



**Nicotiana Germplasm Collection
Task Force**

**Long-Term Public Maintenance of
Nicotiana Germplasm**

Final Report

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1. Executive Summary

Nicotiana Germplasm Collection (NGPC) Task Force denotes the following key points on the ‘Long Term Public Maintenance of *Nicotiana* Germplasm’:

1. Genetic diversity within *Nicotiana tabacum* and related species has been crucial for improvements in tobacco cultivars to meet the needs (e.g. yields, chemistry, quality, economic, etc.) of all stakeholders (farmers, processors, manufacturers, etc.) in the tobacco industry.
2. Continued long-term public access to this genetic diversity is vital to the sustainability of the tobacco industry to meet current and future agronomic and regulatory concerns for conventional and next generation products.
3. The Task Force recommends the tobacco industry (1) contribute annually to a fund administered through CORESTA to support one or more *Nicotiana* germplasm collections OR (2) establish an endowment with North Carolina State University’s Agricultural Foundation that would perpetually maintain the current publicly available United States *Nicotiana* Collection in the U.S.
 - a. Approximately USD \$2.1 million would be required to fully fund an endowment.
 - b. This collection could absorb a reasonable number of unique accessions from other *Nicotiana* collections and place them in the public domain.
 - c. CORESTA would act as a conduit for member organizations, that cannot contribute directly, to contribute to this endowment.
4. The Task Force recommends the establishment of a new Task Force to assess allelic variability and genetic relationships amongst diverse materials maintained in various germplasm collections around the world.

2. Purpose and Scope of Proposed Work Item

Genetic diversity within *Nicotiana tabacum* and related species has been essential for historical improvements in tobacco cultivars during the last 100 years. Continued progress from tobacco breeding is based upon the existence, maintenance, and use of genetic diversity within the genus *Nicotiana*. Public availability of this genetic variability should be considered of extremely high importance to the tobacco industry as further improvements in tobacco production efficiency are needed, as well as possible future modifications of chemical profiles of the tobacco plant. Reduced support from public institutions and governments for tobacco related activities during the last 20 years has made it difficult to maintain publicly available tobacco germplasm collections, however. Study of potential systems for long-term support of public *Nicotiana* germplasm maintenance is likely in the best interest of the tobacco industry.

3. Introduction

Tobacco yield, disease resistance, and cured leaf quality affect the profitability, stability, and sustainability of tobacco cultivation and product manufacture. These factors are highly influenced by plant genetics, and use of diverse genetic variation has been applied to tobacco for approximately 90 years, leading to the development of dramatically improved tobacco varieties relative to those that were available in the 1930s. For example, yields of U.S. flue-cured tobacco have increased by approximately 1200 lbs per acre over the last 80 years. This translates directly into increased grower profitability and affects the affordability of cured leaf to manufacturers. Improved disease resistance allows for increased supply chain stability and sustainability of tobacco production (saving tens of millions of dollars per year to U.S. growers, alone). The utilization of TMV-resistance derived from *N. glutinosa* and black shank resistance derived from *N. tabacum* accession ‘Florida 301,’ alone, can likely be associated with avoidance of 100’s of millions of dollars of economic losses since 1950. Indeed, use of diverse germplasm has resulted in the sustainability of tobacco production in several important regions worldwide. Favorable genetics controlling plant chemistry permit for the production of high fractions of useable cured leaf. Maintenance and utilization of genetic diversity within the genus *Nicotiana* was responsible for all of these achievements. Genetic diversity is also **REQUIRED** for continued tobacco variety improvement, and for maintaining flexibility for developing future tobacco varieties with alternative chemical profiles that might be important for next generation tobacco products or for compliance with potential regulations. Future modification **IS NOT** possible without strategic use of genetic diversity within the genus *Nicotiana*.

Genetic diversity needed for further tobacco variety development is maintained in *Nicotiana* germplasm collections, some curated by public agencies and some maintained by private companies. For example, the United States *Nicotiana* Germplasm Collection maintains ~2,100 accessions of *N. tabacum* and 223 accessions of 59 wild *Nicotiana* relatives. Approximately 1200 of the *N. tabacum* accessions were collected in Central and South America by plant explorers prior to 1938. If lost, the vast majority of these materials could not be ‘re-discovered’ in these regions due to historical changes in agricultural landscapes (both physical and economic). From 2014 to 2019, the U.S. collection distributed an average of 1545 seed packets per year. Seed requests of reasonable amounts (usually ~1000 seeds) are distributed free of charge worldwide, without the requirement to sign a Material Transfer Agreement or related legal documentation. Although there is no financial support for this collection provided by the Federal government, the U.S. collection does have the advantage of being linked with the National Plant Germplasm System and the Genetic Resources Information Network (GRIN) which provides an accessible website and database. In addition, this relationship facilitates legal shipping of seeds worldwide with appropriate phytosanitary certification. The U.S. collection is backed up locally and at a long-term facility in Fort Collins, Colorado.

Many private companies also maintain their own internal germplasm collections. However, the depth, volume, and relative amount of genetic diversity preserved within these collections is generally not publicly known. These collections bear internal financial costs through physical infrastructure requirements, required personnel, retention of know-how, and long-term commitment. Genetic materials from private collections are less likely to be made available to outside organizations, and their maintenance is susceptible to change due to shifting short-term business objectives. On the other hand, public *Nicotiana* germplasm collections are on an

unstable financial footing because of negative attitudes regarding expenditure of taxpayer dollars on tobacco-related research activities. In addition, tobacco manufacturer/dealer consolidation, lack of priority for long-term research activities, and shifting attitudes regarding support of public-sector tobacco-related research places the future of public collections in a precarious and perhaps unsustainable situation.

The CORESTA Task Force on Long-Term Public Maintenance of *Nicotiana* Germplasm was established for the purpose of investigating options for potential support of public *Nicotiana* germplasm maintenance.

4. Meetings and Outcomes

The Task Force had an introductory meeting via Microsoft Teams on May 12, 2021 with a large number of participants (21) representing most sectors of the tobacco industry in attendance. A preliminary discussion regarding the importance of diverse *Nicotiana* germplasm was held along with brief conversation on the status of various collections around the world. This discussion resulted in e-mail based polling of Task Force participants with respect to three questions relevant to the issue of long-term public maintenance of *Nicotiana* germplasm:

1. Where are publicly available, non-privately-owned, *Nicotiana* germplasm collections located and what are the volumes of their holdings? Do they make these materials readily available worldwide?
2. Does the CORESTA Task Force believe that public collections are important, and worthy of further discussion regarding strategies for long-term financial support?
3. What are some ideas regarding potential strategies for tobacco industry partnership in such activities? In the last meeting, several possibilities were briefly mentioned. These included the use of CORESTA as a conduit to (1) collect annual financial support from interested companies, or (2) collect industry contributions to be deposited in a Foundation account whereby annual support would be generated via interest. A tiered system of partnership could be used, based upon company size, and facilitated by CORESTA.

Responses from Task Force members are provided in *Appendix I*, at the end of this report.

On July 12, 2021, the Task Force held a second meeting via Microsoft Teams and discussed participant responses to the e-mail based survey questions with relevance to drafting a report containing specific recommendation(s)/options to the Scientific Commission regarding long-term maintenance of public *Nicotiana* germplasm.

5. Task Force Recommendations

The Task Force identified several publicly-available, non-privately owned *Nicotiana* germplasm collections that are maintained throughout the world. The most significant are (1) the United States *Nicotiana* Germplasm Collections maintained by N.C. State University, and (2) two collections maintained in Germany by NiCoTa and IPK Gaterslaben. Of all collections reported by the Task Force, the U.S. collection contains the greatest volume of materials and very likely contains the greatest amount of unique allelic variability (particularly amongst

~1200 Tobacco Introductions collected from Central and South America prior to 1938). All survey respondents indicated that establishing a system of financial support for one or more publicly-available *Nicotiana* germplasm collections would be in the best interest of the tobacco industry, as a whole.

Given the cost of maintaining multiple private and public collections around the world, and potential instability of these essential resources, several Task Force members supported the suggestion of a system of organized financial support for the U.S. collection (See Appendix I).

This industry/University partnership would benefit the tobacco industry by:

- 1) gained confidence that an invaluable public genetic resource for the future of the tobacco industry will be preserved for future needed tobacco varietal modifications.
- 2) providing opportunity for private companies to reduce operating costs by donating a reasonable number of accessions (non-duplicate) to the U.S. collection for maintenance and distribution (as needed).

The KTRDC (University of Kentucky) has already indicated a willingness to support the collection maintained by N.C. State University and transfer their materials (non-duplicates) to this collection.

There was support amongst Task Force members to either (1) contribute annually to a fund administered through CORESTA to support one or more *Nicotiana* germplasm collections OR (2) suggest to CORESTA that it serve as a facilitator to organize the financing of an endowment to generate annual support of the United States *Nicotiana* Collection. CORESTA is encouraged to invite monetary contributions from tobacco manufacturers and leaf dealers for the purpose of ultimately creating a ~\$2,100,000 endowment with the Agricultural Foundation affiliated with N.C. State University. Once established, ~\$63,000 per year could be generated to maintain the U.S. collection into perpetuity. The annual budget would be used to support the salary and benefits of a curator who would carry out seed increases and maintain inventories, collect data, maintain the website, and distribute seed requests. A small amount of money (~\$1,000 per year) would be needed for materials and supplies. Industry contributions could be calculated based upon company size according established CORESTA schedules, and could be made in single payments or paid over time.

As part of this potential arrangement, N.C. State would:

- 1) Agree to maintain the United States *Nicotiana* Collection into perpetuity as a resource to the international tobacco community.
- 2) Provide seed at no cost at the request of CORESTA participants, pursuant to laws regulating seed availability to requesting countries (i.e., there are currently laws/regulations prohibiting shipment of seed to Iran). Due to its affiliation with the National Plant Germplasm System (NPGS), the U.S. collection can leverage an existing USDA system for shipping seed with phytosanitary documentation to international recipients. The collection could consider charging for seed requests from non-CORESTA members, although this would not be expected to generate significant revenue.
- 3) Maintain and enhance the United States *Nicotiana* Germplasm with continued addition of accession images and phenotypic descriptions.

- 4) Maintain primary seed inventory, as well as local backup (in Raleigh area) and permanent backup at the USDA facility in Ft. Collins, Colorado.
- 5) Agree to absorb a reasonable number of accessions (that are not duplicates) from contributing CORESTA members for the purpose of reducing their own internal maintenance costs. The U.S. Collection would not want to be increased to a size of greater than 4,500 accessions, however.

An additional recommendation of the current Task Force was to establish a second Task Force to assess allelic variability and genetic relationships amongst diverse materials maintained in various germplasm collections around the world. Inventories of the large collections would be studied to determine overlap, and strategically selected accessions would be genotyped via industry collaboration to determine genetic variability and genetic relationships amongst these materials. Derived information would be useful for more strategic use of diverse tobacco materials for tobacco improvement, possible future genetic research studies, and more efficient curation of *Nicotiana* germplasm, such as removal of duplicates.

Appendix I – Summary of Survey Comments

Question #1: Where are publicly available, non-privately-owned, *Nicotiana* germplasm collections located and what are the volumes of their holdings? Do they make these materials readily available worldwide?

1) I am not aware of any *Nicotiana* germplasm banks that are publicly available & non-privately owned. Like many people, I know of a lab or two with a few species on hand at any given time, but nothing that I would consider a germplasm collection.

2) No, I am not aware of other public collections. I know of some private collections that may share material, but these are not what I would consider open access collections.

3) In Japan, there are no public *Nicotiana* germplasm collections. We have only privately-owned collections.

4) In Switzerland, no public *Nicotiana* germplasm collections exist.

5) Tirtash Research and Education Center (Iran) has a limited gene bank, which includes ~150 flue-cured genotypes, ~60 air-cured genotypes, ~70 oriental and semi-oriental genotypes. Due to financial restrictions, we are not able to send seeds to other countries.

6) For Malawi, the role to maintain and conserve *Nicotiana* germplasm is vested in the Ministry of Agriculture which also houses the National Plant Genetic Resources Centre. Realizing that tobacco is an important crop not only to the economic development of the country but also to sustainability of livelihoods of the Malawi population, publicly available, non-privately owned *Nicotiana* germplasm is maintained at ARET on delegated duty by the Ministry. The Trust undertakes the duties as an institution that is mandated by the Government to conduct research, extension and training in support of the tobacco industry in Malawi. ARET's holdings are about 650 in variable quantities of at least 5-10 gm each depending on need in local breeding efforts. The germplasm is specially regulated because the crop is considered as a special crop under Malawi's legal set up.

7) The situation of the *Nicotiana* collection in Germany is as follows: the owner of one collection is the Federal State of Baden Württemberg but NiCoTa is maintaining and describing this collection. NiCoTa is also allowed to distribute seeds worldwide and we do so for small fees or for free (depending on the quantities and the asking institutions/persons). In total we have 893 introductions (see attached file). You can find all introductions at our website (http://nicota.de/en/index_f.html). A second collection in Germany is maintained by IPK Gatersleben (see the following link: <https://gbis.ipk-gatersleben.de/gbis2i/faces/index.jsf>).

8) The United States *Nicotiana* Germplasm Collection maintains ~2,100 accessions of *N. tabacum* and 223 accessions of 59 wild *Nicotiana* relatives. Approximately 1000 of the *N. tabacum* accessions were collected in Central and South America by plant explorers in the 1930s. Seed requests of reasonable size are distributed free of charge worldwide, without the requirement to sign a Material Transfer Agreement or related legal documentation. Although there is no financial support for this collection provided by the Federal Government, the U.S. collection does have the advantage of being linked with the National Plant Germplasm System and the Genetic Resources Information Network (GRIN) which provides an accessible website and database. In addition, this relationship facilitates legal shipping of seeds worldwide with appropriate phytosanitary certification. The U.S. collection is backed up locally and at a long-term facility in Fort Collins, Colorado.

9) The collection housed in the KTRDC farm headhouse holds ~760 *Nicotiana* accessions. These include nearly all the species, with the notable exception of *N. tomentosiformis*. This number also includes multiple lots of the same accession that are mostly duplicates after rejuvenation and that were often done in the greenhouse, so probably a limited number of plants. Many of these refer to receiving them from Verne Sisson, so this must be from the USDA collection, but there are quite a few that were collected from New Mexico and Arizona by UK staff members. Then there is an assortment of varieties that have been used for some work over the years. Also, with few exceptions, no rejuvenations have been done here since 2002. It is not often that we are asked for any seed, but then it is not widely known that we have this seed bank.

Question #2: Does the CORESTA Task Force believe that public collections are important, and worthy of further discussion regarding strategies for long-term financial support?

- 1) Yes
- 2) I agree with this statement
- 3) I disagree with this statement
- 4) Yes, I think having an open access or public germplasm tobacco collection is strategic and critical for the long-term future of tobacco production.
- 5) No question about the value of maintaining the public collections.
- 6) We believe that public collections are important for scientific research in general. However, for business side, we cannot answer yes or no because the value or future benefit of collection is unpredictable with current information (whole USDA collection and maintenance/funding cost).
- 7) YES, as a member of CORESTA, ARET considers and believes that public collections are important. The belief is based on the fact that tobacco is globally traded, its production environments are variably prone to climate change and other types of external shocks, and that consumer demands are dynamic, which renders genetic variability as an important element for sustaining the industry and economies and livelihoods that depend on the commodity. The use of male sterility in variety development as a strategy for ensuring seed integrity, traceability and variety protection certainly eventually reduces genetic variability that otherwise used to emerge from natural outcrossing of diverse *Nicotiana* populations. The subject of Long-term Maintenance of Public *Nicotiana* Germplasm therefore deserves further discussion regarding strategies for long-term financial support. However, the strategies must incorporate mechanisms for free worldwide access by all to cater for those nations or economies that depend on the commodity, but are themselves economically vulnerable and less capable of ensuring long-term storage of their own genetic endowment.
- 8) We believe that it is one of the missions of the tobacco industry to preserve the genetic heritage of the *Nicotiana* genus which is an important part of the world heritage. The CORESTA must work as a facilitator and encourage initiatives in that way. Our taskforce must be able to explore all the opportunities in order to support the existing collections, enrich and secure them.

Question #3: What are some ideas regarding potential strategies for tobacco industry partnership in such activities? In our last meeting, several possibilities were briefly mentioned. These included the use of CORESTA as a conduit to (1) collect annual financial support from interested companies, or (2) collect industry contributions to be deposited in a Foundation account whereby annual support would be generated via interest. A tiered system of partnership could be used, based upon company size, and facilitated by CORESTA.

- 1) Option 2 seems to be better and you know my position relate to the tiered system.
- 2) I would like to have a permanent endowment, that once total funded, would provide revenue to maintain this collection forever. Companies could contribute directly, or through CORESTA, to this account.
- 3) I support rather option 2.
- 4) This is tough to answer. My sense is that we are here because the various tobacco companies have decreased or ceased funding the USA Universities with tobacco research programs, including the *Nicotiana* germplasm collection that you curate. So now we come back to CORESTA asking tobacco companies to support the germplasm bank. It may be a hard sell. I plan to do what I can, but I do not sense much appetite from my management. It will help to have the recommendation from this Task Force and more structure around the cost. We should also consider a user fee for requests (tiered for lower cost for nonprofits and higher cost for profits). Another idea is getting some financial support from CORESTA membership fees (some \$ amount from the membership fees go to fund the germplasm bank).
- 5) Considering the highly regulated nature of tobacco and its products, the structured corporate nature of companies that survive on the commodity, and the variable sizes of company operations, ARET suggest option (2) where CORESTA would collect industry contributions to be deposited in a Foundation account whereby annual support would be generated via interest.
- 6) We agree that the foundation approach would be the most sustainable, if this could be achieved. KTRDC would probably be able to make a small contribution to this foundation. We would rather help to support your collection knowing that we have access to that material than use ever-dwindling resources to maintain our parallel and less extensive collection. Along these lines, if UK (i.e. KTRDC) could somehow alleviate the burden of this on you/NCSU, as in one of the following suggestions, then it makes sense to transfer any accessions in our collection that are not yet in yours and essentially scrap the one here.
 - a. Without any detailed know how of the rejuvenation protocol, could the number of accessions requiring rejuvenation annually be based on germ tests? These tests could be farmed out through other US institutions (*viz.* universities).
 - b. Another offer we can make if it is of any value to you but which does not talk to the main issue:
 - KTRDC can keep a duplicate of your collection for storage purposes only, i.e. expressly without the purpose of distribution.
- 7) An exchange network between collections could be considered in order to ensure a better safety. On the other hand, a database of the location of the different varieties could be created. Phenotypic, genetic and chemical information could be associated. In order to ensure the funding of the collections, a contribution from users can't be excluded in addition to the proposals already mentioned.