Power Analysis of Soil Measurements: Soil carbon and greenhouse gases

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WHAT IS POWER ANALYSIS?

- ❑ A statistical approach used to estimate the probability of statistically significant differences among experimental treatments.
- ❑ It can be done before (*ad-hoc*) or after (*post-hoc*) an experiment.
- ❑ To conduct power analysis it is necessary to:
  - Hypothesize a practically meaningful the difference between the treatment means.
  - Estimate the variances of particular experimental design. For *ad-hoc* power analysis the estimates of variances are assumed from published data from similar sites. For *post-hoc* power analysis the variances are calculated from measured data.
  - Specify the level of significance (i.e., α). Commonly used is $\alpha = 0.05$.
  - Calculate the power of detecting the hypothesized difference if it is indeed present or
  - Determine the number of samples (replications or sub-samples) needed for the experiment to have specific level of power.
- ❑ Commonly used power values are 80-90%
- ❑ The correct power analysis depends on:
  - ❑ Correctly hypothesized differences
  - ❑ Correct estimation of variances
  - ❑ Correctly conducted experiment
- ❑ Power calculations are specific to the statistical tests conducted

REFERENCES

- Kravchenko. A.N. and Robertson G.P. 2011. Whole-Profile soil carbon stocks: The danger of assuming too much from analyses of too little
- VandenBygaart, A.J., E.G Gregorich, and D.A. Angers. 2003. Influence of agricultural management on soil carbon: A compendium and assessment of Canadian studies. Can. J. Soil Sci. 83: 363-380.

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INTRODUCTION

Accurate estimates of soil carbon (C) and greenhouse gas (GHG) emissions are very important in agronomic and soil sciences. These measurements are highly variable, which makes detecting statistical differences due to land use and management systems difficult. It is a very common mistake to interpret a lack of statistical significance as evidence for an absence of difference (VandenBygaart et al., 2003). This mistake is costly in identifying the practices that effect the C-cycling or GHG flux fluctuations. Cover crop (CC) and tillage (till) management practices in corn fields are expected to have large impact on soil C and GHG emissions. The use of power analysis allows researchers to infer whether a lack of statistical significance, when it occurs, is due to absence of meaningful differences or due to a lack of a sufficient number of measurements and replications.

OBJECTIVES

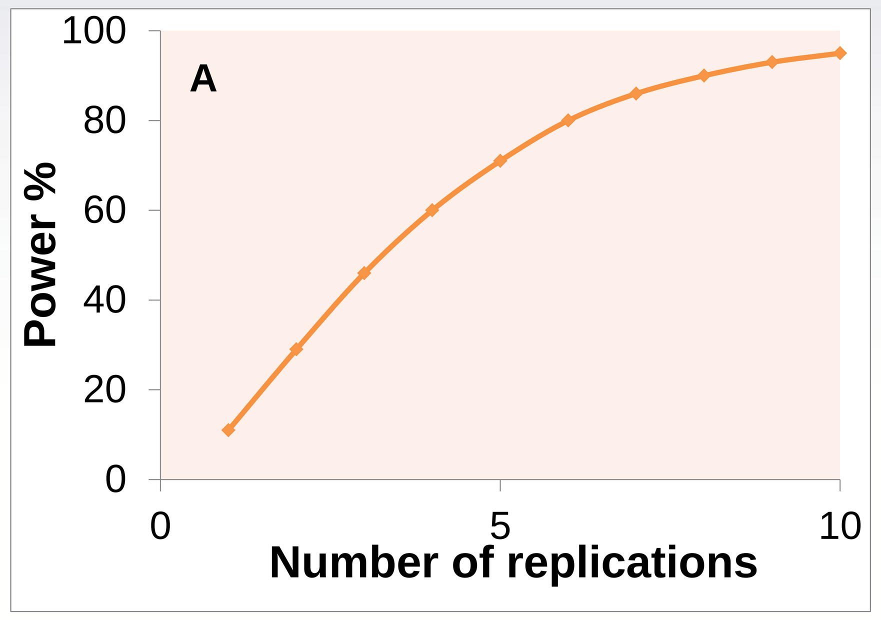
- ❑ To evaluate the utility of ad-hoc power analysis for soil C in Corn fields under CC and Till management.
- ❑ To estimate the number of replications needed to detect a significant difference in treatments
- ❑ To estimate the minimum detectable differences which can be statistically significant

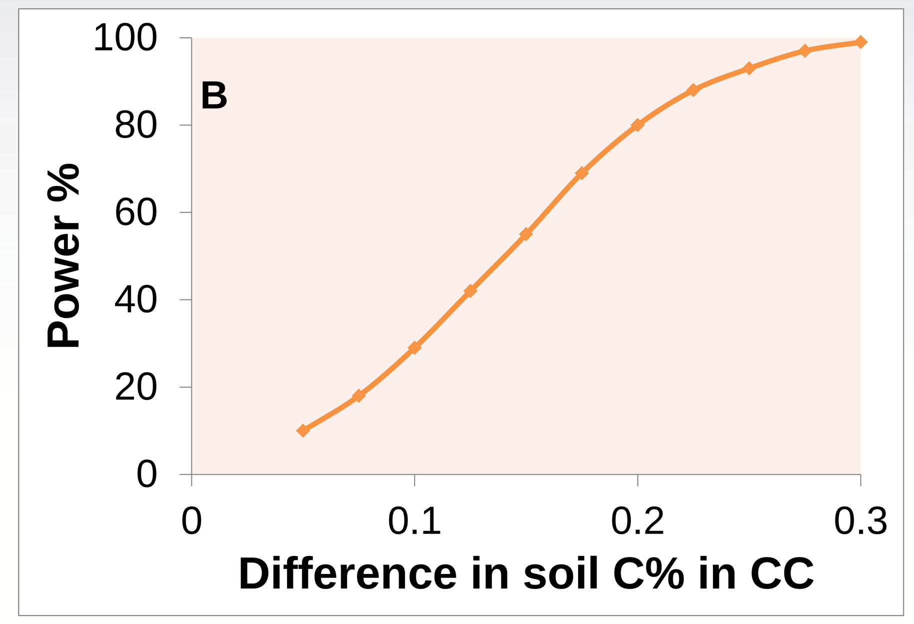
MATERIALS & METHODS

1. The data for this power illustration came from the CSCAP project study sites in Wisconsin (WI) and Michigan (MI)
2. The three study sites in WI are used to see the effect of tillage on soil C. We hypothesized that the conservation till will increase total C by 0.25% compared to conventional till
3. The two study sites in MI were used to examine the effect of CC treatment on soil C. We hypothesized that the CC treatment will increase total C by 0.20% compared to NCC
4. For CC we assumed the C mean is 0.9% while for NCC it is 1.1%. Similarly, for conventional till the total C is 1.50% and for conservation till it is 1.75%. These differences were chosen because the farmers can get C credit if they gain these differences in C sequestration
5. All sites have RCBD design with 6 replications.
6. The power analysis was performed using the step-by-step procedure outlined in Kravchenko and Robertson (2011).
7. The variances were estimated using previous data from these study sites.

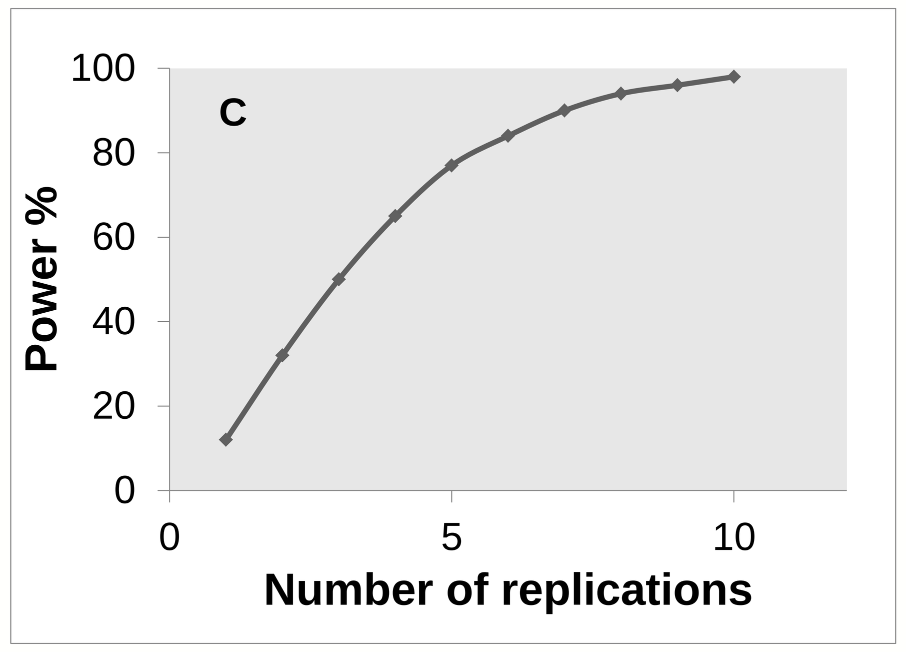
RESULTS & DISCUSSION

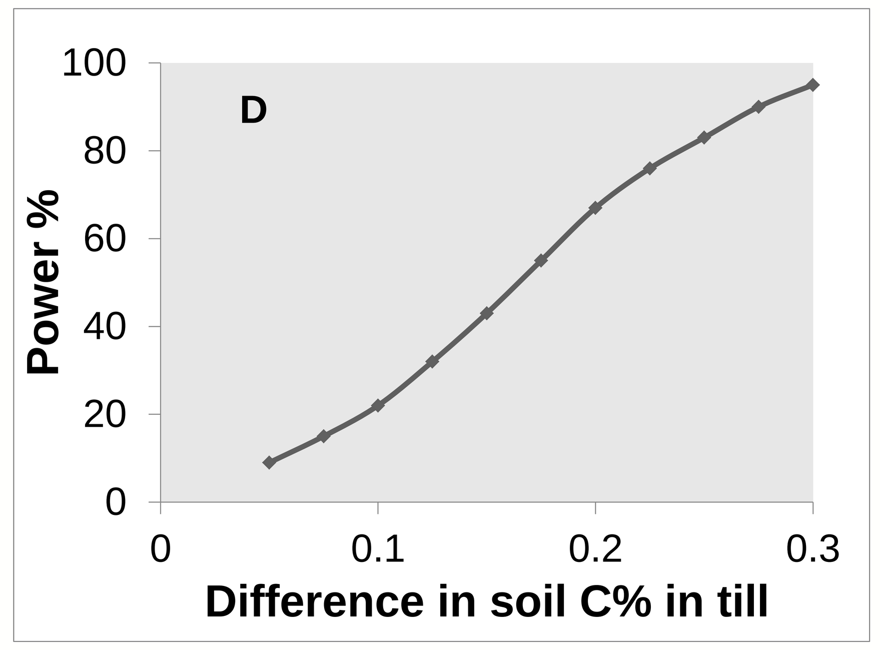
- ❑ With the existing number of replications of 6, the probability of finding significant differences in the CC treatment is 80% at the constant mean difference of 0.20% (Fig A).
- ❑ Similarly, in CC treatment, the 80% probability of finding significant differences (i.e., power level) is only possible if the treatment shows a difference of 0.20% in C as compared to NCC (Fig B).





- ❑ In Till treatment with the existing number of replications of 6, the probability of seeing the significant difference is 84% at the constant mean difference of 0.25% (Fig C).
- ❑ In the Till experiment the mean difference between conservation till and conventional till should be at least 0.25% to see a significant difference at 80% power (Fig D).
- ❑ The main sources of variation in these power estimations are the initial hypothesized mean differences in C.
- ❑ In this case, CC and conservation till increases the C sequestration with probability of 80% with the hypothesized mean differences and existing experimental set up. This information can help in choosing management practices to increase C sequestration.





CONCLUSION

Conclusions about absence of statistically significant differences among the studied treatments are meaningless without performing power analysis.

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