〔中央農研研報　4：1－16（2004）
Bull. Natl. Agric. Res. Cent.〕

Evaluations for the Suppressive Effects of Some Commercialized Antagonistic Plant Cultivars Alone or with Joint Use of *Pasteuria penetrans* on *Meloidogyne incognita*

Takayuki Mizukubo[*1], Kei Shimizu[*2], Satoshi Aiba[*1],
Kenji Itou[*1] and Takashi Narabu[*3]

Summary

The effects of antagonistic plants on root-knot nematode, *Meloidogyne incognita* (Mi), were evaluated in a series of six field experiments. The effects of antagonistic plants in combination with application of *Pasteuria penetrans*, a biological-control agent of *M. incognita*, were also investigated.

1. The effects of the winter antagonistic plants rye *Secale cereale* cv. 'Raitaro' (Takii Seeds Co.) and wild oats, *Avena sterilis* cv. 'Negusare-Taiji' (Takii Seeds Co.) in control of root-knot nematode were evaluated in a field study conducted from November, 1997 to May, 1998 at the National Agriculture Research Center (NARC) Tsukuba, Japan. The control was a clean fallow kept free of plants. The average initial population (Pi) per 20 g soil was 100 J_2 in the field plots. Final populations (Pf) of Mi per 20 g soil after cultivation of rye, oats and clean fallow were 73, 56 and 57 J_2, respectively. The standardized reproduction indices of Mi (Pf/Pi ratio as percentage of Pf/Pi ratio of the control) in rye and oats were 117 and 98, respectively. Fresh shoot weight of oats was twice that of rye. None of the root systems of rye or oats were galled. Mi final populations in the plots of antagonistic plants and clean fallow suggested that rye and oats were not hosts and did not serve as trap crops for Mi J2. It was concluded that although the winter antagonistic cultivars 'Raitaro' (rye) and 'Negusare-Taiji' (oats) maybe useful for some nematode species, they were not effective under the conditions of the experiment in control of Mi

2. The effects of the summer antagonistic plants crotalaria, *Crotalaria brevifora* cv. 'Nekobu Killer II' (Takii Seeds Co.), guinea grass, *Panicum maximum* cv. 'Natsukaze' (Takii Seeds Co.), sudan grass, *Sorghum sudanense* cv. 'Berusudan HS9401' (Takii Seeds Co.), sorghum, *Sorghum vulgare* cv, 'Lucky Sorugou II' (Takii Seeds Co.), African marigold, *Tagetes electa* cv. 'African marigold' (Takii Seeds Co.), guinea grass, *Panicum maximum* cv. 'Soil clean' (Snow brand Co.), and sorghum, *Sorghum vulgare* cv. 'SS701' (Snow brand Co.) on control of root-knot nematode were evaluated in field experiments conducted from May, 1997 to September, 1997 at the NARC in Tsukuba. Eggplant, *Solanum melongana* cv. 'Senryo' (Takii Seeds Co.) and clean fallow were the controls. The average initial population per 20 g soil in these plots was less than 10 J_2. The final populations of Mi per 20 g soil in the plots of the seven antagonistic plants were also all less than 10 J_2. Sorghum 'SS701' had the lowest reproduction index (15 %) standardized by the clean fallow. The other antagonistic plants had indices of 100 % or more. Fresh shoot weight of sorghum 'SS701' (1.3 t per 10 a) was nearly twice as much as the weights of the other cultivars.

3. The decrease in Mi populations after 'Soil clean' and 'SS701' cultivation were measured using a bioassay

Received: 16 July, 2003
[*1] National Agricultural Research Center
[*2] Retired: formerly National Agriculture Research Center
[*3] National Agricultural Research Center for Hokkaido Region

with the Mi susceptible tomato cultivar 'Kyoryoku Beiju' (Takii seeds Co.). Seedlings were transplanted just after the antagonistic cultivars were harvested and were grown for three months. The clean fallow plot was also transplanted with tomato seedlings and served as the control. Root-knot indices of all plants were 14 to 18 (0-100 index). The Pfs of Mi per 20 g soil were also very low for all plots with values ranging from 0.5 to 2.7.

4. The persistence of the suppressive effects of antagonistic plant cultivation on Mi in the following year was measured using carrots, *Daucus carota* cv 'Asubeni Gosun' (Takii seeds Co.). Carrots were grown for 86 days from April to July 1998. Mi populations increased after carrot cultivation in all plots previously planted with the seven antagonistic cultivars. Relatively higher populations were present in plots previously planted with the two sorghum cultivars. Mi final populations in the plots that were previously clean fallow were used to standardize the reproduction index. The indices averaged 900 in plots that were previously 'SS701', 20 in plots previously 'Nekobu killer', and 40 in plots previously 'African marigold'. There were no significant differences in the total harvest (kg) of carrot or in gall indices between plots of treatments including the plots that were formerly clean fallow. The gall indices were commonly 30, irrespective of previous plantings. It was concluded that clean fallow and all the cultivars of antagonistic plants examined had similar effects on suppressing Mi in the next year of cropping.

5. The effects of the summer antagonistic plants marigold *Tagetes electa* cv. 'African Tall' (Kaneko Seeds Co.), marigold *Tagetes electa* cv. 'Tall Kongou' (Sakata Seeds Co.), sorghum *Sorghum vulgare* cv. 'Sudakkus' (Kaneko Seeds Co.), and sorghum *Sorghum vulgare* cv. 'SS701' (Snow brand Co.) on control of Mi were evaluated in a field experiment conducted from May to August, 1999 in a field at the NARC. A Mi susceptible tomato, *Lycopersicon esculentum* cv. 'Ohgata-fukuju' and clean fallow were the controls. Populations of Mi in the antagonistic plant plots declined with time. Populations of Mi at the intermediate and final sampling period did not differ from those of the fallow. No galls were observed in the root systems of the four antagonistic plant cultivars. The yield or fresh shoot weight of sorghum 'SS701' was 10 t per 10 a, which did not significantly differ from the yield of 'Sudakkusu' (8.8 t / 10 a).

6. The combined effects of *Pasteuria* and the summer antagonistic plants marigold 'African Tall', marigold 'Tall Kongou', sorghum 'Sudakkus', and sorghum 'SS701' on Mi control were measured. In the year 2000 all plots described in previous heading 5 were divided into subplots without a *P. penetrans* application (Pp -) and subplots with a *P. penetrans application* (Pp +). A commercial product of P. penetrans containing 10^9 endospore per 1 g powder was applied to the Pp + plots at the densities of 2.5 g / m^2. Tomato, *Lycopersicon esculentum* cv. 'Kyoryoku-beiju' was grown for 132 days in these plots from May to September. The gall indices of tomato roots were 80 or more (0-100 index), irrespective of the antagonistic plant cultivars previously planted. Moreover, there were no significant differences in gall indices between the previously antagonistic plant plots or between subplots with or without *Pasteuria* (Pp+ or Pp -) of the same antagonistic plant plots. There was significant yield reduction of tomato fruits in the continuous tomato cropping plots compared to plots previously planted with antagonistic plants. Neither previously planting an antagonistic plant nor application of *P. penetrans* had a significant affect on yield as expressed by total fruit yield (g) per plant, number of fruits per plant, and number of marketable fruits per plant. The Mi population in the continuous tomato-cropping plot was significantly lower than those in the antagonistic plant plots as well as the clean fallow. Mi populations did not differ significantly between plots previously planted with antagonistic plants and the clean fallow, irrespective of *P. penetrans* treatment (Pp+ or Pp-). *Pasteuria penetrans* treatment did not affect the Mi population within each of the antagonistic plant plots. It was concluded that the control effect of antagonistic plants was insufficient when Pi of Mi exceeded a certain threshold population (30 J_2 per 20 g soil just before the cultivation of an antagonistic plant). There was no synergistic effect between antagonistic plants and *P. penetrans* treatment on control of Mi in the first year of the *Pasteuria* application.

や線虫の初期密度が高い場合に，線虫防除をただひとつの手段にだけ頼ることは危険である．対抗植物は線虫防除の有力な手段の一つではあり，環境保全型防除の一翼を担うものであるが，他の手段と同様，その線虫防除効果には一定の限界がある．対抗植物も体系防除のなかで合理的な利用を図っていく必要がある．

Ⅵ　摘　要

1）冬作線虫対抗植物の「ライ麦ライ太郎」，野生エンバク「ネグサレタイジ」のサツマイモネコブセンチュウ（以下ネコブセンチュウまたは線虫と略称）に対する防除効果評価試験栽培を1997年11月から1998年5月の間に実施した．対照を休耕とした．最終密度（60頭前後／土20g）は休耕と同様高かった．対照区を基準としたエンバクとライムギの線虫補正密度指数は，それぞれ117および98であり，密度の変動も休耕と同様であった．エンバクの生草重はライムギの約2倍であった．供試作物の根系に根こぶは認められなかった．供試したエンバクとライムギの品種はネコブセンチュウの非寄主であり，線虫をトラップして土壌中の密度を低下させる機能がないと考えられることから，この線虫の防除には活用できない．

2）夏作線虫対抗植物のクロタラリアの「ネコブキラーⅡ」，ギニアグラス「ナツカゼ」，スーダングラス「ベールスーダンHS9401」，ソルゴー「ラッキーソルゴーⅡ」，マリーゴールド「アフリカンマリーゴールド」，ギニアグラス「ソイルクリーン」，ソルゴー「SS701」（商品名「つちたろう」）のネコブセンチュウ防除評価試験を1997年に実施した．対照はナス「千両2号」と休耕区とした．7種の夏作対抗植物栽培区の線虫密度は定植前も栽培終了後も10頭以下の低いレベルであった．概して対抗植物栽培区の線虫補正密度指数は休耕と同程度か高かったが，ソルゴー「SS701」栽培区の線虫の補正密度指数は休耕区より著しく低かった．本試験の線虫密度は初期値も最終値も一桁の低密度であったため，サンプリング誤差，線虫分離誤差が重なって補正密度指数の差が過大に表現された可能性がある．生草重はソルゴー「SS701」が最も重く，10a換算で約13tの収量であった．他草種はその半分以下の収量であった．

3）上記試験のソイルクリーン，SS701および対照の休耕区跡に試験終了直後の9月から3ヶ月間トマト「強力米寿」を栽培し，線虫防除効果を生物検定した．根こぶ指数は3処理区とも15前後の低い値であり，トマト栽培後の線虫密度も3処理区で3頭／20g土以下の低い密度であった．

4）対抗植物栽培翌年の線虫密度抑制効果の持続性を評価するため，1998年に上記7種線虫対抗植物栽培区跡にニンジン「アスベニ五寸」を4月から86日間栽培した．ニンジン栽培後は全区で線虫密度が上昇した．根こぶ指数は全体に軽微（30前後）であった．対抗植物跡区および休耕跡区の処理区間には線虫密度，総収量，根こぶ指数の全てについて有意差が無かった．供試した対抗植物はいずれも翌年までネコブセンチュウの防除効果を維持したが，草種間に防除効果の差がなく，休耕と同等の防除効果を示した．

5）夏作線虫対抗植物のマリーゴールド「アフリカントール」，同トール混合，ソルゴー「スダックス」および同「SS701」のネコブセンチュウ防除効果評価試験栽培を1999年の5月から89日間実施した．ネコブセンチュウ感受性品種のトマト「大型福寿」および休耕を対照とした．線虫密度は対抗植物栽培区および休耕区で経時的に低下した．中間調査時点および栽培終了時点の4種の対抗植物区におけるネコブセンチュウの実密度および補正密度指数は，常に休耕区の同線虫の密度と同等であった．4種対抗植物の根には根こぶが認められなかった．ソルゴー「SS701]の総生草重（10t）とスダックスの総生草重（8.8t）は有意に異ならなかった．

6）上記試験区を次年度（2000年）にそれぞれ2等分し，通常の栽培区とパスツーリアの製剤を処理する区を設けて，線虫害抑制に及ぼす対抗植物とパスツーリアの組み合わせ効果の判定に供した．これらの区にトマト「強力米寿」を5月から132日間栽培した．常法の5段階（0～4）の調査に基づく根こぶ指数は，どの処理区でも80以上と高くなり，ネコブセンチュウ防除効果は持続しなかったと判断された．根こぶ指数は，トマト連作区を除き，前作の

対抗植物の間で有意に異ならず，同一対抗植物の栽培跡のパスツーリア処理区と無処理区間には有意差が無かった．前作の対抗植物の種類，パスツーリア処理の有無はトマト果実収量（株当たり総収量，個数および可販個数）に影響しなかった．トマト連作区ではパスツーリアの処理の有無にかかわらず，休耕を含めた他の全ての処理区より著しく減収した．収量，根こぶ被害，線虫密度に関するパスツーリアと対抗植物の処理の相乗効果は施用初年度には認められなかった．

引　用　文　献

1．安達　宏・奈良部　孝・百田洋二（1992）毛状根によるサツマイモネコブセンチュウの培養．応動昆，36，225-230.

2．荒城雅昭・林田至人・須藤　允（1990）市販飼料作物の線虫抑制効果．九病虫研会報，36，129-131.

3．Bergson, G. B.（1971）Response of muskmelon to fumigation for control of *Meloidogyne incognita* following one year of a non host crop. Pl. Dis. Reptr., 55, 55-56.

4．近岡一郎（1983）キタネグサレセンチュウによる作物被害と防除に関する研究，特に対抗植物の利用について．神奈川農総研報，125，1-72.

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

6．Hackney, R.W., and O.J. Dickerson（1975）Marigold, castor bean, and chrysanthemum as controls of *Meloidogyne incognita* and *Pratylenchus alleni*. J. Nematol., 7, 84-90.

7．橋爪　健（1995）緑肥を使いこなす．農文協，東京，132pp.

8．橋爪　健（1998）「つちたろう」（SS701）の成績紹介と使い方　＝サツマイモネコブセンチュウ対抗ソルゴー＝．牧草と園芸，46(6)，10-13.

9．Kasumimoto, T., R. Ikeda, and H. Kawada（1993）Dose response of *Meloidogyne incognita* infected cherry tomatoes to application of *Pasteuria penetrans*. Jpn. J. Nematol., 23, 10-18.

10．北上　達・大久保憲秀・山本敏夫（1993）*Crotalaria spectabilis*を対抗植物としたサツマイモネコブセンチュウの防除技術．三重農技センター研報，21，13-20.

11．古賀成司・古閑孝彦（1981）ネコブセンチュウの耕種的防除法に関する研究．熊本農試研報，7，51-91.

12．Miller, P. M. and J. F. Ahrens（1969）Influence of growing marigolds, weeds, two cover crops and fumigation on subsequent populations of parasitic nematodes and plant growth. Pl. Dis. Reptr., 53, 642-646.

13．水久保隆之（2000）最近の線虫研究の動向と線虫問題．植物防疫，54, 11-22.

14．水久保隆之（2001）線虫防除剤ーパストリア水和剤の利用ー．農及園，76，162-169.

15．水越　亨（1997）北海道のハウス果菜類に発生したサツマイモネコブセンチュウの防除対策．第4報　対抗植物の効果．北農，64(1)，32-38.

16．宮田将秀・大沼　康（1994）マリーゴールドの間植によるキュウリのサツマイモネコブセンチュウ防除．宮城農セ報，60，39-47.

17．西沢　務（1990）線虫の天敵細菌．植物防疫，44，524-530.

18．農林水産技術会議事務局（1977）連作障害要因に関する研究．研究成果，98，204 p.

19．農林水産技術会議事務局（1981）地力維持,連作障害克服のための畑地管理技術指針，505 p.

20．大林延夫（1989）ダイコンを加害するキタネグサレセンチュウの防除技術に関する研究．神奈川園試研報，39，1-90.

21．大石剛裕・小林義明・池田二三高・杉山芳浩・水口長八（1993）対抗植物とD-D剤によるヤマトイモのネコブセンチュウの防除効果．関東病虫研報，40，303-304.

22．大島康臣（1989）病害虫雑草制御技術　1．生