



ENGINEERING SCIENCES

WMA: Wizard System Architecture for the execution of meta-analysis: A case study applied to verify the efficacy of fluquinconazole in the control of Asian soybean rust

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Abstract: Meta-analysis is a probabilistic technique that combines results from several studies that approach the same topic and produce a result that sums up the whole. In the agricultural field, it is used to make empirical estimates of efficiency for the development of productivity and economic research on agriculture. Meta-analysis can be applied through software such as R, which is executed through commands, and produces results without providing user interactivity, nor does it reproduce a friendly and easy-to-understand interface. This paper presents the creation of a computer system, the WMA, which aims to simplify the execution of meta-analysis, providing a graphical interface and improves the display of the results through an interactive visualization using the Hierarchical Information Visualization Technique Bifocal Tree. For validation, the meta-analysis was applied in the agricultural area in a case study that grouped studies that used the fungicide fluquinconazole to combat the soybean rust disease, the results obtained through the application of the meta-analysis were analyzed using the WMA proposed tool.

Key words: Bifocal Tree, Hierarchical Information Visualization Technique, Interactive Visualization, R Software.

INTRODUCTION

Meta-analysis (MA) combine and analyze the results of several experiments to better analyze the data. It is a popular practice in the medical, pharmaceutical, educational and marketing fields. The effective visualization of this data provides essential and better displayed information to researchers, improving their capacity to understand the problem and make decisions from the observed results (Arvanitis et al. 2000).

MA can be applied in a fixed or random effect model by using existing software, for example, R software (Sutton et al. 2000). R

software operates through command lines previously known by the user and displays its results by means of statistical graphs. It does not provide interactivity with the user, nor does it provide a user-friendly interface that is easy to understand and operate.

In order to obtain a visual exploratory analysis there are information visualization techniques which are applied to map the data in graphic form, aiming to broaden the user's understanding of the data (Thiam et al. 2001).

Considering the complexity to execute the calculation of the meta-analysis and to visualize their results, this study aimed to create an application, the WMA, that simplifies

the steps to perform a meta-analysis and improves the display of the results through an interactive visualization, using the hierarchical visualization information technique Bifocal Tree structure (Cava et al. 2002), allowing greater user interaction with the data and better exploration of the achieved results.

The WMA software architecture was developed with the objective of simplifying visual communication with the user, with graphical data input, performing an interface with the R software and displaying the results through an interactive visualization.

In order to validate the operation of the system proposed, the WMA meta-analysis was applied to an agriculture case study that grouped several studies, all of which used the fluquinconazole fungicide to combat Asian soybean rust disease and formed a database entitled "Fluquinconazole database". The meta-analysis was performed by WMA tool and the results were analyzed by using the proposed tool for information visualization technique.

BACKGROUND

Meta-analysis

The meta-analysis uses statistical techniques that combine and analyze the results of several studies of an area so as to obtain more specific, and sometimes even definitive, results (Patel 1989).

The most important prerequisite of meta-analysis is that the various individual studies approach the same research subject or one study that examines different aspects of a broader issue (Delahaye et al. 1991).

The quality of the statistical accuracy obtained from meta-analysis depends on the completeness of bibliographical research, i.e., it is proportional to the number of samples found. According to Delahaye et al. (1991), some steps

in the execution of the meta-analysis guarantee the best quality, they are: setting objectives, performing bibliographic research, collecting data from each study, evaluating the quality of each study group, grouping, performing sensory analysis, and concluding.

In order to combine the studies in a meta-analysis, it is necessary to determine the measure of effect (ME) and calculate it for each study. The choice of ME depends on the research matter, the type of the variable involved, and the number of comparing groups (Borenstein et al. 2009). Some of the most used measures of effect for the calculation of the meta-analysis are (Borenstein et al. 2009) standardized average difference, reason of risk, and correlation. The case study applied in this article uses the standardized mean difference effect measure.

To set the measure of effect, it is important to point out the presence or absence of heterogeneity between the studies classified (Ziegelmann 2013). Different studies may produce various estimates for the same measure of effect. This difference is called the heterogeneity and, the greater the distinction, the greater the heterogeneity. The two most common ways to explore the heterogeneity are the Cochran Q test (Cochran 1954) and I^2 of Higgins and Thompson (Higgins & Thompson 2002). After calculating heterogeneity between studies, it is necessary to choose the most appropriate model for the case study, fixed or random (Higgins et al. 2003).

The fixed model assumes that all studies included in the meta-analysis are from the same population of studies. The random effect model assumes the measure of effect may not be identical in all the studies; a given variability among them is acceptable (Ziegelmann 2013).

The random effect model can be calculated through various methods, such as DerSimonian & Laird (1986), Maximum Likelihood and Restricted Maximum Likelihood (REML) (Littell et

al. 2006), Hedges et al. (1999), Hunter & Schmidt (2004), and Sidik-Jonkman (Madden & Paul 2011).

Meta-analysis can be performed by using statistical software, such as Software R (Sutton et al. 2000).

R software

The R is a software set to a language and environment for statistical computing and graphics. It is a free software distributed under the GNU license (Hornik & Leish 2008).

There are various graphical methods to present statistical results obtained by the application of meta-analysis through R Software, traditionally, the most used are the forest plot graphs (Delahaye et al. 1991).

This is able to synthesize graphically the particularity of each study included in the meta-analysis and their respective results, expressed in a single picture (Delahaye et al. 1991).

The R Software produces the answers in textual and graphic form (Figure 1). The graphics are an integral part of the meta-analysis used to simplify visual communication, highlight important features and display statistical results (Langan et al. 2012). However, the available graphics are displayed to the user in a non-interactive form.

To perform the meta-analysis calculation in the R Software, pre-set commands are used;

these include loading the table, calculate the meta-analysis, load the necessary packages, and present the results. These commands vary according to the measure of effect adopted. The user must know them to arrive at the results of the meta-analysis. Figure 2 shows the commands required to load the *metafor* package (available package for meta-analysis in the R environment), table reading and meta-analysis calculation.

A user-friendly interface and interactive graphics allow the user to perform the calculation even if the required commands are not known, in a simple and effective manner.

Information visualization techniques

Information visualization techniques are used to simplify data analysis because excess information hampers the process of understanding. When using these techniques, it is possible to gather various datasets in a single image, allowing the user to get better information sight and better extract the details (Gershon & Eick 1997).

The visualization is set by mapping the process data and information in a graphical format to perform the visual representations. The scientific area is benefited by the computing power to transform the data in sophisticated visualizations, making the characteristics of the object of interest visible, since this class is based

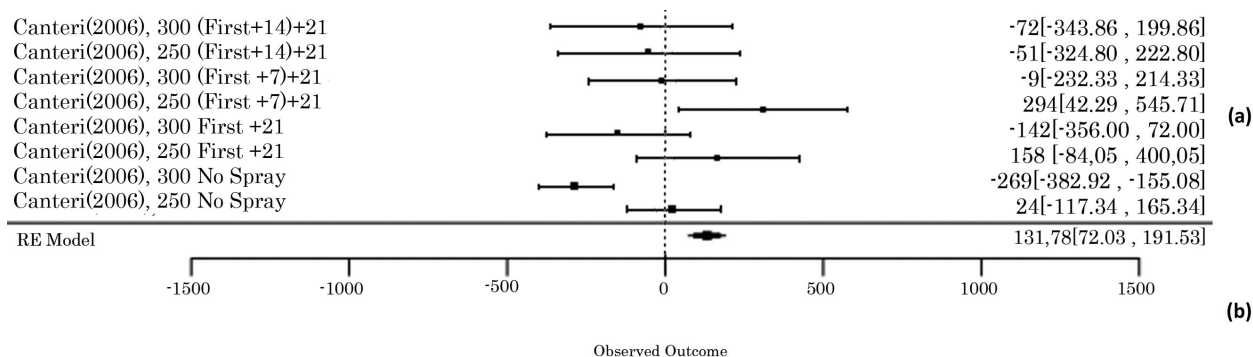


Figure 1. Forest Plot chart displaying the result generated by R Software of meta-analysis application on the use of fluquinconazole in the treatment of soybean seed.

```

> library(metafor)
Loading required package: Matrix
Loading 'metafor' package (version 2.1-0). For an overview
and introduction to the package please type: help(metafor).
> data <- read.table("C:/without.txt", header=T)
> data2<-escalc(measure="COR", ri=r, ni=n, data=data)

```

Figure 2. Commands to perform Meta-Analysis in R Software.

on data supplied by the natural phenomena of the physical world (Card 1999).

Using the visualization techniques in statistical algorithms is an important task to ensure that the research published can give the user a more comprehensive vision (Vaz & Carvalho 2004).

In the context of this work, the hierarchical information visualization techniques will be applied to improve the representation of meta-analytic data. The results of the meta-analysis depend on the number of studies included in the analysis and the results of each study particularly depend on several experiments. Moreover, much of the information present in a domain follows a hierarchical organization, such as administrative organizations, family trees, disk directories, and site address, among others.

Hierarchical information visualization techniques

Given the difficulty in understanding certain hierarchies with numerous elements, visualization techniques assist the user in the cognitive process (Guerra-Gómez & Pack 2015).

Hierarchical information visualization is the technique whose domain data structure are arranged in trees and the type of information is hierarchical.

To improve the graphical representation of the *Forest Plot*, the technical characteristics of data to be presented were analyzed. The analyzed characteristics, described in Gusmão et al. (2016), were:

- **Domain:** domain on relational elements, where each study can have several experiments, i.e. a relationship exists between parent and child node.
- **Data Type:** Alphanumeric, the elements of the data structure are represented by names, not numbers.
- **Nature of the Domain:** Discrete, the elements must be arranged in the graph from their statistical values.
- **Domain Dimension:** 3D, the dimension of the domain is shown by the estimate of the effect, precision of the effect and the name of the experiment.
- **Supported Capability:** CS1 (maximum capability = 200), the capacity required to represent the 64 experiments.

From a study of the 18 information visualization techniques, Gusmão et al. (2016) developed a method to identify the best technique to represent a hierarchical data structure. With this method, it was possible to identify the visualization information technique Bifocal Tree as ideal for graphical representation of this work.

This technique consists of an interactive data structure of a tree where there is a parent node (or root) from which nodes (children) depart and from these leave more nodes. The nodes are visually represented by graphic forms; colors are used to tell the different types of nodes apart. The Bifocal Tree is divided into two subdiagrams: the detail area, which aims to show in detail the sub-tree, whose node was selected by the user, and the context area, which

provides an overview of the whole data structure (Cava et al. 2002).

To find the ideal software to apply the Bifocal Tree technique of displaying the results of the meta-analysis a web search was conducted and the Gephi software was selected to apply the visualization of meta-analytic results.

Related works

A comparison between the related works of this research was carried out. Table I lists the characteristics used in this process.

The graphical methods, presented in Langan et al. (2012) and Shah & Andrade (2015) offer a graphical alternative to improve the presentation and interpretation of the results offered by the funnel plot and forest plot graphs, respectively. Works included in Table I present a Static Data Analysis obtained by the research through static data offered by the traditional plot (forest and funnel plot) using the respective softwares: R, STATA, MetaWin and Review Manager.

There are few studies that apply meta-analysis in agriculture. Rosemberg et al. (2004) applied the meta-analysis to establish the relationship between the severity of foliar diseases of the wheat and the loss of crop yield crop. Challinor et al. (2014) conducted a study that performed a meta-analysis to show the yield of crops under climate change and adaptation but did not specify the software used.

Meta-analysis can also applied to other areas. In medicine, for example, Madeira et al. (2016) conducted a study that estimates the accuracy of ovarian cancer detection. Rosa et al. (2015) verified the effectiveness of the use of substances for the treatment of herpes labialis. These works used the static graphs funnel and forest plot respectively for analysis.

Polanin et al. (2016) reviewed 63 packages available in Software R to perform the meta-analysis, through a comprehensive online survey.

Table I. Characteristics of related work.

Author	Characteristics		
	Graphical Methods	Static Data Analysis	Used Software
Langan et al. (2012)	YES	YES	R and STATA
Shah & Andrade (2015)	YES	YES	R
Rosemberg et al. (2004)	NO	YES	MetaWin
Polanin et al. (2016)	NO	YES	R
Madeira et al. (2016)	NO	YES	STATA
Rosa et al. (2015)	NO	YES	Review Manager
Challinor et al. (2014)	NO	YES	--

This work showed that there was a significant growth in the creation of packages in the last years due to the increase of the meta-analysis studies. The authors performed a tutorial on two of the packages described, *MAVIS* and *RcmdrPlugin.MA*, that features GUI (graphical user interface). The tutorial only displays static tabular results. The authors point out that it is necessary to improve the ease of use of the graphical functions of the meta-analysis, since the available graphs can be difficult for the users. Also, to create a software with user-friendly GUIs could simplify the process in relation to the lines of code, which require prior knowledge and makes it expensive for some researchers.

According to Borenstein et al. (2009), there are three types of software that can be used to perform the meta-analysis. The first option is to use a spreadsheet such as Microsoft Excel, the second is to use general purpose statistical packages such as SPSS, SAS, R or Stata. The third

option is to use a program developed specifically for meta-analysis. For both, the following steps should be used: (i) selection of primary studies on the subject of interest; (ii) definition of the measure of effect for each primary study, i.e., the common outcome of the studies to be evaluated; (iii) combining, by means of statistical models, all primary studies in an overall measure of effect; (iv) evaluation of residual heterogeneity and; (v) Identification of moderating variables.

It is observed that none of the works is concerned with the visualization of the data in an interactive way and this makes it difficult to compare the studies contained in the meta-analysis.

The software used in previous works is not user-friendly, which makes it difficult to compare and interpret the results.

WMA architecture

From the difficulties encountered to perform the meta-analysis and visualization of results in the R Software, the meta-analysis assistant system, WMA, was conceived with the aim to offer a more user-friendly interface for the execution of steps to perform the meta-analysis and present the results interactively, improving the analysis of the results obtained.

Figure 3 shows a comparison between steps to perform the meta-analysis found in the literature (Borenstein et al. 2009), in the WMA, and in the R Software (Hornik & Leish 2008).

Compared to the R, the WMA has the same steps in the process of meta-analysis, however, the first run through command lines and the second through a graphic interface. The meta-analysis performed by the WMA software is based on the literature (Borenstein et al. 2009).

Figure 4 shows the high-level architecture of WMA Software divided into five layers:

- **Client Tier:** In this layer, the stakeholders are identified to manipulate the system, showing that the users of the software are heterogeneous. Researchers, technical professionals from different areas and diverse users are able to use the system by applying the meta-analysis in their respective area.
- **Data Storage:** This layer is the database, created by the user from the compilation of studies and experiments and inserted by it into to perform the meta-analysis. The database should be in .csv format.
- **Web Tier:** This layer contains a web help system that the user if deemed necessary, can access for assistance in using the WMA Software. At each step for the performing of the meta-analysis web system has a specific page detailing its operation.
- **Logic Tier:** This layer contains the logic execution of the proposed WMA Software. The system loads the database entered by the user, reads the information, interfaces with the R Software for processing the statistical calculations required for the

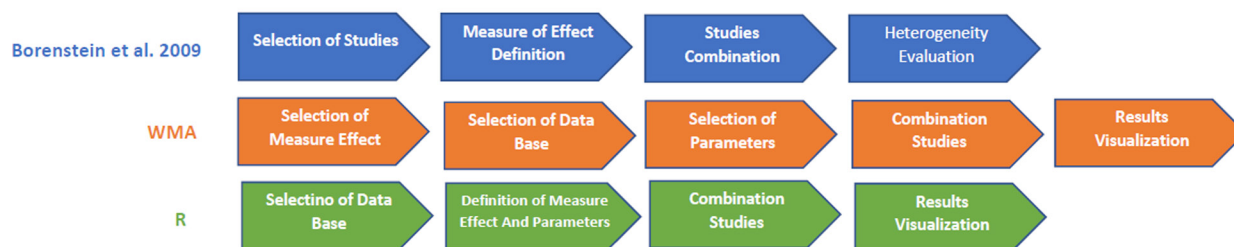


Figure 3. Comparison of processes to perform the meta-analysis.

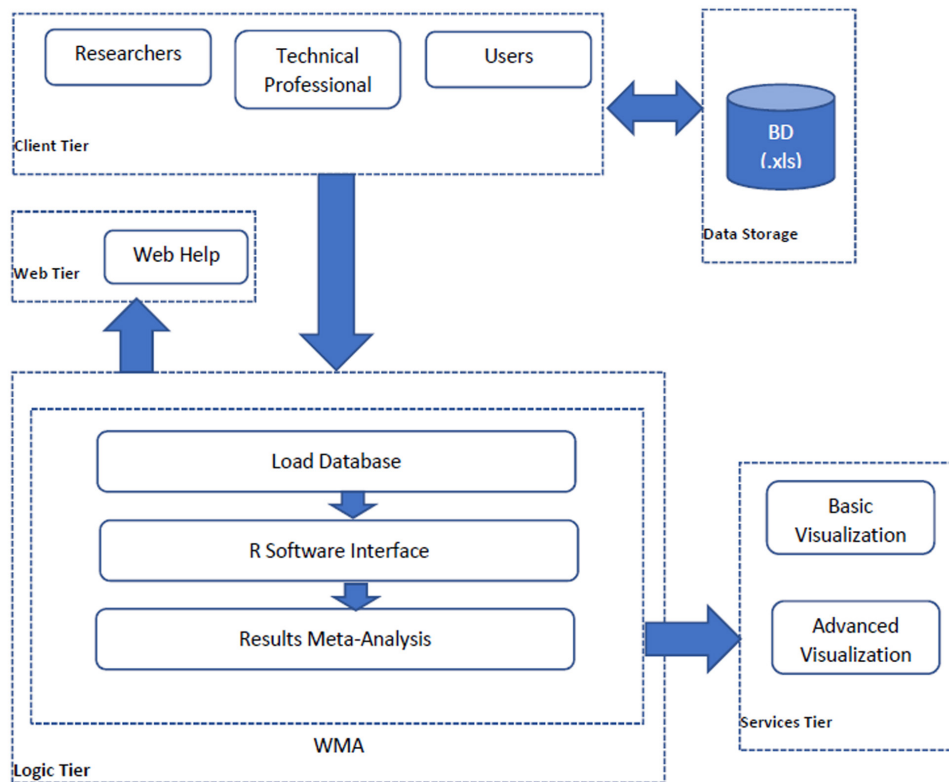


Figure 4. High-level architecture of WMA.

meta-analysis automatically selects the ideal model (fixed or random) for the case study which is being executed by the system and, finally, obtains the results of R.

- **Services Tier:** This layer contains the visualization service, proposed to improve the display of results obtained by R. Basic visualization is displayed by the browser and allows user interaction with the graph. Advanced visualization is loaded into the Gephi Software and allows greater manipulation of the user, and can perform a more specific analysis of the data, alternating between the statistical attributes presented and also provides the layout change of the graph.

WMA is composed of ten packages that represent its operation, as shown in Figure 5. The relationship between the packages is given by a dotted line that shows the dependency

between them, where the arrow always points in the dependent package.

The software architecture was developed to allow the implemented software to be able to perform the calculation of meta-analysis for each measure effect through an interface with Software R, indicate which effect model, fixed or random, is ideal for displaying the result and improve the graphics result by means of the implemented bifocal tree technique.

The package *br.com.wma.Quantitative VariableAssociation* has four files that allocate the variables that are necessary for the calculation of the meta-analysis of each measure of effect. The *br.com.wma.Parameters* package has two files developed to send the parameter to the R that is required for the calculation of the meta-analysis.

The package *br.com.wma.Components* has five files implemented to generate the .xls excel table, which displays the results of the

meta-analysis. The *br.com.wma.Integration* package has three files implemented to create the script file, connects to the R and returns the result to the WMA.

The package *br.com.wma.Script* has five files that are responsible for creating the content of script of each effect measure, which is executed later in R. The package *br.com.wma.script.Result* has three files that calculate the results of the meta-analysis and verifies which effect model, fixed or random, is ideal for displaying the result.

The package *br.com.wma.Screen* has seven files that are responsible for displaying the software interface. The package *br.com.wma.Utils* has three files that are developed to manage the table where the database is loaded. The package resources. Help has six files that were implemented to compose the web help system to support the user. The *resources. Help* package has only one file that was developed to edit the web help system interface.

The package *br.com.wma.Gephi* has only one file that was developed to create the graphic with the implemented bifocal tree technique.

Case study

Perform the Meta-analysis to verify the efficacy of fluquinconazole

To perform the meta-analysis, some steps defined by Delahaye et al. (1991) were applied in the bibliographic research for the collection of data for this work to assure the quality of the statistical accuracy.

From these determined steps, the data were collected, and a database was created (titled the "Fluquinconazole database").

In total, 12 studies were collected, with 64 experiments. The data collected from each study are allocated in a spreadsheet, thus forming the database Fluquinconazole.

Table II shows the Fluquinconazole database populated with the data from the study obtained by Canteri (2006) in his eight experiments.

The Study field is filled out with the name of each selected studies on bibliographical research, along with the name of the test carried out by the study. The Experiment field refers to experiments carried out for that study, each one appointed in order to differentiate them from each other.

The Measure of Effect (ME) is the result of the productivity rate obtained between the difference of a result of treatment (*Res Trat*), without the use of the fluquinconazole, and the result of the witness (*Res Test*), which used the fluquinconazole in the treatment of soybean seed.

The variance is a measure of statistical dispersion used in statistics indicating "how far" the values are from the expected value.

These four attributes populated in the table are mandatory to perform the calculation of the meta-analysis with the measure of effect adopted for this work (standardized mean difference). In addition, we collected other statistical attributes, which are not mandatory;

Table II. Fluquinconazole database for experiments carried out by Canteri's studies (2006).

Study	Experiment	ME	Variance
Canteri (2006)	300 (Beggining+14)+21	-72	192397.46
Canteri (2006)	250 (Beggining +14)+21	-51	195153.66
Canteri (2006)	300 (Beggining +7)+21	-9	129835.7
Canteri (2006)	250 (Beggining +7)+21	294	164931.65
Canteri (2006)	300 Beggining +21	-142	119216.51
Canteri (2006)	250 Beggining +21	158	152521.44
Canteri (2006)	300 SemPulv	-269	33783.72
Canteri (2006)	250 SemPulv	24	52005.69

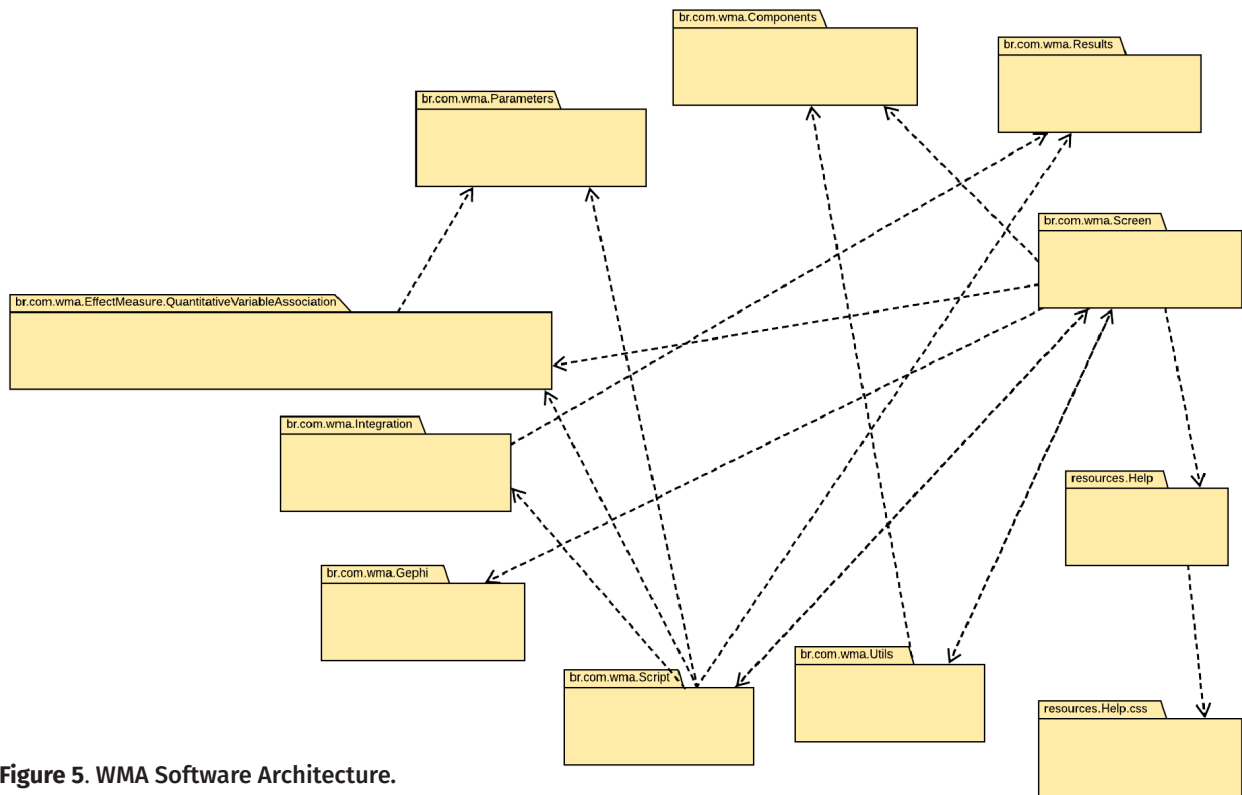


Figure 5. WMA Software Architecture.

however, they can be plotted on the graphic to improve the data analysis. They are the result of the treatment, result of the witness, standard deviation, standard error, number of sprays, and coefficient of variation. With the database ready, data can be compiled to obtain the results of the meta-analysis.

Figure 1 shows the forest plot chart displaying the results obtained through the application of meta-analysis in the R Software with the Fluquinconazole database. In Figure 1a, only the 8 study experiments of Canteri are displayed (2006) because displaying all 64 experiments would be unreadable in one image. Figure 1b shows the result of the meta-analysis of 64 experiments.

Meta-analysis in the WMA

With the purpose of being a practical and interactive tool with the user, the WMA was

developed using the techniques of an assistant software, which follows some steps to carry out the task and also has a help web system.

To perform the meta-analysis through WMA, the following steps must be completed:

- Choice of measure effect
- Selection of the database
- Specify database attributes

After going through all the steps, the software performs the calculation of the meta-analysis. The statistical model (fixed or random effect) is automatically selected by WMA, or the user has the can choose which to use. The system then displays the results in a textual, tabulated way, and also through the standard graphics of R Software (Figure 6).

The software displays the results of the meta-analysis and allows the user to export them to a .xls file. Moreover, four exploratory

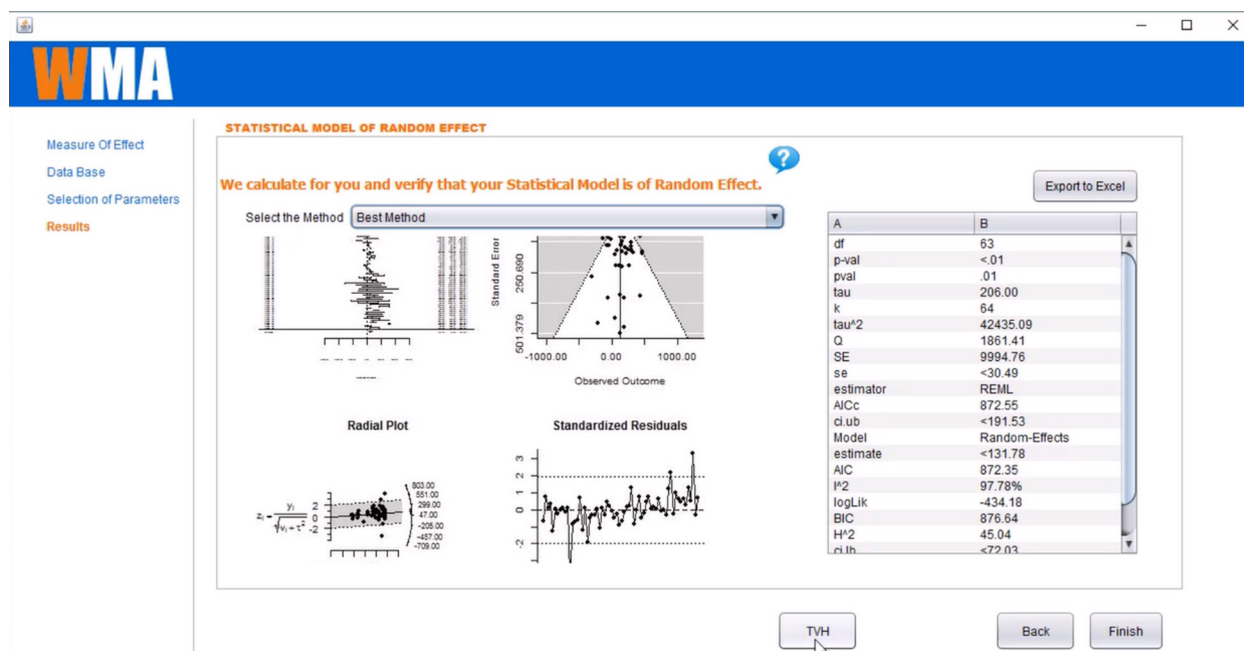


Figure 6. Displaying the results of the meta-analysis through the WMA software.

diagrams of the meta-analysis are displayed. These four diagrams together in the same image are barely visible and blurry, making the user explore the results obtained. Therefore, there is the need to improve the display of results and create an environment of better interaction and data analysis.

To get the results shown by Figure 6 the effect measure chosen was the standardized mean difference because the case study adopts the Fluquinconazole database and it uses the difference between the result of productivity of a culture with the use of fluquinconazole in the treatment of soybean seed and the result of productivity without the use of it.

The fluquinconazole database was loaded, in the next step its attributes were set and the System performed the calculation of the meta-analysis. In this case study, the statistical model (fixed or random effect) was automatically selected by the software, and WMA indicated that the random effect model is ideal.

Application of bifocal tree in WMA

The bifocal tree technique was applied to the problem of the meta-analysis and attached to the WMA software. The technique is displayed in two ways: basic and advanced visualization.

The two ways of visualization were proposed aiming at the use of the software. Advanced visualization was created for more experienced users, who have an aptitude for computing systems since this provides the user with more options to change the layout of the information generated by the dynamism of the graphic. The basic visualization displays the results in a more simplified way for users with little computer experience.

Basic visualization

The basic visualization is displayed in Firefox and Windows Explorer browsers because the used library *gexf-js* supports only these two types. This visualization was proposed for users who do not have technical knowledge of the software. Figure 7 shows the initial part of the

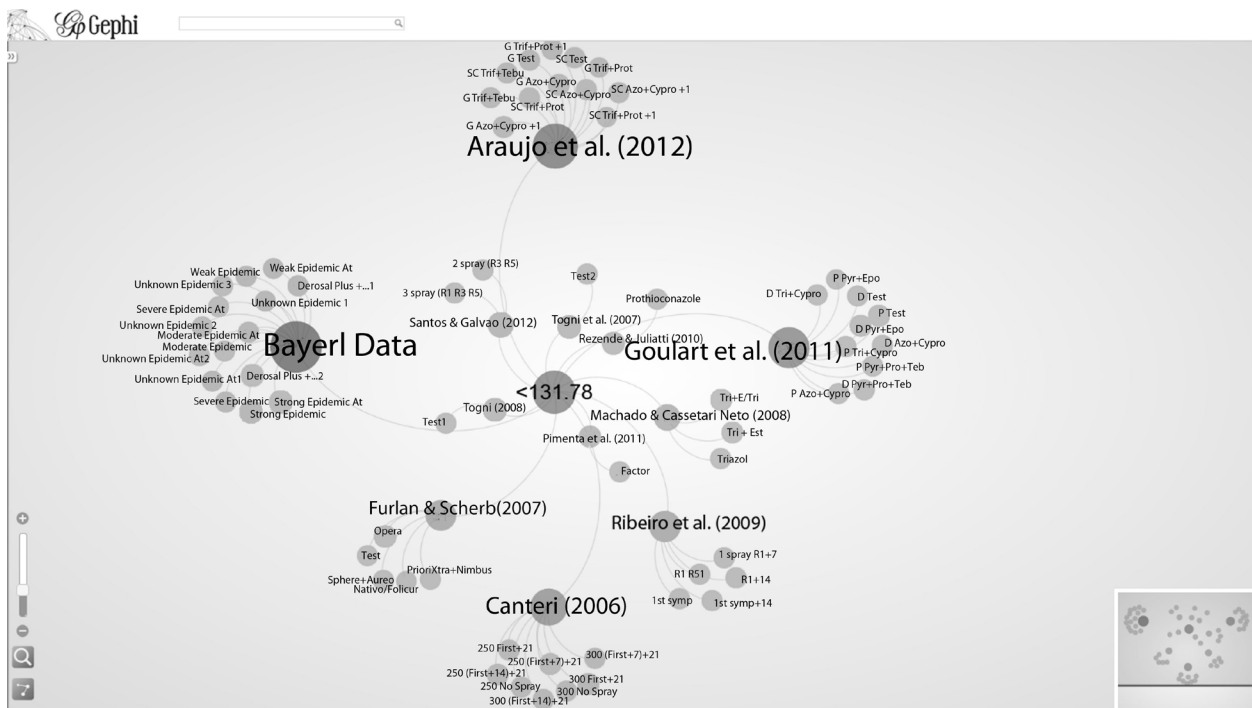


Figure 7. The initial part of the basic visualization of bifocal tree technique.

basic visualization of bifocal tree technique applied.

There is a search field that allows the user to get the desired node, it is not necessary to find it directly on the graphic, making the search easier especially when the quantity of experiments is huge. At the bottom right there is also a context area, which provides an overview of the graphic. At the center of the graphic is the node that represents the meta-analytic result (131.8). The neighboring nodes represent each study included in the meta-analysis and their child nodes are the experiments that each study performed. The area in which the nodes are displayed is known as the detail area.

The colors and size shown on the graphic represent the degree of completeness in the bibliographic meta-analysis. The bluer and bigger the node, more experiments the study performed, therefore, its result is more reliable and not biased.

When the chart is in zoom mode (available for the user on the lower left corner of the graphic), the context area will display a red rectangle showing the location of the node in the graph.

To analyze the results of each experiment, the graph shows the statistical data of the selected experiment, allowing greater visual exploration of the information resulting from the meta-analysis. Figure 8b shows the display of the attributes of the selected *250 Início + 21* experiment that is inserted into the study Canteri (2006). Figure 8a shows the experiments from the same study with the respective estimate of effect and variance. To include more attributes, the user must enter the code in the program console.

In addition to the attributes contained in the database, Figure 8b displays other statistics calculated by the R Software through the `Cumul()`, they are: estimate, if, pvals, ci.lb, zval, ci.ub, QE, QEp, Tau2, I^2 , and H^2 .

The forest plot (Figure 8b) is displayed in summary form because it is unreadable when plotting the 64 experiments. In WMA Software this issue is resolved because the system has zoom, so that the user can browse the entire graph interactively

Only the graph and its attributes could be shown in the basic visualization. To increase interactivity and allow further graphic exploration, the advanced visualization must be used.

Advanced visualization

The Advanced visualization is displayed directly by Gephi 0.8.2 Software (Bastian et al. 2009) so that the user can work interactively with the graphics and better exploit the results.

From this visualization, the software offers the user several options to work interactively with the graphic, for example:

- Display labels of all nodes, allowing the user to view the name of all experiments;
- Display only the labels of the selected nodes and/or neighbors nodes, focusing on the visualization of significant experiments;
- Display the unselected nodes in the background, decreasing the number of information not relevant to the user;
- Change colors: background, nodes, edges, and labels, improving the graphical interface of the information;
- Zoom, helps the user to visualize relevant information when the number of experiments is large;
- Change the font of the labels, improving the accessibility of the graph;
- Display one or more attributes for each node, displaying significant statistical information to the user;
- Change the layout of the graphic through the eleven available algorithms;

- Export the graphics file formats: pdf, .png and .svg.
- Export the graphic in graph formats: .csv, .dl, .gdf, .gexf, .gml, .graphml, .net and .vna

Besides, using advanced visualization is possible to perform an analysis of the data with all the attributes and statistical data that the graphics features.

In order to perform the analysis of the data in the graph, it is necessary to use the tab Filters -Attributes. Filter options can be used for one or more attributes simultaneously. Figure 9 shows an example of a filter that selects only the positive range of the estimate of effect attribute, that is, the graphic is displaying only the experiments that have obtained an increase in the rate of productivity using fluquinconazole in the treatment of rust.

Besides displaying the attributes that have a positive productivity rate, the graphic displays beside each label its respective productivity rate. Besides obtaining the analysis of the data by filtering the attributes, you can also work with the classification of data, using colors and sizes of labels to identify the attributes. Using the same example shown in Figure 9, the classification of data was performed through the estimate of effect attribute. Figure 10 shows the graph result obtained.

This classification was performed using the size and color of the node to tell apart the values of the attributes. The highest was the productivity rate (estimate of effect), its color tends to blue and the node size is larger, as well as, the smaller the value, the smaller the size of the node and its color will tend toward red. This example shows that the user can detect the experiments that have positive values in relation to the selected attribute. The meta-analysis of the case study of this article is available in WMA Video - Supplementary Material.

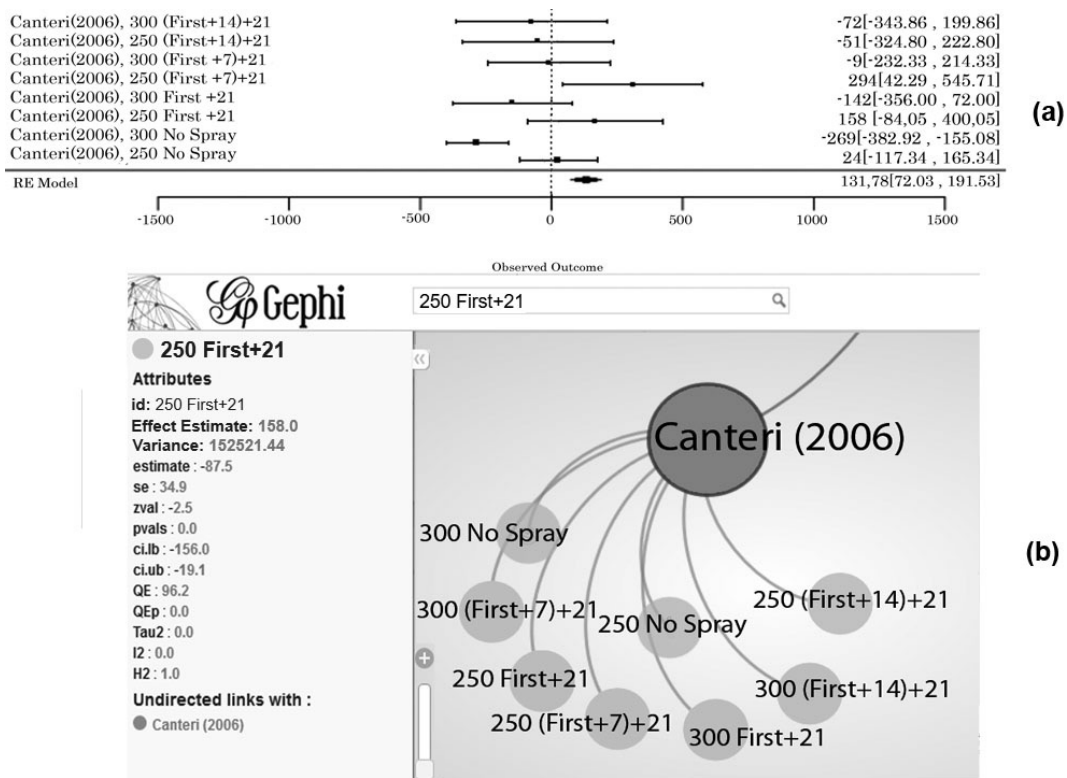


Figure 8. Displaying two attributes of the Canteri (2006) study experiments by the Forest Plot(7A). Displaying several attributes of an experiment from the Canteri (2006) study(7B) by the WMA Software.

RESULTS ANALYSIS

The modeling of an assistant software together with a help system formed by a series of steps required to perform the meta-analysis helps to minimize usability problems, has a user-friendly interface and show interactive results.

In this visualization, it is possible to see which experiments have values closer to the result made by the compilation of studies, resulting in the meta-analysis (central node). This perception can be made both by the color and the size of the node.

The nodes that are represented by the yellow colors on the graphic have no estimate of effect value because they are the nodes that represent the studies (studies have experiments; therefore, the experiments have estimates performed by the study).

In the example above (Figures 9 and 10), we used the Estimate of Effect attribute, however, the analysis of the data performed by both the filtering of the attributes and classification of the data can be explored in all attributes the nodes experiments contain (Shown in Figure 8).

The central node of the meta-analysis obtained an estimated value of 131.8 (Represented by number in Figure 7), i.e. with the compilation of the meta-analysis, through the studies, it is possible to see that the use of the soya seed fluquinconazole provides an increase of 131.8 Kg/ha in the productivity rate of the soybeans.

In this way, the user, for example, a producer or agronomist engineer, can make a decision on the use or not of the fungicide in their culture, depending on the resources needed to apply it and the benefit provided by the use.

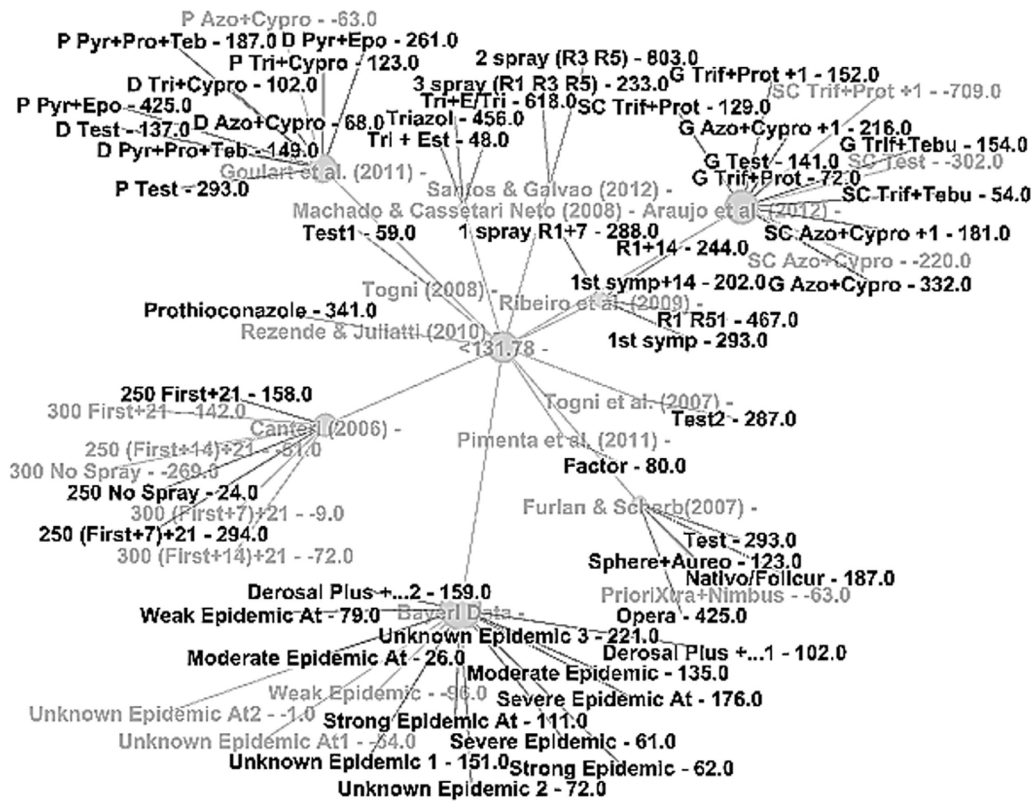


Figure 9. The estimate of effect attribute filtering.

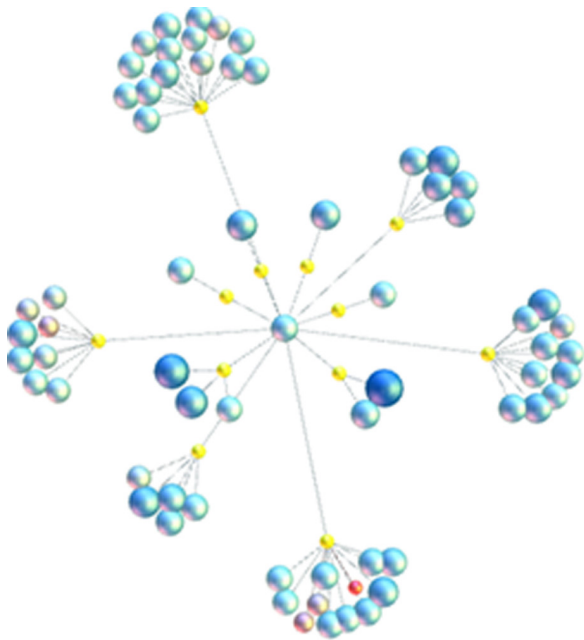


Figure 10. Classification of data through the estimate of effect attribute.

CONCLUSION

The design of an assistant software along with a help system composed of a set of steps required to perform the meta-analysis contributes to minimizing the problems of usability, detected by the R Software and, by including the hierarchical information visualization technique, the bifocal tree, it increases the possibility of using the results.

With the results displayed through the bifocal tree, it was possible to analyze and conclude that the rate of productivity of soybean by using of the fluquinconazole, to minimize the effects of rust had a gain of 131.8 Kg/ha. The perception of the results can be noticed by either the size or the color of the nodes, and the numeric representation.

In this way, the user, for example, a producer or agronomic engineer, can make better

decisions by using, or not, the fungicide on their culture in the light of the resources needed to apply it and the benefit provided by the use.

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SUPPLEMENTARY MATERIAL

WMA Video

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