

Increase the Value of Field Testing on Dairies

Mark Engstrom, Ph.D.

Summary

Several trends increase the need for field testing on commercial dairies: increasing size, tight margins, rapid pace of new technology, and specialized operations. Many dairymen feel they need more than university research to prove that a new technology will work for them, or that the speed of innovation can be increased by field testing. In addition, university researchers may be attracted to research with commercial dairies because of the availability of large numbers of cows. With appropriate statistical designs and management controls, appropriate trials can be done on-farm which can generate good data, speed up technology interchange, and in some cases couldn't be done anywhere else.

Introduction

A leading dairy consultant remarked that “My herds couldn't pick up a 3 lb increase in milk production.” Yet we all know his phone would ring if the herdsman observed a 3 lb *decrease*. The key is signal to noise ratio, and a 3 lb drop in the bulk tank will generate a lot of signal and a lot of noise! Others will tell you that university herds don't properly represent their commercial conditions, because of differences in housing, production levels, or objectives (i.e. organic milk or methane). Today the US dairy industry produces 40% more milk with 60% less cows and 40% less feed than it did 80 years ago (anon, 2007). The pressure to evaluate, incorporate and adapt new technologies has increased as margins tighten, yet availability of university herds for product proof has decreased.

Experimental Designs

Suppose you'd like to evaluate a new feed additive (shown by previous university research to improve fiber digestion and increase milk production) on one or several commercial dairies (St.-Pierre, 1999). Further, let's say this new additive will increase input costs \$0.05/hd/d (\$15,250/yr per 1000 cows), and is expected to return \$0.20/hd/d in extra milk income (\$61,000/yr per 1000 cows). The Illini Dairy Net might classify such an additive as “Recommended” or “Experimental” depending on available support data (Hutjens, 2002). Several designs have been well-documented for testing such a product on a commercial dairy.

1. Split-herd design

In this common trial design (Kononoff and Hanford, 2006; St.-Pierre, 1999; Robinson, et al 2006; Tempelman, 2004), the herd is split by pens into treatment and control groups. Cows and/or pens are allotted randomly, and the two groups are fed

concurrently. Replication and large numbers of cows/pen usually increase the statistical power of this design (St.Pierre, 1999; Robinson, et al 2006)

Advantages: straightforward statistics, less lagtime than a switchback

Drawbacks: lack of pen-to-pen uniformity, animals moving among pens, difficult to pair pens in early lactation, requires separate record-keeping for each treatment group (i.e. can't use bulk tank measurements), extra rations needed.

2. Switchback design

Many examples of switchback designs can be found in the literature (Ferguson, et al 2000a; Sanchez et al 2005; Harrison, et al 2006). Depending on days in milk, post-peak the lactation curve is virtually linear or mathematically characterizable, allowing switchbacks to compare previous vs. current performance. If treatment lagtime and carryover are short (< 2 weeks), multiple switchbacks can be used to replicate testing.

Advantages: uses herd, pen, or cow as control, less concern for allotment to treatment. Less management changes if entire herd is involved

Drawbacks: More lagtime than a split-herd design, very sensitive to environmental (non-treatment) effects. Avoid AM/PM testing to compare testday periods. Limited applicability to early lactation

3. Paired-herd design

A variation of the switchback design (Sanchez, et al 2005), this design can be used to correct for seasonality of response of SCC (Engstrom, et al 2006) or changes in production merely due to season or forage harvesting. Herd pairs within a geographic region are allotted so that when one herd receives the control regimen, the other receives the treatment, and vice versa.

Advantages: uses advantages of both switchback and split-herd designs, but removes some environmental effects

Drawbacks: new design, requires pairs of herds in close regional proximity

4. Multi-site design

A "classic" multi-site dairy nutrition study was reported by Ferguson et al (2000a, 2000b), in which 35 dairies from 5 regions of the US fed a protein supplement (Prolak®). This study generated 33,190 milk records from 7135 cows. The protocol was able to detect 2 lb changes in daily milk production/hd from cows having a coefficient of variation of 6-14%. Shaver and Garrett (1997) reported a variant of the multi-site design, using 11 herds in an "OFF-ON-ON-OFF" switchback to account for lagtime in reaching a treatment effect. See Figure 1 for a schematic of the Shaver and Garrett design for post-peak cows and heifers.

Advantages: powerful design, can be used to measure regional effects

Drawbacks: expensive, time-consuming, logistically difficult, requires several trained monitors working with identical protocols

Regardless of the allotment procedure used, the most acceptable designs are double-blind, where a treatment and placebo are used at the dairy without knowledge of the researcher or managers which is which. Replication and statistical analysis should determine the magnitude of response and the likelihood that the observed response was actually due to the treatment and not just from chance (see Figure 2). The multi-site design may be helpful in determining which conditions are most favorable for generating a response.

Meta-Analysis

Defined as “synthesizing results from separate but similar experiments,” meta-analysis is gaining popularity as a research tool, especially for identifying subtle trends or effects unrelated to the initial experimental designs (Mann, 1990). Jaded nutritionists may suggest that meta analysis is merely an attempt by statisticians to get back in the limelight, but meta analysis allows researchers to calculate the relative strength of a given database. Developed initially for human clinical trials, the meta analysis technique has developed a new vocabulary, including “publication bias”—a bias toward either more positive (or negative) results being published, and “Fail-Safe N”—the number of studies needed to negate or reverse a conclusion.

Statistical Process Control

Several researchers (Lukas et al, 2005; Dooley et al, 1997) have used statistical process control (SPC) techniques to separate random variation from true changes in bulk tank somatic cell counts (BTSCC) and component (butterfat, protein) measurements. Originally developed for use by manufacturing industries, SPC shows promise for dairies wherever:

- a. routine measures of management (i.e. dry matter intake, BTSCC, milk fat %, milk production/cow) can be made, or better yet, are already being made; i.e. free information.
- b. timeframe/seasonality can be determined and predicted
- c. variability of the response measure will be equal to or less than the desired observed response in a controlled setting

Figure 3 shows a control chart for BTSCC measurements from a dairy, where sequential measurements are plotted by time. Significant changes in a process or measurement can be evaluated through the application of rules, and upper and lower control limits can be calculated as the moving average +/- 3 sigma, estimated from the dataset.

Reproduction/Calves/Clinical Trials

Suppose a dairy is interested in evaluating a strategy to improve 21-day pregnancy rate, or decrease ketosis, or increase calf survival. Although the statistics used to evaluate survival or event occurrences will often be different from those used to evaluate milk production (Galligan, 2007), the above designs (split-herd, switchback, etc) can be used effectively in on-farm testing. However, accurate event histories (i.e. ketosis cases in DairyComp305) will be critical for any analysis, and lagtimes between a treatment and its desired effects can range up to several months (Engstrom et al, 2006; Quigley, 2007), so that the opportunity for confounding effects increases dramatically. For example, suppose a nutritional treatment, fed during the dry period, is hypothesized to improve early embryonic mortality. The time between feeding and measurement of the effect would include the dry period, the voluntary waiting period (if using timed artificial insemination), and pregnancy determination—a total often more than 150 days. During that period, other environmental changes could affect the outcome, and need to be anticipated or controlled in the design.

What We Still Need

Because of the unique shape of the lactation curve (and lack of immediate response with many treatments), researchers have investigated ways to use 150day milk, 305ME's, or Everett's test-day model (Stanton, et al 1992) to measure instantaneous responses in milk production (Grossman et al, 1999; Scott et al 1996). The transition period is particularly important to understand, but difficult to characterize as days in milk change. The longer a trial goes on, the more random effects (forage quality, other management changes, season) add noise to the system, which can obscure a true response.

1. For milk production, we need a dependable continuous function, per cow (corrects for parity, breed, season, age, stage of lactation, components, etc).
2. The model must be acceptable to all dairy researchers and statisticians.
3. Although FeedWatch® and other tracking programs are a start, accurate dry matter intake determination on a commercial dairy is very difficult because of cow movements among pens, % dry matter changes, and other sources of variation.

Conclusions/Guidelines

1. Don't take "no" for an answer ("I can't find 2 pounds of milk when my variation is 10 lb")—usually an acceptable protocol exists where on-farm testing can be used, in combination with published data, to validate a technology on your dairy.
2. Use statistics. This limits the role of chance in making decisions. Contact the statistician before doing the trial, rather than as a salvage operation.
3. When testing a technology or product, consider the mode of action, lagtime, or other interactions on the farm. Change only one thing at a time. Consider what management on the dairy is really capable of, and don't add jobs that can't get done.

4. Use an accepted (i.e. published) protocol, especially if you'd like to make recommendations to others. Publications have value to others, and can be used in meta-analysis to test related hypotheses.

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Figure 1: Switchback OFF-ON-ON-OFF Trial Design

OFF-ON-ON-OFF Design For Milk Production By Test Day

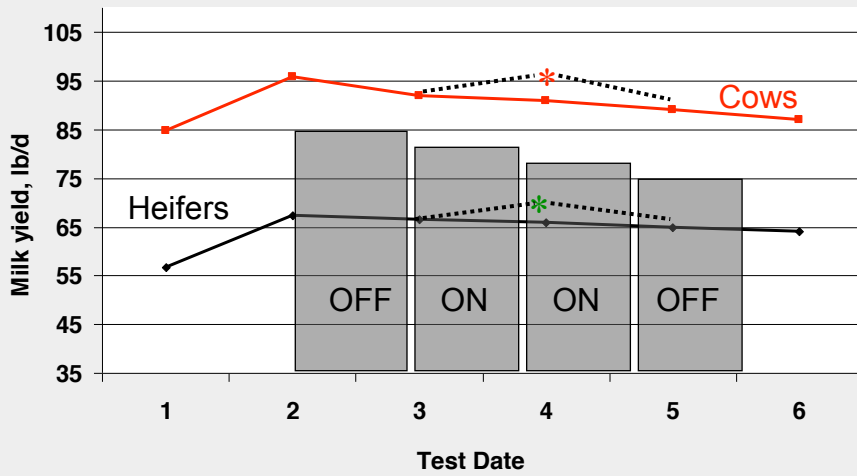


Figure 2: Histogram of Trial Results

Diamond V Yeast Culture Lactating Dairy Studies N = 54 Studies, Mean = 3.24 lb FCM

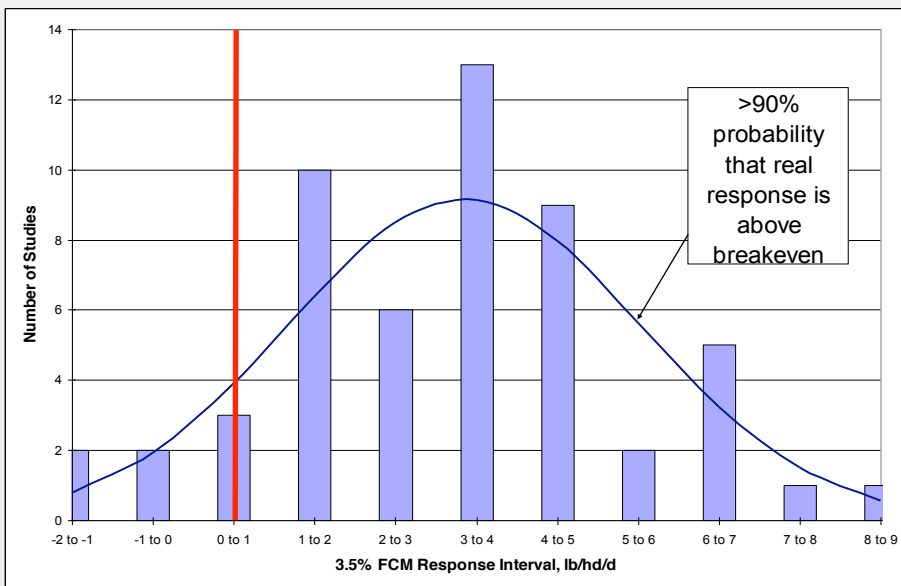


Figure 3: SPC Control Chart

CO 2050 Cow Dairy

Bulk Tank 1

Somatic Cell Count Control Chart

