Interaction Between a South African Population of *Xiphinema index* and Different Grapevine Rootstocks*

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Thirty-one grapevine rootstocks were used to test for reproduction, root feeding symptoms and transmission of grapevine fanleaf virus by a South African population of *Xiphinema index*. Grapevine fanleaf virus was transmitted within four months to the roots and systemically spread within six months to the leaves of all the rootstocks tested. No root damage and a low reproduction rate of *X. index* were found on the rootstocks Harmony, Freedom and 1613 C, all which have *V. Longii* and Othello in their parentage.

Xiphinema index Thorne & Allen, 1950 is considered one of the most damaging pests of grapevine worldwide due to its ability to feed on grapevine roots (Weischer, 1980) and to transmit grapevine fanleaf virus (GFLV) (Hewitt *et al.*, 1958). It was shown that a South African population of *X. index* is capable of transmitting GFLV to *Vitis rupestris* cv. St. George (Malan & Meyer, 1992). In South Africa *X. index* occurs along the Breë River catchment area in the Worcester and Robertson districts, where it is one of the most common *Xiphinema* spp. (Barbercheck *et al.*, 1985).

The control of *X. index* is difficult once the soil is infested. Fumigation of vineyard soil before replanting only temporarily reduced numbers of *X. index* (Lear *et al.*, 1981). Allowing vineyard soil to lie fallow is impracticable, because the nematodes may persist for up to ten years on root fragments in the soil (Raski *et al.*, 1965).

Replanting vineyards in the Breë River vine-producing region with rootstocks resistant to *X. index* therefore appears to be the only practical solution. However, *X. index* populations from Italy, California, Israel and France differed in their reactions to the same rootstock (Coiro & Brown, 1984; Coiro *et al.*, 1990), indicating race differences. Therefore, local populations should be screened against rootstock gene bank collections. In this study root injury by *X. index*, reproduction of the nematode, transmission of GFLV and systemic spread to the leaves were studied in different rootstocks.

MATERIALS AND METHODS

Inoculum: Virus-free *X. index* was obtained from cultures of rooted cuttings of *Ficus carica* L. (domestic fig) grown in steam-sterilised soil. The test population of *X. index* was originally obtained from a vineyard near Robertson (33° 50′, 19° 54′). The nematodes were allowed to feed for a minimum period of four months on rooted cuttings of GFLV-infected *Vitis rupestris* cv. St. George grown in pots. The infected plants were obtained from the virus collection at the Plant Quarantine Station, Stellenbosch and serologically checked for the presence of GFLV.

Hosts: A total of thirty-one rootstock cultivars was evaluated consecutively in three groups of eight, six and 17 rootstocks respectively. Two-bud cuttings were rooted in steam-sterilised soil mixture in 250 ml plastic pots in a glasshouse at 20°-25°C. After sufficient shoot growth, a 5 ml suspension with 150±20 *X. index* of all stages was pipetted onto the soil of each pot. Each treatment was replicated 16 times. The experiments were laid out in a two-way design. Four plants of each rootstock were left untreated as controls.

Reproduction: After four months the nematodes were extracted according to the method of Flegg (1967). After 24 h on a modified Baermann funnel, the total number of juveniles and adults in each pot was determined. Prior to analysis a log transformation was used to stabilise the variance in the total number of nematodes. Comparisons were made using orthogonal contrast. Reproduction potential was determined using the five replicates showing the highest reproduction of nematodes.

Root symptoms: Each plant was scored for root injury on a scale of one to four (Kunde *et al.*, 1968; Meredith *et al.*, 1982) as follows: 1 – no root symptoms, 2 – few localised curvings or swellings of root tips, 3 – swellings of root tips very evident throughout the root system, 4 – similar to 3 except some segments of roots greatly enlarged, attacks very severe throughout the root system and little or no lateral root formation. A score for each rootstock was determined as the mean of 16 replicates.

Virus transmission: A 0.5 g sample of roots from each plant was analysed for the presence of GFLV by using the double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) (Hill, 1984). The plants were re-

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planted in 5ℓ plastic pots and left in a shadehouse for two growing seasons during which the top leaves were tested regularly for systemic spread of the virus by ELISA.

RESULTS

Nematode numbers: From Fig. 1, Experiment 1, the rootstocks can be separated into three groups, with Freedom on its own, having fewer nematodes than Ramsey, 101-14 Mgt and 110R (t_{101}=6.94; P<0,001), which formed the second group. The rootstocks 101-14 Mgt and 110R both had *V. rupestris* as one parent. This group in turn had fewer nematodes than the third group containing Jacquez, 99R, US 2-1 and US 1-6 (t_{101}=6.37; R<0.001). The last two rootstocks are crosses between 99R and Jacquez. Only on Freedom the nematodes extracted after four months were fewer than of the initial inoculum (Table 1).

In Fig. 1, Experiment 2, three groups can be distinguished, with Harmony forming a group on its own with fewer nematodes than 140 Ruggeri, 3306 C and 775 Paulsen (t_{69} = 9.67; P<0.001) which formed the second group. The third group, having more nematodes than the second group (t_{69} = 7.57; P<0.001), consisted of Selection Oppenheim No. 4 (SO4) and Grezot-1. The number of nematodes extracted from Harmony after four months was fewer than of the initial inoculum (Table 1).

In Fig. 1, Experiment 3, no definite groups were evident although there was variation among the different rootstocks. The lowest reproduction was found in 161/49 Couderc, US 8-7 and 1613 C (Table 1) with the highest in US 35-1-15 and 1045 Paulsen.

Root symptoms: In Experiment 1, the most severe root symptoms were recorded on Jacquez with a score of 3.50

TABLE 1
Root injury and reproduction potential of *Xiphinema index* and transmission of GFLV on grapevine rootstock cultivars of different genetic origin.

Rootstock Cultivar	Genetic Origin	Root injury[1]	Reproduction potential[2]	% Transmission of GFLV to:	
				Roots[3]	Leaves[4]
Experiment 1					
Freedom	*(V. Longii* x Othello) x Dog Ridge	1.00	92	94	94
101-14 Mgt	*V. riparia* x *V. rupestris*	1.50	470	88	100
Ramsey	*V. Champini*	2.67	554	100	100
US 1-6	Jacquez x 99 Richter	2.81	1 798	100	100
110 Richter	*V. Berlandieri* x *V. rupestris*	2.94	744	100	100
99 Richter	*V. Berlandieri* x *V. rupestris*	3.31	1 824	100	100
US 2-1	Jacquez x 99 Richter	3.31	866	100	100
Jacquez	*V. aestivalis* x *V. cinerea* x *V. vinifera*	3.50	1 326	94	94
Experiment 2					
Harmony	*(V. Longii* x Othello*)* x Dog Ridge	1.00	78	56	88
3306 Couderc	*V. riparia* x *V. rupestris*	1.45	482	74	74
775 Paulsen	*V. Berlandieri* x *V. rupestris*	2.44	674	68	81
Grezot- 1	*(V. Longii* x *V. riparia)* x *V. rupestris*	2.56	3 862	81	88
140 Ruggeri	*V. Berlandieri* x *V. rupestris*	3.31	438	86	87
SO 4	*V. Berlandieri* x *V. riparia*	3.63	2 744	88	88
Experiment 3					
1613 Couderc	*V. Longii* x Othello	1.00	160	100	100
143 B Mgt	*V. vinifera* x *V. riparia*	1.62	1 250	94	100
US 8-7	Jacquez x 99 Richter	1.69	214	100	100
US 12-6-8	Jacquez x 99 Richter	2.31	266	100	100
161-49 Couderc	*V. riparia* x *V. Berlandieri*	2.47	160	100	100
4453 Malèque	*V. riparia* x *(V. cordifolia* x *V. rupestris)*	2.75	1 328	100	100
US 16-13-23	*(V. vinifera* x *V. rupestris)* x 99 Richter	2.81	316	73	100
US 4-4	Jacquez x 99 Richter	2.81	1 156	100	100
Dog Ridge	*V. rupestris* x *V. candicans*	3.00	1 078	100	100
C. Metallica	*V. rupestris* var. *Martin*	3.00	1 036	100	100
Rupestris St. George	*V. rupestris*	3.38	1 392	100	100
US 35-1-15	*V. Berlandieri* x *V. rupestris* x *V. Longii*	3.56	1 794	100	100
1045 Paulsen	*V. Berlandieri* x A.R.G.1	3.63	1 746	100	100
216/3 Castel	*(V. Longii* x *V. riparia)* x *V. rupestris*	3.71	612	100	100
Gloire du Montpellier	*V. riparia* variety	3.75	1 778	100	100
US 24-10	Ramsey x 99 Richter	3.81	1 264	100	100
1103 Paulsen	*V. Berlandieri* x *V. rupestris*	3.88	1 528	100	100

1 = Root injury expressed on a scale of one to four.
2 = Representing the mean of the 5 pots with the highest increase in population.
3 = ELISA of roots after four months.
4 = ELISA of leaves after 18 months.

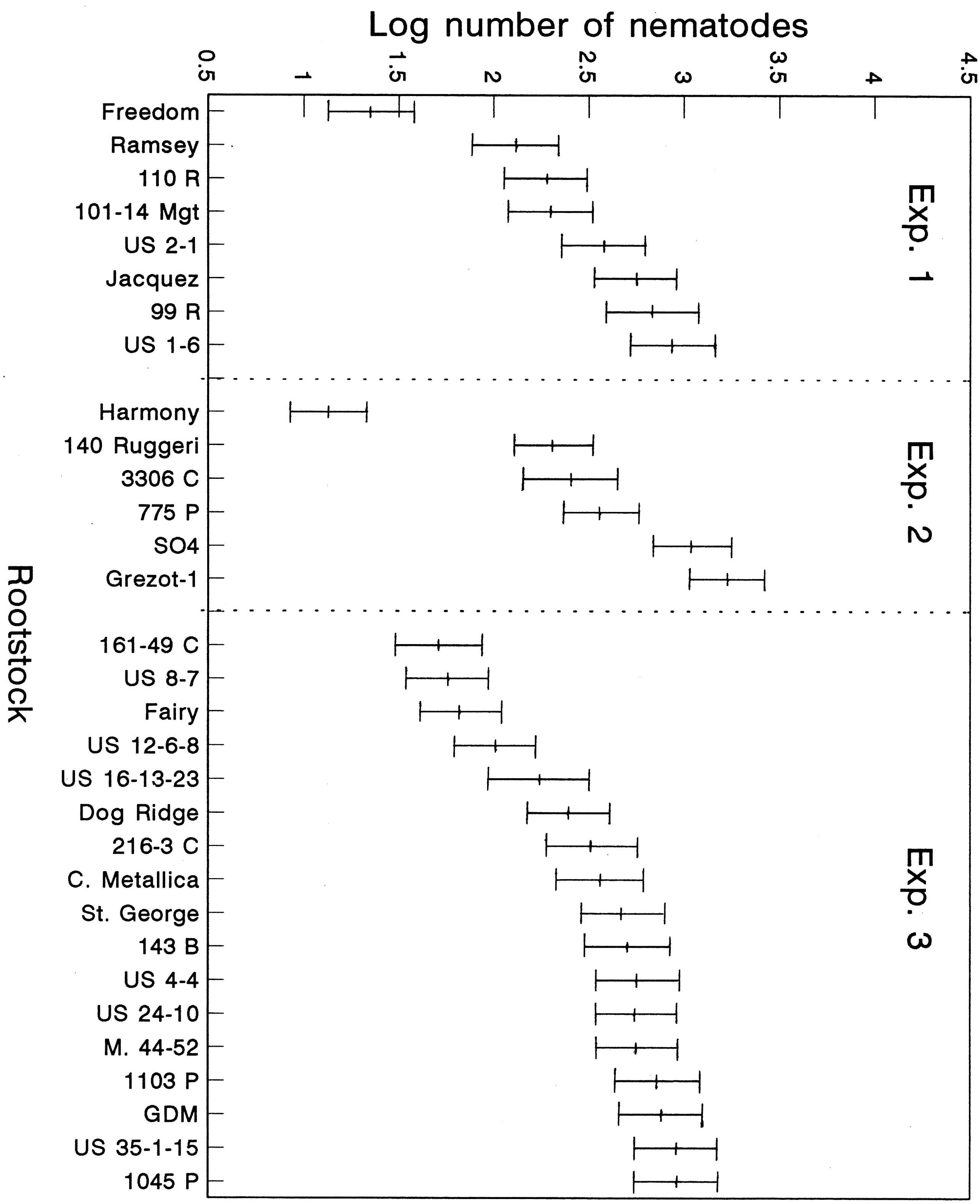

FIGURE 1

Number of nematodes on different grapevine rootstocks, grown in 250 ml pots, after a four-month reproduction period. Nematode numbers were log transformed prior to analysis and are the mean of 16 replicates.

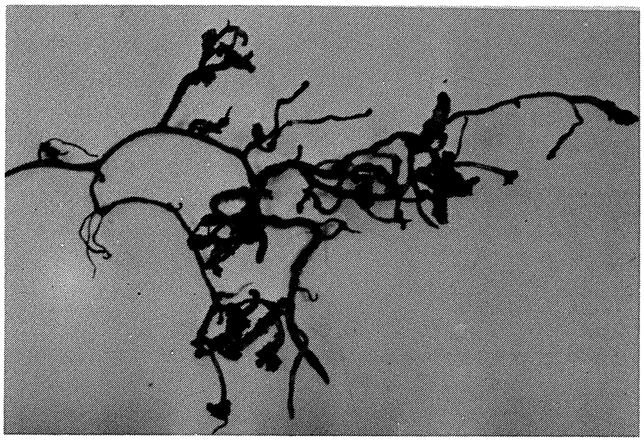

FIGURE 2

Root feeding symptoms of *Xiphinema index* on grapevine roots.

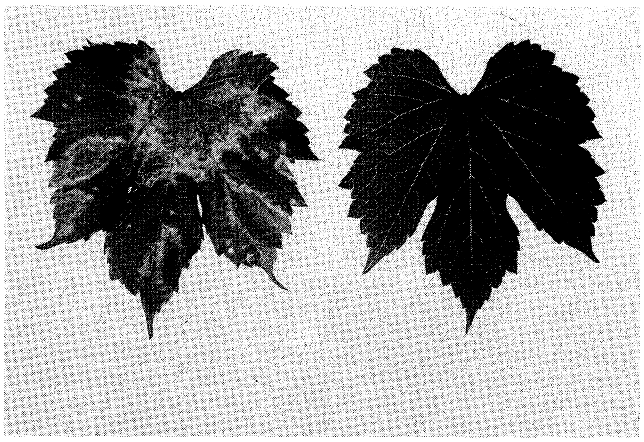

FIGURE 3

GFLV symptoms on the leaves of the grapevine rootstock US 8-7 after the second growth period (18 months).

(Table 1), and in experiment 2 on SO4 with a score of 3.63. In the third experiment, 41% of the rootstocks studied received a score of above 3.50 which included the rootstocks St. George, US 35-1-15, 1045 Paulsen, 216/3 Castel, Gloire du Montpellier (GDM), US 24-10 and 1103 Paulsen (Fig. 2). Freedom, Harmony and 1613 C showed no root symptoms.

Virus transmission: After four months GFLV was found in roots of all rootstocks tested (Table 1). Systemic spread of GFLV from the roots to the leaves was recorded within a period of six months in all rootstocks, with a higher percentage testing positive the following growth period. GFLV symptoms on the leaves were observed in the second growth period with the most severe symptoms in US 35-1-15, 143 B Mgt and US 8-7 (Fig. 3).

DISCUSSION

In this study three parameters were used to determine the influence of *X. index* on different rootstocks, e.g. root symptoms, reproduction and the transmission of GFLV. Kunde *et al.* (1968) and Harris (1983) used visible root symptoms and reproduction as parameters. Staudt & Kassemeyer (1990) used root symptoms and tested for the presence of GFLV over a period of 3-10 months, while Coiro *et al.* (1990) used only nematode numbers to determine variance in resistance between rootstocks.

The results show that Freedom, Harmony, 161/49 Couderc, US 8-7 and 1613 C had a low reproduction potential for *X. index* and no root damage, except in 161/49 Couderc and US 8-7 where some root damage was evident. These results agree with those of Harris (1983) who found Harmony and Freedom to be resistant by using both nematode numbers and visible root symptoms as criteria. A high level of resistance to reproduction was also found in 1613 C by Coiro *et al.* (1990) for four different populations of *X. index* from Italy, California, Israel and France.

The rootstock 1613 C is known to be a complex hybrid; its parentage is a cross between *V. Longii* and the variety Othello. Othello is a cross between *V. labrusca, V. riparia* and *V. vinifera.* Both Freedom and Harmony are crosses between 1613 C and Dog Ridge. Although both US 35-1-15, 216/3 Castel and Grezot-1 had *V. Longii* as one of their parental crosses, they showed a high score for root damage as well as reproduction of the nematode when crossed with the susceptible *V. rupestris* and *V. Berlandieri.*

With the South African population of *X. index,* Ramsey and Dog Ridge showed reproduction potential as well as root damage. In contrast, Kunde *et al.* (1968) and Meredith *et al.* (1982) found a high level of resistance to root damage by a Californian population of *X. index.* Coiro *et al.* (1990) showed a high level of resistance for reproduction of the Californian population on Ramsey and some resistance to the French and Israeli populations, while a high level of resistance for reproduction of the four *Xiphinema* populations was found on Dog Ridge.

In addition to a low reproduction and no root damage to Harmony, Freedom and 1613 C by *X. index*, these three rootstocks were also found to be resistant to root-knot nematode *(Meloidogyne incognita)* (Loubser & Meyer, 1987) and moderately resistant to crown gall *(Agrobacterium tumefaciens)* (Ferreira & Van Zyl, 1986). On the other hand, although SO4, which is a cross between *V. Berlandieri* and *V. riparia,* is resistant to root-knot nematode (Loubser, 1988), it was found to support the highest number of nematodes of all the rootstocks tested and had a high score for root damage by *X. index.*

There was no evidence of resistance to the transmission of GFLV in any of the rootstocks studied, even though some had a low reproduction potential for *X. index* and no root damage was observed. However, resistance to GFLV is known to occur, as was demonstrated by Bouquet (1981) in *Vitis rotundifolia.* Unfortunately it failed as a rootstock in France because of poor horticultural performance.

It is clear that none of the 31 rootstocks studied is resistant to the transmission of GFLV through feeding of *X. index.* If soil and climatic conditions in the Breë River vine-producing region are suitable, the rootstocks Harmony, Freedom and 1613 C could be considered for replanting of old vineyards in order to limit nematode populations and minimise the spread of GFLV.

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