Simulated On-Farm Research: A 15-Day Class Exercise

Peter E. Hildebrand[1]
Food and Resource Economics Dept
University of Florida
Gainesville FL 32611-0240

Abstract

A simple, rapid and inexpensive procedure for simulating on-farm research is described. The exercise has been used for many years in a graduate-level farming systems methods course and has been found to be effective in giving students a feel of the need for and the requirements of on-farm research. An example analysis is included.

Introduction

Very often, particularly in developing countries, but also in North America and Europe, farmers do not adopt new farm technologies because the responses achieved on experiment stations are not achieved using farmer management under farm conditions. Technology developers, who expected farmers to be able to achieve experiment station results, began to look at reasons for the "yield gap" (Ghodake and Walker, 1982) or "yield constraint" (De Datta et al., 1978). In order to make realistic estimates of expected responses, and to help sales persons and extension agents make more specific recommendations, on-farm research has become an accepted procedure (Hildebrand and Poey, 1985). The purpose of on-farm trials is not to determine which factors are responsible for different responses such as is desired from on-station trials, but rather to ascertain under what biophysical and socioeconomic conditions different technologies are more appropriate, therefore making specific recommendations feasible. Treatment by environment interaction requires a very different approach, design and analytical procedure for on-farm research. Because of the diversity among farms, it is necessary to sample a wide range of biophysical and socioeconomic conditions in on-farm trials. A relatively simple procedure for designing and analyzing on-farm trials to achieve this is "Adaptability Analysis" (Hildebrand and Russell, 1996). This procedure, based on "stability analysis" long used by plant breeders (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966), utilizes an "environmental index" over a wide range of farm environments to test the response of technologies to different conditions.

A simulated on-farm trial based on Adaptability Analysis and its predecessor, Modified Stability Analysis (Hildebrand, 1984; Hildebrand and Poey, 1985), has been used for more than 20 years in the farming systems research-extension methods graduate course (formerly AGG 5813 and more recently AEE 5232) at the University of Florida. For several years, nitrogen response of radishes, with a five-week requirement between planting and harvest was the type of trial used. Based on student evaluations, it was one of the highlights of the course even though it required two Saturday mornings outside normal class time to complete.

The result of one student's Ph.D. research, incorporating the shrunken 2 gene for enhanced sweetness (Parera, 1990), convinced the author that it would be more efficient to use several cultivars or lines of sweet corn and measure only seedling emergence, highly sensitive to less than optimum environments. This cut duration of the trial to two weeks, reduced significantly the amount of land required, eliminated the cost of purchasing fertilizer, and allowed the trials to be installed and harvested during the two-hour, regularly scheduled class period instead of an entire Saturday morning.

Materials and Methods

To simulate the wide biophysical diversity found among farms, the exercise requires an area of which part has shade in the morning, part has shade in the afternoon, part has no shade, and part has no sun. An area with trees on the east, south and west (in the northern hemisphere) works well, although shade screen could also be used. However, screen would require annual installation and removal, plus added cost for materials. Each of these sun/shade environments represents a village or community from which several farms are incorporated in the exercise. To generate socioeconomic diversity of farm environments, half of the farms in each village are irrigated and half are rainfed. Depending on the number of students in the class, they are divided into teams of one to three persons to install the trial, take data and analyze the results. Each team represents a farm in each of the four environmental (sun/shade) locations. One trial for a class of 12 students divided into four teams of three persons each is described for one year as follows:

Sweet corn is an important seasonal staple in the northern part of the country of Floriland. The producers eat it, but there is also a very active market for urban consumption. Sweet corn is best when eaten shortly following harvest because the quality and taste decline rapidly as sugar in the kernels is

[1] Professor Emeritus

converted to starch. Sweet corn varieties containing the "supersweet" gene have a high sugar content at edible maturity and a low sugar to starch conversion rate, both of which increase shelf life, postharvest eating quality and market value. However, the use of "supersweet" varieties has been limited in Floriland due to poor germination and subsequent poor stand establishment attributed to low seed vigor and susceptibility to soil borne diseases (Parera, 1990). Poor germination and emergence in the supersweet varieties are further aggravated by stressful environmental conditions. To compensate, more seed could be planted per ha, but "supersweet" seed is expensive, and Floriland's farmers have little cash available at time of sweet corn planting.

"On-farm" trials will be conducted in Floriland to test the effects of cultivar and environment on sweet corn emergence. The **research domain** consists of four villages situated on the 1) western, 2) eastern, 3) northern and 4) southern slopes of the only mountain in Floriland. Because Floriland is in the northern hemisphere, the villages receive: 1) AM Shade, 2) PM Shade, 3) Full Shade, or 4) No Shade, respectively. Included in the trials will be a hybrid cross of a variety popular many years ago (**Golden Cross Bantam**), the most common local hybrid (**Silver Queen**), a related yellow hybrid (**Golden Queen**), and one material with the supersweet gene (**Florida Staysweet**). Four farmers will be selected in each of the villages to participate in the trial (each team in the class will represent a "farm" in each village). Because some fields in each village are rainfed and some are irrigated, two rainfed and two irrigated fields will be selected in each village in order to help assure sampling a wide range of environments.

In each field, four contiguous 60 x 60 cm plots will be selected. In each plot, 25 seeds from one cultivar will be planted in a 40 x 40 cm grid (seed spacing is 10 x 10 cm). A template will be provided so locations for the seeds can be marked with a pencil or stick. **One person** from each team should plant all 100 seeds in a single field to avoid unnecessary experimental error associated with different practices in the same field. Mark the center of each field with a flag indicating team number (farm name) and whether the field is irrigated or rainfed. Before moving on to the next village, **draw a map of the village** with location of all four fields (by name and whether rainfed or irrigated) included in the trial. In each field, **indicate location of each of the plots by variety.**

Seedling emergence (%) by variety, village and field will be recorded four, seven, and eleven days after planting. The data will be analyzed by Adaptability Analysis.

In Adaptability Analysis, environments (separate farms or fields) are assigned an index based on the average yield (in this case percent emergence) of the four treatments at that location. Because all locations have the same treatments, those with a high index (EI) value obviously represent a better environment for producing the crop than those with a low EI value. Each treatment is then regressed across all environments providing a treatment response to environment. In this way all treatments can be compared, as in Figure 1. Environments can be grouped into recommendation domains (Harrington and Tripp, 1984), and within domains the risk of lower yields for each treatment can be assessed using the distribution of lower confidence limits and a one-tailed t-test, Figures 2 and 3. Recommendation domains describe biophysical and socioeconomic environments for which specific technologies are adapted and can be recommended.

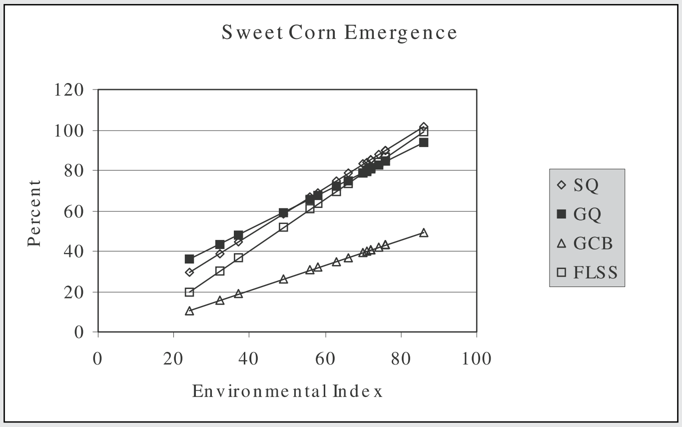

Figure 1. Regression of individual variety response to environment as measured by EI. SQ=Silver Queen, GQ=Golden Queen, GCB=Golden Cross Bantam and FLSS=Florida Staysweet.

Results and Discussion

Results from the exercise in spring 1998 are reproduced in Table 1. Data are sorted by the environmental index, EI, from lowest to highest.

Table 1. Percent emergence of sweet corn varieties, spring 1998, sorted by environmental index (EI) in ascending order[1]

Village	Farm	RF/IRR	SQ	GQ	GCB	FLSS	EI
All shade	4	RF	28	16	36	16	24
All shade	3	IRR	52	40	4	32	32
All shade	1	IRR	36	76	4	32	37
All shade	2	RF	68	60	4	64	49
PM shade	3	RF	64	56	40	64	56
PM shade	1	RF	48	80	56	48	58
AM shade	4	IRR	68	80	36	68	63
No shade	3	RF	84	60	36	84	66
No shade	4	IRR	80	72	44	84	70
PM shade	4	IRR	84	84	28	88	71
AM shade	1	RF	84	84	24	96	72
PM shade	2	IRR	92	88	40	68	72
No shade	2	IRR	100	84	32	80	74
AM shade	2	RF	84	84	64	72	76
No shade	1	RF	96	84	32	92	76
AM shade	3	IRR	100	84	64	96	86

[1]SQ=Silver Queen, GQ=Golden Queen, GCB=Golden Cross Bantam and FLSS=Florida StaySweet. RF=rainfed and IRR=irrigated.

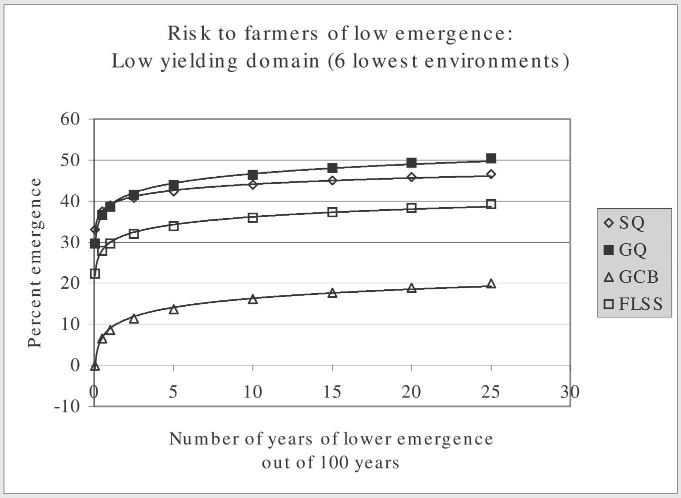

Figure 2. Estimating risk to farmers of low emergence on west facing slopes and rainfed north facing slopes (recommendation domain A, comprised of poorer or lower-yielding environments). SQ=Silver Queen, GQ=Golden Queen, GCB=Golden Cross Bantam and FLSS=Florida Staysweet. The lower confidence limit = $_{(df=n-1,p)}$) (s_d)/√n] is the risk of lower emergence in this recommendation domain the treatment mean of observations within this recommendation domain, $_d$ = the sample standard deviation associated with the mean,

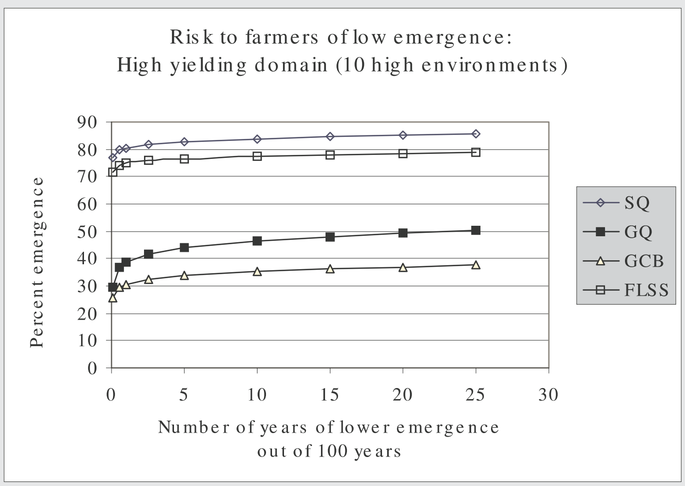

Figure 3. Estimating risk to farmers of low emergence on south and east facing slopes and irrigated north facing slopes (recommendation domain B, comprised of better or higher-yielding environments). SQ=Silver Queen, GQ=Golden Queen, GCB=Golden Cross Bantam and FLSS= Florida Staysweet. The lower confidence limit = $_{(df=n-1,p)}$) (s_d)/√n] is the risk of lower emergence in this recommendation domain the treatment mean of observations within this recommendation domain, $_d$ = the sample standard deviation associated with the mean,

Following analysis procedures in Hildebrand and Russell (1996), the response of each variety is regressed on EI. Results are shown in Figure 1.

Based on the regression analysis for percent germination from these simulated on-farm data (Figure 1) as well as an analysis of risk from the same data (Figures 2 and 3) several conclusions can be made and recommendation domains described for 'Floriland.' Golden Cross Bantam is not adapted to any of the environments sampled on “farms” in Floriland with a 25% risk of not achieving 40% emergence even in the 10 high environments (Figure 3) and should not be recommended. On rainfed fields of the north slope of the mountain (all shade) and for all fields on the west slope (AM Shade), which are the lowest environments (Figures 1 and 2) planting is risky but Silver Queen and Gold Queen can be recommended if farmers want to plant sweet corn in those locations. However, seed per acre would have to be doubled to achieve an adequate (80%) emergence density two weeks after planting. In general, sweet corn did well in the other three communities (plus irrigated fields on the north-facing slope) with Silver Queen outperforming Florida Staysweet slightly. If farmers want to plant the super sweet variety, Florida Staysweet, it can be recommended for the better environments (the south and east facing slopes and the irrigated north slope but not in the poorer environments. Cost considerations should also be considered.

This in-class exercise has been found to achieve a very realistic simulation of an on-farm trial. It allows students to understand the purpose of utilizing a wide range of environments to help them ascertain under what biophysical and socioeconomic conditions different technologies are more appropriate, therefore allowing them to make different recommendations for specific socioeconomic and biophysical conditions.

Literature Cited

De Datta, S.K., K.A. Gomez, R.W. Herat and R. Barker. 1978. A handbook on the methodology for an integrated experiment-survey on rice yield constraints. IRRI, Philippines.

Eberhart, S.A. and W.A. Russell. 1966. Stability parameters for comparing varieties. Crop Sci. 6:36-40.

Finley, K.W. and G.N. Wilkinson. 1963. The analysis of adaptation in a plant-breeding programme. Aust. J. Agric. Res. 14:742-754.

Ghodake, R.D. and T.S. Walker. 1982. Yield gap analysis in dryland agriculture: Perspectives and implications for the eighties. Economics Program, ICRISAT, India.

Harrington, L.W. and R. Tripp. 1984. Recommendation domains: A framework for on-farm research. CIMMYT Economics Program Working Paper 02/84. CIMMYT, Mexico.

Hildebrand, P.E. 1984. Modified stability analysis of farmer managed, on-farm trials. Agronomy Journal 76:271-274.

Hildebrand, P.E. and F. Poey. 1985. On-farm agronomic trials in farming systems research and extension. Lynne Rienner Publishers, Inc.

Hildebrand, P.E. and J.T. Russell. 1996. Adaptability analysis: A method for the design, analysis and interpretation of on-farm research-extension. Iowa State University Press.

Parera, C.A. 1990. Improved seed germination and stand establishment in sweet corn carrying the sh2 gene. Ph.D. Diss. Dept. of Horticultural