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Walker

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(54) **NEMATODE RESISTANT GRAPE PLANT ROOTSTOCK '9407-14'**

(50) Latin Name: **'L6-1'***Vitis champinii* **'Ramsey'**×*V. riparia* **'Riparia Gloire')**×*V. champinii* **'c9021'**
Varietal Denomination: **9407-14**

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(21) Appl. No.: **12/009,063**

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(51) **Int. Cl.**
A01H 5/00 (2006.01)

(52) **U.S. Cl.** **Plt./205**

(58) **Field of Classification Search** Plt./205, Plt./206
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

PP19,981	P2 *	5/2009	Walker et al.	Plt./205
PP20,051	P2 *	6/2009	Walker	Plt./205
PP21,358	P3 *	10/2010	Walker	Plt./205

* cited by examiner

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(57) **ABSTRACT**

Rootstock '9407-14' originated as a single plant from a cross of 'L6-1' (*Vitis champinii* 'Ramsey'×*V. riparia* 'Riparia Gloire')×*V. champinii* 'c9021'. This invention relates to a new and distinct variety of grape rootstock with resistance to a broad array of soil-borne nematodes including root-knot, dagger, lesion and citrus nematodes. The variety has moderate resistance to ring nematode, and resists grape phylloxera. Although the variety supports phylloxera on its root tips, the variety does not allow phylloxera feeding on its structural roots (i.e., those that develop periderm bark and on which phylloxera feeding is damaging to the roots).

2 Drawing Sheets

Botanical/commercial classification: 'L6-1' (*Vitis champinii* 'Ramsey'×*V. riparia* 'Riparia Gloire')×*V. champinii* 'c9021'.
Variety denomination: '9407-14'.

BACKGROUND OF THE INVENTION

Nematodes are important pests in vineyards around the world, and these soil-borne pests can be particularly problematic in California vineyards. Two factors intensify the impact of nematodes—the high value of grapes and of vineyard land. These factors force growers to ignore the steps of leaving land fallow and rotating crops, both of which reduce nematode build up and delay the selection of adapted strains. Nematicides and fumigants help control nematodes, but the use of these pesticides has been greatly restricted and their future use in doubt because they must be persistent and penetrate deeply through the soil profile to be highly effective. In addition, grape rootstocks were bred to resist grape phylloxera (a devastating root-feeding aphid), and were not selected for nematode resistance. The grape rootstocks Freedom and Harmony were released by the USDA/Fresno to provide resistance to nematodes, but they are not resistant to grape phylloxera. More recently, McKenry at UC Riverside released two rootstocks, 'RS3' and 'RS9' (siblings of a 'Schwarzmann'× 'Ramsey' cross), designed to resist multiple nematode species and provide growers with nematode resistant rootstock alternatives. However, they have nematode resistance from a relatively narrow genetic base, which may promote the evolution of strains capable of feeding on them. Therefore, there is a need to develop nematode resistant grape rootstock.

BRIEF SUMMARY OF THE INVENTION

This invention relates to a new and distinct variety of grape rootstock with resistance to a broad array of soil-borne nematodes including root-knot, dagger, lesion and citrus nematodes. It has moderate resistance to ring nematode, and resists grape phylloxera. Although it supports phylloxera on root tips it does not allow phylloxera feeding on its structural roots (i.e. those that develop periderm bark and on which phylloxera feeding is damaging to the roots. The '9407-14' grape rootstock originated as a single plant from a cross of 'L6-1' (*Vitis champinii* 'Ramsey'×*V. riparia* 'Riparia Gloire')×*V. champinii* 'c9021'.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**: number of ring nematodes recovered off rootstock selections growing in 1 gal pots with three soils collected from the Gallo Livingston Ranch, known to have severe and chronic nematode pressure. Results per soils are means of three replicate pots.

FIG. **2**: a photograph showing rootstock '9407-14'.

DETAILED DESCRIPTION OF THE INVENTION

A breeding program was initiated in 1990 at UC Davis to provide a group of rootstocks with broad and durable resistance to the nematodes found in California vineyards. This program commenced with an evaluation of selections that remained from breeding efforts in the late 1960s and early 1970s. These selections from the late 1960s and early 1970s were previously screened against two root knot nematode species (*Meloidogyne incognita acrita* and *M. arenaria thamsei*), the lesion nematode (*Pratylenchus vulnus*), and the dagger nematode (*Xiphinema index*). In 1990, these selections were evaluated for their ability to root and for growth habits

such as brushy growth, internode length and the degree of lateral shoot production. In 1993 and 1994, the best of these selections were crossed to species chosen for their ability to reduce scion vigor or improve the rooting of the progeny. The parentage and species composition of the '8905-05' and other crosses are listed in Table 1. About 5,000 progeny were planted in the vineyard and their evaluation for nematode resistance was initiated in 1996.

The first phase of the selection process examined the progeny for their general vigor and horticultural characters such as internode length and the degree of lateral shoot formation. The best 1,000 progeny, selected from a large number of families, were advanced to a rooting assay. Ten 2-node dormant cuttings of the best 1,000 were taken in December 1996 and tested for their ability to form roots. Rootstocks that root well generally graft well, thus this evaluation was a key indicator of their future success as rootstocks. One hundred of the progeny were selected, again with an effort to get a broad representation from the large number of families.

The second phase of the selection process involved testing these 100 selections for resistance to *M. incognita I*3. This root-knot nematode isolate is capable of feeding on many rootstocks, but does not feed on rootstocks that derive their resistance from *V. champinii* ('Freedom', 'Harmony', 'Dog Ridge' and 'Ramsey'). All of the nematode testing in this breeding program utilized potted plants under greenhouse conditions with optimized soils and irrigation techniques to promote nematode feeding. Resistance to this isolate of root-knot nematode was evaluated by assaying the number of galls on the roots after inoculation with 1,000 J2 larvae (the free-living infectious stage of this nematode). Resistance was also evaluated by extracting the J2 nematodes in the pots after the root galls were counted. Later phases of the root-knot nematode screening evaluated resistance by counting the number of egg masses formed using a technique developed in the Walker lab (Cousins and Walker 2001 Plant Disease 85:1052-1054). There were no root galls on 33 of the 100 selections and the 33 selections were advanced to the next phase of screening.

The third phase of the selection process tested the 33 root-knot nematode resistant selections against two aggressive strains of root-knot nematode and against the dagger nematode, *X. index*. The two aggressive strains were selected in the Walker lab from soils provided by McKenry, from a declining vineyard of 'Harmony' rootstock. Root-knot nematodes were extracted from this soil and the larvae were placed onto tomato plants with high susceptibility to root-knot nematodes. Two egg masses were collected from these infested plants and J2 larvae from each mass were put on a separate uninfested tomato plant to create new strains from a single egg mass (root-knot nematodes are parthenogenic). These new strains were multiplied on tomato and were then used to inoculate potted plants of 'Harmony' rootstock to verify their ability to feed aggressively on this resistant rootstock. These two strains were named HarmA and HarmC. Later investigations determined that HarmA was a strain of *M. arenaria* while HarmC was a strain of *M. incognita*. The dagger nematodes were collected from several vineyards in the Napa Valley of California, which were known to have fanleaf degeneration.

The 33 selections were then inoculated with each of the three nematode strains independently. The root-knot nematode screens used 1,000 J2 larvae to inoculate plants growing in 1,000 cm^3 plastic pots with a coarse sand/clay loam soil mix. The dagger nematode screens were done in the same pots and soils, but used 200 adult *X. index* as the inoculum. Fourteen selections did not produce egg masses when inoculated with the three root-knot nematode strains nor did they produce root tip galls after inoculation with *X. index* (Table 2).

In the fourth phase, the 14 selections were subjected to a series of tests. The first was a combined inoculum of all four nematodes at once to determine the impact of simultaneous nematode feeding on resistance (Table 3). They were also tested against the four nematodes over a range of temperatures, 24, 27, 30 and 32° C. There was some erosion of resistance to HarmA (the most aggressive strain of root-knot nematode) at this temperature, but 6 of the selections performed very well (Table 4). Root-knot nematode resistance is known to fail at about 28° C. in a wide range of species including tomato, pepper and plum. The 14 selections were also evaluated for resistance to lesion (*Pratylenchus vulnus*), citrus (*Tylenchulus semipenetrans*) and ring (*Mesocriconema xenoplax*) nematodes (Table 3). From this series of tests a number of six rootstock selections were made, including '9407-14'. A summary of the '9407-14' characteristics is presented below.

Grape phylloxera are capable of feeding and producing galls (nodosities) on the young roots of virtually all grape rootstocks and species. In order to gauge the phylloxera hosting ability of the final six selections, they were tested for the ability to support phylloxera on nodosities and compared to a set of commercial rootstocks. Three sets of young root pieces from each selection were inoculated with 10 phylloxera eggs collected from '101-14 Mgt' rootstock roots. Over a 21-day period, the number of eggs and juveniles that were produced were summed and divided by 10 (the original inoculum) to produce the average rate of increase. Table 5 presents these results for the six selections. Nodosity galling on young roots does not appear to damage grapevines, only feeding and galling on mature roots (tuberosities) leads to vine death. The high rate of phylloxera feeding, galling and reproduction on '101-14 Mgt' (7.98 average rate of increase) has been observed in past tests. Most of the values were very low, although this '101-14 Mgt' strains is well adapted to '9407-14'. Three of the selections were very resistant: '8909-05', '9363-16' and '9449-27'. The low values for AXR#1 demonstrate that the results of this test do not reflect field level or tuberosity level feeding and damage, and that phylloxera adapt independently to rootstock hosts.

It will take years to determine which sites each of these rootstock selections are best suited to, but they have unparalleled levels of resistance to nematodes and should excel in sites with single and mixed nematode species infestations. Four of the selections ('9365-43', '9365-85', '9407-14' and '9449-27') were grafted to 'Fiesta Seedless' and planted in a Fresno rootstock trial in 2004. That year two of these selections ('9365-43' and '9365-85') were also included in a Chardonnay rootstock trial in Santa Maria. The six rootstock selections in large pots using soils from the Gallo Livingston Ranch where nematode pressure from root-knot, lesion, ring and *Xiphinema americanum*, is known to be severe and chronic. This test was conducted to evaluate these selections under "field conditions" using infested soil without added inoculations. All of the selections performed very well against root-knot nematodes (Table 6) and two, '9407-14' and '8909-05', also performed very well against ring nematode (FIG. **1**).

The grape rootstock '9407-14' originated as a single plant from the stated cross and has been successfully asexually propagated from herbaceous and woody cuttings. The grape rootstock '9407-14' was first asexually propagated in Davis, Calif. by both herbaceous and woody cuttings.

The grape rootstock '9407-14' has shown better and broader nematode resistance than currently available commercial grape rootstocks.

DETAILED BOTANICAL DESCRIPTION

Rootstock '9407-14' derives its resistance from *V. champinii* 'Ramsey' and from c9021 a form of *V. champinii* that appears to intergrade with *V. berlandieri*. *Vitis riparia* was used to improve the rooting and grafting of cuttings. '9407-14' had excellent root-knot and dagger nematode resistance in the combined testing, resisted citrus and lesion nematodes, and supported a low number of ring nematodes (Table 3). The variety is a staminate flowered vine with moderate growth, but long canes, good internode lengths and few laterals. '9407-14' has glossy leaves with short rounded teeth and slightly puckered surface, and the leaves are mildly susceptible to powdery mildew in a no-spray block at the UCD campus. Preliminary propagation results indicate that '9407-14' has a deep rooting angle. This selection supported the highest level of nodosity based phylloxera, but research to date has concluded that high nodosity level feeding does not cause vine damage.

Color definition used throughout the following botanical description of '9407-14' was set by the Munsell Color Chart for Plant Tissues with Hue Value/Chroma values.

The following is a further description of rootstock '9407-14':

Shoot tips: The variety has shoot tips which are partially enveloped, green in color (2.5GY 6/6), and sparsely covered with long arachnose tomentum.

Young leaves: The variety has young leaves which are green in color (2.5GY 6/6), entire, glabrous with fine arachnose tomentum, and relatively short and rounded teeth.

Mature leaves: The variety has mature leaves with an upper surface that is green in color (5GY 4/6) and a lower surface that is green in color (5GY 5/8). The leaves are also entire, medium-sized (10.6×11.2 cm), cordate leaves with relatively short rounded to convex teeth, and medium-length petioles. The upper surface is glabrous and flat with a waxy surface reminiscent of *Vitis vulpina*. The lower surface has scattered arachnose tomentum mostly along the major and minor veins, and fine bristles along the major veins. The petiolar sinus is broad spreading U-shape with a small V-shaped notch at the petiolar attachment. Typical cordate leaves are 12.1 cm wide and 11.4 cm from the petiole attachment to the tip of the apical lobe. Typical petioles have arachnose tomentum and are 5.9 cm long. The average leaf surface is glabrous and bullate.

Canes: The variety has canes which are dark brown in color (5YR 8/4), with long internodes, straight shoots and relatively limited lateral shoot development, nodes have small pointed buds. Canes are slightly oval in cross-section, have medium diaphragms and medium-sized pith. On average the variety has normal cane production in terms of length and number. The intermodal distance is relatively longer than an average rootstock pruned in the same way. Cane diameters are average. The texture of the canes is not different than other rootstocks and the one-year-old canes have arachnose tomentum.

Flowers: The variety has flowers which are staminate. The variety is a male flowered plant. Once the variety sheds pollen, the flower cluster abscises from the stem. The variety has an average bloom date about 2 to 3 weeks later than the early flowering 'Rupestris St. George' variety. The male flowered clusters do not set fruit and are typically on the vine for about 3 weeks. Flowers of the variety all have a fragrance. The petals of flowers of the variety are united into a calyptra.

TABLE 1

Parentage of the five nematode resistant grape rootstock selections.

Selection	Parentage
'8909-05'	*V. rupestris* x *M. rotundifolia*
'9363-16'	(*V. rufotomentosa* x (*V. champinii* 'Dog Ridge' x 'Riparia Gloire')) x 'Riparia Gloire'
'9365-43'	(*V. rufotomentosa* x (*V. champinii* 'Dog Ridge' x 'Riparia Gloire')) x *V. champinii* 'c9038' (probably *V. candicans* x *V. monticola*)
'9365-85'	(*V. rufotomentosa* x (*V. champinii* 'Dog Ridge' x 'Riparia Gloire')) x *V. champinii* 'c9038' (probably *V. candicans* x *V. monticola*)
'9407-14'	(*V. champinii* 'Ramsey' x 'Riparia Gloire') x *V. champinii* 'c9021' (probably *V. candicans* x *V. berlandieri*)

TABLE 2

Selections with broad resistance to four nematodes when inoculated individually.

Selection	*X. index*	*M. incognita* I3	*M. arenaria* - HarmA	*M. incognita* - HarmC
'8909-05'	R	R	R	R
'9317-06'	R	R	R	R
'9332-43'	R	R	R	R
'9344-03'	R	R	R	R
'9363-16'	R	R	R	R
'9365-43'	R	R	R	R–
'9365-62'	R	R	R	R
'9365-85'	R–	R	R	R
'9403-35'	R	R	R–	R–
'9403-107'	R	R	R	R
'9407-14'	R	R	R	R
'9449-23'	R	R	R	R
'9449-25'	R	R	R	R
'9449-27'	R	R	R	R
Control Group:				
'1616C'	S	R	R–	R–
'Harmony'	S	R	S	S
'Colombard'	S	S	S	S

R = Resistant, no gall symptoms or egg masses observed
R– = Trace infection
S = Susceptible, symptoms present, nematode reproduction supported

TABLE 3

Summary results for 14 nematode resistant selections when tested against combined inoculum with three root-knot nematode (RKN) strains and dagger nematode (Xi).
Results of testing against citrus, lesion and ring are also reported.

Genotypes	Xi Galls in Combined Testing		RKN Egg Masses in Combined Testing		Citrus		Lesion		Ring	
'8909-05'	R	0	R	0	R	<100	R	<10	R	<1,000
'9317-06'	MS	<1	S	<5	R	<100	R	<50	HS	<20,000
'9332-43'	S	<5	S	<5	R	<100	R	<50	S	<10,000
'9344-03'	S	<5	MS	<1	S	>400	S	<200	S	<10,000
'9363-16'	R	0	R	0	S	>400	R	<50	S	<10,000
'9365-43'	R	0	R–	<1	R	<100	R	<50	MS	<5,000
'9365-62'	MS	<1	S	<5	R	<100	R	<50	MS	<5,000
'9365-85'	MS	<1	R–	<1	R	<100	R	<50	S	<10,000
'9403-107'	R	0	S	<5	R	<100	R	<50	MS	<5,000
'9403-35'	S	<5	S	<5			R	<50	MS	<5,000
'9407-14'	R	0	R	0	R	<100	R	<50	LS	<3,000
'9449-23'	MS	<1	R	0	R	<100	R	<50	S	<10,000
'9449-25'	MS	<1	R	0	R	<100	R	<50	S	<10,000
'9449-27'	MS	<1	R–	<1	R	<100	R	<50	S	<10,000

TABLE 3-continued

Summary results for 14 nematode resistant selections when tested against combined inoculum with three root-knot nematode (RKN) strains and dagger nematode (Xi).
Results of testing against citrus, lesion and ring are also reported.

Geno-types	Xi Galls in Combined Testing		RKN Egg Masses in Combined Testing		Citrus		Lesion		Ring	
'1616C'	S	>50	S	<5	S	>400	S	<200	HS	<20,000
'Freedom'	S	>10	S	<10	R	<100	R	<50	HS	<20,000
'Colom-bard'	S	>100	S	>100	S	<1000	S	<300	HS	<30,000
'Harmony'	S	>10	S	<50	S	<1000	S	<200	HS	<30,000
'St. George'	S	<100	S	<50	S	>400	R	<50	S	<10,000

TABLE 4

Number of egg masses per potted plant and per gram of root after inoculation with 1,000 *M. arenaria* HarmA nematodes and testing at 32° C.

Genotype	Egg Mass/Plant	Egg Mass/g Root
'Colombard'	442.50 a	155.86 a
'Harmony'	156.00 b	123.28 b
'9365-85'	32.25 c	16.49 c
'9365-43'	7.25 c	6.04 cd
'9363-16'	6.75 c	5.74 cd
'9449-27'	0.25 c	0.22 d
'9317-06'	0.00 c	0 d
'8909-05'	0.00 c	0 d

TABLE 5

The average rate of population increase of phylloxera on nodosities formed on young root tips of advanced rootstock selections and a set of standard rootstocks. The phylloxera were selected from a vineyard planted on '101-14 Mgt' rootstock.

'8909-05'	0.59
'9363-16'	0.89

TABLE 5-continued

The average rate of population increase of phylloxera on nodosities formed on young root tips of advanced rootstock selections and a set of standard rootstocks. The phylloxera were selected from a vineyard planted on '101-14 Mgt' rootstock.

'9365-43'	1.86
'9365-85'	1.99
'9407-14'	9.83
'9449-27'	0.30
'1103P'	2.10
'101-14 Mgt'	7.98
'Teleki 5C'	1.38
'AxR#1'	2.15
'O39-16'	0.43

TABLE 6

Number of root-knot nematode egg masses recovered from rootstock selections growing in 1 gal pots with soils collected from sites at the Gallo Livingston vineyards. This vineyard is known to have severe and chronic nematode pressure.
Results per soils are means of three replicate pots.

Selection	Soil 1	Soil 2	Soil 3
'Colombard'	69.02	89.8	74.6
'Harmony'	31.2	0	2.8
'St. George'	9.8	26.2	16.0
'9365-85'	1	0	1.4
'9407-14'	0	0	0
'9363-16'	0	0	1.4
'9365-43'	0	0	0.2
'9449-27'	0	0	0.8
'8909-05'	0	0	0

What is claimed is:

1. A novel and distinct variety of grape plant rootstock designated as '9407-14' having the characteristics described and illustrated herein.

* * * * *

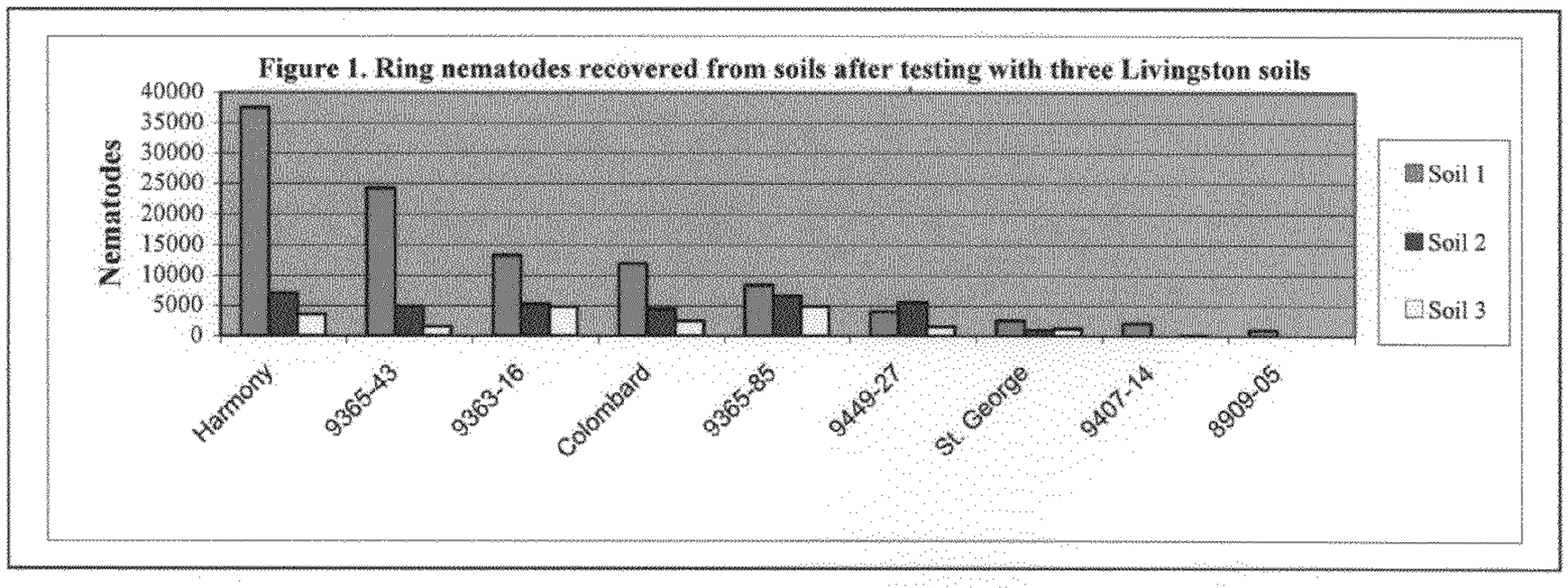
Figure 1. Ring nematodes recovered from soils after testing with three Livingston soils
Nematodes
40000
35000
30000
25000
20000
15000
10000
5000
0
Harmony
9365-43
9363-16
Colombard
9365-85
9449-27
St. George
9407-14
8909-05
Soil 1
Soil 2
Soil 3

Figure 1

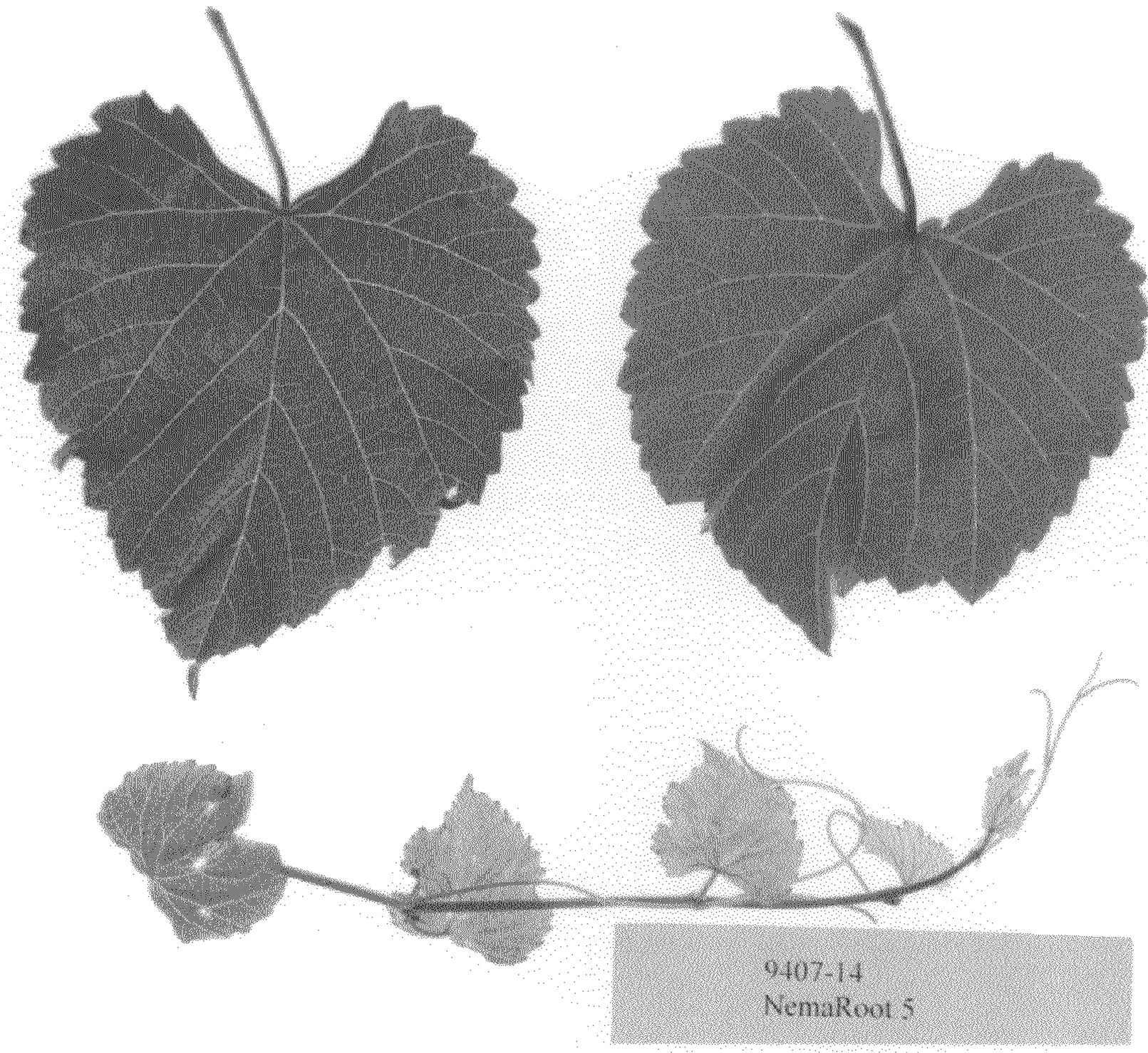

Figure 2