OLIVE 香川大学学術情報リポジトリ

Tech. Bull. Fac. Agr. Kagawa Univ., Vol 39, No. 1, 5 ~ 9, 1987

OBSERVATION ON THE ROOT HAIRS OF THREE CITRUS ROOTSTOCKS

Roedhy POERWANTO, Hiroshi INOUE and Ikuo KATAOKA

3種のカンキツ台木の根毛の観察

プルワント　ルディ，井上　宏，片岡郁雄

Growing fibrous roots of one-year-old trifoliate orange (*Poncirus trifoliata* (L.) Raf.), Yuzu (*Citrus junos* Sieb. ex Tanaka) and Natsumikan (*Citrus natsudaidai* Hayata) seedlings grown in three different media (paddy soil, granite soil and vermiculite) were sampled to observe root hair formation using a scanning electron microscope. Root hairs were found on all fibrous roots of Yuzu and Natsumikan seedlings and on some fibrous roots of trifoliate orange seedlings grown in all medium treatments. Root hairs on Yuzu (14-130 μ) and Natsumikan (5-100 μ) were more abundant and longer than on trifoliate orange (4-50 μ). Root hairs occurred from about 1-2 mm distance from root-tip on all treatments. They did not cover all surfaces of fibrous roots, but they were distributed in groups of dense, sparse or free root hairs alternately. The most common shapes of root hairs on trifoliate orange were papillate and tubular, whereas on Yuzu and Natsumikan were tubular. Medium treatments did not affect the shape of root hairs, however, root hairs of the trees grown in vermiculite seemed to be longer.

3種の培土（水田土壌，花崗岩土壌，バーミキュライト）で生育したカラタチ，ユズ及びナツミカンの1年生実生の新しい細根の根毛を電子顕微鏡で観察した。

根毛はどの培土でも，ユズとナツミカンの細根のすべてに，カラタチでは一部に観察された。根毛はユズ（14-130 μ）とナツミカン（5-100 μ）でカラタチ（4-50 μ）よりも長く，多かった。根毛は細根の先端から1-2 mmの位置から発生した。根毛の発生帯には密生部と疎生部及び非発生部が交互に分布した。根毛の最も普通の形はカラタチでは乳頭状と円柱状、ユズとナツミカンでは円柱状であった。培土は根毛の形には影響しなかったが、バーミキュライトでは長くなるように思われた。

INTRODUCTION

Generally, root hairs of crops significantly affect the efficiency of mineral absorption. As for citrus, the presence of the root hairs was already defined in several species such as valencia orange seedling (4), rough lemon, sour orange, sweet orange, Rusk citrange (2), trifoliate orange and Natsumikan (5). However, the favorable conditions for their generation has not been clearly determined (10).

Trifoliate orange in genus Poncirus has been widely used as a rootstock for most of citrus Varieties in Japan. Yuzu and Natsumikan in genus Citrus are also utilized locally (7). In this study, the morphological characteristics of root hairs were compared among these three kinds of citrus rootstocks grown in different media by scanning electron microscope (SEM).

MATERIALS AND METHODS

Growing fibrous roots were sampled from one-year-old trifoliate orange (*Poncirus trifoliata* (L.) Raf.), Yuzu

OLIVE 香川大学学術情報リポジトリ

(*Citrus junos* Sieb. ex Tanaka), and Natsumikan (*Citrus natsudaidai* Hayata) seedlings grown in the field on June 4, 1985. The other trees from the same collection were transplanted from the field to unglazed pots (21 cm in diameter) filled with three different media, i. e. paddy soil, granite soil and vermiculite on June 28, 1985. They were put under plastic house condition, watered at one day intervals and fertilized with Hyponex solution on July 4, 1985. About one month after transplanting, on July 24, 1985, all trees were harvested and newly formed fibrous roots were sampled.

For SEM observation, the apicals of actively growing roots were collected. These samples were fixed and postfixed in 4% glutaraldehyde and 2% osmium, respectively and dehydrated in ethanol. The alcohol was exchanged with iso-amyl acetate. After critical-point-dried samples were coated with gold and viewed with SEM.

RESULTS AND DISCUSSION

No root hair was found on fibrous roots of any trees grown in the field. However, root hairs were observed on all the samples of Yuzu and Natsumikan and on some trifoliate orange grown in different media sampled on late July. Hayward and Long (4) found that good aeration and a pH of 6 or lower are apparently favorable for root hair formation of valencia orange seedling. Since rootstock collections were grown in the field where aeration was considerably poor due to the rain fall, the root hair formation migh have been suppressed.

Root hairs were observed from 1-2 mm distance from root-tip on all samples (Table 1 and Figure 1). Root hairs, however, did not cover all surface of fibrous root, but they were distributed in groups of dense, sparse or free root hairs alternately. Generally, on trifoliate orange sparse groups of root hairs were most commonly found, whereas on Yuzu and Natsumikan many dense groups were found.

Root hairs were more abundant on fibrous roots of Yuzu and Natsumikan than on trifoliate orange (Figure 2).

Root hairs on trifoliate orange (4-50μ) were relatively shorter than those of other rootstocks (Yuzu 14-130 μ and Natsumikan 5-100 μ). The root hairs of these rootstocks were, however, relativelly shorter than those of other speies. Previous reports (2, 4, 5, and 8) have also shown that citrus trees have short root hairs. And Gerdemann (3) based on Baylis (1) and Kleinschmidt and Gerdemann (6) concluded that citrus which is highly mycorrhiza dependent has extremely short root hair.

Three shapes of root hair were found: papillate, tubular and conical. Root hairs on trifoliate orange were papillate and tubular. On Yuzu tubular root hairs were more common than papilate. All shape of root hairs

Table 1. Some anatomical characteristics of root hairs of three citrus rootstocks grown on three different media.

Rootstocks	Medium	Root hair		
		Distance from tip (mm)	Shape	Length (μ)
Trifoliate orange	paddy soil	2.0	papillate, tubular	4- 40
	granite soil	1.8	papillate, tubular	7- 35
	vermiculite	1.1	papillate, tubular	9- 50
Yuzu	paddy soil	1.7	tubular, conical	19- 90
	granite soil	1.8	tubular, conical	17-100
	vermiculite	1.6	tubular, conical	22-130
Natsumikan	paddy soil	1.6	tubular, papillate, conical	6-100
	granite soil	2.0	tubular, papillate, conical	8- 60
	vermiculite	1.6	tubular, papillate, conical	5- 70

OLIVE 香川大学学術情報リポジトリ

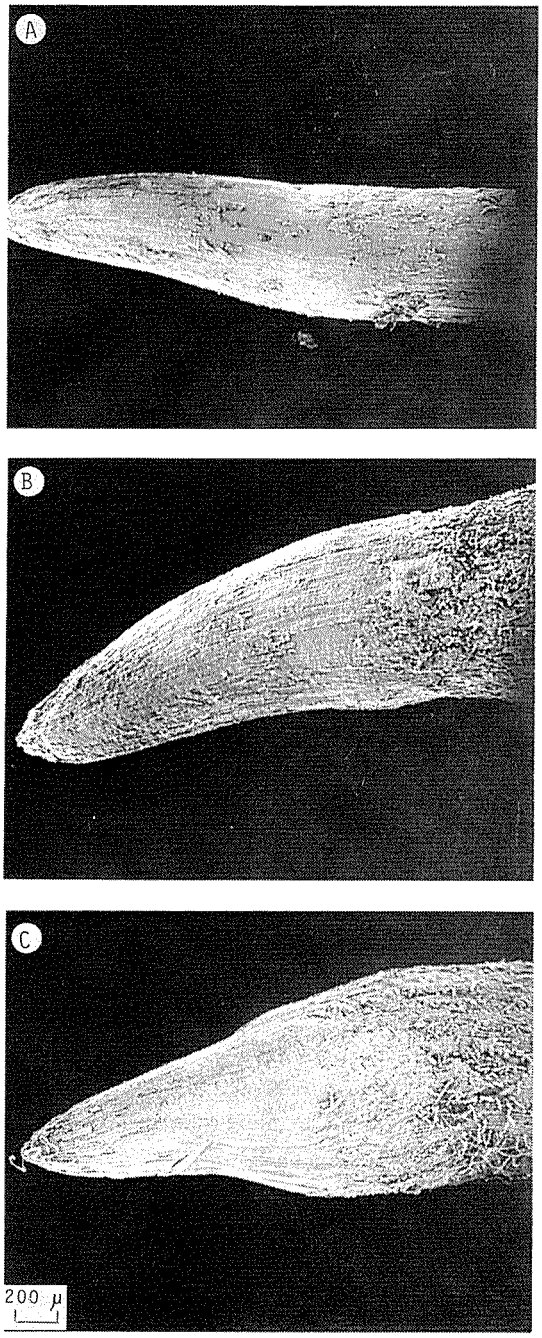

Figure 1. The apicals of fibrous roots of trifoliate orange (A), Yuzu (B) and Natsumikan (C) seedlings grown in paddy soil.

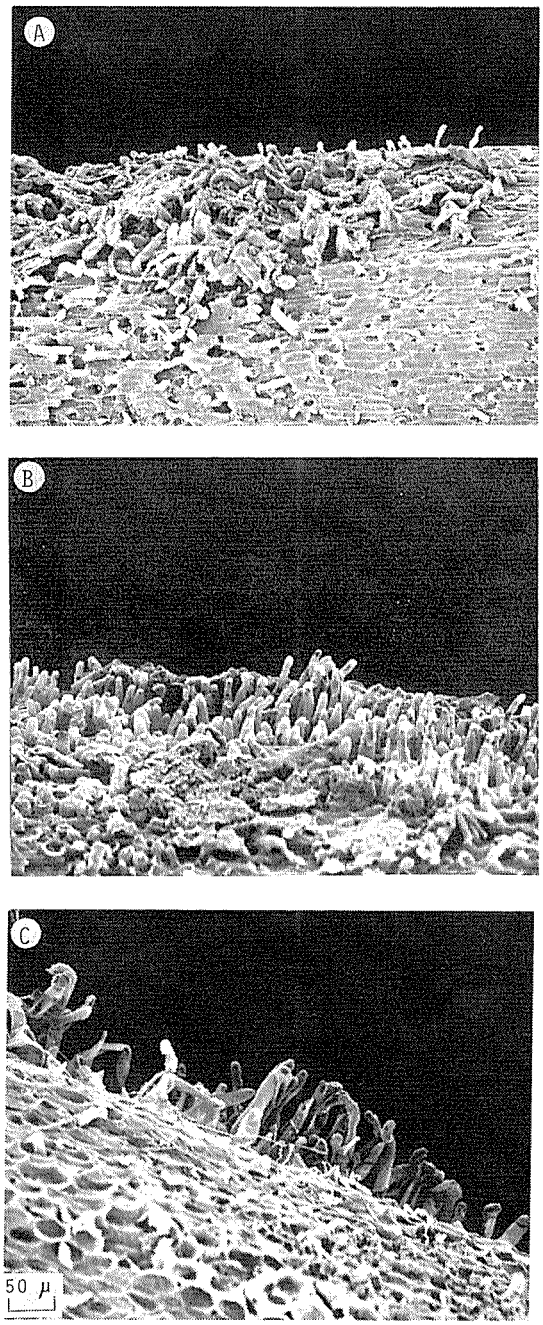

Figure 2. Dense groups of root hairs of trifoliate orange (A), Yuzu (B) and Natsumikan (C) seedlings grown in paddy soil.

were found on Natsumikan roots, but tubular root hairs were the most dominant. Generally, tubular root hairs were longer and in higher density and papillate root hairs were shorter while in lower density. Papillate root hairs are considered to be dormant, or just recently resumed gowth (2)

Medium did not affect the distribution of root hair shape, but influenced the length of root hairs (Figure 3).

OLIVE 香川大学学術情報リポジトリ

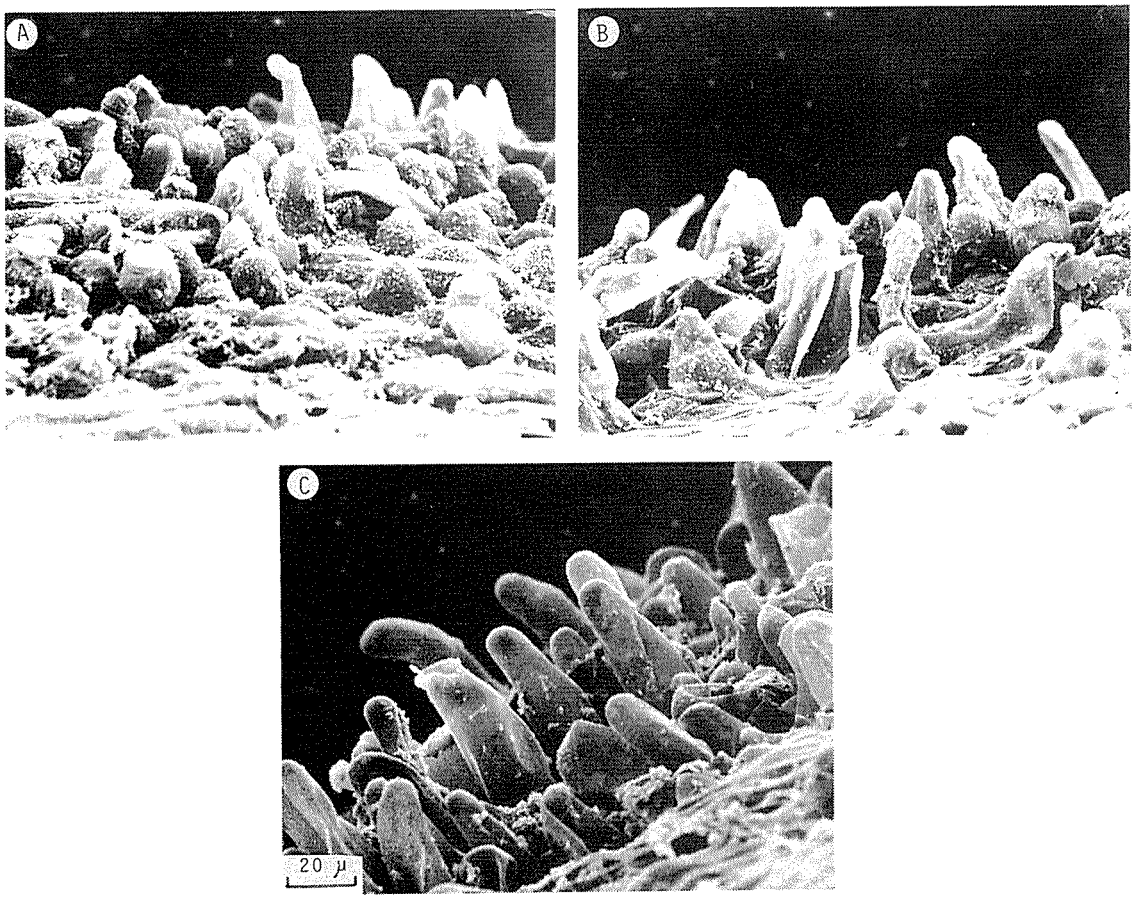

Figure 3. Root hairs of Natsumikan seedling grown in paddy soil (A), granite soil (B) and vermiculite (C).

Root hairs of seedlings grown in paddy soil and granite soil were not significantly different in length. However, root hairs of those grown in vermiculite were seemed to be longer. Vermiculite has good aeration and water holding capacity. So, as metioned above (4) longer root hairs might be formed. In addition, water content in vermiculite was sufficient to produce root hair. As sugested by Reynold (9), root hairs are produced in response to conditions of intermediate soil moisture supply when roots are growing rapidly.

LITERATURE CITED

(1) BAYLIS, G. T. S. 1970. Root hairs and phycomycetous mycorrhizas in phosphorus-deficient soil. Plant and Soil 33: 713-716.

(2) CASTLE, W. S. and A. H. KREZDORN. 1979. Anatomy and morphology of field-sampled citrus fibrous roots as influenced by sampling depth and rootstock. HortScience 14: 603-605.

(3) GERDEMANN, J. W. 1975. Vesicular-arbuscular mycorrhizae p. 575-591. In: Torrey, J. G. and D. T. Clarkson (eds.) The development and function of roots. Academic Press, London.

(4) HAYWARD, H. E. and E. M. LONG. 1942. The anatomy of seedling and roots of Valencia orange. USDA Tech. Bul. 786: 1-30.

(5) KADOYA, K., S. KIRINO, K. YAKUSHIJI, S. YOSHINO, S. CHIKAIZUMI, and K. MATSUMOTO. 1980. Observation of root hairs on citrus. Agric. Hort. 55: 445-446 (in Japanese).

(6) KLEINSCHMIDT, G. D. and J. W. GERDEMANN. 1972. Stunting of citrus seedlings in fumigated nursery soil related to the absence of endomy-

OLIVE 香川大学学術情報リポジトリ

corrhizae. Phytopathology 62 : 1447-1453.
(7) KOZAKI, I. 1981. Introduction to the citriculture in Japan. Proc. Int. Soc. Citriculture 1 : XXVIII-XXXIII.
(8) POERWANTO, R. 1987. The effect of temperature on the vegetative development of satsuma mandarin. MS Thesis. Graduate School of Agriculture, Kagawa Univ., Kagawa.
(9) REYNOLDS, E. R. C. 1975. The rootlets and their distribution, p 163-177. In : Torrey, J. G. and D. T. Clarkson (eds.) The development and fuction of roots. Acad. Press, London.
(10) SCHNEIDER, H. 1968. The anatomy of citrus, p. 1-85 In Reuther, W(ed.) The citrus industry, Vol II. Univ. Calif. Agr. Press.

(Received May 29, 1987)