**Root and Bulb Vegetable Crop Germplasm Committee Crop Vulnerability Statement**

**Adopted March, 2017**

**Summary of key points (1 p. maximum)**

**1. Introduction to the crop (2 pp. maximum)**

**1.1 Biological features and ecogeographical distribution**

Carrot (*Daucus carota* L.) is a diploid outcrossing species that is regarded as a cool-season crop. Wild carrot grows widely in temperate, and some warmer, climates globally. The center of diversity and likely center of domestication of carrot is Central Asia based on the fact that wild carrots from Central Asia are genetically most similar to cultivated accessions (Iorizzo et al., 2013).

Garlic (*Allium sativum* L.) is grown worldwide and has been cultivated for over 5000 years. There are no known wild populations of garlic (Brewster, 2008). *A. longicuspis* is the closest relative of garlic and considered by some to be the same species, is distributed in Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Iran, southeastern Turkey and Pakistan (GRIN-Global Taxonomy).

Onion (*Allium cepa* L.) is also grown worldwide and is the most economically important crop of those crops that are assigned to this germplasm committee. Onion is grown and/or consumed in every country in the world. Onion is a biennial, diploid species in which bulbing is daylength sensitive. The center of origin of *Allium cepa* is thought to be central Asia. Since it is a cultivated species, the species does not exist in the wild but is thought to most closely resemble *A. vavilovii*.

**1.2 Genetic base of crop production**

For carrot, comparative genetic diversity of wild and cultivated accessions suggests the absence of a genetic bottleneck during carrot domestication (Iorizzo et al., 2013). While the overall breadth of cultivated carrots globally is broad, hybrids account for most of the major production area in the US and Europe. Since relatively few hybrids account for much of the production, allelic diversity in the cultivated crop of these areas is not particularly broad. There is a relatively rapid turnover of cultivars in many production regions and this may contribute to maintaining a fairly broad range of diversity in the cultivated crop over time.

For garlic, domestic production falls into two categories: large scale production for fresh market, seed and processing; and small scale production for local sale at farmers markets and via the internet. The majority of large scale garlic production is one or two varieties of softneck type garlic. Small scale production embraces a wider base of garlic varieties with hardneck and novel characteristics in demand.

Onion cultivars are both open-pollinated populations and hybrids. Cultivars are classified as short-day, intermediate-day, and long-day depending upon the daylength required to initiate bulbing. Within these categories, short-day onion germplasm is the most genetically diverse. Cultivars grown in different countries and regions differ in their daylength sensitivity and horticultural characteristics based upon the market demands in that area. Hybrid cultivars are increasing in their prevalence displacing land races and open-pollinated cultivars particularly in developing countries.

**1.3 Primary products and their value (farmgate)**

The land area devoted to world carrot production has more than tripled since 1965 while yields per unit area have not changed on a worldwide basis in this period. Most of this increase came in Asia before 1975, but Asia has had the largest increase in carrot production since 1975 as well. Although the carrot production area in Europe has risen steeply since 1965, the European share of world carrot production has dropped slightly during that period. Carrot production in Europe plus Asia accounts for about 80% of world production.

Africa’s carrot production has risen at a rate comparable to the rest of the world but yields have stayed low. Very little effort has been dedicated to carrot improvement for African production, so it may be possible to make yield advances there by selecting for better adaptation to warmer climate, as has been successful in South America. Global warming would, in fact, make this a vital carrot breeding goal in much more of the world.

The total global market value of the more widely traded carrot seed crop has been estimated to be in the range of $100 million (Simon, 2000), but such estimates have little reliable data to confirm them and true value is likely much more. The development of cultivars adapted for cultivation in both summer and winter seasons on all continents has allowed a year-round availability of carrot products with relatively stable prices to consumers. Some production areas harvest crops year-round.

Garlic is primarily grown for fresh market, dehydration or seed. In 2015, garlic production in the US was 382.5 million pounds with a value of $279.2 million (ERS, USDA yearbook 2016). Organic production was 3% of total production with 24,162 acres harvested and 28.4% of the total garlic producing operations in 2014 (ERS, USDA 2016).

Dry bulb onion is grown for fresh market, processing, dehydration, and seed while green onions are grown for fresh market and seed. In 2015, bulb onions for fresh market, processing, and dehydration were valued at $1.07 billion farm gate. On a worldwide basis, dry bulb onions in 2013 were valued at $44.3 billion US while green onions were valued at 1.97 billion US.

**1.4 Domestic and international crop production**

Carrot is among the top-ten most economically important vegetable crops in the world, in terms of both area of production and market value (<https://www.nass.usda.gov/>; <http://www.fao.org/faostat/en/#data> ; Rubatzky et al., 1999; Simon, 2000). In 2014, world production approached 39 Mt on 1.3 million hectares.

Carrot production in the United States has dramatically increased in both area and yield since 1925. Early estimates of production area may be low since small, locally-distributed production was often not included. Yet it is clear that carrot yields have risen significantly. Production practices and carrot breeding have both had a role in yield increases. The sharp rise in carrot yields between 1955-1975 coincides with the transition from open-pollinated to hybrid carrot varieties. The most recent increase in production area and yield since 1975 reflects the popularity of modern "baby" carrots, which are planted more densely. Small, whole "baby" carrots have been produced for several hundred years, but the modern "baby" carrots, also called "cut and peeled" are lightly processed 3 to 7 cm segments of ‘Imperator’ roots. With the convenience and value of this product, per capita availability and total farm value have also increased steeply. It is interesting to note the dramatic shift in U.S. carrot production to California and away from New York since 1925. Concomitant with this geographic shift has been a move to production for fresh market sales, which is readily achieved year-round in California. Without regular input of raw product from other areas, single season production areas like New York can only meet year-round raw product needs with long-term refrigeration or importation from other areas.

Current US carrot production in 2015 has a farmgate value of $777M from 835,000 ha of which approx. 80% of the production and 95% of the value is fresh market (<https://www.nass.usda.gov/>). Per capita consumption is steady or rising. Approximately 15% of the US carrot production is under organic management, one of the highest % organic production among crops reported.

Garlic in the US is primarily produced in CA with 24,600 acres in 2016. Less than 2000 acres of production in NV, OR and other states was reported in 2014 and 2015 and none were reported in 2016 (NASS, USDA 2017). China, Spain, Mexico, and Argentina are major world garlic producers and import to the US. China accounts for 70% of the global garlic production. The top 12 garlic producing countries were China, India, Korea, Bangladesh, Egypt, Russian Federation, Myanmar, Ukraine, Spain, US, Uzbekistan and Argentina with a total production of 235 million tons in 2014. Production was reported in 86 additional countries with tons produced ranging from 17 to 93,769 (FAOSTAT, 2017).

Dry bulb onions are produced in numerous states within the US with the major producing states being California, Washington, Oregon, Idaho, Georgia, New Mexico, New York, Texas, Colorado, Wisconsin, Michigan, Utah, and Nevada. Onions grown in the southern states are typically short-day cultivars that are autumn-sown, grown over the winter, and are first to be harvested in March, April, and May. Onions in California and New Mexico are harvested in June and July. Onions grown in the Pacific Northwest, Rocky Mountain states, Wisconsin, Michigan, and New York are harvested in the months of August and September. These onions are mostly long day cultivars that are stored and sold during the winter months until March of the following year. In 2015, 133,600 ac of fresh market onions were harvested with a total production of 360,000 tons.

In 2014, 5.3 million ha of dry bulb onions and 220,000 ha of green onions were harvested worldwide for a total production of 8.8 million metric tons of dry bulb onions and 4.2 million metric tons of green onions. A total of 160 different countries grow, harvest, and sell onions with China, United States, Egypt, Iran, Russia, India, Pakistan, Turkey being the largest producers.

**2. Urgency and extent of crop vulnerabilities and threats to food security (4 pp. maximum)**

**2.1 Genetic uniformity in the “standing crops” and varietal life spans**

Carrot has a highly diverse nuclear genome among major cultivars, but wide use of cytoplasm-genic male sterility could make for somewhat more uniformity in the mitochondrial genome. Although two cytoplasms exist for producing hybrids, U.S. carrot seed production and breeding relies almost exclusively on the petaloid type. To the extent that single cytoplasms are a concern for genetic uniformity, carrot would fall into a group that should be carefully watched.

 Garlic has relatively few clones in wide use, and is thus highly vulnerable, as was demonstrated with an outbreak of garlic rust several years ago. Until recently, no sexual crossing was possible and thus all clones existed as vegetatively-propagated germplasm. Among the four major crops covered by this Crop Germplasm Committee, garlic is perhaps the most vulnerable from a genetic uniformity point of view.

 Onion in the U.S. relies on a single cytoplasm for hybrid seed production. Thus, cytoplasmic uniformity is likely quite high. Nuclear genome variability exists across U.S. germplasm collection. To the extent that single cytoplasms are a concern for genetic uniformity, onion would fall into a group that should be carefully watched.

 Table beet and hybrid chard rely on a single cytoplasm for hybrid seed production, and this is the same cytoplasm used for sugar beet. Nuclear genome variation exists, although it is quite limited since very little effort is directed at table beet breeding in the U.S. All the sterile female lines in the U.S. (and worldwide) come from a single public program (Wisconsin) and share a high degree of genetic similarity. Most of the table beet production in the U.S. is handled with a few open pollinated and hybrid cultivars. To the extent that single cytoplasms are a concern for genetic uniformity, table beet would also fall into a group that should be carefully watched, particularly in light of the fact that the same cytoplasm is shared by sugar beet.

**2.2 Threats of genetic erosion in situ**

Central Asia isrecognized as the main center of origin for *Allium* species and for garlic. Kamenetsky et al (2007) found a high level of heterogeneity in garlic and *A. longicuspis* from this region. With the import of inexpensive garlic from other regions of the world, landrace and wild and pseudo-wild populations are in danger.

For onion, expanded collections from Central and Southern Asia is necessary. These regions are located in the center of diversity for onion and habitat destruction threatens wild forms and wide acceptance of hybrids is causing many land races to disappear.

**2.3 Current and emerging biotic, abiotic, production, dietary, and accessibility threats and needs**

**2.3.1 Biotic (diseases, pests)**

For carrots, the main pest and disease issues are several species of root-knot nematode, Alternaria leaf blight, Pythium/cavity spot, and Cercospora leaf spot. For garlic, the main pest issues are dry bulb mite, Allium leafminer, and nematodes. The main diseases of concern are Fusarium basal rot, Penicillium, Potyviruses, garlic rust, and white rot. For onion, the main pests are Allium leafminer, several species of nematodes, onion maggot, Rhizogyphous bulb mites, and thrips. The main diseases are bacterial bulb rots, neck and leaf Botrytis, downy mildew, Fusarium basal rot, *Iris yellow spot virus*, *Onion yellow dwarf virus*, pink root, rust, smut, purple blotch, Stemphyllium leaf blight, and white rot. The main diseases of table beet are Cercospora leaf blight, *Phoma* species, including *betae*, and Rhizoctonia root rot

**2.3.2 Abiotic (environmental extremes, climate change)**

Rising climatic temperatures, reduced water supplies, and increased salinity in carrot growing regions in the US and globally threaten future production. Carrot production has historically been in cooler climates, but with the development of carrot cultivars for subtropical regions of Brazil in the last 40 years, carrot production has expanded dramatically in warmer climates around the world. For example, carrot production in Bangladesh has risen significantly in recent years.

If projected trends for increased average temperature are realized with climate change already being observed, these same global regions will be most negatively affected by warmer agricultural growing conditions, reduced supplies of irrigation water and, in some regions, greater salinization of irrigation aquifers. Carrot is an irrigated crop in the majority of US production regions and is a salt-sensitive crop. With these anticipated challenges, developing breeding stocks for crop plants that have the genetic potential to meet these challenges becomes imperative to maintain an urgently needed sustainable food supply

A major abiotic threat to garlic is winter kill. The major abiotic threats to onions are premature bolting and winter kill on autumn-sown onions.

**2.3.3 Production/demand (inability to meet market and population growth demands)**

Root-knot nematodes threaten most of the US production areas, and available nematicides are becoming increasingly limited. Alternaria leaf blight can reduce carrot yields very significantly in any of the global carrot-growing regions with relatively high relative humidity. Southeastern and Midwestern US carrot growers are particularly subject to Alternaria leaf blight attack.

For table beets, widespread use of glyphosate resistant sugar beet is reducing the number of labeled herbicides for use on table beet. In addition, the limited use of effective herbicides in organic systems requires changes in early season plant growth habit.

One threat to Allium production is thrips resistance to many commonly used insecticides for onion and garlic production

* + 1. **Dietary (inability to meet key nutritional requirements)**

Orange carotenoids of carrot, α- and β-carotene, are vitamin A precursors that make carrot the largest single provitamin A source in the US diet, accounting for about half of our intake (Simon et al., 2009). The essentiality of vitamin A as a nutrient is well-established, and it is a shortfall nutrient (i.e. approaching less than the recommended intake). Heirloom and foreign carrot germplasm of colors that include purple, yellow, white, and red, have been bred for US production. These novel colors are not only striking in appearance, but the purple anthocyanins, yellow lutein, and red lycopene are natural “phytonutrient” compounds that are associated with reduced risk of atherosclerosis, cancer, and inflammation, and improve antioxidant status. Nutritious and flavorful vegetables and fruits are critical to counteract the national trend toward obesity. Consequently, carrots with novel colors serve as an untapped vegetable that can be promoted for their novelty and health benefits. Fortunately, carrot pigments are highly heritable and amenable to breeding efforts. Carotenoid content is reduced when the carrot crop is grown in excessive heat, cold, or drought. Consequently, changing climatic conditions of the type predicted may contribute to an increased likelihood that nutritional requirements may not be met.

 Surveys and ex post analyses of food flavor and preference are fairly standard in evaluating new foods, but no studies have been reported for carrot. QTL for flavor, which includes sweetness due to sugars, and harshness due to volatile terpenoids in fresh carrots have not been identified. While nutritional value is of interest for consumers, flavor is even more important in shaping consumer decisions. The US carrot germplasm collection has only minimally been screened for flavor and pigments.

**2.3.5 Accessibility (inability to gain access to needed plant genetic resources because of phytosanitary/quarantine issues, inadequate budgets, management capacities or legal and bureaucratic restrictions)**

Collection of *Daucus* and *Allium* germplasm is challenging due to their predominant occurrence in Central Asia, the Middle East, Turkey, and North Africa where political issues limit accessibility

**3. Status of plant genetic resources in the NPGS available for reducing genetic vulnerabilities (5 pp. maximum)**

**3.1 Germplasm collections and in situ reserves**

**3.1.1 Holdings**

 Currently there are 274 accessions of *A. sativum* from 40 countries and 37 accessions of *A. longicuspis* from 6 countries in the NPGS collection.

Five major carrot germplasm collections were noted in 2008, including in excess of 6000 accessions (Simon et al., 2008). The NPGS collection holdings are tallied below.

NPGS *Daucus* germplasm collection. The 27 species and 48 taxa (including subspecies and varieties) recognized by [GRIN](http://www.ars-grin.gov/npgs/aboutgrin.html), and numbers of germplasm holdings in the NPGS, countries where they have been reported, and references documenting these areas of collection.

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| --- | --- | --- |
| Taxon | Number of accessions in the US National Plant Germplasm System. Numbers in parentheses new since 2012 | Countries of occurrence |
| [*Daucus arcanus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453841) García-Martín & Silvestre | 0 (1) | Spain |
| [*Daucus aureus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13331) Desf. | 10 (16) | Spain (Canary Islands), Algeria, Egypt, Libya, Morocco, Tunisia, Cyprus, Israel, Lebanon, Syria, Italy |
| *Daucus bicolor* | (8) | Greece, Turkey |
| [*Daucus biseriatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?454004) Murb. | 0 | Algeria |
| [*Daucus carota*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?300172) L. (no infraspecific taxon designated) | 900 (904) | Widely naturalized |
| *Daucus carota* infraspecific hybrids | 14 | Tunisia, Spain, Turkey |
| [*Daucus carota* subsp. *capillifolius*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13336) Gilli | 1 (23) | Libya, Morocco |
| *Daucus carota var. atrorubens* | 2 | Egypt |
| [*Daucus carota* subsp. *azoricus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453969) Franco | 0 | Only cultivated |
| [*Daucus carota* var. *boissieri*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13338) Schweinf. | 2 (0) |  |
| [*Daucus carota* subsp. *cantabricus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453951) A. Pujadas | 0 (1) | Spain |
| [*Daucus carota* subsp. *carota*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13337) | 16 (108) | Widely naturalized |
| [*Daucus carota* subsp. *commutatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?419326) (Paol.) Thell. | 2  | Spain |
| [*Daucus carota* subsp. *drepanensis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102088) (Arcang.) Heywood | 3 | Widely in Mediterranean Region |
| [*Daucus carota* subsp. *fontanesii*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453954) Thell. | 4 (1) | Spain, Tunisia, Italy, France |
| [*Daucus carota* subsp. *gadecaei*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102089) (Rouy & E. G. Camus) Heywood | 1 | France |
| [*Daucus carota* subsp. *gummifer*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13339) (Syme) Hook. f. | 4 (12) | Morocco, Libya, UK, France, Portugal, Spain |
| [*Daucus carota* subsp. *halophilus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453843) (Brot.) A. Pujadas | 1 | Portugal |
| [*Daucus carota* subsp. *hispanicus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?419327) (Gouan) Thell. | 1 (6) | Algeria, France, Spain |
| [*Daucus carota* subsp. *major*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453976) (Vis.) Arcang. | 0 (4) | Italy |
| [*Daucus carota* subsp. *majoricus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453953) A. Pujadas | 0 (13) | Spain |
| [*Daucus carota* subsp. *maritimus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102090) (Lam.) Batt. | 17 (14) | Portugal, Algeria, Libya, Morocco, Tunisia, Turkey, Greece. Italy, (former) Yugoslavia, France, Portugal, Spain |
| [*Daucus carota* subsp. *maximus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102091) (Desf.) Ball | 16 (29) | Spain, Algeria, Morocco, Tunisia, Afghanistan, Cyprus, Iran, Israel, Jordan, Lebanon, Syria, Turkey, Pakistan, Greece, Italy, (former) Yugoslavia, France, Portugal, Spain |
| [*Daucus carota* subsp. *parviflorus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453967) (Desf.) Thell. | 0 | Algeria, Morocco |
| [*Daucus carota* subsp. *rupestris*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453971) (Guss.) Heywood | 0 | Italy, Malta |
| [*Daucus carota* subsp. *sativus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?446682) (Hoffm.) Arcang. | 2 (5) | Only cultivated |
| [*Daucus carota* var. *sativus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?50010) Hoffm. | 97 (100) | Widely cultivated |
| [*Daucus conchitae*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?454000) Greuter | 0 (18) | Greece |
| [*Daucus crinitus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13341) Desf. | 12 (28) | Algeria, Morocco, Tunisia, Portugal, Spain  |
| [*Daucus durieua*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13342) Lange | 2 (9) | Spain, Algeria, Libya, Morocco, Tunisia, Cyprus, Israel, Lebanon, Syria, Portugal, Spain |
| [*Daucus glochidiatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102093) (Labill.) Fisch. & C. A. Mey. | 1 | Australia, New Zealand |
| [*Daucus gracilis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?105725) Steinh. | 0 | Algeria |
| [*Daucus guttatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102094) Sm. | 18 (39) | Egypt, Libya, Cyprus, Iran, Iraq, Israel, Lebanon, Syria, Turkey, Albania, Bulgaria, Greece, Italy, Romania, (former) Yugoslavia |
| [*Daucus hochstetteri*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453991) A. Braun ex Drude | 0 | Eritrea, Ethiopia |
| [*Daucus involucratus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?415152) Sm. | 4 (3) | Cyprus, Turkey, Greece |
| [*Daucus jordanicus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13346) Post | 0 | Libya, Israel, Jordan |
| [*Daucus littoralis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?100777) Sm. | 2 (3) | Egypt, Libya, Cyprus, Iran, Israel, Jordan, Lebanon, Syria, Turkey |
| *Daucus mauritii* | (1) | Morocco |
| [*Daucus microscias*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453844) Bornm. & Gauba | 0 | Iran, Iraq |
| [*Daucus montanus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13349) Humb. & Bonpl. ex Schult. | 0 | Mexico, Costa Rica, El Salvador, Guatemala, Honduras, Venezuela, Bolivia, Colombia, Ecuador, Peru, Argentina, Chile |
| *Daucus minusculus* Pau | (2) | Spain |
| [*Daucus muricatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13351) (L.) L. | 9 (27) | Portugal, Algeria, Libya, Morocco, Tunisia, Italy, France, Portugal, Spain |
| *Daucus pumilus* (L.) Ball | (9) | Spain, Tunisia |
| [*Daucus pusillus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13355) Michx. | 8 (35) | Canada, United States, Mexico, Brazil, Argentina, Chile, Uruguay |
| [*Daucus reboudii*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453987) Coss. | 0 | Algeria, Tunisia |
| *Daucus rouyi* Spalik & Reduron | (1) | Tunisia |
| [*Daucus sahariensis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453979) Murb. | 0 (7) | Egypt |
| [*Daucus setifolius*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13356) Desf. | 0 (6) | Algeria, Morocco, Tunisia, Portugal, Spain |
| *Daucus setulosus* | 19 | Greece, Turkey |
| [*Daucus syrticus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453980) Murb. | 0 (10) | Egypt, Libya, Tunisia |
| [*Daucus tenuisectus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453996) Coss. ex Batt. | 0 (4) | Morocco |
| [*Daucus virgatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453984) (Poir.) Maire  | 0 | Algeria, Tunisia |
| [*Daucus* spp.](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?300173) (no designation as to taxon) | 70 (12) |  |
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| **New generic Daucus ingroups based on taxonomic expansion of Banasiak et al. (2016)** |  |  |
| *Daucus annuus* (Bég.) Wojew. & al. [≡ *Tornabenea annua* Bég.] | 0 | Cape Verde |
| *Daucus insularis* (Parl. ex Webb) Spalik & al. [≡ *Tornabenea insularis* (Parl. ex Webb) Parl.] | 0 | Cape Verde |
| *Daucus tenuissimus* (A.Chev.) Spalik & al. [≡ *Tornabenea tenuissima* (A.Chev.) A.Hansen & Sunding] | 0 | Cape Verde |
| *Daucus rouyi* Spalik & Reduron [≡ *Rouya polygama* (Desf.) Coincy] | 1 | Tunisia, Italy (Corsica) |
| *Daucus pumilus* (L.) Hoffmanns. & Link [≡ *Pseudorlaya pumila* (L.) Grande] | 5 | Portugal, Spain, Morocco, France, Italy, Greece, Israel |
| *Daucus minusculus* Pau ex Font Quer [≡ *Pseudorlaya minuscula* (Pau ex Font Quer) Laínz] | 2 | Portugal, Spain, Morocco |
| *Daucus mirabilis* (Maire & Pamp.) Reduron & al. [≡ *Pachyctenium mirabile* Maire & Pamp.] | 0 | Libya |
| *Daucus dellacellae* (E.A.Durand & Barratte) Spalik & al. [≡ *Athamanta dellacellae* E.A.Durand & Barratte] | 0 | Libya |
| *Daucus elegans* (Webb ex Bolle) Spalik & al. [≡ *Cryptotaenia elegans* Webb ex Bolle] | 0 | Canary Islands |
| *Daucus decipiens* (Schrad. & J.C.Wendl.) Spalik & al. [≡ *Melanoselinum decipiens* (Schrad. & J.C.Wendl.) Hoffm.] | 0 | Madeira |
| *Daucus edulis* (Lowe) Wojew. & al. (≡ *Monizia edulis* Lowe) | 0 | Madeira |

**References documenting the above distributions**

Ali, S. I. & S. M. H. Jafri, eds. 1976–. Flora of Libya.

Allan, H. H. B. et al. 1961–. Flora of New Zealand.

Angely, J. A. 1965. Flora analitica do Parana.

Black, J. M. 1943–1957. Flora of Southern Australia, ed. 2.

Burbidge, N. T. & M. Gray. 1970. Flora of the Australian Capital Territory.

Cabrera, A. L., ed. 1965–1970. Flora de la provincia de Buenos Aires.

Castroviejo, S. et al., eds. 1989–. Flora iberica: plantas vasculares de la Peninsula Iberica e Islas Baleares.

Chinese Academy of Sciences. 1959–. Flora reipublicae popularis sinicae.

Clapham, A. R. et al. 1962. Flora of the British Isles ed. 2.

Correa, M. N. 1969–. Flora patagonica.

Correll, D. S. & M. C. Johnston. 1970. Manual of the vascular plants of Texas.

Davis, P. H., ed. 1965–1988. Flora of Turkey and the east Aegean islands.

Davis, R. 1952. Flora of Idaho.

Encke, F. et al. 1984. Zander: Handwörterbuch der Pflanzennamen, 13. Auflage.

Foreman, D. B. & N. G. Walsh. 1993–. Flora of Victoria.

Gleason, H. A. & A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada.

Hansen, A. & P. Sunding. 1993. Flora of Macaronesia: checklist of vascular plants, ed. 4. Sommerfeltia vol. 17.

Harden, G. J., ed. 1990–1993. Flora of New South Wales.

Harling, G. & B. Sparre, eds. 1973–. Flora of Ecuador.

Harrington, H. 1954. Manual of the plants of Colorado.

Hedberg, I. & S. Edwards. 1990–. Flora of Ethiopia.

Hickman, J. C., ed. 1993. The Jepson manual: Higher plants of California.

Jahandiez, E. & R. Maire. 1931–1941. Catalogue des plantes du Maroc.

Jessop, J. P. & H. R. Toelken, eds. 1986. Flora of South Australia, ed. 4.

Komarov, V. L. et al., eds. 1934–1964. Flora SSSR.

Leung, A. Y. & S. Foster. 1996. Encyclopedia of common natural ingredients used in food, drugs, and cosmetics, ed. 2.

Macbride, J. F. et al., eds. 1936–1971. Flora of Peru.; new ser. 1980-

Mansfeld, R. 1959. Die Kulturpflanze, Beiheft 2. (Mansfeld)

Markle, G. M. et al., eds. 1998. Food and feed crops of the United States, ed. 2.

**3.1.2 Genetic coverage and gaps**

 There is a need to collect A. tricoccum (ramps) germplasm as the current representatives of this species is limited in the US the collection. There is a need to collect additional Allium sect. Cepa germplasm for the collection. There is only one accession of *A. roylei*. Collection of asexually propagated shallot is necessary. The garlic collection does not have any *A. longicuspis* accessions from Kyrgyzstan, Pakistan, Iran or Turkey. There are only 6 accessions from tropical origins. There are very few accessions of red or pigmented table beet and Swiss chard in the NPGS collection.

 Cultivated carrot: There is an urgent need to collect landrace carrots globally, since collecting expeditions in Uzbekistan, Syria, Turkey, Tunisia, Morocco, Portugal and Spain found very few landraces available, and in Uzbekistan, Tunisia and Turkey those landraces found were held by elderly farmers and not being grown by their younger family members. In Greece, no land races were identified, even with relatively extensive inquiry of local farmers.

*Collecting Priorities:* 1) Landraces from Central Asia are particularly useful since this is the domestication center of the crop and primitive cultivars have been reported. Landraces from Iran, Afghanistan, Pakistan, and India would be particularly interesting and useful.

2) In North Africa and the Middle East, carrot landraces from Algeria, Jordan, Israel, and Lebanon are valuable and have not been collected.

3) An expedition collected several landraces from western Turkey, but germplasm from central and eastern Turkey as well as Albania, Armenia, Moldova, Czech Republic, and Bulgaria are valuable to provide future carrot breeders with allelic diversity that may be lost as landraces become extinct.

4) There may be landraces in Italy and France as well as in Cyprus and other Mediterranean island nations; and also in South America.

 Wild carrot and other *Daucus*:

*Collecting Priorities:* 1) Concomitant with any collection of landraces in locales where landraces are collected, collections of wild carrot (all wild *D. carota* L. subspecies) are important.

2) Nine-chromosome *Daucus* germplasm from North Africa, especially Algeria and Libya, as well as from Jordan, Lebanon, and Israel, and from the Macronesian Islands of Cape Verde, The Azores, and the Canary Islands are important.

3) NPGS wild carrot holdings documented in 3.1.1 (above). The following taxa (areas of collections) hold less than five accessions: [*Daucus arcanus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453841) García-Martín & Silvestre (Spain), [*D. biseriatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?454004) Murb. (Algeria), *D. carota var. atrorubens* (Egypt), [*D. carota* subsp. *cantabricus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453951) A. Pujadas (Spain), [*D. carota* subsp. *commutatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?419326) (Paol.) Thell. (Spain), [*D. carota* subsp. *drepanensis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102088) (Arcang.) Heywood (Widely in Mediterranean Region), [*D. carota* subsp. *fontanesii*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453954) Thell. (Spain, Tunisia, Italy, France), [*D. carota* subsp. *gadecaei*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102089) (Rouy & E. G. Camus) Heywood (France), [*D. carota* subsp. *halophilus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453843) (Brot.) A. Pujadas (Portugal), [*D. carota* subsp. *major*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453976) (Vis.) Arcang. (Italy), [*D. carota* subsp. *parviflorus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453967) (Desf.) Thell. (Algeria, Morocco), [*D. carota* subsp. *rupestris*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453971) (Guss.) Heywood (Italy, Malta), [*D. glochidiatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?102093) (Labill.) Fisch. & C. A. Mey. (Australia, New Zealand), [*D. gracilis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?105725) Steinh. (Algeria), [*D. hochstetteri*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453991) A. Braun ex Drude (Eritrea, Ethiopia), [*D. involucratus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?415152) Sm. (Cyprus, Turkey, Greece), [*D. jordanicus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13346) Post (Libya, Israel, Jordan), [*D. littoralis*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?100777) Sm. (Egypt, Libya, Cyprus, Iran, Israel, Jordan, Lebanon, Syria, Turkey), *D. mauritii* (Morocco), [*D. microscias*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453844) Bornm. & Gauba (Iran, Iraq), [*D. montanus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?13349) Humb. & Bonpl. ex Schult.(Central and South America), [*D. reboudii*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453987) Coss. (Algeria, Tunisia), [*D. tenuisectus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453996) Coss. ex Batt. (Morocco), [*D. virgatus*](http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?453984) (Poir.) Maire (Algeria, Tunisia).

However, many of these varieties and subspecies of *D. carota* have been (and are continuing to be) the subject of recent taxonomic studies suggesting that many of them will be placed in synonymy:

* Spooner, D. M., M. P. Widrlechner, K. R. Reitsma, D. E. Palmquist, S. Rouz, Z. Ghrabi-Gammar, M. Neffati, B. Bouzbida, H. Ouabbou, M. El Koudrim, and P. W. Simon. 2014. Reassessment of practical subspecies identifications of the USDA Daucus carota germplasm collection: Morphological data. Crop Science 54: 706-718.
* Arbizu, C. I., S. L. Ellison; D. Senalik; P. W. Simon; and D. Spooner. 2016. Genotyping-by-sequencing provides the discriminating power to investigate the subspecies of Daucus carota (Apiaceae). BMC Evolutionary Biology 16:234.

Hence, those countries of highest priority of collections from a purely taxonomic standpoint are Algeria, Australia (and New Zealand), Eritrea, Ethiopia, Libya, Israel, Jordan, Iran, Iraq, and any of a number of countries in South America for *D. montanus*. In addition, the Azores, the Cape Verde Islands, and the Canary Islands are in need of collection for *Daucus* generic ingroups recently placed in the Daucus clade on the basis of molecular data.

**3.1.3 Acquisitions**

 There is a need to collect landraces of onion from developing countries before these landraces are replaced by commercial hybrids and are lost forever. There is a need to collect additional short-day onion germplasm. There is a need to collect additional open pollinated table beet and Swiss chard cultivars from Eastern Europe and Asia before these are replaced by hybrids or otherwise lost.

**3.1.4 Maintenance**

 There is a need to remove plant viruses and fungal contamination from garlic accessions within the collection. There is a need to remove redundant carrot and onion accessions from the collection. There is a need to remove onion accessions from the collection that have been identified as commercial hybrid cultivars.

 There are 185 accessions identified only to species in the *Allium* collection. These need to be grown and given full taxonomic identification. There has not been a systematic effort to identify red or pigmented table beet accessions in the collection, and there is also likely some redundancy among accessions.

* + 1. **Regeneration**

 There is a need to regenerate short-day onion accessions within the collection so that seed of more accessions is available for distribution. There is a need to regenerate wild Allium species accessions.

**3.1.6 Distributions and outreach**

**3.2 Associated information**

**3.2.1 Genebank and/or crop-specific web site(s)**

**3.2.2 Passport information**

**3.2.3 Genotypic characterization data**

Extensive phenotypic and genotypic characterization of cultivated carrots in the USDA germplasm collection is being initiated.

**3.2.4 Phenotypic evaluation data**

Onion accessions should be screened for resistance to Fusarium basal rot, onion thrips, Iris yellow spot virus, and bacterial diseases. More onion accessions should be evaluated for their daylength sensitivity. Table beet should be screened for reaction to both *Rhizoctonia* and *Cercospora.*

**3.3 Plant genetic resource research associated with the NPGS**

**3.3.1 Goals and emphases**

**3.3.2 Significant accomplishments**

**3.4 Curatorial, managerial and research capacities and tools**

**3.4.1 Staffing**

**3.4.2 Facilities and equipment**

**3.5 Fiscal and operational resources**

**4. Other genetic resource capacities (germplasm collections, in situ reserves, specialized genetic/genomic stocks, associated information, research and managerial capacities and tools, and industry/technical specialists/organizations) (2 pp. maximum)**

Warwick Crop Centre - Genetic Resource Unit: http://www2.warwick.ac.uk/fac/sci/lifesci/wcc/gru/

**5. Prospects and future developments (2 pp. maximum)**

**6. References**

Brewster, J.L., 2008. *Onions and other vegetable alliums* (No. 15). CABI.

Economic Research Service, USDA. (2016) Vegetable and Pulses Outlook. VGS-357.

Economic Research Service, USDA. (2016) Vegetable and Pulses Yearbook.

FAOSTAT (2017) http://www.fao.org/faostat/en/#data/QC accessed 2/22/17

GRIN-Global Taxonomy. https://npgsweb.ars-grin.gov/gringlobal/taxonomy . accessed 2/23/17

Iorizzo, M., D.A. Senalik, S.L. Ellison, D. Grzebelus, P.F. Cavagnaro, C. Allender, J. Brunet, D.M. Spooner, A. Van Deynze, P.W. Simon. Genetic structure and domestication of carrot (Daucus carota L. subsp. sativus L.) (Apiaceae). Amer. J. Bot. 100: 930–938. 2013.

Iorizzo, M., S. Ellison, D. Senalik, P. Zeng, P. Satapoomin, M. Bowman, M. Iovene, W. Sanseverino, P. Cavagnaro, M. Yildiz, A. Macko-Podgórni, E. Moranska, E. Grzebelus, D. Grzebelus, H. Ashrafi, Z. Zheng, S. Cheng, D. Spooner, A. Van Deynze, and P.W. Simon. A high-quality carrot genome assembly reveals new insights into carotenoid accumulation and Asterid genome evolution. Nature Genetics, 48:657-666. 2016.

Kamenetsky, R., Khassanov, F., Rabinowitch, H. D., Auger, J., & Kik, C. (2007). Garlic biodiversity and genetic resources. *Med Arom Plant Sci Biotechnol*, *1*(1), 1-5.

National Agricultural Statistics Service, USDA. (2017). Vegetables 2016 Summary.

Rubatzky, V.E., C.F. Quiros, and P.W. Simon. Carrots and related vegetable Umbelliferae. CABI Publishing. New York, NY. 294 pp. 1999.

Simon, P.W. Domestication, historical development, and modern breeding of carrot. Plant Breed. Rev. 19:157-190. 2000.

Simon, P.W., R. E. Freeman, J. V. Vieira, L. S. Boiteux, M. Briard, T. Nothnagel, B. Michalik, and Young-Seok Kwon. Carrot: In Handbook of Crop Breeding, Volume 1,Vegetable Breeding. Edited by: J. Prohens ,  M.J. Carena and F. Nuez. Springer-Verlag, GmBH, Heidelberg, Germany pp. 327-357. 2008.

Simon, P.W., L. M. Pollak, B. A. Clevidence, J.M. Holden, D.B. Haytowitz. Plant breeding for human nutrition. Plant Breeding Rev.31:325-392. 2009.

**7. Appendices (number and lengths at the CGC’s discretion)**