stateaser

Workshop Schedule

DOE Simplified
May 29: Minneapolis, MN

An overview of Design of Experiments (DOE) from A to Z, based on the popular book. $295*

Statistics for Technical Professionals
June 24–25: Minneapolis, MN

Revitalize the statistical skills you need to stay competitive. $995*

Experiment Design Made Easy
April 1–3: Philadelphia, PA
June 10–12: Minneapolis, MN
August 5–7: San Jose, CA

Study the practical aspects of DOE. Learn about simple, but powerful, two-level factorial designs. $1495*

Response Surface Methods for Process Optimization
July 15–17: Minneapolis, MN

Maximize profitability by discovering optimal process settings. $1495*

Mixture Design for Optimal Formulations
May 13–15: Minneapolis, MN
August 12–14: Minneapolis, MN

Find the ideal recipe for your mixture with high-powered statistical tools. $1495*

Robust Design: DOE Tools for Reducing Variation
April 22–24: Minneapolis, MN
September 16–18: Minneapolis, MN

Use DOE to create products and processes robust to varying conditions. A must for Six Sigma. *Factorial and RSM proficiency are required.* $1495*

Real-Life DOE
May 20–21: Minneapolis, MN
September 23–24: Minneapolis, MN

Learn advanced analysis tricks - how to deal with missing data, split plots and more. *Factorial proficiency required.* $995*

Big discounts for three or more students. Attendance limited to 20. For more information, call Sherry at **800.801.7191 x18.**

*Includes a $95 student materials charge which is subject to state and local taxes.

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Miracle Flowers Survive— In Spite of Shari!

Every spring I get the urge to dig in the dirt and see if I can make something grow. Last summer I decided to return to the roots of DOE and try applying it to agriculture! (For those of you who don't know, DOE originated in the 1920's with Sir Ronald Fisher. He first applied it to the agricultural industry in England.)

Shari's Experiment

I wanted to grow lush plants similar to (or better than) my neighbor's. I went to the nursery, picked up some flats of Verbena flowers, and apologized for what I was about to do to them! I set up a 5-factor, 16-run half-fractional design in Design-Expert 6 with the factors shown in the box below. Let me explain my reasons for choosing some of these factors.

Soil Type (A): For years I have been purchasing the well-marketed Miracle Gro soil in the belief that somehow, this must help plants. My curiosity peaked last year when they began advertising growth rates at least 50% better than regular soil. I was naturally suspicious of this claim.

Pinch Off Buds (D): During my winter reading of various gardening magazines, I came across an article advising me to pinch off all buds at the time of planting in order to generate root growth, leading to a larger and stronger plant.

Water with Fertilizer (E): The nursery swears by the concept of adding special fertilizer to the water and watering plants daily. I have actually never tried fertilized water before, putting my faith instead in that special soil.

With the help of my kids I set about creating the 16 different conditions that the design required. The plants were carefully labeled so we knew how to water each of them. We were off to a good start.

Everything was going well until the

A: Soil Type
Regular or Miracle Gro
B: Pot Size
4" or 7"
C: Location
Partly Sunny or Sunny
D: Pinch Off Buds
No or Yes
E: Water with Fertilizer
No or Yes

Fig. 1 - DOE Factors

— Continued from page 1.

family decided to take a Fourth of July vacation and temperatures were in the upper 90's while we were away. I nearly cried at the condition of my flowers upon my return - the ones in the sunny location were a dried-out mess and I thought that I had just lost my entire experiment! Some tender loving care over the next few weeks brought back most of them. I did lose two plants that were in the sun in small pots (the plants in large pots recovered!) So, as is common in a designed experiment, I was left with two missing data points and only 14 out of 16 runs.

My goal was to have large, bushy plants, so my response consisted of measuring the circumference of the plants at potting and again at the end of the summer and calculating the change. Analysis of this data indicated a few very significant effects, as shown in the half normal plot of effects (see Fig. 2a). The significant factors were B: Pot Size, E: Water with Fertilizer, and an interesting interaction between B: Pot Size and D: Pinch Off Buds. (D was selected to maintain model hierarchy since BD was significant.) The effects graphs (see Fig. 3a & 3b) show that adding fertilizer to the water should add approximately 3.5" to the circumference of these plants. The BD interaction is unexpected. It says that if I use large pots (which produce larger plants) then pinching off the buds is actually undesirable. Perhaps this is because the roots have enough room to grow on their own? I'm not a gardener, so you may have your own theory on this.

Expert Details
Wait a minute - what is the impact of my missing data? Since I ran a fractional factorial design, did this cause more aliasing than originally planned? Yes, it did. If you look under the Effects button in Design-Expert and choose View, Alias List, the impact of missing data
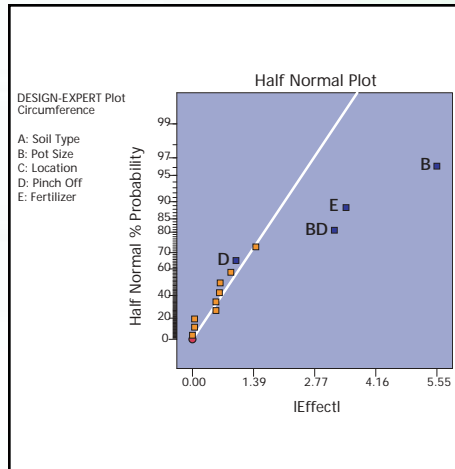
Figures 2a & 2b—Half Normal Plot of Effects & Associated Aliasing

can be seen for a particular response. In contrast, the alias structure shown in Design Evaluation doesn't take into account the effects calculations.

My original design was a Resolution V half-fraction and had the main effects separated from the two-factor interactions. Since I lost two runs, I lost the ability to estimate two effects. Design-Expert computes effects hierarchically. It checks to make sure it can estimate all the main effects - in this case it can (they are aliased, but only to insignificant terms— see Fig. 2b). Then it checks to make sure it can estimate all the two-factor interactions (2FI). With missing data, there are not enough degrees of freedom (df) to do this. Design-Expert then uses a forward selection routine that selects the most

significant 2FI terms one at a time until it runs out of df. The remaining terms are those with the smallest SS. They are least likely to be significant and so are designated as the aliased terms (in this case, the BC and DE interactions.) Because of this process, even with missing data, I can still rely on the labels on the Half Normal Plot of Effects to tell me which terms belong in the model.

This summer I plan to spend my money more wisely. Foregoing the special growing soil, I will instead invest in liquid fertilizers to use on a regular basis. My flowers will thrive in their new large growing containers. Finally, I will definitely ask my neighbor to water my plants while I am on vacation! Happy gardening!

Shari Kraber (*Shari@StatEase.com*)
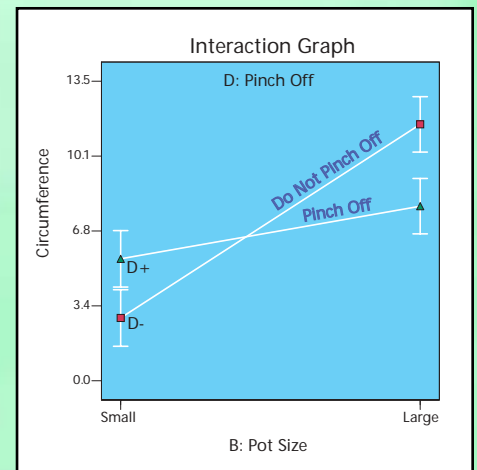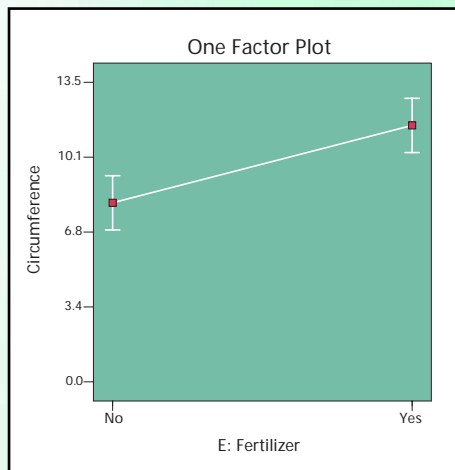
Figures 3a & 3b—Effects Plots for Significant Factors

New Joint Venture with Beckman Coulter

January 2003 marked the launch of a unique joint venture. Stat-Ease has partnered with Beckman Coulter, Inc. to create a training program that introduces students to experimental design and Beckman Coulter's SAGIAN Automated Assay Optimization (AAO) FX software.*

Beckman Coulter develops high-tech liquid handling equipment, such as the Biomek® FX pictured in Fig. 1, that research laboratories use to automate the screening and optimization of assays. The traditional one-factor-at-a-time (OFAT) method of optimizing assays required a great deal of time and produced limited information. By combining the use of liquid handling robotics and sophisticated software, scientists are now able to create methods and perform complex optimizing experiments that were otherwise too difficult manually.

Together with Stat-Ease, Beckman Coulter has developed a training program for their customers. It focuses on the process of using design of experi-

ments (DOE) and AAO FX software to write Biomek FX programs that optimize assay conditions. Students learn to:

♦ Set up factorial designs using Design-Expert software.
♦ Import these DOEs into AAO FX software to create a Biomek FX method.
♦ Run the method on the Biomek FX simulator.
♦ Export the response data for the DOE into Design-Expert and then analyze it.

Beckman trainers are world-class experts on liquid handling technology. Their knowledge, together with Stat-Ease expertise in statistics and DOE, creates a synergistic partnership.

Stat-Ease is available to work with other organizations on joint ventures such as this one. We can help you integrate DOE into your business or help you teach your customers the tools they need to improve their products and processes.

Stat-Ease consultants are available as a statistical resource for your DOE proj-

Fig. 1—Biomek FX Laboratory Workstation

ects. Use our consulting services to guide you when in-house resources are unavailable. For more information on joint ventures or consulting services, e-mail info@statease.com or call Mark Anderson at 612.378.9449.

*Please see http://www.beckman.com/customersupport/trainingeducation/training/course_desc.asp?CourseID=102 for more information.

Where can you find us?

Stat-Ease is teaming up with universities to provide engineering students with exposure to sound experimental practices. Already this year we've presented lectures at Ohio State University, South Dakota School of Mines and Technology, Auburn University, and the University of Minnesota. You can also find us at:

April 14-15 — MN Quality Conference and BioMedical Focus, Minneapolis, MN, Booth 14.
Talk by Shari Kraber:
"Drive Six Sigma Success with DOE"

May 19-21 — 57th Annual Quality Congress, Kansas City, MO, Booth 115.
Talk by Mark Anderson:
"How to Use Graphs to Diagnose and Deal with Bad Experimental Data"

August 3-7 — Joint Statistical Meetings, San Francisco, CA, Booth 205.
Roundtable Discussion by Shari Kraber:
"Altering Central Composite Designs"

Mixture Case Studies Available!

Three case studies illustrating the use of designed mixture experiments are now available as reprints free of charge (see the order form on page 4). In addition, a new review of Design-Expert 6.0 (DX6) is available.

#60: "Design, Analyze and Optimize with Design-Expert", by Katherine Alben, New York State Department of Health, reprinted from *Analytical Chemistry*, April 2002. This review highlights the computational capabilities and functions of DX6.0.6.

#61: "Technology Flexes Its Muscles" by Stephen C. Lapin, reprinted from *Adhesives Age Magazine,* March 2002. Northwest Coatings Corp. used DOE to

improve electron beam (EB)-curable laminating adhesives for flexible packaging.

#62: "A Hot Formula" by Michael O'Brien, Kip Hillshafer and Erik Williamson, reprinted from *Adhesives Age*, November 2001. Mixture designs are used to evaluate new ortho-phthalic-based polyols developed for polyurethane reactive (PUR) hot-melt adhesive applications.

#63: "Mixture DOE Uncovers Formulations Quicker" by Mark Anderson and Pat Whitcomb, reprinted from *Rubber & Plastics News*, October 2002. Case studies illustrate why factorial designs don't work well for formulations but mixture designs will do the trick.

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	Upgrade to DX6 from DX5 ($395.00 to upgrade from DX4 or earlier) **Old Serial # required:**	$295.00	
	DOE Simplified Book (Comes with a 180-day CD-ROM of Design-Ease 6 software)	$39.95	
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