Development of Efficient Screening Methods for Resistant Cucumber Plants to *Meloidogyne incognita*

Sung Min Hwang, Kyoung Soo Jang, Yong Ho Choi, Jin-Cheol Kim and Gyung Ja Choi*

Research Center for Biobased Chemistry, Korea Research Institute of Chemical Technology, Daejeon 305-600, Korea

Keywords: *Cucumis sativus*, Cultivar, Host resistance, *Meloidogyne incognita*

Root-knot nematodes represent a significant problem in cucumber, causing reduction in yield and quality. To develop screening methods for resistance of cucumber to root-knot nematode *Meloidogyne incognita*, development of root-knot nematode of four cucumber cultivars (‘Dragonsamchuk’, ‘Asiastrike’, ‘Nebaljia’ and ‘Hanelbacakadaki’) according to several conditions such as inoculum concentration, plant growth stage and transplanting period was investigated by the number of galls and egg masses produced in each seedling 45 days after inoculation. There was no difference in galls and egg masses according to the tested conditions except for inoculum concentration. Reproduction of the nematode on all the tested cultivars according to inoculum concentration increased in a dose-dependent manner. On the basis of the result, the optimum conditions for root-knot development on the cultivars is to transplant period of 1 week, inoculum concentration of 5,000 eggs/plant and plant growth stage of 3-week-old in a greenhouse (25 ± 5°C). In addition, under optimum conditions, resistance of 45 commercial cucumber cultivars was evaluated. One rootstock cultivar, Union was moderately resistant to the root-knot nematode. However, no significant difference was in the resistance of the others cultivar. According to the result, we suggest an efficient screening method for new resistant cucumber to the root-knot nematode, *M. incognita*.

**Research Article**

*Corresponding author*
Tel : +82-42-860-7434
Fax: +82-42-861-4913
E-mail: kjchoi@kRICT.re.kr

Received February 4, 2014
Revised May 9, 2014
Accepted May 14, 2014
밀도가 높아져 병해 발생이 심각하다(Cho 등, 2000a, b; Kim 등, 1998; Kim과 Han, 1998).

뿌리혹선충병의 방재는 화학적 방재(살산총 억제방재), 물리적 방재(대양염소, 은산 침지법), 경종적 방재(토양개방, 각도, 덜면응약, 저항성 품종의 육종, 저항성 윤작, 유인식물 재배), 생물적 방재(살산총 전적) 등의 다양한 방안 중에서(Chen 등, 1996; Han과 Kim, 1997; Heald과 Robinson, 1987; Kim과 Han, 1998; Park 등, 1995b) 포장재, 방재 효과 및 경제성 등을 고려하여 적합한 방재 방법들을 선택하게 된다(Chen 등, 1996; Park 등, 1995a). 선충의 화학적 방재는 최근 약효가 우수한 살산총제가 많이 개발되었지만, 토양 및 물의 이동, 유조, 농기구 등에 의해 제조모가 변형할 뿐만 아니라 살산총제의 농축 도급 및 일조 기간으로 인해 토양 미생물에 대한 해로성이 높아 토양 생태계를 불균형화 가능한 환경 문제를 발생시키기로 근본적인 방재는 아직까지는 없는 것으로 인식되고 있다(Birch 등, 1993; Kim과 Choi, 2001). 최근에는 환경친화적인 측면에서 저항성 품종을 재배하기가, 천적을 이용한 생물적 방재, 경종적 방재, 살산총물질을 함유한 식물축출물을 이용하여 방재하는 방법 등 전환 경계가 특이한 작가의 가진 새로운 살산총물질의 탐색을 강구하고 있으며(Boina 등, 2008; Gurr, 1992; Prakash과 Rao, 1997), 장기적인 환경친화적 방재방법으로 저항성 대묘이나 품종을 통한 윤작이 유류가게 이용 될 수 있을 것이다(Kinloch과 Hinson, 1972; Rhoades, 1976). 최근까지 과제국 작물에서의 뿌리혹선충의 저항성 품종 육종이 진행되고 있지만 높은 저항성을 끌 내는 계통은 아직 많지 않은 것으로 보고되어 있으며 작물의 저항성을 이용한 뿌리혹선충 방재에 관한 방법으로 스크리닝을 통해 선발된 선충 저항성 토마토 품종을 이용한 윤작 동건환경방재에 대한 연구가 이루어지고 있다(Cho 등, 1986; Choi 등, 2006; Han과 Kim, 1997; Kim, 2001; Park 등 1995a; Rhoades, 1976). 하지만 뿌리혹선충은 선충의 종과 레이스에 따라 저항성품종에 대한 저항성 반응이 상이하고 기주 범위가 매우 넓어 경제성이 높은 저항성 윤작 작물 찾기가 어렵다는 단점이 있다.

본 연구는 오이 품종의 저항성 연구 및 새로운 저항성 육종 소재를 개발하는데 있어서 Meloidogyne incognita로 동정된 뿌리혹선충(Hwang 등, 2014)으로서 접종원의 농도, 오이의 성장 시기 및 이식 시기 등의 병발 조건에 따른 4개의 오이 품종들의 뿌리혹선충병 발생을 조사하였고, 이를 통해 효율적인 뿌리혹선충병 저항성 검정 방법을 확립하고자 하였다. 또한 뿌리혹선충병 발생의 적절 조건에서 선충증인 45개 오이 품종의 뿌리혹선충병 저항성 정도를 조사하여 저항성 품종을 육성하는 기반을 구축하고 기초 자료를 제공하기 위해 연구를 수행하였으며.

재료 및 방법

토마토 뿌리혹 선충의 채집, 분리 및 동정. 토마토 뿌리혹 선충은 부여 토마토 재배 포장에서 뿌리혹이 발생한 ‘유니콘’ 토마토 품종의 뿌리를 샘플링하였다. 뿌리 혹을 흙은 몽돌 잘 섞어서 뿌리속의 뿌리혹선충의 암과 윤종을 개정된 sodium hypochlorite(NaOCl) 방법을 사용하였다. 분리방법은 깨끗이 뿌리 중 1 cm 간격으로 절단하여 200 ml의 1% NaOCl 용액이 들어있는 펌스기에 넣고 고온으로 1분간 화학식시하였다(Chen과 Lee, 2008). 그리고 박스기 내의 뿌리 짚치가, 알, 유충은 75 μm와 28 μm 체를 통사하고 28 μm 체에 걸린 이후 방화할 때까지 25°C 상온에 보관하였다. 분리한 알과 유충으로부터 추출한 DNA와 M. incognita 특이적 레이터를 혼합하여 PCR 증폭하여 단편의 크기를 1% agarose gel에서 확인하였다(Hwang 등, 2014).

식물체 준비. 다양한 조건(접종원 농도, 오이 이식 시기 및 생육 시기)에서의 뿌리혹선충 검정 실험에는 4품종인 ‘드레�虻션적’(고래곤종묘), ‘아시아스트라이크’(아시아종묘), ‘네박자’(전주종묘), ‘에르 하나님의(전주종묘)를 이용하였고, 적합한 조건에서 시판 중인 대묘 6개 품종(눈부시, ‘뉴타입’, ‘시포트’, ‘수퍼후크’, ‘유나인’, ‘온가바(EX)와 오기 39개 품종(예: 백현과, ‘일국백판’, ‘골로리작’, ‘난도소백’, ‘네박자’, ‘노다지백다기’, ‘녹아청정’, ‘대선’, ‘드레connexion’, ‘로스보이’, ‘무천산’, ‘미나서’, ‘미나서’, ‘미원백다기’, ‘백미백다기’, ‘백정백’, ‘신세대’, ‘철정’, ‘심청백다기’, ‘아시아토끼’, ‘아시아여건’, ‘아시아청장’, ‘오대백다기’, ‘일광하작’, ‘월광하작’, ‘온미에스’, ‘온백다기’, ‘일등청정’, ‘정삼작’, ‘프로주백자’, ‘곳삼작’, ‘정목백’, ‘청화후진’, ‘통일백다기’, ‘하늘백다기’, ‘한성백다기’, ‘호롱백’, ‘홍봉상작’)에 대하여 뿌리혹선충병 저항성 검정을 실시하였다.

식물체 성장. 접종원의 농도에 따른 영향과 시판증인 45개 오이 품종의 저항성 검정 실험에서의 생육 조건으로 오이 종자 를 5 × 8 육모용 연절포트(70 ml/pot, 범농시)에 원예용 상토(축축이, 농우바이오)를 채워 넣고 파종하여 윤리온실(25 ± 5°C)에서 21일 동안 재배한 이후 육모용 오이를 원예용 상토와 별규 모래가 혼합(1:1, v/v)된 플라스틱 포트(직경 9.0 cm, 높이 8.0 cm)에 이식하여 7일이 지난 이후 접종물을 접종하여 윤리온실(25 ± 5°C)에서 45일간 재배하였다. 윤리온실(25 ± 5°C)에서 생육시키기 조건에 따른 실험을 위해 오이의 이식 및 접종시키기를 동일하게 하여 파종 이후 2주, 3주, 4주 동안 재배한 식물체를 이식하여 7일 이후에 접종하였고 45일간 재배하였다. 이식시키 조건 실험을 위해서는 접종시키기를 동일하게 하여 21일 동안 재배한 후 1일, 3일, 접종 직전 이식한 식물체에 접종하여 45일간 재배하였다.
Table 1. Root-knot nematode severity of four cucumber cultivars according to inoculum concentration of Meloidogyne incognita

| Cucumber cultivar | Inoculum concentration (the number of eggs) |
|------------------|---------------------------------------------|
|                  | 500  | 1,000 | 5,000 | 10,000 | 30,000 |
| Dragonsamchuk    | 17 ± 2.1d (0.7 ± 0.2%d) | 51 ± 5.3c (1.8 ± 0.2c) | 123 ± 5.7b (6.0 ± 0.0b) | 137 ± 6.5ab (8.7 ± 0.2a) | 145 ± 7.1a (8.7 ± 0.2a) |
| Asiastrike       | 13 ± 1.2b (0.5 ± 0.0c) | 26 ± 3.3b (1.2 ± 0.2c) | 110 ± 2.5a (6.0 ± 0.0b) | 123 ± 11.1a (8.7 ± 0.5a) | 122 ± 3.1a (9.3 ± 0.2a) |
| Nebakja          | 19 ± 2.1c (0.5 ± 0.0c) | 53 ± 3.9b (1.3 ± 0.2c) | 124 ± 5.0a (6.5 ± 0.4b) | 130 ± 8.7a (8.2 ± 0.6a) | 137 ± 7.4a (8.5 ± 0.4a) |
| Hanelbakdadi     | 15 ± 4.3c (0.7 ± 0.2c) | 50 ± 7.9b (0.8 ± 0.2c) | 116 ± 7.0a (6.2 ± 0.6b) | 126 ± 6.5a (7.5 ± 0.4ab) | 132 ± 9.0a (8.2 ± 0.2a) |
| Mean             | 16 (6.0) | 45 (1.3) | 118 (6.2) | 129 (8.3) | 134 (8.7) |

1One week after transplanting, the potted 28-day-old seedlings were inoculated with *M. incognita*. The inoculated plants were incubated in a greenhouse (25 ± 5°C). Forty-five days after inoculation, disease severity of the seedlings was rated on the number of egg masses and gall index of a scale 0 to 10.
2The number of egg masses/plant. Each value represents the mean ± standard deviation of two runs with three replicates each.
3Values in the labeled with the same letter in each line are not significantly different in Duncan’s multiple range test at *P* = 0.05.
4Each value represents the mean gall index ± standard deviation of two runs with three replicates each.
Table 2. Root-knot nematode severity of four cucumber cultivars according to inoculation timing at different growth stage of plant

| Cucumber cultivar       | Inoculation timing at different growth stage of plant (days after sowing) |               |               |               |
|-------------------------|----------------------------|---------------|---------------|---------------|
|                         | 14                          | 21            | 28            |               |
| Dragonsamchuk           | 119 ± 8.2a (8.8 ± 0.6a)     | 133 ± 7.0a (8.7 ± 0.5a) | 114 ± 7.1a (8.8 ± 0.2a) |               |
| Asiastrike              | 105 ± 5.2a (8.5 ± 0.4a)     | 106 ± 11.0a (9.2 ± 0.2a) | 92 ± 4.1a (9.2 ± 0.2a) |               |
| Nebakja                 | 138 ± 5.3a (9.2 ± 0.2a)     | 131 ± 5.4a (9.0 ± 0.4a) | 132 ± 8.6a (9.2 ± 0.5a) |               |
| Hanelbakadaki           | 117 ± 14.2a (8.7 ± 0.5a)    | 117 ± 7.8a (8.2 ± 0.2a) | 125 ± 5.7a (8.7 ± 0.2a) |               |
| Mean                    | 120 (8.8)                   | 122 (8.8)     | 116 (9.0)     |               |

1One week after transplanting, the potted seedlings were inoculated with *Meloidogyne incognita*. The inoculated plants were incubated in a greenhouse (25 ± 5°C). Forty five days after inoculation, disease severity of the seedlings was rated on the number of egg masses and gall index of a scale 0 to 10.

2The number of egg masses/plant. Each value represents the mean ± standard deviation of two runs with three replicates each.

3Values in the labeled with the same letter in each line are not significantly different in Duncan's multiple range test at P = 0.05.

4Each value represents the mean gall index ± standard deviation of two runs with three replicates each.

514 days (two-leaf stage), 21 days (four-leaf stage), 28 days (six-leaf stage).

Table 3. Root-knot nematode severity of four cucumber cultivars according to days after transplanting of seedlings for inoculation of *Meloidogyne incognita*

| Cucumber cultivar       | Inoculation days after transplanting |               |               |               |
|-------------------------|--------------------------------------|---------------|---------------|---------------|
|                         | 0                                    | 3             | 9             |               |
| Dragonsamchuk           | 120 ± 9.5a (7.7 ± 0.5a)              | 115 ± 10.2a (7.0 ± 0.8a) | 109 ± 9.9a (8.8 ± 0.2a) |               |
| Asiastrike              | 79 ± 6.0a (8.0 ± 0.4a)               | 88 ± 4.2a (8.7 ± 0.5a) | 79 ± 7.9a (8.3 ± 0.5a) |               |
| Nebakja                 | 105 ± 25.7a (7.5 ± 0.7a)             | 116 ± 11.8a (7.3 ± 0.5a) | 119 ± 12.5a (7.2 ± 0.2a) |               |
| Hanelbakadaki           | 108 ± 4.5a (8.0 ± 0.8a)              | 110 ± 13.1a (7.3 ± 0.2a) | 103 ± 8.7a (7.5 ± 0.4a) |               |
| Mean                    | 103 (7.8)                            | 107 (7.6)     | 103 (8.0)     |               |

1One, three, and nine days after transplanting, the potted 28-day-old seedlings were inoculated with *M. incognita*, respectively. The inoculated plants were incubated in a greenhouse (25 ± 5°C). Forty five days after inoculation, disease severity of the seedlings was rated on the number of egg masses and gall index of a scale 0 to 10.

2The number of egg masses/plant. Each value represents the mean ± standard deviation of two runs with three replicates each.

3Values in the labeled with the same letter in each line are not significantly different in Duncan’s multiple range test at P = 0.05.

4Each value represents the mean gall index ± standard deviation of two runs with three replicates each.
| Cucumber cultivar         | No. of egg mass | Resistance reaction |
|--------------------------|-----------------|---------------------|
| Asiacheongiang           | 132 ± 7.8^a     | S                   |
| Asiauncheon              | 109 ± 16        | S                   |
| Asianogak                | 106 ± 16        | S                   |
| Asiastrike               | 105 ± 9.3       | S                   |
| Baekchimmatjjang         | 112 ± 53        | S                   |
| Baekmibakdadi            | 123 ± 3.9       | S                   |
| Cheonghwaeukjinju        | 137 ± 8.8       | S                   |
| Cheongnimmatjjang        | 112 ± 3.9       | S                   |
| Daesun                    | 102 ± 7.4       | S                   |
| Dragonsamcheok           | 105 ± 12        | S                   |
| Eumis                    | 85 ± 10         | S                   |
| Glorysamcheok            | 113 ± 9.0       | S                   |
| Gyedabaekgya             | 112 ± 9.6       | S                   |
| Haneulbaekdadi           | 112 ± 6.5       | S                   |
| Hansungbaekdadi          | 113 ± 58        | S                   |
| Heukryngsamcheok         | 105 ± 26        | S                   |
| Hodongcheongiang         | 113 ± 11        | S                   |
| Ildongcheongiang         | 104 ± 25        | S                   |
| Jelljunbaekhim           | 100 ± 11        | S                   |
| Jungboksamcheok          | 100 ± 9.3       | S                   |
| Jungsunsamcheok          | 117 ± 5.4       | S                   |
| Miinbaekdadi             | 114 ± 5.1       | S                   |
| Minicue                  | 102 ± 8.2       | S                   |
| Minisayeop               | 134 ± 4.9       | S                   |
| Mujinjing                | 120 ± 4.1       | S                   |
| Nakdongcheongiang        | 120 ± 12        | S                   |
| Nebakja                  | 120 ± 8.0       | S                   |
| Nodajbaekdadi            | 119 ± 8.0       | S                   |
| Nokyacheongcheong        | 118 ± 6.6       | S                   |
| Ohdaebaekdadi            | 102 ± 3.7       | S                   |
| Russboy                  | 140 ± 6.8       | S                   |
| Septembersemigreen       | 114 ± 58        | S                   |
| Singsingbaekdadi         | 129 ± 48        | S                   |
| Sinjeongp                | 93 ± 85         | S                   |
| Sinsade                  | 128 ± 7.4       | S                   |
| Tongilbaekdadi           | 125 ± 7.5       | S                   |
| Unchunbaekdadi           | 119 ± 59        | S                   |
| Wellbeingmatjjang        | 124 ± 16        | S                   |
| Wolhasamcheok            | 137 ± 6.6       | S                   |
| Nubusher (Root-Stock)     | 50 ± 15         | S                   |
| Newtype (Root-Stock)      | 73 ± 7.0        | S                   |
| Support (Root-Stock)      | 65 ± 48         | S                   |
| Superheukjung (Root-Stock)| 55 ± 9.2        | S                   |
| TsuyaEX (Root-Stock)      | 96 ± 64         | S                   |
| Union (Root-Stock)        | 24 ± 3.4        | S                   |

^1One week after transplanting, the potted 28-day-old seedlings were inoculated with *M. incognita*. The inoculated plants were incubated in a greenhouse (25 ± 5°C). Forty five days after inoculation, disease severity of the seedlings was rated on the number of egg masses and gall index of a scale 0 to 10.

^2Resistance reaction of cucumber cultivar was determined by the number of egg masses per plant. R, resistant, 0–14; MR, moderately resistant, 15–35; S, susceptible, more than 36.

^3The number of egg masses/plant. Each value represents the mean ± standard deviation of two runs with three replicates each.

^4Each value represents the mean gall index ± standard deviation of two runs with three replicates each.
Acknowledgement

This research was supported by Golden Seed Project Vegetable Seed Center (213002-04-1-SBZ10) and Golden Seed Project Horticultural Seed Center (213003-04-2-WTV11), Ministry of Agriculture, Food and Rural Affairs (MAFRA), Ministry of Oceans and Fisheries (MOF), Rural Development Administration (RDA) and Korea Forest Service (KFS).

References

Abad, P., Gouzy, J., Aury, J. M., Castagnone-Sereno, P., Danchin, E. G. J. and Deleury, E. 2008. Genome sequence of the metazoan plant-parasitic nematode Meloidogyne incognita. Nat. Biotechnol. 26: 909–915.

Barker, K. R., Schmitt, D. P. and Imbriani, J. L. 1985. Nematode population dynamics with emphasis on determining damage potential to crops. In: An Advanced Treatise on Meloidogyne. Vol. II, ed. by K. R. Barker, C. C. Carter and J. N. Sasser, pp. 135–148. North Carolina State University, Raleigh, North Carolina, USA.

Birch, A. N. E., Robertson, W. M. and Fellows, L. E. 1993. Plant products to control plant parasitic nematodes. Pestic. Sci. 39: 141–145.

Boina, D. R., Lewis, E. E. and Bloomquist, J. R. 2008. Nematicidal activity of anion transport blockers against Meloidogyne incognita, Caenorhabditis elegans and Heterorhabditis bacteriophora. Pest Manag. Sci. 64: 646–653.

Bridge, J. and Page, S. L. J. 1980. Estimation of root-knot nematode infestation levels on roots using a rating chart. Trop. Pest Manage. 26: 296–298.

Chen, Z. X., Dickson, D. W., McSorley, R., Mitchell, D. J. and Hewlett, T. E. 1996. Suppression of Meloidogyne arenaria race 1 by soil application of endospores of Pasteuria penetrans. J. Nematol. 28: 159–168.

Cho, H. J., Han, S. C. and Choi, D. G. 1986. Screening of peanut, pepper, cucumber, and tomato varieties for resistance to root-knot nematode, Meloidogyne hapla. Res. Rept. RDA. 28: 94–97. (In Korean)

Cho, M. R., Lee, B. C., Kim, D. S., Jeon, H. Y., Yiem, M. S. and Lee, J. O. 2000a. Distribution of plant-parasitic nematodes in fruit vegetable production areas in Korea and identification of root-knot nematodes by enzyme phenotypes. Korean J. Appl. Entomol. 39: 123–129. (In Korean)

Cho, M. R., Na, S. Y. and Yiem, M. S. 2000b. Biological control of Meloidogyne arenaria by Pasteuria penetrans. J. Asia Pac. Entomol. 3: 71–76.

Choi, D. R., Lee, J. K., Park, B. Y. and Chung, M. N. 2006. Occurrence of root-knot nematodes in sweet potato fields and resistance screening of sweet potato cultivars. Korean J. Appl. Entomol. 45: 211–216. (In Korean)

Chon, H. S., Park, H. J., Yeo, S. G., Park, S. D. and Choi, Y. E. 1996. Technical development for control on soil nematodes (Meloidogyne spp.) of oriental melon in plastic film house. RDA J. Agri. Sci. 38 (C.P.): 401–407. (In Korean)

Fassuliotis, G. 1985. The role of nematologist in the development of resistance cultivars. In: An Advanced Treaties on Meloidogyne. Vol. I, Biology and Control, ed. by J. N. Sasser and C. C. Cater, pp. 234–240. North Carolina State University, Raleigh, North Carolina, USA.

Gurr, G. M. 1992. Control of potato cyst nematode (Globodera pallida) by host plant resistance and nematicide. Ann. Appl. Biol. 121: 167–173.

Han, S. C. and Kim, Y. G. 1997. Screening of resistant red pepper varieties to Meloidogyne hapla and their resistance mechanisms. Korean J. Appl. Entomol. 36: 185–191. (In Korean)

Heald, C. M. and Robinson, A. F. 1987. Effects of soil solarization of Rotylenchus reniformis in the Lower Rio Grande Valley of Texas. J. Nematol. 19: 93–103.

Hwang, S. M., Park, M. S., Kim, J.-C., Jang, K. S., Choi, Y. H. and Choi, G. J. 2014. Occurrence of Meloidogyne incognita infecting tomato Mi cultivars and development of an efficient screening method for resistant tomato to the Mi-virulent nematode. Korean J. Hort. Sci. Technol. 32: 217–226. (In Korean)

Jung, C. and Wyss, U. 1999. New approaches to control plant parasitic nematodes. Appl. Microbiol. Biotechnol. 51: 439–446.

Kinloch, R. A. and Hinson, K. 1972. The Florida program for evaluating soybean (Glycine max L. Merr.) genotypes for susceptibility to root-knot nematode disease. Proc. Soil Crop Sci. Soc. Florida 32: 173–176.

Kim, D. G. 2001. Occurrence of root-knot nematodes on fruit vegetables under greenhouse conditions in Korea. Res. Plant Dis. 7: 69–79. (In Korean)

Kim, D. G. and Choi, S. K. 2001. Effects of incorporation method of nematicides on reproduction of Meloidogyne arenaria. Korean J. Appl. Entomol. 40: 89–95. (In Korean)

Kim, D. G. and Lee, J. H. 2008. Economic threshold of Meloidogyne incognita for greenhouse grown cucumber in Korea. Res. Plant Dis. 14: 117–121. (In Korean)

Kim, H. H., Choo, H. Y., Park, C. G., Lee, S. M. and Kim, J. B. 1998. Biological control of the northern root-knot nematode, Meloidogyne hapla with plant extract. Korean J. Appl. Entomol. 37: 199–206. (In Korean)

Kim, J. I. and Han, S. C. 1998. Effect of solarization for control of root-knot nematode (Meloidogyne spp.). Korean J. Appl. Entomol. 27: 1–5. (In Korean)

Kim, S. H., Shin, J. E., Kyung, J. L., Sheng, J. X. and Kim, B. S. 2012. Evaluation of disease resistance of cucurbit cultivars to powdery mildew and root-knot nematode. Res. Plant Dis. 18: 29–34. (In Korean)

Park, S. D., Kwon, T. Y., Choi, B. S., Lee, W. S. and Choi, Y. E. 1995a. Studies on integrated control against root-knot nematode of fruit vegetable (oriental melon and cucumber) in vinyl house.
Korean J. Appl. Entomol. 34: 75–81. (In Korean)
Park, S. D., Kwon, T. Y., Jun, H. S. and Choi, B. S. 1995b. The occurrence and severity of damage by root-knot nematode (Meloidogyne incognita) in controlled fruit vegetable field. RDA. J. Agri. Sci. 37: 318–323. (In Korean)
Prakash, A. and Rao, J. 1997. Botanical Pesticides in Agriculture. CRC Press Inc. Boca Raton. 461 pp.
Rhoades, H. L. 1976. Effects of Indigofera hirsute on Belonolaimus longicaudatus, Meloidogyne incognita, and M. javanica and subsequent crop yield. Plant Dis. Rep. 60: 384–386.
Taylor, A. L. and Sasser, J. N. 1978. Biology, Identification and Control of Root Knot Nematodes (Meloidogyne spp.). Department of Plant Pathology, North Carolina State University and United States Agency for International Development, Graphics, Raleigh, North Carolina. 111 pp.
Thorne, G. 1961. Principles of Nematology. McGraw-Hill Book Co. Inc. New York, Toronto, London. 553 pp.
Umesh, K. C., Ferris, H. and Bayer, D. E. 1994 Competition between the plant-parasitic nematodes Pratylenchus neglectus and Meloidogyne chitwoodi. J. Nematol. 26: 286–295.
van der Putten, W. H., Cook, R., Costa, S., Davies, K. G., Fargette, M., Freitas, H., Hol, W. H. G., Kerry, B. R., Maher, N., Mateille, T., Moens, M., de la Pena, E., Piskiewicz, A. M., Raeymaekers, A. D. W., Rodriguez-Echeverria, S. and van der Wurff, A. W. G. 2006. Nematode interactions in nature: models for sustainable control of nematode pests of crop plants? Adv. Agron. 89: 227–260.