Disease Resistance in Collections of *Beta* Species

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ABSTRACT

In a collaborative EU-funded program (GENRES CT95-42), up to 600 *Beta* accessions are being screened for resistance to several important diseases of sugarbeet (*Beta vulgaris* ssp. *vulgaris*) including beet mild yellowing virus (BMYV), beet yellows virus (BYV), *Aphanomyces cochlioides*, *Pythium ultimum* and powdery mildew (*Erysiphe betae*). Results are promising, with between 0.3 and 16% of accessions exhibiting high levels of resistance. A preliminary analysis of BMYV, *Aphanomyces*, and powdery mildew data indicates some differences in disease resistance among *Beta* types. Early testing of progeny derived from plants highly resistant to BMYV and powdery mildew has shown that these traits are heritable.

Additional Key Words: *Aphanomyces cochlioides*, BMYV, BYV, powdery mildew, *Pythium ultimum*, Sugarbeet.

Sugarbeet production in northwest Europe is affected significantly by several diseases, including virus yellows diseases caused by beet mild yellowing virus (BMYV) and beet yellows virus (BYV), seedling damping-off diseases caused by the fungi *Aphanomyces cochlioides* and *Pythium ultimum*, and powdery mildew caused by the fungus *Erysiphe betae*. Where these pathogens are economically important, control is achieved almost exclusively by the use of pesticides. For virus yellows, insecticides are used to control the aphid vectors, primarily through seed treatment (Dewar et al., 1996), although foliar applications can be made where infestations are severe (Werker, 1998). Fungicides are used for control of the other diseases, applied on the seed surface for damping-off control (Payne &

Williams, 1990) or to the foliage at critical times for powdery mildew control (Asher & Williams, 1996).

As attitudes towards pesticide use are changing, because of their high cost and the potential negative effects on the environment and human health, the sugarbeet industry would like to improve inherent disease resistance in sugarbeet cultivars. Currently, resistant sugarbeet available to growers in Europe is limited; available cultivars do not exhibit effective resistance to virus yellows or damping-off diseases, and resistance to powdery mildew in commercial cultivars is only partial (Luterbacher et al. 1998). In part, the lack of disease resistant material is a result of other breeding priorities, usually agronomic, especially bolting resistance and yield. Also, discovering new sources of disease resistance is relatively difficult. To address this problem, researchers at IACR, UK are screening ca. 600 *Beta* accessions from the BAZ genebank (Braunschweig, Germany) for resistance to BMYV, BYV, *Aphanomyces cochlioides, Pythium ultimum*, and powdery mildew. This work forms a part of a European Union led initiative to improve *Beta* germplasm utilization in agriculture. This paper reports the progress made in screening for each resistance trait and the potential future use of resistant material.

MATERIALS AND METHODS

Beta Germplasm

Currently, 553 *Beta* accessions are under evaluation with 72% of European origin, but some are from other parts of the world including 9% from the Middle East and 9% from the former Soviet Union (Figure 1). Most accessions are of cultivated origin (62%), e.g., fodder, garden, leaf and sugarbeet, but other non-cultivated *Beta* species are represented including 33% from the Section Beta, 3% from Corollinae and 2% from Procumbentes (Figure 2). The most common non-cultivated type under evaluation is the maritime beet *B. vulgaris* ssp. *maritima* L. (25%).

Virus Yellows (BMYV and BYV)

Twenty-four seedlings per accession were grown to the two true-leaf stage in a glasshouse and inoculated with aphids (*Myzus persicae*) carrying BMYV or BYV. After 4 days, plants were fumigated to remove aphids and grown under high light intensity for an additional 3 (BYV) or 4 (BMYV) weeks. Virus content was quantified by ELISA using leaf discs cut from the originally inoculated leaves. The mean virus content of the 24 plants tested was calculated relative to a standard dilution series of virus for each accession.

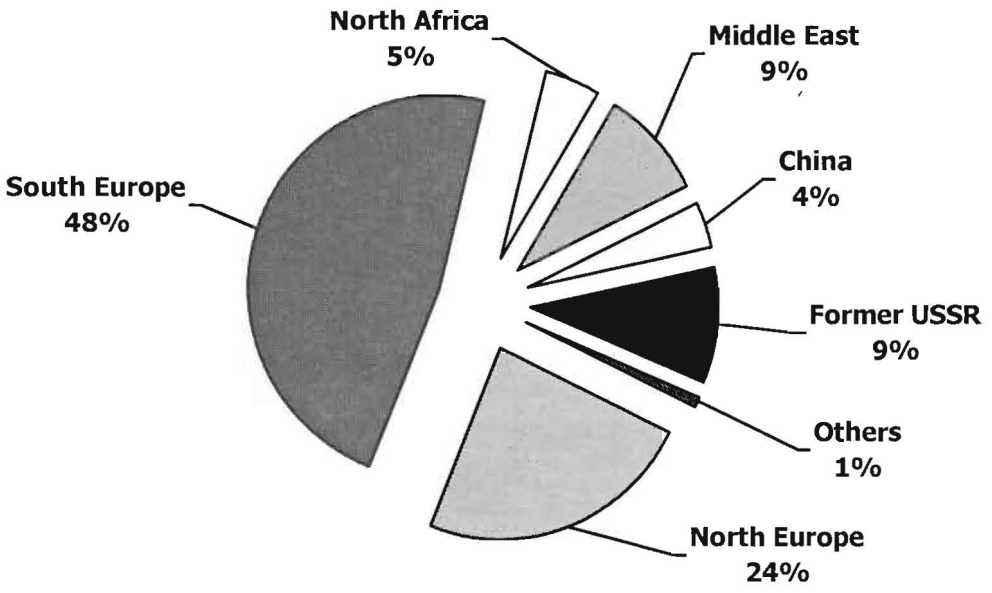

Figure 1. The origin of *Beta* germplasm used in resistance testing.

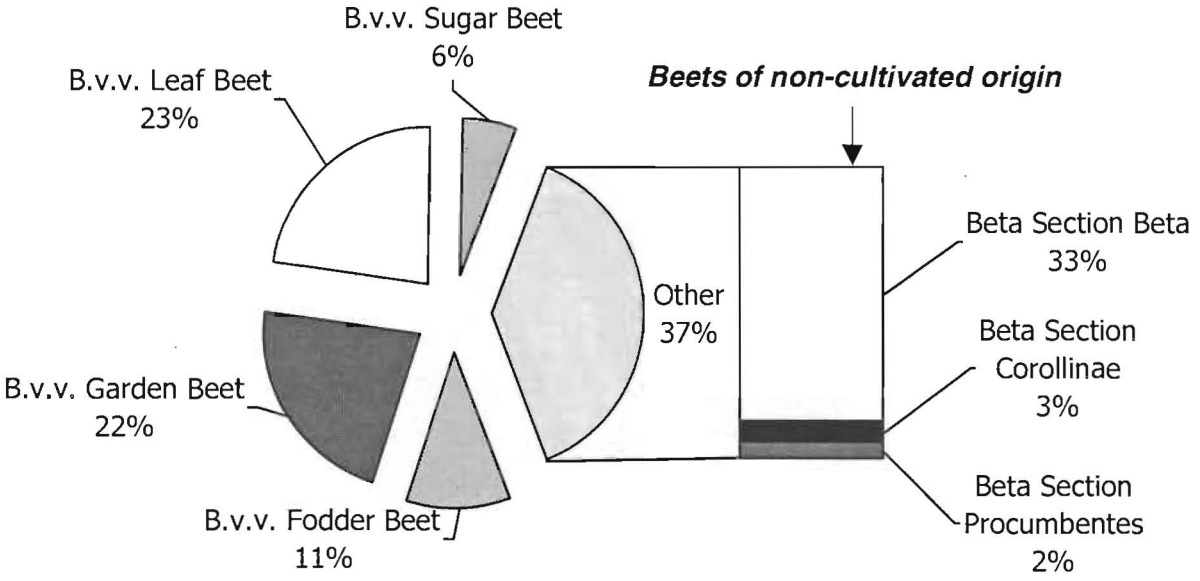

Figure 2. Identity of *Beta* germplasm used in resistance testing

Seedling damping-off (*Aphanomyces cochlioides* & *Pythium ultimum*)

For each accession, 96 seeds (four replicates of 24 seeds) were sown in cellular trays containing partially sterilized soil inoculated with *Aphanomyces cochlioides* (0.2% w/w) or *Pythium ultimum* (0.75% w/w). Both pathogens were previously grown on cornmeal/sand medium for 3 weeks (Williams & Asher, 1996). Trays containing seeds were maintained in a controlled environment room at 22°C with high soil moisture content for 3 (*Pythium*) or 4 (*Aphanomyces*) weeks. As *Pythium* can infect pre-emergence, a control treatment of 48 seeds per accession (two replicates of 24 seeds) was sown in uninoculated partially sterilized soil to assess emergence in disease-free conditions. Emerged seedlings were scored individually for *Aphanomyces* or *Pythium* infection on a 0 to 4 scale (0 = no infection; 4 = seedling dead). Pre-emergence death by *Pythium* was determined by reference to the uninoculated control; where observed, a score of 5 was given. For each accession, a mean disease score for the four replicates was calculated.

Powdery Mildew

Screening for powdery mildew resistance was conducted in field plots. One plot per accession containing 25 to 30 plants was sown in the field in May. Natural field epidemics of powdery mildew were allowed to infect plants. Plots were interplanted at regular intervals with a susceptible sugarbeet cultivar (cv. Sandra) to encourage pathogen development. Plants that bolted or senesced prematurely were cut back to generate vegetative growth and lengthen the growing period. Disease assessments on 25 plants were made in August/September using a 0 to 5 infection scale (0 = no infection, 5 = almost total infection of leaves). For each accession, a mean disease score for the 25 plants evaluated was calculated.

To reduce variation between tests of each resistance trait, all means were adjusted relative to that of a standard sugarbeet cultivar included in each experiment (cv. Saxon, except powdery mildew where cv. Sandra was used). These adjusted scores were transformed to a standard 1 to 9 score (1 = most resistant, 9 = most susceptible).

RESULTS AND DISCUSSION

With between 164 and 374 *Beta* accessions tested for each disease resistance trait, early results are promising. A broad range of reactions was observed (Table 1) and, encouragingly, a sizeable proportion of accessions exhibited much higher resistance than the standard commercial sugarbeet cultivar included in each test. At present, between 0.3 and 16% of accessions have appeared to be highly resistant (disease score 1). Resistance has

Table 1. Testing for disease resistance in *Beta* germplasm: frequency distribution of disease scores of individual accessions tested for each resistance trait.

	Number of accessions in each resistance category (Frequency distribution) Resistance categories									Total No. of *Beta* Accessions Tested
	<resistant								*susceptible>*	
Disease Resistance Trait	1	2	3	4	5	6	7	8	9	
BMYV	11	39	64	51	64*	52	36	27	29	373
BYV	11	33	38	39*	20	9	7	3	4	164
Aphanomyces cochlioides	6	13	31	67	98*	79	39	12	17	362
Pythium ultimum	33	38	48	35*	21	16	10	6	0	207
Powdery mildew	1	6	12	29	62	109*	100	45	10	374

* indicates disease resistance score of standard cultivar included in each test (all cv. Saxon except powdery mildew where cv. Sandra was used).

usually been confirmed with re-testing. Based on the current rate of discovery, projections are that between 2 and 88 accessions with resistance to a particular disease will be detected by the completion of the project. These accessions provide novel sources of resistance genes for introgression into sugarbeet breeding lines. Early testing for BMYV resistance in progeny derived from selfing resistant plants indicated that the resistance trait is heritable, a finding with important implications for future breeding work (Luterbacher *et al.* 1998). More recently, powdery mildew resistance in these sources has also been found to be inherited in the progeny of resistant parents.

A preliminary examination of results in relation to taxonomy suggests possible differences in resistance among various *Beta* types (Table 2). Classifying disease scores 1 to 3 for each trait as 'resistant', *B.v.maritima*

Table 2. Testing for disease resistance in *Beta* germplasm: percent of *Beta* species exhibiting high resistance.

Beta Species	Accessions tested	*Aphanomyces*	BMYV	Powdery mildew
			%	
B.v. maritima	97 – 100	26	14	8
B.v.v Fodder Beet	42	7	45	2
B.v.v Garden Beet	67 – 71	9	44	3
B.v.v Leaf Beet	106 – 111	6	22	5

accessions appear more resistant to *Aphanomyces cochlioides* infection than the other types. Conversely, *B.v. maritima* fared relatively poorly when compared to fodder and garden beet in relation to BMYV resistance. Resistance to powdery mildew was generally low across all species. Although these observations could have important consequences for sugarbeet breeding programs, such data must be interpreted with care. Potentially confounding factors such as the country of origin of each *Beta* accession and, consequently, the local disease infection pressure, have not been taken into account. A more detailed analysis will be undertaken on completion of the project when a greater volume of data are available.

The data from these screening trials will assist researchers and breeders in several ways. Most importantly, it will provide information to breeders, via a central database, on the resistance status of individual *Beta* accessions so appropriate selections can be made for inclusion in future sugarbeet breeding programs. The process of providing records on the relative disease resistance of accessions for inclusion in the International *Beta*

Database (IDBB), maintained at the BAZ genebank in Germany, has begun. In due course, the information will be made available through the BAZ website.

Researchers at IACR are beginning to explore the heritability of individual resistance traits so that the genetic mechanisms involved (e.g., monogenic or polygenic control) are better understood. This information will allow optimal use of resistant material in breeding programs. At the same time, molecular markers for individual resistance traits are being developed to aid genetic studies (Francis et al.,-1998). These may allow the use of marker-assisted selection in future resistance-breeding programs, thus improving efficacy. Ultimately, sugarbeet growers will benefit as new disease resistant cultivars appear on the market, and increase the range of management options available to them, whilst reducing the cost of production through lower pesticide use. This in turn will benefit consumers and the environment.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Asher, M.J.C. and G.E. Williams. 1996. Forecasting, epidemiology and control of powdery mildew in sugar beet. p. 83-93. *In* Proc. 59th IIRB Cong.

Dewar, A.M., L.A. Haylock, and P.M.J. Ecclestone. 1996. Strategies for controlling aphids and virus yellows in sugar beet. Proc. Brighton Crop Protection Conf. – Pests and Diseases 1:185-190.

Francis, S.A., M. Redfearn, D.M. Chwarszczynska, M.J.C. Asher, and R.T. Lewellen. 1998. Use of molecular markers in breeding for disease resistance in sugar beet (*Beta vulgaris* L.). Aspects of Appl. Biol. 52: 279-285.

Luterbacher, M.C., J.M. Smith, and, M.J.C. Asher. 1998. Sources of disease resistance in wild *Beta* germplasm. Aspects of Appl. Biol. 52: 423-429.

Payne, P.A. and G. E. Williams. 1990. Hymexazol treatment of sugar beet to control seedling diseases caused by of *Pythium* spp. and *Aphanomyces cochlioides*. Crop Prot. 9:371- 377.

Werker, R. 1998. The future in virus yellows forecasting. Brit. Sugar Beet Rev. 66 (1):36-38.