Adv. Hort. Sci., 2020 34(4): 449-453
DOI: 10.13128/ahsc-8859

Short note

AHS
Advances in Horticultural Science

Stable growth inhibition of potted fig (*Ficus carica* L.) trees by soil sickness

A. Hosomi
Department of Agriculture and Food Safety Research, Research Institute of Environment, Agriculture and Fisheries, Osaka Prefecture, Habikino, Osaka 583-0862, Japan.

Key words: planting timing, root enclosing, rooted cutting size, shoot growth.

Abstract: The study was conducted to know a damage progress of soil sickness of fig trees and effect of initial planting conditions on it. Shoot growth of 10-liter potted 'Masui Dauphine' figs was inhibited with sick soil from the 1st year of planting, and a stable dwarfish growth was maintained form the 2nd to 9th years, with only a few trees dying. The sick soil affected trees planted in 25-liter pots in June worse than those planted in February, and trees with roots enclosed by non-woven fabric worse than without it. However, these differences had faded by the 3rd year. The sick soil affected trees in 60-liter pots in the 1st year of planting worse in smaller rooted cuttings than in larger ones. However, in subsequent years, growth inhibition was not affected by the rooted cutting size. These results suggest that the initial conditions, such as planting timing, physical barriers to rooting, and rooted cutting size, all affect potted fig tree growth in the early growing period, and influence the observed damage caused by sick soil. However in subsequent years, dwarfish growth in sick soil may attain a stable level, which is maintained for many years with very low mortality.

OPEN ACCESS

(*) **Corresponding author:**
vividlyoceanly@gmail.com

Citation:
HOSOMI A., 2020 - *Stable growth inhibition of potted fig (Ficus carica L.) trees by soil sicknes.* - Adv. Hort. Sci., 34(4): 449-453

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no competing interests.

Received for publication 11 January 2020
Accepted for publication 18 February 2020

1. Introduction

In the Japanese fig industry, the common-type fig 'Masui Dauphine' ('San Piero' sensu Condit, 1955) is a major cultivar and its second crops is sold along with fresh fruits. The fig is regarded as an easily cultivable fruit tree; however, some obstacles exist. An extreme decline in tree vigour, so called "soil sickness", has long been a serious obstacle for fig culture in Japan (Hirai and Nishitani, 1953; Hosomi, 2011). Although the exact cause of soil sickness is still unclear, there exist several causal hypotheses, e.g., toxic chemicals (Hatsuda *et al*., 1960), nematode pests (Condit, 1947; Sato and Shichijo, 1953), and some soil-borne diseases (Hosomi and Uchiyama, 1998). It is a common characteristic that some trees in a field will begin to weaken within a few years after planting and that normal growth cannot be expected merely by replanting (Hirai and Nishitani, 1953). However, it is unknown whether soil sickness damage increases year by year and finally kills the trees, or if the soil does not degenerate further and sometimes recovers. In other fruit, it is known that rooted cutting size influences growth inhibition by sick soil (Iwasaki, 1962; Hirano, 1968), but it is also unknown for fig trees whether such initial planting condition influences subsequent inhibition by sick soil for long periods.

In the present study, yearly changes in shoot growth were investigated using potted 'Masui Dauphine' fig trees with sick soil. Whether the timing of planting, physical disturbing of rooting or the size of rooted cuttings influence growth inhibition by sick soil, have also been investigated. The results will aid in recognition of the infestation process of soil sickness, and give information for a replanting plan of cultivated fig trees.

2. Materials and Methods

Yearly shoot growth of potted fig trees with sick soil (Exp. 1)

Every April from 1990 to 1994, the rooted cuttings of 'Masui Dauphine' figs were planted in 10-liter unglazed pots filled with a mixture of sandy soil, Kanuma soil and vermiculite (1:1:1, v/v/v). These were grown for 9 years in the open. In each June of the 1st planting year, 500 milliliter (ml) of the stored sick soil, which had been collected from fig orchards exhibiting the symptoms of soil sickness (Hosomi and Uchiyama, 1998), were added to the bed surface of 4 to 8 trees (28 trees in total). Four to 5 trees in each planting year (23 trees in total) were controls. Each surface of the bed (including control) was mulched with 500 ml of peat moss. Fifty ml of slow-release fertilizer (100 days type N: P_2O_5: K_2O=16: 5:10 plus micronutrients) was applied each June. Irrigation was applied automatically to prevent soil drying. One shoot per tree was elongated and the other shoots were disbudded. Each March, the shoots were pruned above their 2nd or 3rd node from the base and the dry weight was measured.

Growth inhibition by soil sickness under conditions of planting timing with/without physical barriers to rooting (Exp. 2)

In December 1999, 18 rooted cuttings of 'Masui Dauphine' figs was raised in individual bag (22×5 cm) with vermiculite under the greenhouse heated at 15-25°C. The bags were made of non-woven fabric, which had been treated by cupric hydroxide (Spin Out; Griffin Co.) to prevent root spiraling. Two shoots per rooted cutting were elongated. In February 2000 the rooted cuttings were removed from the bag and planted in 25-liter plastic pots filled with a mixture of Kanuma soil and vermiculite (1:1, v/v). Each 2.3-liter root area in 6 rooted cuttings was enclosed with non-woven fabric (polylactic acid span-bond 100 g/m^2) at planting. Two-liter of the stored sick soil in experiment 1, was added to each bed surface at 25 days after planting. The sick soil was also added to each bed of other 6 rooted cuttings without enclosing the roots. The remaining 6 rooted cuttings were controls. Soon after the sick soil addition, each surface of the beds (including controls) was mulched with 1.5- to 2-liter of peat moss. The other 36 rooted cuttings were likewise raised by cuttings from April 2000, and were planted in 25-liter plastic pots in June 2000. At that time 12 rooted cuttings had the root areas enclosed and were added with sick soil, a further 12 rooted cuttings were added with sick soil alone, and the other 12 were controls.

The trees were grown for 3 years in unheated greenhouse ventilated by roof and side vents. One hundred ml of slow-release fertilizer in experiment 1 was applied to each tree in March (February planting) or July (June planting) in the 1st year, and in June in the 2nd and 3rd year. Irrigation was applied automatically to prevent soil drying. Only 2 shoots per tree were elongated, and all other shoots were disbudded each year. Each March from 2001, the shoots were pruned above their 2nd or 3rd node from the base and the dry weight was measured.

Growth inhibition by soil sickness under conditions of different rooted cutting size (Exp. 3)

From April 1998, the rooted cuttings of 'Masui Dauphine' figs were raised by cuttings in 1.3-liter, 10-liter and 18-liter plastic pots filled with vermiculite with 6.5 ml, 50 ml and 90 ml respectively of slow-release fertilizer in experiment 1. The inner walls of these pots had previously been painted with cupric hydroxide (Spin Out; Griffin Co.) to prevent root spiraling. One shoot per tree was elongated and all other shoots were disbudded. In June 1999, the shoots were pruned and their length, basal diameter and dry weight was measured. I also took the rooted cuttings from the pots, washed off the soil, and calculated the root volume from the loss in weight when the roots were dipped in water. Thus, each of 10 rooted cuttings in 3 size categories (S, M and L) were prepared as in Table 1 and were planted to 60-liter plastic pots filled with a mixture of Kanuma soil and vermiculite (1:1, v/v). Two weeks after planting, 5-liter of the stored sick soil in experiment 1 was added to the bed surface of 6 trees in each category. Four

Table 1 - Rooted cuttings used in the test examining the effect of its size on sick soil damage

Size categories	Silck soil inoculation [z]	Shoot [y]			Root volume [x]	
		Length (cm)	Basal diameter (mm)	Dry weight (g)	In each group (cm^3)	In each size (cm^3)
Large (L)	+	116.5±5.5 [w]	15.8 ± 0.4	43.5±2.4	369.7±63.4	357.6
	-	126.5±6.9	15.3 ±0.7	40.7±5.8	339.5±65.9	
Medium (M)	+	107.8±5.0	14.4±0.5	33.4±3.2	296.8±32.9	280.2
	-	116.8±4.8	14.0±1.0	33.8±4.4	255.3±53.2	
Small (S)	+	65.5±2.1	11.4±0.2	11.1±0.4	148.5±26.1	168.2
	-	66.5±4.3	12.8±0.3	13.0±1.3	197.8±20.9	

[z] Yes (+) or No (-) of scheduled sick soil inoculation.
[y] Only one shoot per rooted cutting was elongated, pruned before planting and its size was measured.
[x] Estimated from the loss in rooted cutting weights when dipping roots in water.
[w] Mean±SE.

trees in each category were controls. Each surface of the beds (including controls) was mulched with 1.5-liter of peat moss, and all trees were grown for 4 years in the open. Three hundred ml of slow-release fertilizer in experiment 1 was applied each June. Irrigation was applied automatically to prevent soil drying. Three shoots per tree in the 1st year, and 6 shoots in subsequent years, were elongated and all other shoots were disbudded. Each March the shoots were pruned above their 2nd or 3rd node from the base and dry weight was measured.

3. Results and Discussion

Yearly shoot growth of potted fig trees with sick soil

The results are shown in figure 1. For the control trees, the average dry weight of shoot (shoot weight) varied in the range of 48 to 80 g. For trees with sick soil, the shoot weight was 49 g (81% of control) in the 1st year, decrease in the 2nd year and was maintained the range of 24 to 29 g (32 to 50% of control) in subsequent 8 years. Only 2 trees died in the sick soil during the testing period. In other word, the sick soil, added to bed soil, inhibit growth of 10-liter potted fig trees from the 1st planting year. It takes 1 year to confirm the growth inhibition, after which sick soil cause stable dwarf growth for many years without trees dying.

Growth inhibition by soil sickness under conditions of planting timing with/without physical barriers to rooting

The results are shown in figure 2. For control trees, the average dry weight of total shoot per tree

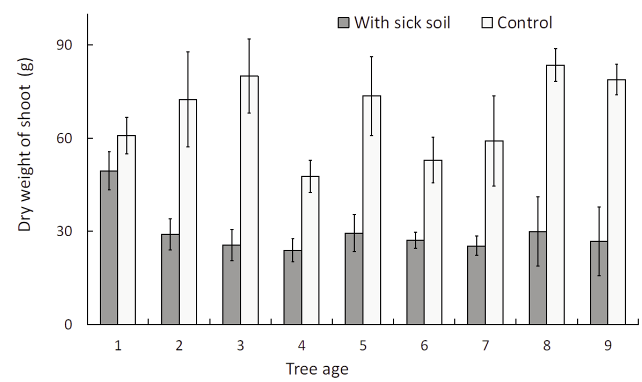

Fig. 1 - Yearly change in dry weight of shoot per 'Masui Dauphine' fig trees grown in 10-liter potted with/without sick soil. Vertical bars indicate SE.

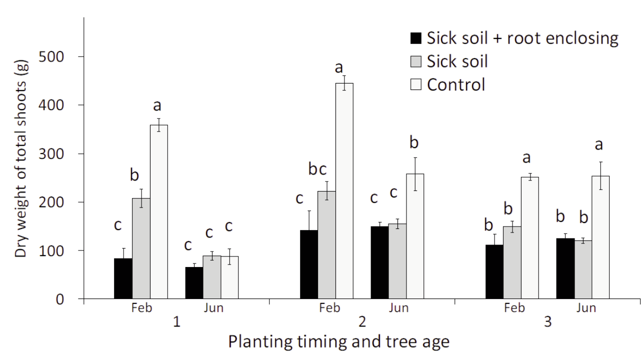

Fig. 2 - Dry weight of total shoot per 'Masui Dauphine' fig trees grown in 25-liter pots with/without sick soil under conditions of planting timing (February and June) with/without root-enclosing by non-woven fabric. Vertical bars indicate SE. Different letters indicate significance among conditions in each age at 5% level by Tukey-HSD test using R project 3.6.1.

(total shoot weight) varied in the range of 88 to 445 g, and the values of the trees planted in June was apparently less than those planted in February in the 1st and 2nd years, and equalized with them in the 3rd year.

For trees with sick soil, the total shoot weight varied in the range of 89 to 223 g, less than in controls. These values for June planted trees were less than for February planted ones in the 1st year, but were equalized form the 2nd to the 3rd year. For trees with sick soil plus root-enclosing by non-woven fabric, the total shoot weight varied in the range of 66 to 149 g. In early years for February planting trees, inhibited growth by sick soil plus root-enclosing tended to be less than those with sick soil alone. Uchida *et al.* (1998) reported that root wrapping materials such as woven flax disturbed the initial root growth of deciduous trees (*Magnolia kobus* and *Quercus acutissima*) for up to 10 months after planting. In this experiment the fabric may also disturb root elongation before rooting out, and may act as a growth inhibitor in the early growing period.

For June planting trees, however, no effect to the corresponding control was detected in sick soil application in the 1st year, and in root-enclosing in all tested years. Hirano (1968) reported that, in peach *Prunus persica* Batsch trees, growth inhibition by sick soil infestation was greater when vigorous growth was expected. It seems that the damage of sick soil and root-enclosing of this study were masked under delayed growth conditions due to the late planting.

Growth inhibition by soil sickness under conditions of different rooted cutting size

The results are shown in figure 3. For control trees, the dry weight of total shoot per tree (total shoot weight) was about 125 g in the 1st year and did not differ between the rooted cutting size (L, M and S). After the 2nd year the values increased, and varied in the rage of 230 to 336 g with a tendency to be greater in size-S. Ishimaru *et al*. (2003) reported that a smaller size of the rooted cuttings cause high relative initial growth rate in 3 species of broad-leaved tree (*Quercus serrata*, *Q. glauca* and *Myrica rubra*). The smaller rooted cuttings in this experiment also increase shoot vigour in the early period, and overcome the initial handicap of the tree biomass.

For trees with sick soil, the total shoot weight was about 107 g (86% of control) in rooted cutting size-L and M, and 70 g (56% of control) in size-S in the 1st year. Values were about 73 g in the 2nd year, 169 g in the 3rd year and 196 g in the 4th year, and apparently less than in controls, but did not differ between the size categories. In other word, the smallness of the rooted cutting intensified the sick soil damage in the planting year. However after the 2nd year from planting, that damage intensification and the vigour of small rooted cuttings compensate for each other and the shoot growth of every group with sick soil equalized. It had been reported that growth inhibition by sick soil is severe in smaller rooted cuttings in satsuma mandarin *Citrus unshiu* (Iwasaki, 1962) and peach (Hirano, 1968). My results are not inconsistent with these reports, because the phenomena they report were observed only in the 1st planting year.

The results of my 3 experiments suggest that tree growth with sick soil may stabilize to a particular level determined by the pot size. Longer times may be required for stabilization in larger pots with sick soil: One year in experiment 1 (10-liter pots), over 2 years in experiment 2 (25-liter pot) and over 3 years in experiment 3 (60-liter pot). Probably the longer terms for stabilization are because larger pots take longer to full with roots. The initial conditions, such as the timing of planting, physical barriers to rooting, and rooted cutting size, affect tree growth and observed damage due to soil sickness for the early planting period. However, the initial delays in growth made up, and did not determine future growth inhibition by sick soil. Hosomi and Uchiyama (1998) reported that parasitization by some microorganisms are most important factors in sick soil in fig orchards. Stable inhibition of soil sickness may be because root regeneration activity in certain restricted root zone balances the damage caused by these parasites. In

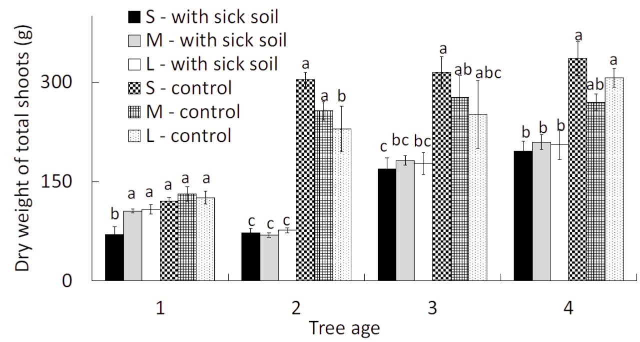

Fig. 3 - Dry weight of total shoot per 'Masui Dauphine' fig trees grown in 60-liter pots with/without sick soil under conditions of different rooted cutting size. The rooted cuttings in 3 size categories (S, M and L) were prepared as in Table 1. Vertical bars indicate SE. Different letters indicate significance among conditions in each age at 5% level by Tukey-HSD test using R project 3.6.1.

peach orchards, Yamada and Ono (1970) observed that the trees grew for 7 years with a constant difference between with and without sick soil. In fig orchards, it is also estimated that a stable dwarfish growth is maintained for many years in sick soil. I can expect an effect to overcome the problem in a methods to accelerate tree growth permanently, for example a vigour root stock (Hosomi *et al*., 2002), and are unable to expected it in devising the methods of planting. All results in present study use potted trees in which rooting is restricted physically by the pot wall. Field tests with free rooting and sick soil are needed to learn more about these competing effects.

4. Conclusions

Dwarfish growth by sick soil inoculation in potted 'Masui Dauphine' figs was maintained form the 2nd to 9th years after inoculation, resulting in few deaths. The initial planting conditions, such as planting timing (February and June), non-woven fabric as physical barriers to rooting, and rooted cutting size, all influence the observed damage caused by sick soil in the initial growth of those potted trees. However, in subsequent years, their growth converged to similar levels of weakness. A certain and stable growth inhibition on figs over many years, irrespective of planting condition, seems to be a basic characteristic of soil sickness in fig culture.

References

CONDIT I.J., 1947 - *Insects and other pests*, pp. 177-187. - In: CONDIT I.J. (ed.) *The fig*. Chronica Botanica Co., Waltham, Mass., Usa, pp. 222.

CONDIT I.J., 1955 - *Fig varieties: A Monograph*. - Hilgardia, 23(11): 323-538.

HATSUDA Y., MURAO S., TERASHIMA N., YOKOTA T., 1960 - *Biochemical studies on the soil sickness. Part 1. On the toxic substance in fig roots.* - Nippon Nogeikagaku Kaishi, 34(6): 484-486.

HIRAI J., NISHITANI K., 1953 - *Studies on the fig sick soil. (IV) Effect of successive planting upon the growth*. - Studies from the Institute of Horticulture, Kyoto University, 6: 32-34.

HIRANO S., 1968 - *Studies on peach sick soil. VI. Some factors affecting the growth of replants in old peach soil.* - J. Japan. Soc. Hort. Sci., 37(3): 192-198.

HOSOMI A., 2011 - *Incidence of Soil Sickness in Areas Producing 'Masui Dauphine' Figs.* - Bun. Res lnst. Env. Agr. Fish. Osaka, 4: 9-13.

HOSOMI A., DAN M., KATO A., 2002 - *Screening of fig varieties for rootstocks resistant to soil sickness.* - J. Japan. Soc. Hort. Sci., 71(2): 171-176.

HOSOMI A., UCHIYAMA T., 1998 - *Growth inhibiting factors in sick soil of fig orchards.* - J. Japan. Soc. Hort. Sci., 67(1): 44-50.

ISHIMARU K., IWAMA T., OSAWA N., TAKEDA H., 2003 - *Effect of sapling size on erosion control plantation.* - J. Jpn. Soc. Reveget. Tech., 29(1): 39-44.

IWASAKI T., 1962 - *Growth inhibiting factors and countermeasure in sick soil of mandarin orange orchards.* - Kajitunihon, 17(1): 41-43.

SATO K., SHICHIJO T., 1953 - *Growth of young fig trees in old fig orchard soils.* - J. Japan. Soc. Hort. Sci., 22(3): 163-166.

UCHIDA H., KATO M., MURAMOTO J., HAGIWARA N., 1998 - *Evaluation of the above-grand and root growth of deciduous trees when different root-wrapping materials are used.* - J. JILA 61(5): 487-492.

YAMADA Y., ONO T., 1970 - *Study on the replanting problem of peach 1. On the growth of young peach trees grown in old peach orchards.* - Bull. Yamanashi. Fruit Tree Exp. Stn., 2: 1-14.