Allium Genetic Resources with Particular Reference to Onion

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Abstract

As in many other crop species, also in *Allium* crops genetic erosion is taking place. In this mini review the current global state of the art is presented on *Allium* ex situ genetic resources and more in particular on onion genetic resources. Furthermore future possible actions are indicated to preserve the *Allium* genepool in a more effective way, amongst which a proposal to develop an *Allium* genetic resources internet site.

INTRODUCTION

The availability of genetic variation within crops, present in ex situ and in situ collections, is of pivotal importance for a sustainable agriculture, even in the era of X-omics. However, since the beginning of the 20th century genetic erosion of crops has become increasingly a reality in many crop species (Pistorius, 1997). Genetic erosion can take place on several levels: a) on the crop level: decrease of genetic variation can take place due to the use of more uniform and highly productive cultivars which replace in a continuous pace old landraces; b) on the habitat level: the loss of habitats can be very detrimental for the survival of crop wild relatives; and c) on the knowledge level: losses on this level can mean that crops are forgotten or even can get lost. In this review paper I will be dealing primarily with the crop and habitat level as the erosion on the knowledge level for edible *Allium* crops is most probably not large.

HISTORY OF *ALLIUM* PGR

In the first large overview on onions and related crops (Jones and Mann, 1963), the topic of *Allium* genetic resources is not mentioned. Astley et al. (1982) were the first that made an overview of global edible *Allium* genetic resources. They identified major *Allium* collections worldwide, and presented the numbers of accessions per species per collection. Furthermore a draft *Allium* descriptor list was included in their report together with a list of collecting priorities. In total ca. 9000 accessions were reported to be present worldwide and the number of onion accessions was by ca. 7000 by far the largest. The collection of local/modern cultivars and landraces of *Allium cepa* (dry bulb onions and shallots) was considered as an important future collection priority as modern F_1 hybrids were thought to quickly replace old landraces. A decade later, Astley (1990) described *Allium* ex situ conservation by focusing on characterization, evaluation, documentation and utilization of collections. Also he indicated that wild *Allium* taxa are seriously underrepresented in global collections and that species' distribution areas are not adequately covered. Last but not least, Cross (1998) suggested that the cultivated *Allium* species are well collected, however collections from the centers of biodiversity of *Allium* are poor and therefore the variation sampled until present might be inadequate.

PRESENT SITUATION ON *ALLIUM* PGR

Currently around 27,000 *Allium* accessions are held in genebanks worldwide (www.ipgri.cgiar.org/germplasm/dbintro.htm). However, one must consider this number with caution as not all genebanks have uploaded their accessions to the aforementioned database. Furthermore, the percentage of duplications within and between *Allium* collections is unknown, misclassification is not accounted for and also availability of

accessions is unclear in many cases. Especially the percentage of duplication can be of influence on the total number of accessions. In this respect Van Hintum and Boukema (1999) showed for lettuce that around 60% of the accessions were duplicated among the collections of the major collection holders. In table 1, the number of *Allium* accessions is shown that are present in global collections: onion (*A. cepa*) is represented most, followed by garlic (*A. sativum*) and leek (*A. porrum*). It could be argued that for these three species less collection efforts should be carried out, however one should be careful in this respect in view of the duplications and misclassifications that can occur in worldwide genebanks. For all the other 750 *Allium* species (Gregory et al., 1998), next to onion, garlic and leek, genetic resources are certainly not sufficient and collection missions or in situ conservation actions are needed, because wild relatives are important for the development of better cultivars (Kik, 2002).

PRESENT SITUATION ON ONION PGR

As has already been mentioned previously the onion germplasm has been sampled most extensively when compared to the other species within the genus *Allium*. Concerning the various onion genepools, Van Raamsdonk et al. (2003) reviewed the existing literature and found that only a few species can be crossed directly with onion, namely *A. cepa*, *A. vavilovii*, *A. galanthum* and *A. roylei*. These species can be considered as species from the primary genepool of onion. The secondary genepool is at least composed of *A. fistulosum* and its progenitor *A. altaicum*, as Khrustaleva and Kik (2000) showed that *A. roylei* can act as a bridging species between onion and *A. fistulosum*/*A. altaicum*. The tertiary genepool consists of *A. pskemense* and *A. oschaninii* and another 20 species from the subgenera *Cepa*, *Reticulatabulbosa*, *Polyprason* and *Anguinum* (phylogeny according to Friesen et al., 2005; Table 2) or another 220 species (phylogeny according to Hanelt et al., 1990; Table 2).

In Table 3 an overview is given of the number of accessions per species present in the different onion genepools. From this table it can be concluded that although the onion germplasm is reasonably available, the germplasm of its wild relatives is only scarcely represented in worldwide genebanks. It is clear that collection missions or in situ conservation measures should be carried out to safeguard these important genetic resources. This is even more true as from literature as it is known that these resources are under severe threat in their natural conditions (area delimited in the west by the Pamir Altai and in the east by the Tien Shan mountain range) due to human activities (Fritsch and Friesen, 2002).

FUTURE ACTIVITIES IN *ALLIUM* PGR

In general it can be stated that for future activities in the area of *Allium* genetic resources, serious conservation efforts should be undertaken as parts of the genus are under threat. This is especially true for onion and its wild relatives but also for garlic (Kamenetsky et al., 2005). In this context it would be important to develop an internet platform for *Allium* species in which the global ex situ genetic resources are indicated and also the global in situ initiatives. In this way the status of the *Allium* PGR can be monitored in a more efficient way. Furthermore it would be desirable to determine the amount of duplications in *Allium* ex situ collections worldwide as this might prove to be a serious problem. Also the identification of the primary, secondary and tertiary genepools, for important *Allium* crop species like onion, leek and garlic, would be of great help for the ongoing breeding research in these crops. Last but not least characterization and evaluation of *Allium* accessions would be of importance for the utilization of the germplasm.

Literature Cited

Astley, D., Innes, N.L. and Van der Meer, Q.P. 1982. Genetic Resources of *Allium* species, IBPGR secretariat, Rome, Italy p.38.

Astley, D. 1990. Conservation of genetic resources. p.177-198. In: H.D. Rabinowitch and

J.L. Brewster (eds.), Onions and Allied Crops, CRC Press Inc, Boca Raton, Florida, USA Vol. I.
Cross, R.J. 1998. Review paper: global genetic resources of vegetables. Plant Varieties and Seeds 11:39-60.
Friesen, N., Fritsch, R.M. and Blattner, F.R. 2005. Phylogeny and new intrageneric classification of *Allium* L. (Alliaceae) based on nuclear ribosomal DNA ITS sequences. Aliso 22:372-395.
Fritsch, R.M. and Friesen, N. 2002. Evolution, domestication and taxonomy. p.5-30. In: H.D. Rabinowitch and L. Currah (eds.), *Allium* Crop Science: Recent Advances, CABI Publ., Wallingford, UK.
Gregory, M., Fritsch, R.M., Friesen, N.W., Khassanov, F.O. and McNeal, D.W. 1998. Nomenclator Alliorum. Whitstable Litho Printers Ltd., Whitstable, Kent, UK p.83.
Hanelt, P. 1990. Taxonomy, Evolution and History. p.1-26. In: H.D. Rabinowitch and J.L. Brewster (eds.), Onions and Allied Crops, CRC Press Inc, Boca Raton, Florida, USA.
Jones, H.A. and Mann, L.K. 1963. Onions and their Allies, Leonard Hill Ltd, London p.286.
Kamenetsky, R., London Shafir, I., Khassanov, F., Kik, C., Van Heusden, A.W., Vrielink-van Ginkel, M., Burger-Meijer, K., Auger, J., Arnault, I. and Rabinowitch, H.D. 2005. Diversity in fertility potential and organo-sulphur compounds among garlics from Central Asia. Biodiversity and Conservation 14:281-295.
Khrustaleva, L.I. and Kik, C. 2000. Introgression of *Allium fistulosum* into *A. cepa* mediated by *A. roylei.* Theor. Appl. Genet. 100:17-26.
Kik, C. 2002. Exploitation of wild relatives for the breeding of cultivated *Allium* species. p.81-100. In: H.D. Rabinowitch and L. Currah (eds.), *Allium* Crop Science: Recent Advances, CABI Publ., Wallingford, UK.
Pistorius, R. 1997. Scientists, plants and politics, A History of the Plant Genetic Resources Movement, IPGRI, Rome, Italy p.134.
Van Hintum, Th.J.L. and Boukema, I. 1999. Genetic resources of leafy vegetables. p.59-72. In: A. Lebeda and E. Kristkova (eds.), Eucarpia Leafy Vegetables '99, Palacky University, Olomouc, Czech Republic.
Van Raamsdonk, L.W.D., Ensink, W., Van Heusden, A.W., Vrielink-van Ginkel, M. and Kik, C. 2003. Biodiversity assessment based on cpDNA and crossability analysis in selected species of *Allium* subgenus *Rhizirideum*. Theor. Appl. Genet. 107:1048-1058.

Tables

Table 1. Number of accessions per species and occurrence (%) of species in worldwide *Allium* collections (source: www.ipgri.cgiar.org/ germplasm/dbintro.htm).

Allium species	No. of accessions	%
cepa	12740	46.7
sativum	4560	16.7
porrum	2148	7.9
fistulosum	951	3.5
tuberosum	434	1.6
schoenoprasum	274	1.0
nutans	95	0.3
chinense	27	0.1
wild relatives	6073	22.2
TOTAL	27302	100.0

Table 2. Number of species present in subgenus *Rhizirideum* (sensu Hanelt, 1990), and the number of species/accessions present in genebanks worldwide. In the parentheses very rarely sampled species are indicated.

Subgenus (sensu Friesen)	No. of species/subgenus	No. of species in genebanks	No. of accessions in genebanks
Cepa	22 (8)	18 (2)	14641
Reticulatabulbosa	55 (18)	34 (6)	393
Polyprason	61 (14)	29 (5)	252
Rhizirideum	20 (11)	19 (1)	681
Butomissa	4	3	615
Anguinum	5 (5)	4 (2)	56
Cyatophora	3 (1)	2	75
TOTAL	170 (57)	109 (16)	16723

Table 3. The onion genepools; number of accessions based on the IPGRI database (source:www.ipgri.cgiar.org/ germplasm/ dbintro.htm).

Genepools	No. of accessions
Primary	
A. cepa	12740
A. vavilovii	20
A. galanthum	34
A. roylei	4
Secondary	
A. fistulosum	951
A. altaicum	121
Tertiary	
A. pskemense	21
A. oschaninii	41