

Nicotiana hybridization map – „blank spots” yet to be filled

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The sphere of this presentation: 80/81[†] reported species of the genus Nicotiana

Section *Rusticae*

Nicotiana rustica

Section *Undulatae*

Nicotiana arentsii
Nicotiana glutinosa
Nicotiana thyrsoflora
Nicotiana undulata
Nicotiana wigandioides

Section *Petunioides*

Nicotiana acuminata
Nicotiana attenuata
Nicotiana corymbosa
Nicotiana linearis
Nicotiana longibracteata
Nicotiana miersii
Nicotiana pauciflora
Nicotiana spegazzinii

Section *Noctiflorae*

Nicotiana acaulis
Nicotiana ameghinoi
Nicotiana glauca
Nicotiana noctiflora
*Nicotiana paa**
Nicotiana petunioides

Section *Nicotiana*

Nicotiana tabacum

Section *Tomentosae*

Nicotiana kawakamii
Nicotiana otophora
Nicotiana setchellii
Nicotiana tomentosa
Nicotiana tomentosiformis

Section *Paniculatae*

Nicotiana benavidesii
Nicotiana cordifolia
Nicotiana cutleri
Nicotiana knightiana
Nicotiana paniculata
Nicotiana raimondii
Nicotiana solanifolia

Section *Repandae*

Nicotiana nesophila
Nicotiana nudicaulis
Nicotiana repanda
Nicotiana stocktonii

Section *Sylvestres*

Nicotiana sylvestris

Section *alatae*

Nicotiana alata
Nicotiana bonariensis
Nicotiana forgetiana
Nicotiana langsdorffii
Nicotiana longiflora
Nicotiana mutabilis
Nicotiana plumbaginifolia
*N. x sanderiae***
*N. rastronensis**

Section *Trigonophyllae*

Nicotiana obtusifolia
Nicotiana palmeri

Section *Polydiciae*

Nicotiana clevelandii
Nicotiana quadrivalvis

Section *Suaveolentes*

Nicotiana africana
Nicotiana amplexicaulis
Nicotiana benthamiana
Nicotiana burbridgeae
Nicotiana cavicola
Nicotiana debneyi
*N. eastii**
Nicotiana excelsior
Nicotiana exigua
Nicotiana fragrans
Nicotiana goodspeedii
Nicotiana gossei
Nicotiana hesperis
Nicotiana heterantha
Nicotiana ingulba
Nicotiana maritima
Nicotiana megalosiphon
Nicotiana occidentalis
Nicotiana rosulata
Nicotiana rotundifolia
Nicotiana simulans
*Nicotiana stenocarpa**
Nicotiana suaveolens
Nicotiana truncata
Nicotiana umbratica
Nicotiana velutina
Nicotiana wuttkei
*Nicotiana sp. „Corunna” (?)**
*Nicotiana fatuhivensis**
*Nicotiana monoschizocarpa**

[†]not including/including cultivated tobacco *N. tabacum*

* putative, doubtful or presently non-recognized species

**An interspecific hybrid:
a plant resulting from uniting genomes of two different species**

In this genus genetic blocks to hybridization have evolved less rapidly than have gene and chromosome alterations” T. H. Goodspeed „The Genus Nicotiana”



The above statement plus the size of the genus account for wealth of interspecific combinations obtained and recorded over many decades: the current estimate puts them above 300. Actually, there may be more of them

What interspecific hybrids between *Nicotiana* species are made for?

1. For purely academic interest: e.g. to study mutual phylogenetic relationships among species within the genus

2. For more practice-oriented interests

- To transfer useful genes from a wild species to cultivated tobacco: resistances to various diseases
- **To use the cytoplasmic genome of a wild species as a source of male sterile cytoplasm (CMS) for the production of hybrid cultivars**
- And some more

How can an interspecific hybrid be arrived at?

a) the conventional (most natural) approach:
by pollinating the stigma of one species with pollen of
another species

b) the laboratory approach:
by fusing isolated protoplasts of one species with those of another
– somatic hybrid is the result

c) the recently discovered approach:
by grafting the scion of one species on the stock of another species:
as of now only one hybrid (allopolyploid of ***Nicotiana tabacum*** and
N. glauca) was produced in this way (Fuentes et al. (2014) Nature 511: 232-
235)

The objective of this literature-based study was to find out if

all *Nicotiana* species have a record of being hybridized to another
sister *Nicotiana*

If not:

Which *Nicotiana* species were not hybridized
with *N. tabacum* – the cultivated species?

Which *Nicotiana* species were not hybridized
with any other ?

**Available publications were searched
for items containing references to interspecific hybrid/s
involving any of 80 known or putative *Nicotiana* species**

Concerning:

both sexual and parasexual (somatic) unions, symmetric and asymmetric

reports on transgenic transfers, if any, were excluded

**Available publications were searched
for items containing references to interspecific hybrid/s
involving any of 80 known or putative Nicotianas species**

Covering:

detailed descriptions to brief mentions, both explicit and implicit:

e.g. reference to cms undulata was treated as hybrid undulata x tabacum since it implied the existence of such a hybrid, reference to resistance in N. tabacum transferred from N. gossei implies the existence of the hybrid of N. gossei with N. tabacum etc.);

**Publications were searched
for items containing references to interspecific hybrid/s
involving any of 80 known or putative Nicotianas species**

Found in:

scientific papers, conference and meeting proceedings, books and monographs, in-house reports etc.

Found over ther period:

from the very beginning (19th century) to date (2015)

Acquisition, processing and storing of data

Data collecting systems:

- Popular on-line scientific databases and search engines: CORESTA, AGRIS, Jstor, Scielo, Scopus, Google Scholar, ScienceDirect ; SpringerLink, Wiley, Elsevier, Oxford Journals etc.)
- Conventional perusal of printed copies: tracking information through the text body and through lists of references

Data storing and retrieval system: Microsoft Access

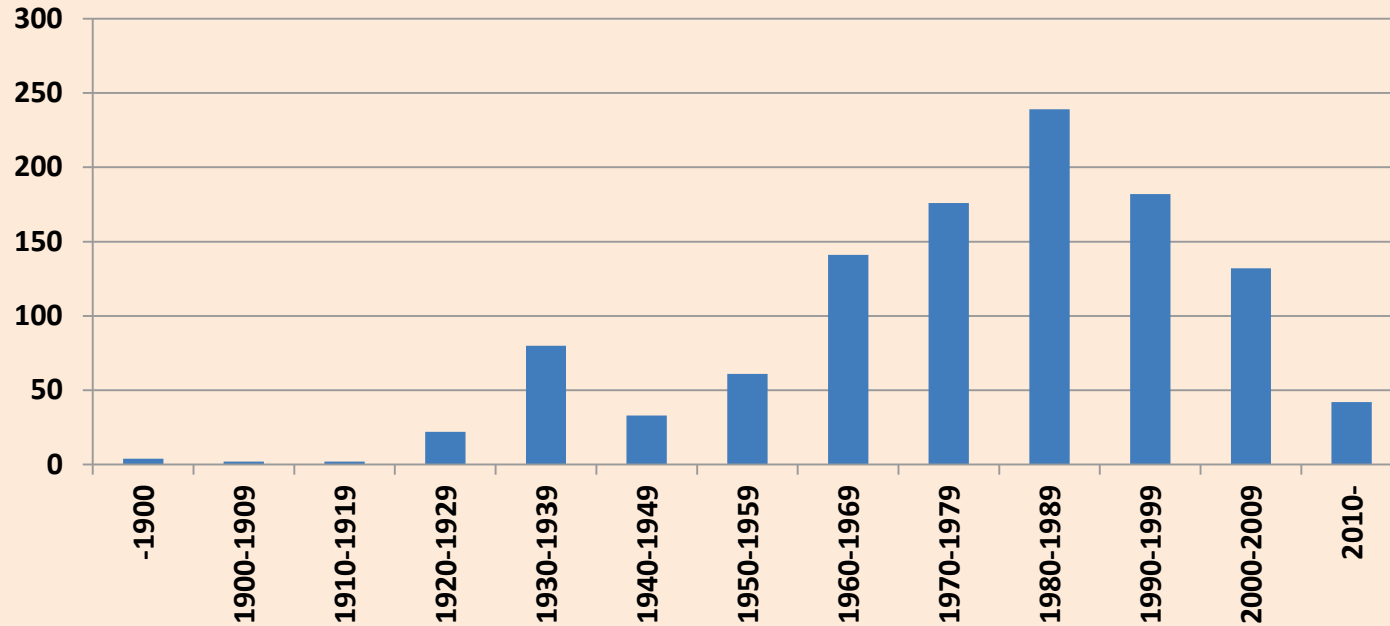
- Each record in the Access database represented one publication
- One record could contain information on one or more hybrids

OUTCOME

Ca. 1170 publication items containing reference/s to interpecific hybrids of *Nicotiana* were identified

When were they published?

Number of records found (papers, books, reports etc.) which contain reference/s to interspecific hybrids in *Nicotiana* over decades



**Top of the list:
species cited most frequently as coming into an interspecific hybrid**

with any Nicotiana

with *N. tabacum*

Species	Section	Number of reports	Species	Section	Number of reports
<i>N. debneyi</i>	Suaveolentes	176	<i>N. debneyi</i>	Suaveolentes	147
<i>N. glauca</i>	Noctiflorae	170	<i>N. rustica</i>	Rusticae	113
<i>N. glutinosa</i>	Undulatae	166	<i>N. glutinosa</i>	Undulatae	100
<i>N. rustica</i>	Rusticae	158	<i>N. glauca</i>	Noctiflorae	95
<i>N. sylvestris</i>	Sylvestres	130	<i>N. plumbaginifolia</i>	Alatae	88
<i>N. plumbaginifolia</i>	Alatae	122	<i>N. sylvestris</i>	Sylvestres	73
<i>N. suaveolens</i>	Suaveolentes	106	<i>N. suaveolens</i>	Suaveolentes	72

Downside: species with low or no hybridization record

Species which were not hybridized with *N. tabacum* but came into hybrids with some other species:

Total: 10 species

Species which had no hybridization record (with *N. tabacum* or any other species)

Total: 13 species

Species with no record of hybridization with *N. tabacum* but hybridized with some other *Nicotianae*

No.	Species	Hybrids recorded with:	Possible reasons for low hybridization record	Potential usefulness/unique trait
1	<i>N. attenuata</i> Section: Petunioides	<i>N. glauca, N. miersii, N. paniculata, N. rustica</i>	hybridization barrier?	resistance to herbivores?
2.	<i>N. miersii</i> Section: Petunioides	<i>N. attenuata, clevelandii, megalosiphon, langsdorfii, paniculata, petunioides, quadrivalvis, suaveolens</i>	Serious hybridization barrier	Resistance to <i>Globodera</i> (cyst nematodes)
3.	<i>N. corymbosa</i> Section: Petunioides	<i>N. acuminata, linearis, petunioides</i>	No useful genetic traits identified?	Unknown
4	<i>N. linearis</i> Section: Petunioides	<i>N. corymbosa</i>	No useful genetic traits identified?	Unknown

Species with no record of hybridization with *N. tabacum* but hybridized with some other *Nicotianae*



N. attenuata

Source: www.planlust.com
by S. Shebs



N. miersii

Source: Author's



N. linearis

Source: Knapp S. 2013. Nat.Hist. Museum
NaturePLus. Seeking nightshades in South
America (blog) www.nhm.ac.uk



N. corymbosa

Source: www.chileflora.com

Species with no record of hybridization with *N. tabacum* but hybridized with other *Nicotianae* (continued)

No.	Species	Hybrids recorded with:	Possible reasons for low hybridization record	Potential usefulness/unique trait
5.	<i>N. petunioides</i> Section: Noctiflorae	<i>N. corymbosa</i> , <i>noctiflora</i> , <i>miersii</i>	No useful genetic traits identified; hybridization barrier	Unknown
6.	<i>N. mutabilis</i> Section: Alatae	members of the section Alatae except <i>N. longiflora</i> and <i>N. plumbaginifolia</i>	Newly discovered species	Possible resistance to TSWV? Ornamental
7.	<i>N. rastroensis</i>* Section: Alatae	Other members of the section Alatae except <i>N. longiflora</i> and <i>N. plumbaginifolia</i>	Restricted availability for study; Newly discovered species	Unknown Several descriptions and studies available

*species with not established taxonomic status

Species with no record of hybridization with *N. tabacum* but hybridized with other *Nicotianae* (continued)



N. petunioides

Source: www.boldsystems.org



N. mutabilis

Source: Anne's Annuals&Perennials
www.annesannuals.com

Species with no record of hybridization with *N. tabacum* but hybridized with other *Nicotianae* (continued)

No.	Species	Hybrids recorded with:	Possible reasons for low hybridization record	Potential usefulness/ unique trait
8	<i>N. wigandioides</i> Section: Undulatae	<i>N. undulata</i> , <i>N. glutinosa</i>	Seed accessions may be difficult to maintain (poor seed set) Hybridization barrier?	Resistance to <i>Alternaria alternata</i> , resistance to <i>Chalara elegans</i> Potential ornamental
9	<i>N. thyrsiflora</i> Section: Undulatae	<i>N. glauca</i>	Difficult to bring to flower, strong hybridization barrier ?	Resistance to frencing
10	<i>N. cordifolia</i> Section: Paniculatae	<i>N. raimondii</i> , <i>N. knightiana</i>	Difficult to explain (lack of interest?)	Resistance to <i>Globodera</i> (cyst nematodes)

Species with no record of hybridization with *N. tabacum* but hybridized with other *Nicotianae* (continued)



N. wigandioides

Source: www.nybg.org



N. cordifolia

Source: www.flickr.com

Species with no record of hybridization with other *Nicotianae*

No.	Species	Possible reasons for no hybridization record	Potential usefulness/unique trait
1	<i>N. longibracteata</i> Section: Petunioides	Not available for study	Consistently included in classifications of <i>Nicotiana</i> , but missing from any other studies.
2	<i>N. spegazzinii</i> Section: Petunioides	Strong hybridization barrier? Lack of interest?	Unknown. Studied for some chemical constituents
3.	<i>N. acaulis</i> Section: Noctiflorae	Difficult to bring to flower. Strong hybridization barrier ? Lack of interest?	Resistance to frenching, Species propagates vegetatively by runners
4.	<i>N. paa</i>* Section: Noctiflorae	Not available for study. Relatively newly discovered species, Lack of interest?	Unknown, only discoverer's description and an ethnobotanical study exist

*species with not established taxonomic status

Species with no record of hybridization with other *Nicotianae*



N. longibracteata

This foto taken in the Andes supports
its real existence

Source: www.floradechile.cl

N. spegazzinii

Source: Knapp S. 2013. Nat.Hist.
Museum NaturePLUS. Seeking
nightshades in South America
(blog) www.nhm.ac.uk



N. acaulis, probably the most singular-looking *Nicotiana*

Source: www.alpinegardensociety.net

Species with no record of hybridization with other *Nicotianae* (continued)

No.	Species	Possible reasons for no hybridization record	Potential usefulness/unique trait
5.	<i>N. ameghinoi</i> * Section: Noctiflorae	Not available for study	Unknown
6.	<i>N. cutleri</i> Section: Paniculatae	Not available for study Relatively newly discovered species	Unknown
7.	<i>N. burbridgeae</i> Section: Suaveolentes	Not available for study Relatively newly discovered species. Lack of interest?	Unknown Only discoverer's description exists
8.	<i>N. heterantha</i> Section: Suaveolentes	Restricted availability for study Newly discovered species	Unknown, only discoverer's description and phylogenetical studies exist

***until recently known only as a herbarium specimen. Rediscovered in a natural site in Patagonia and collected in 2013 by Dr. Sandra Knapp**

Species with no record of hybridization with other *Nicotianae* (continued)



N. ameghinoi (by S. Knapp)

Source: Knapp S. 2013. Nat.Hist. Museum
NaturePLus. Seeking nightshades in South
America (blog) www.nhm.ac.uk



N. burbridgeae

Source: www.seedbank.com.au



N. heterantha

Source: www.florabase.dpaw.wa.gov.au

Species with no record of hybridization with other *Nicotianae* (continued)

9.	<i>N. stenocarpa</i>* Section: Suaveolentes	Not available for study; lack of interest; strong hybridization barrier?	unknown
10.	<i>N. truncata</i> Section: Suaveolentes	Not available for study Newly discovered species	unknown
11.	<i>N. sp. "Corunna"</i>** Section Suaveolentes?	Restricted availability for study. Newly discovered putative species.	Possible tolerance of CMV

***species with contested status of a separate species (regarded by C. Marks as synonymic with *N. rosulata*)**

****species with unestablished taxonomic status.**

Species with no record of hybridization with other *Nicotianae* (continued)



N. truncata

Source: www.seedbank.com.au



N. sp. "Corunna"

Source: www.seedbank.com.au

Species with no record of hybridization with other *Nicotianae* (continued)

No.	Species	Possible reasons for no hybridization record	Potential usefulness/unique trait
12	<i>N. fatuhivensis</i> Section: Suaveolents	Not available for study;	Unknown
13.	<i>N. monoschizocarpa</i> Section: Suaveolentes	Not available for study	unknown

***absent from the recent *Nicotiana* classifications, but assigned the status of species in a recent study of the section by Australian investigators in 2011**

Concluding remarks

For 23 out of 80 species or putative species of *Nicotiana* no indication was found, explicit or implicit, that they were ever used to produce an interspecific hybrid with cultivated tobacco, *Nicotiana tabacum*.

For 13 of these species no evidence was found to be hybridized with any *Nicotiana* species.

The probable reasons for those „blank spots”

- **unavailability of the species for study**
- **hybridization barriers**
- **lack of incentive to make the hybrid**

Concluding remarks (continued):

A good practical reason to try and fill in those gaps: search for novel cms combinations:

- **around 30 known alloplasmic combinations include a few which are used in hybrid cultivars and hybrid seed production.**
- **The ideal combination uniting unimpaired agronomic performance with easy and efficient seed production is still to be found**

4. Last but not least: get to know what is yet unknown and create what has not yet been created.



Thank you!