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Development of a Practical Banker Plant System for Aphid Control in Commercial Greenhouse Crops in Japan

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Abstract

A banker plant system can provide a continuous reservoir of natural enemies in advance of an outbreak of the target pest. In Europe, wheat or barley seedlings (the banker plants) are used to rear aphids that do not target the crop plant. These aphids are in turn used as hosts of the aphid parasitoid *Aphidius colemani*, which parasitizes the pest aphid well. During 2002 through 2005, we have been developing a similar banker plant system for controlling aphids in greenhouse crops in cooperation with growers in Kochi Prefecture, where is one of the largest regions for the production of greenhouse vegetables (e.g., eggplant and sweet pepper) in Japan. The cotton aphid *Aphis gossypii*, green peach aphid *Myzus persicae*, and thrip *Thrips palmi* are major pest insects of these crops. The minute pirate bug *Orius strigicollis* has been used in integrated pest management programs to control the thrip. However, insecticides sprayed against the aphids are detrimental to *O. strigicollis*.

In order to protect *O. strigicollis*, a banker plant system has been developed to reduce the use of insecticides to less than 1/10 of the area of each greenhouse throughout the main harvesting season (February to May). In the initial field trial year, wheat was planted at one location (ca. 0.2 m^2) per 1000 m^2 in December. A month later, ca. 2000 bird cherry-oat aphids, *Rhopalosiphum padi*, were placed on the wheat, and a few week later ca. 500 adult parasitoids, *A. colemani*, were introduced. Approximately two months later, the banker plants were replanted and bird cherry-oat aphids were reintroduced. Successful pest aphid control was obtained in about one-third (27 of 76) of the greenhouses. Full chemical insecticide use was required in the remaining greenhouses. We assumed that the banker plant system was unsuccessful in these cases because of (1) the failure or delay of the bird cherry-oat aphids and parasitoids to settle, (2) the occurrence of secondary parasitoids that parasitized the introduced parasitoids, (3) the occurrence of pest aphids (*Macrosiphum euphorbiae* and *Aulacorthum solani*) that were not hosts of the introduced parasitoid, and/or (4) an insufficient number of banker plant plantings. During the subsequent growing seasons, the banker plants were introduced one month earlier in at least four locations per 1000 m^2. These trials resulted in successful aphid control in two-thirds of the greenhouses. In 2005, this banker plant system was in use in 226 commercial greenhouses in Kochi Prefecture.

Key words: banker plant system, aphid control, *Aphidius colemani*, commercial greenhouse crops

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Introduction

In the production of greenhouse vegetables in Japan, aphids are one of the most serious pest insects. Aphids are difficult to control during the long growing periods in the commercial greenhouses of eggplants and sweet peppers, because they are too small for growers to quickly identify during the early stages of colonization, and they multiply very rapidly. When natural enemies are utilized to control aphids, determining the appropriate timing, dosage, distribution and frequency of release is difficult.

A banker plant system can provide a continuous reservoir of natural enemies in advance of an outbreak of the target pest, or even in advance of the invasion of target pests into the greenhouse. According to van Lenteren (1995), the idea behind the banker plant system is that non-crop plants are placed in the greenhouse with a host insect (that is not a pest of the target crop) that serves as food source and reproduction host of parasites or predators. In Europe, wheat or barley seedlings (the banker plants) are used to rear the bird cherry-oat aphid *Rhopalosiphum padi* (Linne), an aphid that does not damage the crop plant. This aphid is a host of the aphid parasitoid *Aphidius colemani* Viereck, a parasitoid with a host range of 65 species including the cotton aphid *Aphis gossypii* Glover and green peach aphid *Myzus persicae* (Sulzer) (Takada, 1998). This system was developed for the protection of cucumber plants grown in greenhouses against the cotton aphid (Bennison and Corless, 1993). In Japan, however, there have been little attempts to develop a practical banker plant technique.

Kochi prefecture is one of the largest regions in Japan for the production of greenhouse vegetables such as eggplant and sweet pepper. The thrips *Thrips palmi* Karny, cotton aphid, and green peach aphid are major pest insects of these crops. The minute pirate bug *Orius strigicollis* (Poppius) has been used in integrated pest management (IPM) programs to control the thrips. However, insecticides sprayed against the aphids are detrimental to *O. strigicollis*. In order to protect *O. strigicollis* populations, the use of natural enemies of the aphids is necessary.

We have been developing a practical banker plant technique for controlling aphids on commercial greenhouse crops. The effectiveness of the banker plant system like that used in Europe was evaluated on eggplant in experimental greenhouses. We have also attempted to expand this banker plant technique on a larger scale in cooperation with growers in Aki City, Kochi Prefecture. Our goal was to reduce the use of chemical insecticides against aphids to less than 1/10 of the area of each greenhouse throughout the main harvesting season (February to May).

Materials and Methods

1. Control of cotton aphid *Aphis gossypii* on eggplants in experimental greenhouses using the aphid parasitoid *Aphidius colemani* in a banker plant system

Effectiveness of a banker plant system for the protection of eggplants against cotton aphids was evaluated at experimental greenhouses in Shikoku National Agricultural Experiment Station (Zentsuji, Kagawa Prefecture). In four greenhouses, which had areas of 50 m^2 each, twenty eggplants were planted on October 16, 2000. On March 27, 2001, 50 cotton aphids were placed on each of the eggplants. We designated this condition as an early stage of pest aphid colonization. Changes in the number of pest aphids were examined in following four different treatments: 1) no release of the parasitoid *A. colemani* (No aphid parasitoid release), 2) weekly release of 40 adults of the parasitoid (26 females and 14 males) for 3 weeks immediately after the settlement of cotton aphid (Inoculative release), 3) weekly release of 40 parasitoid adults for 3 weeks together with wheat seedlings which were infested with ca. 2000 bird cherry-oat aphids (Banker plant system), 4) the same as treatment 3 except 20 parasitoids were released on a weekly basis. At weekly intervals, the number of cotton aphids and mummified aphids on 10 eggplants at each greenhouse was examined. The mummified aphids were marked in order to prevent multiple scoring.

The cotton and bird cherry-oat aphids were obtained from colonies maintained in our laboratory. These aphids originated from insects that were field-collected from an experimental field of the Shikoku National Agricultural Experiment Station in 1999. The cotton and bird cherry-oat aphids were reared on eggplant and wheat seedlings, respectively, at 25℃ under a photoperiod of 16L:8D. The bird cherry-oat aphid could continue to reproduce parthenogenetically on wheat plants even at 15℃ under a photoperiod of 8L:16D.

The aphid parasitoid *A. colemani* was purchased from a commercial supplier (Tomono-aburabachi AC). When allowed to live in a relatively large space (at least 1.9 m^2), this parasitoid prefers cotton aphids on eggplants as a host rather than the bird cherry-oat aphids on wheat plants. However, when confined to a smaller space (0.07 m^2), this species parasitizes these aphids without preference. In 50 m^2 greenhouses, *A. colemani* populations increased ca. 50-fold on banker plants within one generation.

2. Controlling aphids in commercial greenhouses using a banker plant system

The trials to develop a practical banker plant technique were performed in commercial greenhouses in Aki City, Kochi Prefecture. Seedlings of greenhouse crops such as eggplant and green pepper were planted in early September. The main harvesting seasons of these crops extended from February to May of the following year. The reduction of insecticide use during the main harvesting seasons is the primary goal of the growers. In order to do this, the growers involved in these trials released the minute pirate bug *O. strigicollis* against pest thrips such as *T. palmi*. Outbreaks of aphids begin to occur from mid-February in normal years.

In the initial field trial year (2001-2002), the banker plant system was applied in 76 commercial greenhouses. The areas of these greenhouses were mostly more than 1000 m^2. The use of the banker plant systems was scheduled such that the control agent *A. colemani*, could be settled by mid-February. Wheat was planted at one location (ca. 0.2 m^2) per 1000 m^2 by mid-December, 2001. A month later (mid-January, 2002), ca. 2000 bird cherry-oat aphids *R. padi*, were placed on the wheat. About 500 parasitoid adults per a greenhouse were released by the beginning of February. The growers were advised to replant the wheat and reintroduce bird cherry-oat aphids approximately two months later (around March or April). Bird cherry-oat aphids were reared at the National Agricultural Research Center for Western Region (Ayabe, Kyoto Prefecture), and were provided to the growers. The growers purchased the aphid parasitoids from commercial suppliers.

The growers used chemical insecticides against pests such as thrips and aphids according to the grower's own empirical thresholds. The main insecticides that were sprayed during the trials were pyriproxyfen and spinosad against thrips, and pymetrozine against aphids. The applications of insecticides were carefully recorded. The use of insecticides against the aphids was categorized as follows: full use, partial use (i.e., less than 1/10 of the area of each greenhouse), and no use throughout the main harvesting season (February to May). Most growers applied chemical pesticides at full or partial use. Cases where the insecticides were sprayed between 10% and 90% of the greenhouse were categorized as full use because it was assumed that these levels would have a detrimental effect on the *O. strigicollis* populations. Partial and no insecticide use were recognized to be successful control of pest aphids.

More than 20 greenhouses were surveyed every month in order to record the presence of banker plants, bird cherry-oat aphids and mummified aphids on the wheat plants as well as the occurrence of pest aphids on crop plants, and secondary parasitoids. Because the number of greenhouses was too large for us to examine directly, observations made by the growers were incorporated into our findings. In total, data collected from 19, 29, and 18 greenhouses was used for the evaluation of the application regimes, occurrence of pest aphids, and occurrence of secondary parasitoids, respectively.

地の施設栽培において，各種害虫に総合的に対処するIPM技術の組み立ての中で，アブラムシ対策技術として有効に利用されていくと期待できる．しかし，マニュアルで示したことは基本的なことであり，作目や作型，生産者の状況に適合した技術に改変していく必要がある．そのとき，大切なのは，技術を使う人と，広める人，そして研究する人の協力である．生産者の参加の下で地域に適合した形へとバンカー法が発展していくことを願うものである．

一方，ここで用いたコレマンアブラバチは導入天敵であり，日本への導入の初期には在来種への影響が懸念されていた（Takada[41]）．ショクガタマバエに関しても，製剤化されているものは海外系統であると考えられる（Shirota et al.[36]）．この研究を始めた当時は，化学合成農薬に代わる防除技術として天敵を使いやすくすることが重要という認識で，技術の実用化研究を進めてきた．10年経過した現在では，天敵利用はある程度普及し，また導入生物の環境への影響についての認識も浸透した．そして，日本在来の天敵の製剤化もなされるようになった．アブラバチ類に関しては，日本在来のギフアブラバチ（太田[29]）やダイコンアブラバチ（長坂ら[19]）でバンカー法が検討されている．アブラコバチ類についても在来系統の製剤化とバンカー法が検討されている（巽ら[44]）．また，ショクガタマバエについても国内系統の育成が始まっている（安部ら[1]）．

こうした日本在来の天敵を用いたアブラムシ対策としてのバンカー法だけでなく，別の害虫に対する別の在来天敵を使ったバンカー法の開発も必要とされている．そのときに，本稿に記したコレマンアブラバチを用いたバンカー法の検討過程が，効率的な研究開発に資することを期待する次第である．

謝　辞

この研究を開始するにあたり，中央農業総合研究センターの矢野栄二博士（現在，近畿大学）から，当時では稀少な関連文献をご紹介いただくとともに，有益なご助言をいただいた．そして，本稿に対してもご指導をいただいた．また，アブラバチ類ならびにそれに寄生する二次寄生蜂については，当時，京都府立大学の高田肇教授から懇切なご指導をいただいた．本課題遂行中には，長坂がアメリカへの留学や綾部への転勤を経験したにもかかわらず，IPMプロジェクト，ナスサブチームの皆様（九州大学：高木正見教授，（当時）高知県農業技術センター：高井幹夫氏，（当時）野菜茶業研究所：浜村徹三博士）には暖かく支えていただいた．近畿中国四国農業研究センター総合研究第4チーム在籍時には，本務の地域総合研究と両立できるよう野菜部四方平和部長（現在，生物系特定産業技術研究支援センター），ならびに故田中和夫博士，尾島一史氏，および，桑田将能氏はじめとする業務科の皆様に多大なご協力をいただいた．また，本稿とりまとめに際しては，中央農業総合研究センター，総合的害虫管理研究チームの守屋成一チーム長をはじめとする諸氏から貴重なご意見をいただいた．特に光永貴之博士にはデータの統計処理についての相談に多くの時間を割いていただいた．最後に，多くの生産者の皆様，ならびに塹江まほ氏をはじめとする普及センターの皆様から多大なるご協力をいただいたおかげで，この仕事を成し得ることができた．これらの皆様に心より感謝申し上げたい．

摘　要

日本の促成栽培施設において試みられている天敵利用を基幹技術としたIPM構築に資することのできる個別技術として，アブラムシ対策としてのバンカー法の実用化研究を実施した．バンカー法では，害虫とはならない天敵の代替餌（代替寄主）をその寄主植物とともに導入し，そこで天敵を維持・増殖しておく開放型飼育システムを用いて，施設内での害虫の発生前から天敵を長期継続的に放飼する．害虫侵入直後の低密度の状態で天敵を働かせることができるため，安定した防除効果が期待できる．アブラムシ対策としてのバンカー法には，ヨーロッパですでに実用化されている方法がある．ムギ類で維持する代替寄主ムギクビレアブラムシを用いて，天敵コレマンアブラバチを維持しつつ，ハウス内に継続

的に放飼する方法である．この方法を，日本の栽培環境や作業者の状況に適合した形に改変し，普及技術とすることが，本研究の目的である．

日本の促成栽培では冬期を経るところがヨーロッパでの栽培と大きく異なっているため，天敵を利用する場合には低温と休眠性が問題となる場合がある．この点について，室内実験および圃場試験で確認したところ，コレマンアブラバチは15℃の条件でも十分増殖し，実際に秋期の無加温ハウス内でも世代間増殖率は約50倍であった．また，害虫であるワタアブラムシと代替寄主であるムギクビレアブラムシへのコレマンアブラバチによる選好性を比較したところ，小さな空間ではほぼ同等であるが，広い空間では害虫の方を好むことがわかり，この系は天敵維持と害虫防除に都合の良いことが支持された．そして，$50m^2$の実験ハウスにおいて，ナス上のワタアブラムシに対する防除効果を，バンカー法での天敵放飼，接種的天敵放飼（通常の天敵放飼法），天敵無放飼で比較したところ，促成栽培でアブラムシ類が問題となる秋期，春期ともにバンカー法で最も害虫密度を抑えることができた．また，秋期から春期まで作を通してバンカー法を継続した場合には，天敵コレマンアブラバチに寄生する二次寄生蜂が春に向かって増加し，アブラムシ防除に失敗する場合があることも，実験圃場で確認した．

高知県のナス・ピーマン産地では天敵利用を基幹技術としたIPMを模索していたので，ここにアブラムシ対策としてのバンカー法を組み込むための現地実証試験を，10a規模の生産施設70カ所以上の協力を得て実施した．収穫盛期にあたる2月から5月において，アブラムシ防除薬剤散布を部分散布（施設面積の1/10以下の散布）に抑えることができれば，バンカー法による防除が成功したと見なした．1年目の試行では，成功は1／3の施設でしか得られなかった．失敗の主な原因は①バンカー法の実施スケジュールがタイトであったこと，②二次寄生蜂の発生，③コレマンアブラバチが寄生できないジャガイモヒゲナガアブラムシ等の発生，④バンカーの設置箇所数の不足であった．特に，二次寄生蜂については，3月よりも前にバンカー上での全寄生蜂の50％以上を占める状況となった場合には，バンカー法に失敗する確率が高まることもわかった．こうした問題点に対して，①導入に1ヶ月余裕を持ったスケジュールとし，②アブラムシの種類を見分け，そのコロニーの拡大の様子を観察して，必要に応じて部分散布等を行うこと，③バンカーを10ａあたり4カ所以上設置するといった対応策を採った．その結果，2年目以降の試行では，成功する施設が2／3以上となった．

こうした取り組みの結果，バンカー法によるアブラムシ類防除の効果，ならびに労力軽減効果について，生産者の8割以上が満足する技術となった．この技術によりアブラムシ類への農薬の散布量を減少させることが可能となった．バンカー法は，天敵を安定して利用できる環境づくりに寄与することから，ナス・ピーマンにとどまらず，他の施設野菜においても天敵利用を基幹技術としたIPM構築に活用され始めている．

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During the subsequent trial years, the banker plants were introduced one month earlier (in November) in at least four locations (ca. 0.2 m^2 for each) per 1000 m^2. In this case, the establishment of the banker plant system, including settlement of the parasitoids, was scheduled to complete by the end of January. In addition, the banker plants were changed to barley instead of wheat to avoid mildew disease. Before the beginning of the growing seasons, examples of the successful and unsuccessful control of aphids were explained to the growers. In addition, we distributed informational pamphlets, which carried photographs of a good banker plant example, pest aphids, primary parasitoid, and secondary parasitoids, as well as revised schedule of the banker plant technique.

During the second trial year (2002-2003), the banker plant system was applied in ca. 150 commercial greenhouses. At the end of the growing season, representatives of 84 of these greenhouses answered a questionnaire that we provided. During the third and forth years (2003-2004 and 2004-2005), the banker plant technique was applied in ca. 200 greenhouses. At the end of the trial years, representatives of only 21 of these greenhouses answered our questionnaire. A survey of the presence of banker plants, bird cherry-oat aphids and mummified aphids on the wheat plants, occurrence of pest aphids on the crop plants, and secondary parasitoids were made on a monthly basis of 9-25 greenhouses during each trial year.

Results

1. Control of cotton aphid *Aphis gossypii* on eggplants in experimental greenhouses using the aphid parasitoid *Aphidius colemani* in a banker plant system

In the greenhouse in which parasitoids were not released, a 3- to 9-fold weekly increase in the mean number of cotton aphids was found (Fig. 1, A). Under this condition, the mean number of aphids per plant was over 5000 at the third week post aphid settlement. At the fourth week post settlement a chemical insecticide was sprayed on the plants, resulting in no detectable cotton aphids.

In the greenhouse that underwent inoculative releases of parasitoids, the mean density of cotton aphids reached a maximal level of 954 aphids per plant at four weeks post aphid settlement (Fig. 1, B). Subsequently, at five weeks post aphid settlement, the mean number of mummified aphids increased to 134 per plant, and the number of cotton aphids decreased. At the sixth week post aphid settlement, cotton aphids were not detected.

In greenhouses where the banker plant system was applied, the mean number of cotton aphids per plant increased 2- and 3-fold following the aphid settlement (Fig. 1, C, D). However, by the second week post settlement there was a dramatic decline in the cotton aphid populations under both treatments, and no cotton aphids were detected by the third week post settlement. These results demonstrated that the banker plant system was more effective than inoculative release of the aphid parasitoids.

2. Controlling aphids in commercial greenhouses using a banker plant system

First trial year

During the first year of field trials of the banker plant technique, 49, 25, and 2 greenhouses underwent full, partial, and no chemical insecticide treatment, respectively, throughout the main harvesting season (February to May). As a result, successful pest aphid control was obtained in about one-third (27 of 76) of the greenhouses (Fig. 2).

The occurrence of green peach aphid *M. percicae* or cotton aphid *A. gossypii* was observed in 79% of the greenhouses (23 of 29) during the main harvesting season. Glasshouse-potato aphids *Aulacorthum solani* (Kaltenbach) or potato aphids *Macrosiphum euphorbiae* (Thomas), which cannot be parasitized by *A. colemani*, were found in 34% of the greenhouses (10 of 29). In addition, secondary parasitoids, which parasitize the control agent *A. colemani*,

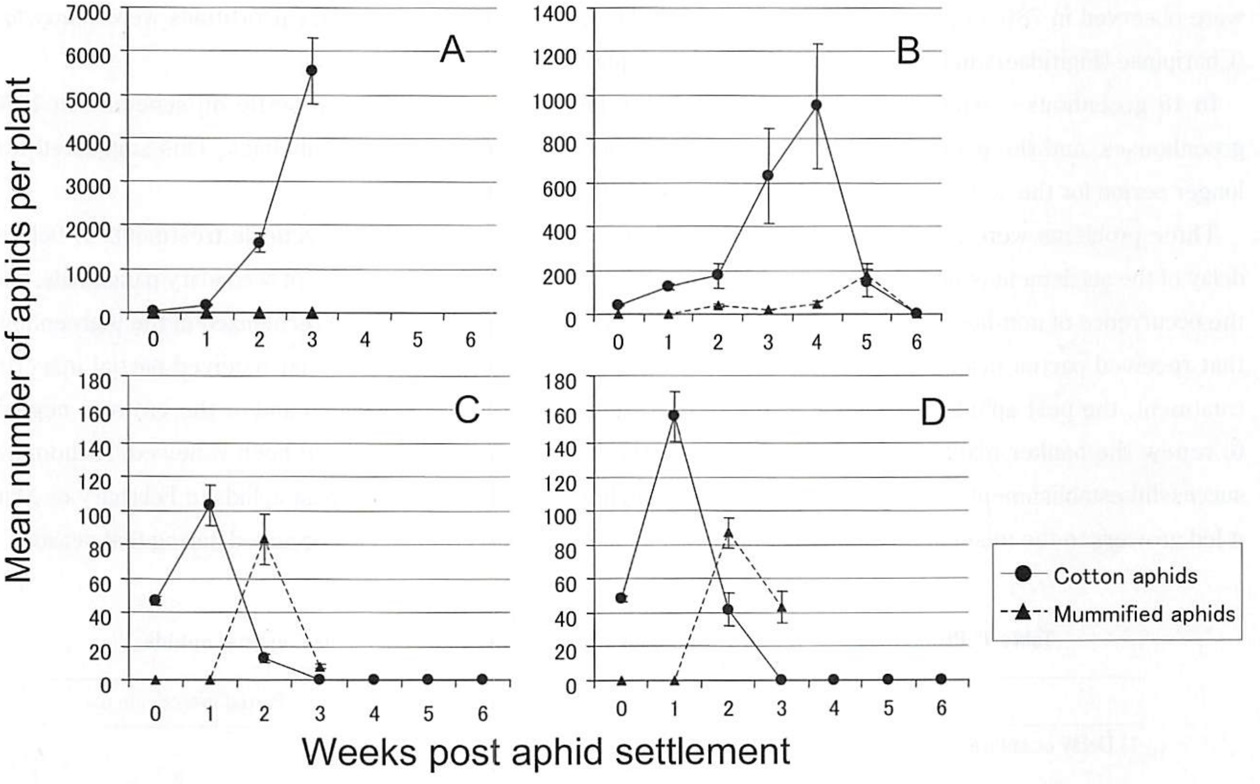

Fig. 1 The weekly changes in aphid density at the four experimental greenhouses.
A: No aphid parasitoid release, B: Inoculative release of aphid parasitoids, 40 parasitoids released per week, C: Banker plant system, 40 parasitoids released per week, D: Banker plant system, 20 parasitoids released per week. Bars indicate the standard error of mean.

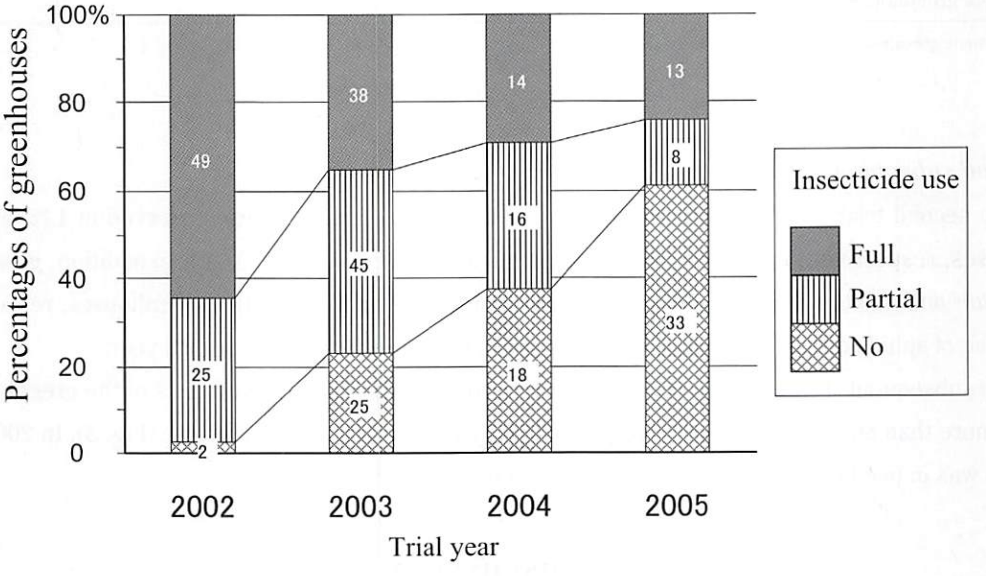

Fig. 2 Insecticide use against aphids through the main harvesting season during each of the four trial years.
The greenhouses were categorized by the type of chemical insecticide treatment they received: full insecticide use against aphids (Full), partial insecticide use, i.e., less than 1/10 of the area of each greenhouse (Partial), and no insecticide use (No) throughout the main harvesting season (February to May). Partial and no insecticide use still resulted in successful control of all four species of pest aphids.

were observed in 78% of the greenhouses (14 of 18). The main species of secondary parasitoids were *Alloxysta* sp. (Charipinae (Figitidae)) and *Dendrocerus laticeps* (Megaspilidae).

In 18 greenhouses where continuous records were kept, the aphids failed to settle on schedule in 11% of greenhouses, and the parasitoids failed to settle on schedule in 56% of the greenhouses. This suggested that a longer period for the settlement of aphids and parasitoids was necessary.

Three problems were recognized in the 13 greenhouses which received full insecticide treatment: 1) failure or delay of the settlement of bird cherry-oat aphids and/or *A. colemani*, 2) the occurrence of secondary parasitoids, and 3) the occurrence of non-host aphids for *A. colemani* (Table 1). Similar problems were recognized in the 9 greenhouses that received partial insecticide treatment. In addition, in 5 of the greenhouses that received partial insecticide treatment, the pest aphids were found at the farthest distances from banker plants and/or the growers neglected to renew the banker plants in April, at which time the banker plants should have been renewed. Although the successful establishment of the banker plant system might induce the absence of pest aphids in February or March, it led growers to the misunderstanding that no invasion of aphids into greenhouses occurred during that season.

Table 1 Problems observed in greenhouses that required insecticide use against aphids.

	Full insecticide use	Partial insecticide use
1) Delay or failure of establishment of banker plant system	7	2
2) Occurrences of secondary parasitoids, which parasitize on *A. colemani*	5	6
3) Occurrences of glasshouse-potato aphids or potato aphids, which cannot be parasitized by *A. colemani*	2	4
4) Others <number of bankers, discontinuance of banker system>		5
No. of greenhouses observed	13	14

* In some greenhouses plural problems were observed.

Second and subsequent trial years

During the second trial year, target pest aphids *M. perciae* and *A. gossypii* were observed in 14% and 77% of the 84 greenhouses, respectively, during the main harvesting season (February to May). In addition, glasshouse-potato aphids *A. solani* and potato aphids *M. euphorbiae* were found in 3% and 21% of the greenhouses, respectively. Thus, the occurrence of aphids during the second trial year was similar to that of the first trial year.

During the subsequent trial years, successful aphid control was obtained in two-thirds of the greenhouses (Fig. 2). In addition, more than 80% of the growers were satisfied by this banker plant technique (Fig. 3). In 2005, this banker plant system was in use in 226 commercial greenhouses in Kochi Prefecture.

Discussion

We evaluated a banker plant system using the aphid parasitoid *A. colemani* and bird cherry-oat aphid *R. padi* on wheat plants for the control of the cotton aphid *A. gossypii* on eggplants in the experimental greenhouses. This banker plant system was more effective than inoculative release of the aphid parasitoids. The effectiveness of such banker plant system has been previously shown in cucumber greenhouses (e.g., Bennison and Corless, 1993; van

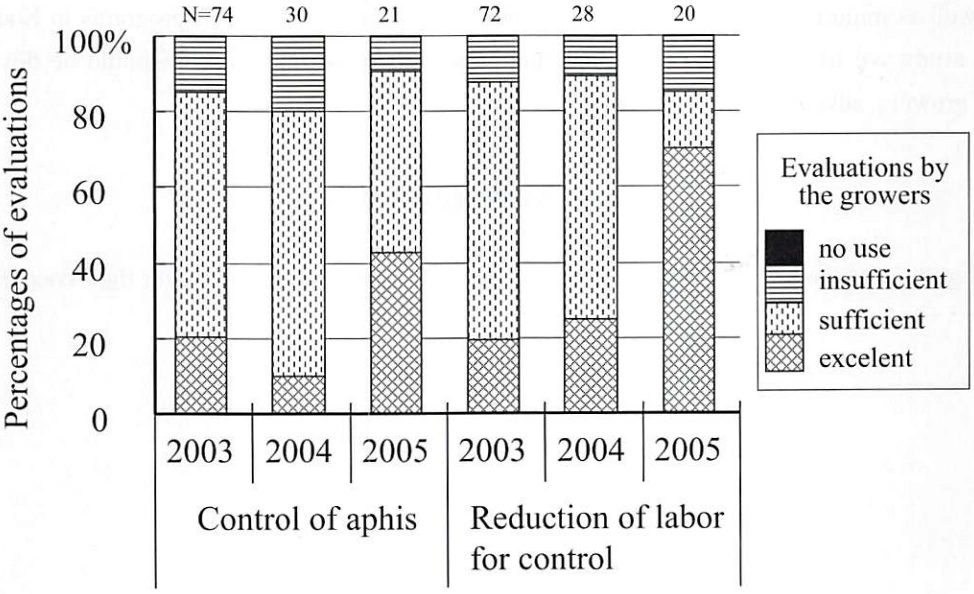

Fig.3 Evaluations of the banker plant technique by the growers.

Steenis, 1995). In addition, banker plant systems have been in use in commercial greenhouses in Europe. However, basic data under the Japanese cultivation system was necessary in order to develop and spread a banker plant system for the protection of greenhouse vegetables in Japan.

After the initial year of field trials at the greenhouses producing eggplant and sweet pepper in Kochi, Japan, problems with the initial banker plant regime were identified. Following the identification of these problems, the number of greenhouses in which successful pest aphid control was achieved, increased two-fold during the second and subsequent trial years. We advised the growers on mainly three points: 1) the banker plant system should be established by January, prior to outbreaks of aphids in normal years, 2) the banker plants should be distributed at more than 4 locations per 1000 m^2, and 3) careful observation of pest insects, natural enemies and secondary parasitoids is necessary. The first point is the basic tactic that has been emphasized in previous studies (e.g., Stacey, 1977; Hansen, 1983; Bennison, 1992). The combination of the first and second points suggests that the control agents should lie in wait for the pest aphids' invasion both in time and space.

Some problems that remain with our current banker plant regime include the occurrence of secondary parasitoids such as *Alloxysta* sp. and *D. laticeps* that parasitize on the control agent *A. colemani*, and the occurrences of glasshouse-potato aphids *A. solani* and/or potato aphids *M. euphorbiae* that were not the hosts of *A. colemani*. During the first trial year, the crops in a few greenhouses were seriously damaged by the occurrence of secondary parasitoids or glasshouse-potato aphids. Van Steenis (1995) also reported the problem of secondary parasitoids. Glasshouse-potato aphids were not a serious problem in these greenhouses until this trial. Without employment of the banker plant system, glasshouse-potato aphid populations seemed to be suppressed simultaneously by the chemical insecticide sprayed against cotton aphid and green peach aphid. Most of the growers in our trials were able to discriminate between the beneficial and secondary parasitoids, and pest and non-pest aphids. In the cases where secondary parasitoids or glasshouse-potato/potato aphids occurred, the growers determined the timing and area of insecticide use after they carefully observed the populations of pest aphids in addition to beneficial insects.

As the banker plant system is more commonly accepted by the growers of greenhouse vegetables in Japan, the reduction of chemical insecticide use against pest aphids should result in the protection of introduced populations of the minute pirate bug *O. strigicollis*. This will lead to the better control of thrips. At present, this banker plant technique as well as minute pirate bug introductions plays important roles in IPM programs in Kochi Prefecture. Through this study, we realized that practical techniques to use natural enemies should be developed in the corporation of growers, advisers and researchers.

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