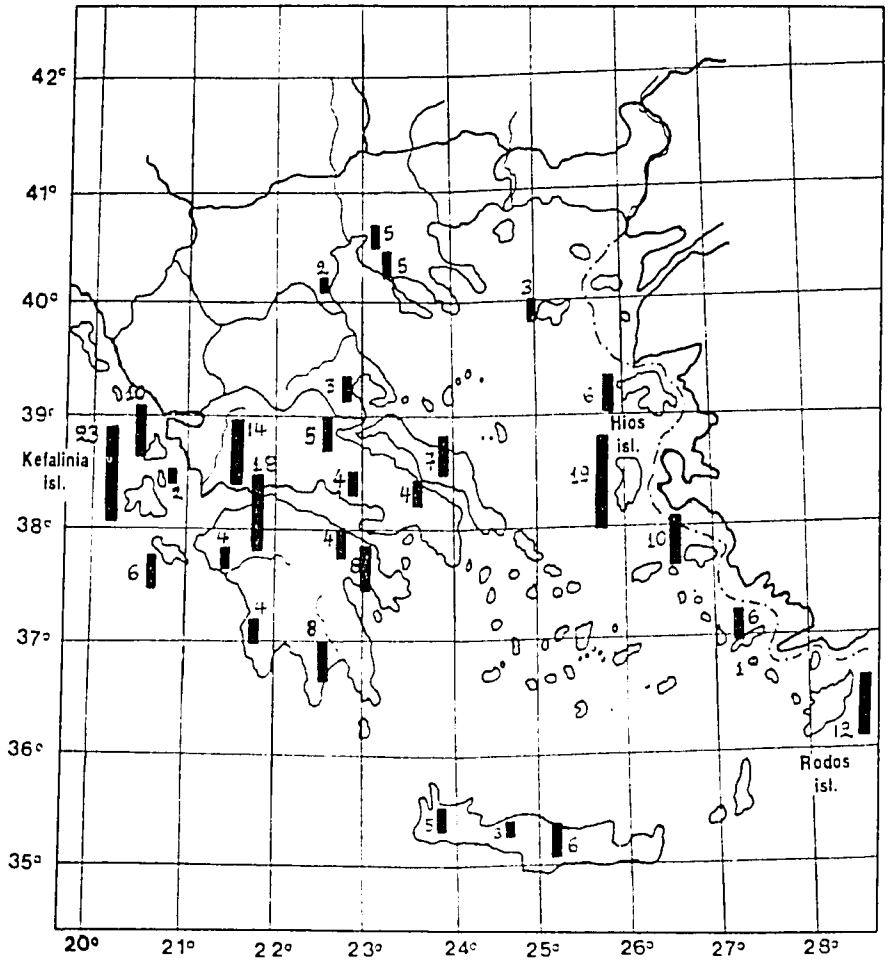


Figure 13 Distribution of *Beta maritima* in Greece

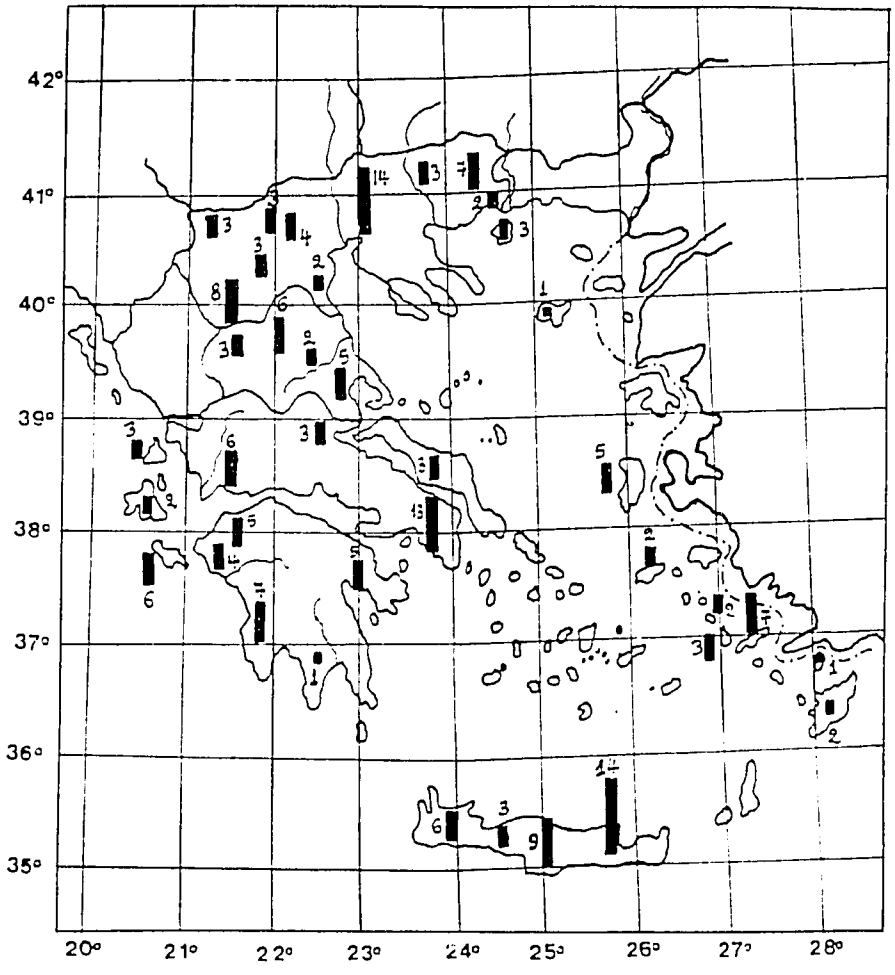


Figure 14 Distribution of *Beta vulgaris* in Greece

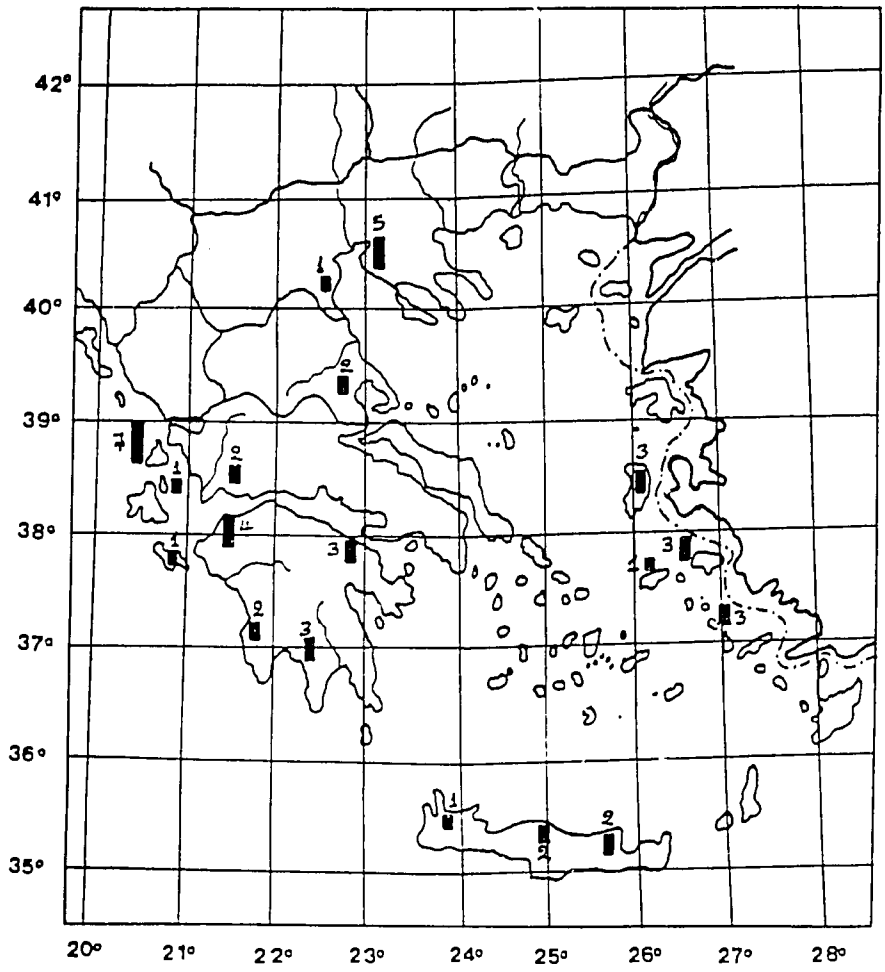


Figure 15 Distribution of *Beta* natural hybrids in Greece

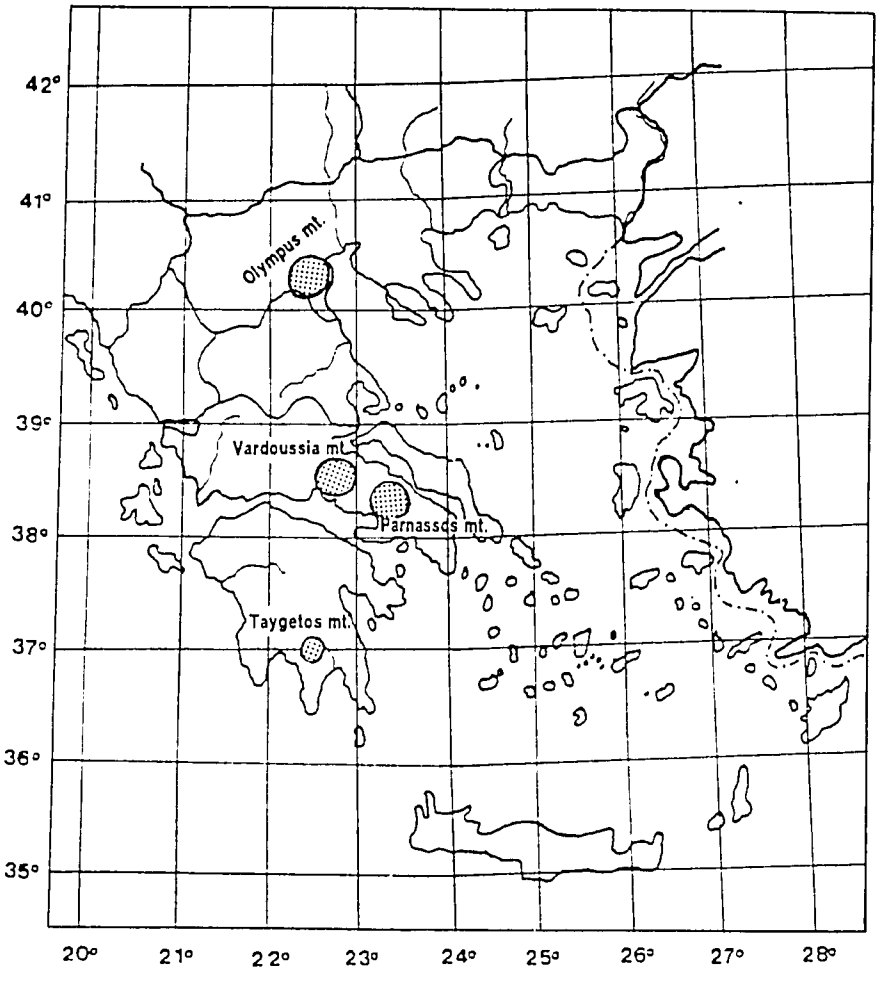


Figure 16 Distribution of *Beta nanae* in Greece

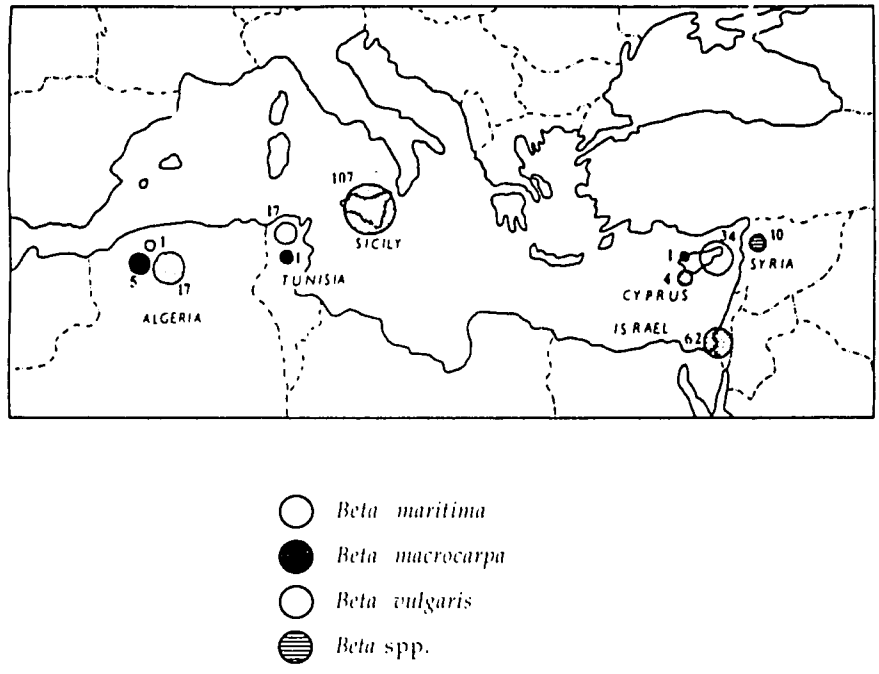


Figure 17 Greek genebank *Beta* accessions from certain Mediterranean countries

Needs and actions

To date, 746 *Beta* seed samples have been preserved for up to 12 years in the Genebanks's active collection. Approximately half of the accessions have not yet been regenerated. There is an urgent need to regenerate before the seeds lose their viability. Further seed increase is also needed for some accessions in order to complete identification and enable evaluation. Funds for these and other relevant activities are not available. The authorities at the GGB would welcome any type of support or cooperative activity that would enable the preservation and evaluation of the endangered collection, and thus secure useful genes for crop improvement.

WBN newsletter

In introducing this issue, Dr. Srivastava pointed out that a WBN newsletter would improve the flow of information between WBN members and keep them informed about ongoing research programmes or any other beet genetic resources matters. If edited and published in India the costs for the newsletter could be kept low and, if about 500 copies could be sold, the profit could help to improve the WBN budget. His suggestion raised

eager discussion. Finally, it was decided to discuss this issue during the sessions of the regional panels during which participants were asked to come up with a recommendation.

Panel discussions

This session was chaired by Dr. B. V. Ford-Lloyd who had prepared a guideline for discussion, copies of which were given to the panel chairpersons. Because some of the East European WBN members had to cancel their participation, it was decided to join the East European and the Northwest European groups. The contribution of Dr. Z. Stanescu (Romania) is included in this report as Appendix 5. The minutes and recommendations, as summarized by the chairpersons of the regional panel discussions, are given below.

Asian panel

This working group comprised Dr. Srivastava (chairman), Prof. Sun Yi-Chu and Dr. Shimamoto. Unfortunately, M. Nassser Arjand could not attend the WBN meeting because of visa problems.

The panel recommended further collection of wild and cultivated germplasm in Iran, India, China and Japan. All four countries have sent passport data of their *Beta* holdings to the IDBB. In Iran and India, *Beta* germplasm has been evaluated for yield and quality attributes and important diseases. Also, available varieties and other germplasm in India, have been evaluated for high-temperature tolerance. Scientists of the region feel that there is need for exchange of information and germplasm between the countries of the region and other network members. There was a general consensus too that training of scientists in *Beta* taxonomy would benefit future collection missions.

The group strongly recommended the publication of a WBN newsletter to spread information about the activities of the WBN to a larger scientific community. The necessary finance could be provided by subscriptions from the members of the network. Further, it was felt that there is a need for technical bulletins or reports on seed handling and taxonomic identification of beets to help breeders and curators. All the members of the Asian panel felt that the regional committees should continue to convene and work on specific aspects of germplasm conservation and utilization.

It was generally felt that IPGRI and sugarbeet seed companies should continue to support WBN activities. Further, it was thought that the WBN should try to raise funds by publishing books on beet breeding, *Beta* genetic resources and similar topics. Chapters for such books could be contributed by WBN members.

East and Northwest European panel

The chairman, Dr. Frese, opened the session and welcomed 13 participants from eight countries. Since the number of items on the discussion guideline was rather extensive it was agreed that a shorter list of priority topics be discussed. Germplasm has been collected in many regions of East and Northwest Europe; the only geographic gaps in collection known to exist in the region were noted to be northern Spain (wild beets) inland Spain (cultivated forms), Bulgaria, Romania and Azerbaidjan. Dr. Kulik reported that most of the multigerm, open-pollinated sugarbeet varieties were no longer available in the Ukraine. He said that he is interested in establishing a *Beta* collection within the newly-founded genebank of Ukraine. Concerning seed-storage facilities, the panel members felt that the storage conditions at their specific locations were, in general, satisfactory.

A more extensive discussion on documentation followed. It was noted that most genebanks within the region were using dBase and/or ORACLE software. The

commercial plant breeders asked how access to information held by the IDBB could be improved. Dr. Frese explained that direct access to the database through Email facilities was not yet possible. Also, after conversion from ORACLE 5.0 to version 6.0, the different user/security levels as well as user menus need to be reprogrammed. Without menus, a sporadic user not familiar with the query language of ORACLE would find it difficult to trace required information. Though a copy of the database could be sent to those with a license for ORACLE 6.0, Dr. Frese added that he prefers to respond to specific user's requests: in general, information is provided to users on a printout or on floppy disc. On hearing this, the panel members said that they would prefer to search in the database themselves and suggested the development of a dBase version of the IDBB. Since most of the members have a license for the dBase program and the necessary experience, this could be an efficient way of disseminating the information. It was suggested that an annual update of the IDBB be distributed. Dr. Frese agreed to consider the development of an IDBB dBase version. Because plant breeders need quick access to the exact data, the concept of storing evaluation data as metadata, as recommended by the WBN meeting of 1991, was criticized. However, the metadata concept is very attractive from the database manager's point of view because it precludes the problem of data standardization and makes data registration very easy. The panel agreed to resume the discussion on evaluation data during the plenary discussion.

Dr. Ford-Lloyd outlined the progress achieved with the inventory of the Birmingham collection which, he said, was made possible through extra funds given by the British Minister of Agriculture and Fisheries with the obligation to transmit the seed-stock data to the IDBB. The University of Birmingham only stores *Beta* germplasm and the collection cannot be considered as a genebank since no funds for seed regeneration are available. Hence, the Birmingham collection can only be maintained through external support. From recent correspondence with the GGB, Dr. Frese was able to report that between 1991 and 1993 no *Beta* accessions were multiplied in Greece. There also is a need for support in regeneration of the *Beta* collection, especially since the resignation of the curator, Dr. H. Cortessi. Dr. Dalke informed the panel that the seed-increase facilities at Bydgoczs (12 isolation plots per year) were sufficient to maintain the Polish collection and Dr. Kulik expressed his willingness to increase seed of a considerable quantity of cultivated germplasm at Kiev and to share the seed yield with the donor of the accessions. Mr. I. Lozanov of Bulgaria, had informed the meeting by letter that the seed-increase facilities at Sadovo are rather limited so Dr. Frese suggested that not all of the accessions of the Bulgarian collection need to be maintained at Sadovo since many of them are duplicated in Germany and Greece. Japanese sugarbeet material and some native wild germplasm would also be threatened if not regenerated in time. In France the *Beta* collection is looked after by the INRA breeding station at Dijon. No detailed information on the status of the collection was forthcoming. The situation in former Czechoslovakia is unclear. The Research Institute of Sugar Beet at Semcice, responsible for the sugar- and fodder-beet collection, has been privatized and genetic resources work has probably been discontinued. The vegetable-beet collection is located at the Research Institute of Vegetables, at Olomouc, where the number of staff has been reduced. Detailed information on the current status of both collections is lacking.

The discussion on evaluation focused on the IIRB Breeding and Genetics Group project and Dr. Frese was asked to continue organizing this voluntary cooperation between genebanks and members of the IIRB. Dr. Ford-Lloyd mentioned that evaluation activities were going on at Broom's Barn (UK). The panel concluded that though there is interest in evaluation, the funds needed to run the various screening projects are very limited, even within breeding companies. Dr. Frese told of a genetic resources programme, soon to be approved by the Commission of the European Community (CEC), that has been developed with the specific purpose of supporting genebank routine work such as evaluation of disease resistance. It was also noted that

previously, in different European countries, various research projects dealing with taxonomic or evolutionary aspects of the genus *Beta* have been implemented without any coordination. The question was raised whether or not a concerted action towards analysis of genetic relationships between taxa of the genus *Beta* or, possibly, even the genome mapping, could be funded by EC programmes.

Dr. Frese commented on very successful pre-breeding work in corn. Genetically broad-based corn breeding populations (composite crosses) and material derived by recurrent selection cycles have, during the past few decades, contributed significantly to breeding progress in corn. He said that he would like to see similar activity in the public and/or private sectors for the benefit of sugarbeet production. During the discussion on pre-breeding, Dr. W. Lange informed the panel that the Centre for Plant Breeding and Reproduction Research (CPRO) might fund a Rizomania and possibly a *H. schachtii* programme. It was suggested that such pre-competitive breeding work could possibly be funded by breeding companies or the EC. Dr. Middelburg favored pre-breeding projects on the basis of input in kind from the IIRB members. He suggested evaluation of the material first and, in a second step, crossing of selected exotic germplasm with sugarbeet material provided by various companies. Various crosses could be submitted to different selection pressures and, after some selection cycles, the material could be released to participating breeding companies and to genebanks. The panel felt that the Europeans should feel obliged to supplement the efficient pre-breeding work done in the USA.

The proposal to publish a WBN newsletter was discussed thoroughly. Interest was expressed in the publication of selected short information on *Beta* genetic resources activities in its broadest sense and the group felt that annual publication of a WBN newsletter would suffice. Dr. Z. Stanescu reiterated that the publication of a WBN newsletter would help to improve the communication among network members and facilitate the exchange of research results. Doubts were raised as to whether the target of 500 subscriptions could be achieved. It was recommended that the costs and possible income through subscriptions be calculated carefully.

After brief deliberation, the panel agreed that there is no need to establish sub-committees in the region because the group is comparatively small. With respect to funding of the next WBN meeting at Izmir (1995), the members suggested that the WBN secretary contact FAO, IPGRI and breeding companies, as has been done in the past. The organizers should prepare a budget estimate, as soon as possible, for the information of prospective sponsors.

Finally, the panel discussed the proposed revision of the *Beta* section *Beta* taxonomy and agreed on changes suggested by J. Letschert and reported by Dr. Lange on 5th August, 1993.

Mediterranean panel

The session was attended by six persons from five countries (Turkey, Egypt, Morocco, France and Italy) and chaired by Dr. Tan.

This regions contribution to global *Beta* genetic resources programmes was assessed to be insufficient bearing in mind that the region is the possible center of origin of beets. The participants expressed willingness to contribute to WBN activities in Spain, Italy, Greece and North African countries. It was noted that the wild species, as progenitors of cultivated beets, would provide new sources of important traits suitable for improvement of varieties of sugar- and vegetable-beets. Collections of wild beets and/or landraces and cultivars are available in Turkey, Greece, France, Morocco, Egypt, Spain and Italy. The following collecting missions, with special emphasis on landraces, were deemed to be necessary:

Turkey:	Section *Beta* in Black Sea and NW Aegean coastal and inland areas. Section *Corollinae* in transitional regions and the European part of Turkey. Collection of *B. macrorhiza*
France:	Inland forms of *B. vulgaris* ssp. *maritima*
Egypt:	Red Sea and West Mediterranean coasts
Morocco:	Areas not covered by previous missions. Sections *Beta* and *Procumbentes*

Since the last meeting, little progress was considered to have been achieved in the region. The countries represented by this panel continued to cooperate with the IDBB and it was suggested that the IDBB should again try to establish more active contacts with those countries not yet fully involved in the WBN. It was also recommended that the IDBB should distribute information on recent developments, at regular intervals.

The group identified the need for joint seed-increase programmes within the region and adequate financial support. Technical assistance from experienced counterparts from within or outside the region, is necessary. With respect to evaluation, it was noted that priority should be given to characterization of a minimum set of traits during seed multiplication of wild- and vegetable-beets. Pre-breeding was thought to be necessary in vegetable types. Technical assistance and financial support for research on genetic diversity, is needed from outside the region or from international organizations.

With respect to the possible publication of a WBN newsletter, concern was expressed about the difficulty of maintaining high quality for each issue. It was proposed alternatively, to publish a leaflet with a reference list of articles published on beet germplasm research; more news on vegetable-beet research would, in fact, meet with great interest. The reports on WBN meetings were found to be very satisfactory and should continue to be published, as in the past. Since not all countries are fully involved in germplasm activities, it was considered that there is no current need for sub-committees. Concern was expressed about the need for a broader approach to collection, conservation, utilization and evaluation of vegetable beets, which are as important in the region as is sugarbeet.

The suggestion was made to contact, through IPGRI, national plant genetic resources programmes in countries which are not yet participating actively in the WBN organization. It was noted that strengthening of the international cooperation within and between regions on all aspects and research programmes of beets, is an important issue. It was recommended that at the next WBN meeting there be more contributions dealing with research on vegetable beets.

North American panel

The chairman, Dr. L. Panella, introduced himself, presented the topics on the discussion guideline and solicited the discussion; Dr. L. Goldman kept the minutes. Only representatives from the United States of America were present.

Taxonomy

All of the participants agreed strongly with changes in the section *Beta*, as proposed by Drs Frese and Lange. A lively discussion ensued as to whether or not the new system had already been published in a peer-reviewed journal and fulfilled the other prerequisites of the international botanical society. Recommendation was made to wait on accepting the new taxonomy until this had been done. It was mentioned that the next meeting, in Turkey, will deal primarily with taxonomy. Some of the issues may be cleared up then. To allow for further discussion, Dr. S. Martin suggested that a session on taxonomy be scheduled at the ASSBT meeting as well.

Newsletter

Initially there was little interest in a newsletter but frequency of publication was discussed. Annual publication was recommended. An Internet bulletin board was also suggested as an alternative.

Areas for cooperation within the region

A very positive line of communication between breeders of the public- and private-sectors was opened during this discussion time. Most of the discussion centred around the relationship between these groups in dealing with the improvement of pre-breeding materials. Those representing industry strongly supported efforts in pre-breeding by the public sector (USDA). In response to the public-sector requests for help in screening some of these materials, industry thought that it could possibly be arranged. The public-sector researchers pointed out that they need access to high-sucrose, high-agronomic performance lines to produce useful germplasm for the private sector. The private breeders agreed, and there was much discussion about how this could be done. No recommendations were made; the subject will be discussed further at the next *Beta* Crop Advisory Committee meeting.

The role of the WBN in relation to American research

Over the past few years, interactions on an international basis have been very positive and it is important for this to continue. In today's research climate of high costs and shrinking budgets, cooperation is a necessity. It is especially necessary to promote cooperation with the developing countries as between equals, rather than wanting these countries to have a dependence on those that are more developed. It was pointed out that, costwise, travel to Europe was no more expensive than travel in the US and that more Americans should attend European meetings.

Funding of the WBN

It was suggested that the registration fee could reasonably be raised slightly, enough to cover the costs of the next conference. The main cost to the WBN is the support of scientists from countries that have a shortage of hard currency (80-90% of total cost). It was suggested that outside sources of money be carefully investigated. Some of the organizations suggested were FAO, World Bank and US AID. It was also suggested that scientists in the developing countries be encouraged to check carefully with their own governments for available sources of funding.

Summing-up session

Recommendations

The concluding session was chaired by Dr. Doney who pointed out that during this session recommendations for further WBN actions should be formulated. He then introduced the first topic:

Collection needs

The following areas of naturally-occurring *Beta* germplasm were identified as being deficient in *ex situ* collections:

Spain:	Northern and northeast coast
Iran:	Mountains, northwest, and coast

India:	North-western hills, upper Ganges plains, north-eastern hills and sea coast
Morocco:	Areas uncollected by Japanese and landraces
Egypt:	No specific areas were mentioned but old landraces should be sought
Red Sea:	Coast
Greece:	Eastern Greece
Turkey:	Inland areas
Syria:	No specific areas were mentioned
Lebanon:	No specific areas were mentioned
Iraq:	No specific areas were mentioned
Romania:	No specific areas were mentioned.

Mr. Arjmand is continuing to extend his collection efforts in Iran and Dr. Stanescu, who has collected in eastern Romania, was encouraged to continue his efforts. China and Iran fund their collection trips from their institutes' budgets and would require at least some extra support from outside sources. It was mentioned that IPGRI could possibly assist in the collection of vegetable beets. A joint collection expedition between USDA/ARS and India was proposed.

Recommendation: Future collection efforts include, in addition to wild types, old landraces which are not very well represented in the world *Beta* holding.

Multiplication and evaluation

The following agreed to conduct *Beta* evaluation:

- Several members of the IIRB for *Cercospora* leaf spot, Rhizomania and Virus Yellows (see Table 5).
- The US Sugarbeet Crop Advisory Committee, for *Cercospora* leaf spot, Rhizomania, Virus Yellows, Sugarbeet Cyst Nematode, Curly Top, root maggot, *Rhizoctonia* root rot, and *Aphanomyces* (approximately 60 per year).
- India (H. M. Srivastava) for *Cercospora* leaf spot, salt tolerance, and high vigour.
- Japan for Rhizomania.

The above evaluations may be delayed due to lack of sufficient seed for evaluation purposes. It is imperative that seed of accessions for evaluation be multiplied as soon as possible. Since the seed samples routinely supplied by genebanks are small, they need to be increased before any screening can start. A part of the necessary multiplications is done by commercial plant breeders. However, the number of seed increases is much lower than the number of evaluation plots offered. The WBN members were urged to provide seeds in order to make maximum use of the IIRB support. It would be wasteful if, after years of discussion with the IIRB members, the genebanks of the network use only a small fraction of the support offered.

Recommendation: The new BCC persuade genebanks to fill the gap between seed increase and evaluation capacity by sending surplus seed lots from their yearly routine seed regeneration programmes to Braunschweig from where they can be forwarded to the various plant breeders.

Taxonomy

The revision of section *Beta*, as suggested by the paper entitled "A taxonomical revision of *Beta* section *Beta*", was discussed by each panel. All recommended that the new taxonomical revision be accepted. The North American panel, however, noted that

official acceptance in the US cannot be granted until the revision is published in a refereed journal. It was mentioned that the system currently used by the IDBB was outdated in parts and should be changed as soon as possible. Finally, the discussion focused on the question of whether a publication of the new taxonomic system in a PhD thesis would fulfil the requirements of the international botanical society. With regard to the changes of botanical names of cultivated material, is was suggested that information from a botanical conference held in the Netherlands, in September, 1993, be used in deciding on the naming of the cultivar groups. The new classification system for *Beta* section *Beta* would be:

B. vulgaris ssp. *maritima* (L.) Arcangeli
B. vulgaris ssp. *adanensis* (Pamukcuoglu) Ford-Lloyd & Williams
B. macrocarpa Gussone
B. patula Aiton
B. vulgaris ssp. *vulgaris*
- cultivar group - leaf vegetable
- cultivar group - root vegetable
- cultivar group - fodder beets
- cultivar group - sugarbeets

Recommendation: The new taxonomic system for *Beta* section *Beta* be adopted as soon as the prerequisites of the international botanical society are fulfilled.

Use of IDBB

There was lively discussion on the issue of the IDBB's documenting of evaluation data. Whereas the US participants and the IDBB manager were still in favor of the metadata concept, another faction of the group advocated the registration of exact data. Dr. Frese pointed out that the registration of exact data would be much more time-consuming because it requires more complicated database structures and more administrative work than does the metadata concept. He said that if the WBN recommended the registration of exact data in deviation from the decision of the 1991 meeting, he would need support in terms of man-power. The task of a short-term collaborator would be to develop a concept and to create the logical structures within the IDBB.

Recommendation: The new BCC was asked to consult IPGRI in the matter.

WBN newsletter

The following proposal was made by Dr. H. M. Srivastava:

Publication:	WBN Newsletter - published by the WBN
Frequency:	Biannual - March and September
Cost:	US$10.00 per biannual membership
Printer:	In India - some examples were displayed
Editors:	WBN Coordinating Committee and one reporter from each region
Contents:	*Beta* germplasm activities and related news

Much discussion was generated by this proposal in each of the group panels. There was a general feeling that there would be insufficient material for a publication twice a year and that one per year would be satisfactory. Some of the participants felt that the publication of the WBN conference proceedings (biennial) may fulfil the role of the newsletter. Dr. Padulosi, of IPGRI, suggested that IPGRI's newsletter may be the proper outlet for *Beta* germplasm news rather than creating a newsletter just for *Beta*.

This generated some discussion concerning the distribution, costs, and content of the IPGRI publication. The participants were not prepared to make a decision on this proposal and carried a motion to request that the new BCC investigate this proposal in more detail and bring recommendations to the next WBN workshop.

Publication of technical WBN reports

Recommendation: A pamphlet on seed-increase procedures, as applied by the WBN members, be published.

Need for subcommittees

Each panel discussed the proposal to develop regional subcommittees of the WBN in order to strengthen cooperation within the region and between experts of various disciplines. The Asian group voted for the establishment of subcommittees whereas the European panel felt that they were unnecessary. The Sugarbeet CAC is already a regional committee and the North American panel recommended that no additional committees be developed for North America. Other panels expressed little interest in regional committees.

Recommendation: No regional committees be formed, at present.

Finance

In the past, IBPGR has been a strong financial supporter of the WBN. The past two conferences have also received significant financial support from private industry. Such support has been mainly to assist in the development of the network and is not a long-term commitment. Hence future financial support from both IPGRI and private industry may be significantly reduced. Suggestions were solicited for potential sources of future financial support. The following are some of the suggestions:

World Bank
International foundations
Aid sources
Publication of a book on sugarbeet
Increasing registration fees to cover conference costs.

Recommendations:

- Registration fees be increased to cover conference costs.
- The new BCC investigate international foundations, financial institutions, etc. as possible sources of the travel costs for participants from developing countries.
- Not to sponsor a publication on sugarbeet, since a very similar publication is in the final stages of preparation.

The next WBN conference

The next WBN conference is to be held at Izmir, Turkey. Dr. Tan gave a presentation during which she invited everyone present to attend. The conference will be devoted to *Beta* taxonomy. There are believed to be more species and more types of *Beta* in Turkey than in any other country. It was recommended that a concerted effort be made to invite participants from the Mediterranean- and Middle Eastern countries. Since Turkey is located relatively close to these countries, travel costs will be minimal.

Recommendation: More efforts should be undertaken by the new BCC and the organizer to include under-represented countries such as Pakistan, Iraq, Syria, Lebanon, Algeria, Albania, Italy and Spain. It was also recommended that the dates of the conference be scheduled immediately before or after the summer meetings of the IIRB.

Publication of the WBN report

The scientific papers will be published in a special edition of the Journal of the ASSBT to allow for their broader distribution. It was suggested that the report on the meeting should be published by IPGRI as has been done in previous years.

Recommendation: The WBN expressed the wish to publish the report on the meeting in IPGRI's Network Series and asked the new BCC to ensure that this be done.

New *Beta* Coordinating Committee

The following persons were elected to serve on the BCC for a term of two years:

Dr. H. M. Srivastava - India
Dr. W. Lange - The Netherlands
Dr. L. Panella - United States
Dr. L. Frese (Executive Secretary) - Germany

Acknowledgements

Participants warmly thanked the general chairman Dr. D. Doney, the organizing committee, the Beet Sugar Development Foundation and all the staff involved in the organization of an excellent and very stimulating conference and for their generous hospitality. On behalf of the developing countries and the East European countries, Dr. Srivastava expressed his gratitude to the breeding companies and IBPGR for their financial support which enabled the organizers to implement a truly international meeting.

Appendices

Appendix 1

Agenda

WBN Conference Chairpersons

General
D. L. Doney (USDA/ARS)
Pre-breeding Session
J. J. Kern (American Crystal Sugar Co.)
Gene Transfer Session
J. W. Saunders (USDA/ARS)
WBN Reporting Session
L. Frese (FAL)
Panel Session
B. V. Ford-Lloyd (University of Birmingham)
Regional Panels
Asia: *H. M. Srivastava*
Northwest European region: *L. Frese*
Mediterranean: *A. Tan*
North America: *L. Panella*
East European region: *Z. Stanescu*
Wrap-up Session
D. L. Doney (USDA/ARS)

Wednesday, 4 August, 1993

7:00 - 8:00	Registration
8:00 - 8:15	Welcoming and introductory addresses by *G. A. Smith* (Research Leader, USDA/ARS) by *D. C. Zimmerman* (Center Director, USDA/ARS) by *H. R. Lund* (Dean NDSU) by *T. K. Schwartz* (Executive Vice-President, BSDF)

Pre-breeding

8:15 - 8:35	Theory of pre-breeding by *G. A. Smith*
8:35 - 8:50	Pre-breeding from the perspective of the beet seed company by *R. Stander*
8:50 - 9:05	Broadening our genetic base by *D. L. Doney*
9:05 - 9:25	Pre-breeding for Virus Yellows and Rhizomania by *R. T. Lewellen*
9:25 - 9:40	Pre-breeding to change root architecture by *J. C. Theurer*

9:40 - 9:55 Break

9:55 - 10:15 Pre-breeding for nematode resistance
by *W. Lange, Th. S. M. de Bock* and *R. K. Lankhorst*

10:15 - 10:30 Pre-breeding for root-rot resistance
by *L. G. Campbell* and *W. M. Bugbee*

10:30 - 10:50 Pre-breeding in India
by *H. M. Srivastava*

10:50 - 11:10 Utilization of male sterility from *Beta maritima* sources in sugarbeet breeding
by *L. Dalke*

11:10 - 11:30 Pre-breeding in the former USSR
by *A. Kulik*

11:30 - 12:30 Lunch

Poster Session

12:30 - 17:00 Northern Crops Science Laboratory
(Large Conference Room)

12:30 - 14:30 Authors at posters

Development of diagnostics for evaluating *Beta* germplasm
by *T. H. Thomas, H. A. Smith, M. J. C. Asher* and *N. A. Clarke*

Isozyme characterization of the wild beet *Beta corolliflora* Zoss. and its hybrids with *B. vulgaris* L.
by *S. M. Reamon-Büttner* and *G. Wricke*

Meiotic chromosome pairing of species and hybrids in the section *Procumbentes* genus *Beta*
by *R. Sobek, A. Brandes* and *G. Wricke*

Resistance to *Polymyxa betae* and Beet Necrotic Yellows Vein Virus in *Beta* species of the section *Corollinae*
by *H. Paul, B. Henken, O. E. Scholten, Th. S. M. de Bock* and *W. Lange*

The use of RAPD for the identification of sugarbeet varieties
by *B. V. Ford-Lloyd*

The development of 'core collections' for *Beta* germplasm
by *B. V. Ford-Lloyd*

Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from *Cercospora* Leaf Spot infections
by *J. Miller, M. Rekoske* and *A. Quinn*

Screening of sugarbeet genotypes against *Sclerotium* Root Rot in sub-tropical India
by *H. M. Srivastava, S. Srivastava* and *R. C. Tripathi*

Evaluation of sugarbeet genotypes for high-temperature tolerance
by *H. M. Srivastava*

Cytomorphological and isozyme studies in *Beta vulgaris* and *Beta palonga*
by *H. M. Srivastava, S. Srivastava, R. Kapur,* and *V. K. Saxena*

Callus induction and plant regeneration of *Beta* germplasm
by *Y. Shimamoto, J. Abe, H. Nakashima* and *T. Mikami*

Collection of wild *Beta* species in Morocco and Spain
by *M. Tsuge* and *T. Masutani*

Weed beets: Origin, evolution and the risk of the use of transgenic sugarbeets
by *H. Van Dijk, P. Boundry* and *K. Broomberg*

Sugarbeet breeding, germplasm usage and collection, and biotechnological studies in China
by *C. Zhang* and *S. Liu*

Sugarbeet Seed Institute (SBST) activities during the past fifty years
by *M. N. Arjmand*

Database demonstrations

14:00 - 16:00 Northern Crop Science Laboratory - Sugarbeet Conference Room

pcGRIN: Database of the Germplasm Resources Information Network (GRIN) for personal computers
by *M. Bohning* and *Q. Sinnott*

14:00 - 16:00 Northern Crop Science Laboratory - Oilseeds Conference Room

IDBB: International Database for *Beta*
by *L. Frese*

Tours

13:00, 14:30 and 15:30
Northern Crop Science Laboratory USDA/ARS demonstration field plots

18:00 - 19:30 Visit Bonanzaville

19:30 - 21:00 Steak Fry at Bonanzaville

Thursday, 5 August, 1994

Gene Transfer

8:00 - 8:20 Gene transfer for herbicide resistance
by *P. Steen*

8:20 - 8:40 Transfer of nematode resistant gene(s) into the sugarbeet genome
by *C. Jung*

8:40 - 9:00 RFLP as molecular markers
by *A. Berville*

9:00 - 9:20 Use of RFLP markers in the *Beta* genus
by *C. Bornman*

9:20 - 9:50 Progress toward a general somatic hybridization protocol for *Beta*
by *R. Hall*

9:50 - 10:00 Break

10:00 - 10:20 Use of ß-glucuronidase as a genetic marker of transformation in sugarbeet
by *C. Wozniak*

10:20 - 10:40 Insect resistance mediated through plant growth regulators in transgenic plants
by *A. Smigocki*

10:40 - 11:00 A taxonomical revision of *Beta* section *Beta*
by *J. P. W. Letschert, W. Lange, L. Frese* and *R. van der Berg*

World Beta *Network Reports*

11:00 - 11:15 IPGRI objectives and strategies
by *S. Padulosi*

11:15 - 12:00 *Beta* Coordinating Committee meetings
by *L. Frese*
International Database for *Beta* (IDBB) up-date
by *L. Frese*
Evaluation proposal
by *L. Frese*

12:00 - 13:00 Lunch

13:00 - 14:45 Report on collections since previous meeting:
- Egypt, by *D. Doney*
- Russia, etc., by *L. Frese*
- Iran, by *N. Arjmand*
- China, by *S. Yi-Chu*
- Morocco and Spain, by *M. Tsuge*

WBN newsletter
by *H. M. Srivastava*

14:45 - 15:00 Break

15:00 - 17:00 Regional panel discussion groups

Asia
Northwest European region
Mediterranean region
North America
East European region

19:00 - 20:00 Hay ride at Runck Ranch

20:00 - 21:00 Dinner at Runck Ranch

FRIDAY, 6 AUGUST, 1994

Panel Reports

8:00 - 8:15 Opening remarks
by *B. V. Ford-Lloyd*

8:15 - 8:30 Asia, by *H. M. Srivastava*

8:30 - 8:45 Northwest Europe, by *L. Frese*

8:45 - 9:00 Mediterranean, by *A. Tan*

9:00 - 9:15 North America, by *L. Panella*

9:15 - 9:30 Eastern Europe, by *Z. Stanescu*

9:30 - 10:00 Discussion

10.00 - 10:20 Break

Summing-up Session

10:20 - 12:00 Recommendations
Assignments
Election of new *Beta* Coordinating Committee (BCC)
Next meeting - Izmir, Turkey

12:00 - 13:00 Lunch
Luncheon Speaker: *H. Shands* Associate Deputy Administrator - Genetic Resources - USDA/ARS

Tours

13:00 - 17:00
- American Crystal Sugar Co. research facilities
- American Crystal Sugar Co. beet storage facilities
- Sugarbeet farm
- Research trials

Appendix 2

List of Participants

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Appendix 3

Abstracts of papers and posters

Pre-breeding

The theory of pre-breeding

G. A. Smith
USDA-Agricultural Research Service, Northern Crop Science Laboratory, Fargo, North Dakota, USA.

Population changes and their dependent gene frequencies are affected by mutation, selection, random fluctuations, meiotic drive, and migration. The effects of selection pressure on relatively small populations can have dramatic effects on gene frequency, and hence on breeding progress. This selection, driven by necessity, has resulted in "narrow base" sugarbeet populations. This paper presents examples of population changes which can occur (have occurred in sugarbeet) in populations subject to intense selection. The utility of gene frequency analysis and its use as a predictive tool is outlined. Sugarbeet breeders, geneticists, and agronomists now attempting to collect and introgress wild germplasm into breeding populations will be aided by heeding principles presented in this paper.

Pre-breeding from the perspective of the private plant breeder

J. R. Stander
Betaseed, Inc., Kimberly, Idaho, USA.

Collection and preservation activities have enriched the range of genetic diversity available to plant breeders. Apparently, however, there has been limited use, by private plant breeders, of exotic materials from collections or other sources. Various reasons have been suggested for this. Because of the emphasis on short term breeding goals, private breeders tend to use breeding materials with which they are familiar and which are reasonably adapted to the target environment, as compared with alien materials which require a lengthy programme of pre-adaptation. The genetic variability in sugarbeets in the United States has increased in the last two decades; it does not appear that sugarbeet culture in the United States is particularly at risk because of genetic vulnerability. In the long run, however, the broadening of both cytoplasmic and nuclear genetic variation, may be of decisive importance in securing sugarbeets against epidemics, as well as providing the base for continued breeding progress.

Broadening our genetic base

D. L. Doney
USDA-Agricultural Research Service, Northern Crop Science Laboratory, Fargo, North Dakota, USA.

The narrow base from which sugarbeet originated, the need for disease resistance, and the negative relationship between root yield and sugar accumulation, have all contributed to the narrowness of the current genepool from which most present-day sugarbeets originate. Of the wild germplasm available, *Beta vulgaris* ssp. *maritima* offers the greatest promise for broadening the genetic base for future sugarbeet

improvement. Crosses between *B. maritima* and sugarbeet male-sterile inbreds have been advanced through four successive cycles of mass selection for root shape. Two of these crosses are approaching sugarbeet in root shape, root yield, and sucrose concentration; they are still, however, below commercial sugarbeet hybrids in root yield and sugar concentration. Even though these populations are inferior to commercial sugarbeet hyorids, it is the author's belief that superior combining-germplasm exists in this material and that combining these with commercial germplasm will produce superior hybrids. Additional populations (crosses between sugarbeet and regional populations of *Beta maritima*) are in the developmental stage. Sugarbeet inbreds segregating for genetic male sterility were used in the initial crosses to ensure crossing and recombination in each selection cycle.

Pre-breeding sugarbeet for virus yellows and Rhizomania resistance

R. T. Lewellen

USDA-Agricultural Research Service, US Agricultural Research Station, Salinas, California, USA.

Possibly as a consequence of a narrow genetic base, sugarbeet (*Beta vulgaris*) has proved to be vulnerable to diseases and pests. *Beta maritima* is believed to be the ancestral species of all cultivated beets and should be an important and useful germplasm resource for host-plant resistance. To test for useful genetic variability and to overcome the problems of evaluating wild types, an advanced sugarbeet breeding line was crossed to 59 accessions of wild beet from the pre-1980 USDA collection. Individual F_2 lines were produced from crosses to each wild beet accession. Mother roots were selected based upon non-bolting and agronomic type from the F_2 lines grown in a field plot. Photothermally-induced mother roots were bulked and randomly intermated to produce an F_3 source (cycle 0) and cycle 1, 2, 3, and 4 synthetics were evaluated in comparison with each other and the sugarbeet parental line. Genetic variability was obvious for most traits examined. Selection programmes for resistance to virus yellows (based upon individual plant performance for sugar yield) and resistance to Rhizomania (based upon root conformation), were done. These phenotypic recurrent selections significantly increased the performance of the respective synthetic when grown under diseased conditions. Even in the absence of, or under mild exposure to, the targeted disease, the selected synthetics were superior to the F_3 source. These data suggest that an improvement for root and sugar yield also occurred. When grown under mild to severe disease pressure, the selected synthetics had higher root- and sugar-yield than did the sugarbeet parental line.

Pre-breeding to change root architecture

J. C. Theurer

USDA-Agricultural Research Service, Michigan State University, East Lansing, Michigan, USA.

Considerable economic improvement of sugarbeet production and processing is possible if the traditional architecture of the sugarbeet is modified to a smooth root (SR) beet. Root shape of sugarbeet is a multigenic character and several generations of selection are needed to reach any degree of homozygosity. In recent years, conical-shaped SR beets have been developed in the eastern US, and globe-shaped beets have been developed in The Netherlands, using phenotypic recurrent selection. SR beets tend to have less-fibrous rootlets near the soil surface than do grooved-root beets, but rootlets still proliferate mainly along two vertical planes. SR testcross progenies have shown

significantly less taproot-tip breakage than does a commercial variety. Root yield of SR genotypes and experimental hybrids has been equal to or superior to commercial varieties, but sucrose content has been 1-2% less. Soil tare for SR genotypes has ranged from 25-75% less than for commercial varieties. Globe-shaped beets have lower soil tare than do conical-shaped SR beets. Conical-shaped beets appear to be more suited to current sugarbeet harvesting equipment than are globe-shaped roots since the latter grow further out of the soil and are often dislodged from the row when tops are flailed.

Pre-breeding for nematode resistance in beet

W. Lange, Th. S. M. De Bock and R. K. Lankhorst

DLO-Center for Plant Breeding and Reproduction Research (CPRO-DLO), Wageningen, The Netherlands.

Pre-breeding for partial resistance to the beet cyst nematode, *Heterodera schachtii* (BCN), included repeated mass selection in descendants of *Beta vulgaris* ssp. *maritima* accession BMH and preliminary studies on the inheritance and mechanism of this resistance. The selection in accession BMH and in progenies of a cross with fodder beet resulted in rather high levels of partial resistance. The mean numbers of cysts per plant were 20-40% and 15-30%, of those of the susceptible control varieties, respectively. The progenies of crosses between accession BMH and sugarbeet were less advanced; additional selection for biennial habit may have decreased the progress in selection for BCN resistance. The resistant materials showed a wide variation in cyst size. Many of the cysts were considerably smaller than those on the susceptible control varieties. This phenomenon will reduce the multiplication rate of the nematodes. The number of cysts in progenies of pair crosses between accession BMH and cultivated materials generally were slightly below the mid-parent values. The results are discussed in the light of pre-breeding strategies and the possible application of marker-facilitated selection procedures.

Pre-breeding for root-rot resistance

L. G. Campbell and W. M. Bugbee

USDA-Agricultural Research Service, Northern Crop Science Laboratory, Fargo, North Dakota, USA.

A number of root- and crown-rot diseases reduce yields in sugarbeet. Since many of these diseases are limited to small geographic areas and, in those areas disease incidence often is sporadic among years and fields, the development of resistant genotypes has not been a high priority. Sugarbeet production has been discouraged in a few areas due to the severity of outbreaks of, for example, *Sclerotium*. Losses from three root- and crown-rots (*Rhizoctonia*, *Aphanomyces*, and *Erwinia*) have been sufficient to justify major breeding programmes to develop commercially-useful resistant germplasm. A summary of these efforts covers the diversity of the sources of resistance, inheritance of resistance, and success rates of the breeding programmes. A summary of breeding efforts to develop genotypes with resistance to prevalent storage-rot fungi is also discussed. Results from recent screening of the USDA *Beta* collection are presented and the potential of this material for increasing the genetic diversity within the resistance breeding programmes is discussed.

Sugarbeet pre-breeding in India

H. M. Srivastava
Indian Institute of Sugarcane Research, Lucknow, India.

Sugarbeet is primarily a crop of temperate climates. In the last two decades, however, its cultivation has spread to sub-tropical climates. Sugarbeet was introduced into India about 23 years ago as a supplementary sugar crop to augment sugar production in hot summer months when recoveries from sugarcane decline. Initially, sugarbeet varieties were introduced from eastern Europe, the then USSR and the USA. Work was initiated in 1971 to develop Indian breeding materials and varieties suitable for specific climatic conditions. Since sugarbeet does not flower in the plains of India due to the absence of low-temperature induction, breeding and seed production is done in the hills at and above elevations of 5000 m above sea level. The root crop is grown in the plains. The three main breeding objectives were high sugar yield, resistance to diseases and tolerance to high temperature conditions at harvest. Due to the non-availability of initial breeding material and germplasm, in the first phase efforts concentrated on developing basic breeding material from the imported diploid open-pollinated varieties, using simple breeding methods. As a result of this work, 40 diploid multigerm inbred lines, one CMS line and its O-type were developed. In the second phase of our programme, efforts concentrated on developing some populations which might be introduced as varieties and serve as base material for future varieties. As a result, some composites (IISR Comp-1, LKC-2, Pant Comp-3), and synthetics (LKS-10, PS-10) were developed. LS-6, a highly promising diploid variety, was developed through modified mass selection. Continuous screening of available varieties/germplasm was done, simultaneously, for resistance to *Sclerotium* root rot and tolerance of high temperatures. In the third phase of the programme, with the availability of some CMS lines and O-types from USDA stations at Salinas and Fort Collins, USA, work was started on developing our experimental hybrids. Tetraploids were also induced and isolated. Work on screening and evaluation of available material for salt tolerance under conditions prevailing at Sunderbans (W. B.) and Banthara (Lucknow) was also initiated. This paper details the above activities and discusses future possibilities of sugarbeet improvement in India.

Possibilities for utilizing the male sterility from *Beta maritima* source in sugarbeet breeding

L. Dalke and M. Szota
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CMS plants, originating from natural populations on stony beaches of the Brittany Peninsula in France, were crossed with sugarbeet O-type plants in order to incorporate the sterile cytoplasm from wild subspecies into sugarbeet. F_1, B_1, B_2, and B_3 generations have been obtained. Pollen sterility from these hybrids has been found to be induced by both cytoplasmic and genetic factors. Studies of meiosis have shown that meiotic divisions proceeded normally with only small deviations until the tetrad stage, followed by the degeneration of the pollen grain. In the F_1 and B_1 generations, all plants were self-sterile with white stamens lacking viable pollen, suggesting dominance of the wild morphological features. Great variation in degree of pollen sterility and morphological features was found in the B_2 generations. Full sterility was found in some of the analyzed progenies. It can be assumed that the variation is due to the degree of recombination with nuclear genes from wild subspecies, and that the

maintainer nuclear genes from sugarbeet O-type are similar to, but not the same as, those in *Beta maritima*. Variation in agronomic characters (root shape, sugar content and monogermity) between progenies and their maternal parent, are presented.

Pre-breeding in the former USSR

A. Kulik
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Abstract not available.

Posters

Development of diagnostics for evaluating *Beta* germplasm

T. H. Thomas, H. G. Smith, M. J. C. Asher and N. A. Clarke
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Several useful characters have been identified in *Beta* germplasm. Resistance/tolerance to aphid-transmitted yellowing viruses and to *Polymyxa betae*, the fungal vector of the BNYVV, which causes Rhizomania, are being examined using ELISA techniques and molecular probes. Specific molecular markers for such desirable characters are also being sought. Other targets for diagnosis include stress tolerance and improved seed characteristics.

Isozyme characterization of the wild beet *Beta corolliflora* Zoss. and its hybrids with *B. vulgaris* L.

S. M. Reamon-Büttner and G. Wricke
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Several accessions of *Beta corolliflora* with *Beta vulgaris* have been screened with different isozyme systems to determine genetic diversity and to gain insights into the genetic constitution of *B. corolliflora*. The enzymes leucine aminopeptidase (LAP), peroxidase (PRX), superoxide dismutase (SOD) and glutamate oxaloacetate (GOT) were polymorphic in at least one locus. A total of five alleles were found in LAP, three at PRX1 and SOD3, and four at GOT3. The different phenotypes observed suggest that *B. corolliflora* is an autotetraploid. The accessions could also be differentiated by the frequency and type of alleles they contain. The hybrids between *B. corolliflora* and *B. vulgaris* were of intermediate morphology between the two species. They were triploids (3x=27) and had two sets of chromosomes from *B. corolliflora* and one from *B. vulgaris*. In the LAP zymogram, the segregation of each species could be observed independently. Tetrasomic segregation, specifically the chromatid type, has been found in *B. corolliflora* indicating further that this species could have originated through autotetraploidy.

Meiotic chromosome pairing of species and hybrids in section *Procumbentes* genus *Beta*

R. Sobek, A. Brandes and G. Wricke
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The meiotic chromosome pairing of species and hybrids in section Procumbentes was studied to understand interspecific relationships in this section. Knowledge of wild beet taxonomy is useful for breeding because it provides information on whether or not desirable genes in different species come from the same origin. Pairing intensity was measured by the number of chiasmata/pollen mother cells (PMC). Section *Procumbentes* consists of two diploid species (*B. procumbens* and *B. webbiana*) and one tetraploid species (*B. patellaris*). The genetic constitution of *B. patellaris* is not yet known. Results showed normal bivalent pairing in *B. procumbens* and *B. webbiana*; and *B. procumbens* x *B. webbiana*. Formation of few quadrivalents (0.12/PMC) in *B. patellaris* and similar frequencies of trivalents in the triploid hybrids *B. patellaris* x *B. procumbens* (2.26/PMC) and *B. patellaris* x *B. webbiana* (2.27/PMC), were observed. In the triploid hybrids (236/240 PMC) nine pairing groups were found, suggesting two homologous chromosome sets which, in turn, are homeologous to the third set. The chiasma frequency of these two sets was significantly higher than in *B. procumbens* or *B. webbiana*. From these results, *B. patellaris* is probably an autotetraploid. A genetic mechanism which suppresses multivalent formation in this species could be assumed. *B. procumbens* and *B. webbiana* are very closely related, as shown by the normal chromosome pairing in their hybrids and by the similarity of the meiosis in the hybrids with *B. patellaris*. If *B. patellaris* is an autotetraploid, its relationship to the diploid species is not as close as that between *B. procumbens* and *B. webbiana*. Thus, *B. patellaris* could have evolved separately, earlier than *B. procumbens* and *B. webbiana*.

Resistance to *Polymyxa betae* and beet necrotic yellow vein virus in *Beta* species of the section *Corollinae*

H. Paul, B. Henken, O. E. Scholten, Th. S. M. de Bock and W. Lange
CPRO-DLO, Wageningen, The Netherlands.

Seedlings of *Beta* species of the section *Corollinae* were grown in a mixture of sand and soil containing *Polymyxa betae* infested with beet necrotic yellow vein virus (BNYVV). Twenty-one different accessions were chosen to represent the species of the section and the area of distribution. Resistance to *P. betae* was determined by counting the number of resting spores in the roots. Low numbers were found in various accessions of *B. corolliflora*, *B. lomatogona* and *B. macrorhiza*, but only a few plants were found without resting spores. Resistance to BNYVV was estimated by measuring virus concentration with ELISA. Low virus concentrations were found in various accessions of *B. intermedia*, *B. corolliflora* and *B. lomatogona*. Low numbers or the absence of resting spores of *P. betae* did not always result in low concentrations of BNYVV.

The use of RAPD (random amplified polymorphic DNA) for the identification of sugarbeet varieties

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Criteria for varietal identification. Three general criteria have been proposed for characters suitable for varietal identification: distinguishable intervarietal variation, environmental stability and experimental reproducibility. The third criterion involving experimental reproducibility has now been shown to apply to characters derived from RAPD for a range of plant material. The authors have examined whether or not the first two criteria can be met when RAPD is used to generate characters for identifying varieties of sugarbeet, an outbreeding crop where varieties are far from genetically uniform. Considerable genetic variation within varieties can be detected using both isozymes and RFLPs which could hinder attempts to identify sugarbeet varieties using molecular methods.

Multivariate analysis of RAPD data. Superficially it appears that the first two of the three criteria for varietal identification cannot be met using RAPD (as indeed is the case with isozymes and RFLPs) because of intervarietal variation. However, multivariate analyses of the RAPD data go some way towards solving the problem. When sufficient numbers of plants were used per variety, with the application of cluster analysis and two-way indicator species analysis, a much greater prospect for discriminating between varieties was demonstrated. Using both analyses, distinct groupings of plants from each variety were achieved.

Possibilities for success. It seems clear that in terms of varietal identification in sugarbeet no single amplification product (or band) derived from RAPD could be used alone for identification purposes. Equally, the selection of one or a small number of plants from varieties would not lead to the unequivocal identification of those plants. However, with the use of multivariate techniques, discrimination between varieties might be achieved, provided that sufficiently large numbers of plants from any variety are used.

The development of 'core collections' for *Beta* germplasm

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The large size of germplasm collections can present problems in terms of choosing material for plant breeding and evaluation, and in terms of maintenance of those collections. Although the total number of *Beta* accessions being conserved worldwide is not large in relative terms, members of the *Beta* genetic resources community are nevertheless confronted with similar problems to those mentioned above. One answer to these problems is to develop a core collection of accessions for each species or section within the genus, perhaps made up of some 10% of the total collections, these accessions being chosen to represent the total diversity in existence. This would then allow concerted study (documentation, characterization, full evaluation, molecular characterization, etc.), efficient maintenance (viability, rejuvenation and multiplication, etc.) and subsequent utilization to be undertaken in stages and in different laboratories throughout the world, as a low-cost, ongoing, collaborative project of the World *Beta* Network. How is the choice of the core material to be made? Various procedures have already been proposed and implemented for other germplasm collections. Stratified sampling, sampling based upon ecogeographic information, and

purely random selection are some of these procedures. Recent work at the University of Birmingham (Lawrence *et al.*, in press) has addressed the problem of the minimum number of plants that need to be sampled from a population to be certain, at a given very high probability, of capturing at least one copy of each allele present at each locus. The conclusions have been extrapolated from sampling populations to sampling species and capturing allelic diversity in genetic resources collections. The results are surprising in that as few as 172 plants would appear to allow the capture of all alleles occurring at a frequency of 0.05 or greater. If these conclusions are correct, then it would be entirely feasible for us to develop core collections for sections of *Beta*, each containing approximately 200 accessions, with a very high degree of statistical certainty that this core material was representative of the total diversity of available *Beta* germplasm.

Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infections

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Cercospora (*Cercospora beticola*, Sacc.) leaf spot infections can result in significant losses in many sugarbeet producing areas of the United States. The principal means of controlling losses is through resistant varieties and/or fungicide protectants. Currently-available resistant varieties significantly outperform non-resistant genotypes under conditions of severe Cercospora infections but may be up to ten percent lower-yielding in the absence of disease. In some areas of potentially heavy infection, Cercospora leaf spot is managed primarily through the use of triphenyltin fungicides. Strains of Cercospora, resistant to the triphenyltin compounds, were reported in Greece in 1979. Sugarbeet researchers are concerned that similar strains of Cercospora may develop in the United States. Fungicide-resistant strains could cause an epidemic similar to that which occurred in southern Minnesota in 1981, when Benomyl-resistant strains of Cercospora emerged. Furthermore, the Environment Protection Agency (EPA) has restricted the use of triphenyltins, and could ban them, due to human safety considerations. No replacement fungicides with similar efficacy are available. Therefore, in areas where fungicide use is the primary form of control for Cercospora, committees approving new sugarbeet varieties should anticipate the potential loss of chemical protection and implement a gradual increase in the genetic resistance required.

Screening of sugarbeet varieties against Sclerotium root rot in India

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In recent years, evaluation of sugarbeet germplasm and varieties has received considerable attention due to the need to identify genes for resistance to diseases and pests. In India and some other sub-tropical countries, sugarbeet is primarily affected by root rot caused by *Sclerotium rolfsii*. The disease in its epidemic form causes plant losses of 20-30% in infested fields and often reduces sugar yield by as much as 20%. Screening of diploid and polyploid varieties of sugarbeet was conducted in the field under artificial epiphytoic conditions created in the months of February/March, the crop having been sown in the previous October. Data on root yield and percentage of disease incidence was recorded at time of harvest (April-May). Two sets of varieties

comprising diploid and polyploids were screened in the 1986/87 to 1988/89 crop seasons. None of the varieties tested were resistant to *Sclerotium* root rot. The percentage of disease incidence ranged from 33% to 54.5% under Lucknow conditions. Details of the results are described and discussed in this paper. There is a need to identify resistant/tolerant genotypes in a wider germplasm collection for use in future breeding programmes for the sub-tropical climates.

Callus induction and plant regeneration of *Beta* germplasm

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Callus cultures of 21 *Beta* germplasms, including 18 sugarbeet (*B. vulgaris*) lines, two accessions of *B. maritima*, and a *B. macrocarpa* accession, were initiated from aseptically germinated seeds. Plant regeneration through organogenesis was obtained either on MS or B5 medium containing various concentrations and combinations of NAA, BAP, TIBA and AbA. *Beta* germplasms differed in their callus formation and plant regeneration abilities.

Collection of wild *Beta* species in Morocco and Spain

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In 1990, an exploration for wild *Beta* species (seeds) was conducted in the coastal areas of Morocco, Gran Canaria Island, and areas near Zaragoza and Tarragona in Spain. A collection of 32 accessions was acquired. Of these, 15 were collected in Morocco, 12 in Gran Canaria Island, and five in Spain. Sixteen accessions were planted for investigation of botanical features and for reproduction.

Weed beets: Origin, evolution and the risk of the use of transgenic sugarbeets

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Wild beets have expanded in European sugarbeet fields since the 1970s. They form a serious new weed problem for this crop. Their mitochondrial and chloroplast DNA are characteristic for sugarbeet, whereas nuclear information (B. gene, i.e. genes for early flowering) clearly originates from southern wild populations. The presence of these weed beets may have serious consequences resulting from the use of herbicide-resistant transgenic sugarbeets.

Sugarbeet Seed Institute (SBSI) activities during 50 years

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SBSI activities in breeding and sugarbeet production go back more than 50 years (since 1941). It is the only institute in Iran which deals with breeding and sugarbeet seed production. Since its establishment, it has met the country's needs for sugarbeet seed. The seed has been prepared with due attention being given to the different climatic conditions of the major sugarbeet-growing areas. The Institute's headquarters are located at Karaj and consist of the following research departments and laboratories: plant breeding; agronomy; sugarbeet technology; cytology and *Beta* genebank; computer and statistics; tissue culture; plant nutrition; and seed technology. In addition, the SBSI supervises several regional sections in the main agricultural areas.

Collection and study of the wild beet (*Beta maritima*) in Egypt

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The first systematic collection of wild beet (*Beta maritima*) in Egypt was conducted in June of 1992. Twenty-six populations representing the different ecological conditions in Egypt, were sampled. All collection samples were divided between the Sugar Crops Research Institute, (A.R.C., M.O.A., Egypt) and the USDA-ARS, Sugarbeet Unit, (Fargo, North Dakota, USA). Samples taken to the USA were deposited in the *Beta* collection at Ames, Iowa (NC-7 Plant Introduction Station). These accessions will be increased under controlled isolation conditions at Logan, Utah, USA during the summer of 1993. Fifteen seed samples stored at Egypt's Sugar Crops Research Institute were planted at the Nubarin Research Station on 14th November, 1992. The experiment was replicated three times in a completely randomized block design. Seed was harvested on 15th May, 1993. Data were taken on field emergence, leaf shape, root weight and seed characters.

Endospermic embryony in sugarbeets

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A new variant of apomixis (endospermic embryony) was found in inbred lines developed at the Yaltushky Breeding Station. In this case apomictic embryos are formed from endospermic cells. They are located in the center of the embryo sac or in its chalazal part. Plants were found in these materials through cytological analysis. The new variant of apomixis is of interest for maintaining heterosis.

Database demonstrations

PcGRIN: Database of the Germplasm Resources Information Network (GRIN) for personal computers

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The United States' National Plant Germplasm System (NPGS) is a coordinated network of Federal, State, and private organizations involved in the acquisition, preservation, evaluation and distribution of plant genetic resources. A key component of the NPGS is the Germplasm Resources Information Network (GRIN), which is a centralized computer database of information on these genetic resources. Its purpose is to improve the management and operation of the NPGS and to enhance communication with plant scientists around the world. Currently, GRIN contains taxonomic, passport, inventory, character, evaluation, genetic marker and order processing data on over 410,000 accessions representing in excess of 8300 species. This information is available through telecommunication systems (Internet and commercial lines), CD-ROM, magnetic tape, printed reports or a query package designed to operate on any IBM-compatible personal computer.

IDBB: International Database for *Beta*

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The International Database for *Beta* was established in 1987 as a central crop-specific information unit with the primary task of making an inventory of the global *Beta* holding. Today, the IDBB serves as a central link within a decentralized network of *Beta* seed holdings kept at genebanks and other governmental agencies in various countries. The IDBB uses the program package ORACLE 6.0 and currently stores passport data on 9168 accessions. This information was received from 25 different institutions located in 21 countries. The IDBB is used by breeding companies and research institutes to search for specific kinds of germplasm within the world holding. Since its establishment, the IDBB has greatly improved access for public users, to the various national *Beta* germplasm seed stocks. In addition, within the World *Beta* Network, the database assists in coordinating germplasm collection, multiplication and evaluation activities. To visualize the geographic origin of the germplasm, the mapping program MAPVIEW 2.0 has been adopted as a tool to improve the information service of the IDBB. This program can be used to map collection sites of accessions and to identify geographic gaps within the world *Beta* holding. The data contained in the IDBB can be distributed as ASCII-files on floppy discs or as printed reports. Institutions having a license for ORACLE 6.0 can be provided with a full copy of the information system, on request. All information is distributed free to any user.

Gene transfer

Gene transfer for herbicide resistance

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Since 1990, Maribo Seed has made field trials with transgenic sugarbeet (*Beta vulgaris*). Glyphosate tolerance has been the main objective. Trials are performed in Denmark, France, England, and Belgium. As sugarbeet varieties are hybrids, the transformation can be made on either multigerm, diploid father lines or monogerm mother lines (CMS lines). The development work has involved a range of different genetic constructs from Monsanto. The *Agrobacterium* vector transfers the insert into random chromosomal positions in single or multiple copies. Transformed plants are cloned to about 10 copies each, and tested. If the GUS-gene is present, GUS analysis on pollen can distinguish between plants which are homozygous and those that are heterozygous for the introduced traits. Transgenic beets, and also progenies of transgenic beets, show considerable variation in the expression of the genes inserted (position effects). There are indications of interactions between transgenes and active genes. In most cases transgenes segregate according to Mendel's laws. The occurrence of meiotic irregularities, chimeries and multicopy inserts can add to the complexity of developing transgenic lines which are identical to the parental line except for the introduced trait.

Transfer of nematode-resistant gene(s) into the sugarbeet genome

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Monogenic resistance to the sugarbeet nematode (*Heterodera schachtii* Schm.) has been introduced from three wild species of the *Beta* section IV. The available resistant material can be classified as follows: (i) monosomic addition lines (2n=19) carry the original sugarbeet chromosome or a chromosome fragment housing the resistance gene; (ii) diploid sugarbeet introduction lines (2n=18) carry a translocation from the wild beet. The agronomic performance of these lines, however, is poor and the transmission rates for the resistance genes are considerably low, due to meiotic disturbances. Therefore, attempts have been made to clone the gene and transfer it into susceptible sugarbeet. The cloning procedure was divided into three steps. First, single copy and repetitive probes, closely linked to the gene in *B. procumbens* and *B. patellaris* were identified from fragment addition lines or translocation lines. In a second step using yeast artificial chromosome vectors (YACs), these probes were used for map-based cloning of longer stretches of DNA where the resistance gene is putatively located. Finally, the resistance gene was identified from the overlapping clones (contigs) via genetic complementation into susceptible sugarbeet using *Agrobacterium rhizogenes* vector systems.

Possible use of RFLP in repeated sequence families in sugarbeet breeding and for management of sugarbeet genetic resources

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Because they usually correspond to unique sequences, RFLP markers are used in genome mapping, variety distinction, variety homogeneity tests and in reconstruction of phylogenies. They are, nevertheless, not the most suitable markers for all these applications. Their use in taxonomy is not simple since these sequences are highly conserved in the *Beta* genus. Genetic variability analysis leads to calculated genetic distance enabling the construction of phenograms but not phylogenetic trees. Since phylogenetic trees are approached through other methods based on parsimony, they do not always fit within taxonomic groups. The authors, therefore, turned to other molecular markers which had already been found within main taxonomic divisions. RFLPs in repeated sequences generally are not used although they also offer a complementary wide range of applications; some have been used already and some appear to have potential. Some results with mildly and highly-repeated sequences which display RFLP or are genome specific when used as probes, are presented and the main advantages and disadvantages of both RFLP types are discussed.

Genetic variation among wild and cultivated beets of the section *Beta* as revealed by RFLP analysis

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The level of genetic variation detected among seven sugarbeet and four fodderbeet breeding lines was compared to the variation found among 21 accessions of wild beets of the section *Beta*. RFLP analysis used a set of 32 beet DNA sequences as probes to score a total of 351 bands over all accessions. The band data was used to calculate genetic distances between all pairs of accessions. The distance estimates were subsequently used in a cluster analysis to produce a dendrogram of genetic distances. The analysis unambiguously defined all accessions and clearly defined a fodderbeet cluster within that of sugarbeet. The cultivated beets were all separated from the wild beets. The sugarbeet breeding lines showed a considerable amount of genetic variation, comparable with the level of variation detected among the wild beet accessions.

Progress towards a general somatic hybridization protocol for *Beta*

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Beta vulgaris is notoriously recalcitrant concerning regeneration techniques. Krens *et al.*, (1990) were able, for the first time, to report normal, diploid regenerated plants from mesophyll protoplasts of sugarbeet. Since that time they have confirmed that the described techniques are also applicable to a range of beet lines (sugarbeet- and fodderbeet- breeding lines and varieties). This encouraging breakthrough has lead to the application of a range of techniques to enhance the efficiency of the method. For example, the use of alginate embedding procedures and the choice of plant tissue for use as the starting material have proven to enhance cell division frequencies 10- to 1000 fold. In parallel with this work, they have also been investigating the applicability

of a range of protocols for obtaining (a)symmetric beet hybrids involving either chemical or electrical protoplast fusion in combination with selection techniques based on gamma radiation or chemicals. Their ultimate goal of developing a protocol whereby just a fraction of a plant genome (e.g., that concerned with cytoplasmic male sterility) can be efficiently transferred between genotypes/species is discussed. Other research being carried out in this field on *Beta* and on other species is compared.

Use of ß-glucuronidase as a genetic marker of transformation in sugarbeet

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Accurate quantification of an introduced genetic marker into sugarbeet (*Beta vulgaris* L.) is based on the absence of native activities in the plant that could confound analysis of marker expression. During the course of experiments designed to optimize DNA transfer from *Agrobacterium tumefaciens* to sugarbeet leaf disc cells, an endogenous enzyme activity was discovered which utilizes all the common substrates recognized by the marker enzyme, ß-glucuronidase (GUS) from *Escherichia coli*. This native sugarbeet enzyme (SB-GUS) was characterized immunologically and biochemically to compare the two activities. GUS and SB-GUS were found to be distinct with regard to pH optima, thermal stability, reaction to denaturants and protein-modifying reagents, inhibition by metals and saccharo-lactone, and mass. The two activities are not immunologically related, as judged by western blot and immunoprecipitation analysis. A protocol was developed to accurately quantify introduced GUS in the presence of SB-GUS, by using the selective inhibition of GUS at pH 7.0 by saccharic acid 1,4-lactone. SB-GUS was found to be insensitive to 10 mM saccharic acid 1,4-lactone at this pH; GUS was decreased 100% in activity under these conditions.

Cytokinin-mediated insect resistance in plants transformed with the IPT gene

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Plant hormones are important in the regulation of growth and productivity of beneficial plants. One of the classes of hormones, the cytokinins, has also been implicated in natural defense mechanisms of plants against a wide range of pathogens. Because field applications of hormones are costly and problems with uptake, metabolism, and utilization by the plant have been encountered, endogenous production of cytokinin is desired. This paper discusses how tobacco and tomato plants were genetically engineered with a gene involved in cytokinin biosynthesis. This gene was reconstructed to allow for it to be switched on upon insect chewing or mechanical wounding of the leaves. *Manduca sexta* larvae consumed up to 70% less of the leaves from flowering tobacco plants expressing the cytokinin gene as compared with leaves from transgenic controls. Green peach aphid nymph development was delayed and only half as many adult females reproduced in comparison with nymphs feeding on normal plants. Levels of zeatin and zeatinriboside cytokinins were elevated about 70-fold in leaves of transgenic plants. The mode of action of the cytokinin-gene product on enhanced insect resistance is not clear but may involve the products of secondary metabolic pathways. Extension of this study to other crops and insects may prove to be a beneficial and environmentally-safe approach which, in combination with an

integrated pest management programme, will enable plants to reach maturity and increase yields.

A taxonomical revision of *Beta* section *Beta*

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The taxonomic histories of the genus *Beta* and of section *Beta* within this genus are summarized. The subdivision of the genus agrees largely with (im)possibilities to produce hybrids. Classification within section *Beta* has been very variable, with examples of overclassification and severe lumping of taxa. The present study includes a morphometric analysis of variation, research on the patterns of allozyme differentiation, and studies of available herbarium specimens. After a description of the taxonomic criteria used, and after the stabilization of four Linaean names through typification, the results of the various studies are combined and used to formulate a revision of *Beta* section *Beta*. It is proposed to distinguish three species: *B. vulgaris* (a large and variable species containing both cultivated and wild materials); and two easily distinguishable species namely, *B. macrocarpa* and *B. patula*. *B. vulgaris* is subdivided into three subspecies: ssp. *vulgaris*, containing all cultivated materials; ssp. *maritima*, a large and variable group of plant types; and ssp. *adanensis*. Further subdivision is considered to be of little or no use. The so-called weed beets are classified as ssp. *maritima*. A key to the species and subspecies of section *Beta* is presented. Allozyme studies indicate that the development of self-compatibility and autogamy might have been important in the formation of taxa. Results are also discussed in relation to sampling strategies for genebanks.

Appendix 4

Beta germplasm collection and its application status in China

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Introduction

Leaf beet (*Beta vulgaris* ssp. *cicla*) has been used in China for more than 1500 years. It is widely distributed in Central China, and along the Yangtze- and Yellow River valleys. It has been used as a vegetable and as a Chinese herbal medicine. Recently, it has been used as a fodder for livestock. Many kinds of leaf beet are used by the peasant families, but its economic value is less than that of other vegetables. It has not been studied systematically. Twenty-seven samples have been collected from Sichuan, Hebei, Jiangsu, and Zhejiang. Of these, 18 samples have been propagated and preserved.

Sources and distribution

More than 20 samples collected from peasant farms have been planted at the research station farm. Two of these came from livestock farms in Sichuan and Hangzhou where they were used as livestock feed during the winter and spring to supplement other fodder sources. One sample was collected in Xinjiang.

Leaf beet is distributed throughout Sichuan, Henan, Guizhou and Hunan. These regions are hilly with sloping fields; soils are red or grey. The summers are moist and the winters are cold with temperatures ranging between 0°C and 10°C. Soil analysis has not been conducted due to lack of funds and time.

Taxonomy

The beets have been classified into five types, based on observations made on grow outs at the Hulan research station:

- White leaf beet. White petiole, pale-green blade, oval leaf, plant height 45-50 cm, semi-erect leaf rosette, low fibre and high adaptability. Examples = BCs 01, 09 and 027.
- Green leaf beet. Pale green petiole, green blade, long oval leaf, semi-erect leaf rosette, and high stress resistance. Examples = BCs 03, 06, 021 and 024.
- The "Four Seasons" leaf beet. Vigorous leaf growth, semi-erect leaf rosette, oval blade, green and curled leaves, white and light green petiole, plant height greater than 60 cm, non-bolting, late maturing, high disease-resistance, and good quality. Example = BC010.
- Curly leaf beet. Semi-straight leaves, wide petioles, winding heart leaf, dark green and curled leaves, reverse oval blade shape, high resistance, medium quality, low fibre and some late bolting.
- Red leaf beet. Straight leaves, vigorous growth, green oval blade, light purple veins and petiole, high disease-resistance, and poor quality. Examples = BCs 012, 017 and 022.

The growth habit response to different environments varied within types. Samples collected from Sichuan, Hunan, Guizhou and Henan behaved as biennials when grown at their collection site: that is, when planted in September - October and allowed to stay over winter in the open field, they flowered and produced seed the second year in June-July. However, under Hulan conditions, some samples flowered and produced seed the

first year (August - September) if planted in early April. (Examples = BCs 017, 018 and 020)

Colour of seedling hypocotyl has been investigated (Table 1).

Table 1. Seedling hypocotyl colour of 13 leaf beet collections.

Sample Number	Hypocotyl colour	
	% Red	% Green
BC004	39.5	60.5
BC005	50.0	50.0
BC006	64.7	35.3
BC007	100.0	0.0
BC001	100.0	0.0
BC003	0.0	100.0
BC0013	100.0	0.0
BC0016	72.7	27.3
BC0018	0.0	100.0
BC0019	85.7	14.3
BC0020	44.4	55.6
BC0021	37.5	62.5
BC0027	0.0	100.0

Collections BC007, BC001, and BC013 were homozygous for red hypocotyl colour, while collections BC003, BC018 and BC027 were homozygous for green hypocotyl colour. The other seven collections were heterozygous for hypocotyl color (Table 1).

This investigation of germplasm involving collection, classification and seed propagation, will be continued. Wild beets of the *Procumbentes*, *Corollinae*, and *Nanae* sections have not been found in China.

Utilization

Introgression of resistance genes from wild beet into the sugarbeet and the improvement of the processing properties are important research aims in China. The Sugarbeet Institute of the CAAS is cooperating in this field with the Heilongjiang University. Sugarbeet was crossed with leaf beet (*B. vulgaris* ssp. *cicla*) and *B. vulgaris* ssp. *maritima*. Twenty-two combinations of F_2 and F_3 generations have been obtained. Four combinations showed 100% bolting in the sowing year and the percentage varied in the others. Two combinations have long roots and are bigger (*B. vulgaris x B. vulgaris* ssp. *maritima*). In future, more attention will be paid to the selection and improvement of *Beta* germplasm, including wild forms, through crossing and genetic engineering. Furthermore, the collection of *Beta* germplasm distributed in China (especially in some regions which have not yet been sampled) and the evaluation as well as classification of accessions, will be continued.

Cultivars of sugarbeet

Four kinds of cultivars are being used for sugarbeet production in China:

- Common polyploids. Between 55-60% of these are triploid. Examples = Tianyan 301-304 and Shangfen 305. These cultivars have wide adaptability, high yield, high sugar content, disease resistance (leaf spot and root rot) and are adapted to the natural

conditions of China's main sugarbeet production regions. They account for 60-70% of the sugarbeet plantings in that country.

- **MS hybrids.** Hybrids Tianyan 201 and 202, and Gongnong 302 are planted in the east of Inner-Mongolia and some parts of the Heilongjiang province.
- **Common diploids.** Cultivars Tian 4, Jintian 3, and Gongnong 5 are planted in Inner-Mongolia, Shanxi, and Gan Su. These are all multigerm.
- **Monogerm cultivars.** Diploid monogerm cultivar Shuangdan 1 and polyploid monogerm cultivar Tiandan 1 are grown on the state farm of the Heilongjiang province.

The monogerm seed has not spread due to the soil and climatic conditions of the sugarbeet production regions, i.e. dry springs, poor soil texture, low level of mechanization. It is not popular too because of its low sugar content. Some monogerm seed is used in the regions of high farm mechanization and soil preparation. Better results have been obtained with technical monogerm seed which has been processed by the seed company of the state General Bureau Farm.

Approximately 650,000 ha of sugarbeets are planted in China, mainly in the North East, North, and North West China:

Xinjiang and Gansu regions have the highest yield and sugar content in China. Characteristics are: a very dry climate; dependency on irrigation; large fluctuation in temperature in Aug-Sept; high light intensity; average yields between 45-50 t/ha; and sugar content between 17-19%.

The characteristics of sugarbeet cultivation in Heilongjiang province are: rain fed, sufficient rainfall in the summer and autumn, serious root rot and leaf spot, root yields between 15-20 t/ha, and sugar content between 16-17%.

Conditions in Xinjiang province are similar to Heilongjiang province but lower yields are recovered.

In the past, Xinjiang's cultivars have been found to have lower yield, sugar content and serious diseases when grown in Heilongjiang, whereas Heilongjiang's cultivars grown in Xinjiang have lower root yield and average sugar content. This situation has changed in recent years. The newly registered polyploid cultivars, Tianyan 303 and 302, have higher root yield and sugar content than the local control cultivars.

The genotypes of the cultivars used in China originated in Poland, the former Soviet Union, East Germany and the United States (CLR, MLR, AJi, P632 and GW65). After acclimatization and selection, their economic characteristics have been improved, especially with respect to sugar content and resistance to Cercospora leaf spot.

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Appendix 5

Contribution of Romanian scientific research to the activities of the World *Beta* Network

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In Romania, local populations of *B. vulgaris* ssp. *vulgaris* var. *altissima* and material selected from Polish varieties (CLR and MLR), German varieties of KWS origin and Ukrainian varieties (Belotercovskaia), have been used to create sugarbeet varieties. At present, more than 97% of the sugarbeet production area is cultivated with varieties developed by Romanian breeders using selection, hybridization and polyploidy. In hybrid seed production, mainly monogerm male-sterile lines and, to a lesser extent, multigerm material were used. Some varieties, especially monogerm ones, have a high ability to adapt to local conditions, ensuring high yields, both under high water stress with temperatures of 30-35°C (in the Danube plain and at the Black Sea coast), as well as under high humidity conditions (600-800 mm annual rainfall) in the intra-Carpathian depression.

The search for wild *Beta* germplasm in the spontaneous flora of Romania has not been a major part of the Institute's scientific work because it was considered to be a task of the field botanists of the herbarium of the Institute of Biology. That herbarium contains a few *B. trigyna* plants. As a consequence of participating in the WBN meeting at Braunschweig in 1991, the "detection, multiplication and use of *Beta* germplasm of the spontaneous flora" became part of the research programme of the Institute for Sugarbeet, in Fundulea. Since 1991, one wild population has been detected at Jassy, a town situated in the northeast of the country. It was preliminarily classified as *B. corolliflora*. The plants have large, white to yellowish tepals and the glomerules are made up of three fruits. The fruit ball is triangular-shaped. The steckling leaves are resistant to attack by *Mamestra brassicae* L. and *Noctuide loxostege sticticalis* L. larvae which are widespread in the temperate climates of southern Europe, Asia and North America. In Romania these larvae cause serious damage to the sugarbeet crop by destroying the leaves. In 1992, another *Beta* population, possibly *B. trigyna*, was found growing near the Black Sea coast on the southern aspect of a limestone slope.

A tetraploid (2x = 36) population of *B. patellaris*, received from a foreign botanical garden, is being multiplied at the Sugarbeet Institute. Cytological and embryological studies on this wild *Beta* material have been initiated. In the gardens situated all around Bucharest, annual multigerm beet populations of *B. vulgaris* have been encountered. After 60 days of vegetative growth these populations start to form flowering branches. The populations segregate for red and pink colour. Some plants produce flowering branches on the whole main stem.

At present, the Romanian institute lacks the logistical basis required for a more systematic *Beta* exploration. Rapid progress in the conservation of native *Beta* genetic resources distributed along the Black Sea coast and in the Danube plain can only be achieved if external support becomes available.