MONTREAL PROTOCOL

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TECHNOLOGY AND ECONMOMIC ASSESSMENT PANEL

MAY 2006

SPECIAL REPORT:
VALIDATING THE YIELD PERFORMANCE OF ALTERNATIVES TO METHYL BROMIDE FOR PRE-PLANT FUMIGATION

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Reproduction: **UNEP Nairobi; May 2006**

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Acknowledgements:

The Technology and Economic Assessment Panel and acknowledges with thanks the contributions of Dr Jose Lopez-Aranda, Prof. Mohamed Besri, Dr James Gilreath, Michelle Marcotte, Dr Clive Noble, Jack Norton, Marta Pizano, Dr Jim Schaub, and the other individuals and organisations who provided support to this project. The work was sponsored by the Trust Fund of the Montreal Protocol and the Department of Primary Industries in Victoria, Australia. Parties to the Montreal Protocol authorized this scientific investigation in Decision XVI/5.

This document is also available in portable document format from:
http:// www.unep.org/ozone/teap/Reports/TEAP_Reports/

ISBN: 92-807-2730-3

Foreword

On behalf of the Montreal Protocol Technology and Economic Assessment Panel (TEAP) we are pleased to release the ***TEAP/MBTOC Special Report, 'Validating the Yield Performance of Alternatives to Methyl Bromide for Pre-Plant Fumigation'***.

The study was undertaken by Methyl Bromide Technical Options Committee (MBTOC) Co-Chair Dr. Ian Porter, Leanne Trinder, and Debra Partington with the assistance of Dr. Jonathan Banks, Stefan Smith, Murray Hannah, and Natalie Karavarsamis. MBTOC members and members of their global expert network contributed to the report and TEAP members peer reviewed and edited the final version. MBTOC members and members of their global expert network contributed to the report.

The policy-relevant technical findings are that crops produced with certain alternatives to methyl bromide have statistically equivalent yields to crops produced with methyl bromide.

These findings give extraordinary confidence to global efforts to minimize and eliminate exemptions for Critical Use of methyl bromide allowed under the Montreal Protocol for developed countries.

The results will be welcome by farmers, farm workers and their families who are particularly vulnerable to skin cancer and cataracts from the long hours working under conditions of high ultraviolet-B (UV-B) solar radiation that is increased by stratospheric ozone depletion.

This report is one of the most comprehensive meta-analyses studies ever conducted for the agricultural sector. It considered the available global library of peer reviewed reports of field studies. These studies were collected by MBTOC members and by the authors from global internet agricultural data bases. It used sophisticated analytical techniques and computer modelling to compare yields of crops grown with methyl bromide and methyl bromide alternatives and displays its results in tabular and graphical formats that are suitable for interpretation by agricultural specialists, agribusiness managers, and policy makers.

The report was reviewed and endorsed by the MBTOC and TEAP.

Parties to the Montreal Protocol and their agricultural advisors will want to carefully study this report in order to consider the alternatives to methyl bromide that best accomplish their goal of a rapid phaseout of methyl bromide. The Multilateral Fund and its implementing agencies can use the analysis to identify the alternatives that maintain crop yields for favourable cost-effectiveness. Pest control advisors and their suppliers will want to use the analysis to guide agricultural sectors to the best alternatives. And chemical suppliers will want to use the results to focus future research on those uses that have less satisfactory options.

Action by national and regional environmental and agricultural authorities is particularly necessary in cases where the most suitable alternatives are not yet registered or where use restrictions inhibit protection of the ozone layer.

TEAP congratulates the authors and collaborators for this important analysis that supports global efforts to protect the earth for our and future generations.

Stephen O. Andersen, Lambert Kuijpers, and Jose Pons
TEAP Co-Chairs

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GLOSSARY OF KEY ACRONYMS

CUN	Critical Use Nomination
CUE	Critical Use Exemption
EC	Emulsifiable Concentrate
HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
LSI	Least Significant Interval
SE	Standard Error
VIF	Virtually Impermeable Films

EXECUTIVE SUMMARY

The report presents a formal meta-analysis that validates the yield performance of alternatives to methyl bromide for some major pre-plant treatments that are currently subject to the Critical Use Exemptions under the Montreal Protocol. The policy-relevant technical finding is that crops produced with certain alternatives to methyl bromide have statistically equivalent yields to crops produced with methyl bromide.

Evaluation of Critical Use Nominations for Methyl Bromide is a very difficult and complex task. Analysis of international research studies is key part of this process. MBTOC and TEAP are required by the Parties to provide well-considered and authoritative advice on whether particular nominations meet the criteria for a Critical Use Exemption, and particularly whether there are technically and economically feasible alternatives to the nominated use available within the context of Decision IX/6.

Decision XVI/5 provided financial support to the Methyl Bromide Technical Options Committee's (MBTOC) co-chairs *inter alia* for expert to provide more detailed assessment of the nominations' claims against the criteria of Decision IX/6 and also expert assistance with the preparation of the Methyl Bromide Technical Options Committee's reports on its assessment of the critical-use nominations, so as to ensure that such reports provide sufficient levels of transparency and detail to meet the requirements of the Parties.

This report is endorsed by TEAP and MBTOC and its development was supervised by MBTOC, with funding provided under Decision XVI/5.

The report presents the methodology and outcomes of a formal meta-analysis into methyl bromide alternatives for some major pre-plant treatments that are currently subject to the CUNs. This quantative statistical analysis allows a comparison of effectiveness of alternatives in a transparent and rigorous way for some crops for which complex CUNs have been made. It provides the statistical best estimate of the relative effectiveness of the major alternatives to methyl bromide as determined by analysis of information across a large number of studies in different regions and under different pathogen pressures. Effectiveness was assessed by comparing relative yield of the alternative to the respective methyl bromide/chloropicrin (MB/Pic) treatment. The study takes account of both registered and unregistered products.

The key steps to achieve this outcome were:

a) a literature review of refereed and non refereed publications and develop a bibliography database of trials conducted in studies reported since 1997 evaluating alternatives to methyl bromide for pre-plant fumigation. A limitation on resources prevented reviewing previous studies. Also more recent studies are considered more appropriate as improvements in performance of new alternatives often occur with repeated trialing, new formulations and new application technologies.

b) development of a PC based (Microsoft Access) multifactor database of parameters contained in the major studies so that the data can be used for comparative analyses of the information.

c) development of a PC based (Excel) multifactor database of trial details in numeric format which enabled biometrical analyses.

d) a meta-analyses using statistical comparisons of yields, paying particular attention to variations in inoculum density of the pests (fungal pathogens and nematodes), nutsedge, soil type, barrier films, method and rate of application of alternatives from major studies relevant to major crops applying for Critical Use Nominations (CUNs).

This report concentrates on two major crops, strawberry fruit and tomatoes. Comparisons are made to peppers, melons, eggplants and cucurbits data where possible. Too few articles have

been published to allow meta-analysis of the latter crops on an individual basis. However, much of the information for tomatoes (i.e. effect on target pathogens and weeds) is relevant to the outcomes for these other crops. The meta-analysis also includes a detailed assessment of the effect of alternatives for nutsedge under different pressures and the influence of low permeability barrier films across a range of regions and crops.

Sufficient published articles for the two main crops (tomatoes and strawberry fruit) have been captured during this study to provide accurate trends with most alternatives. It is recognised that there may be additional relevant studies that have been completed, but were not incorporated in this present study because full details of results were not provided or were unavailable. Incorporation of further data from these other studies may improve the precision of the meta-analysis. Conclusions about some of the newer alternatives are limited by the lack of reported studies.

The report outlines the power of the meta-analysis for decision making, and some of the challenges encountered during the data collection phase of the project and the procedures used to resolve these issues. The meta-analysis deals only with technical efficacy of alternatives measured by relative yield outcome. It considered relative yield for the crop following treatment only and made no attempt to analyse the effect on the subsequent crop(s). To this extent it closely mirrored the comparison of alternatives for many of the Critical Use Nominations. The study considered only alternatives which may directly replace MB for fumigation of soils – it did not consider methods which avoid the need for fumigation, i.e. soilless media and other substrates, potted plants and hydroponic systems which are considered as potential methods to replace production in fumigated soils.

This study has been conducted independently of restrictions to use of alternatives due to regulations, registration and market forces and recognises that economic feasibility also needs to be taken into account before a treatment can be considered a suitable alternative to MB under Decision IX/6. Full assessment of Critical Use Nominations by MBTOC takes into account both technical and economic feasibility.

OVERVIEW OF FINDINGS

The relative efficacy and variability in yield of a wide range of alternatives were compared to a standard MB/Pic treatment. The alternatives most often reported were chemicals, although a number of non-chemical alternatives were also included in the studies (eg. solarization, biofumigation, composts and biological control agents). Data from a large number of trials from regions which have applied for critical use exemptions, i.e. Europe, North America and Australasia, 101 for strawberries and 61 for tomatoes, have been included in this study.

Analyses from strawberry fruit trials showed that a large number of alternatives used alone or in various combinations had mean estimated yields which were within 5% of the estimated yield of the standard methyl bromide treatment (MB/Pic 67:33). Of these a number of alternatives and MB/Pic formulations (50:50, 30:70) had mean estimates with least significant intervals (LSI's) that were similar to MB/Pic 67:33. These included PicEC (chloropicrin), TC35EC (1,3-dichloropropene/chloropicrin), TC35 and TC35ECMNa (TC35 combined with metham sodium) and MI60 (methyl iodide/chloropicrin) which is undergoing review for registration in several countries.

Analyses from tomato trials showed that a range of alternative treatments used alone or in various combinations had mean estimated yields which were within 5% of the estimated yield of the standard methyl bromide treatment (MB/Pic 67:33). Of these, many contained the deregistered product, pebulate, but most did not. Several treatments, PicMNa (chloropicrin combined with metham sodium), 1,3D/Pic in combination with a range of herbicides and MI60 (methyl iodide/chloropicrin) (not registered), were similar to MB/Pic 67:33.

1 INTRODUCTION

1.1 *Current use of methyl bromide in pre-plant fumigation*

Under the Montreal Protocol, approximately 56,083 metric tonnes of methyl bromide was scheduled to be phased out of developed countries for pre-plant fumigation and non QPS post harvest uses by 1 Jan, 2005. Of this amount, approximately 51,000t was used for preplant soil use. As of the 17th Meeting of the Parties to the Montreal Protocol, (i.e. December, 2006), 16,050t and 13,418t of methyl bromide has been granted critical use exemptions (CUEs) for 2005 and 2006 respectively, for continued pre-plant soil use worldwide.

1.2 *Evaluation of CUNs on the basis of technical feasibility*

Paragraph 1(a)(ii) of Decision IX/6 states that a use of methyl bromide only qualifies as "critical" if the nominating party can demonstrate:

> *"There are no technically and economically feasible alternatives or substitutes available to the user that are acceptable from the standpoint of the environment and health and are suitable to the crops and circumstances of the nomination".*

Decision XVI/4 Annex I assigns the nominating Party responsibility for providing information regarding the lack of technical feasible alternatives or substitutes.

Evaluation of Critical Use Nominations for Methyl Bromide is a very difficult and complex task. Analysis of international research studies is key part of this process. MBTOC and TEAP are required by the Parties to provide well-considered and authoritative advice on whether particular nominations meet the criteria for a Critical Use Exemption, and particularly whether there are technically and economically feasible alternatives to the nominated use available within the context of Decision IX/6.

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The report presents the methodology and outcomes of a formal meta-analysis into methyl bromide alternatives for some major pre-plant treatments that are currently subject to CUNs. This quantative statistical analysis allows a comparison of effectiveness of alternatives in a transparent and rigorous way for some crops for which complex CUNs have been made.

This analysis has been conducted to assist Parties and TEAP/MBTOC to more clearly identify alternatives to methyl bromide. During past assessments, it has been difficult for MBTOC to validate the effectiveness of alternatives when nominations are based on one study or a limited number of studies, especially when data from a large number of studies conducted internationally showed that alternatives performed similarly to methyl bromide. It was also difficult to draw conclusions about the suitability of alternatives to the circumstances of the nomination or to substantiate reported yield losses. The meta-analysis more accurately identifies the effects of many factors, such as the influence of severe pathogen or weed pressures. Without this method to investigate these correlations, MBTOC has been unable to clearly identify whether alternatives are likely to show consistent effects across parameters specified in a nomination.

2 METHODOLOGY

The key steps in the conduct of this project were to collect and organise data so that a rigorous scientific comparison of the performance of a wide range of alternatives to methyl bromide for pre-plant fumigation could be made.

In its assessment reports (TEAP 2002), MBTOC has defined ‘alternatives’ as those non-chemical or chemical treatments and/or procedures that are technically feasible for controlling pests, thus avoiding or replacing the use of MB. `Existing alternatives’ are those in present or past use in some regions. `Potential alternatives´ are those in the process of investigation or development.

MBTOC has assumed that an alternative demonstrated in one region of the world would be technically applicable in another unless there were obvious constraints to the contrary, e.g. a very different climate or pest complex.

In this study, alternatives included existing and potential alternatives as defined above, and included all registered and non-registered experimental products (chemicals, biological and some physical methods) from trials on methyl bromide alternatives.

The key stages of this study included:

a) Conduct of a structured literature review of alternative studies for pre-plant fumigation and created a citation database (ProCite®)

b) Development of a relational PC based database (Microsoft Access®) of parameters from major studies relevant to the CUNs

c) Construct of an analysable PC based database (Microsft Excel®) with parameters in comparable numeric format ready for analysis

d) Conduct of a meta-analyses using statistical comparisons of yields, focusing on the variations in inoculum density of the pests, soil type, climate, method and rate of application.

2.1 QUANTITATIVE LITERATURE REVIEW

The first procedure in the study was to collect data from trials with methyl bromide alternatives for pre-plant fumigation. These trials were obtained from peer reviewed papers and non peer reviewed papers and reports since 1997. A citation database was created to enable efficient retrieval and grouping of these studies.

2.1.1 *The Citation Database*

The citation database was created using ProCite®. Information, such as, title, author, abstract, source, and year, was recorded regardless of whether studies were included in the analysis (Mosteller and Colditz, 1996). Studies were sourced from published literature, unpublished literature, research reports and works in progress. Selection criteria for the studies are shown below. Literature searches were conducted using Internet search engines and the Department of Primary Industries on-line databases. Agricola, Science Direct and CABAbstracts provided comprehensive search results containing the keyword ‘methyl bromide’ for studies post 1997.

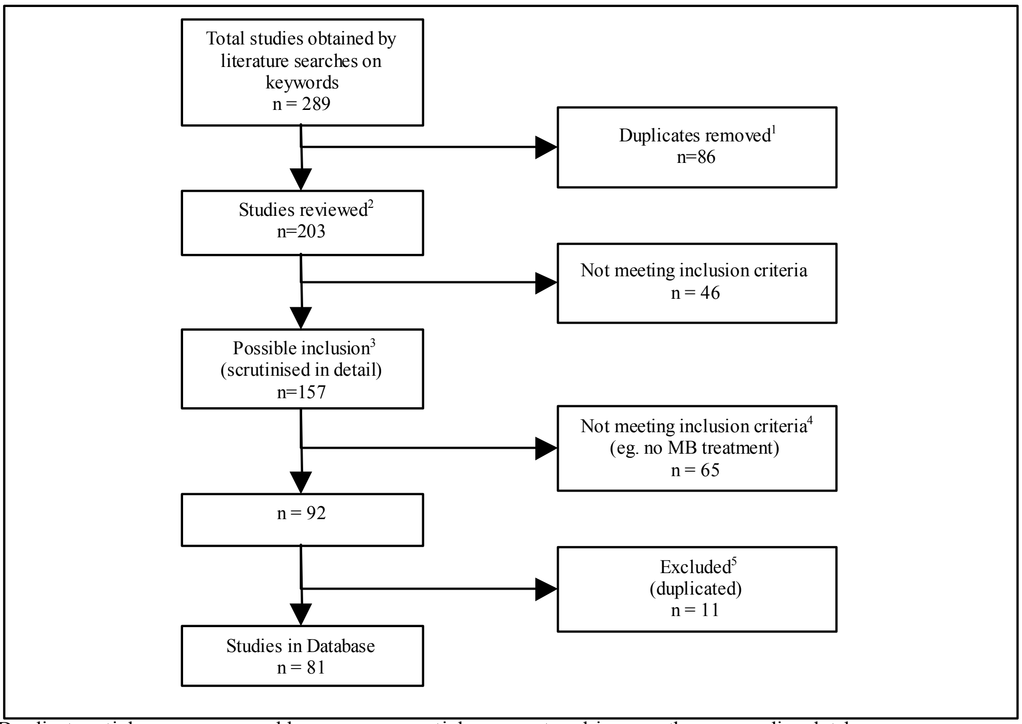
In total to date, over 460 articles have been exported into the citation database from the online searches. Of these, 289 were relevant to CUNs and 81 articles (42 for strawberry fruit containing results of 101 trials, and 30 for tomatoes containing results of 61 trials, and 9 for peppers, cucurbits, melons) contained a summary of trials that had information that could be analysed in the meta-analysis (see Tables 1, 10.1 and 10.2). These consisted of 27 refereed publications, 44 conference proceedings and 10 final reports. *Figure 1* shows a schematic of the process of selecting relevant papers/studies for inclusion in the meta-analysis.

In addition to the online database searches, information has been gathered by reviewing the Proceedings of the Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions (MBAO) and equivalent European Conferences, Major authors within the major industries were contacted by email to ensure good coverage of published literature. Post 1997 studies were entered into the citation database. The list of studies (see Tables 10.1 and 10.2) included in the meta-analysis was sent to MBTOC members in June 2005 in order to seek out further studies relevant to CUN's. This yielded a further small number of studies.

The minimum inclusion criteria for the studies included:

- Those from climatic regions and production regions relevant to those regions where Parties have applied for CUNs. In most cases studies were from within regions which had applied for CUNs.
- year (studies reported since1997 onwards generally containing trials from 1997 - 2005)
- yield (reported in numeric format)
- a methyl bromide treatment
- an alternative treatment
- data on control of pathogenic fungi, parasitic nematodes or nutsedge
- a relevant crop (tomato, strawberry fruit, peppers, cucurbits, melons, eggplants)

Figure 1: Flow chart showing how study reports were scanned and selected for inclusion in the meta-analysis for tomatoes and strawberry fruit studies from 1997-2005



[1] Duplicate articles were removed because many articles were stored in more than one online database. [2] Full article and data could not be obtained. Abstracts were examined to determine article relevance based on inclusion criteria. [3] All articles printed in hard copy. [4] Body of article was examined and did not satisfy the inclusion criteria e.g. article contained histograms, spatial maps, and economic reports. [5] Duplicated experiments were removed e.g. Kabir (2003) and Fennimore (2004) reported same experiment.

2.2 THE MAIN STUDY DATABASE

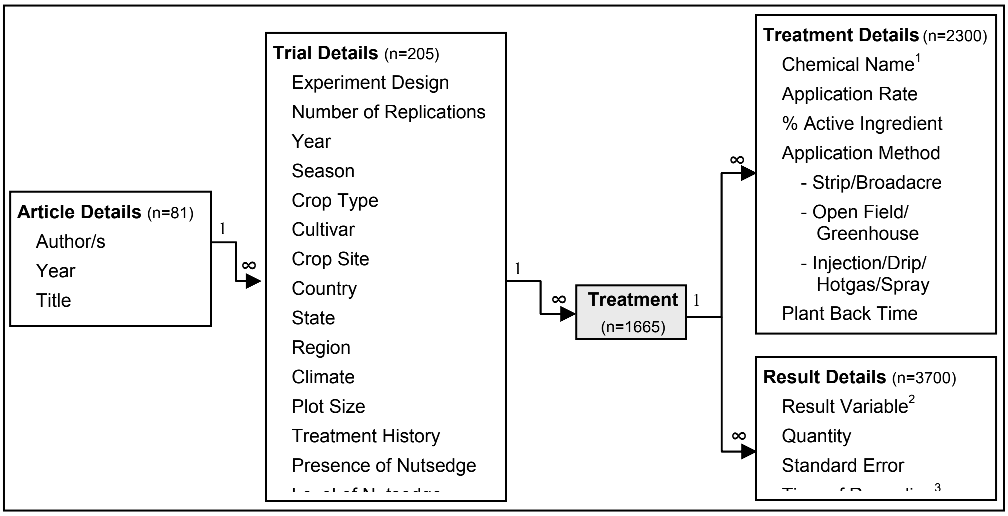
2.2.1 *The Database Structure*

The second database was constructed using a relational database management system using Microsoft Access (Fig 2). Detailed information about experimental conditions and the output data (i.e. yield) were gathered for each treatment and are presented in columns for each respective treatment.

For tomatoes and strawberries, the database consists of 1665 rows of data in 220 columns with 3700 entries of results, primarily expressed as either input data (Fig 3) or output data (Fig 4). Major input variables included treatments, rates, application method, type of plastic mulch and soil type. Major output variables included yields, disease incidence, pathogen population densities and weed numbers. The dataset consisted of 220 variables that could influence the output of the meta-analysis (variables were recorded in columns).

This database is the key to the accuracy of the meta-analysis and the development of relationships between parameters. The database structure enabled multiple trials, treatment combinations and experimental variables to be recorded. These variables were identified as key parameters which influenced the performance of pre-plant fumigant alternatives.

Fig 2. *Size and Structure of the Access Database for Pre-Plant Fumigation Experiments*



[1] *Chemical Name* includes the details of fumigants, herbicides, solarisation, biological controls etc. (see Appendix 1 for full Chemical Name list). [2] *Result Variable* itemizes all treatment response variables, such as: marketable crop yield, total crop yield, nematode variety, fungi variety, weed variety. [3] *Time of Recording* is measured in days after planting.

***Fig 3.** Example of the structure of trial details (eg. inputs) into the main study database (220 columns of parameters included in total)*

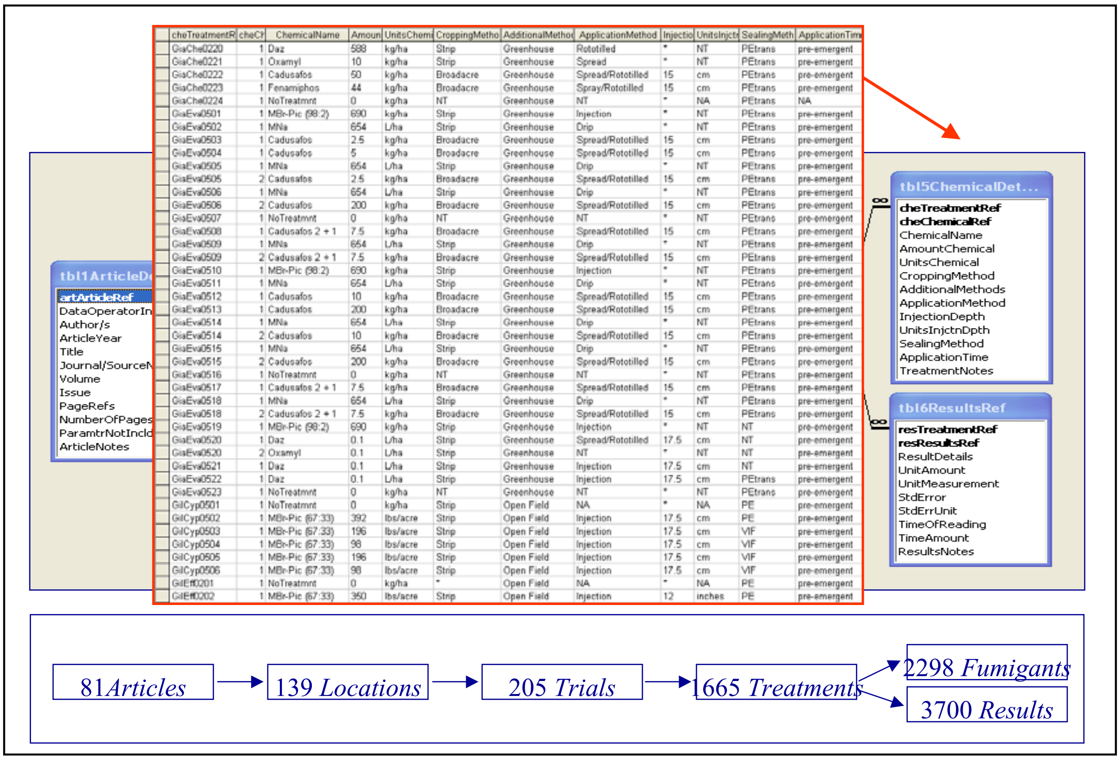
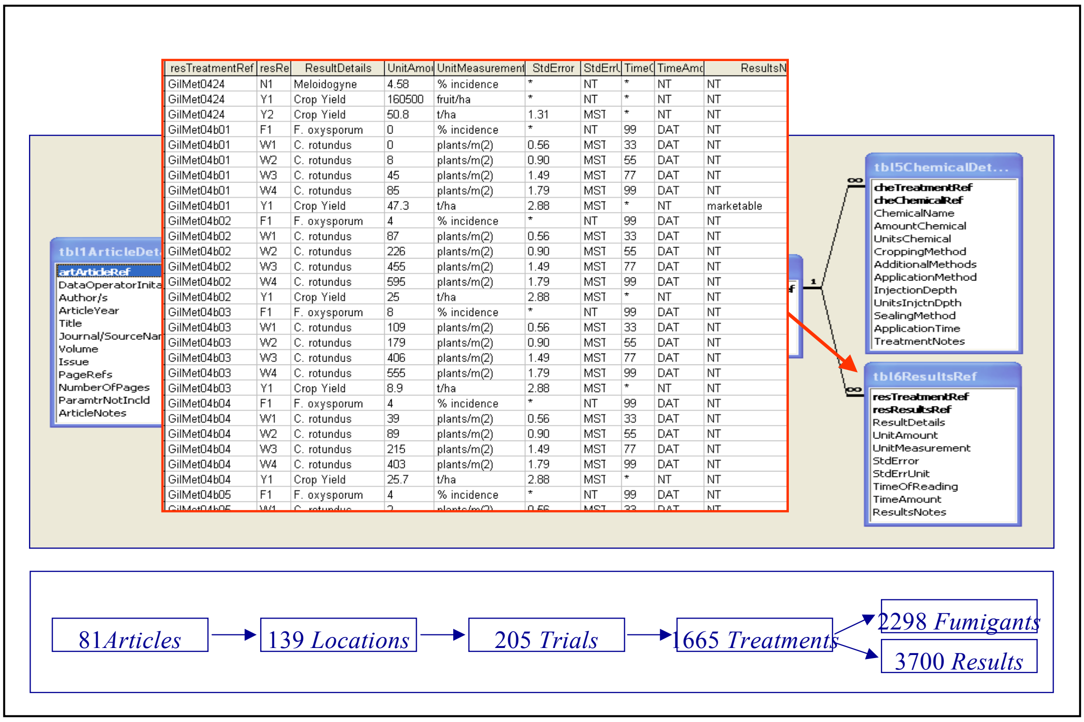


***Fig 4.** Example of the structure of the trial outputs (eg. Yield, nutsedge population densities, standard errors) into the main study database*



Of the studies entered into the database, 101 trials were conducted on strawberry fruit crops and 61 trials were conducted on tomato crops (Section 10.1 and 10.2). *Table 1* shows that there was a good spread of studies for strawberries but that two thirds of the trials included for the tomato industry analysis were conducted on sites in Florida. Although this has some potential to create a location or author selection bias, the data has significant relevance to the CUN's submitted from this region.

Table 1. Trial description of studies included in the meta-analysis

		Strawberry Fruit *(42 studies)*	Tomatoes *(30 studies)*
Total Number of Trials:		101	61
Location:	*USA - California*	28	1
	USA - Florida	15	40
	Spain	25	0
	New Zealand	15	0
	Italy	0	9
	Australia	9	0
	Other	9	11
Experiment Year:	*pre 1999*	22	19
	1999-2002	69	37
	post 2002	10	5
Nematodes:	*Present in soil*	13	35
	Not Reported	29	26
Fungi	*Present in soil*	18	33
	Not Reported	24	28
Nutsedge Level:	*Low (1-5 plant/*m^2)	3	5
	Moderate (6-30 plant/m^2)	2	4
	High (>30 plant/m^2)	3	10
	Not Reported	93	42

Of the 220 possible variables collected, only 32 were prioritized as essential for the meta-analysis; the other variables provided reference material for future comparisons. The 32 variables used are shown in Table 2.

Table 2. Important variable codes used in the meta-analysis

• Study Code • Trial Code • Treatment Code • Crop Site • State • Country • Climate • Season • Year • Cultivar • Soil Type • Pathogenic Fungi Present	• Pathogenic nematodes Present • Nutsedge Group (3 levels) • Treatment Code • Treatment/Plastic seal Code • Treatment Group 1 (All) • Treatment Group 2 (Grouped) • Crop Yield • Relative Yield • Adjusted Relative Yield • Untreated Control Yield	• First Chemical Name • Rate of Application • Application Method • Strip/Broadarce • Sealing Method • Field Type • Second Chemical • Pebulate • Variance Group • Weed

2.2.2 *Consistency of Categories*

To ensure the consistency of data entry, tables that allowed for quick cross referencing were created in the database. These contained names within specific variables. For example, recording fumigants under consistent names was essential for correct analysis and interpretation. For instance, in some studies fumigants were reported as their product name and in other studies by their chemical components, e.g. 1,3-dichloropropene/chloropicrin was reported as: Telone C35 Gas; 1,3-dichloropropene 65% + chloropicrin 35%; and Telopic 35. For the current study TC35 was used to account for all similar products. *Appendix 1* provides a list of all alternative treatment products used including their code names.

Table 3. Table of variables in the meta-analysis and the respective categories

Variable	*No of Levels for analysis*	*Categories*
Treatments	63 tomato, 83 strawberry	See Appendix 1 for Treatment Codes
Application Rate	Numerous	Actual number used[A]
Application method	4 and NS*	Drip, injection, spray, hotgas, (not specified*)
Sealing method	2	Non-barrier, barrier
Soil type	3 and NS	Sand, clay, loam, (not specified)**
Climate	Not Analysed	temperate hot/cool, temperate high elevation, arid, sub tropical
Initial density- weeds	3 and NS	Nutsedge levels: 1-5, 6-30, >30 plants/m^2 (not specified)
Inoculum density-fungi	2	Yes (fungi present), not reported***
Inoculum density - nematodes	2	Yes (nematodes present), not reported***

- *NS = Not specified. Note: Meta-analyses were conducted with and without the not specified levels.
- ** The major soils groupings represented those most often reported in studies, but also represented consolidation of a number of soil sub groupings from international standards determined for soil texture keys and particle size analysis. Eg silty clay = clay.
- *** Not reported. Note: Not reported

[A] In the initial analysis all rates were assumed effective as a result of initial regression analysis which showed that most trials used effective rates for alternatives.

2.2.3 *Standardization and Assumptions in the Database*

Assumptions were made on the reporting of application rates of a number of factors.

a) Application rates (unless otherwise specified) were considered to be the actual dosage rate equivalent (i.e. kg/ha) for broadacre treatment.

b) In the initial analysis, a regression of application rates against yields showed that studies generally used application rates that provided consistent responses in yield. For this reason, all application rates were considered to fall in the effective dose range for MB and the alternatives used. The only exception was for when 'raw' mean comparisons were made for metham sodium studies for nutsedge where some dosage rates were below an application threshold of 200kg/ha of active ingredient.

c) Active ingredient of metham sodium. Application rates specified in studies were reported for a product rate. Fumigants listed in the database containing metham sodium contained products with active ingredients ranging from 43.2% to 52.3%

d) Nutsedge infestation levels were categorized into low, moderate and high groups based on the number of plants reported in the untreated control plots (i.e. 1 to 5 plants/m^2; 6 to 30 plants/m^2; and greater than 30 plants/m^2, respectively). This categorisation also matched the breakdown used in the US nominations.

e) When multiple yield data was reported, preference was given to data from:
   - final harvest (as opposed to progressive harvest data)
   - marketable/commercial weight - then total weight
   - weight per area (including number of trays or crates per plot)
     - then weight per plant
     - then weight per fruit

2.2.4 *Consistency of Units*

Treatments in the database were coded to account for all the chemical combinations used. Some treatments were grouped together according to their expected behaviour e.g. MB67 and MB70 were grouped under MB67. This step was necessary in order to identify which treatments could be considered to be "in common" between studies. If a treatment included specific formulations which may alter the efficacy of a chemical i.e. EC formulation, then the treatment was left as an independent treatment and the treatment code allocated to reflect this e.g.TC35EC or PicEC.

2.2.5 *Calculations for extracting datasets*

Microsoft Access also permits mathematical calculations and conversions prior to data analysis. The descriptive details of the two major industries reviewed for the analysis (strawberry fruit and tomato crops) are given in Table 1 and the categories for analysis shown in Table 2. For example, nutsedge infestation levels were categorized into low, moderate and high groups based on the number of plants reported in the untreated control plots (i.e. 1 to 5 plants/m^2; 6 to 30 plants/m^2; and greater than 30 plants/m^2, respectively). The dataset has therefore been used to assess the performance of different alternatives under different nutsedge infestation levels. This will assist making technically-based recommendations and decisions on nutsedge thresholds where the use of methyl bromide is critical.

2.2.6 *Benefits of the final database*

Benefits of the Access database are that it provides:

- easy access to results from studies conducted on key crops to CUNs.
- results presented in a standardized format and are therefore able to be compared.
- searches that can be conducted for studies of similar characteristics of the CUNs, such as pests pressures, locations.
- searches can be conducted for studies using individual alternatives that are of interest to CUNs.
- data subsets can be extracted for further analysis (eg: subsets based on location, level of nutsedge, type of pathogen).

Further advantages of the database are:

- result details have automatically been converted into a standardized format. This feature allows data to be recorded in its original format so that there is less chance of data entry errors due to manual conversions.
- complete information about the treatment has been recorded. For example preplant incorporated metolachlor at 840 g/ha, followed by injection of 1,3-D + Pic at 330 L/acre and post-emergence application of trifloxysulfuron at 5.3 g/ha.

3 THE META-ANALYSIS

3.1 *Definition*

A meta-analysis is a quantitative review and synthesis of the results from related but independent studies (Glass, 1976). The purpose of a meta-analysis is to use statistical analysis to integrate the findings of a large collection of previously analysed results. Classical meta-analysis combines estimates from studies, usually as a weighted mean of the individual estimates, using weights proportional to individual within-study precisions ($1/SE^2$).

The meta-analysis process involves three important stages:

1. Undertake a detailed literature review with set protocols for study identification.
2. Evaluating the quality of the literature retrieved based on inclusion criteria.
3. Develop quantitative methods to combine the studies.

A secondary aim of the meta-analysis may be to measure whether the estimates differ by more than their individual within-study precisions and, if so, to understand why this treatment by study interaction (differential treatment responses in different studies) may be so. Treatment by study interaction typically occurs where environmental differences between studies are important. In the current study the treatment by study interaction is likely to constitute the dominant source of variance, the variation in treatment response between studies being much larger than within-study error variance, and a random effects meta-analysis is essential. This meant that the residual errors from the trials were ignored. They were also difficult to obtain from publication as they are rarely published.

For the meta-analysis to provide successful outcomes it was important to establish the underlying variance across studies. This was accomplished by grouping like treatments and comparing the similarity of the variance. This was particularly important because trials were conducted in different biological systems where variation occurs in a large number of factors, eg. plant back times, chemical combinations, physical layouts, etc. In the final model treatment combinations were evaluated as independent variables and only a few treatments were able to be grouped. Grouping only occurred when relative yield was considered to be almost identical, eg MB/Pic 70:30 was equivalent to MB/Pic 67:33.

3.2 *Processes to establish best estimate of the mean effect of alternatives*

In order to get the best estimate of the estimated mean effect of an alternative from the studies the data were analysed by three processes:

1. Raw Mean Analysis. "Averaged means from studies" were expressed as a % yield relative to a within-study methyl bromide treatment (relative yields). The priority order for the standard treatment was (MB/Pic 67:33, then MB/Pic 50:50, then MB/Pic 98:2). The average means for each observation were pooled and then divided by the number of studies to determine the raw mean for the treatment. There was no further analysis.
2. Partial Meta-analysis. Partially modelled means were used in the analysis. The means were obtained by modelling the relative yields to the within-study methyl bromide treatment, allowing for both treatment and study effects.
3. Full Meta-analysis. Fully modelled means were used in the analysis. The means were obtained by modelling the raw (unscaled) data, allowing for treatment effects and effects of study (including scale), and expressing the results relative to a standard methyl bromide treatment.

Ultimately the full meta-analysis (Analysis 3) presents the best estimate of the performance of an alternative across a range of studies providing a sufficient number of studies have been entered into the database. In cases where study numbers are low the partial meta-analysis provides a better estimate. Raw mean analyses provide a quick way of comparing means and observing trends in the average performance of alternatives and can provide a reasonable estimate of the performance of an alternatives when a large number of studies have been used. Statistical correlations with other factors are not possible with this method.

This final full meta-analysis developed was able to:

a) compare the average performance of methyl bromide alternatives, relative to methyl bromide, across all environments.
b) test for equivalence between alternatives and methyl bromide, across a number of key parameters. This was restricted to the major parameters due to the limited resources available, although these parameters represented the key factors presented in CUNs.
c) test for statistical significance of differences between methyl bromide alternatives relative to that of methyl bromide.
d) identify the dependence of treatment performance upon factors such as inoculum and weed infestation pressure, soil type and climate.
e) identify effects of method of application on the performance of methyl bromide and alternatives.

3.3 *Treatment categories for the meta-analysis*

Individual treatments were grouped into 'Treatment' categories according to the chemical types, formulation applied and the method of application. All rates were considered to be effective dosage rates in this study as regression showed no significance influence of dosage rates. This is somewhat expected as most studies included used effective dosage rates for alternatives and not ineffective dosage rates. It was also assumed that researchers applied treatments using best practice and that the study effect would account for any variation. All treatments considered to potentially have a different effect were left as stand alone treatments. Consequently final treatments consisted of single or combined treatments of up to 5 factors. Each treatment was given a code (Appendix 1). Where possible treatments were consolidated e.g. all solarisation treatments with clear plastic film were considered equivalent.

3.4 *Standardisation of parameters to achieve best estimates of means*

The units of measurement of each outcome in a study (e.g. crop yield) often differed between studies and the model needed to be able to handle variable input data. It was not feasible to convert these to a common standard unit because the data was not available in the published papers (Section 7). Consequently, comparisons between treatments were based purely on the (multiplicative) relativities between treatment responses within studies. To facilitate this, the meta-analyses were performed on a logarithmic scale and an additive term for the main effect of study was necessarily included in each statistical model to account for units. Once this log-scale analysis was complete, the resulting treatment mean estimates were re-expressed, back transformed, as relative to a standard MB treatment, MB/Pic 67:33, for presentation. In the latter stages of analysis, the problem of scale was dealt with by expressing all data relative to the within study MB treatment prior to analyses.

The table below summarises the variation in units used in articles for strawberry yields. As the model used relative values it was able to cater for all of the different units reported in studies provided that the yields for methyl bromide and the alternatives from within the same study had the same numerical units for yield.

Table 4. Variation in units used for expressing yields in strawberry trials

Unit	Frequency
flats/ha	7
no. 5.4kg flats/ha	9
12 lb flats/ha	13
25lb crate/acre	136
g/m^2	36
gm/20 plants	3
gm/fruit	13
gm/plant	176
kg/ha	22
kg/row m	9
plants/ha	5
t/ha	15
lbs/acre	37
Yield Relative to MB67 (%)	91
Yield Relative to MB70 (%)	47

3.5 *The Meta-analysis procedure, models and assumptions*

The analysis was performed on the log-data using mixed (fixed and random effect) models in GenStat 8. The fixed effects were structured as follows:

Study + Treatment + Factor1 + Treatment.Factor1

or

Study + Treatment + Treatment.Factor2

Where additive terms indicate main effects and the "." indicates an interaction. 'Factor1' represented factors of interest such as sealing method, rate of application, method of application and pebulate i.e. (exclusion of pebulate studies) that were applied within studies. 'Factor2' represented environmental management factors such as level of nutsedge, level of nematode, level of fungi, climate, season, country, etc, that varied between and were confounded with studies.

Only one Factor1 or one Factor2 was included at a time. This was because inclusion of several factors was complicated by partial confounding between them. These complexities require further analysis.

The study by treatment interaction was characterized as a random effect and provided the error variance against which fixed effects were assessed. Random effects of the study by treatment interaction and the within study error variance were thus pooled into a single term. This was primarily because information on within-study precision was rarely available. Thus, there was no differential weighting of data according to the study from which they came. However, there was differential weighting of data according to treatment. Some treatments (notably the untreated control) were likely to be more subject to environmental challenge than other treatments (e.g. methyl bromide) and thus more variable in their outcome. This was confirmed by plotting residuals verses Treatment label or number. Separate variances were henceforth included in the mixed model for each level of Treatment provided there were at least 7 occurrences of the treatment in the data.

4 PRESENTATION AND INTERPRETATION OF RESULTS

The mixed-model analysis provided a Wald asymptotic chi-square test for each term in the model, in particular for differences between treatments and for interactions between treatments, inoculum densities, application or production methods, soil type or other management factors. Appendix V shows the Strawberry and Tomato chi-square outcomes for the major parameters in the meta-analysis.

The mixed model outputs also include predicted means (adjusted for study on the log-scale) and their variance-covariance matrix (Appendix VII and VIII). These were used to construct error bars in the form of 5% least significant intervals (LSIs). These intervals provide an indication of the precision with which the adjusted treatment means were estimated. The size of these intervals depends on both the inherent variance of the treatment and the design (including both the number of times the treatment occurred within the data set and pattern of occurrence with other treatments within studies). LSI's are constructed specifically to approximate the pair wise least significant differences and are useful for graphical presentation. If a pair of intervals overlaps then the corresponding estimated means were judged not significantly different at the 5% level. Like standard errors from which they are derived, LSIs do not indicate the spread of data for each treatment, but the precision of estimation of the predicted mean. In general, as observations for a treatment increase the accuracy of the estimated mean increases and the LSI's become smaller. The estimated means and LSI's were back-transformed and scaled as a percentage relative to a selected standard treatment (MB/Pic 67:33) for presentation. Their interpretation is preserved in this process.

The analysis proceeded under the assumption of no selection bias for treatments into the database. A normal distribution of the residuals was also assumed and checked using histograms and graphs of residuals by fitted values. Unequal variances were modelled, not assumed.

4.1 *Statistical Design Structure of available data*

The structure of the data was comparable to an unbalanced incomplete block design in which studies were analogous to blocks. It turned out that the *design* (allocation of treatments to "blocks") was *connected*. This means that there were sufficient treatments common between studies to enable all treatments to be compared with one another.

5 RESULTS AND DISCUSSION

Results (Figs 6 and 7) show the fully modelled mean estimates (i.e. meta-analysis) for yields for both strawberry fruit and tomato crops. Codes used for treatments used in discussion of results are shown in Appendix 1.

Modelled estimates are presented for the main effect of alternative treatments (single treatments or combinations) compared to the standard commercial treatment, i.e. MB/Pic 67:33, for strawberries and tomatoes. Fully modelled mean estimates are also provided in Appendices III and V, for seven combined factors as shown below in Table 5. In general, the results show that the greater the number of observations the smaller the LSI and the more accurate the mean estimate for the treatment.

Results are shown for both registered and unregistered products. As the registration processes within each country differ, it is important to take this into account when considering their suitability as an alternative to MB. Similarly deregistration of a product can alter the status of alternatives. A key example was the deregistration of pebulate in the US. Data obtained with pebulate in combination with other treatments was still considered useful as the results showed similar rankings to treatments without pebulate.

Results of the meta-analysis and modelled outcomes (Wald Tables) are shown in Appendices VII and VIII. The strawberry table shows that, of the parameters analysed, there was a significant effect of ‘treatment’ and ‘treatment x application’ method. The tomato table shows that, of the parameters analysed, there was a significant effect of ‘treatment’, ‘treatment x nutbase’ (i.e. nutsedge inoculum densities) and ‘treatment x soil type’.

Table 5. Single factors and combined factors analysed during the meta-analyses
(Note: The meta-analyses were conducted with and without the categories in brackets (eg. not specified, hotgas, fungi number for strawberries)

Term	General Levels
A. Single factor	
Treatment Groupings	See Appendix 1
B. Combined factors	
Treatment x Nutsedge	1-5, 6-30,>30, (Not Specified)
Treatment x Fungi	(No) Yes, Not specified
Treatment x Nematodes	No, Yes, (Not specified)
Treatment x Plastic seal	Non Barrier, Barrier
Treatment x Application method	Drip, (Hotgas), Injection, Spray, Spread (Not specified)
Treatment x Production Practice	Greenhouse(tunnel), Open Field (Not specified)
Treatment x Soil Type	Clay, Loam, Sand, (Not specified)

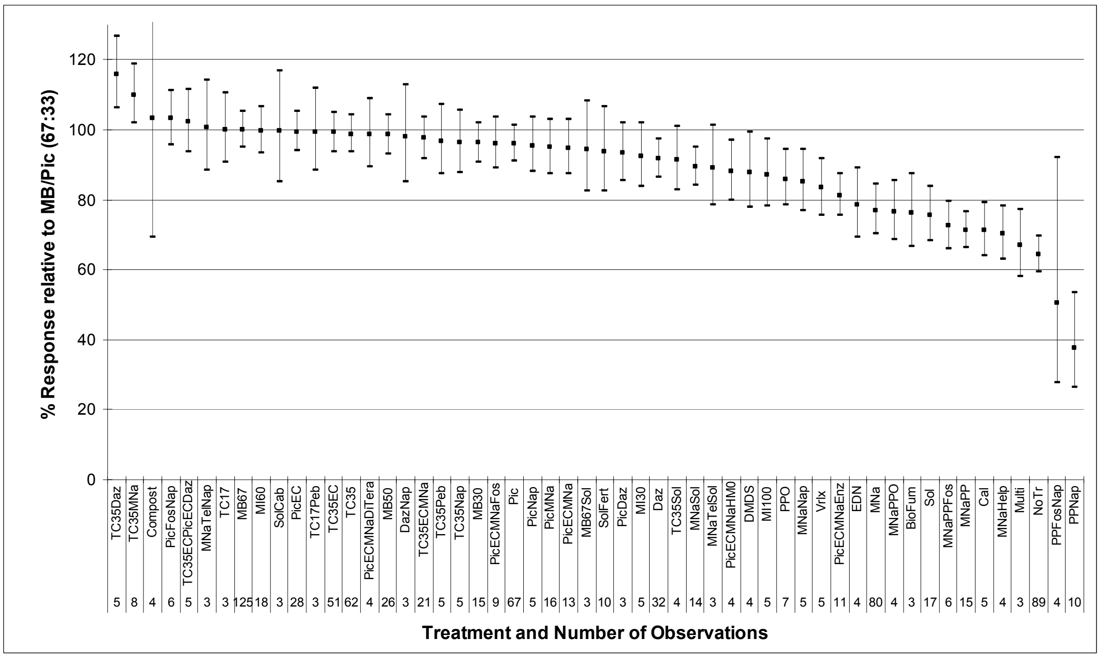
5.1 *Meta-analysis for effect of treatment on yields of strawberry fruit*

Effect of Alternative Treatments, (Fig 6, Table 6): The Wald test (meta-analysis) (Appendix VII, Wald = 382.4, $p<0.001$)) showed a significant difference between chemical treatments, as would be anticipated.

A large number (approximately thirty) treatment combinations of alternatives had mean estimated yields which were not significantly different from the estimated yield for the standard MB/Pic 67:33 by more than 5%. Of these, a number of alternatives and MB/Pic formulations (50:50, 30:70) had mean estimates with LSI’s that were similar to standard MB/Pic 67:33. Treatments which had relatively small LSI’s and means not significantly different to the MB/Pic standard included MI60 (methyl iodide/chloropicrin), PicEC (chloropicrin), TC35EC (1,3-D/chloropicrin), MB50, TC35 and TC35ECMNa (TC35 combined with metham sodium). TC35 combined with either dazomet or metham sodium gave a trend towards a higher estimate of mean yield than the mean estimate for MB/Pic 67:33. Four other treatments also had trends where mean estimates were greater than MB/Pic 67:33, but LSI’s were more variable (i.e. Compost, PicFosNap, TC35ECPicECDaz, MNaTelNap).

Comparisons of the modelled means in the meta-analysis against the partially modelled means, using comparisons of alternatives to the within study methyl bromide, and against the ‘raw’ means showed similar estimates of the means for treatments when observations were high (i.e. greater than 5) (Table 6). These results showed that the raw means provide a closer approximation of the likely effect (i.e. the modelled estimate of means) when a large number of trials have been evaluated. The results also show that the partially modelled means using relativity of alternatives to the within study methyl bromide provides a better estimate of the likely effect when trial numbers are very small (<3). For this reason, only the results for alternatives which have greater than 3 observations from independent trials have been shown in Fig 6.

Fig 6. Relative yield data from the full meta-analyses and LSI intervals for alternatives compared to methyl bromide (67:33) from international research studies in strawberry fruit crops from 1997 to 2005 (Treatments with three or more observations).



5.2 *Meta-analysis for effect of treatment on yields of tomatoes*

The Wald test (meta-analysis) *(Appendix VIII* (Wald = 266, $p<0.001$)) showed a significant difference between chemical treatments, as would be anticipated. Approximately twenty treatment combinations of alternatives had mean estimated yields which were either greater or not significantly different from the estimated yield for the standard MB/Pic 67:33 by more than 5% (Fig 7, Table 7). Of these many contained the deregistered product pebulate, but nine did not. Of the treatments with greater than 3 observations, MI60 (ie. methyl iodide/chloropicrin) and PicMNa (chloropicrin combined with metham sodium) had mean estimates with LSI's that were similar to MB/Pic 67:33. Pic/Tel (chloropicrin combined with 1,3-D) and MNa combined with Cad (cadusafos) were the next closest mean estimates with reasonably small LSI's and mean estimates within 5%. Although only a small number of trials has been conducted, 1,3-D/Pic in combination with a range of herbicides gave mean estimates within 5% of MB/Pic 67:33. The smaller number of studies available for the dataset has led to greater LSI's and less certainty about the performance of some alternatives than that obtained with the strawberry data.

Comparisons of the modelled means in the meta-analysis against the partially modelled means using comparisons of alternatives to the within study methyl bromide and against the 'raw' means showed similar estimates of the means for treatments when observations were high (i.e. greater than 5) (Table 7). As with strawberries, these results showed that the raw means provide a better estimate of the modelled estimate of means when a large number of trials have been evaluated. The results also show that the partially modelled means using relativity of alternatives to the within study methyl bromide provides a better estimate of the likely effect when trial numbers are very small (<3). For this reason only the results for alternatives which have greater than 3 observations have been shown in Fig 7.

Fig 7. Relative yield data from the full meta-analyses and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005 (Treatments with three or more observations).

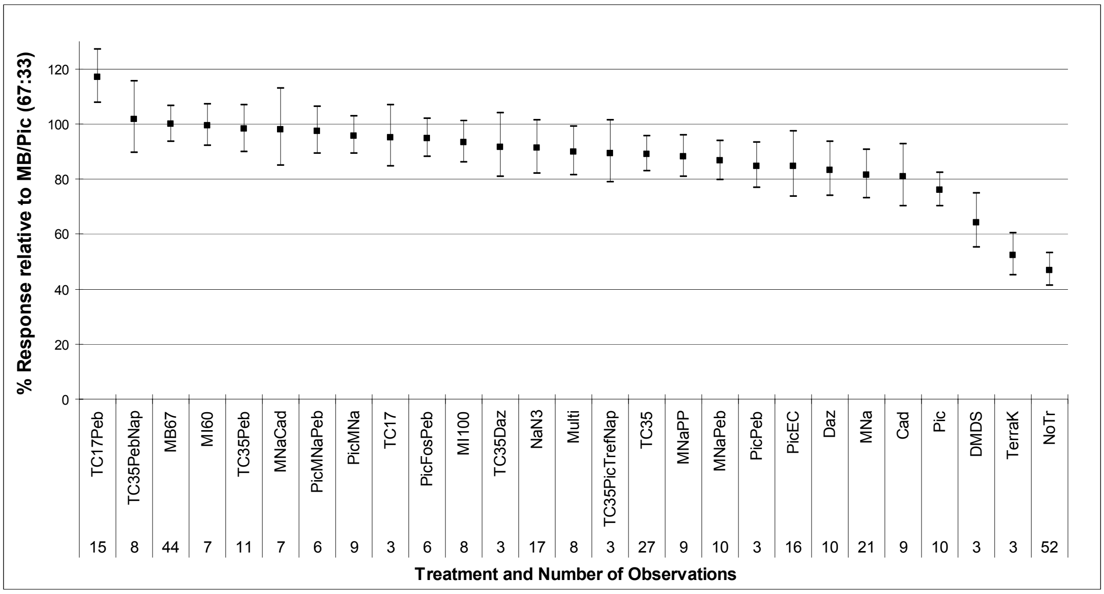


Table 6. Relationship between number of observations and treatments, and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from (i) the full meta-analysis (*M*); (ii) a restricted meta-analysis, (*RM)* and (iii) the raw means averaged for individual treatments across studies

Obs	Treatment	Meta-analysis (M)	(M) LSI's	Restricted Meta-analysis (RM)	(RM) LSI's	Raw Means
5	TC35Daz	115.9	± 10.7	120.1	± 9.0	112.1
8	TC35MNa	110	± 8.7	112.9	± 7.4	107.3
1	PicECDaz	109.7	± 30.7	111	± 14.6	107.9
1	PicMNaDiTera	108.2	± 59.6	113.2	± 25.8	104.2
2	PicDazEnz	107.7	± 20.1	110.7	± 10.5	107.9
2	PicECDazEnz	106.3	± 19.9	107.6	± 10.4	104.5
1	MB30Cal	104.7	± 29.4	104.8	± 14.8	111.5
2	TC35ECDaz	103.7	± 14.4	107.7	± 14.6	109.4
6	PicFosNap	103.3	± 8.1	104.4	± 6.5	102.5
4	Compost	103.3	± 50.7	87	± 17.8	82
1	MB50Cal	103	± 28.9	103.1	± 14.8	109.8
5	TC35ECPicECDaz	102.1	± 9.3	103.8	± 9.0	108
3	MNaTelNap	100.5	± 13.7	100.2	± 8.4	101.3
1	MycCom	100.2	± 31.0	100.2	± 18.8	100.2
3	TC17	100.1	± 10.3	99.93	± 9.4	99.3
125	MB67	100	± 5.3	100	± 3.8	99.9
18	MI60	99.7	± 6.8	103	± 6.1	100.6
3	SolCab	99.7	± 17.0	77.18	± 9.8	72.1
28	PicEC	99.4	± 5.8	100.1	± 4.4	101.6
3	TC17Peb	99.3	± 12.4	103	± 12.7	99.9
51	TC35EC	99.2	± 5.8	99.78	± 4.4	100.2
4	PicECMNaDiTera	98.8	± 10.2	100.7	± 7.2	102.8
62	TC35	98.8	± 5.5	98.9	± 4.1	99.9
26	MB50	98.6	± 5.7	97.92	± 4.4	101.8
1	TC35Nap	98.3	± 19.8	101.3	± 21.5	91.4
3	DazNap	98	± 15.0	98.13	± 9.1	98.8
1	DazSol	97.9	± 28.2	99.12	± 15.5	100.9
21	TC35ECMNa	97.5	± 6.2	98.65	± 5.3	100.6
2	PicDMDS	97.3	± 10.7	97.16	± 9.9	100
1	TC35MNaOrgFung	96.9	± 20.4	95.59	± 22.4	94.3
5	TC35Peb	96.8	± 10.4	99.59	± 10.5	97.9
5	TC35Nap	96.3	± 9.3	101.3	± 21.5	91.4
15	MB30	96.3	± 5.8	95.33	± 4.6	96.4
1	TC35Pic	96.2	± 17.8	97.31	± 17.7	88.6
9	PicECMNaFos	96.1	± 7.6	97.61	± 5.6	99.1
67	Pic	96.1	± 5.2	96.3	± 4.0	98.1
1	PicCal	95.7	± 14.6	95.28	± 14.1	102
5	PicNap	95.4	± 8.1	97.1	± 7.2	95.3
2	TC17Nap	95.2	± 13.6	97.46	± 14.9	91.3
16	PicMNa	95	± 8.1	96.84	± 6.4	97.8
13	PicECMNa	94.8	± 8.0	96.28	± 6.0	96.5
3	MB67Sol	94.4	± 13.8	93.58	± 8.4	99.9
1	PicTel	94	± 17.9	93.59	± 17.8	94.5
10	SolFert	93.8	± 12.8	94.15	± 8.5	93.7
3	PicDaz	93.5	± 8.6	92.88	± 8.1	99.4
5	MI30	92.4	± 9.6	93.21	± 10.8	92.8
32	Daz	91.7	± 5.6	91.19	± 4.7	94
4	TC35Sol	91.4	± 9.4	90.74	± 10.3	91.8
14	MNaSol	89.5	± 5.5	89.54	± 4.4	91.3
1	MB50Sol	89.5	± 25.1	88.36	± 14.8	93.6
3	MNaTelSol	89.1	± 12.2	88.61	± 8.4	89.8
4	PicECMNaHM0	88	± 9.1	89.09	± 7.2	89.8
4	DMDS	87.9	± 11.5	87.08	± 7.9	90.1
5	MI100	87.2	± 10.1	89.45	± 6.9	88.6
2	DazLime	86.8	± 15.9	85.84	± 10.2	92.3
2	MNaTelPeb	86.4	± 15.1	90.65	± 11.0	84.8
1	MNaPeb	86.3	± 22.3	88.3	± 15.4	90.7
7	PPO	85.9	± 8.3	87.08	± 6.2	87.1
5	MNaNap	85.2	± 9.3	86.94	± 7.0	85.1
1	SolBio	85.2	± 23.7	83.24	± 14.6	89.5

Obs	Treatment	Meta-analysis (M)	(M) LSI's	Restricted Meta-analysis (RM)	(RM) LSI's	Raw Means
2	PicMNaSol	83.8	± 29.1	86.92	± 17.8	80.7
5	Vrlx	83.4	± 8.5	90.76	± 9.2	100
1	PicTelNap	82.9	± 17.5	82	± 22.5	80.7
1	TC17PicNap	82.2	± 17.3	81.3	± 22.5	80
11	PicECMNaEnz	81.2	± 6.2	87.63	± 5.5	82.8
1	MNaCal	80.1	± 19.3	78.7	± 13.2	85.4
2	Tel	80	± 14.9	85.72	± 8.6	92.5
1	MNaRootshld	78.7	± 19.1	77.64	± 13.2	92.1
4	EDN	78.5	± 10.6	79.76	± 8.3	76.7
2	MNaLime	78.4	± 12.6	77.65	± 9.2	84.1
80	MNa	77	± 7.5	82.86	± 4.3	81.4
4	MNaPPO	76.7	± 8.9	82.43	± 7.1	76.3
3	BioFum	76.3	± 11.2	75.86	± 8.4	82.5
2	PicMNaEnz	76.1	± 26.1	80.06	± 17.4	78.6
2	MNaTel	75.9	± 14.6	79.53	± 11.4	74.3
1	DazCal	75.8	± 21.3	74.11	± 14.8	80.8
17	Sol	75.6	± 8.1	75.3	± 6.3	76.1
1	MNaMes	75.2	± 18.1	77.16	± 13.0	74
2	Lime	74.2	± 13.6	73.35	± 10.2	79.8
2	PicMNaNap	73.6	± 25.5	79.53	± 17.8	73.3
6	MNaPPFos	72.5	± 7.1	71.96	± 6.2	79.2
15	MNaPP	71.3	± 5.3	72.42	± 4.9	74.5
5	Cal	71.2	± 8.1	70.58	± 6.8	75.6
4	MNaHelp	70.3	± 8.0	72.57	± 6.9	73.9
3	Multi	66.9	± 10.3	70.84	± 8.9	61.9
89	NoTr	64.3	± 5.4	69.01	± 4.2	68.9
2	EMF	61.3	± 11.2	61.36	± 10.2	67.5
4	PPFosNap	50.4	± 41.5	62.02	± 23.8	59.1
2	Chick	38.3	± 30.9	43.19	± 26.2	39.3
10	PPNap	37.6	± 16.0	50.04	± 14.2	48

Table 7. Relationship between number of observations and treatments, and the relative estimated means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from (i) the full meta-analysis (*M*); (ii) a restricted meta-analysis, (*RM)* and (iii) the raw means averaged for individual treatments across studies

Obs	Treatment*	Meta-analysis (M)	(M) LSI's	Restricted Meta-analysis (RM)	(RM) LSI's	Raw Means
15	*TC17Peb*	*116.8*	*± 9.0*	*111*	*± 6.6*	*104*
1	*TC35PicPebNap*	*116.3*	*± 28.8*	*118.4*	*± 25.2*	*117.2*
2	*TC35PicPebTrif*	*109.4*	*± 18.7*	*108.7*	*± 17.0*	*109.6*
1	*PicTelPebNap*	*107.8*	*± 26.7*	*109.8*	*± 25.2*	*108.6*
1	TC35TrefNap	*106.1*	± 20.0	104.4	± 18.4	104.6
2	Sol	102.3	± 22.5	103.2	± 16.4	100
2	*MNaPebFos*	*101.8*	*± 14.3*	*98.5*	*± 12.5*	*78.8*
8	*TC35PebNap*	*101.7*	*± 11.9*	*104.6*	*± 10.5*	*101.9*
2	PicTel	101.4	± 11.9	101	± 10.9	91.3
44	MB67	100.0	± 6.1	99.2	± 5.1	99.6
7	MI60	99.4	± 7.1	98.6	± 6.1	91.2
1	*MB67PebNap*	*99.3*	*± 25.8*	*101.2*	*± 22.5*	*100*
11	*TC35Peb*	*98.0*	*± 7.9*	*97.6*	*± 7.0*	*94.3*
7	MNaCad	97.9	± 12.8	97.1	± 9.8	88.7
6	*PicMNaPeb*	*97.4*	*± 7.9*	*96.2*	*± 7.0*	*90.2*
1	Tviride	95.9	± 22.1	92.6	± 17.8	98.8
2	TC35NapHal	95.8	± 13.4	94.2	± 13.1	98
9	PicMNa	95.7	± 6.3	94.6	± 5.5	94.3
3	TC17	95.1	± 10.1	96.1	± 10.1	105
6	*PicFosPeb*	*94.9*	*± 6.5*	*93.1*	*± 5.8*	*94.7*
8	MI100	93.2	± 7.0	92.9	± 6.8	98.8
2	TC35MetTrif	92.9	± 13.0	91.3	± 13.1	95.1
3	TC35Daz	91.6	± 10.6	89.7	± 10.5	94.7
2	MNaFos	91.2	± 12.5	89	± 12.4	102.8
1	DazTviride	91.2	± 24.6	87.5	± 20.1	95.7
17	NaN3	91.2	± 8.9	97.9	± 13.5	106.6
2	*PicEnzPeb*	*89.9*	*± 7.4*	*88.5*	*± 7.2*	*89.2*
1	TC35MesTref	89.7	± 17.0	87.6	± 18.5	88.7
8	Multi	89.7	± 8.1	88.4	± 7.3	96.3
3	TC35PicTrefNap	89.3	± 10.4	87.7	± 10.6	88.2
1	TC35Tviride	89.3	± 19.3	85.8	± 20.8	92
27	TC35	89.0	± 5.9	87.6	± 5.5	90
9	MNaPP	88.2	± 7.0	86.5	± 6.8	91.5
10	*MNaPeb*	*86.6*	*± 6.6*	*87*	*± 6.5*	*84.7*
3	*PicPeb*	*84.7*	*± 7.7*	*85.3*	*± 7.6*	*74.2*
16	PicEC	84.7	± 10.7	84.4	± 9.2	89.9
1	PicMNaEnz	84.1	± 12.1	80.9	± 13.7	94.7
2	MNaTel	83.4	± 12.3	82.6	± 10.7	83.3
10	Daz	83.3	± 9.0	85.6	± 7.5	81.3
2	PPO	82.0	± 12.4	80.3	± 11.1	84.1
21	MNa	81.5	± 8.1	84.8	± 6.5	85
9	Cad	80.7	± 10.2	83.1	± 9.1	76.4
1	IndmusTviride	79.5	± 21.4	75.2	± 20.1	83.4
1	TC25	79.0	± 12.4	75.5	± 15.9	83
1	MI100MNa	79.0	± 16.7	81.3	± 16.1	66.9
2	Tel	78.9	± 12.8	79.8	± 12.0	78.9
1	TvirideFert	78.4	± 21.2	74.1	± 20.1	82.3
2	Fos	76.4	± 11.7	74.6	± 12.7	82.3
10	Pic	76.0	± 5.8	79.1	± 7.8	86.6
1	Fen	73.4	± 17.4	70.8	± 19.2	83.5

1	Oxa	69.9	± 16.6	66.8	± 19.2	79.5
1	SolSoil	68.3	± 15.9	71.8	± 18.7	61.1
3	DMDS	64.3	± 8.8	60.3	± 10.9	71.8
1	Quil	55.3	± 11.6	53.8	± 15.9	57.5
3	TerraK	52.2	± 7.0	51.4	± 10.4	55.2
52	NoTr	46.8	± 5.3	55.2	± 5.6	55.2
1	*NoTrPebNap*	*44.5*	*± 11.6*	*46*	*± 22.5*	*44.8*

Rows in italics contain treatments which contain a deregistered product, pebulate and are unsuitable for comparing yields for nutsedge control but may be suitable for comparison for pathogen control.

6 FACTOR INTERACTIONS FOR STRAWBERRY FRUIT ANALYSES

The following sections (7.0 and 8.0) discuss the comparisons of the relative efficacy of alternatives on yields of strawberry fruit and tomatoes in the presence of another parameter (eg. fungal presence, nutsedge inoculum density.). The parameters selected were those considered to have most influence on the performance of an alternative and those which Parties may have used to partly support the request for CUN's.

Note: Codes used for treatments are shown in Appendix 1.

6.1 *Meta-analysis for effect of treatment x nutsedge levels on yields of strawberry fruit, Appendix III-1*

Of the 101 trials in strawberry fruit, very few were conducted on nutsedge and fewer (for most treatments less than 3 observations only were recorded) had recorded population densities of nutsedge. This still enables conclusions to be drawn about the performance of alternatives but less certainty exists about the mean estimates due to the large variances in the LSI's. Conduct and review of more studies with nutsedge as a major factor may improve results. In spite of the low number of studies, some treatments had mean estimates and LSI's similar to the mean estimate for MB/Pic 67:33 depending on the inoculum density of nutsedge.

The Wald test (Appendix VII) showed there was no significant interaction of treatment x nutsedge population densities (ie alternatives performed similarly at each level of nutsedge). At 1-5, 6-30 and greater than 30 plants/m^2, 16, 7 and 3 treatments respectively (excluding treatments with pebulate) had mean estimates that were within 5% of the mean estimate of MB/Pic 67:33. As stated above, higher study numbers for these treatments would decrease the LSI's and increase the certainty of the estimated mean. At high nutsedge levels and when pebulate treatments were excluded, MNa, MNa with 1,3-D, or dazomet combined with napropamide were the most effective alternatives.

6.2 *Meta-analysis for effect of treatment x fungal levels on yields of strawberry fruit, Appendix III-2*

The Wald test (Appendix VII) showed there was no significant interaction of treatment x fungal presence. This meant there was a similar trend in the performance of alternatives whether the fungal inoculum density was stated or not. Results also showed that a much larger number of studies (101 observations of MB/Pic 67:33) were conducted on sites where the level of fungal inoculum densities was unknown than where fungal inoculum densities were known (21 observations of MB/Pic 67:33). When fungal levels were not specified, there were 20 treatments which gave a mean estimate within 5% of the mean estimate for MB/Pic 67:33 and two treatments, ie. TC35 combined with either dazomet or MNa, which exceeded the mean estimate of MB/Pic 67:33 by over 10%. When fungal pathogens were known to be present (i.e. inoculum levels stated), there were insufficient studies of the same treatments stated above to determine their effect, and TC35 and Pic combined with napropamide were the treatments which provided the closest mean estimate to MB/Pic 67:33. A large proportion of the studies where pathogenic fungi were present comes from trials that were artificially infested (eg. Horner, 1999) and this may have attributed to the lower relative mean estimates for yield for some alternative treatments compared to the yield obtained under natural infestation levels at commercial grower sites.

The results have relevance for the assessment of CUNs, because they demonstrate;

i) that best estimate of mean yields for alternatives compared to the standard commercial MB/Pic formulation when used in regions under high (sometimes artificially inoculated) and unknown pest pressure.

ii) The modelled mean estimate for yields (including MB/Pic formulations) were generally higher when pathogen levels were unknown. This would be expected as some unknown sites may not have pathogens.

iii) that 83% of studies on MB alternatives by researchers on strawberries in this study were conducted without reporting of the inoculum levels of fungal pathogens. Most of these studies were also conducted at sites on growers' properties. This may indicate that high levels of pathogens did not exist at many test sites, even though they were naturally infested field sites.

iv) Yields in untreated plots in all studies (when fungal pressure was not known) were significantly lower (ie approximately 30%) than the yields obtained with most fumigant treatments. This indirectly indicates that some biological factors (probably pathogenic fungi) were affecting yields at many trial sites.

6.3 ***Meta-analysis for effect of treatment x nematode levels on yields of strawberry fruit, Appendix III-3***

The Wald test (Appendix VII) showed there was no significant interaction of treatment x nematode presence. Results also showed that a much larger number of studies (111 observations of MB/Pic 67:33) were conducted on sites where the level of nematode inoculum densities was unknown or not published than where nematode levels were specified (12 observations of MB/Pic 67:33). When nematode levels were not specified, there were 16 treatments which gave a mean estimate within 5% of the mean estimate for MB/Pic 67:33 and one treatment, TC35 combined with MNa, which exceeded the mean estimate of MB/Pic 67:33 by approximately 10%. When pathogenic nematodes were known to be present (i.e. inoculum levels stated), there were several treatments which showed efficacies which were similar to MB. Pic combined with fosthiosate and napropamide, TC35, Pic and MI60 were the treatments which provided the closest mean estimate to MB/Pic 67:33.

The results have relevance for the assessment of CUNs, because they demonstrate;

i) that best estimate of mean yields for alternatives compared to the standard commercial MB/Pic formulation when used in regions under high (sometimes artificially inoculated) and unknown nematode pressure.

ii) that 90% of studies on MB alternatives by researchers on strawberries in this review were conducted without reporting the inoculum levels of nematodes. Most of these studies were also conducted at sites on growers' properties. This may indicate that damaging levels of nematodes did not exist at many test sites, even though they were naturally infested field sites.

iii) when nematodes were known to be present, the modelled estimate of the mean for MB/Pic 67:33 was higher indicating that nematodes were not the primary pest of strawberries in many studies.

iv) Yields in untreated plots in all studies (when nematode pressure was not known) were significantly lower (approximately 30%) than the yields obtained with most fumigant treatments. This indirectly indicates that some biological factors, eg. pathogenic fungi, as discussed above, were leading to the yield losses at trial sites.

6.4 *Meta-analysis for effect of treatment x application method on yields of strawberry fruit, Appendix III-4*

The Wald test (Appendix VII) showed there was a significant interaction of treatment x application method, however this was almost solely due to variability in metham sodium effectiveness when applied by different methods. MNa applied by injection or drip was a better treatment than application to the surface and irrigated into the soil. Conclusions about other treatments are difficult because of the low number of studies comparing similar treatments applied by different application methods.

6.5 *Meta-analysis for effect of treatment x plastic film type on yields of strawberry fruit, Appendix III-5*

The Wald test (Appendix VII) showed there was no significant interaction of treatment x film type. This result has relevance for assessment of CUN's because it shows that despite lower rates being used with methyl bromide (refer TEAP Report, October 2005) and alternatives barrier films in studies that similar relative yields were obtained compared to standard the commercial rates for methyl bromide and alternatives used in trials. Sufficient studies had been made to make comparisons of the effect of barrier films for use with the alternatives (PicEC, TC35EC, Pic, TC35 and dazomet) and one MB/Pic formulation (MB/Pic 50:50).

6.6 *Meta-analysis for effect of treatment x production method on yields of strawberry fruit, Appendix III-6*

The Wald test (Appendix VII) showed there was no significant interaction of treatment x production method. This meant that the relative trend for how alternatives performed compared to MB/Pic 67:33 was similar for both greenhouse and open field trials.

6.7 *Meta-analysis for effect of treatment x soil type on yields of strawberry fruit, Appendix III-7*

The Wald test (Appendix VII) showed there was no significant interaction of treatment x soil type. This meant that the relative trend for how alternatives performed compared to MB/Pic 67:33 was similar for the different soil types.

6.8 *Comparison of raw data means against the modelled mean estimates from the meta-analysis for effect of treatments on yields of strawberry fruit, Appendix III-8*

Results showed that for the treatments presented in the chart that the raw means from international studies on alternatives formed a reasonable estimate of the modelled estimated means in the meta-analysis. Although some variation is seen in the raw means these fell within the LSI's (not shown) of the estimated modelled means. The raw means that were most consistent across regions and provided the closest prediction of the modelled mean estimate across all regions were TC35 injected, chloropicrin combined with metham sodium (PicMNa) and chloropicrin (Pic) injected. These results suggest that of the treatments shown these would provide the best alternatives to methyl bromide.

6.9 *Partial meta-analysis results for effect of treatment on yields of strawberry fruit, Appendices III-9 and III-10*

An analysis of results showing the comparison of the relative means of alternatives when compared to the methyl bromide treatment from within the same study showed that similar trends are observed to those shown for the modelled means in Fig 6. The key advantage of this comparison is that when observations for treatments were small (<3) the analysis provides a better estimate of the treatment effect relative to the standard methyl bromide treatment. This is because the variation resulting from the differences between studies is not included in this comparison. For instance, treatments which had low numbers but mean estimated yields predicted above MB/Pic 67:33 and not shown in the modelled analysis (See Fig 6) included PicMNaDiTera, PicECDaz, PicDazEnz, TC35Daz, PicECDazEnz, TC35Nap and MycCom.

6.10 *Correlation between the fully modelled means and the partially modelled means for strawberry fruit observations, Appendix III – 11*

The comparison between the fully modelled means and the partially modelled means showed that there was a good correlation between the effect of alternatives in nearly all studies (ie the effect of alternatives relative to the methyl bromide treatment were similar for most studies). This comparison provided a means of determining outliers which could be cross checked and omitted from the meta-analysis if data was found to be in error (ie. the untreated mean was greater than methyl bromide or the methyl bromide was too low when compared to other treatments).

7. FACTOR INTERACTIONS FOR TOMATO FRUIT ANALYSES

7.1 *Meta-analysis for effect of treatment x nutsedge levels on yields of tomato fruit, Appendix V-1*

Of the 61 trials in tomatoes, 24 trials were made on nutsedge. Many treatments were not studied across all nutsedge density groupings and this limited some of the comparisons. For instance, MB/Pic 98:2, had not been used as a treatment when nutsedge densities were stated at 1-5 plants/m^2. Some treatments, however, had mean estimates and LSI's similar to the mean estimate for MB/Pic 67:33 depending on the inoculum density of nutsedge.

The Wald test (Appendix VIII) showed there was a significant interaction of treatment x nutsedge population densities. This meant that at least some alternatives performed differently at each level of nutsedge. At 1-5plants/m^2, there were insufficient treatments without pebulate to determine which treatments had mean estimates similar to methyl bromide so results could not be shown (see Appendix V-1). At 6-30 plants/m^2, MNa (metham sodium) and TC35 (1,3-D/chloropicrin) provided mean estimates within 5% of the mean estimate for MB/Pic 67:33. At greater than 30 plants/m^2, three treatments (excluding treatments with pebulate) had mean estimates that were within 5% or greater than the mean estimate of MB/Pic 67:33. MI60 and dazomet were the treatments which had the closest mean estimates to MB/Pic 67:33 at high nutsedge densities. The relatively low numbers of studies conducted without pebulate and with many of the alternatives make it difficult to be certain about the consistency and relative effectiveness of many of the alternatives shown.

The results have relevance for the assessment of CUN's, because they demonstrate;

i) that best estimate of mean yields for alternatives compared to the standard commercial MB/Pic formulation when used in regions under moderate to severe nutsedge pressure.

7.2 *Meta-analysis for effect of treatment x fungal levels on yields of tomato fruit, Appendix IV-2*

The Wald test (Appendix VIII) showed there was no significant interaction of treatment x fungal presence. This meant there was a similar trend in the performance of alternatives whether the fungal inoculum density was stated or not. Results showed that there were a similar number of studies where the level of fungal inoculum densities was unspecified to those where fungal inoculum densities were known.

When treatments without pebulate were considered and fungal levels were not specified, four treatments gave a mean estimate within 5% of the mean estimate for MB/Pic 67:33 (MNa combined with cadusafos, Pic combined with MNa, MI60 and MI100). In studies where it was known that fungal pathogens were present, (i.e. inoculum levels stated), PicMNa and TC35 gave the best mean estimate of yield relative to MB.

The results have relevance for the assessment of CUN's, because they demonstrate that:

i) the relative efficacy, the key alternatives and the likely variability in performance (eg. LSI) of mean yield of an alternative compared to the mean estimate of yield of a standard commercial MB/Pic formulation when fungal pressure are both known and unknown.

ii) the yields in untreated plots in all studies (when fungal pressure was not known) were significantly lower (ie approximately 50%) than the yields obtained with most fumigant treatments.

iii) the modelled mean estimate for yields (including MB/Pic formulations) were generally equivalent when fungal pathogen levels were known or unspecified. This together with large yield reductions in the untreated plots indicates that the meta-analysis of all studies provides relevant information on the performance of alternatives whether or not the level of fungal pressure is known.

7.3 *Meta-analysis for effect of treatment x nematode levels on yields of tomato fruit, Appendix IV-3*

The Wald test (Appendix VIII) showed there was no significant interaction of treatment x nematode presence. There were similar studies where nematode levels were known than when nematodes were unspecified, leading to good comparisons of the effects of alternatives. Several alternatives with the unregistered product pebulate gave mean estimates that were greater than 5% of the mean estimates for methyl bromide treatments.

When treatments without pebulate were considered, six treatments gave a mean estimate within 5% of the mean estimate for MB/Pic 98:2 (NaN3, MI60, PicMNa, Multi, MNaPP, Daz) when nematode levels were not specified. When nematodes were known to be present (i.e. inoculum levels stated), three treatments provided mean estimates within the mean estimate of MB67:33 ie. MNaCad, MI60 and PicMNa.

The results have relevance for the assessment of CUNs, because they demonstrate;

i) the relative efficacy, the key alternatives and the likely variability in performance (eg. LSI) of mean yield of an alternative compared to the mean estimate of yield of a standard commercial MB/Pic formulation. It also shows this comparison in regions where pathogenic nematodes (presence or absence) are known and unknown to occur.

ii) Yields when nematodes were known to be present were reduced by approximately 60% in untreated plots, whereas several alternatives gave similar or better yields than the standard MB (67:33) treatment

7.4 *Meta-analysis for effect of treatment x application method on yields of tomato fruit, Appendix IV-4*

The Wald test (Appendix VIII) showed there was no significant interaction of treatment x application method. MB applied by injection gave modelled estimates higher than when applied by hotgas. TC35 and MNa gave better modelled estimates when applied by injection compared to drip application.

7.5 *Meta-analysis for effect of treatment x plastic film type on yields of tomato fruit, Appendix V-5*

The Wald test (Appendix VIII) showed there was no significant interaction of treatment x film type. This result has relevance for assessment of CUN's because it shows that despite lower rates of MB/Pic 67:33 being applied with methyl bromide (refer TEAP Report, October

2005) and the alternative TC35 under barrier films, similar effectiveness was obtained compared to the standard commercial rates.

7.6 *Meta-analysis for effect of treatment x production method on yields of tomato fruit, Appendix V-6*

The Wald test (Appendix VIII) showed there was no significant interaction of treatment x production method. This meant that the relative trend for how alternatives performed compared to MB/Pic 67:33 was similar for both greenhouse and open field trials. Results did show, however that there were fewer alternatives identified for greenhouse production as several of the alternatives used in open fields are not registered or impractical to use in greenhouse structures. As shown above, MI60, PicMNa and Telone C17 gave mean estimates within 5% of the MB/Pic 67:33 standard treatment. Metham sodium combined with cadusafos (MNaCad) was the treatment which gave the best estimate of the mean comparable to MB/Pic 67:33 for greenhouses.

7.7 *Meta-analysis for effect of treatment x soil type on yields of tomato fruit, Appendix V-7*

The Wald test (Appendix VIII) showed there was a significant interaction of treatment x soil type. This result has relevance for assessment of CUN's because it indicates that soil type can influence the relative effectiveness of alternatives in regions where tomatoes are grown. For instance, chloropicrin (Pic) and sodium azide (NaN3) were more effective when applied to a loam or clay respectively than when applied to a sand.

7.*8* *Partial meta-analysis results for effect of treatment on yields of strawberry fruit, Appendices V-8*

An analysis of results showing the comparison of the relative means of alternatives when compared to the methyl bromide treatment from within the same study showed that similar trends are observed to those shown for the modelled means in Fig 7. The key advantage of this comparison is that when observations for treatments were small (<3) the analysis provides a better estimate of the treatment effect relative to the standard methyl bromide treatment. For instance, treatments which had low numbers, but mean estimated yields predicted within 5% of the mean estimate of MB/Pic 67:33 (not shown in the modelled analysis) (see Fig 6) were TC35TrefNap (TC35 combined with the herbicides Treflan and napropamide), Sol, (Solarisation), PicTel (chloropicrin combined with 1,3-D) and TC35NapHal (TC35 combined with napropamide and halsulfuron).

7.9 *Correlation between the fully modelled means and the partially modelled means for strawberry fruit observations, Appendix V - 9*

The comparison between the fully modelled means and the partially modelled means showed that there was a good correlation between the effect of alternatives in nearly all studies (i.e. the effect of alternatives relative to the methyl bromide treatment were similar for all studies).

This comparison provided a means of determining outliers which could be cross checked and omitted from the meta-analysis if data was found to be in error (i.e. the untreated mean was greater than methyl bromide or the methyl bromide was too low when compared to other treatments). For tomatoes there were no studies which needed to be excluded on this basis.

7.10 *Relative ('averaged' raw means) of nutsedge control for treatments in international studies on tomatoes, Appendix V-10*

This figure shows the effect of treatments on nutsedge numbers directly when the mean data from all relevant studies was averaged for each treatment. There was insufficient data to do a full meta-analysis of the information. It is important for assessment of treatment effects because it shows the direct effect of treatments on nutsedge whereas previous results have used 'relative' yield as a direct comparison of the effect of alternatives on nutsedge. The results are also important because they give an indication of the carryover of nutsedge from one crop to another.

The results show that of the studies that showed nutsedge data, that sodium azide (NaN3) and PicTelNap (chloropicrin combined with 1,3-D and the herbicide, napropamide) tended to give control of nutsedge that was as effective as the methyl bromide treatments (MB/Pic 98:2 and 67:33). TC17, TC35 combined with metalochlor and trifluralin and TC35 combined with napropamide and halsulfuron, appeared to be the next most effective treatments. These findings are only an indication of possible trends.

8 'RAW' MEAN COMPARISON OF YIELDS FOR FOUR CROPS

Appendix VI shows the 'raw' mean comparisons from studies for several major alternatives considered in four crops where there were insufficient studies to conduct a proper meta-analysis. The 'raw' means for tomatoes have been compared to the modelled estimates in Table 7. This figure gives an indication of treatments which provide consistent effects across different crops and those which vary widely.

9 BIBLIOGRAPHY

Ajwa, H., Trout, T. (2000). Strawberry Growth and Yield with Three Years of Drip Fumigation. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 25-1.

Ajwa, H. A., Fennimore, S., Kabir, Z., Martin, F., Dunniway, J., Browne, G., Trout, T., Khan, A., Daugovish, O. (2004). Strawberry Yield with Chloropicrin and Inline in Combination with Metam Soduim with VIF. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2004. 31 October - 3 November, 2004, Orlando, Florida, USA, pp. 38-1.

Bartual, R., Cebolla, V., Bustos, J., Giner, A., Lopez-Aranda, J. M. (2002). The Spanish project on alternatives to methyl bromide. (2): The case of strawberry in the area of Valencia. Acta Horticulturae, 431-434.

Benlioglu, S., Boz, O., Yildiz, A., Kaskavalci, G., Benlioglu, K. (2005). Alternative soil solarization treatments for the control of soil-borne diseases and weeds of strawberry in the western Anatolia of Turkey. Journal of Phytopathology-Phytopathologische Zeitschrift, 153: 423-430.

Cebolla, V., Bartual, R., Bustos, J., Giner, A. (2002). New chemicals as possible alternatives to methyl bromide in the area of Valencia: preliminary results. Acta Horticulturae, International Society for Horticultural Science (ISHS), Leuven, Belgium: 2002: 435-438.

Csinos, A. S., Webster, T. M., Sumner, D. R., Johnson, A. W., Dowler, C. C., Seebold, K. W. (2002). Application and crop safety parameters for soil fumigants. Crop Protection, 21: 973-982.

Dickson, D. W., Locascio, S. J., Mitchell, D. J. (1998). Evaluation of methyl bromide alternatives fumigants on tomato under polyethylene mulch in 1998. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1998. 7-9 December, 1998, Orlando, Florida, USA, pp. 27-1.

Dickson, D. W., Mendes, M., Hamill, J. (2003). Comparison of Methyl Iodide Formulations with Methyl Bromide and an Untreated Control on the Management of Root-Knot Nematodes, Weeds and Yield of Tomato in Florida. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 2003. 3-6 November, 2003, San Diego, California, USA, pp. 22-1.

Duniway, J. M., Xiao, C. L., Ajwa, H., Gubler, W. D. (1999). Chemical and cultural alternatives to methyl bromide fumigation of soil for strawberry. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1998. 1-4 November, 1999, San Diego, California, USA, pp. 2-1 .

Fennimore, S. A., Duniway, J. M., Martin, F. N., Browne, G. T., Kabir, Z., Winterbottom, C. Q. , Ajwa, H. A., Westerdahl, B. B., Goodhue, R. E., Haar, M. J. (2004). Alternative Fumigants for Strawberry Nursery Production in California: A Summary. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2004. 31 October - 3 November, 2004, Orlando, Florida, USA, pp. 16-1.

Ferguson, L. M., Fernandez, G. E., Brannen, P. M., Louws, F. J., Poling, E. B., Sydrovych, O. B., Safley, C. D., Monks, D. W., Pesic-Van Esbroeck, Z., Sanders, D. C., Smith, J. P. (2001). Alternative Soil Treatments for Strawberry in the Southeastern United States. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 2001. 5-9 November, 2001, San Diego, California, USA, pp. 42-1.

Ferguson, L. M., Louws, F. J., Fernandez, G. E., Brannen, P. M., Poling, E. B., Sydrovych, O. B., Safley, C. D., Monks, D. W., Pesic-Van Esbroeck, Z., Sanders, D. C., Smith, J. P. (2002). Chemical and Biological Alternatives to Methyl Bromide for Strawberry in the Southern Eastern US. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2002. 6-8 November, 2002, Orlando, Florida, USA, pp. 103-1.

Fernandez, G. E., Abad, Z. G., Louws, F. J. (2000). Chemical Alternatives to Methyl Bromide fro Strawberry Production in North Carolina. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 35-1.

Freitas, L., Dickson, D. W., Mitchell, D. J. (1999). Methyl Bromide and Chloropicrin Effects on Pasteuria Penetratis. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1999. 1-4 November, 1999, San Diego, California, USA, pp. 24-1.

Fritsch, J. (1998). Strawberry Crops in Frnace: Different Methods to Apply Methyl Bromide and Metam Sodium Open Fields. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1998. 7-9 December, 1998, Orlando, Florida, USA, pp. 14-1.

Giannakou, I. O., Anastasiadis, I. (2005). Evaluation of chemical strategies as alternatives to methyl bromide for the control of root-knot nematodes in greenhouse cultivated crops. Crop Protection, 24: 499-506.

Giannakou, I. O., Sidiropoulos, A., Prophetou-Athanasiadou, D. (2002). Chemical Alternatives to Methyl Bromide for the Control of Root-Knot Nematodes in Greenhouses. Pest Management Science, 58: 290-296.

Gilreath, J. P., Jones, J. P., Santos, B. M., Overman, A. J. (2004c). Soil Fumigant Evaluations for Soilborne Pest and Cyperus Rotundus Control in Fresh Market Tomato. Crop Protection, 23: 889-893.

Gilreath, J. P., Mirusso, J. M., Noling, J. W., Jones, J. P., Gilreath, P. R. (2002a). Effectiveness of Broadcast Application of Telone C-35 and Tillam + Devrinol in Tomato. Proc. Fla. Stat Hort. Soc, 115: 276-280.

Gilreath, J. P., Noling, J. W., Gilreath, P. R., Jones, J. P. (1997). Field validation of 1,3 dichloropropene + chloropicrin and pebulate as an alternative to methyl bromide in tomato. Proceedings of the Annual Meeting for the Florida State Horticultural Society. 2-4 November, 1997, Orlando, Florida, USA, pp. 273-276.

Gilreath, J. P., Noling, J. W., Locascio, S. J., Chellemi, D. O. (1999). Effect of Methyl Bromide, 1,3-Dichloropropene + Chloropicrin with Pebulate and Soil Solarisation on Soilborne Pest Control in Tomato Followed by Double-Cropped Cucumber. Proceedings of the Florida State Horticultural Society, 112: 292-297.

Gilreath, J. P., Poling, E. B., Noling, J. (2002b). Nursery and Fruiting Field Fumigant Effect on Strawberry. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2002. 6-8 November, 2002, Orlando, Florida, USA, pp. 15-1.

Gilreath, J. P., Santos, B. M. (2004a). Efficacy of Methyl Bromide Alternatives on Purple Nutsedge (Cyperus Rotundus) Control in Tomato and Pepper. Weed Technology, 18: 341-345.

Gilreath, J. P., Santos, B. M. (2004b). Methyl Bromide Alternatives for Weed and Soilborne Disease Management in Tomato (Lycopersicon Esculentum). Crop Protection, 23: 1193-1198.

Gilreath, J. P., Santos, B. M., Gilreath, P. R., Noling, J. W. (2005c) Validation of 1,3-dichloropropene plus Chloropicrin Broadcast Application in Tomato Grower Fields. Journal of Vegetable Crop Protection, In press.

Gilreath, J. P., Santos, B. M., Jones, J. P., Noling, J. (2004e). Efficacy of Mulches and Methyl Bromide Alternatives on Soilborne Pests and Weeds in Spring Tomato. Asian Journal of Plant Sciences, 3: 670-674.

Gilreath, J. P., Motis, T. N., Santos, B. M., Mirusso, J. M., Gilreath, P. R., Noling, J. W., Jones, J. P. (2005a). Influence of supplementary in-bed chloropicrin application on soilborne pest control in tomato (Lycopersicon esculentum). Crop Protection, In press.

Gilreath, J. P., Santos, B. M., Busacca, J. D., Eger, Jr. J. E., John M. Mirusso, Gilreath, P. R. (2005b). Validating broadcast application of Telone C-35 complemented with chloropicrin and herbicides in commercial tomato farms. Crop Protection, In press.

Gilreath, J. P., Santos, B. M., Gilreath, P. R., Jones, J. P., Noling, J. W. (2004d). Efficacy of 1,3-dichloropropene plus chloropicrin application methods in combination with pebulate and napropamide in tomato. Crop Protection, 23: 1187-1191.

Glass, G.V. (1976). Primary, secondary, and meta-analysis of research. Educational Researcher, 5, 3-8.

Gullino, M. L., Minuto, A., Gilardi, G., Garibaldi, A., Ajwa, H., Duafala, T. (2002a). Efficacy of Preplant Soil Fumigation With Chloropicrin for Tomato Production in Italy. Crop Protection, 21: 741-749.

Gullino, M. L., Minuto, A., Camponogara, A., Minuto, G., Garibaldi, A.. (2002b). Soil disinfestation in Italy: status two years before the phase-out of methyl bromide, Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2002. 6-8 November, 2002, Orlando, Florida, USA, pp. 12-1.

Haglund, W. A. (1999). Metam Sodium a Potential Alternative to Methyl Bromide. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1999. 1-4 November, 1999, San Diego, California, USA, pp. 23-1.

Haglund, W. A. (2000). Metam Soduim and Metam Combinations a Viable Replacement for Methyl Bromide. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 49-1.

Hamill, J. E., Dickson, D. W., T-Ou, L., Allen, L. H., Burelle, N. K., Mendes, M. L. (2004). Reduced rates of MBR and C35 under LDPE and VIF for control of soil pests and pathogens. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 2004. 31 October - 3 November, 2003, Orlando, Florida, USA, pp. 2-1.

Horner, I. (2003). Methyl Bromide Cirtical Use Nomination For Preplant Soil Use (Open Field or Protected Environment). The Horticulture & Food Research Institute of New Zealand Ltd, Auckland, New Zealand, 19-40.

Horner, I. J. (1999). Alternative Soil Fumigant Trials in New Zealand Strawberry Production. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1999. November, 1999, San Diego, California, pp. 87-1.

Ioannou, N. (2000). Soil solarization as a substitute for methyl bromide fumigation in greenhouse tomato production in Cyprus. Phytoparasitica, 28: 248-256.

Kabir, Z., Fennimore, S., Martin, F., Ajwa, H., Dunniway, J., Browne, G., Winterbottom, B., Westerdahl, B., Goodhue, R., Guerrero, L., Haar, M. (2003). Alternative Fumigants for the Control of Soil Pests: Strawberry as a Model System. Annual International Conference on Methyl Bromide Alternatives and Emissions Reduction 2003. 3-6 November, 2003, San Diego, California, USA, pp. 125-1.

Kokalis-Burelle, N., Dickson, D. W. (2003). Effects of Soil Fumigants and Bioyield on Root Knot Nematode Incidence and Yield of Tomato. Annual International Conference on Methyl Bromide Alternatives and Emissions Reductions. 3-6 November, 2003, San Diego, California, USA, pp. 50-1.

Locascio, S. J., Alligood, M. R., Dickson, D. W. (2003). Tomato Production as Affected by Bed Width and Fumigant. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 2003. 3-6 November, 2003, San Diego, California, USA, pp. 39-1.

Locascio, S. J., Dickson, D. W. (2000). Broadcast vs In-Row Application of 1,3-D Plus Chloropicrin as an Alternative for Tomato Fumigants. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 42-1.

Locascio, S. J., Dickson, D. W. (2001). Alternative Fumigants Applied with PE and VIF Muclhes for Tomato. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. 5-9 November, 2001, San Diego, California, USA, pp. 17-1.

Locascio, S. J., Dickson, D. W., Mitchell, D. J. (2000). Chloropicrin Enhancement of Metam-Sodium as an Alternative to Methyl Bromide for Mulched Tomato. Proceedings for the Florida State Horticultural Society, 113: 198-200.

Locascio, S. J., Dickson, D. W., Mitchell, D. J. , Olson, S. M., Gilreath, J. P., Noling, J. W. , Chase, C. A., Sinclair, T. R., Rosskopf, E. N. (1999). Alternative Treatments to Methyl Bromide for Strawberry. Proceedings of the Florida State Horticultural Society, 112: 297-301.

Lopez-Aranda, J. M. (1999). The Spanish National Project on Alternatives to MB: The Case of Strawberry. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1999. 1-4 November, 1999, San Diego, California, USA, pp. 8-1.

Lopez-Aranda, J. M., Medina, J. J., Miranda, L. (2002a). Demonstration stage on MB alternatives for strawberry production in Huelva (Spain). Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2002. 6-8 November, 2002, Orlando, Florida, USA, pp. 17-1.

Lopez-Aranda, J. M., Medina, J. J., Miranda, L., De Los Santos, B., Dominguez, F., Sanchez-Vidal, M. D., Lopez-Medina, J., Flores, F. (2001a). Agronomic Behaviour of Strawberry Coming From Different Types of Soil Fumigation in Nurseries. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 2001. 5-9 November, 2001, San Diego, California, USA, pp. 38-1.

Lopez-Aranda, J. M., Medina, J. J., Miranda, L., Dominguez, F. (2000). Three Years of Short-Term Alternatives To MB on Huelva Strawberries. Annual International Research Conference on

Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 10-1.

Lopez-Aranda, J. M., Medina, J. J., Miranda, L., Dominguez, F., Bartual, R., Cebolla, V., Lopez-Medina, J. (2002b). The Spanish project on alternatives to methyl bromide. (1): The case of strawberry in the area of Huelva. Proc. 4th Int. Strawberry Symp. Acta Horticulturae, 567, pp. 427-430.

Lopez-Aranda, J. M., Miranda, L., Soria, C., Romero, F., De Los, B., Montes, F., Vega, J. M., Paez, J. I., Bascon, J., Medina, J. J. (2004). Chemical Alternatives to Methyl Bromide for Strawberry Production in Huelva (Spain). 2003/04 Results. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2004. 31 October - 3 November, 2004, Orlando, Florida, USA, pp. 41-1.

Lopez-Aranda, J. M., Romero, F., Montes, F., Medina, J. J., Miranda, L., De Los Santos, B., Vega, J. M., Paez, J. I., Dominguez, F., Lopez-Medina, J., Flores, F. (2001b). Chemical and Non-Chemical Alternatives to MB Fumigation of Soil for Strawberry. 2000-2001 Results. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions 2001. 5-9 November, 2001, San Diego, California, USA, pp. 40-1.

Martin, F. N. (2003). Altenative fumigants in strawberry production and the use of remote sensing. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2003. 6-8 November, 2003, San Diego, California, USA, pp. 42-1.

Martinez, C., Fennimore, S., Ajwa, H. (2000). Strawberry Production with Methyl Bromide Alternatives: A Farmer's Perspective. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 11-1.

Mattner, S., Shanks, A. L., Gounder, R. K., and Porter, I. J. (2002). Best Cropping Strategies as Alternatives to Preplant Soil Disinfestation with Methyl Bromide for Temperate Strawberry Fruit and Runner Production. HAL Milestone Report Project Number BS98004, Horticulture Limited, Sydney, Australia.

Mattner, S., Shanks, A. L., Gounder, R. K., and Porter, I. J. (2005). Best Cropping Strategies as Alternatives to Preplant Soil Disinfestation with Methyl Bromide for Temperate Strawberry Fruit and Runner Production. HAL Final Report Project Number BS98004, Horticulture Limited, Sydney, Australia.

Medina, J. J., Miranda, L., Romero, F., Santos, B. d. l., Montes, F., Vega, J. M., Paez, J. I., Bascon, J., Lopez-Aranda, J. M. (2004). Six-year work on alternatives to methyl bromide (MB) for strawberry production in Huelva (Spain). Acta Horticulturae, International Society for Horticultural Science (ISHS), Leuven, Belgium: 2004:

Mosteller, F., and Colditz, G.A. (1996). Understanding research synthesis (meta-analysis). Annual Review Public Health, 17, 1-23.

Nelson, M., Olsen, B., Johnson, B., Norton, J. (2000). Results from 1999-2000 USDA IR-4 MBA Field Trials in CA and FL Strawberries. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. 6-9 November, 2000, Orlando, Florida, USA, pp. 3-1.

Nelson, M., Olsen, B., Vander Mey, B., Lepez, G., Rodriguez, L. (2001). Results from 2000-01 USDA IR-4 MBA Field Trials in CA and FL Strawberries. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2001. 5-9 November, 2001, San Diego, California, USA, pp. 43-1.

Nelson, M., Rodriguez, L., Vander Mey, B., Lepez, G., Norton, J. (2002). Results from the 2001-02 USDA IR-4 MBA Field Trials in California Strawberries. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2002. 6-8 November, 2002, Orlando, Florida, USA, pp. 16-1.

Nelson, S. D., Locascio, S. J., Allen, L. H., Dickson, D. W., Mitchell, D. J. (1999). Soil Flooding and Chemical Alternatives to Methyl Bromide in Tomato Production. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 1999. 1-4 November, 1999, San Diego, California, USA, pp. 13-1.

Noling, J. W., Gilreath, J. P. (2004). Evaluations of Chemical Alternatives to Methyl Bromide for Nematode Control and Tomato Yield in Field Microplots. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2004. 31 October - 3 November, 2004, Orlando, Florida, USA, pp. 50-1.

Porter, I.J., Brett, R., Wiseman, B. (1998). Alternatives to soil fumigation with methyl bromide in the strawberry and ornamentals industries. HAL Final Report, Project Number VG96033, Horticultural Australia Limited, Sydney, Australia.

Rodriguez-Kabana, R., Akridge, J. R., Burkett, J. E. (2003). Sodium azide (sep-100) for control of nutsedge, root-knot nematode and fusarium crown rot in tomato production. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2003. 3-6 November, 2003, San Diego, California, USA, p. 2003.

Sances, F. V. (2000). Conventional and Organic Alternatives to Methyl Bromide on Californian Strawberries. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction 2000. November, 2000, Orlando, Florida, pp. 24-1.

Santos, B.M., Gilreath, J.P., Motis, T.N., Noling, J.W., Jones, J.P., Norton, J.A. (2005). Comparing methyl bromide alternatives for soilborne disease, nematode and weed management in fresh market tomato. Crop Protection, In press.

Slusarski, C. Pietr, S.J. (2003). Validation of chemical and non-chemical treatments as methyl bromide replacements in field grown cabbage, celeriac and tomato. 2003 Vegetable Crops Research Bulletin 58, pp. 113-126.

10 STUDIES USED IN THE META-ANALYSIS

Table 10.1 Studies and Partial Trial Details of Studies used in the Strawberry Fruit Meta-Analysis

Source	Location	Year	Cultivars	VIF Study	UTC Group	Nut Group	Nem	Fungi
1. Ajwa *et al.* (2004)	California, USA	2002/03	.	Yes	50-85	.	.	.
		2003/04	.	Yes	50-85	.	.	.
2. Ajwa & Trout (2000)	California, USA	1998	Selva	No	50-85	.	.	.
		1999	Selva	No	<50	.	.	.
		2000	Selva	No	<50	.	.	.
		1998	Selva	No	>85	.	.	.
		1999	Selva	No	50-85	.	.	.
		2000	Selva	No	50-85	.	.	.
3. Bartual *et al.* (2002)	Valencia, Spain	1998	Pajaro	Yes	50-85	.	.	.
		1998	Camarosa	Yes	50-85	.	.	.
4. Benlioglu *et al.* (2005)	Turkey	2002/03	Camarosa	No	<50	.	.	.
		2003/04	Camarosa	No	50-85	.	.	.
5. Cebolla *et al.* (2002)	Valencia, Spain	1998/99	Camarosa	No	50-85	.	.	Yes
		1998	Pajaro	Yes	50-85	.	.	.
		1999	Camarosa	Yes	50-85	.	.	.
6. Duniway *et al.* (1999)	California, USA	1998	Selva	No	<50	.	.	.
		1999	Selva	No	50-85	.	.	.
7. Fennimore *et al.* (2004)	California, USA	2003/04	.	Yes	NoYield	?Type	.	.
		2002/03	.	Yes	NoYield	.	.	.
8. Ferguson *et al.* (2001)	North Carolina, USA	2000/01	Camarosa	No	50-85	.	.	.
	Georgia, USA	2000/01	Camarosa	No	50-85	.	.	Yes
9. Ferguson *et al.* (2002)	North Carolina, USA	2001/02	Camarosa	No	>85	.	.	.
		2001/02	Camarosa	No	50-85	.	.	.
		2001/02	Camarosa	No	50-85	.	Yes	.
10. Fernandez *et al.* (2000)	North Carolina, USA	1998	Chandler	No	50-85	.	.	.
		1999	Chandler	No	50-85	.	.	.
		2000	Chandler	No	50-85	.	.	.
11. Fritsch (1998)	Dordogne, France	1996/97	.	Yes	50-85	.	.	.
12. Gilreath *et al.* (2002b)	Florida, USA	2001/02	.	No	>85	6-30	Yes	No
13. Haglund (1999)	Washington, USA	1999	.	No	>85	.	.	.
14. Horner (2003)	New Zealand	1998	Pajaro	Yes	50-85	.	.	Yes
		2000B	Pajaro	No	50-85	.	.	Yes
		2000	Pajaro	No	50-85	.	.	.
		2001	Pajaro	No	50-85	.	.	.
		1999/00	Pajaro	No	<50	.	.	.
		1998	Pajaro	Yes	50-85	.	.	Yes
		1999	Pajaro	Yes	50-85	.	.	Yes
		2000	Pajaro	Yes	<50	.	.	Yes
		2001	Pajaro	Yes	50-85	.	.	Yes
		1999B	Pajaro	No	<50	.	.	Yes
		1998	Pajaro	No	NoUTC	.	.	.
		1999	Pajaro	No	NoUTC	.	.	.
		2000	Pajaro	No	>85	.	.	.
		2001	Pajaro	No	50-85	.	.	.
		1999	Pajaro	No	NoUTC	.	.	.
15. Kabir *et al.* (2003)	California, USA	2001	Camarosa	No	NoUTC	.	.	.
		2002	Camarosa	No	NoUTC	.	.	.
		2003	Camarosa	No	NoUTC	.	.	.
		2002	Camarosa	No	NoUTC	.	.	.
		2003	Camarosa	No	NoUTC	.	.	.
16. Locascio & Dickson (2000)	Florida, USA	1999	Florida 47	No	50-85	>30	Yes	Yes

Table 10.1 Studies and Partial Trial Details of Studies used in the Strawberry Fruit Meta-Analysis

Source	Location	Year	Cultivars	VIF Study	UTC Group	Nut Group	Nem	Fungi
		2000	Florida 47	No	50-85	>30	Yes	Yes
17. Locascio *et al.* (1999)	Florida, USA	1998	Chandler	No	50-85	>30	Yes	Yes
		1998	Chandler	No	50-85	1-5	.	.
		1998	Chandler	No	50-85	.	Yes	Yes
		1997/98	Chandler	No	<50	6-30	.	Yes
		1997/98	Chandler	No	50-85	6-30	.	Yes
18. Lopez-Aranda (1999)		1998	Camarosa	Yes	<50	.	.	.
19. Lopez-Aranda *et al.* (2002a)	Huelva, Spain	2002	Camarosa	No	NoUTC	.	.	.
		2002	Camarosa	No	NoUTC	.	.	.
		2002	Camarosa	No	NoUTC	.	.	.
		2002	Camarosa	No	NoUTC	.	.	.
		2002	Camarosa	Yes	NoUTC	.	.	.
20. Lopez-Aranda *et al.* (2002b)		1997/98	Camarosa	Yes	>85	.	.	.
		1998/99	Camarosa	Yes	50-85	.	.	.
21. Lopez-Aranda *et al.* (2001a)	Huelva, Spain	1999/00/01	Camarosa	Yes	>85	.	.	.
22. Lopez-Aranda *et al.* (2000)	Huelva, Spain	1997/98	Camarosa	Yes	50-85	.	.	.
		1999/00	Camarosa	Yes	50-85	.	.	.
23. Lopez-Aranda *et al.* (2004)	Huelva, Spain	2002/03	Camarosa	Yes	50-85	.	Yes	.
		2002/03	Camarosa	Yes	>85	.	.	.
		2003/04	Camarosa	Yes	50-85	.	Yes	.
		2003/04	Camarosa	Yes	50-85	.	Yes	.
24. Lopez-Aranda *et al.*	Huelva, Spain	2000/01	Camarosa	Yes	50-85	.	.	.
(2001b)	Huelva, Spain	2000/01	Camarosa	Yes	50-85	.	.	.
25. Martin (2003)	California, USA	2003	.	No	50-85	.	.	.
26. Martinez *et al.* (2000)	California, USA	1999	Camarosa	No	NoUTC	.	.	.
27. Mattner *et al.* (2002)	Victoria, Australia	1999	Selva	No	50-85	.	.	?
		2000	Selva	No	>85	.	.	.
		2000	Selva	No	50-85	.	.	.
		2000	Seascape	No	>85	.	.	.
28. Mattner *et al.* (2005)	Victoria, Australia	2003	Diamante	No	>85	.	.	Yes
		2004	Diamante	No	50-85	.	.	Yes
29. Medina *et al.* (2004)	Huelva, Spain	2001/02	Camarosa	No	NoUTC	.	Yes	.
		2002/03	Camarosa	No	NoUTC	.	.	.
		2002/03	Camarosa	No	NoUTC	.	.	.
30. Nelson *et al.* (1999)	Florida, USA	1998/99	Florida 47	No	<50	1-5	Yes	Yes
31. Nelson *et al.* (2000)	California, USA	1999/00	Camarosa	No	50-85	.	.	.
		1999/00	Diamante	No	50-85	.	.	.
		1999/00	Sweet Charlie	No	<50	.	.	.
		1999/00	Camarosa	No	<50	.	.	.
32. Nelson *et al.* (2001)	California, USA	2000/01	Camarosa	No	50-85	.	.	.
	California, USA	2000/01	Diamante	No	50-85	.	.	.
	Florida, USA	2000/01	Camarosa	No	<50	.	.	.
	Florida, USA	2000/01	Camarosa	No	>85	.	.	.
	California, USA	2000/01	592	No	>85	.	.	.
33. Nelson *et al.* (2002)	California, USA	2001/02	Camarosa	No	50-85	.	.	.
	California, USA	2001/02	Diamante	No	50-85	.	.	.
	California, USA	2001/02	BG-269	No	50-85	.	.	.
	Florida, USA	2001/02	Camarosa	No	>85	1-5	Yes	.
	Florida, USA	2001/02	Camarosa	No	<50	.	Yes	.

Table 10.1 Studies and Partial Trial Details of Studies used in the Strawberry Fruit Meta-Analysis

Source	Location	Year	Cultivars	VIF Study	UTC Group	Nut Group	Nem	Fungi
34. Porter *et al.* (1998)	Victoria, Australia	1996	Selva	No	>85	.	.	Yes
		1997	Selva	No	50-85	.	.	Yes
		1997	Selva	No	50-85	.	.	Yes
35. Sances (2000)	California, USA	1999/00	Camarosa	No	NoUTC	.	.	.

Table 10.2 Studies and Partial Trial Details of Studies used in the Tomato Fruit Meta-Analysis

Source	Location	Year	Cultivars	VIF Study	UTC Group	Nut Group	Nem	Fungi
1. Csinos *et al.* (2002)	Georgia, USA	1997	Heinz H8704	No	NoYield	?Type	.	Yes
		1997	Heinz H8704	No	NoYield	?Type	.	Yes
2. Dickson *et al.* (1998)	Florida, USA	1998	AgriSet 761	No	50-85	*	Yes	Yes
3. Dickson *et al.* (2003)	Florida, USA	2003	Florida 47	No	<50	>30	Yes	.
4. Freitas *et al.* (1999)	Florida, USA	1999	AgriSet 761	No	>85	.	Yes	.
5. Giannakou & Anastasiadis	Macedonia, Greece	2001/02	Arleta	No	<50	.	Yes	.
(2005)	Macedonia, Greece	2001/02	Arleta	No	<50	.	Yes	.
6. Giannakou *et al.* (2002)	Macedonia, Greece	1999/00	Arleta	No	>85	.	Yes	.
		1999/00	Savina	No	>85	.	Yes	.
		1999/00	Savina	No	50-85	.	Yes	.
7. Gilreath & Santos (2004a)	Florida, USA	1995/96	Solar Set	No	<50	>30	.	.
8. Gilreath & Santos (2004b)		1997	Sunbeam	No	50-85	>30	.	Yes
		1997	Sunbeam	No	<50	>30	.	Yes
9. Gilreath *et al.* (2004c)	Florida, USA	1998	Solar Set	No	<50	6-30	Yes	.
		1997	Solar Set	No	<50	>30	Yes	.
10. Gilreath *et al.* (2002a)	Florida, USA	2000	Florida 47	No	<50	1-5	Yes	Yes
		2001	Florida 47	No	<50	1-5	Yes	Yes
11. Gilreath *et al.* (2005a)	Florida, USA	2000	Florida 47	No	<50	.	Yes	Yes
		2001	Florida 47	No	50-85	.	Yes	Yes
		2002	Florida 47	No	<50	.	Yes	Yes
12. Gilreath *et al.* (1997)	Florida, USA	1997	.	No	NoUTC	.	.	.
		1997	.	No	NoUTC	.	.	.
		1997	.	No	NoUTC	NoUTC	.	.
		1997	.	No	NoUTC	NoUTC	Yes	.
13. Gilreath *et al.* (1999)	Florida, USA	1998	Solimar	No	<50	1-5	Yes	Yes
14. Gilreath *et al.* (2005b)	Florida, USA	2002	Sanibel	No	NoUTC	NoUTC	Yes	.
		2002	Florida 47	No	NoUTC	NoUTC	Yes	.
15. Gilreath *et al.* (2005c)	Florida, USA	1999/00	Florida 47	No	NoUTC	NoUTC	Yes	.
16. Gilreath *et al.* (2004d)	Florida, USA	2000	Florida 47	No	<50	1-5	Yes	Yes
		2001	Florida 47	No	<50	1-5	Yes	Yes
		2000/01	Florida 47	No	NoUTC	NoUTC	Yes	.
17. Gilreath *et al.* (2004e)		1998	Sunbeam	No	50-85	6-30	Yes	Yes
18. Gullino *et al.* (2002)	Liguria, Italy	1999	Cuore di bue	Yes	NoYield	.	.	Yes
19. Gullino *et al.* (2002b)	Sicily, Italy	1999	Principe Borghese	No	50-85	.	.	Yes
		1999	Vulcano	No	<50	.	.	Yes
	Liguria, Italy	1999	Principe Borghese	No	NoYield	.	.	Yes
	Liguria, Italy	1999	Principe Borghese	No	<50	.	.	Yes
	Liguria, Italy	1999	Principe	No	<50	.	.	Yes

Table 10.2 Studies and Partial Trial Details of Studies used in the Tomato Fruit Meta-Analysis

Source	Location	Year	Cultivars	VIF Study	UTC Group	Nut Group	Nem	Fungi
			Borghese					
	Liguria, Italy	1999	Vulcano	No	<50	.	.	Yes
	Liguria, Italy	2000	Principe Borghese	No	>85	.	.	Yes
	Liguria, Italy	2000	Vulcano	No	50-85	.	.	Yes
20. Haglund (2000)	Florida, USA	2000	.	No	50-85	>30	Yes	.
		2000	.	No	<50	6-30	Yes	.
21. Hamill *et al.* (2004)	Florida, USA	2004	.	Yes	<50	>30	Yes	.
22. Ioannou (2000)	Cyprus	1996	Dombito	No	<50	.	Yes	Yes
		1996	Dombito	No	50-85	.	Yes	Yes
23. Kokalis-Burelle & Dickson (2003)	Florida, USA	2003	Florida 47	No	<50	.	Yes	.
24. Locascio *et al.* (2003)	Florida, USA	2002	Florida 47	No	50-85	*	Yes	Yes
		2002	Solar Set	No	50-85	6-30	Yes	.
25. Locscio & Dickson (2001)	Florida, USA	2001	Florida 47	Yes	<50	>30	.	Yes
26. Locscio *et al.* (2000)	Florida, USA	1997	Solar Set	No	50-85	>30	.	Yes
		1998	AgriSet 761	No	50-85	>30	.	Yes
		1998	AgriSet 761	No	50-85	*	.	Yes
27. Nelson *et al.* (2002)	Florida, USA	2001/02	.	No	<50	.	Yes	.
	California, USA	2001/02	.	No	>85	.	.	.
	Florida, USA	2001/02	Florida 47	No	50-85	.	.	.
28. Noling & Gilreath (2004)	Florida, USA	2003	.	No	<50	.	Yes	.
		2004	.	No	50-85	.	Yes	.
29. Rodriguez-Kabana & Akridge (2003)	Alabama, USA	2002	Paragon	No	>85	.	.	.
30. Santos *et al.* (2005)	Florida, USA	2003	Florida 47	No	50-85	6-30	Yes	Yes
		2003	Florida 47	No	50-85	6-30	Yes	Yes
31. Slusarski & Pietr (2003)	Poland	2000	Rumba	No	50-85	.	.	Yes
		2001	Rumba	No	50-85	.	.	Yes

APPENDIX 1: LIST OF TREATMENT CODES/ABBREVIATIONS USED FOR TREATMENT APPLICATIONS IN THE FINAL DATABASES

Treatment Code	Treatment Description	Tomatoes	Strawberries
BioFum	Bio - Brassica; ChickManure		Yes
Cad	Cadusafos 2 + 1	Yes	
Cal	Calcium cyanamide		Yes
Chick	ChickManure; SheepManure		Yes
Compost	Compost		Yes
Daz	Dazomet	Yes	Yes
DazCal	Dazomet; Calcium cyanamide		Yes
DazLime	Dazomet; Lime		Yes
DazNap	Dazomet; Napropamide		Yes
DazSol	Dazomet; Solarization		Yes
DazTviride	Dazomet; *Trichoderma viride*	Yes	
Dip	Diphenamid 80WP	Yes	
DMDS	Dimethyl disulphide	Yes	Yes
EDN	Ethane dinitrile		Yes
EMF	Electronic Waves		Yes
Fen	Fenamiphos	Yes	
Fos	Fosthiazate 900 EC	Yes	
IndmusTviride	Indian mustard; *Trichoderma viride*	Yes	
Lime	Lime		Yes
MB30	Methyl bromide/chloropicrin(30:70)		Yes
MB30Cal	Methyl bromide/chloropicrin(30:70); Calcium cyanamide		Yes
MB50	Methyl bromide/chloropicrin(50:50)		Yes
MB50Cal	Methyl bromide/chloropicrin(50:50); Calcium cyanamide		Yes
MB50Sol	Methyl bromide/chloropicrin(50:50); Solarization		Yes
MB67	Methyl bromide/chloropicrin(67:33)	Yes	Yes
MB67PebNap	Methyl bromide/chloropicrin(67:33); Pebulate; Napropamide	Yes	
MB67Sol	Methyl bromide/chloropicrin(67:33); Solarization		Yes
MB98	Methyl bromide/chloropicrin(98:2)	Yes	Yes
MI100	Methyl iodide (100)	Yes	Yes
MI100MNa	Methyl iodide/chloropicrin(98:2); Metham sodium	Yes	
MI30	Methyl iodide/chloropicrin(30:70)		Yes
MI60	Methyl idoide/chloropicrin(50:50)	Yes	Yes
MNa	Metham sodium	Yes	Yes
MNaCad	Metham sodium; Cadusafos	Yes	
MNaCal	Metham sodium; Calcium Cyanamid		Yes
MNaFos	Metham Sodium; Fosthiazate 500 EC	Yes	
MNaHelp	Metham sodium; Help (ReZist + Stabiliser)		Yes
MNaLime	Metham sodium; Lime		Yes
MNaMes	Metham sodium; Messenger		Yes
MNaNap	Metham sodium; Napropamide		Yes
MNaPeb	Metham sodium; Pebulate	Yes	Yes
MNaPebFos	Metham sodium; Pebulate; Fosthiazate	Yes	
MNaPP	Metham sodium; PlantPro 45	Yes	Yes
MNaPPFos	Metham sodium; PlantPro 45; PlantPro 45; Fosthiazate 500 EC		Yes
MNaPPO	Metham sodium; Propylene Oxide		Yes
MNaRootshld	Metham sodium; Rootshield		Yes
MNaSol	Metham sodium; Solarization;		Yes
MNaTel	Metham sodium; 1,3-Dichloropropene	Yes	Yes

Treatment Code	Treatment Description	Tomatoes	Strawberries
MNaTelNap	Metham sodium; 1,3-Dichloropropene; Napropamide		Yes
MNaTelPeb	Metham sodium; 1,3-Dichloropropene; Pebulate		Yes
MNaTelSol	Metham sodium; 1,3-Dichloropropene; Solarization		Yes
Multi	Multiguard Protect	Yes	Yes
MycCom	Compost; Mycorrhizal		Yes
NaN3	Sodium azide	Yes	
NoTr	NoTreatment	Yes	Yes
NoTrPebNap	NoTreatment; Pebulate; Napropamide	Yes	
Oxa	Oxamyl	Yes	
Pic	Chloropicrin	Yes	Yes
PicCal	Chloropicrin; Calcium cyanamide		
PicDazEnz	Chloropicrin; Dazomet; Enzone		Yes
PicDMDS	Chloropicrin; Dimethyl disulphide		Yes
PicEC	Chloropicrin EC	Yes	Yes
PicECDaz	Chloropicrin EC; Dazomet		Yes
PicECDazEnz	Chloropicrin EC; Dazomet; Enzone		Yes
PicECMNa	Chloropicrin EC; Metham Sodium		Yes
PicECMNaDiTera	Chloropicrin EC; Metham Sodium; DiTera ES		Yes
PicECMNaEnz	Chloropicrin EC; Metham Sodium; Enzone		Yes
PicECMNaFos	Chloropicrin EC; Metham Sodium; Fosthiazate 500 EC		Yes
PicECMNaHM0	Chloropicrin EC; Metham Sodium; HM0122		Yes
PicEnzPeb	Chloropicrin; Enzone; Pebulate	Yes	
PicFosNap	Chloropicrin; Fosthiazate 500 EC; Napropamide 50WG;		Yes
PicFosPeb	Chloropicrin; Fosthiazate; Pebulate	Yes	
PicMNa	Chloropicrin; Metham Sodium	Yes	Yes
PicMNaDiTera	Chloropicrin; Metham Sodium; DITera DF		Yes
PicMNaEnz	Chloropicrin; Metham Sodium; Enzone	Yes	Yes
PicMNaFos	Metham Sodium; Chloropicrin; Fosthiazate 500 EC	Yes	
PicMNaNap	Metham Sodium; Chloropicrin; Napropamide		Yes
PicMNaPeb	Metham Sodium; Chloropicrin; Pebulate	Yes	
PicMNaSol	Metham Sodium; Chloropicrin; Solarization		Yes
PicNap	Chloropicrin; Napropamide		Yes
PicPeb	Chloropicrin; Pebulate	Yes	
PicTel	Chloropicrin, 1,3-Dichloropropene	Yes	Yes
PicTelNap	Chloropicrin; 1,3-Dichloropropene; Napropamide		Yes
PicTelPebNap	Chloropicrin; 1,3-Dichloropropene; Pebulate; Napropamide	Yes	
PPNap	PlantPro 45B EC; Napropamide 50WG;		Yes
PPFosNap	PlantPro 45B; Fosthiazate 500 EC; Napropamide 50WG		Yes
PPO	Propylene oxide		Yes
Quil	Quillaja Sopanaria	Yes	
SheepPoul	SheepManure; PoultryManure		Yes
Sol	Solarization	Yes	Yes
SolBio	Solarization; Biofumigation		Yes
SolCab	Solarization; Cabbage residue		Yes
SolFert	Solarization; Chicken Manure		Yes
SolSoil	Solarization; SoilGard	Yes	
TC17	1,3-Dichloropropene (17%)	Yes	Yes
TC17MNa	TC17; Metham Sodium	Yes	
TC17Nap	TC17; Napropamide		Yes
TC17Peb	TC17; Pebulate	Yes	Yes
TC17PicNap	TC17; Chloropicrin; Napropamide		Yes
TC25	1,3-Dichloropropene (25%)	Yes	

Treatment Code	Treatment Description	Tomatoes	Strawberries
TC35	1,3-Dichloropropene (35%)	Yes	Yes
TC35Daz	TC35;Dazomet	Yes	Yes
TC35Nap	TC35; Napropamide		Yes
TC35EC	TC35 EC	Yes	Yes
TC35ECDaz	TC35 EC; Dazomet;	Yes	Yes
TC35ECMNa	TC35 EC; Metham Sodium		Yes
TC35ECPicECDaz	TC35 EC; Chloropicrin; Dazomet		Yes
TC35ECTrefNap	TC35 EC; Treflan; Napropamide	Yes	
TC35MesTref	TC35; Messenger; Treflan	Yes	
TC35MNa	TC35; Metham Sodium		Yes
TC35MNaOrgFung	TC35; Metham Sodium; *Bacillus subtillis*		Yes
TC35Nap	TC35; Napropamide		Yes
TC35Peb	TC35; Pebulate	Yes	Yes
TC35PebNap	TC35; Pebulate; Napropamide	Yes	
TC35Pic	TC35; Chloropicrin		Yes
TC35PicPebNap	TC35; Chloropicrin; Pebulate; Napropamide	Yes	
TC35PicPebTrif	TC35; Chloropicrin; Pebulate; Trifluralin	Yes	
TC35PicTrefNap	TC35; Treflan; Napropamide; Chloropicrin	Yes	
TC35Sol	TC35; Solarization		Yes
TC35Tviride	TC35; *Trichoderma viride*	Yes	
Tel	1,3-Dichloropropene	Yes	Yes
TerraK	TerraKleen	Yes	
Tviride	*Trichoderma viride*	Yes	
TvirideFert	*Trichoderma viride;* Straw; Urea	Yes	
Vrlx	Vorlex CP		Yes

APPENDIX II-1 Relationship for treatment x nutsedge interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

STRAWBERRY - Treatments x nutsedge (3 levels: 1-5, 6-30 and >30)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	1-5 PicFosNap	82.7	109.9	146
1	1-5 PicECMNa	69.9	102.4	149.9
1	1-5 PicMNaEnz	68.9	101.7	150.2
1	1-5 TC35Sol	74.2	100.4	135.7
3	1-5 MB67	78.4	100	127.5
1	1-5 TC35Nap	73.7	99.6	134.7
1	1-5 MNaTelNap	17.3	98.8	564.3
1	1-5 PicECMNaHM0	70.7	98.4	136.8
1	1-5 PicNap	76.1	98.1	126.4
1	1-5 MI60	72	97.7	132.6
1	1-5 TC35	71.7	97.7	133.2
1	1-5 DazNap	84.5	96.6	110.3
2	1-5 MNa	48.1	96.4	193.1
2	1-5 PicMNa	66.4	96.3	139.8
1	1-5 PPO	66.1	95.7	138.5
1	1-5 TC17Peb	67.9	95.3	133.8
1	1-5 TC35Daz	67.9	95	132.9
3	1-5 PPNap	55.9	95	161.3
1	1-5 MNaNap	68.3	91.5	122.7
1	1-5 TC35Peb	65.1	91.5	128.4
1	1-5 Sol	55	87.6	139.7
1	1-5 MNaTelSol	15.3	87.3	498.1
3	1-5 NoTr	45.7	74.5	121.5
1	1-5 MNaTelPeb	12.5	72	415.4
1	6-30 TC35	95.6	131.5	180.9
1	6-30 MI30	87.9	120.4	164.8
3	6-30 MB67	79.6	102	130.7
2	6-30 PicNap	76.7	98.5	126.6
1	6-30 DazNap	84.5	96.6	110.3
2	6-30 TC35Nap	72.5	95.5	126
1	6-30 DazSol	67.6	94.5	132.2
2	6-30 MI60	69.9	94.4	127.6
2	6-30 TC17Nap	71	93.6	123.3
2	6-30 PicMNaSol	60.6	82.4	112.1
2	6-30 MNaNap	56.2	73.7	96.7
2	6-30 PicMNaNap	53.2	72.3	98.4
3	6-30 NoTr	40.9	67	109.7
3	6-30 Sol	37.3	51.9	72.2
1	>30 MNaTelPeb	17.6	101.8	589.7
2	>30 TC17Peb	74	101	137.9
1	>30 MNaTelNap	17.5	100.4	575.8
3	>30 MB67	76.8	99.8	129.8
4	>30 TC35Peb	73.5	98.8	132.9
1	>30 MNaNap	71.8	97.6	132.6
1	>30 DazNap	84.5	96.6	110.3
1	>30 TC35Nap	67	91.9	126
1	>30 MNaTelSol	15.6	89.2	511.6
1	>30 TC35Sol	64.6	88.5	121.4
1	>30 MNaPeb	61.9	87.2	122.9
1	>30 PicNap	60.5	79.1	103.5
1	>30 Sol	47.8	77	124.1

3	>30 NoTr	33.1	54.7	90.4

APPENDIX II-2 Relationship for treatment x fungal interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

STRAWBERRY - Treatment x fungi (2 levels: Presence and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	Yes MNaTelNap	81.9	100.8	123.9
23	Yes MB67	88	100	113.6
3	Yes TC17Peb	83.5	99.1	117.5
2	Yes DazNap	78.6	98	122.3
1	Yes MB30Cal	73.8	97.9	130
5	Yes TC35Peb	82.4	96.6	113.2
1	Yes MB50Cal	72.6	96.4	127.9
1	Yes DazSol	71.7	96.1	128.7
1	Yes TC35MNa	75	95.2	120.9
10	Yes MB30	83.6	95.1	108.2
4	Yes TC35Nap	80.2	94	110.2
4	Yes PicNap	80.2	93.3	108.5
2	Yes TC17Nap	77.1	92.8	111.6
11	Yes TC35	79.9	91.3	104.5
5	Yes MB50	79.9	91.3	104.3
1	Yes TC35MNaOrgFung	71.8	91.1	115.7
3	Yes PicMNa	73.5	90.8	112
1	Yes PicCal	74	89.6	108.3
2	Yes MNaTelSol	72.7	89.4	109.9
2	Yes TC35Sol	73.5	88.4	106.4
3	Yes PicDaz	76.1	88.2	102.3
15	Yes Pic	77.3	87.8	99.8
1	Yes MNaPeb	66	86.5	113.3
2	Yes MNaTelPeb	69.7	85.9	105.9
9	Yes Daz	73	84	96.7
1	Yes TC35ECMNa	65.6	83.3	105.7
2	Yes DazLime	66.5	82.3	101.9
4	Yes MNaNap	69.4	82.3	97.7
2	Yes PicMNaSol	58.8	81.7	113.5
4	Yes MI30	68.4	80.2	94
1	Yes PicTelNap	61.4	77.9	98.9
1	Yes TC17PicNap	60.9	77.3	98.2
16	Yes MNa	59.9	76.1	96.6
1	Yes MnaCal	58	74.9	96.9
2	Yes MnaLime	61.1	74.4	90.6
2	Yes MNaTel	57.9	72.4	90.5
2	Yes PicMNaNap	51.6	71.7	99.6
4	Yes EDN	59.5	71.3	85.3
1	Yes DazCal	53.4	70.9	94.1
2	Yes Lime	56.9	70.4	87.1
3	Yes Cal	61.5	69	77.5
5	Yes Sol	47.8	59.2	73.4
21	Yes NoTr	47.8	58.1	70.5
5	NS TC35Daz	107.6	120.4	134.8
1	NS MI30	98.2	119.9	146.4
7	NS TC35MNa	104.4	116	128.9
1	NS PicECDaz	88.1	114.5	148.9
2	NS PicDazEnz	93	112.4	135.9
1	NS PicMNaDiTera	72	112.3	175.4
2	NS PicECDazEnz	91.7	110.9	134.2
4	NS Compost	73.3	110.1	165.4

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	NS TC35ECDaz	93.8	109	126.5
6	NS PicFosNap	97.2	107.7	119.3
5	NS TC35ECPicECDaz	95.6	106.9	119.6
3	NS SolCab	89.7	106.9	127.3
3	NS TC17	92.9	104.6	117.8
51	NS TC35	96	104.5	113.7
18	NS MI60	95.3	104.5	114.5
21	NS MB50	95.7	104.4	113.8
1	NS MycCom	78.7	104.2	137.8
28	NS PicEC	95.5	104	113.4
102	NS MB67	95.8	104	113
51	NS TC35EC	95.2	103.7	113
4	NS PicECMNaDiTera	91.5	103.4	116.9
20	NS TC35ECMNa	93.7	102.6	112.4
2	NS PicDMDS	90.2	102.5	116.6
1	NS TC35Nap	83.6	101.9	124.3
52	NS Pic	93.7	101.9	110.8
1	NS TC35Nap	82.4	101.6	125.2
1	NS MNaTelNap	78.6	100.7	129.1
1	NS TC35Pic	84.1	100.5	120.2
9	NS PicECMNaFos	90.7	100.5	111.4
1	NS PicNap	83.6	100	119.5
1	NS PicTel	82.8	99.4	119.3
13	NS PicMNa	88.7	99.3	111.3
13	NS PicECMNa	89.1	99.1	110.3
3	NS MB67Sol	84.6	99	115.9
1	NS DazNap	74.8	98.4	129.5
10	NS SolFert	85.6	98.3	112.9
23	NS Daz	89.3	97.9	107.3
2	NS TC35Sol	83.5	97.3	113.3
1	NS MB50Sol	73.1	95.1	123.7
14	NS MNaSol	85.9	93.9	102.6
1	NS MNaNap	72.8	93.3	119.5
4	NS DMDS	80.4	92.9	107.4
5	NS MB30	84.1	92.7	102.3
4	NS PicECMNaHM0	81.3	91.9	103.9
5	NS MI100	79.9	91.3	104.2
7	NS PPO	80.2	90.2	101.5
1	NS SolBio	68.8	89.3	115.9
1	NS MNaTelSol	69.4	88.9	113.9
12	NS Sol	76.9	87.6	99.9
5	NS Vrlx	75.7	85.5	96.5
11	NS PicECMNaEnz	76.6	84.7	93.7
2	NS Tel	69.7	84.3	101.9
1	NS MNaRootshld	65.4	82.9	105
3	NS BioFum	71.6	80.4	90.2
64	NS MNa	70.7	80	90.6
4	NS MNaPPO	69.8	79.8	91.3
2	NS PicMNaEnz	58.5	79.4	107.6
1	NS MNaMes	62.1	78.5	99.3
6	NS MNaPPFos	67.6	76.1	85.8
15	NS MNaPP	67.5	74.5	82.3
4	NS MNaHelp	64.4	73.5	83.9
2	NS Cal	59.7	72.1	87
3	NS Multi	59.3	69.8	82.1
68	NS NoTr	61.5	68.8	76.9

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	NS EMF	53.7	64.7	78
4	NS PPFosNap	29.2	52.7	95.1
2	NS Chick	22	40	72.7
2	NS SheepPoul	22	39.9	72.6
10	NS PPNap	27.5	39.2	55.8

APPENDIX II-3 Relationship for treatment x nematode interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

STRAWBERRY - Treatments x nematode (2 levels: Presence and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	Yes MI30	90.1	113.4	142.8
2	Yes TC35Daz	87.5	108.2	133.7
2	Yes TC35MNa	84	106.2	134.4
4	Yes PicFosNap	88.7	105.8	126.1
2	Yes MNaTelNap	83.8	102.5	125.2
6	Yes TC35	87.2	102.2	119.7
2	Yes PicECMNa	79.7	101.8	130.1
3	Yes Pic	86	100.9	118.5
12	Yes MB67	86.2	100	116.1
3	Yes MB50	85.2	99.8	116.9
1	Yes DazNap	74.2	99.7	134.3
3	Yes TC17Peb	81.5	99.4	121.2
2	Yes PicDMDS	83.6	99.1	117.5
1	Yes TC35Nap	75	97.8	127.4
1	Yes PicECMNaHM0	74.7	96.5	124.7
5	Yes TC35Peb	80	96.5	116.5
4	Yes MI60	80.3	95.6	113.9
2	Yes TC35Nap	76.1	94.9	118.2
2	Yes MNaNap	76.1	94.3	116.9
4	Yes Daz	77	93.2	112.7
4	Yes MNa	57.3	92.5	149.1
2	Yes MNaTelSol	74.4	90.9	111.1
7	Yes PicMNa	74.4	90.7	110.7
2	Yes PicNap	74.9	90.6	109.6
1	Yes TC35Pic	71.3	90.5	115.1
2	Yes TC35Sol	72.2	89.9	112
1	Yes MNaPeb	66.5	86.6	112.9
5	Yes PPO	71.9	86.4	103.9
2	Yes MNaTelPeb	70.6	86.2	105.3
1	Yes TC35ECMNa	64.7	84.8	111.4
2	Yes DMDS	67.3	84.5	106.1
1	Yes TC35EC	60.3	76.6	97.3
2	Yes PicMNaEnz	54.7	76.3	106.4
2	Yes Sol	52.1	74.2	105.8
2	Yes Cal	61.8	69.6	78.4
12	Yes NoTr	49.3	63.3	81.2
6	Yes PPNap	35.7	54.7	83.7
3	NS MB98	110.6	130.9	155.1
3	NS TC35Daz	97.7	112.3	129.2
1	NS PicECDaz	78.9	101	129.3
6	NS TC35MNa	89.2	99.8	111.8
1	NS PicMNaDiTera	64.6	99.6	153.6
2	NS PicDazEnz	81.9	98.1	117.5
2	NS PicECDazEnz	80.7	97.8	118.5
2	NS TC35ECDaz	82.3	96.9	114
4	NS Compost	64.4	94.5	138.8
5	NS TC35ECPicECDaz	83.5	93.8	105.7
14	NS MI60	85.5	93.8	103
1	NS MycCom	70.2	92	120.7
6	NS PicMNa	78.7	92	107.7
111	NS MB67	84.7	91.8	99.6

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
4	NS PicECMNaDiTera	80.8	91.4	103.3
50	NS TC35EC	83.7	91.4	99.6
28	NS PicEC	83.4	90.9	99.2
3	NS TC17	80.3	90.6	102.4
3	NS SolCab	76.5	90.5	107.3
3	NS PicNap	80.3	90.5	102
2	NS PicFosNap	79.4	90.2	102.3
20	NS TC35ECMNa	82.2	90.1	98.8
21	NS MB50	82.6	90.1	98.2
57	NS TC35	82.6	89.7	97.6
1	NS DazSol	69.3	89.5	115.6
3	NS TC35Nap	77.1	89.2	103.1
9	NS PicECMNaFos	79.9	88.7	98.5
2	NS DazNap	73.6	88.6	106.6
1	NS TC35MNaOrgFung	69.9	88	110.7
1	NS MNaTelNap	72.8	87.9	106
2	NS TC17Nap	74.1	87.6	103.7
59	NS Pic	80.5	87.5	95.1
1	NS PicTel	71.2	86.3	104.6
11	NS PicECMNa	77	86	96
13	NS MB30	78.7	86	94.1
10	NS SolFert	73.9	85.7	99.3
2	NS DMDS	71.2	85.5	102.8
3	NS MB67Sol	73.6	85.5	99.4
2	NS TC35Sol	71.8	84.7	99.7
5	NS Vrlx	73.6	84.3	96.4
26	NS Daz	74.6	81.9	89.8
14	NS MNaSol	74.8	81.6	89.1
1	NS MB50Sol	63.3	81.2	104
5	NS MI100	71.2	80.8	91.7
2	NS PPO	65.9	80.4	98
4	NS MI30	69.9	79.2	89.9
3	NS Tel	67.8	78.9	91.8
3	NS PicECMNaHM0	68.9	78.8	90.2
4	NS Vrlx	67.6	78	90
1	NS MNaTelSol	64.3	77.6	93.6
2	NS Tel	64.8	77.4	92.5
2	NS PicMNaSol	57.1	77.1	104.2
1	NS SolBio	60.1	77	98.6
1	NS PicTelNap	59.8	75.2	94.7
11	NS PicECMNaEnz	67.7	75	83.1
1	NS TC17PicNap	59.3	74.7	93.9
3	NS MNaNap	63.4	72.9	83.9
1	NS MNaRootshld	58.8	72.5	89.3
4	NS MNaPPO	61.9	70.6	80.4
4	NS EDN	60.6	70.4	81.8
3	NS BioFum	61.8	69.6	78.4
73	NS MNa	61.6	69.4	78.1
2	NS MNaTel	57.6	69.3	83.5
15	NS Sol	61	69.3	78.8
1	NS MNaMes	56.3	69.2	85.1
2	NS PicMNaNap	50.1	67.8	91.6
6	NS MNaPPFos	59.2	66.7	74.9
15	NS MNaPP	59.2	65.4	72.2
4	NS MNaHelp	56.9	64.4	72.7
3	NS Multi	52	61.8	73.5

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
75	NS NoTr	52.7	58.7	65.4
2	NS EMF	47	56	66.9
4	NS PPFosNap	28	45.9	75.3
2	NS Chick	20	35.2	61.7
2	NS SheepPoul	19.9	35.1	61.6
4	NS PPNap	11.9	19.6	32

APPENDIX II-4 Relationship for treatment x application method interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

STRAWBERRY - Treatments x application method (5 levels: Injection, Drip, Spray, Spread and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
3	Injection MB98	123.9	144.4	168.3
2	Injection TC35Daz	105.4	122.3	141.9
1	Injection PicMNaDiTera	70.1	108.1	166.8
2	Injection PicDazEnz	90.8	107.1	126.2
4	Injection TC35MNa	90.8	101.9	114.4
4	Injection PicFosNap	91.4	100.3	110
3	Injection TC35ECPicECDaz	88.6	100.1	113.1
122	Injection MB67	94.3	100	106.1
3	Injection MNaTelNap	90.9	99.4	108.8
3	Injection TC17Peb	87	99.3	113.3
3	Injection TC17	89.3	99.1	110
13	Injection MI60	91.7	99.1	107
62	Injection TC35	92.9	98.8	105
24	Injection MB50	92.5	98.6	105.1
1	Injection TC35Nap	78.6	97.2	120.2
2	Injection PicDMDS	87	96.9	107.9
3	Injection DazNap	84.1	96.5	110.7
5	Injection TC35Peb	85.3	96	108.1
1	Injection PicECMNaHM0	78.2	96	117.7
62	Injection Pic	90.3	96	102
2	Injection TC35ECMNa	82.3	95.3	110.4
1	Injection DazSol	74.9	95.2	121.1
5	Injection TC35Nap	85.6	95	105.5
1	Injection TC35Pic	79.4	94.7	113
13	Injection MB30	88.2	94.4	101
1	Injection TC35MNaOrgFung	75.6	94.3	117.6
5	Injection PicNap	86.4	94.2	102.6
2	Injection TC17Nap	80.3	93.5	109
1	Injection PicTel	77.9	93.5	112.1
5	Injection MI30	84.1	93.2	103.2
5	Injection Vrlx	82.3	92.7	104.4
10	Injection PicMNa	81.3	91.2	102.3
28	Injection Daz	83.6	89.8	96.5
4	Injection MI100	79.5	89.5	100.8
4	Injection DMDS	77.8	87.8	99.1
1	Injection MNaPeb	70.7	86.4	105.5
2	Injection MNaTelPeb	77.3	86.2	96.3
3	Injection Tel	75.3	86.1	98.5
7	Injection PPO	77.8	85.7	94.5
5	Injection MNaNap	76.3	84	92.6
32	Injection MNa	73.5	82.8	93.2
2	Injection PicMNaSol	61.3	82.4	110.6
1	Injection PicTelNap	64.6	80.6	100.5
1	Injection TC17PicNap	64.1	80	99.7
1	Injection MNaSol	70.2	79.3	89.5
4	Injection EDN	68.9	78.6	89.7
2	Injection PicMNaEnz	56.7	75.9	101.5
9	Injection NoTr	59.3	75.2	95.4
2	Injection MNaTel	63.4	75.1	89
2	Injection PicMNaNap	53.9	72.3	97.1

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	Injection Cal	57.9	68.1	80.1
2	Injection MNaHelp	57.6	65.8	75.2
1	Injection MNaPPO	48.1	57.4	68.6
3	Injection Sol	41	52	66.1
4	Injection PPFosNap	33.5	50.2	75
7	Injection PPNap	18.9	25.3	33.9
5	Drip MI60	92.8	101.7	111.4
28	Drip PicEC	92.6	98.8	105.5
51	Drip TC35EC	92.5	98.6	105.2
16	Drip TC35ECMNa	89.8	96.7	104.2
13	Drip PicECMNa	86.9	94.6	102.9
3	Drip PPNap	57.2	92.7	150.1
1	Drip MNaPPO	77.2	92.1	109.8
41	Drip MNa	74.2	82.6	92.1
1	Drip TC35	68.5	81.9	97.8
1	Drip MI100	62.9	79.3	100.1
1	Drip MNaMes	63.9	76.6	91.8
3	Drip Multi	57.3	67	78.4
2	Spray TC35MNa	99.7	116	134.9
3	Spray PicMNa	86.7	105.7	128.7
3	Spray TC35ECMNa	89.7	101.4	114.7
4	Spray PicECMNaDiTera	89.3	99.2	110.1
9	Spray PicECMNaFos	88.7	96.5	105.1
3	Spray PicECMNaHM0	76	85.5	96.1
2	Spray MNaPPO	72.3	82.3	93.6
11	Spray PicECMNaEnz	74.6	81	88
1	Spray MNaRootshld	65.9	79.2	95.1
2	Spray MNaHelp	66.2	75.4	85.9
6	Spray MNaPPFos	66.3	72.9	80.2
15	Spray MNaPP	65.9	71.2	76.9
4	Spray MNa	12.7	18.1	25.7
2	Spread TC35Daz	106.3	123.4	143.2
2	Spread PicECDazEnz	90.6	108.2	129.2
2	Spread TC35ECPicECDaz	90.5	104.8	121.5
2	Spread TC35ECDaz	89	103.4	120.1
2	Spread SolFert	75.9	101.5	135.7
1	Spread Daz	68.3	88.1	113.8
2	Spread Chick	22.1	38.4	66.8
2	Hotgas TC35MNa	99.8	115.9	134.5
1	NS PicECDaz	88.5	111.7	141
2	NS PicFosNap	93.7	107.2	122.6
3	NS SolCab	85.7	99.9	116.4
1	NS Daz	73.9	95.5	123.5
3	NS MB67Sol	81.9	93.5	106.8
1	NS TC35Daz	74.9	92.7	114.8
6	NS SolFert	77.7	91.1	106.8
4	NS TC35Sol	80.5	90	100.6
11	NS MNaSol	84.1	90	96.2
1	NS MB50Sol	70.7	89.3	112.8
3	NS MNaTelSol	80.5	88.1	96.4
1	NS SolBio	66.6	84.1	106.2
14	NS Sol	72.8	81.1	90.4
2	NS Compost	45.9	79.8	138.5
1	NS MycCom	56.7	76.1	102.1
1	NS MB67	66.7	75.9	86.4
3	NS BioFum	66.7	75.9	86.4

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
69	NS NoTr	56.4	61.8	67.7
2	NS EMF	51.9	61	71.6
2	NS SheepPoul	22.1	38.4	66.6

APPENDIX II-5 Relationship for treatment x plastic seal interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

STRAWBERRY - Treatments x plastic seal (2 levels: Barrier film and Non Barrier flim)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	Barr TC35ECMNa	75.7	154.4	315.2
8	Barr PicEC	111.4	146	191.2
2	Barr PicECMNa	28.7	141.9	701.7
8	Barr TC35EC	89.2	140.3	220.7
2	Barr NoTr	40.5	112	310
22	Barr MB67	72.6	100	137.8
7	Barr TC35	50	81.8	134.1
2	Barr PicDMDS	13	81.3	507.5
2	Barr PPO	8.9	79.2	708.4
4	Barr Pic	43.5	78.5	141.8
2	Barr PicMNa	10.4	77.3	576
4	Barr MB50	41.3	72.6	127.6
7	Barr Daz	41.4	70.9	121.4
2	Barr DMDS	36.7	70.6	135.7
1	NonBarr TC35Pic	67.5	239.5	849.7
2	NonBarr TC35ECDaz	87.1	183.1	385.1
5	NonBarr TC35ECPicECDaz	100	160.3	256.9
9	NonBarr PicECMNaFos	89	146.7	242
5	NonBarr MI100	92.8	140.5	212.9
4	NonBarr PicECMNaDiTera	66.8	137.8	284.2
20	NonBarr PicEC	105.8	137.2	177.9
19	NonBarr TC35ECMNa	98.4	135.5	186.6
43	NonBarr TC35EC	97.8	131.7	177.5
1	NonBarr PicECDaz	56	129	297
2	NonBarr PicECDazEnz	69.1	124.9	226
3	NonBarr Multi	73.9	121.8	200.7
15	NonBarr MNaPP	80.8	107.9	144
6	NonBarr MNaPPFos	73.1	102	142.3
1	NonBarr MNaRootshld	54.9	99.8	181.5
8	NonBarr TC35MNa	65.8	98.3	146.7
5	NonBarr Vrlx	59.2	98.1	162.5
11	NonBarr PicECMNaEnz	59.2	95.7	155
1	NonBarr DazSol	39.8	95.4	228.6
2	NonBarr TC17Nap	43.9	93.6	199.3
1	NonBarr MNaMes	48.6	88.5	160.9
5	NonBarr TC35Nap	52	88.2	149.6
3	NonBarr MNaTelNap	50.9	87.8	151.4
5	NonBarr PicNap	29	87.4	263.3
3	NonBarr TC17Peb	41.1	86.9	184
18	NonBarr MI60	55.1	86.2	134.9
1	NonBarr TC35Nap	30.4	85.1	237.7
3	NonBarr TC17	41.9	84.8	171.6
1	NonBarr MycCom	20	83.7	349.7
5	NonBarr TC35Peb	43.3	83.7	161.7
101	NonBarr MB67	64.1	83.5	108.7
2	NonBarr PicMNaSol	11.8	82.4	576.4
3	NonBarr MB98	46.9	81.6	142.2
13	NonBarr MB30	55.3	80.4	117
5	NonBarr MNaNap	51.7	78	117.5
2	NonBarr MNaTelPeb	38.3	77.6	157.3
11	NonBarr PicECMNa	39.6	74.8	141.1

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
3	NonBarr MB67Sol	44.8	74.1	122.5
1	NonBarr TC35MNaOrgFung	25.3	74.1	216.9
2	NonBarr PicMNaNap	10.3	72.3	506.1
3	NonBarr DazNap	41.4	72.1	125.5
1	NonBarr MNaPeb	32.8	71.6	156.5
58	NonBarr Pic	53.8	71.4	94.7
56	NonBarr TC35	53.2	70.6	93.7
23	NonBarr Daz	49.5	69.6	97.7
5	NonBarr MI30	29.6	69.3	162.4
10	NonBarr SolFert	50.7	69.1	94
20	NonBarr MB50	49.3	68.7	95.8
1	NonBarr SolBio	29.3	68	157.7
1	NonBarr TC35Sol	23.9	67.3	189.8
14	NonBarr MNaSol	51.1	66.8	87.5
77	NonBarr MNa	47.1	63.8	86.3
1	NonBarr PicTelNap	21.6	63.4	185.5
2	NonBarr DMDS	32.9	63.3	121.7
1	NonBarr TC17PicNap	21.5	62.9	184.1
2	NonBarr MNaTel	31.2	61.5	121.3
1	NonBarr PicTel	14.6	60.7	251.7
4	NonBarr MNaPPO	42	60.5	87.2
4	NonBarr EDN	33.1	59.1	105.3
3	NonBarr BioFum	35.4	58.6	96.9
1	NonBarr PicMNaDiTera	3.3	57.3	1002.3
2	NonBarr Cal	29.7	57.1	109.9
3	NonBarr SolCab	32.4	56.5	98.4
14	NonBarr Sol	41.8	56.1	75.3
1	NonBarr MB50Sol	24	55.7	129.1
85	NonBarr NoTr	39.1	51.5	67.8
4	NonBarr MNaHelp	35.5	51.2	73.7
2	NonBarr EMF	26.9	49.2	89.8
2	NonBarr PicDazEnz	25.9	46.8	84.7
4	NonBarr PicECMNaHM0	17.6	36.4	75.4
3	NonBarr Tel	21.1	35	58.1
4	NonBarr Compost	19.1	34.1	60.7
5	NonBarr TC35Daz	19.1	30.8	49.5
5	NonBarr PPO	8.4	30.3	109
2	NonBarr Chick	13	29.1	65.1
2	NonBarr SheepPoul	13	29.1	65
11	NonBarr PicMNa	13.1	28.2	60.9
4	NonBarr PPFosNap	7.7	21.9	62.2
6	NonBarr PicFosNap	5.5	14.4	38
2	NonBarr PicMNaEnz	0.9	6	41.3
10	NonBarr PPNap	3.1	5.9	11.2

APPENDIX II-6 Relationship for treatment x production system interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

STRAWBERRY - Treatments x production system (2 levels: Greenhouse and Open field)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
3	Greenhouse BioFum	18.9	36.9	72
2	Greenhouse Cal	13.6	36	95.2
13	Greenhouse Daz	20.6	46.3	104.3
4	Greenhouse DMDS	17.6	42.1	100.9
2	Greenhouse EMF	12.2	31.2	79.5
18	Greenhouse MB50	22.8	49.3	106.5
1	Greenhouse MB50Sol	11.3	34.7	107
19	Greenhouse MB67	22.6	48.5	104.1
3	Greenhouse MB67Sol	19.3	46.1	110.3
4	Greenhouse MNa	11	36.9	123.2
8	Greenhouse MNaSol	20.3	41.9	86.5
13	Greenhouse NoTr	15.2	35	80.1
11	Greenhouse Pic	22	48.6	107.3
2	Greenhouse PicDMDS	6.9	51.3	378.2
2	Greenhouse PicMNa	5.7	48.7	416.1
4	Greenhouse PPO	9.5	46.8	230.1
6	Greenhouse Sol	16.5	35.3	75.7
1	Greenhouse SolBio	13.8	42.3	129.7
4	Greenhouse SolFert	18.7	41.2	90.9
2	Greenhouse TC17	16.6	52.1	163.7
16	Greenhouse TC35	23.6	51.7	113.3
2	Open Field Chick	18.3	35.7	69.7
4	Open Field Compost	21	39	72.5
17	Open Field Daz	47.8	73	111.4
3	Open Field DazNap	45.3	79.7	140.1
1	Open Field DazSol	45.7	109.9	264.3
4	Open Field EDN	31.4	58.2	107.9
13	Open Field MB30	56.7	86.6	132.3
6	Open Field MB50	29.5	50.7	86.9
104	Open Field MB67	72.6	100	137.8
3	Open Field MB98	52.9	95.3	171.6
5	Open Field MI100	100.6	158.3	249.1
5	Open Field MI30	29.2	70.1	168.5
18	Open Field MI60	59.7	97.3	158.7
73	Open Field MNa	50.5	72.3	103.7
4	Open Field MNaHelp	38.2	57.7	87.2
1	Open Field MNaMes	53.2	99.7	187.1
5	Open Field MNaNap	55.8	86.5	134.2
1	Open Field MNaPeb	37.8	84.1	187.1
15	Open Field MNaPP	86.3	121.7	171.8
6	Open Field MNaPPFos	78.3	115	168.9
4	Open Field MNaPPO	45.2	68.2	103.1
1	Open Field MNaRootshld	60	112.5	211
6	Open Field MNaSol	57.8	82.6	118
2	Open Field MNaTel	34.9	69.9	140
3	Open Field MNaTelNap	54.2	95	166.5
2	Open Field MNaTelPeb	42.8	90.7	192.4
3	Open Field MNaTelSol	48.1	84.2	147.5
3	Open Field Multi	81	137.6	233.5
1	Open Field MycCom	24.6	100.2	408.5
74	Open Field NoTr	41.5	58	81.2

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
51	Open Field Pic	55.7	78.8	111.4
2	Open Field PicDazEnz	28.6	52.8	97.5
28	Open Field PicEC	111.9	154.1	212
1	Open Field PicECDaz	63.2	145.4	334.9
2	Open Field PicECDazEnz	76.3	140.9	260.1
13	Open Field PicECMNa	50.2	91.8	168
4	Open Field PicECMNaDiTera	73.6	155.6	329
11	Open Field PicECMNaEnz	64.4	108.3	182.1
9	Open Field PicECMNaFos	96.7	165.6	283.7
4	Open Field PicECMNaHM0	19.4	41.1	87.2
6	Open Field PicFosNap	6.1	16.3	43.5
11	Open Field PicMNa	14	30.7	67.4
1	Open Field PicMNaDiTera	3.8	64.6	1102.6
2	Open Field PicMNaEnz	1	6.8	46.1
2	Open Field PicMNaNap	12	83.3	577.1
2	Open Field PicMNaSol	13.7	94.8	657.3
5	Open Field PicNap	32.2	97	292.1
1	Open Field PicTel	14.1	58.7	244.5
1	Open Field PicTelNap	25.1	71.8	206
10	Open Field PPNap	3.4	6.6	13
4	Open Field PPFosNap	8.6	24.7	70.9
3	Open Field PPO	4	19.7	95.7
2	Open Field SheepPoul	15.3	35.7	83.3
11	Open Field Sol	46.6	67.9	98.9
3	Open Field SolCab	36.6	65.9	118.6
6	Open Field SolFert	58.6	88.1	132.5
1	Open Field TC17	24.7	95.9	372.5
2	Open Field TC17Nap	50	107.7	232.1
3	Open Field TC17Peb	47.6	101.7	217.3
1	Open Field TC17PicNap	24.9	71.3	204.4
47	Open Field TC35	53.8	76.1	107.5
5	Open Field TC35Daz	21	34.8	57.6
1	Open Field TC35Nap	35	96	263.5
51	Open Field TC35EC	104.5	147.9	209.4
2	Open Field TC35ECDaz	98.1	207.2	437.7
21	Open Field TC35ECMNa	106.5	153.3	220.8
5	Open Field TC35ECPicECDaz	109.4	180.9	299.1
8	Open Field TC35MNa	71.2	110.5	171.6
1	Open Field TC35MNaOrgFung	29.3	84	240.9
5	Open Field TC35Nap	56.9	97.9	168.3
5	Open Field TC35Peb	49.8	98	192.9
1	Open Field TC35Pic	75.3	266.6	944.4
4	Open Field TC35Sol	49	86.4	152.6
3	Open Field Tel	22.4	38.3	65.5
5	Open Field Vrlx	59.7	102.3	175.3

APPENDIX II-7 Relationship for treatment x soil type interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

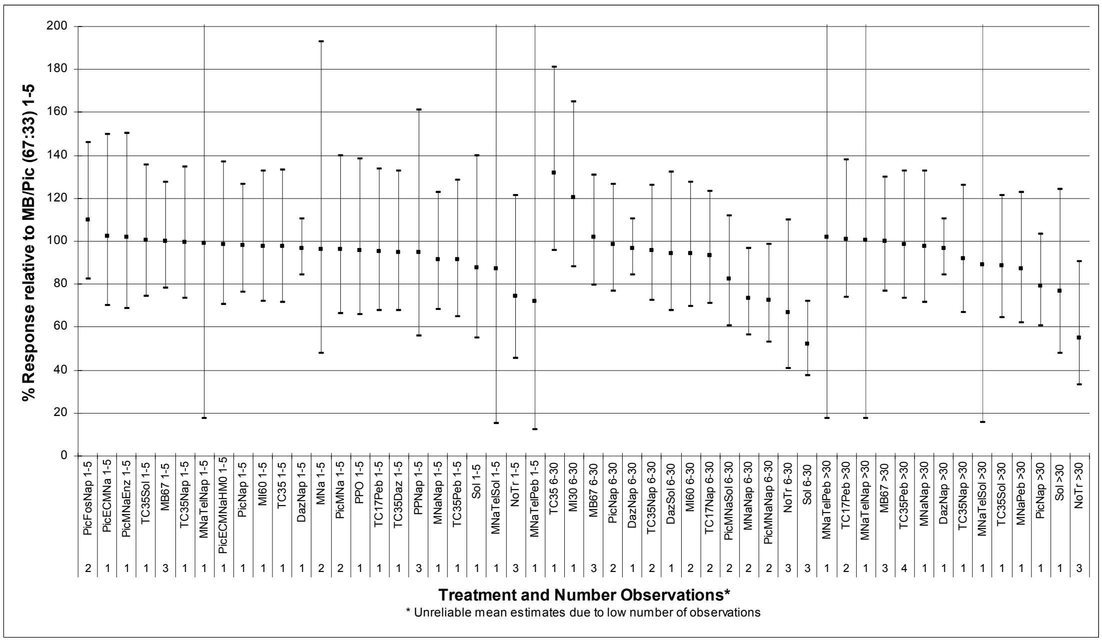
STRAWBERRY - Treatments x soil type (4 levels: Sand, Clay, Loam and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
2	sand SolFert	71.1	103.8	151.5
1	sand Pic	77.3	101	132
10	sand MB67	80.9	100	123.6
2	sand MNaTelNap	78.8	99.7	126.2
3	sand TC17Peb	76.9	99	127.4
1	sand DazNap	87	97.4	109.1
5	sand TC35Peb	75.4	96.2	122.7
1	sand TC17Nap	70.5	95.6	129.7
5	sand TC35	74.6	94.4	119.5
3	sand TC35Nap	73.2	92.7	117.5
2	sand MNaSol	73	92.7	117.6
2	sand MNaTelSol	69.9	88.5	112
3	sand PicNap	70.8	88	109.3
3	sand TC35Sol	69.1	87.6	111.1
1	sand MNaPeb	62.9	86.3	118.4
2	sand MNaTelPeb	66.6	85.9	110.8
3	sand MNaNap	65.3	82.8	105
5	sand Sol	62	81.9	108.3
1	sand PicMNaSol	41.6	79.3	151.3
1	sand PicMNaNap	30.5	58.1	110.8
10	sand NoTr	40.8	55.7	76.1
9	clay TC35	101.1	116.6	134.4
1	clay Tel	83.5	109	142.3
5	clay MB50	92.3	106.7	123.3
2	clay MB67	89.1	105	123.6
9	clay Pic	91	104.5	119.9
1	clay PicMNa	68.3	103.2	156.1
5	clay Vrlx	86.5	102.2	120.7
6	clay MB30	87.3	100.7	116.3
8	clay Daz	87	97.4	109.1
4	clay MI30	81.5	96.2	113.6
2	clay MNa	48.1	94.4	185.2
4	clay EDN	71	85.5	102.8
10	clay NoTr	64.4	83.1	107.2
2	loam PicNap	85.7	103.7	125.5
1	loam TC35Sol	75.6	99	129.5
2	loam TC35Nap	78.7	98.1	122.2
2	loam MB67	80.9	97.6	117.7
1	loam DazSol	72.9	97.6	130.7
1	loam MNaTelNap	76.7	97.5	123.8
2	loam DazNap	87	97.4	109.1
1	loam TC17Nap	70.1	91.8	120.1
1	loam PicMNaNap	48.4	90.3	168.6
1	loam MNaTelSol	67.7	86.1	109.3
1	loam PicMNaSol	46	85.8	160.2
2	loam MNaNap	68.5	85.4	106.5
2	loam NoTr	40.9	72.5	128.4
3	loam Sol	41.7	56	75.2
3	NS MB98	154.9	183.2	216.7
5	NS TC35Daz	131	147.7	166.5
1	NS MI30	122.3	146.6	175.7

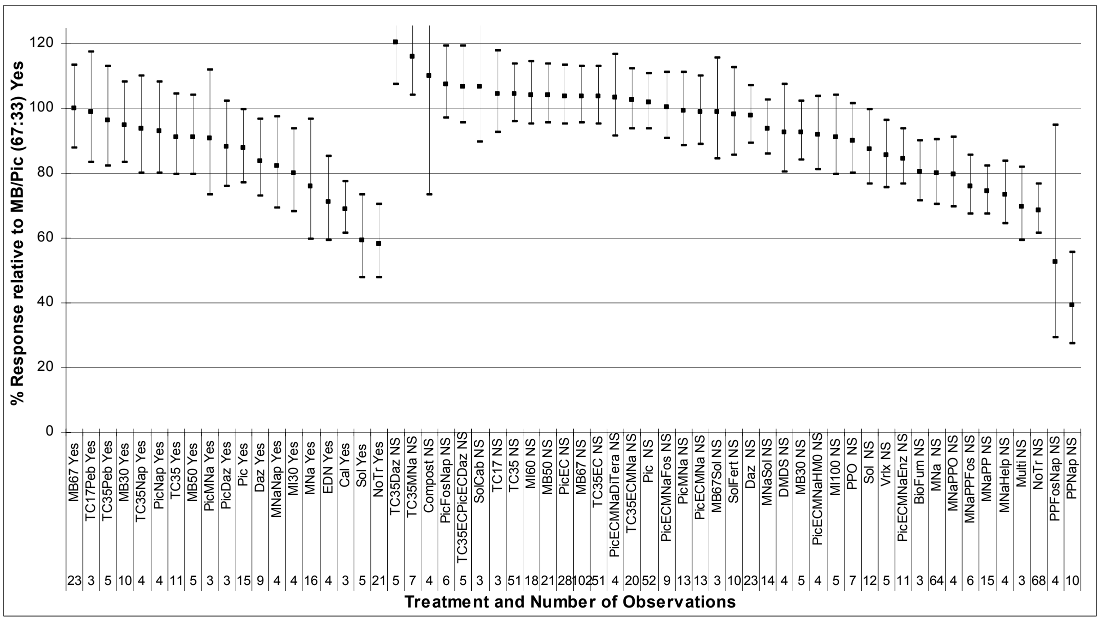
Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	NS PicECDaz	110.1	140.1	178.3
8	NS TC35MNa	125.6	140	156
1	NS PicMNaDiTera	76.4	138.9	252.4
2	NS PicDazEnz	115.4	137.8	164.5
2	NS PicECDazEnz	112.4	135.7	163.9
2	NS TC35ECDaz	113.9	134	157.5
4	NS Compost	90.1	131.6	192.1
6	NS PicFosNap	118	130.8	145
5	NS TC35ECPicECDaz	116	130.6	147.2
1	NS MycCom	98.6	128.4	167.2
18	NS MI60	116.9	128.2	140.6
109	NS MB67	117.8	128.2	139.4
4	NS PicECMNaDiTera	112.1	126.8	143.5
3	NS SolCab	107.1	126.7	149.9
3	NS TC17	112	126.6	143.3
19	NS MB50	115.8	126.5	138.3
28	NS PicEC	115.6	126.4	138.2
51	NS TC35EC	115.4	126.1	137.9
49	NS TC35	114.8	125.1	136.4
21	NS TC35ECMNa	113.5	124.7	137
1	NS TC35Nap	100.1	124.5	154.8
2	NS PicDMDS	110	124.2	140.2
9	NS PicECMNaFos	110.9	123.3	137.2
52	NS Pic	112.7	122.8	133.9
1	NS TC35Pic	101.8	122.7	148
1	NS TC35MNaOrgFung	97.8	122.6	153.6
7	NS MB30	111.4	122.5	134.7
12	NS PicMNa	106.6	121	137.4
13	NS PicECMNa	108.8	121	134.6
1	NS PicTel	99.4	120.4	145.8
3	NS MB67Sol	103	119.5	138.7
8	NS SolFert	99.8	116.8	136.6
22	NS Daz	105	115.6	127.2
1	NS MB50Sol	89.3	113.8	145
12	NS MNaSol	103.6	113.5	124.2
4	NS PicECMNaHM0	99.4	112.5	127.3
4	NS DMDS	97.9	112.4	129.1
5	NS MI100	98.6	112	127.2
7	NS PPO	97.6	109.7	123.3
1	NS SolBio	84.4	107.5	136.9
1	NS PicTelNap	83.6	104.8	131.4
1	NS TC17PicNap	83	104	130.4
11	NS PicECMNaEnz	93.5	103.7	115.1
2	NS Tel	85.8	102.5	122.5
9	NS Sol	87	101.2	117.6
1	NS MNaRootshld	81.2	100.8	125.2
4	NS MNaPPO	85.8	98.2	112.4
3	NS BioFum	87	97.4	109.1
75	NS MNa	86.3	97.3	109.7
2	NS PicMNaEnz	64.6	96.7	145
2	NS MNaTel	80.5	96.7	116
1	NS MNaMes	77.5	96.1	119.1
6	NS MNaPPFos	82.2	92.7	104.6
15	NS MNaPP	82.2	91	100.7
4	NS MNaHelp	79.2	89.9	102
2	NS Cal	73.2	87.3	104.1

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
3	NS Multi	72.4	85.9	101.9
65	NS NoTr	72.3	81.1	90.8
2	NS EMF	66	78.5	93.3
4	NS PPFosNap	36.3	64.5	114.6
2	NS SheepPoul	28.1	48.9	85.1
2	NS Chick	28.1	48.9	85.2
10	NS PPNap	33.8	47.8	67.5

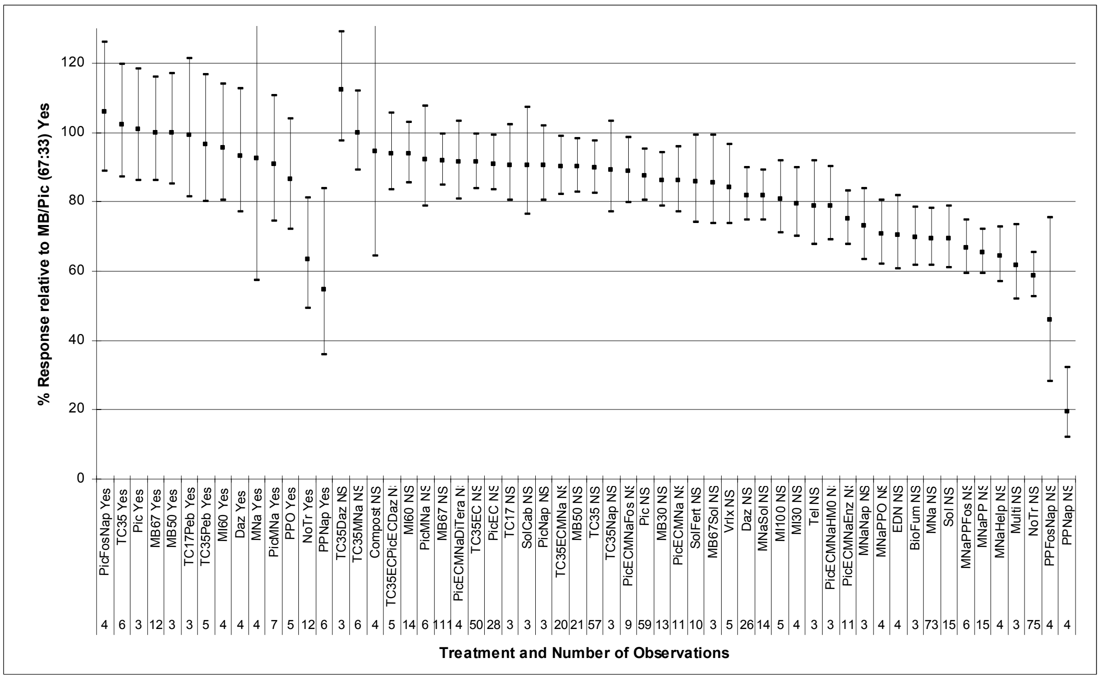
APPENDIX III-1. Relative yield data from the meta-analyses (treatment x nutsedge levels) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005 (All observations)



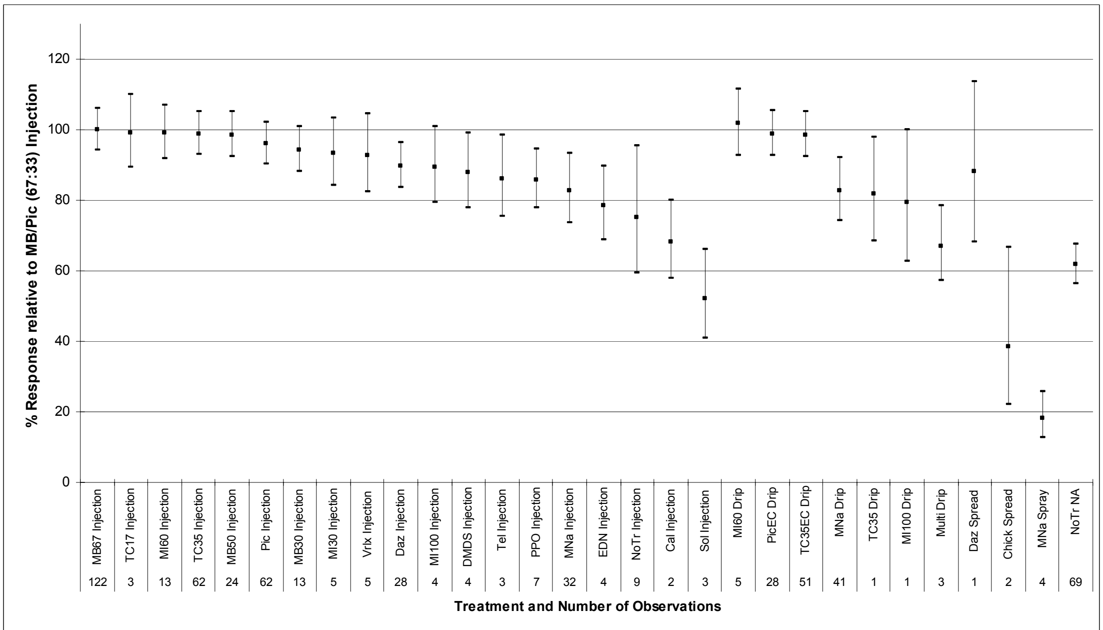
APPENDIX III-2. Relative yield data from the meta-analyses (treatment x fungal presence) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



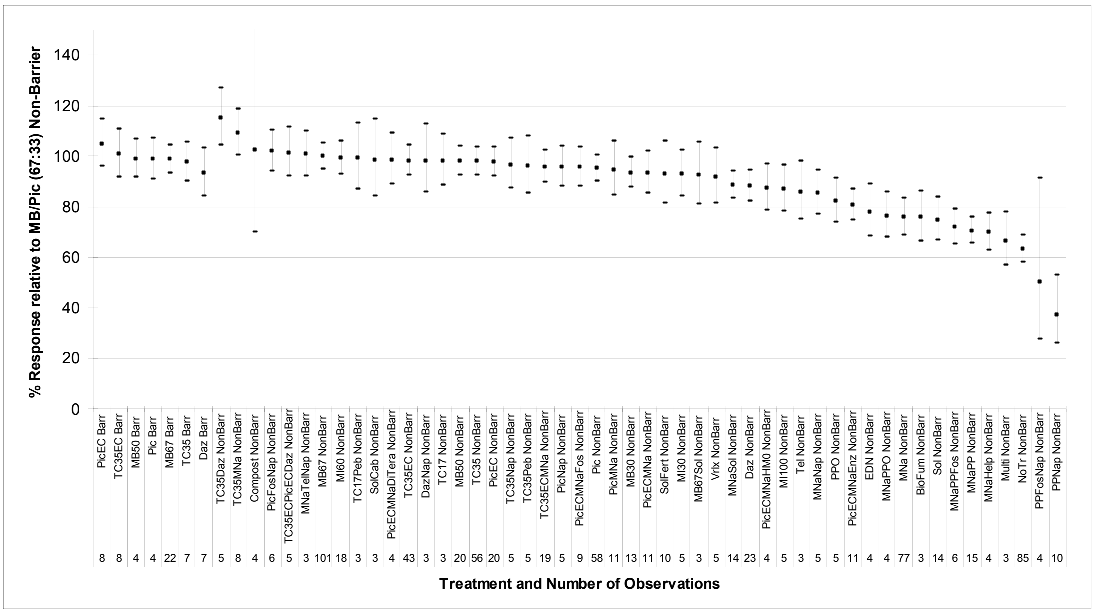
APPENDIX III-3. Relative yield data from the meta-analyses (treatment x nematode) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



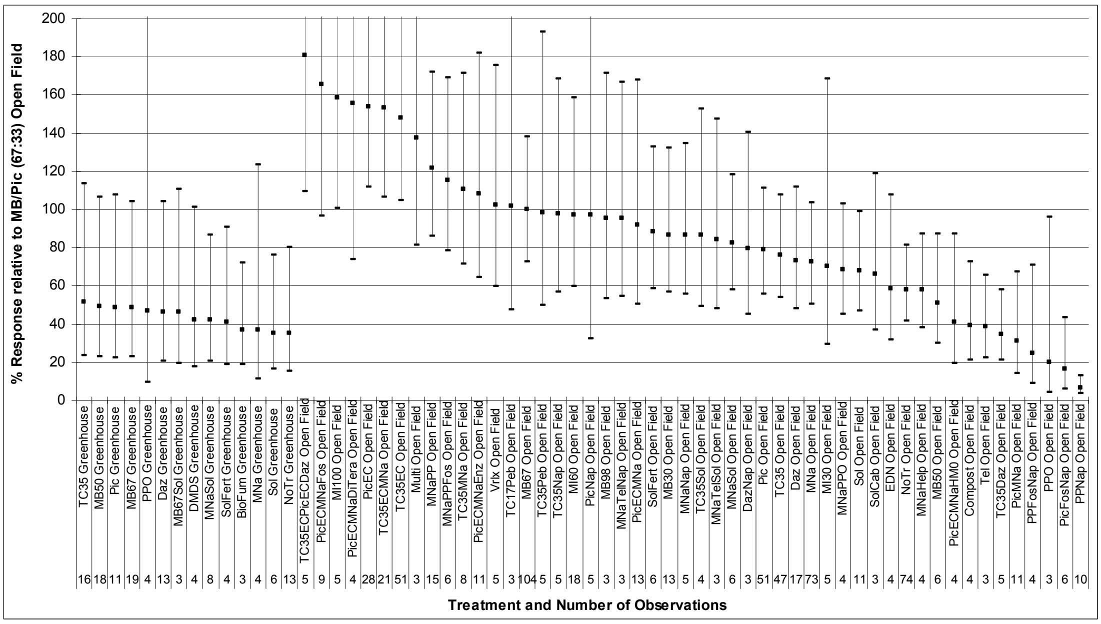
APPENDIX III-4. Relative yield data from the meta-analyses (treatment x application method) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005. Note: Observations were only for single treatments



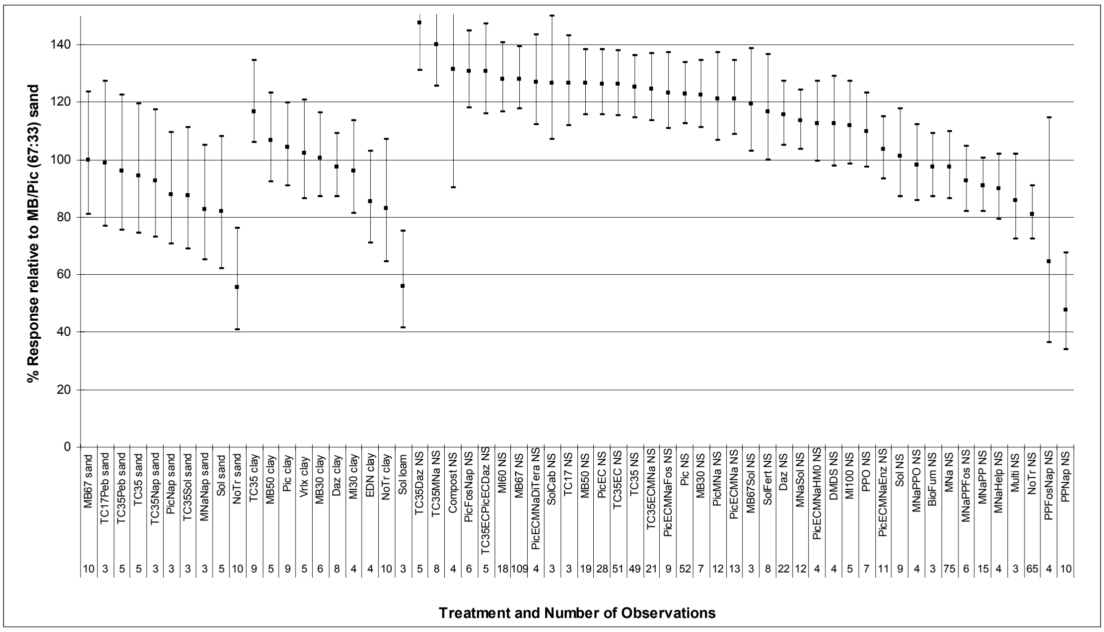
APPENDIX III-5. Relative yield data from the meta-analyses (treatment x plastic seal) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



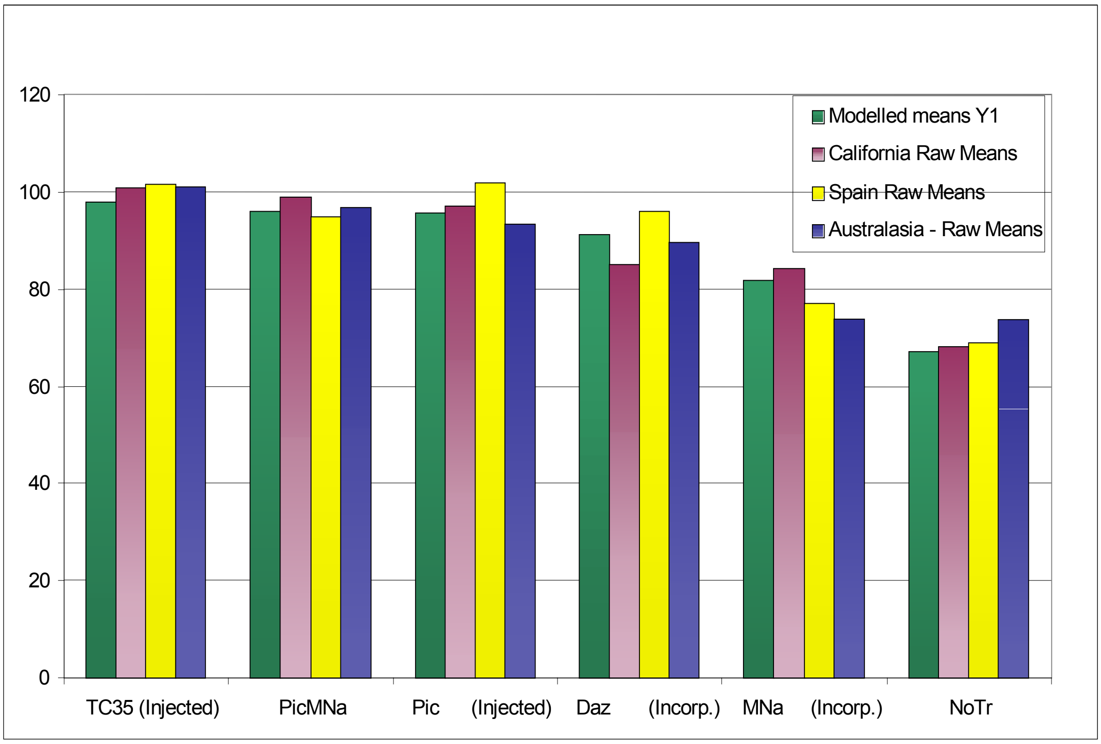
APPENDIX III-6. Relative yield data from the meta-analyses (treatment x production system) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



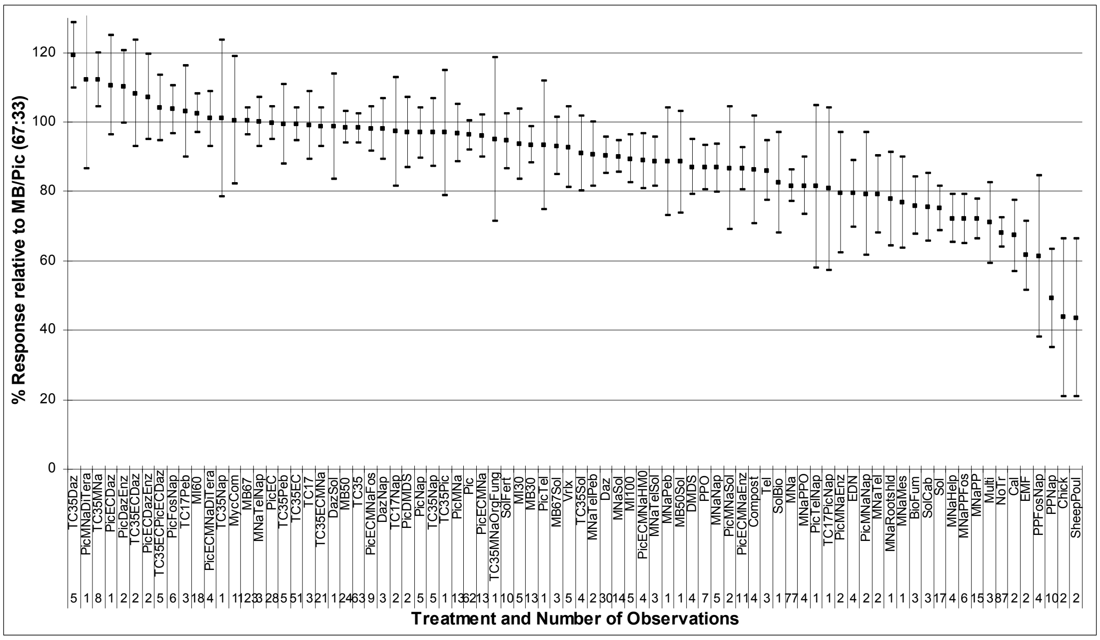
APPENDIX III-7. Relative yield data from the meta-analyses (treatment x soil type) and LSI intervals for alternatives to methyl bromide from international research studies in strawberry crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



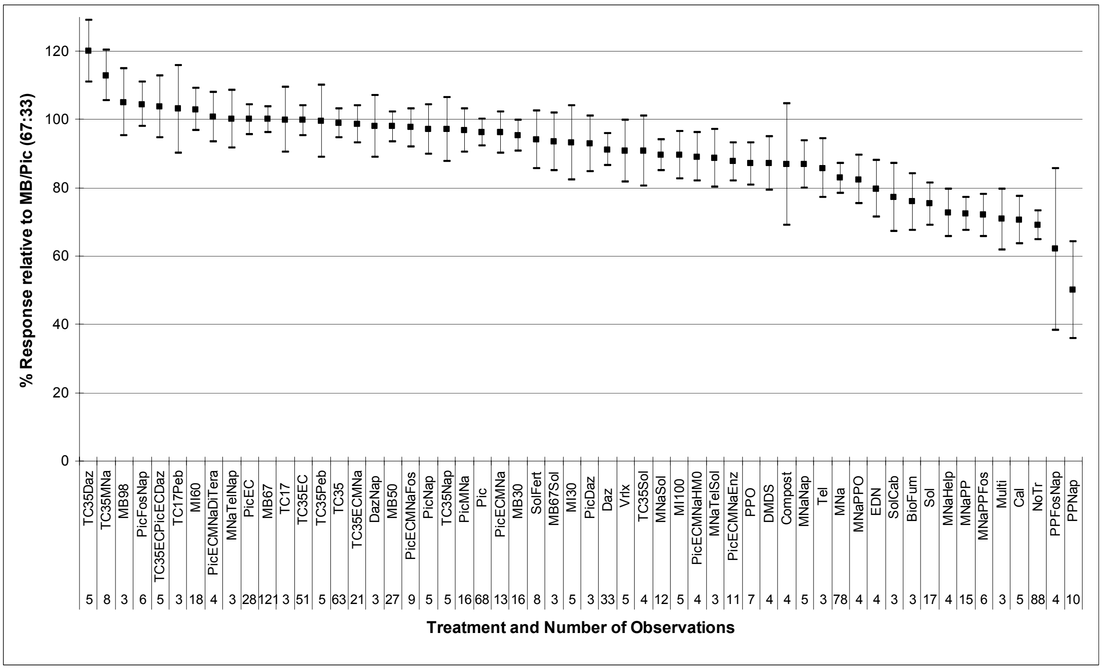
APPENDIX III-8. Comparison of raw means and modelled estimated means from the meta-analysis for the major alternatives to methyl bromide from international research studies from three regions in strawberry crops from 1997 to 2005



APPENDIX III-9. Relative yield data from the partial meta-analyses[A] and LSI intervals for alternatives to methyl bromide from international research studies in strawberry fruit crops from 1997 to 2005. [A] Note: Relative means determined by comparison to the methyl bromide treatment from the same study.

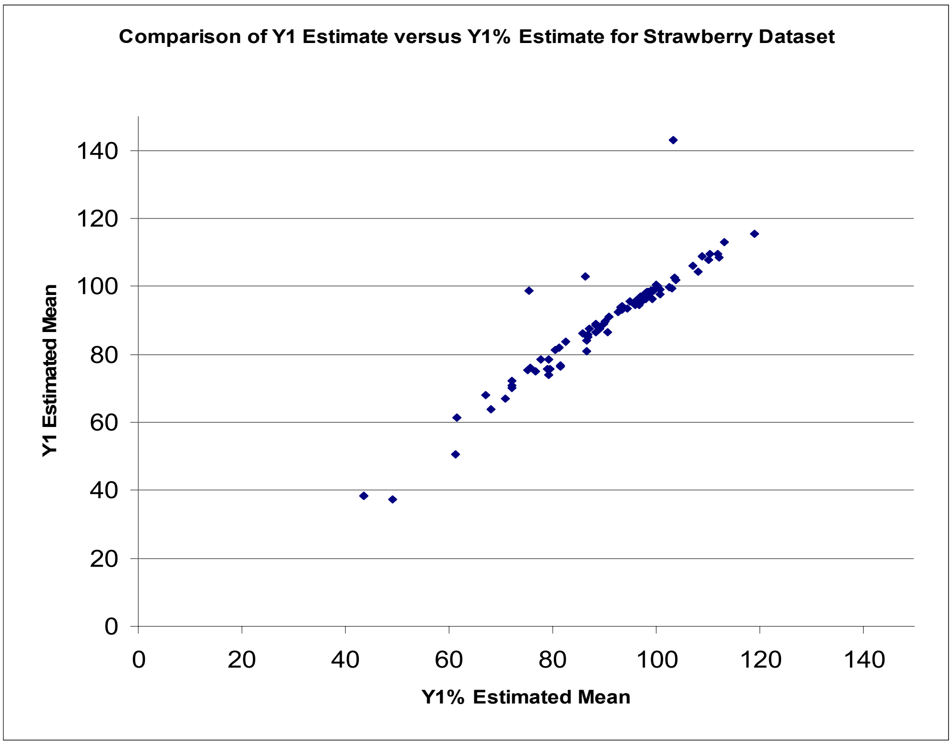


APPENDIX III-10. Relative yield data from the partial meta-analyses[A] and LSI intervals for alternatives to methyl bromide from international research studies in strawberry fruit crops from 1997 to 2005. [A] Note: Relative means determined by comparison to the methyl bromide treatment from the same study, and >2 observations for an alternative were required before inclusion in the figure below.



APPENDIX III-11. Correlation between estimated means from the full meta-analysis (Y1) and the partial meta-analysis (Y1%) for MB and alternatives from international research studies in

strawberry fruit crops from 1997 to 2005 for treatments with greater than two observations.
Note: In the full meta-analysis the means were fully modelled means whereas in the partial meta-analysis the means are relative to the methyl bromide treatment from the same study. The plot enables identification of outliers.



APPENDIX IV-1 Relationship for treatment x nutsedge interaction between number of trials, number of observations, treatments and the estimated relative means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatments x nutsedge (3 levels: 1-5, 6-30 and >30)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
5	1-5 MB67	56.1	62.4	69.5
4	1-5 TC35PebNap	49	59.6	72.5
1	1-5 TC17Peb	40.3	54.7	74.1
1	1-5 SolSoil	26.8	37.2	51.8
5	1-5 NoTr	9.8	14.6	21.6
3	6-30 TC17Peb	112.3	136.3	165.4
1	6-30 MNaPebFos	81.5	107.5	141.6
1	6-30 MNaPeb	78.9	107.3	145.7
5	6-30 MNa	72.7	100.7	139.6
6	6-30 MB67	76.7	100	130.4
5	6-30 TC35	72.7	96.5	128.1
2	6-30 PicPeb	80.1	96.3	115.9
3	6-30 TC35EC	66.9	90	121.1
2	6-30 Daz	56.1	62.4	69.5
7	6-30 NoTr	32.8	48.7	72.2
5	>30 Daz	56.1	62.4	69.5
3	>30 Pic	44.1	49.9	56.4
2	>30 PPO	37.2	46.7	58.6
6	>30 MNa	37.3	46.3	57.5
6	>30 TC17Peb	73.3	84	96.2
1	>30 MNaPebFos	56.8	73.7	95.6
1	>30 PicTel	53.9	67.6	84.7
5	>30 MI60	52.7	62.3	73.7
14	>30 MB67	51.2	59.9	70.1
1	>30 PicPeb	48.7	57.9	68.8
4	>30 PicMNa	47.8	56.1	65.8
2	>30 TC35NapHal	44.1	54.5	67.4
5	>30 TC35Peb	45.6	54.2	64.5
2	>30 PicFosPeb	44.9	53.8	64.5
2	>30 PicMNaPeb	44.2	53.2	64
7	>30 MNaPeb	45.4	53	61.8
2	>30 TC35MetTrif	42.8	52.9	65.4
1	>30 TC17	42	51.1	62.2
1	>30 MI100MNa	37.2	49.8	66.5
7	>30 TC35	41.3	49.2	58.7
2	>30 NaN3	29.4	36.8	46.1
12	>30 NoTr	16.8	21.8	28.3

APPENDIX IV-2 Relationship for treatment x fungal interaction between number of trials, number of observations, treatments and the estimated relative means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatment x fungi (2 levels: Presence and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	Yes PicTel	92.8	117.8	149.5
1	Yes TC35PicPebNap	82	113.3	156.5
7	Yes TC17Peb	95	110.9	129.5
2	Yes MI60	93.1	110.4	131
1	Yes PicTelPebNap	76	104.9	145
17	Yes MB67	86	100	116.3
6	Yes TC35PebNap	79	99.1	124.1
1	Yes PicPeb	79.5	97.5	119.5
1	Yes MB67PebNap	67.4	96.6	138.5
9	Yes TC35Peb	82.4	96.3	112.6
6	Yes PicMNaPeb	79.5	93	108.8
2	Yes Sol	67.9	90.6	120.8
1	Yes Tviride	67.1	90.5	122.2
6	Yes PicMNa	76.9	89.3	103.8
2	Yes TC35NapHal	72.7	88.7	108.2
2	Yes PicFosPeb	74	87.6	103.6
2	Yes TC35MetTrif	70.5	86	105
5	Yes TC35	72.3	85.6	101.4
10	Yes MNaPeb	73.4	85.6	99.8
1	Yes TC35Tviride	65.1	84.3	109.2
1	Yes DazTviride	60.3	84.2	117.7
4	Yes Daz	72.4	82.8	94.7
3	Yes TC35EC	67.1	81.8	99.6
2	Yes PPO	60.7	75.9	95
16	Yes PicEC	61.9	75.1	91.1
1	Yes IndmusTviride	52.5	73.4	102.5
1	Yes TvirideFert	51.9	72.5	101.3
1	Yes SolSoil	51.2	69.9	95.5
8	Yes Pic	57.8	67.1	77.9
5	Yes MNa	51.1	65.6	84.2
2	Yes NaN3	48.5	60.1	74.5
29	Yes NoTr	35.8	44.2	54.6
1	Yes NoTrPebNap	30.2	43.3	62.1
8	NS TC17Peb	95.1	110.7	128.9
1	NS TC35ECTrefNap	86.7	108.2	134.9
2	NS TC35PebNap	80.2	108	145.3
2	NS TC35PicPebTrif	83.5	106.4	135.5
2	NS TC35Peb	78	105	141.3
7	NS MNaCad	86.3	100.5	117
3	NS PicMNa	86.5	99.4	114.2
5	NS MI60	85.4	98.2	112.8
27	NS MB67	85.3	97.1	110.5
8	NS MI100	84.9	96.9	110.7
4	NS PicFosPeb	84.1	96.4	110.4
3	NS TC17	79.7	95.9	115.3
2	NS MNaPebFos	75.2	92.7	114.2
2	NS TC35Daz	77.5	92.6	110.7
1	NS TC35ECDaz	73.5	92.1	115.5
15	NS NaN3	80.2	91.7	104.8
1	NS PicTel	71.4	91.4	117.1
2	NS PicEnzPeb	79.1	91.3	105.4

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
8	NS Multi	78.7	91.1	105.5
2	NS MNaFos	74.5	91	111.2
3	NS TC35PicTrefNap	77.2	90.8	106.9
1	NS TC35MesTref	72.6	90.7	113.2
15	NS TC35	78.1	89.2	101.8
9	NS MNaPP	77.2	89	102.5
4	NS TC35EC	74.4	87.2	102.1
16	NS MNa	72.6	84.8	99
2	NS MNaTel	68.9	84.6	103.8
1	NS PicMNaEnz	68.8	83.9	102.3
9	NS Cad	72.4	82.8	94.7
1	NS TC25	64.3	81.5	103.4
2	NS Fos	65.3	80	97.9
1	NS MI100MNa	59.5	78.5	103.6
2	NS Tel	63.4	78.3	96.8
2	NS Pic	65.8	77.2	90.5
2	NS PicPeb	63.6	74.9	88.2
1	NS Fen	55.8	74	98.2
6	NS Daz	60.8	74	90.1
1	NS Oxa	53.2	70.5	93.5
3	NS DMDS	55.7	67.2	81.1
1	NS Quil	44.4	58.1	75.9
3	NS TerraK	45.5	54.7	65.8
23	NS NoTr	37	45.8	56.7

APPENDIX IV-3 Relationship for treatment x nematode interaction between number of trials, number of observations, treatments and the estimated relative means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatments x nematode (2 levels: Presence and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	Yes TC35PicPebNap	84.1	117.1	163
5	Yes TC35Peb	98.6	115.3	134.9
8	Yes TC17Peb	99.2	114.1	131.3
2	Yes TC35PicPebTrif	86.3	109.5	139.1
3	Yes PicMNaPeb	93.9	108.5	125.4
1	Yes PicTelPebNap	77.9	108.5	151.1
2	Yes Sol	79.7	105.5	139.6
2	Yes MNaPebFos	86.5	104.3	125.9
8	Yes TC35PebNap	85.9	102.4	122
7	Yes MNaCad	87.3	101	116.8
32	Yes MB67	89.2	100	112.1
1	Yes MB67PebNap	71.9	99.9	138.8
2	Yes TC17	80.8	97.5	117.7
4	Yes MI60	84.4	96.2	109.6
2	Yes MNaPeb	79.7	94.9	113.1
4	Yes PicMNa	83.4	93.6	105.1
2	Yes TC35NapHal	76.2	91.9	111
1	Yes MNaTel	71.1	90.8	115.9
4	Yes PicFosPeb	81	90.8	101.8
1	Yes PicTel	72.8	90.3	112.1
2	Yes TC35MetTrif	73.9	89.2	107.7
1	Yes TC35Daz	68.1	87.2	111.6
19	Yes TC35	76.9	86.4	97.1
3	Yes PicPeb	74.2	84.6	96.5
12	Yes MNa	72	84.4	98.9
7	Yes MI100	74.1	83.9	95.1
1	Yes TC35MesTref	65.4	83.7	107.1
6	Yes TC35EC	72.7	83.3	95.3
9	Yes Cad	72.9	83	94.4
1	Yes TC35PicTrefNap	64	81.9	104.8
5	Yes Daz	65.9	79.4	95.6
2	Yes PPO	65.3	78.7	94.8
3	Yes MNaPP	66.5	77.8	91.1
2	Yes Tel	63.6	77.3	93.9
1	Yes MI100MNa	59.7	77.2	99.9
1	Yes PicEnzPeb	68.1	76.5	86
1	Yes TC25	60.7	75.6	94.2
2	Yes Multi	60.9	74.5	91.3
1	Yes Fen	55	73	96.8
8	Yes NaN3	60.8	69.8	80.1
1	Yes Pic	59.4	69.8	82
1	Yes Oxa	52.4	69.5	92.2
1	Yes SolSoil	51.4	68.7	91.8
2	Yes Fos	56	68.3	83.3
3	Yes DMDS	48.6	57.9	69
1	Yes Quil	38.2	49.1	63.2
3	Yes TerraK	38.9	46.3	55.1
1	Yes NoTrPebNap	32.2	44.8	62.2
33	Yes NoTr	36.2	43.1	51.3
7	NS TC17Peb	100.3	118.4	139.8
1	NS TC35ECTrefNap	79.9	105.2	138.5

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	NS PicTel	82.4	103.2	129.1
9	NS NaN3	82.4	98.1	116.7
1	NS PicEnzPeb	83.8	97.8	114.1
3	NS MI60	80.7	94.6	111
1	NS TC35ECDaz	70.7	94.2	125.4
5	NS PicMNa	80.4	93.7	109.2
1	NS TC35EC	73.7	93.1	117.7
2	NS MNaFos	74.5	93	116.2
6	NS Multi	77.1	92.7	111.4
1	NS MI100	76.1	92.5	112.4
3	NS PicMNaPeb	77.2	92.1	109.8
2	NS PicFosPeb	78.8	91.8	107.1
6	NS MNaPP	76.5	91.1	108.4
12	NS MB67	77.7	90.9	106.2
2	NS TC35PicTrefNap	71.7	89.4	111.3
1	NS TC35Daz	67	88.2	116.1
6	NS TC35Peb	73.7	87.8	104.7
1	NS Tviride	61.9	86.6	121.2
1	NS PicMNaEnz	68.2	85.8	107.9
1	NS DazTviride	60.7	84.8	118.7
5	NS Daz	72.9	83	94.4
8	NS MNaPeb	69.2	81	94.9
1	NS TC35Tviride	57.6	80.7	113
1	NS TC35	59	79	105.8
16	NS PicEC	61.5	76.1	94.1
9	NS MNa	61.1	75.3	92.8
1	NS IndmusTviride	52.8	73.9	103.4
1	NS TC17	59.5	73.7	91.4
1	NS TvirideFert	52.2	73	102.1
9	NS Pic	62.2	71.9	83.2
1	NS MNaTel	53.8	70.7	92.9
19	NS NoTr	38.4	48.9	62.2

APPENDIX IV-4 Relationship for treatment x application method interaction between number of trials, number of observations, treatments and the estimated relative means for strawberry yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatments x application method (4 levels: Injection, Drip, Spray and Not specified)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
15	Injection TC17Peb	109.7	121	133.5
1	Injection TC35PicPebNap	85.2	117.6	162.5
2	Injection TC35PicPebTrif	87.1	109.5	137.7
1	Injection PicTelPebNap	78.9	109	150.5
2	Injection PicTel	92.5	106.3	122.2
3	Injection PicMNaPeb	94	106.2	120
8	Injection TC35PebNap	87.8	102.9	120.6
7	Injection MI60	93.7	102.6	112.4
1	Injection DazTviride	76.6	102	135.8
1	Injection PicEnzPeb	93	101.3	110.3
1	Injection MB67PebNap	73.5	100.3	137
11	Injection TC35Peb	90.6	100.3	111.1
37	Injection MB67	92	100	108.7
8	Injection MI100	90.8	100	110.1
1	Injection MNaTel	79.3	98.7	122.9
5	Injection PicMNa	90.3	98.4	107.2
1	Injection TC35Tviride	74.5	96.7	125.5
2	Injection TC35NapHal	81.6	96.4	113.8
4	Injection PicFosPeb	87.6	95.2	103.4
3	Injection TC17	83.3	94.6	107.3
14	Injection TC35	86.3	94.3	103.2
1	Injection TC35PicTrefNap	74.6	93.8	118
2	Injection TC35MetTrif	79.1	93.5	110.5
2	Injection TC35Daz	78.9	93.1	109.9
5	Injection MNaPeb	80.6	90.1	100.7
7	Injection MNa	73.8	89.2	107.7
1	Injection Fos	69.4	88.7	113.4
1	Injection TvirideFert	65.9	87.7	116.9
3	Injection PicPeb	79	87.4	96.7
1	Injection TC35ECDaz	60.3	87	125.7
10	Injection Daz	76.6	86.7	98.2
2	Injection PPO	70.4	82.5	96.6
1	Injection MI100MNa	65.3	81.9	102.6
9	Injection Cad	70.5	81.7	94.7
2	Injection MNaCad	64.4	81.2	102.4
2	Injection Tel	67.1	80.3	96.1
1	Injection TC25	66.9	80.2	96.1
1	Injection PicMNaEnz	57.6	79.2	109.1
10	Injection Pic	68.7	75.5	83
1	Injection Fen	54	71.9	95.6
1	Injection Oxa	51.4	68.4	91.1
2	Injection NaN3	54.8	64.6	76.2
3	Injection NoTr	26	46.5	83.3
1	Drip TC35ECTrefNap	86.6	109	137.1
2	Drip MNaPebFos	91.6	107.9	127.2
5	Drip MNaCad	91.1	107	125.7
2	Drip MNaPeb	81.4	95.4	111.9
13	Drip NaN3	85.8	94.8	104.7
4	Drip Multi	82.2	93.8	107

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	Drip TC35PicTrefNap	72.7	91.4	115
6	Drip TC35EC	78.7	87.9	98.2
2	Drip MNaPP	63.9	87.3	119.4
2	Drip MNaFos	62.9	86	117.6
7	Drip MNa	66.2	79.8	96.2
3	Drip DMDS	60	69.7	80.9
16	Drip PicEC	57.6	69.2	83.2
1	Drip Quil	48.5	60.7	75.8
3	Drip TerraK	49.4	57.1	66.1
7	Hotgas MB98	70.3	82.5	96.9
4	Spray PicMNa	85.7	94.2	103.6
3	Spray PicMNaPeb	82.6	93.4	105.7
6	Spray MNaPP	80.8	90	100.3
3	Spray MNaPeb	68.6	79	91
1	Spray Fos	60.9	78.1	100.1
7	Spray MNa	63.7	76.9	92.8
1	Spray MNaTel	59.1	73.3	90.9
2	NS Sol	93.1	116.7	146.2
1	NS Tviride	81.1	103.9	133.1
2	NS PicFosPeb	90.1	98.7	108.1
1	NS TC35MesTref	72	91	114.9
1	NS TC35PicTrefNap	70.5	89	112.4
1	NS IndmusTviride	66.7	88.8	118.3
2	NS NaN3	62.9	86.7	119.5
1	NS TC35EC	62.1	86	119.2
4	NS Multi	63.6	85.8	115.8
1	NS PicEnzPeb	75.9	83.2	91.3
1	NS MNaPP	52.8	74.9	106.3
1	NS SolSoil	54.4	71.3	93.3
42	NS NoTr	39.1	45.1	52.1
1	NS NoTrPebNap	32.9	45	61.4

APPENDIX IV-5 Relationship for treatment x plastic seal interaction between number of trials, number of observations, treatments and the estimated relative means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatments x plastic seal (2 levels: Barrier film and Non Barrier flim)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
3	Barr MB67	100.9	114.9	130.7
4	Barr TC35	85.5	94.9	105.2
1	Barr NoTr	17.3	52.2	157.5
15	NonBarr TC17Peb	108.1	117.6	127.9
1	NonBarr TC35PicPebNap	86.6	116.8	157.6
2	NonBarr TC35PicPebTrif	89.5	109.5	134.1
1	NonBarr PicTelPebNap	80.2	108.2	146
1	NonBarr TC35ECTrefNap	86.1	107	132.9
2	NonBarr PicTel	90.5	102.9	117
2	NonBarr Sol	79.7	102.8	132.7
2	NonBarr MNaPebFos	87.3	102.2	119.7
8	NonBarr TC35PebNap	89.3	102.1	116.9
7	NonBarr MI60	92.9	100.4	108.4
41	NonBarr MB67	93.5	100	106.9
1	NonBarr MB67PebNap	72.8	99.6	136.2
11	NonBarr TC35Peb	90.2	98.6	107.7
7	NonBarr MNaCad	85.2	98.5	113.8
6	NonBarr PicMNaPeb	89.7	98	107
2	NonBarr TC35NapHal	83	97.2	113.7
1	NonBarr Tviride	74.4	97.2	127
9	NonBarr PicMNa	89.9	96.6	103.8
6	NonBarr PicFosPeb	88.9	95.8	103.2
3	NonBarr TC17	84.4	94.7	106.4
8	NonBarr MI100	87	94.3	102.2
2	NonBarr TC35MetTrif	80.5	94.3	110.4
1	NonBarr TC35ECDaz	73.5	92.1	115.5
2	NonBarr TC35Daz	79	92	107.2
1	NonBarr DazTviride	66.5	91.7	126.6
2	NonBarr MNaFos	78.1	91	106.1
17	NonBarr NaN3	82.1	90.8	100.3
2	NonBarr PicEnzPeb	83	90.7	99.2
16	NonBarr TC35	84.1	90.6	97.6
1	NonBarr TC35MesTref	72.8	90.5	112.6
1	NonBarr TC35Tviride	70.3	90.5	116.5
8	NonBarr Multi	81.6	90.1	99.4
3	NonBarr TC35PicTrefNap	79.2	90.1	102.5
9	NonBarr MNaPP	81.2	88.6	96.6
7	NonBarr TC35EC	79.9	87.4	95.6
10	NonBarr MNaPeb	80.1	87.1	94.6
16	NonBarr PicEC	74.1	85.2	97.9
3	NonBarr PicPeb	76.9	84.9	93.8
2	NonBarr MNaTel	71.4	84.1	99
1	NonBarr PicMNaEnz	71.4	83.9	98.6
10	NonBarr Daz	74.2	83.6	94.1
2	NonBarr PPO	70.3	83.2	98.3
21	NonBarr MNa	73.5	81.9	91.3
9	NonBarr Cad	70.7	81.2	93.4
1	NonBarr IndmusTviride	57.9	79.9	110.3
1	NonBarr MI100MNa	62.7	79.9	101.8
2	NonBarr Tel	66.6	79.9	96
1	NonBarr TC25	66.7	79.4	94.5

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
1	NonBarr TvirideFert	57.2	78.9	108.9
2	NonBarr Fos	65.1	77.2	91.7
10	NonBarr Pic	69.9	75.8	82.2
1	NonBarr Fen	56	74	97.6
1	NonBarr Oxa	53.4	70.4	93
1	NonBarr SolSoil	52.5	69.2	91.2
3	NonBarr DMDS	55.9	65	75.6
1	NonBarr Quil	44	56	71.3
3	NonBarr TerraK	45.5	52.8	61.1
51	NonBarr NoTr	41.4	47	53.3
1	NonBarr NoTrPebNap	32.7	44.7	61.1

APPENDIX IV-6 Relationship for treatment x production system interaction between number of trials, number of observations, treatments and the estimated relative means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatments x production system (2 levels: Greenhouse and Open field)

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
15	Open Field TC17Peb	107.4	117.2	128
1	Open Field TC35PicPebNap	86.6	116.4	156.4
2	Open Field TC35PicPebTrif	90	109.5	133.3
1	Open Field PicTelPebNap	80.2	107.8	144.9
1	Open Field TC35ECTrefNap	85.5	106.3	132.2
2	Open Field MNaPebFos	87.1	101.9	119.3
8	Open Field TC35PebNap	89.1	101.8	116.2
2	Open Field PicTel	88.2	100.9	115.5
44	Open Field MB67	93	100	107.5
7	Open Field MI60	91.7	99.6	108.1
1	Open Field MB67PebNap	72.4	99.3	136.2
11	Open Field TC35Peb	89.5	98.3	107.8
6	Open Field PicMNaPeb	89.1	97.7	107.2
1	Open Field Tviride	73.3	96.4	126.9
2	Open Field TC35NapHal	81.9	96.1	112.6
9	Open Field PicMNa	88.9	96	103.7
3	Open Field TC17	84.5	95.3	107.5
6	Open Field PicFosPeb	87.8	95.1	103
8	Open Field MI100	85.9	93.6	102.1
2	Open Field TC35MetTrif	79.5	93.2	109.3
1	Open Field TC35ECDaz	73.6	92.3	115.8
1	Open Field DazTviride	65.9	91.5	127
2	Open Field TC35Daz	78.3	91.4	106.8
2	Open Field MNaFos	78.1	91.2	106.6
17	Open Field NaN3	81.8	91.2	101.8
2	Open Field PicEnzPeb	82.1	90.2	99
1	Open Field TC35MesTref	72.3	89.9	111.9
8	Open Field Multi	81	89.8	99.6
1	Open Field TC35Tviride	69.7	89.8	115.5
20	Open Field TC35	82.9	89.6	96.9
3	Open Field TC35PicTrefNap	78.5	89.5	102.2
9	Open Field MNaPP	80.6	88.3	96.7
7	Open Field TC35EC	79.4	87.3	96
10	Open Field MNaPeb	79.5	86.8	94.7
3	Open Field PicPeb	76.6	84.7	93.8
17	Open Field MNa	74.8	84.4	95.2
1	Open Field PicMNaEnz	71.4	84.1	98.9
2	Open Field MNaTel	70.4	83.5	99
9	Open Field Daz	73.4	82.7	93.2
2	Open Field PPO	69.1	82.2	97.8
1	Open Field IndmusTviride	57.4	79.7	110.6
1	Open Field MI100MNa	61.6	79.1	101.6
1	Open Field TvirideFert	56.7	78.7	109.2
2	Open Field Fos	64.5	76.7	91.2
10	Open Field Pic	69.9	76.1	83
1	Open Field Tel	56.1	73	95.1
2	Open Field PicEC	53.8	72.5	97.9
1	Open Field SolSoil	51.7	68.3	90.3
3	Open Field DMDS	55.2	64.6	75.5
1	Open Field Quil	43.4	55.6	71.3
3	Open Field TerraK	44.9	52.4	61.1

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
42	Open Field NoTr	39.9	45.9	52.8
2	Greenhouse Sol	77.9	106.4	145.4
7	Greenhouse MNaCad	85.8	99.8	116
1	Greenhouse Daz	62.2	96.3	149.1
14	Greenhouse PicEC	73.2	91.5	114.4
1	Greenhouse Tel	65.3	89.8	123.5
9	Greenhouse Cad	73.4	82.7	93.2
1	Greenhouse Fen	57.3	78.4	107.1
1	Greenhouse Oxa	54.6	74.6	102
4	Greenhouse MNa	55.9	73.3	96.1
10	Greenhouse NoTr	37.7	53	74.5

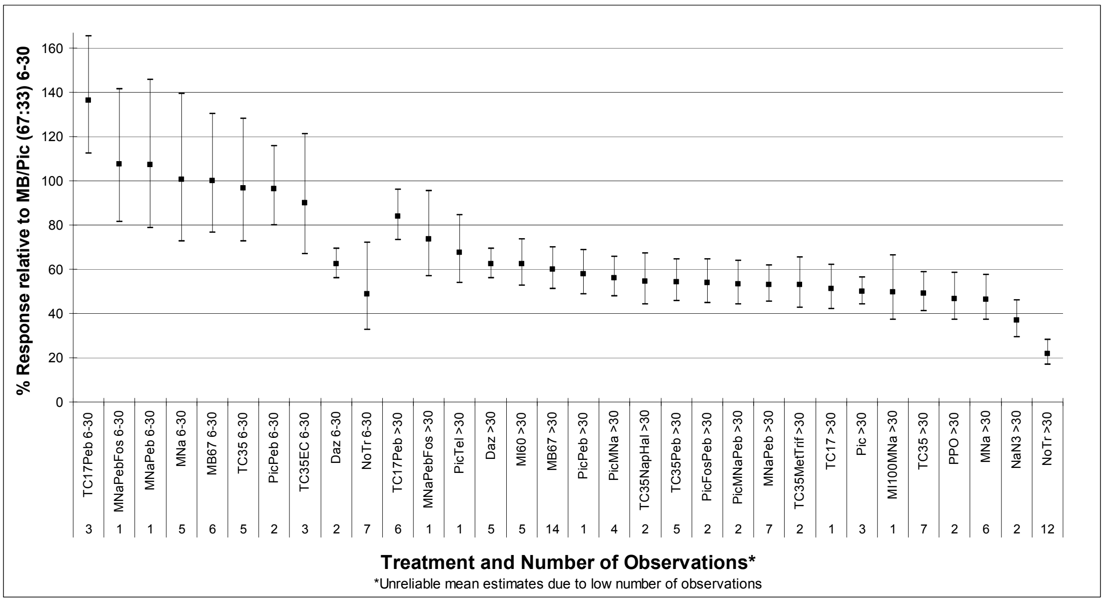
APPENDIX IV-7 Relationship for treatment x soil type interaction between number of trials, number of observations, treatments and the estimated relative means for tomato yields compared to the standard MB treatment (MB/Pic 67:33) from the complete meta-analysis (Y1)

TOMATOES - Treatments x soil type (4 levels: Sand, Clay, Loam and Not specified)

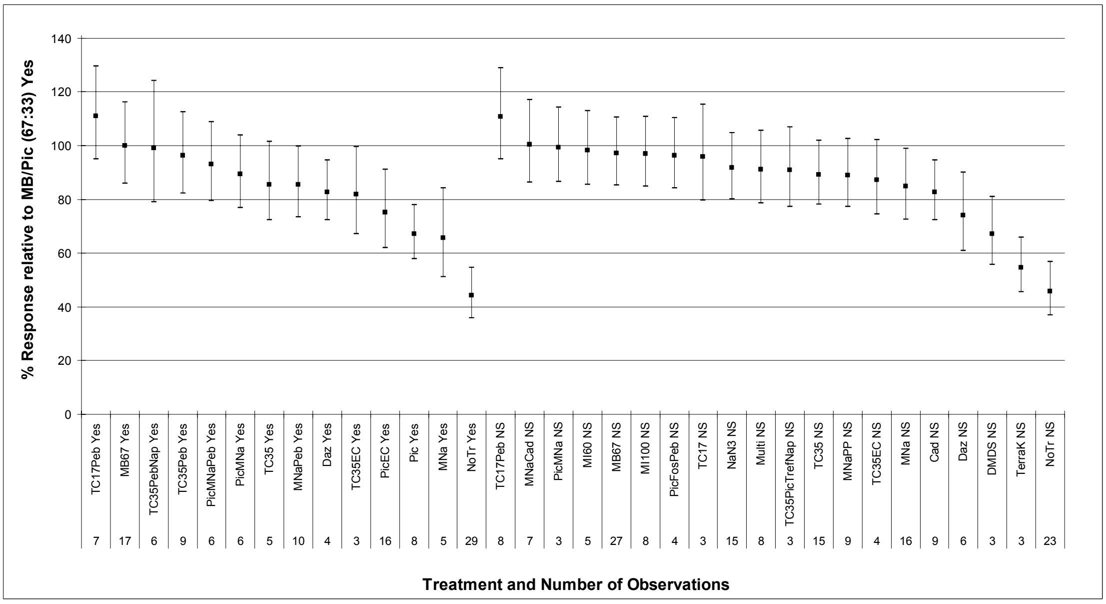
Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
11	sand TC17Peb	110	122.7	136.8
1	sand PicTel	98	118.1	142.3
1	sand TC35PicPebNap	86.7	115.9	154.9
2	sand MI60	97.3	110.7	125.9
2	sand Sol	85.5	110.6	143.2
2	sand TC35PicPebTrif	89.9	109.5	133.4
1	sand PicTelPebNap	80.3	107.4	143.5
2	sand MNaPebFos	89	105.2	124.3
1	sand Tviride	78.6	103.3	135.8
8	sand TC35PebNap	87.6	101.3	117.2
11	sand TC35Peb	89.8	100.9	113.3
23	sand MB67	90.4	100	110.7
1	sand MB67PebNap	72.3	98.8	135.1
6	sand PicMNaPeb	87.7	98.6	110.7
2	sand TC35NapHal	82.4	98.1	116.7
1	sand DazTviride	71.4	98.1	134.7
2	sand PicFosPeb	85.2	96.9	110.1
1	sand TC35Tviride	75	96.2	123.3
6	sand PicMNa	86.2	96.1	107.2
6	sand MI100	84.4	95.8	108.8
10	sand TC35	85.8	95.8	107
2	sand TC35MetTrif	80	95.2	113.2
6	sand TC35EC	79.5	89.8	101.4
10	sand MNaPeb	80.2	89.7	100.3
3	sand PicPeb	78.1	87.7	98.5
9	sand Daz	77.7	85.5	94
1	sand IndmusTviride	62.2	85.4	117.4
1	sand TvirideFert	61.4	84.4	115.9
2	sand Multi	69	84	102.4
2	sand PPO	69.5	84	101.5
1	sand TC17	66.7	80.1	96.3
8	sand MNa	66.2	79.5	95.5
8	sand NaN3	68.8	78.2	88.7
2	sand Fos	63.5	77.1	93.6
3	sand Pic	69.2	77.1	85.8
1	sand SolSoil	52.1	68.6	90.2
3	sand DMDS	54.8	65.5	78.2
1	sand Quil	42.7	55.4	71.9
3	sand TerraK	43.8	52.2	62.2
28	sand NoTr	38.9	46.9	56.5
1	sand NoTrPebNap	32.4	44.3	60.6
2	clay MNaCad	98.3	119.4	145
3	clay NaN3	25.9	103.9	416.2
1	clay Daz	66.8	103.5	160.5
1	clay Tel	71.2	96.6	131
4	clay Cad	77.7	85.5	94
1	clay Fen	62.2	84.2	114
2	clay MNa	57.4	84.1	123.3
1	clay Oxa	59.3	80.2	108.5
3	clay NoTr	24.9	53.2	113.3
1	clay MB67	13.1	52.8	212.6

Obs	Treatment	Lower LSI	Estimated Mean	Upper LSI
6	loam Pic	74	96.5	125.9
5	loam MNaCad	82.1	95.2	110.4
16	loam PicEC	69.5	87.7	110.5
5	loam Cad	77.7	85.5	94
2	loam MNa	47.1	68.6	99.9
9	loam NoTr	36.9	53.8	78.4
4	NS TC17Peb	79.7	92.1	106.5
1	NS TC35ECTrefNap	70.9	88.6	110.6
20	NS MB67	77.7	85.5	94
2	NS TC17	70.8	83.6	98.7
3	NS PicMNa	72.4	81.4	91.5
5	NS MI60	71.5	80	89.4
1	NS TC35ECDaz	63.1	79.3	99.6
4	NS PicFosPeb	70.5	78.9	88.3
1	NS TC35EC	65.1	78.4	94.4
2	NS MNaFos	65.9	78.3	93.2
6	NS Multi	68.2	78	89.2
2	NS TC35Daz	64.1	75.8	89.7
6	NS NaN3	66.9	75.7	85.8
9	NS MNa	63.1	75.2	89.6
2	NS PicEnzPeb	66.2	74.8	84.5
3	NS TC35PicTrefNap	64.1	74.4	86.3
1	NS TC35MesTref	59.4	74.2	92.8
9	NS MNaPP	65.9	74.1	83.2
2	NS MI100	64.8	73.6	83.6
1	NS PicMNaEnz	60.4	72.2	86.3
1	NS PicTel	58.7	71.7	87.6
10	NS TC35	63.4	70.5	78.5
2	NS MNaTel	57.6	69.3	83.3
1	NS TC25	53.2	64.8	79
1	NS MI100MNa	49.4	63.8	82.3
1	NS Pic	52.1	59.8	68.7
1	NS Tel	43.5	56.7	74
12	NS NoTr	28.5	37.7	49.8

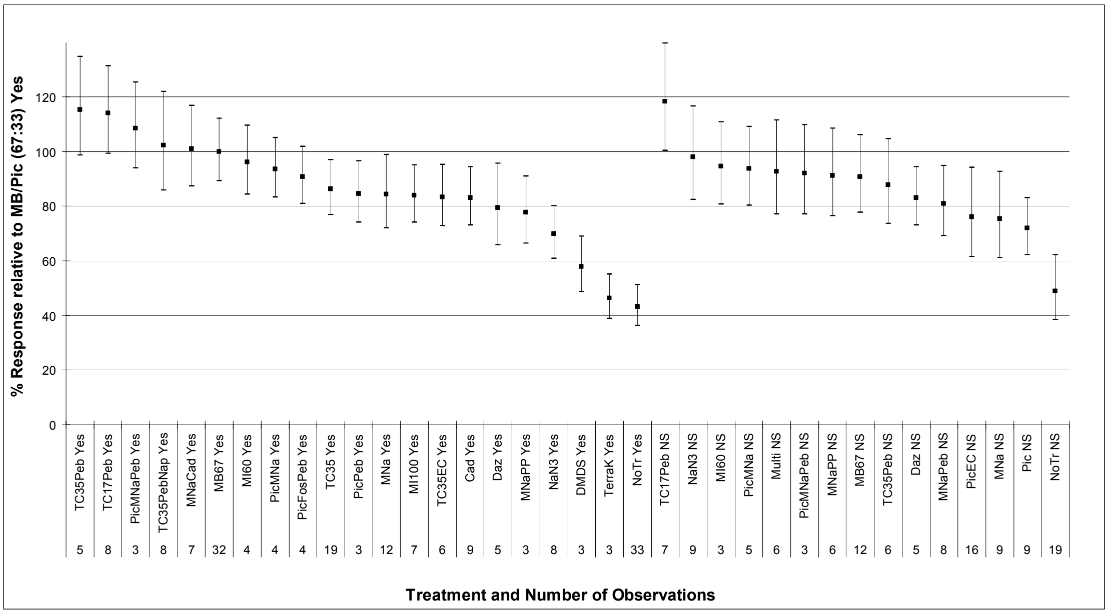
APPENDIX V-1. Relative yield data from the meta-analyses (treatment x nutsedge groupings) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005.



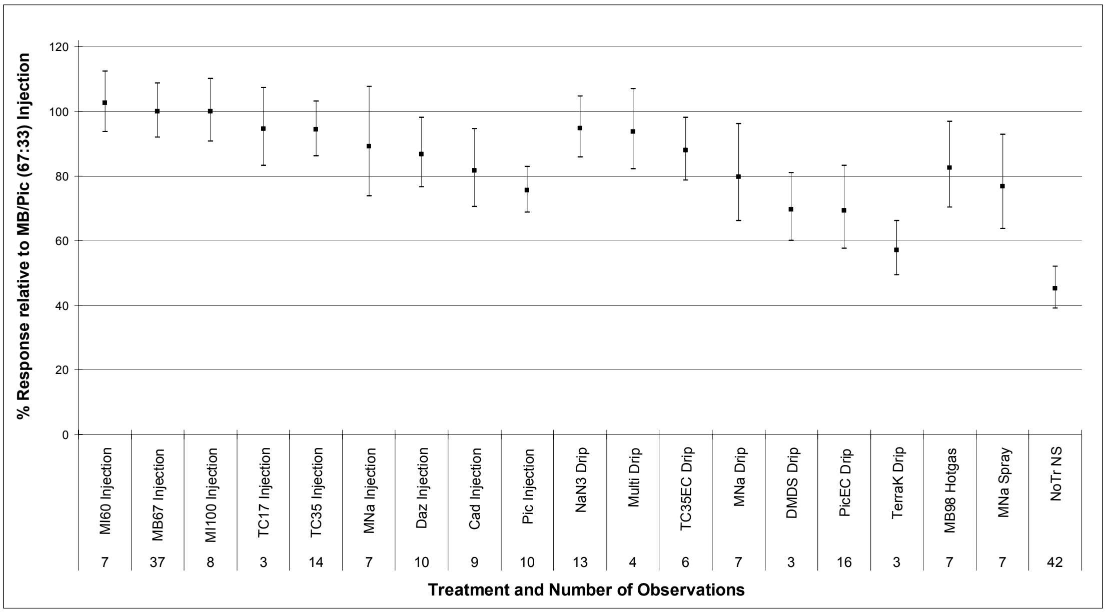
APPENDIX V-2. Relative yield data from the meta-analyses (treatment x fungal presence) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



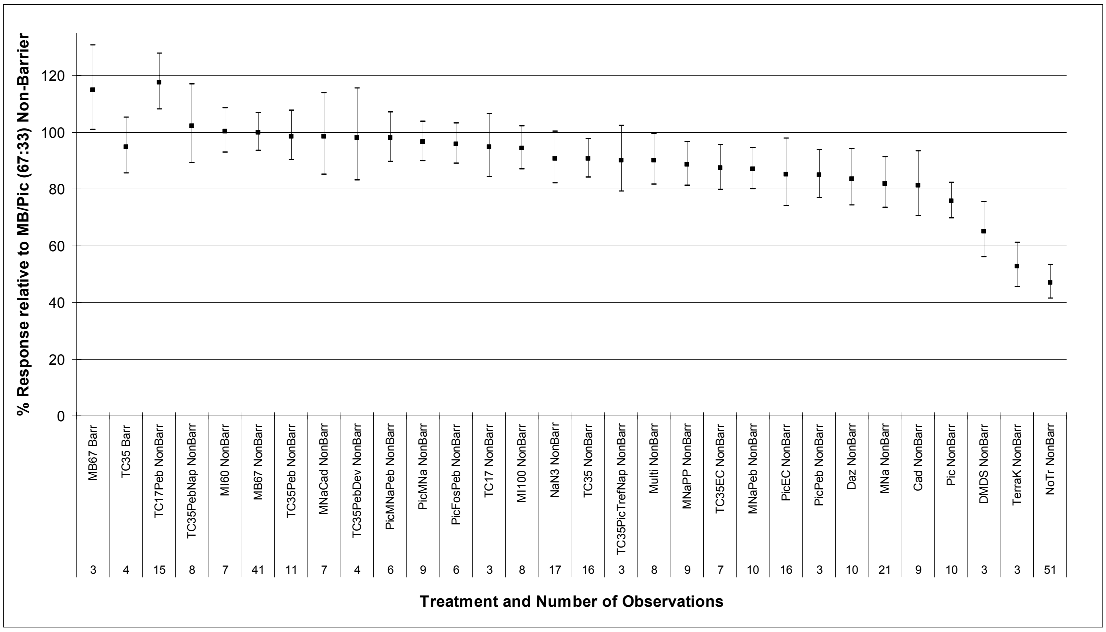
APPENDIX V-3. Relative yield data from the meta-analyses (treatment x nematode presence) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



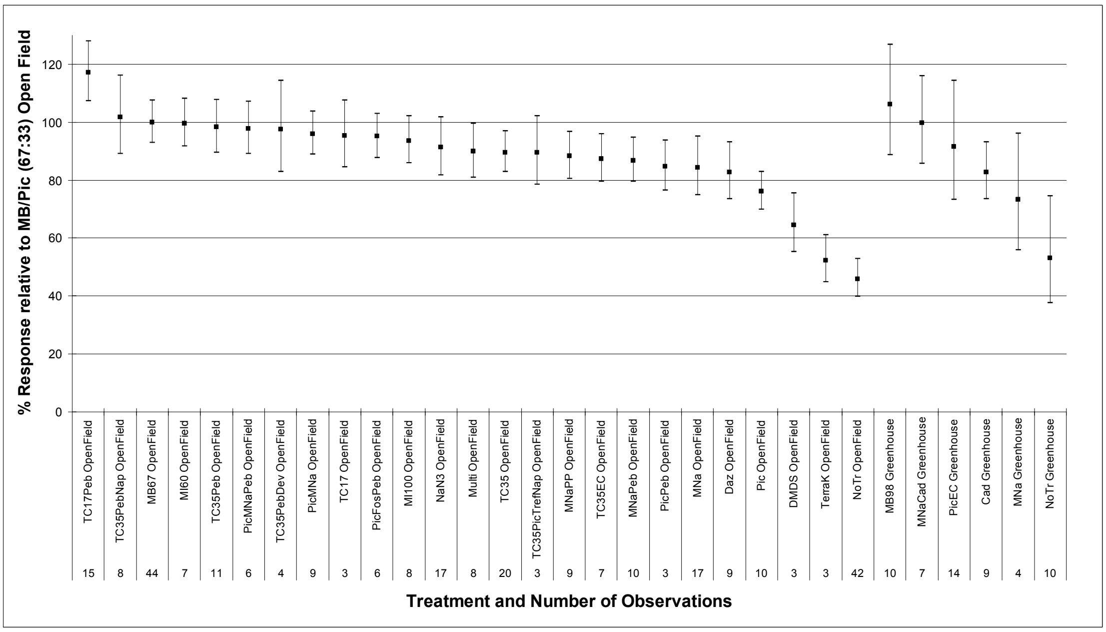
APPENDIX V-4. Relative yield data from the meta-analyses (treatment x application method) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. Note: Observations only for a single chemical and >2 observations for an alternative were required before inclusion in the figure below.



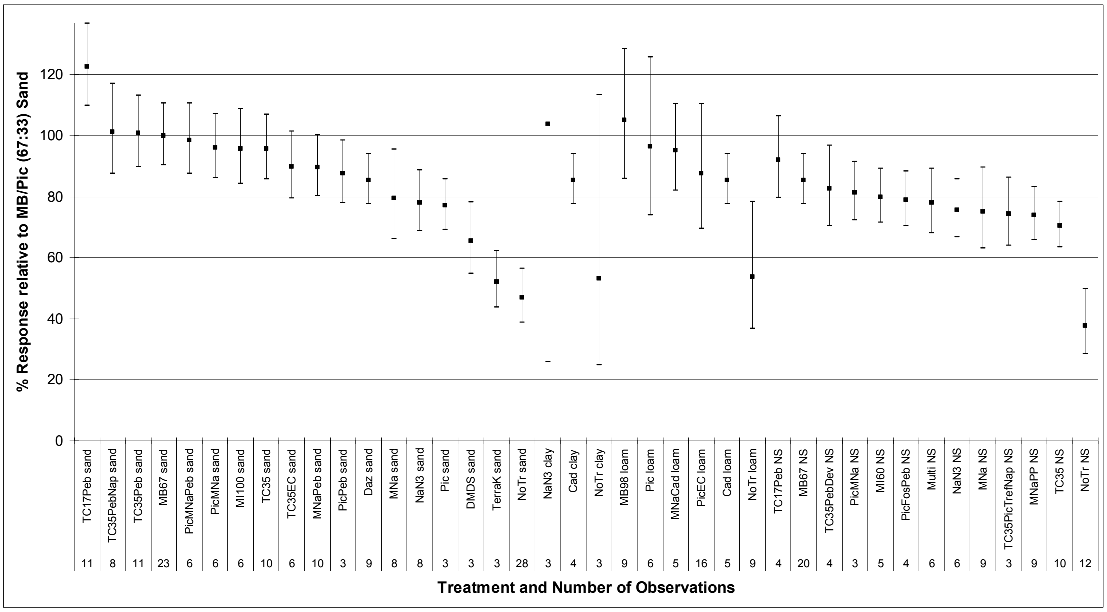
APPENDIX V-5. Relative yield data from the meta-analyses (treatment x plastic seal) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



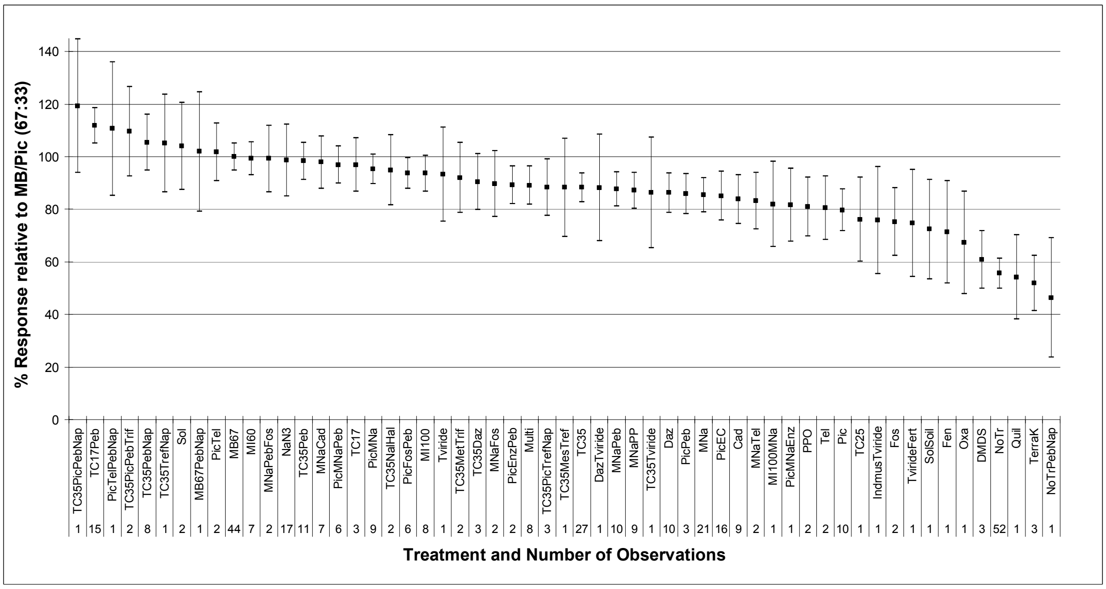
APPENDIX V-6. Relative yield data from the meta-analyses (treatment x production system) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



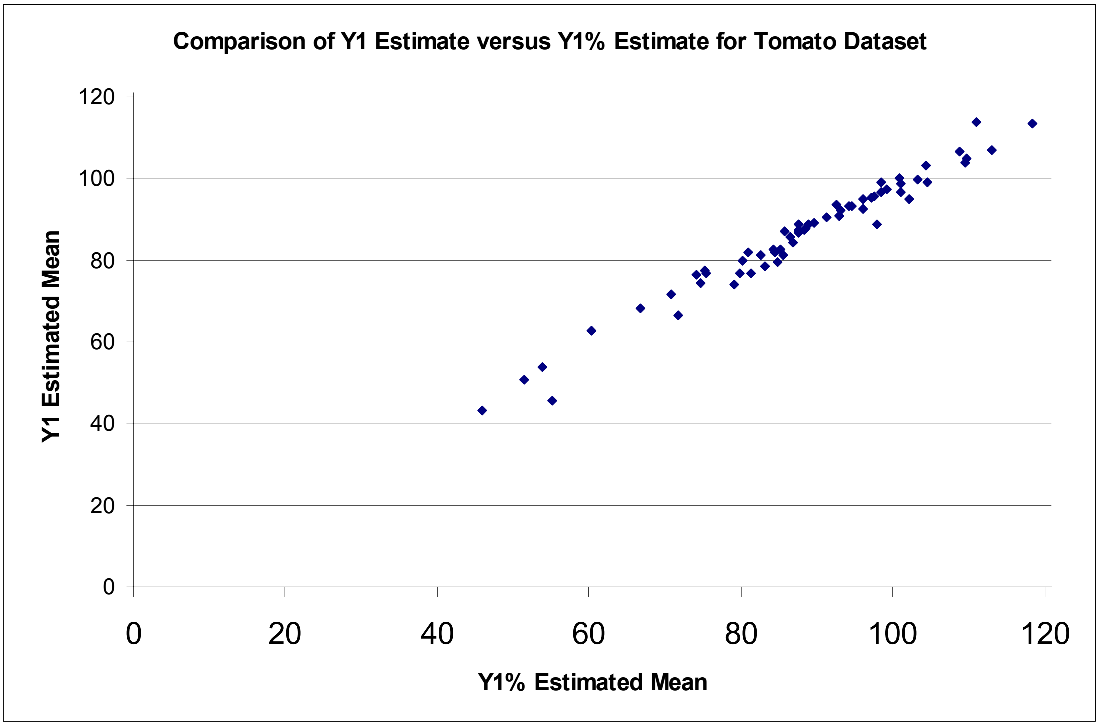
APPENDIX V-7. Relative yield data from the meta-analyses (treatment x soil type) and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. Note: >2 observations for an alternative were required before inclusion in the figure below.



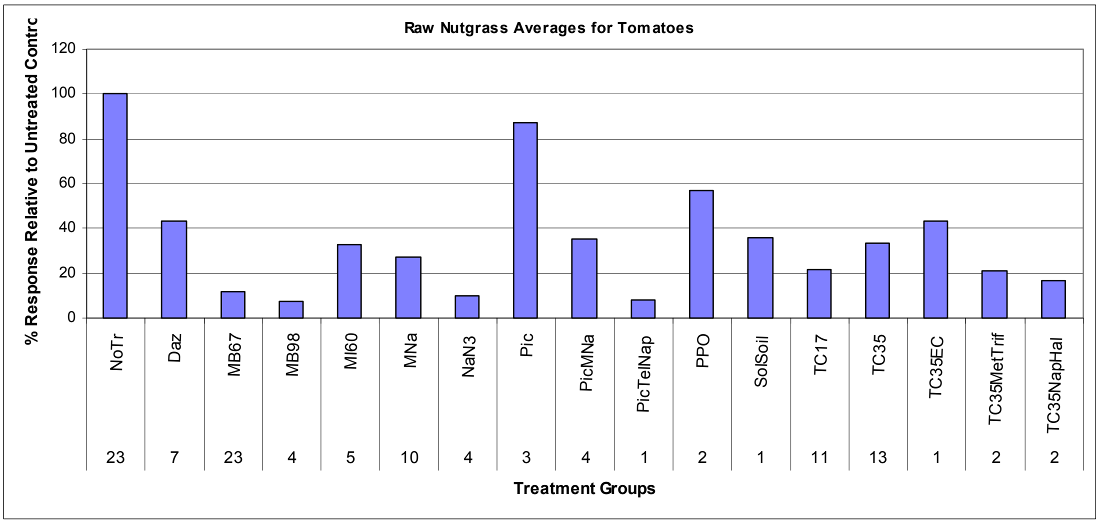
APPENDIX V-8. Relative yield data from the partial meta-analyses[A] and LSI intervals for alternatives to methyl bromide from international research studies in tomato crops from 1997 to 2005. [A] Note: Relative means determined by comparison to the methyl bromide treatment from the same study



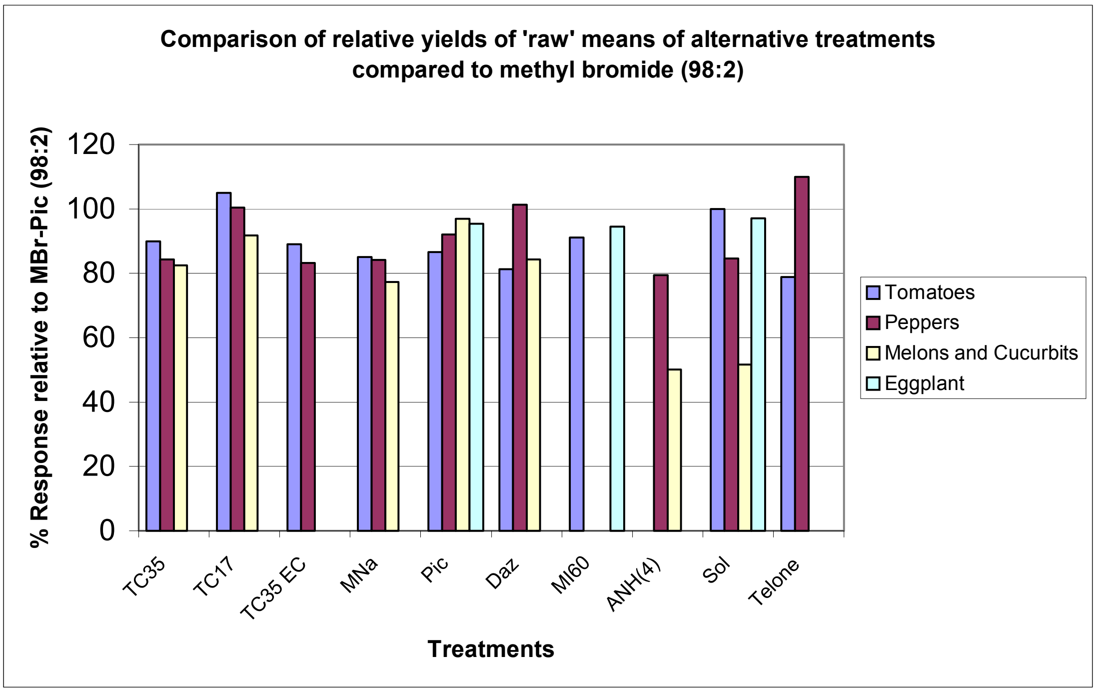
APPENDIX V-9. Correlation between estimated means from the full meta-analysis (Y1) and the partial meta-analysis for MB (Y1%) and alternatives from international research studies in tomato fruit crops from 1997 to 2005 for treatments with greater than two observations. Note: In the full meta-analysis the means were fully modelled means whereas in the partial meta-analysis the means are relative to the methyl bromide treatment from the same study. The plot enables identification of outliers.



APPENDIX V-10. Relative ('averaged' raw means) of nutsedge control for treatments in international studies (ie. population densities quoted in studies) relative to the untreated control. Note: There were insufficient studies of this parameter to do a full representative meta-analysis. Number of observations in studies are shown after the treatment label



APPENDIX VI: Comparison of the 'raw' means (not meta-analysed) from four crops averaged across international studies from trials conducted from 1997 –2005. Note: There were insufficient studies on peppers, melons and cucurbits and eggplant to do a full meta-anlysis



APPENDIX VII - Modelled Analysis Parameters Strawberries

Term	Levels	Wald statistic	chi pr	Unanalysed levels
Main effect				
TrtGrp1a (TG)	See Table 6	382.4	<0.001	
Interactions				
TG x FungiBase	NS 736, Yes 145	14.65	0.745	Unknown 8; No 6
TG x Nematodes	NS 779, Yes 116	22.8	0.696	
TG x NutBase	1-5 33, 6-30 27, >30 22	30.63	0.08	NS 813
TG x Sealing	Non Barrier 812, Barrier 74,	2.69	0.999	Irclear 9
TG x Applctn	Drip 164, Hotgas 2, Injection 503, Spray 65, Spread 13	65.35	<0.001	NA 122, NS 26
TG x Production Practice	Greenhouse(tunnel) 138, Open Field 757**	38.0	0.077	
TG x SoilTyp	Clay 66, Loam 22, Sand 66	21.7	0.794	NS 741

NS – Not specified; NA - Not Available; Irclear – Thermofilm clear;

* *- Unspecified studies were assumed to be open field studies

Model for Treatment Groupings 1a

REML variance components analysis

Response variate:	LOG(Y1)
Fixed model:	Constant + TrlNo + TrtGrp1a
Random model:	TrlNo.TrtGrpAtom
Number of units:	895 (2 units excluded due to zero weights or missing values)

Separate residual terms for each level of experiment factor: VarianceGrp

Sparse algorithm with AI optimisation

Estimated variance components

Random term	component	s.e.
TrlNo.TrtGrpAtom	0.00424	0.00092

Residual model for each experiment

Experiment factor: VarianceGrp

Experiment	Term Factor	Model(order)	Parameter	Estimate	s.e.
Grouped	Residual	Identity	Variance	0.0203	0.0075
Daz	Residual	Identity	Variance	0.0238	0.0074
MBPic	Residual	Identity	Variance	0.00254	0.00061
MIPic	Residual	Identity	Variance	0.00973	0.00458
MNa	Residual	Identity	Variance	0.324	0.054
MNaOther	Residual	Identity	Variance	0.0148	0.0052
MNaSolar	Residual	Identity	Variance	0.00247	0.00393
MNaTelOther	Residual	Identity	Variance	0.00197	0.00586
NoTr	Residual	Identity	Variance	0.232	0.037

OrgFert	Residual	Identity	Variance	0.238	0.156
Pic	Residual	Identity	Variance	0.00352	0.00100
PicEC	Residual	Identity	Variance	0.00395	0.00148
PicECMNa	Residual	Identity	Variance	0.0280	0.0140
PicECMNaOther					
	Residual	Identity	Variance	0.0142	0.0053
PicMNa	Residual	Identity	Variance	0.0518	0.0227
PicMNaOther	Residual	Identity	Variance	0.0707	0.0629
PicOther	Residual	Identity	Variance	0.00494	0.00402
PicTel	Residual	Identity	Variance	0.00931	0.00188
PicTelOther	Residual	Identity	Variance	0.0154	0.0038
PP	Residual	Identity	Variance	0.520	0.215
PPO	Residual	Identity	Variance	0.0219	0.0163
Solar	Residual	Identity	Variance	0.0787	0.0240

Wald tests for fixed effects

Sequentially adding terms to fixed model

Fixed term	Wald statistic	d.f.	Wald/d.f.	chi pr
TrlNo	214716.48	95	2260.17	<0.001
TrtGrp1a	382.44	84	4.55	<0.001

Dropping individual terms from full fixed model

Fixed term	Wald statistic	d.f.	Wald/d.f.	chi pr
TrtGrp1a	382.44	84	4.55	<0.001
TrlNo	176655.53	95	1859.53	<0.001

APPENDIX VIII - Modelled Analysis Parameters Tomatoes

Term	Levels	Wald statistic	chi pr	Unanalysed levels
Main Effect				
TrtGrp1b (TG)	See Table 7	266.0	<0.001	
Interactions				
TG x FungiBase	NS (221), Yes (181)	19.4	0.197	
TG x Nematodes	NS (158), Yes (244)	35.2	0.050	
TG x NutBase	1-5 (24), 6-30 (36), >30 (96)	41.5	<0.001	NS 246
TG x Sealing	Non Barrier (393), Barrier (9)	1.2	0.759	
TG x Applctn	Drip 64, Injection 217,Spray 27	29.1	0.357	NA 52, NS 31, hotgas 8
TG x Production Practice	Greenhouse(tunnel) 60, Open Field 342	2.4	0.788	
TG x SoilTyp	Clay 21, Loam 52, Sand 208	33.3	<0.001	NS 121

NS – Not specified; Not Available

Model for Treatment Group 1b

REML variance components analysis

Response variate:	LOG(Y1)
Fixed model:	Constant + TrlNo + TrtGrp1b
Number of units:	402 (29 units excluded due to zero weights or missing values)

Separate residual terms for each level of experiment factor: VarianceGrp

Sparse algorithm with AI optimisation

Residual model for each experiment

Experiment factor: VarianceGrp

Experiment	Term Factor	Model(order)	Parameter	Estimate	s.e.
RagBag	Residual	Identity	Variance	0.0262	0.0141
Daz	Residual	Identity	Variance	0.0564	0.0296
MB	Residual	Identity	Variance	0.0350	0.0134
MBPic	Residual	Identity	Variance	0.0146	0.0049
MI100	Residual	Identity	Variance	0.00775	0.00478
MIPic	Residual	Identity	Variance	0.00484	0.00350
MNa	Residual	Identity	Variance	0.108	0.036
MNaOther	Residual	Identity	Variance	0.0185	0.0058
NaN3	Residual	Identity	Variance	0.0762	0.0324
Nematicide	Residual	Identity	Variance	0.0264	0.0101
NoTr	Residual	Identity	Variance	0.398	0.080
Pic	Residual	Identity	Variance	0.00311	0.00272
PicEC	Residual	Identity	Variance	0.0141	0.0059
PicMNa	Residual	Identity	Variance	0.00556	0.00395
PicMNaOther	Residual	Identity	Variance	0.0106	0.0075
PicOther	Residual	Identity	Variance	0.00454	0.00292
PicTel	Residual	Identity	Variance	0.0130	0.0040
PicTelOther	Residual	Identity	Variance	0.0220	0.0058

Deviance: -2*Log-Likelihood

Deviance	d.f.
-529.21	266

Note: deviance omits constants which depend on fixed model fitted.

Wald tests for fixed effects

Sequentially adding terms to fixed model

Fixed term	Wald statistic	d.f.	Wald/d.f.	chi pr
TrlNo	85753.57	55	1559.16	<0.001
TrtGrp1b	266.01	62	4.29	<0.001

Dropping individual terms from full fixed model

Fixed term	Wald statistic	d.f.	Wald/d.f.	chi pr
TrtGrp1b	266.01	62	4.29	<0.001
TrlNo	33657.04	55	611.95	<0.001