INTERPRETATION AND PRESENTATION OF RESEARCH INFORMATION[1]

Regis D. Voss
Extension Agronomist
Iowa State University

ABSTRACT

Crop yields have increased over time as the knowledge base supporting crop production practices has increased. The educational process of transfer of information based on research bears a deep sense of responsibility. Selection of research results on which to base recommendations is a matter of judgement that can be enhanced by proper statistical analysis. Experimental objectives, experimental design, treatment selection, number and years of experiments, environments in which the experimentation was carried out, experimental technique, and appropriate statistical tests should be taken into equal or greater consideration than the level of statistical significance in evaluating data to be used as a basis for crop production recommendations. Knowledge of subject matter and the application of proven principles are extremely important in interpreting data and in detecting aberrant but statistically significant data.

INTRODUCTION

Crop productivity in the United States has increased by several measures over time as the knowledge base supporting crop production practices has increased. During the last four decades agricultural output per input has increased 90 percent, yields per acre have doubled and output per hour has increased sevenfold while labor has decreased fourfold (Fig. 1). This has not been a random occurrence. Research results from the agronomic, soil, and crop sciences have been the direct contributor to increasing the knowledge base. Specialists in the private and public sectors have played a primary role in information transfer or extending crop production information based on research to crop producers and those serving them. This is a great responsibility.

We must consider the consequences when the advice is wrong. The advisor and the producer suffer. The advisor may suffer a damaged reputation, loss of credibility, and sales if a product is involved. The crop producer by accepting and using erroneous advice will suffer the economic consequences.

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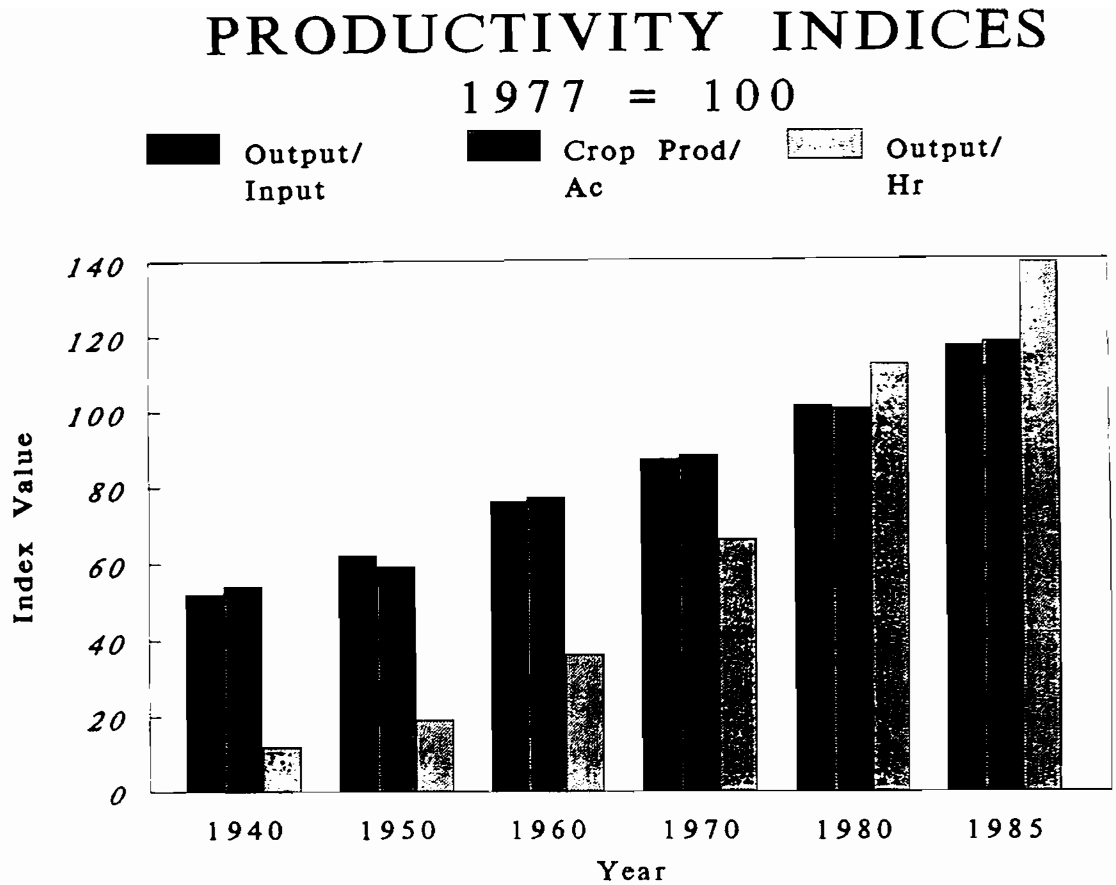

Fig. 1. Trends in productivity of U.S. agriculture (USDA, 1986).

DISCUSSION

Selecting research results by a specialist to extend is a matter of judgement. Several years ago it was relatively easy to show large treatment effects from fertilizer treatments to nutrient deficient soils. In the 1950's in Iowa 67 percent of the soil samples tested low to very low for available P and 26 percent tested low to very low for exchangeable K (Eik, 1975). Data from experiments on these low testing soils were obviously significant from statistical and economic points of view when analyzed. Of course, we still obtain some of this same information today.

In recent years the situation has become more complex: large yield increases are no longer the rule; small yield increases through refinement of practices by our crop producers are the rule. For the recent 1986-89 period 62,000 soil samples in Iowa averaged very high in available P with 60 percent testing high to very high and averaged very high in exchangeable K with 67 percent testing high to very high (Killorn, 1990). As Fig. 2 illustrates, it would be difficult to demonstrate a consistent significant yield increase on a soil testing high in available P.

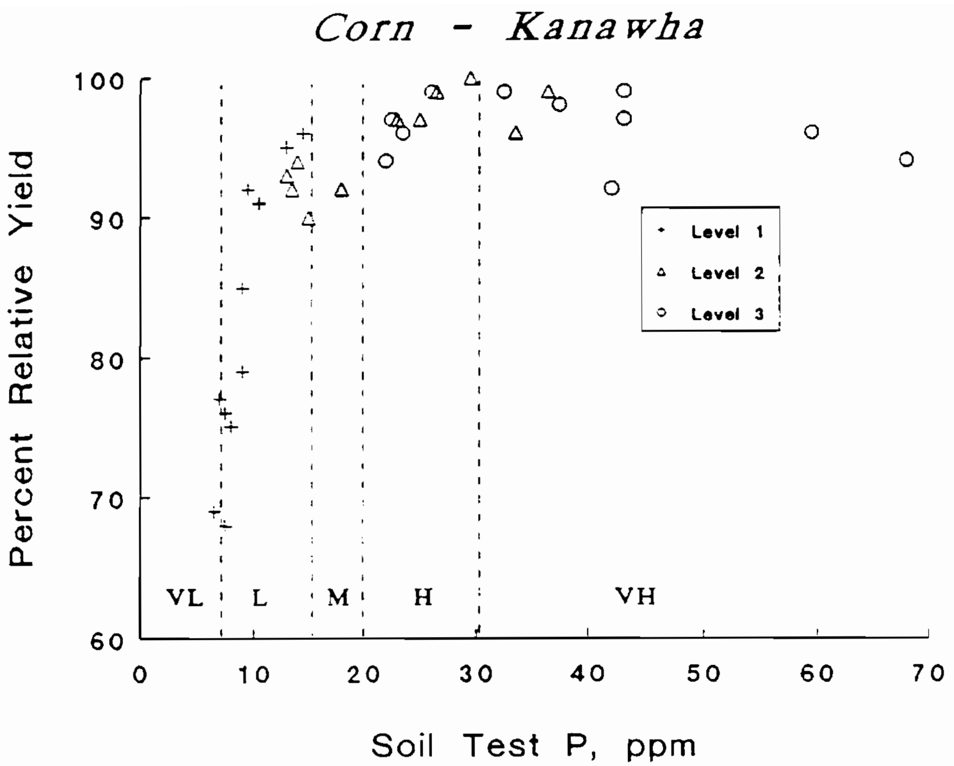

Fig. 2. Effect of soil test P on relative corn yields at Kanawha, IA, 1976-1986 (courtesy of Dr. John R. Webb).

Selection of research results to extend should be based on several parameters. Recommendation of a particular practice or input should not be based on statistical significance alone, but also on economics. The cost, potential return, and expected frequency of return must also be examined. When examining data to extend, experimental procedures and statistical analysis should be examined. Was the statistical design appropriate for the objectives? Were the appropriate measurements made? Was the statistical analysis appropriate?

Statistical analysis is not enough regardless of the chosen level. A measure of precision of the experiment, e.g., CV or standard errors of estimates should be noted. I believe that a significance level of 0.01 obtained in one experiment is not as meaningful as a significance level of 0.10 for that same practice in ten experiments across a range of environments. Look for consistency of effects.

The singular set of data that produces a significance level of 0.01 and meets all accepted criteria for design, experimental technique, and analysis but does not agree with an accepted principle raises a caution flag in my mind. This doesn't mean the practice is totally rejected, but it isn't a practice that will be extended.

Interactions are frequently discussed, but in my mind it is an overused and abused term. We must keep in mind that a similar given production situation, with regard to soil, environment and production practices, must have some frequency of occurrence and relevance before a significant interaction in research data has application.

We should also be aware of errors we can make in accepting statistical significance. Although three types of errors can be made, we are generally aware about two of these and only concerned about one. The two of general awareness are: one, selection of aberrant but statistically significant data; and two, exclusion of real, meaningful but statistically insignificant data. As an example, data in Table 1 illustrate that spring application of nitrogen is better than fall application without a nitrification inhibitor being used. The question is whether spring application of nitrogen is better than fall application when the LSD is not significant at the 0.10 level of significance by only one bushel.

Table 1. Average effect of N rate as NH_3 and time of application on corn grain yield for an 8-year period (adapted form Stehouwer and Johnson, 1990).

	Time of Application			
	Fall		Spring	
	Inhibitor		Inhibitor	
N	w/o	w	w/o	w
lb/acre	bu/acre[1]			
0	56			
80	94	111	116	117
160	127	133	139	140

[1]Without inhibitor yield from spring application was greater than fall application 5 of 8 years.

Yield from spring application without inhibitor was greater than fall application with inhibitor 1 of 8 years. LSD .05 = 7 bu. LSD .10 = 6 bu.

Having just cited an LSD for fertilizer rate research, it should be noted that sufficient rates should be used in order to fit a regression equation or production function. The approved approach is to determine by ANOV if there is a treatment effect. If there is a significant effect, the data should be fit to a production function and the function used to determine most profitable rate of fertilizer to apply.

For data to be properly interpreted there are some requirements that must be met. Comparisons of nutrient sources requires that a zero treatment be included in the design.

The example shown in Table 2 comparing sources of potassium does not contain a zero treatment which makes it impossible to determine the efficacy of the two potassium sources even though the LSD shows no difference in corn yields. If a yield response cannot be documented, nutrient sources cannot be compared. Equal rates of the nutrient from each source should be applied and a low rate in the yield responsive range should be included so that relative effectiveness can be compared. Table 3 shows an example of a fertilizer material source comparison, but unequal rates of nutrients are applied. If a difference in yield had occurred between the materials, what would one conclude? Interestingly, both materials negatively affected yields, which is possible. In both the examples in Tables 2 and 3 no soil test results were provided so it is not possible to determine if the data are consistent with the principles of soil fertility.

Table 2. A paired comparison trial of potassium sulfate and potassium chloride on corn (Exner, 1990).

Pair Number	K Source	
	KCl	K_2SO_4
	- - - - - - bu/acre - - - - - -	
1	118	119
2	125	112
3	120	101
4	115	111
5	117	120
6	120	118
Average	119.1	113.5
LSD .05 = 9.2		

Table 3. Comparison of starter fertilizer sources for corn (Practical Farmers of Iowa, 1989).

Source	$N + P_2O_5 + K_2O$	Yield[1]
	lb/acre	bu/acre
9-18-9	4 + 8 + 4	122a
7-21-7	6 + 18 + 6	125a
0	0	129b

[1]Yields with different letter are significantly different.

Another data set (Table 4) shows what can happen if an experiment is conducted on a non-responsive site and what could be misinterpreted if equal rates of nutrients and a zero treatment are not included. If at location 1 a 30 lb N/acre rate of source A and a 90 lb N/acre rate of source B had only been applied to compare sources and the yield results shown were obtained, what would one conclude? Is source A three times as effective as source B? The results shown for location 2 where a yield response is documented show that both sources of nitrogen are equally effective.

Table 4. Effect of N rate, time of application and N source on yield of corn (Meyer and Webb, 1972).

	Location 1 Source		Location 2 Source	
N Rate	A	B	A	B
lb/acre	bu/acre			
0	140	140	68	68
30	143	139	96	95
90	144	144	135	139
270	145	146	144	151

The needs for comparisons of nutrient rates are similar to those for comparison of nutrient sources. A yield response to a nutrient should be documented, a low rate in the responsive range should be obtained, and soil test results should be provided. Without a zero treatment it cannot be determined if yields were increased, decreased or not affected.

Insufficient soil test information does not permit interpretation of some data. An example of a limestone source promotion illustrates the problem (Table 5). A 300 lb/acre addition of an aglime source is claimed to increase soil pH 0.3. Did it really? How do we know? There is no zero treatment so was the change due to treatment or due to soil conditions or depth of sampling? An experiment with a zero treatment illustrates what can happen. Soil pH values could actually decrease even though the lime treatment had a positive effect on soil pH (Table 6). And an increase in soil pH could cause an erroneous conclusion about the effect of the treatment unless a control is included.

Table 5. Effect of 300 lb/acre of pelletized lime on soil pH (Ampel, 1990).

Field	Initial pH	Final pH
1	5.5	5.9
2	5.4	5.6
3	5.5	5.7
4	6.1	6.7
5	5.2	5.2
6	5.2	5.6
Ave.	5.5	5.8

Table 6. Effect of low rates of pelletized lime (1,528 lb ECCE/ton) on pH of the 0-3 inch soil depth (Plymouth Co., IA).

ECCE lb/acre	Year 0	Year 1	Year 2
	- - - - - - - - - - - -	Soil pH	- - - - - - - - - - - -
0	5.33	5.12	5.42
250	--	5.27	5.56
500	--	5.23	5.50

In evaluating materials it is advantageous to have conventional sources and rates to compare with the material in question. As shown by the pH response curve in Fig. 3 for rates of a conventional limestone source, the promoted limestone source applied at the same rate as the conventional source is no more effective than conventional aglime. The curve illustrates the amount of limestone, expressed as effective calcium carbonate equivalent (ECCE), required to obtain a change in soil pH.

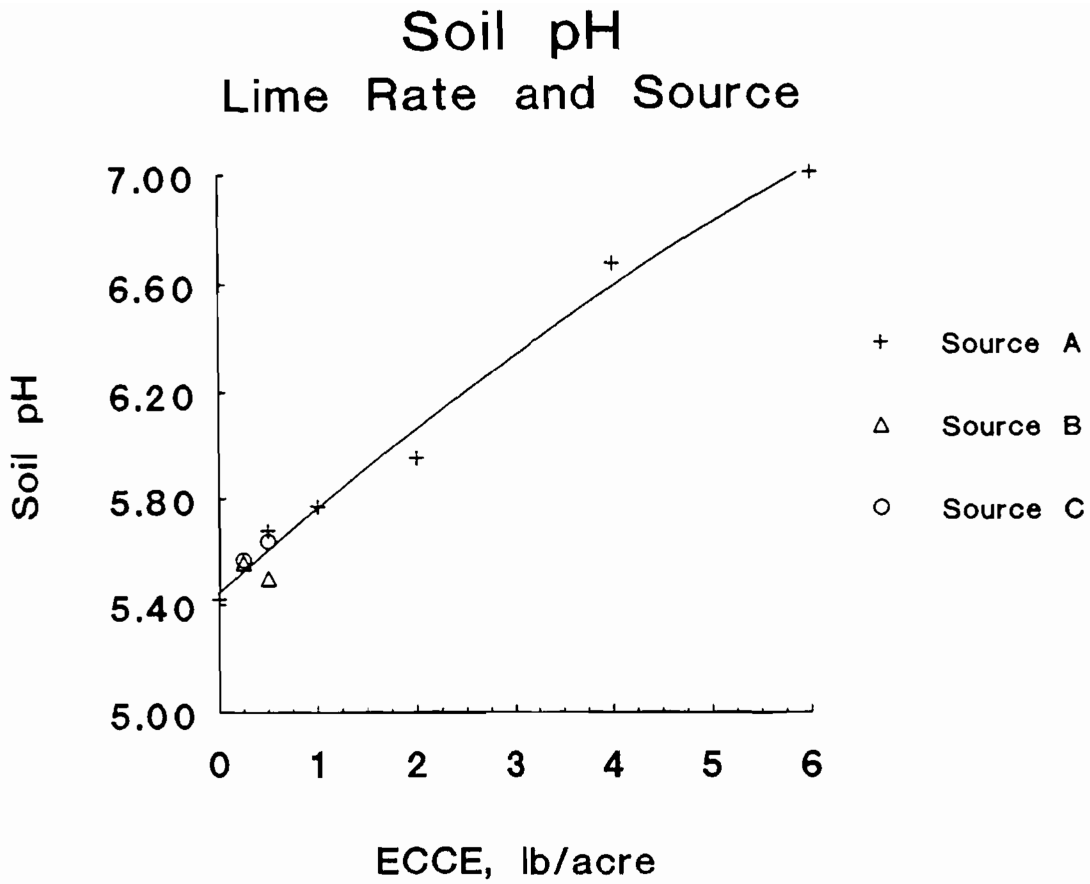

Fig. 3. Change in soil pH due to aglime source and rate in the 0-3 inch soil depth 2 years after application at Plymouth Co., IA. (Source A is conventional aglime with ECCE of 1460 lbs/ton; source B is pelletized limestone with ECCE of 1528 lbs/ton; and source C is fluid limestone with ECCE of 1868 lbs/ton.)

A misinterpretation that is commonly found in the media is that modern-day corn hybrids require more fertilizer nitrogen than hybrids of decades ago. A well replicated study using single cross hybrids made from inbreds representative of each era shows that today's hybrids simply yield more and that the yield increase due to nitrogen is very similar to that of hybrids of earlier eras (Table 7). This could be interpreted to mean that insufficient nitrogen was used in the early eras.

Table 7. Yield response to fertilizer N rates by single-cross hybrids made from inbreds of each era since 1950 (adapted form Carlone and Russell, 1987).

N rate	Era			
	'50	'60	'70	'80
lb/acre	- - - - - - - - - - - - bu/acre - - - - - - - - - - - -			
0	36	62	79	83
70	80	104	119	125
140	103	111	133	146
210	105	116	131	143

Data can be presented in a variety of ways, but it should be simple and be presented in such a manner to meet your objective. One idea I have used for small discussion size groups is to present data with some of the headings absent as shown in Tables 8 and 9. In a discussion of the principles involved the clientele arrive at the correct heading, but the discussion must be led.

Table 8. Corn yields for three methods (broadcast, dribble, inject) of application of urea ammonium nitrate solution to no-till corn (Bandel, Maryland, personal communication).

N Application Method	Location			
	A	B	C	D
	- - - - - - - - - - bu/acre - - - - - - - - - -			
---------------	99	120	136	160
---------------	120	157	150	177
---------------	124	168	156	179

Table 9. Corn yields for time (fall, spring, sidedress) of application of anhydrous ammonia (Gomes, 1982)

N Rate	Time of N Application		
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lb/acre	- - - - - - - - - - - - - bu/acre	- - - - - - - - - - - -	
40	120	87	102
100	138	129	138
160	152	145	143

SUMMARY

The educational process of transfer of information bears a deep sense of responsibility. This requires proper interpretation of the data, but it can only be accomplished by clear objectives, selection of proper treatments arranged in the proper design, measurements made to determine if the effect was due to treatment, and proper statistical treatment of the data. In the application of research results we should not get caught up in the "cult of the asterisk". Statistical significance is important but there is more to it than acceptance or rejection at the 0.05 and 0.01 significance levels.

We should never forget who reaps the consequences of our information transfer. It is of primary importance to be knowledgeable about our subject matter area and to know the principles involved. We must know why things happen or why they don't and not just rely on statistical tests of significance to support validity of treatment effects. It is as important to know about experiments that produced insignificant effects and why, as it is to know about the experiments that produced significant effects and not know why.

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