

## SCENARIO

With your major in food science, you were delighted to find work with Sheffield Farms, a medium-sized supermarket chain in the Middle West. Your first assignment was to a small group that studies consumer food preferences and habits. The group leader is Shirley Gomez. One of your tasks was to research the readability of the new food labels required by the Food and Drug Administration.

You had sought volunteers among people shopping in Sheffield Farm stores. You had provided them labels to read and then questioned them on their understanding of the information on the label. To a high degree they understood the information provided about fat, cholesterol, fiber, protein, and so forth. But as you were conducting your research, you wondered how many Sheffield Farms customers actually made decisions based on the labels.

You brought the idea up to Shirley. “Good thought,” she said. “How would you go about it?”

“I can think of three ways,” you said. “Observation for one. Simply watch to see how many people read a food label when they take food off a shelf. Another would be to ask people at checkout how often they read food labels. Third, we could take some common purchase like cereal out of customers’ baskets, and without showing them the food label, try to find out how much of the information on the label they’re actually aware of.”

“Has anyone done this?” Shirley asked.

“My preliminary search in the journals and on the Web hasn’t turned up anything like what I’m proposing,” you said. “There has been a lot of focus group research about readability and decision making based on the labels, but I found nothing that checked their actual use by ordinary consumers. In any case, we haven’t done anything like this with Sheffield customers. If we find that most our customers really don’t use the labels, we might want to start an awareness program of some sort.”

“Well, check the lit some more,” Shirley said. “If you find the research you propose hasn’t been done, you might have a journal article. In any case, the research report could be useful for us in-house,” As an afterthought, she added, “Check your methodology with me before you begin, though. You can’t be too intrusive, or you’ll annoy our customers. Maybe you can offer people some small reward for answering your questions.”

And so empirical research reports are born. Someone sees a need for the research and checks the literature carefully to see if it really needs to be done. If the need is perceived, the methodology for carrying out the research is planned

and executed. When the results are in and analyzed, it's time to write the report, what this chapter is all about.

## Chapter 15

### Developing Empirical Research Reports

➤ Major Sections of Empirical Research Reports

- Abstract
- Introduction and Literature Review
- Materials and Methods
- Results
- Conclusion
- Acknowledgements and References

➤ Other Examples for Analysis and Comparison

As a student and later as a specialist, you may need to design some device; test some idea, mechanism, product, or process; perform an experiment; and then report your findings. This kind of analytical report is called an empirical research report because it explores a solution to a problem based on extant knowledge, proposes a new solution or process based on what is known and not known, justifies the reasons for this proposed solution or process, tests that solution, and then concludes whether or not the solution is viable. Many scientific journals are basically collections of empirical research reports targeted to specific specialists in the discipline targeted by the journal. Many research organizations test their products and then report the results in studies archived on the company's web site. Readers of research reports will be interested in the kinds of research reported, but the presentation must allow rapid reading and unencumbered access to methods, data, and results. Specialists working on a question related to the topic covered in an empirical research report will want to know that your research procedure is valid; your hypothesis and rationale, logical; and your analysis of your findings, accurate. They will read the reports that interest them carefully, critically, and evaluatively. These readers may want replicate your findings and then use your results to further their own research.

Examples of empirical research reports:

- A report on research conducted by a bioengineering student who was attempting to design a monitor for use with infants who may be prone to Sudden Infant Death Syndrome. Like many research reports, this one reports the progress of the research

to the point at which the report had to be submitted. Thus, its conclusions are not definitive, but they suggest what needs to be done to pursue this research further.

- A report to determine the effectiveness of a weed killer on different kinds of vegetable crops. The conclusions suggest which chemical controls can be used to eradicate/reduce weeds without harming the quality or safety of the vegetable or food crop.
- A report on the ease of use of online voting software and the effectiveness of the software to minimize voting errors.
- A report on the use of dried blood spots from HIV-positive patients as a means of determining subtype.

Empirical research reports, like any other type of technical writing, should be designed for the intended audience(s) who will need to read the report. The level of language used and the specificity of the research will depend on the target readers. While journals that publish research reports almost always have their own required format, research reports nevertheless have similar elements.

How each is developed and where it is placed will depend on the topic, the intended readers, the preferences of the publication in which the report will appear, and the purpose of the report. To illustrate the development of the empirical research report, we will focus on the development of sections of three research reports. We also provide several additional empirical research reports at <http://www.oup-usa.org/sc/0195146123> (Select Chapter 15) that exemplify effective use of style, visual presentation (to report data), or effective review of extant research, presentation of materials and methods, and/or discussion of results. Note that the length of each report varies, depending on the complexity of the project. Keep in mind that the empirical research report needs to be easy for your audience to follow and comprehend. Clear, direct style is another important element.

## **Major Sections of Empirical Research Reports**

Nearly all empirical research reports contain the following content sections, which can be combined or appear as self-identified headings.

### **Abstract (Summary)**

The following components may be combined or appear as separately:

- Introduction—statement of problem, importance of problem,
- Literature Review—What is known about the topic, summary of relevant research with parenthetical citations,
- Purpose of the current empirical research report

Materials and Methods used in this research project

Results of the research

Discussion of Results

Conclusion/Recommendation

References

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## Abstract

In the empirical research report, the abstract is perhaps the most important section. Abstracting services often capture and sell abstracts to researchers in various disciplinary areas. Readers who subscribe to these services may often read only the abstract to an empirical research report. Thus, the purpose and results of the study must be clearly and concisely stated. The following abstract exemplifies an effectively-written abstract that can be understood apart from the entire empirical report. We will color code the parts of the abstract we highlight. Note that the abstract begins with the **project purpose**, then **focuses on the specifics of the methods used in the project**, and **concludes with the results**. The writers combine active and passive voice, use moderate sentence length, and define the ingredients of the chemicals they are testing. They alert readers to the shift from procedure to results by using “**results**” as the subject of each sentence that announces the findings:

**Abstract.** This research evaluated the efficacy of using a chemical barrier applied to the soil area under stacked bales of hay to prevent the red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), from infesting stacked hay. Specifically, we were interested in determining if we could protect “clean” hay bales stored in fire ant infested fields for up to several weeks. Chemicals selected as barrier treatments were Lorsban® 4E, active ingredient chlorpyrifos, which kills ants on contact, and Astro™ Insecticide, active ingredient the pyrethroid permethrin, which can also act as a repellent to ants. We established a series of 12ft x 12ft plots, with a 10ft buffer between plots along a fence row in a fire ant infested field. Plots were grouped into four blocks of three stacks each. Plots within blocks were randomly assigned to each treatment (four plots treated with Lorsban® 4E and four treated with Astro™ Insecticide, and four control plots). Treatments included spraying a 12ftx12ft soil area with a 1-gal solution of each chemical and water formulation. After soil treatments, we placed four square-bales of hay, stacked two a side and interlocking in two layers, in the center of each plot. Stacked bales were sampled for fire ant infestation using 2.5 x 2.5cm olive oil –soaked index cards; one bait card was placed on each side of the top

**layer of hay in each stack.** Results from ANOVA show a significant difference in mean infestation levels among treatments. Stacks of hay sitting in the chlorpyrifos plots had fewer ant infestations compared to the permethrin and control plots. Results after one week showed that only one stack in the permethrin, and two in the control plots were infested with ants, while none in the chlorpyrifos plots were infested. Results show that after three weeks all four control stacks, three stacks in the permethrin treatment, and two stacks in the chlorpyrifos plots were infested. These results indicate that on a short-term basis, such as 1 to 7 days, chlorpyrifos may be an effective short-term treatment option for protecting stacked hay from fire ant infestations.

Ronald D. Weeks, Jr., Michael E. Heimer, and Bastiaan M. Drees , Chemical (Chlorpyrifos And Permethrin) Treatments Around Stacked Bales Of Hay To Prevent Fire Ant Infestations, Texas Imported Fire Ant Research & Management Project, Red Imported Fire Ant Management Applied Research And Demonstration Reports, 2000-2002, Texas Cooperative Extension Service. <http://fireant.tamu.edu/research/arr/year/00-02/2000-2002ResDemHbk.htm#stackedbales>

The complete report can be found on the RTI website. Select empirical research reports.

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## **Introduction and Literature Review**

Like all introductions, the an empirical research report introduction gives the subject, scope, significance, and objectives of the research. The first example incorporates all of these features in three concise paragraphs within the introduction. The literature review explains what is known about the problem, as this knowledge has been reported in relevant published articles and reports. The introduction and literature review may be placed in one section or separate sections, depending on the complexity and length of the literature review. The literature review should support the objectives of the research: why the research is needed, what gap this research will fill in resolving the problem discussed in the report subject.

This first complete empirical report we discuss in this chapter, shows the value of the abstract (or summary) and its relationship to the introduction. Note that a boldface heading introduces the problem statement;. the research objective, with a second heading. The **summary**, **problem statement**, and **objective** provide a clear view of the intent of the report. Note that in this example report, the writer uses the literature review to justify a choice of methods selected for conducting the research.

The Summary begins with a **rationale** for the research topic, moves to the **description of the research conducted**, and **concludes with the results**.

## Evaluation Of Citrex® Fire Ant Killer As A Drench Treatment For Red Imported Fire Ant Mounds

**Summary.** The red imported fire ant, *Solenopsis invicta* Buren, (herein referred to as the fire ant) has become an important economic threat in urban Texas. The fire ant affects recreational activities as well as agricultural operations. This trial evaluated a product that contains a botanically derived insecticide, d-limonene, as a single mound treatment fire ant mounds, at lower-than-labelled rates, on the premises of the Johnson Space Center (JSC) of the National Aeronautics & Space Administration (NASA) in Houston, TX. The data indicates that Citrex® at the 3, 4 and 5 oz/gal rate, when compared to the untreated check, reduced mound activity within 3 days after treatment (DAT). This reduction was still evident 14 (DAT), with the 4 and 5 oz/gal rates having fewer active mounds than the 3 oz/gal rate. This trial was applied April 27, 2001 when temperatures were moderate, moisture was good and fire ant activity was good. This trial demonstrates that the 4 and 5 oz/gal rates are effective in reducing fire ant mound activity as single mound treatments.

The problem statement expands on the economic rationale for the experiment—the damage caused by fire ants, the costs of various treatments, which become significant because of the size of the fire ant problem, and issues surrounding the use of various treatment. In this report, the “literature review” is actually a review of results of various chemicals used to control fire ants. Thus, the problem statement is combined with a description of effects of chemicals used to deal with fire ants:

**Problem.** The red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: ormicidae), has become an important economic threat in urban Texas. According to a 1998 study conducted by the Department of Agricultural Economics, TX A&M University, of fire ant related costs in Dallas, Fort Worth, Austin, San Antonio, and Houston, fire ants have serious economic effects for these metro areas of Texas. Households experienced the largest costs among sectors examined with a average of \$151 per households spent annually which included repairs to property and equipment, first-aid, pesticides, baits, and professional services. A full damage assessment for Texas, including additional sectors, is estimated at over \$1.2 billion per year. Treatment costs accounted for over 50% of the total cost of \$581 million in the five major metroplex areas (Dallas, Fort Worth, Houston, Austin and San Antonio). In Houston, the average medical treatment costs per household of \$25.46. The fire ant limits outdoor activities and homeowners and producers incur added costs in managing the fire ant. Citrex® Fire Ant Killer, containing 78.20% d-limonene (an extract from oil from citrus peels) plus an emulsifier inert ingredient (Surfonic N-95), by Envirosafe Laboratories was introduced in August 1999. This product is considered to be an

"organic" treatment. In 2000, the label rate was 8 fl oz per gal water. At \$15.49/32 fl oz (2002 price), the per mound treatment cost using 8 fl oz/1 gal per mound, the per mound treatment cost was \$3.87. Furthermore, treatments were observed to cause discoloration and death (phytotoxicity) of common turf grasses like Bermuda and St. Augustine grass. In contrast, one of the least expensive individual mound treatments is acephate. For Ortho® Orthene® Fire Ant Killer (50% acephate), applied at 1 Tbsp/mound, 1 lb treats 80 mounds. At \$13.77/lb, the treatment cost is \$0.17 per mound.

The research objective emerges from the problem section, thus showing the logical rationale for the study. This research will attempt to find a treatment effective in terms of cost and toxicity to grass:

**Objectives.** This trial was established to evaluate several lower rates of Citrex® Fire Ant Killer as a single mound treatment for fire ants to reduce treatment cost and phytotoxicity problems associated with treatments. The trial was designed to observe the effectiveness of concentrations of product below the 8 fl oz/gal labelled rate in 1999-2000 in reducing fire ant activity and phytotoxicity over a two week period. Furthermore, reduced volumes of the diluted product below the conventional 1-gallon per mound amount used in this trial offer further reductions in treatment cost. This effort could help lower the treatment cost for fire ant control in turfgrass areas statewide.

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## Materials and Methods

This section should allow other experienced researchers to duplicate the research. Writers should explain clearly and accurately how the research was performed. This section also helps build the credibility of the report—how was the research conducted; what methods and important materials were used; what procedures were followed. This section may include the following:

- Design of the investigation
- Materials used
- Procedure—how you conducted the research
- Methods used for observation, analysis, and interpretation.

Methods sections will vary, depending on the type of research. However, description should be clear, complete, and accurate to allow replication of the experiment (if necessary) and to assure readers that the researcher(s)' approach is sound:

## Materials and Methods

On Thursday, April 26, 2001 on the premises of the JSC and NASA in Houston, TX, approximately 280 active fire ant mounds were identified and flagged in an area approximately 120 ft x 900 ft. The mounds were located by walking back and forth the length of the area in 15-ft widths. Mounds were considered active if more than 100 aggressive fire ants surfaced within 10 sec of probing the mound with the surveying flag wire. On Friday, April 27, 2001, 240 active fire ant mounds were divided into 24 plots of 10 mounds each. The 24 plots, each containing 10 active fire ant mounds, were then marked with a second identifying flag to be either left untreated, treated with Surfonic N-95 (surfactant), treated with Ortho® Orthene® Fire Ant Killer or treated with Citrex® Fire Ant Killer. Plots were randomly selected in oval groupings for 4 repetitions of each of the various treatments. All mounds were then treated between 12:00 pm and 4:00 pm.

Treatments included:

1. Untreated
2. Surfonic N-95 surfactant at 4 oz/gal of water.
3. Orthene Fire Ant Killer at 1 tbls watered in with 2 qt water
4. Citrex® Fire Ant Killer at 3 oz/gal of water.
5. Citrex® Fire Ant Killer at 4 oz/gal of water.
6. Citrex® Fire Ant Killer at 5 oz/gal of water.

The Surfonic N-95, the inert ingredient in Citrex®, and Citrex® Fire Ant Killer (EPA Reg. No. 72244-1) were mixed at the above concentrations in 2.5 gal containers. Application was made to the mounds using 2-qt plastic pitchers. Two quarts were applied to each mound (exceptionally small mounds received 1 qt and unusually large mounds received 3 qt or 1 gal) by starting from the outside edge of the mound and working towards the center of the mound in a circular motion causing the mound to collapse in from the center. Only enough of the Surfonic and Citrex® mixture was used to saturate the mounds. The label rate (1 Tbsp/fire ant mound) of Orthene Fire Ant Killer (EPA Reg. No. 239-2632) was sprinkled on the designated mounds and watered in with 2 qt of water.

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## Results

The results section explains what happened when the procedure was applied. Results should coordinate clearly and precisely with the methods section. Outcomes should be tied to procedure

Discussion--Many empirical research reports, separate the results and discussion. Or, as is the case in this report, one section contains both:

:

### **Results**

On April 28 & 30, and May 4 & 11, 2001, all 240 mounds were inspected starting at 10:00 am and finishing around 2:00 pm. Mounds were probed with a wooden stick and closely inspected for fire ant activity. If after 15 sec ants were seen coming out of the probed mound, the mound was considered active (**Table 1**). Inspection for new ("satellite") mounds occurring within 2 to 3 ft of treated mounds was made. Satellite mounds, mounds that appear within 5 ft of treated mound, were counted and data are presented in **Table2**.

All rates of Citrex® significantly reduced the number of active mounds when compared to the untreated check at each of the evaluation dates (**Table 3**). Statistically, the 4 and 5 oz/gal Citrex® rates performed identically and produced significantly quicker elimination of ants in treated mounds than the 3 oz/gal rate in reducing mound activity 3 days after treatment (DAT) and lower mound activity from these higher rates was still seen at 7 and 14 DAT. Satellite mounds were also found around more of the 3 oz/gal treated mounds, than the 4 and 5 oz/gal treated mounds (**Table2**).

**Table 1:** Active fire ant mounds. Raw data from Citrex® Fire Ant Killer Field Test Results, NASA, 2001.

<u>Treatment</u>	<u>Apr. 28</u>	<u>Apr. 30</u>	<u>May 4</u>	<u>May 11</u>
untreated	9,10,10,10	9,10,10,10	8,10,9,10	8,8,8,8
Surfonic N-95 4 oz/gal	7,9,10,10	5,7,6,6	4,4,6,4	4,4,3,3
Citrex® 3 oz/gal	3,5,5,3	1,3,1,4	3,2,1,2	0,4,4,2
Citrex® 4 oz/gal	1,2,2,1	2,4,1,0	1,2,0,0	0,2,0,0
Citrex® 5 oz/gal	1,1,0,0	0,1,2,0	1,1,0,1	0,2,1,0
Orthene® 2 tsp/gal	4,5,6,2	1,1,4,4	1,4,2,1	0,0,1,0

**Table 2.** Satellite mounds found within 5 ft of treated mound.

<u>Mound Treatment</u>	<u>Day 1</u>	<u>Day 3</u>	<u>Day 7</u>	<u>Day 14</u>
untreated	-	-	-	-
Surfonic N-95	0	0	0	4
Orthene®	0	0	0	1
Citrex® 3 ounce	0	4	4	6
Citrex® 4 ounce	0	0	0	3
Citrex® 5 ounce	0	0	0	1

**Table 3.** Citrex® Fire Ant Killer Field Test Results, NASA, Galveston Co., Texas, treated April 27, 2001.

<u>Treatment</u>	<u>Mean no. active ant mounds/10 (4 replications)*</u>			
	<u>Apr. 28</u>	<u>Apr. 30</u>	<u>May 4</u>	<u>May 11</u>
untreated	9.75a	9.75a	9.25a	8.00a
Surfonic N-95 4 oz/gal	9.00a	6.00a	4.50a	3.50b
Citrex® 3 oz/gal	4.25b	2.50b	2.00b	2.50b
Citrex® 4 oz/gal	1.50c	2.25b	0.75c	0.50c
Citrex® 5 oz/gal	0.50c	1.75b	0.75c	0.75c
Orthene® 2 tsp/gal	4.25b	2.50b	2.00b	0.25c
Mean Square	57.97	46.27	42.54	34.67
<i>F</i>	66.038	28.917	45.177	44.571
<i>P</i>	0.0000	0.0000	0.0000	0.0000
d.f = 5				

\* Means in columns followed by the same letter are not significantly different using analysis of variance (ANOVA) at  $P \leq 0.05$  and separated using Duncan's Multiple Range Test (Microstat).

### Phytotoxicity

#### Phytotoxicity

All 240 mounds were also inspected on each evaluation date for signs of plant damage. The field was a mixture of Bermuda grass, St Augustine, wild flowers and other unknown grasses and weeds. On a scale of 0 to 10, with 0 being no damage and 10 being death of foliage the following was noted:

In total, 120 mounds were treated with Citrex®. No sign of phytotoxicity was noted on either Day 1 or Day 3. Day 7 produced some yellowing/reddening of the vegetation on some of the mounds treated with Citrex®. All of the mounds treated with Citrex® still showed phytotoxicity symptoms on Day 7, but by day

14 these symptoms were less evident. The use of Citrex® at any of the applied solutions may cause yellowing to residential lawns. The higher the rate the more intense the symptoms.

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## **Conclusion**

Following the reporting of results and any analysis of those results (discussion), a writer may include a conclusion to summarize what the research yielded. Or, the conclusion may be incorporated into the discussion. Conclusions need to focus on accuracy, any limitations of findings, and any questions that need further investigation. The conclusions allows the writer to assess the experiment and suggest further research directions:

### **Conclusion**

Results from this limited study showed that rates of Citrex® Fire Ant Killer as low as 3 oz/gal will reduce fire ant mound activity. The 4 and 5 oz/gal rates gave the highest reduction in activity with reduced phytotoxicity problems. The rate of 5 oz/gal of Citrex® was labeled in 2002 as a result of this study, was effective in reducing the activity of treated fire ant mounds. However, data suggested that the 4 oz/rate may be considered just as effective and could offer the user a slightly more economical means treating fire ant mounds. This rate is being considered for the future revision of the product's label. The 4 fl oz/gal rate would cut the cost of the product in half, to \$1.94.

Furthermore, although the amount of volume used to drench each mound with these low rates of Citrex® were not recorded for each mound treated in this trial, application of less than one gal dilute drench per mound could result in additional reductions in treatment cost. For instance, treating a "small" ant mound with a quart of material would cost \$0.48, which is comparable to many other individual ant mound drench products currently on the market.

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## **Acknowledgements and References**

Most researchers note the help of individuals who worked in the research. Acknowledging help may occur in a footnote or in a section at the end of the report. Any specific resources mentioned in the report should have full citations in the Reference section:

## Acknowledgment

The author would like to thank Mr. Craig Gant and EnviroSafe Labs, Conroe, TX, for the Citrex® product used in this study and his help in establishing and evaluating this study.

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Paul R. Nestor, Red Imported Fire Ant Management Applied Research and Demonstration Reports 2000-2002, Texas Imported Fire Ant Research and Management Plan, Texas Agriculture Extension Service,  
<http://fireant.tamu.edu/research/arr/year/00-02/index.html>

## Other Examples for Analysis and Comparison

### Example 1

Let's now look at a second example to see how elements of research reports occur in another kind of research report. This first report explains results of a research procedure to improve African violets: In this report, the **problem statement** appears in paragraph 1. **Documented studies** of pertinent studies appear in paragraph 2 before the **purpose statement, which ends the paragraph**. In short, the introduction includes the statement of the topic, previous research related to the topic, and the purpose of this specific research effort:

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### Use of a Protoplast Regeneration System for African Violet Improvement

#### Introduction

Since African violet growing began in Germany in 1893, breeders have improved this species in many ways. Vegetative habit, time to flowering, and flower retention have been altered. In addition, a wide spectrum of flower colors, patterns, and shapes is available in the modern African violet. This was done mainly by making crosses and subsequently selecting the desirable seedlings. Traditional breeding methods are limited by the range of species which can be combined, and certain desirable features, particularly the introduction of true red and yellow flowering plants, has not been achieved (the Blansit violets appear to be an exception).

Research demonstrating that African violets could be propagated easily in vitro under sterile conditions has opened new ways for increasing genetic variability through biotechnology (Start and Cumming, 1976; Grunewaldt, 1977). Some of these techniques require that plants be regenerated from protoplasts (naked cells

without cell walls) rather than from leaf tissue. Before being able to use methods like direct DNA transfer into protoplasts or fusion of protoplasts of otherwise incompatible species (Saintpaulia and Episcia, for example) it is necessary to develop a reliable method for obtaining whole plants from protoplasts. The aim of our research was to establish such a protoplast regeneration system for African violets.

## **Methods and Results**

In this report, the methods and results sections are combined under one heading. Other research is noted in the methods section to justify why this method was employed. This report was planned as an online report. Thus, the figure numbers appear as links in the text. We include one – Figure 4-- to illustrate how the visual supports the point:

### **Isolation of Protoplasts, Protoplast Culture, and Plant Regeneration**

Protoplasts can be released from plant tissue by one of two methods. The first method involves mechanically isolating the naked cells by dissection or rupture of the cell walls (Bilkey and Cocking, 1982). The more common method involves treating the plant tissue with enzymes that digest the cell wall material. For our work we used a combination of three enzymes: 0.5% macerozyme, a pectinase, to dissolve the tissue; and, 2 % cellulase R10 and 0.1% driselase, two cellulases, to dissolve the cell walls (Winkelmann and Grunewaldt, 1992).

The starting plant material employed for a source of protoplasts proved to be very important for successful regeneration. Only when young shoots from tissue culture were used as the starting material were plants able to be regenerated from protoplasts.

After removing the enzymes by centrifugation, the protoplasts were embedded in alginate. Protoplasts plated in liquid or in a medium solidified with agarose did not develop. The successful medium contained macro- and micronutrients, organic acids, vitamins, and high concentrations of different sugars to stabilize the naked protoplasts until the cell walls reformed. Cell walls were formed and the cells began to divide after 8 to 10 days of growth in the dark ([see Figure 1](#)). The medium also contained two plant growth regulators; 1 mg/liter naphthaleneacetic acid (an auxin); and, 1 mg/liter benzyladenine (a cytokinin). The complete details of the protoplast culture procedure can be found in the reference by Winkelmann and Grunewaldt (1992).

After 14 days growth on the initial culture medium, the osmotic strength and the concentration of growth regulators was reduced. The osmotic strength was reduced again 10 days later. Then, after about 4 weeks of culture, small clumps of unorganized cells, or calli, could be removed and plated on a medium solidified with agarose (see Figure 2). These calli were grown in the dark until they reached a size of 3 to 4 mm in diameter, and then, they were transferred to a medium containing 2 mg/liter benzyladenine to induce plant formation.

As soon as the young plants were visible under a stereomicroscope, the cultures were moved to the light and placed on a shoot elongation medium (see Figure 3). The number of plants per callus varied, ranging between 5 and 50. These plants rooted easily and could be grown on in the greenhouse with few losses. The scheme presented in Figure 4 summarizes the process from protoplast isolation to growth of the plants in the greenhouse.

The next section of this report provides a discussion of the results:

### **Applications for African Violet Improvement**

Protoplasts are useful in genetic manipulations because they do not have cell walls. They are ideal targets for taking up naked DNA and for fusing with protoplasts of other related species. In the related genus, *Episcia*, some species and selections have true yellow and red flowers. We have applied successfully our procedure for plant regeneration from African violet protoplasts to protoplasts of *Episcia cupreata* 'Tropical Topaz' (Winkelmann and Grunewaldt, 1993). As was suggested by Bilkey and McCown (1978), protoplast fusion between African violet and *Episcia* may lead to the production of new flower colors which have not been possible because of genetic barriers. Research toward this goal is now in progress.

Following the discussion of applications, the report ends with Acknowledgement and References:

### **Acknowledgments**

The experiments reported here are part of the Ph. D. thesis of T. Winkelmann, which was supported by the Federal Ministry of Research and Technology (BMFT, Bonn) and Fischer Company (Hannover-Isernhagen). The author would like to thank Prof. R. D. Lineberger for his critical review of the manuscript.

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## Example 2

Examine the following empirical report. How do visuals document results?

### **MICROPROPAGATION OF CHIMERAL AFRICAN VIOLETS**

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<http://aggie-horticulture.tamu.edu/tisscult/chimeras/valprop/val.html>

### **ABSTRACT**

The pinwheel flowering African violets are periclinal chimeras. Plantlets produced from tissue cultured leaf explants do not flower true-to-type. When intact inflorescences were cultured in vitro, plantlets arose in the axils of small bracts on the peduncles. These plantlets flowered between 80% and 95% true-to-type depending on the cultivar under consideration. It is hypothesized that these plantlets result from the growth of dormant axillary buds in the inflorescence. This hypothesis would account for the ability to propagate the periclinal chimeras in a true-to-type fashion since the apical organization of axillary buds is identical to that of the apical meristem.

## INTRODUCTION

African violets which have bicolor flowers with a banded arrangement of the colors are termed "pinwheel flowering". The lateral edge of each corolla segment is a different color than the central portion, giving the whole flower a "spoked" appearance, with the "spokes" being one color and the "spaces between the spokes" a different color.



Figure 1. The pinwheel-flowering African violet cultivar 'Valencia' is characterized by corolla segments with methyl violet margins and a white center stripe.

This patterned arrangement of the flower is not maintained by plants propagated by leaf cuttings, but can be maintained if the terminal portion of the crown is removed and the resulting "suckers" are separated and rooted (1). This technique of propagation gives rise to few propagules per plant, necessitates using large, well-established plants for crown removal, and exposes the stock plants to potential disease problems. The cost of these chimeral plants is therefore very high compared to other African violet types which can be propagated by leaf cuttings.

During the course of experiments designed to separate the component genotypes of several cultivars of pin-wheel flowering African violets, it was noted that some plants produced from inflorescence explants produced pinwheeling flowering plants (2). The procedure reported herein is a refinement of this technique suitable for the high fidelity production of chimeral African violets through tissue culture.

## MATERIALS AND METHODS

Whole inflorescences of the African violet cultivars 'Valencia', 'Dardevil', 'Desert Dawn', and 'Mauna Loa' served as tissue explants for these studies. Inflorescences were harvested several days prior to the opening of the first flower. Explants were washed in 0.1% Alconox for 5 to 10 min., disinfested in 0.5% sodium hypochlorite for 15 min., and rinsed twice in sterile distilled water. The peduncle was cut 5 to 10 mm below the attachment of the lowest flower buds and the whole inflorescence was placed in 25 x 150 mm test tubes containing 12.5 ml of tissue culture medium. The medium used contained the Murashige and Skoog salt formulation and organics (3), with 100 mg/l myo-inositol, 200 mg/l casein hydrolysate, 3% sucrose, 1 mg/l naphthaleneacetic acid, 1 mg/l benzyladenine, and 0.6% Difco Bacto agar (pH 5.7). Cultures were grown in a culture room providing 16 hr. per day of cool white fluorescent light (40 $\mu$  Einsteins/m<sup>2</sup>/sec).

The small plantlets which had formed by 5 weeks were removed from the peduncle and placed in plastic covered foil tins containing moistened Reddi Earth soilless medium (W.R. Grace Co., Cambridge, MA 02140) for rooting. Plantlets were well rooted within 3 to 4 weeks, at which time the plastic lids were loosened to allow the plants to acclimate to lower relative humidities. After approximately 2 to 3 weeks of acclimation, plants were potted into 8 cm plastic pots containing Metromix 350 soilless medium (W.R. Grace Co., Cambridge, MA 02140), placed on a capillary mat watering system in a shaded greenhouse (70% shade), and grown to flowering according to standard African violet culture. Plants were observed through at least one full flowering cycle to ascertain trueness-to-type.

**RESULTS AND DISCUSSION**

Plants produced through in vitro culture of leaf tissue displayed a wide variety of flowering patterns, none of which was the characteristic pinwheel flower (Fig. 2A, compare to Figs. 2B-2L).



Figure 2. Various flower patterns produced on tissue cultured 'Valencia' African violets. A. 'Valencia', true flower type. B - J. Various unstable off-type flower patterns. K, L. Monochromatic flowers of the same color as the corolla segment margin.

Similar variation was observed in plants produced from 'Dardevil' leaf tissue (Table 1). Only one type of variant was produced by leaf culture of 'Desert Dawn' (Table 1). In general, the plants produced through culture of leaf tissue most often displayed monochromatic (solid color) flowers of the same color as the margin of the corolla segments. Some bicolor, irregular combinations of both colors were produced, but in these studies pinwheel flowering plants were never obtained from leaf tissue (Table 1).

Table 1. Flowering Pattern of Plants Produced by In Vitro Culture of Leaf Explants of Three Cultivars of Pinwheel Flowering African Violets.

		Plants with Stated Flowering Pattern			
Cultivar	Number of	Margin	Stripe	Bicolor	Pinwheel

	<b>Plants Observed</b>	<b>Color</b>	<b>Color</b>		
'Valencia'	82	67%	0	33%	0
'Dardevil'	49	43%	35%	22%	0
'Desert Dawn'	36	100%	0	0	0

When whole inflorescences were placed in culture, plantlets grew from the axils of the bracts in a short time period (Fig. 3).

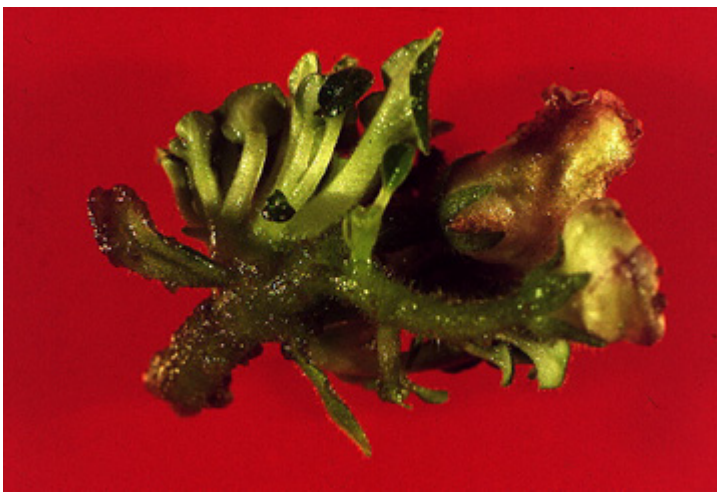


Figure 3. Plantlets produced in the bract axil of 'Valencia' after 5 weeks in vitro.

These plantlets were large enough to be removed for rooting at the end of 5 weeks.

Adventitious shoots which differentiated on leaf or peduncle tissue were just barely visible to the naked eye by 5 weeks, suggesting that these shoots arose from dormant vegetative buds in the inflorescence structure. Further evidence in support of this hypothesis was obtained when small plantlets were observed growing in the inflorescence of an intact 'Valencia' plant in the greenhouse.



Figure 4. Expanded vegetative plantlets produced on a flowering plant of 'Valencia' in the greenhouse.

The occasional production of true-to-type flowering plants from rooted inflorescences also has been reported (1).

Plants produced through short term culture of inflorescence tissue exhibit a high frequency of true-to-type flowering (Table 2). All of the 'Mauna Loa' plants regenerated through tissue culture were pinwheel flowering, while about 80% of the 'Dardevil' and 'Desert Dawn' plants flowered true-to-type. The multiplication rate varied with cultivar, with 'Valencia' achieving the highest multiplication rate (Table 2).

Table 2. Flowering Pattern of Plants Produced by Short Term Culture of Inflorescence Tissue.

Cultivar	Average No. of Plants per Explant After 5 Weeks	Plants with Stated Flowering Pattern			
		No. of Plants Observed	Same Color as Segment Margin	Bicolor	Pinwheel
'Valencia'	9.0	236	1.5%	3%	95.5%
'Dardevil'	3.2	62	8%	0	82%
'Desert Dawn'	3.7	65	20%	0	79%
'Mauna Loa'	2.3	42	0	0	100%

These rates of multiplication appear low for a tissue culture system, but they are quite acceptable since: 1) the system has high fidelity, 2) the explant source (i.e., inflorescence) is produced in abundance on a mature plant, and 3) the taking of explants does not reduce the vigor of the stock plant.

It should be emphasized that the period of in vitro culture should not extend beyond 5 or 6 weeks. Adventitious shoots are produced on the peduncle in the vicinity of the plants believed to be produced from the axillary buds and these adventitious shoots would not be pinwheel flowering types. This phenomenon likely accounts for the observed variation in fidelity of the plants produced by the different cultivars. For example, the 'Desert Dawn' cultures may have been "contaminated" by adventitious shoots to a greater degree than the cultures of 'Valencia'.

The inflorescence culture technique should allow true-to-type propagation of other African violet cultivars which are periclinal chimeras. Plants are produced rapidly on the

explants and these plants show excellent rooting and survival. Care must be taken, however, to determine the extent of variation in the tissue cultured plants, since trueness-to-type was cultivar dependent and varied between 80% and 100%.

### **LITERATURE CITED**

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### **Example 3**

Our final example here is an empirical research report written by a senior Maritime Studies major at Texas A&M University-Galveston. This report shows how the empirical research approach can be applied to related fields, such as archaeological artifacts. This report opens with an introduction, moves to the history of the nails and fasteners found, provides a description (with drawings) of the nails, followed by a discussion of the findings. The conclusion notes the importance of the artifacts. All empirical research reports have one feature in common: careful use of description of method, procedures, and results.

### **Exercises**

1. Find an example of an empirical research report in your field or a related field. How does it compare to the sample reports in this chapter. In what ways is it similar or different?
2. What are the standard research methods in your field. List and explain each method in a slide presentation for the class.

3. Choose one of the sample reports in this chapter or on the RTI website. Use the strategies and techniques of Chapter 4 (Achieving a Readable Style) to make the methods section of this report both shorter and easier to read.
4. Using the same report as in #3, adapt the conclusions section as a one-page recommendation memo to a pertinent decision maker.
5. Study the student empirical research report on bus routes. Go to the RTI website and select empirical research reports. Can you think of a similar problem at your university that would provide a useful topic for an empirical research project?