Interest continues to grow from agricultural stakeholders, academia, and the public about the environmental impacts from agriculture. Papers published to inform policy or position advocacy efforts garner media attention, but the media coverage often boils the topic down to a single headline and can lead the public and policymakers down an incomplete path. It may take more work, but going back to the original research paper can lead to better understanding. This article provides a few tips and items to look for to better interpret the science. Earn 0.5 CEUs in Nutrient Management by reading this article and taking the quiz at www.certifiedcropadviser.org/education/classroom/classes/728.

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Interest continues to grow from agricultural stakeholders, academia, and the public about the environmental impacts from agriculture and how agriculture achieves sustainability goals. Papers published to inform policy or position advocacy efforts garner media attention and are a common approach used today. Recently published papers gaining media favor include topics such as technology-forcing approaches to reduce nitrogen pollution from agriculture (Kanter and Searchinger, 2018), human health effects of growing corn with nitrogen fertilizer (Hill et al., 2019), the use of mobile sensing to estimate methane emissions from fertilizer production (Zhou et al., 2019). These papers explore pathways for agriculture’s environmental impact as well as actions to reduce emissions or loss. However, the media coverage often boils the topic...
down to a single headline and can lead the public and policymakers down an incomplete path.

While reading the originally published paper is a bit more work than just skimming the press release or media spin, incomplete understanding of the experimental design or the performed statistical analysis can lead to misinterpretation of the presented research article. Whether you are considering research results reported in the media or assessing new product performance data, here are a few tips and items to look for in the materials and methods, statistical analysis, and data presented.

How was the research designed?
In academic and on-farm research, there exist fundamental concepts of experimental design that will allow for more rigorous data collection and ultimately results that can be interpreted with more confidence. Replication and randomization are key concepts commonly included in studies to report treatment means, treatment averages across experimental units, and other statistical analyses. It should also be noted how the authors considered the physical organization of field plots or greenhouse pots, whether multiple measurements were taken from the sample location, or whether the ideal number of replicates were considered to allow for statistical power in the data interpretation.

Optimal project design will reduce experimental error and allow a researcher to compute desired statistical summaries of the data. A completely randomized design (CRD) is an experiment that includes randomly and independently assigned treatments to experimental units. A randomized complete block design (RCBD) includes all the components of a CRD design; however, blocks of replications are intentionally placed to ensure environmental variability does not overcome treatment difference when summarizing the data. Additionally, blocking may be useful in situations where fields have gradients of soil properties (texture for example), and it is desirable to minimize the effect texture has on the treatment comparison.

In the Materials and Methods section, you should also find a detailed description of the site, software, or calculations used to analyze the data. Comparing the site descriptions and beginning conditions of published work provides insight into how closely findings on your own acres may relate to the study. When reviewing work on economics or policy, it is important to look at the sources of data used, how recently they were published, and what references the calculations or policy recommendations are based on.

Was the inherent variability reported and discussed?
Every experimental site contains environmental conditions that may create variability in the data outside of what the researcher can control. This inherent variability is reported as experimental error, sometimes referred to as residual error, and is commonly shown in a table that describes the analysis of variance (ANOVA), which allows hypothesis testing and estimation variances of effects within linear models (McIntosh, 2015). It should be possible for a reader to trace discussions of significant findings in the Results sections of published literature to statistical summaries such as ANOVA tables. The use of summary
How strong are the relationships used to draw conclusions?

In many cases, a comparison of treatment means is accomplished by calculating the relationship between two measured variables, independent and dependent. The independent variable is the one changed during the experiment (for example, fertilizer rate or source), and the dependent variable is the one affected during the experiment (for example, plant growth or yield). Some comparisons are shown by plotting the independent variable (x-axis) and dependent variable (y-axis) in a graph that allows calculation of the relationship strength between the two variables. Commonly reported as an $r^2$ value with values ranging from −1.0 to 1.0, a larger value represents a strong positive relationship while a value close to −1.0 would represent a strong negative relationship. This relationship shows how much variation of the dependent variable is explained by the independent variable. Reported with an $r^2$ value for relationships or models that are fit to a set of data is a P-value. Simply put, P-values provide a better understanding of probability that a reported statistical relationship will be represented in other observed results. The smaller the probability (P-value), the stronger the experimental evidence that a set of treatments may have produced different responses. A threshold P-value of 0.05 is commonly used to identify significance; however, this should not be the only metric used to determine the accuracy of a result.

Examining the Kanter and Searchinger paper

Kanter and Searchinger (2018) proposed that one option for reducing nitrogen losses (including nitrous oxide, ammonia, and nitrate) from agriculture would be to increase the use of enhanced efficiency fertilizer (EEF) products through a regulatory approach similar to that imposed on automobile manufacturers to increase vehicle fuel efficiency [Corporate Average Fuel Economy (CAFE) standards]. The proposed creation of CAFE-like standards for nitrogen fertilizer producers aims to increase the nitrogen fertilizer tonnage produced with an EEF (nitrification inhibitor, urease inhibitor, a combination of both, or a slow-release fertilizer) product by a minimum of 30% by 2030 versus the cited 12% use in 2016 (Kanter and Searchinger, 2018). While there is research that demonstrates the ability of EEF-treated fertilizers to reduce $N_2O$ loss by as much as 32% (Eagle et al., 2017), details within the paper reveal that critical aspects necessary for EEF selection were not considered within the assumptions and calculations used to arrive at the concluded policy action. Rainfall, soil moisture, air temperature, and soil temperature can all impact the performance of nitrogen fertilizer treated with an EEF product (Barker and Sawyer, 2017; Eagle et al., 2017; Graham et al., 2018) and should be considered when assessing the environmental impact of EEF use.

Nitrous oxide losses

Nitrous oxide losses are highly sensitive to temperature. A recent meta-analysis reported that a 1°C change in average July temperature was equivalent to the difference in losses related to the use of nitrification inhibitors with higher losses as temperature increases (Eagle et al., 2017). Research conducted in Illinois through the 2015, 2016, and 2017 growing seasons compared three EEF nitrogen products to no N fertilizer and the standard practice of injecting anhydrous ammonia (Graham et al., 2018). Nitrous oxide emissions from the plots, which received the same rate of 180 lb N/acre, varied within and across years for the three products (Graham et al., 2018). For example, in 2015, UAN with nitrapyrin, a nitrification inhibitor, had significantly higher $N_2O$ emissions than SuperU, urea treated with nitrification and urease inhibitor products, but in 2016 and 2017, emissions from these two products were not statistically different (Graham et al., 2018). While reducing nitrogen losses is a component of farm management decisions, the crop response and potential return on the use of the product is also an important part of the evaluation. Yield response to the use of an EEF product also varied across the years of the project, with no difference across products in 2015 and 2017 but significantly lower yield with UAN with nitrapyrin in 2016 (Graham et al., 2018). The dependence of $N_2O$ loss and crop yield response on weather and soil conditions when a nitrogen fertilizer is treated with an EEF product would make it difficult to achieve the desired $N_2O$ emission reduction outcome using the Kanter and Searchinger (2018) proposed policy. Though the desire for a simple solution is applaudable, achieving the desired outcome is more complex than reducing losses through a single prac-
Ammonia losses

While the assumptions in the Kanter and Searchinger (2018) paper are focused on corn-producing states, EEF products are also tested and recommended in other cropping systems. Recent work in Montana compared the source, rate, and timing of nitrogen for no-till wheat production (Engel et al., 2017; Romero et al., 2017). The weather and soil conditions at the time of application affected ammonia (NH$_3$) loss from urea applications with or without NBPT, a urease inhibitor (Engel et al., 2017). The cumulative NH$_3$ loss, expressed as the percent of nitrogen applied, was highest when urea was applied in the late-fall and decreased with the winter application and was lowest with spring application (Engle et al., 2017). When NBPT was added to the urea applications at the three different timings, NH$_3$ emissions were decreased, with the lowest emissions again at the spring application. While timing and use of the NBPT both decreased NH$_3$ losses, changing to spring application of untreated urea had a larger decrease in losses than adding the urease inhibitor to the late-fall or winter applications (Engle et al., 2017). The only variables that impacted grain yield were year and rate of nitrogen—timing and addition of the urease inhibitor did not change grain yield (Romero et al., 2017).

Nitrate losses

Nitrate losses are a third pathway for nitrogen loss from crop production. A project in Iowa in 2013 and 2014 compared six EEF products all applied at the same rate (120 lb N/acre) to no nitrogen application across four sites with and without incorporation of the fertilizer (Barker and Sawyer, 2017). The project measured soil nitrate concentrations to examine the transformation of nitrogen fertilizer in the soil. There was no difference in grain yield, chlorophyll index, or soil nitrate concentrations among the six products tested or between the incorporated or surface-applied fertilizers (Barker and Sawyer, 2017). The authors reported that rainfall amount and timing reduced the potential for urea hydrolysis and volatilization from the surface and soil temperatures staying cool reduced the conversion of ammonium (NH$_4$) to nitrate in the soil. Similar to the results reported above, there is variable response of nitrate leaching concentrations to the use of EEFs, again largely related to local environmental conditions (Maaz, 2018). Part of the challenge in this area is the lack of studies that have measured nitrate leaching losses when EEFs are used.
Conclusions

Reducing nutrient losses and meeting sustainability goals is a big challenge, but considering the influence of environmental conditions on the amount and risk of loss is a key part of being successful. When interpreting research or reading papers on policy proposals, it is important to investigate the procedures, data, and references used to make conclusions. In the example given here, the concept of increasing the use of EEFs to reduce nitrogen losses is not out of line, but the assumptions used to calculate the impact leave out the conditions that are necessary for these products to be effective.

References


1. *Brassica carinata*, or Ethiopian mustard, derived from the interspecific cross between
   a. *B. nigra* and *B. oleracea*      c. *B. nigra* and *B. juncea*
   b. *B. rapa* and *B. nigra*      d. *B. oleracea* and *B. juncea*

2. The seed meal of carinata is high in protein and currently approved as feed for
   a. beef cattle.     c. swine.
   b. poultry.        d. aquaculture.

3. Which of the following states, to date, has carinata NOT been commercially contracted in?

4. Carinata pods are 1.5 to 2 inches long with 10 to 16 seeds per pod, and 1,000 seeds weigh
   a. 3.7 g.       c. 5.5 g.
   b. 4.2 g.       d. 5.9 g.

5. Agronomist Christine Bliss commented that carinata is ideal following which crop?
   a. Soy.       c. Peanut

6. The current commercial Agrisoma variety for the Southeast, *Avanza 641*, produces approximately
   a. 1,500 lb/ac.   c. 2,500 lb/ac.
   b. 2,300 lb/ac.   d. 2,800 lb/ac.

7. Florida Extension publication authors state that ____ deficiency at any stage will reduce yields.
   a. N   c. S
   b. P   d. K

8. The article discusses the importance of starting with a clean field. Which of the following herbicides was NOT mentioned?

9. Which insects are stated in the article as being problematic for carinata?
   a. Diamondback moth and yellow margined leaf beetle.
   b. Boll weevil and eriophyid mite.
   c. Yellow margined leaf beetle and boll weevil.
   d. Eriophyid mite and diamondback moth.

10. A net return chart in the Florida Extension publication shows a per-acre return range from a low of $87 to a high of ____ depending upon the year and conditions.
    a. $239     c. $327
    b. $275     d. $351

Digital Extra

The digital version of *Crops & Soils* magazine features exclusive articles not found in print. Here’s what’s new this issue:
- Newly certified
- Quantification of soybean leaf senescence and maturation as impacted by soil- and foliar-applied nitrogen