



## **IHARF On-Farm Research Guide & Data Analysis Tool (v1.1)**

Part of the Indian Head Agricultural Research Foundation's (IHARF) mission is to facilitate research and technology transfer activities for the benefit of both its members and the agricultural community at large. One way to help achieve this goal is to encourage growers to complete simple research experiments on their own farms and provide support to those who wish to do so.

The purpose of on-farm research is to test the success or failure of adopting new products or practices. Taking the time to properly implement simple experiments can be rewarding in numerous ways. If a product or practice is consistently successful in field trials, it can be adopted with confidence. Failure, on the other hand, allows growers to save time and/or money by rejecting the change prior to adopting it on the entire farm. Regardless of the outcome, on-farm research allows growers to assess what works and what does not on their own farms. Furthermore, initiating their own trials allows growers to have full control over the research that is completed and increases their understanding of the design, benefits and limitations of research.

The purpose of this guide is to provide growers and agronomists with some of the basic information required to properly conduct basic field experiments – complimenting it is an Excel spreadsheet, the IHARF Data Analysis Tool (v1.1), which allows growers to statistically analyze the results of their research with ease. While it is tempting to simply look at the overall grain yields of two treatments to conclude whether or not they differ, fields tend to be variable and proper analytical methods are essential. Careful experimental design and statistics allow us to determine with a certain degree of confidence whether an observed difference is due to a treatment effect or simply the result of naturally occurring variability. In addition, the effects of products or practices often vary by year and field – thus it is often necessary to replicate experiments in several different locations on the farm and for more than one growing season.

### ***I: Hypothesis Formulation***

The first step in conducting on-farm research is to reduce your research interests into simple, testable, questions, or hypothesis. In many cases, only two treatments will be required; one for which the treatment is applied and a control. The IHARF Data Analysis Tool (1.1) is designed to deal only with two treatment experiments. A few examples of different hypothesis and treatments which could be tested are:

**H1:** *Does applying foliar fungicide affect the yield of malting barley?*

**Treatments:** fungicide applied versus no fungicide applied

**H2:** *Does applying phosphate fertilizer affect grain yield?*

**Treatments:** phosphate fertilizer applied versus no phosphate fertilizer applied

**H3:** *Does straight-harvested canola yield differently from swathed canola?*

**Treatments:** straight-harvested versus swathed

**H4:** *Does applying pod-sealant affect the yield of straight-harvested canola?*

**Treatments:** pod-sealant applied versus no-pod sealant applied

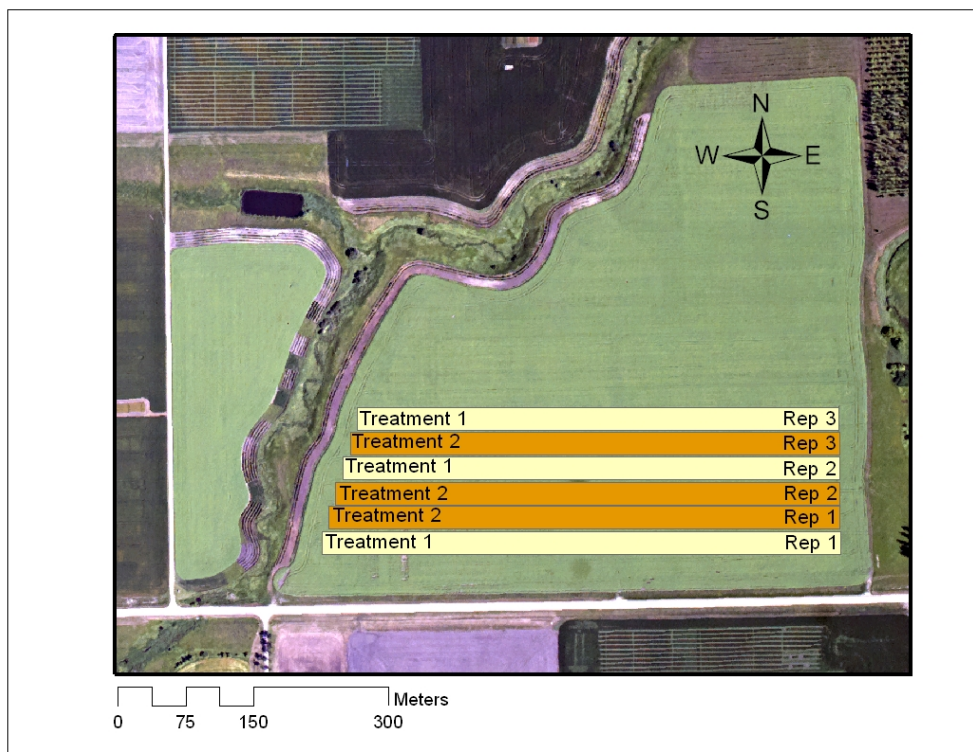
While studies H3 and H4 could conceivably be combined into a single experiment, we provide an example of how more complex experiments can be simplified to two treatments. Logistically, it may make sense to locate both studies in the same field, with H4 nested within the straight-harvested treatment of H3. The questions which may be asked are limitless; however, it is better to do a good job on fewer treatments or studies properly than a poor job on many.

## ***II: Choose an Experimental Design***

Which experimental design is most appropriate mainly depends on the product or practice being tested, the physical layout of the field and the amount of time that can be invested.

### **Randomized Complete Block Design (RCBD)**

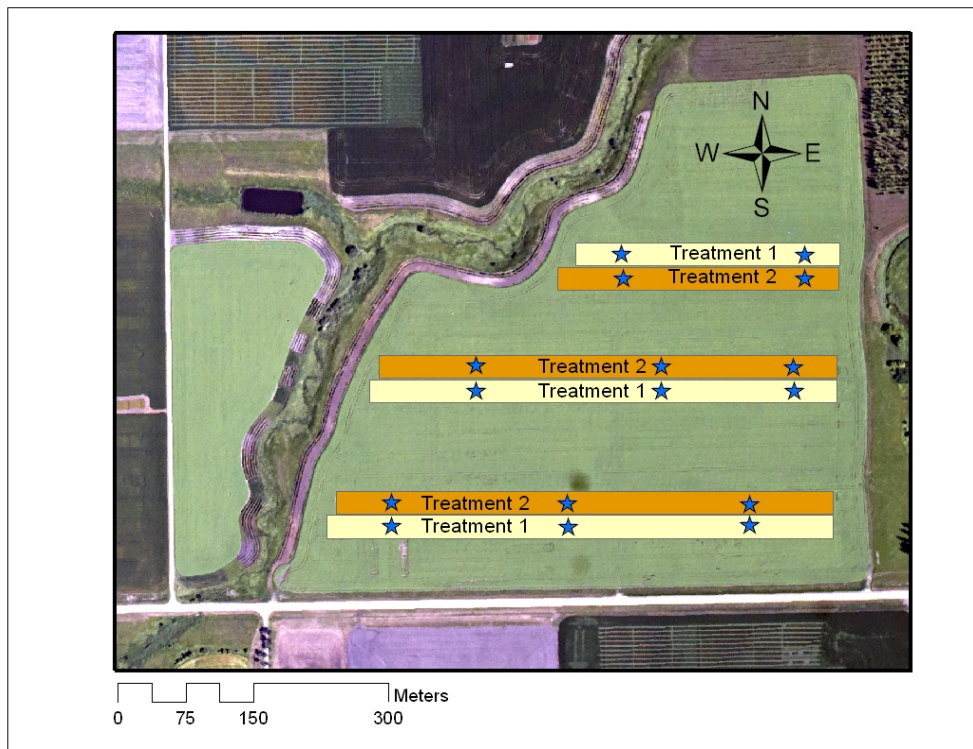
The most common experimental design in research is the Randomized Complete Block Design (RCBD). For this design, treatments are randomly arranged within separate strips of the field. The strips can be located in separate areas of the field, separate fields or even separate years provided that both treatments are represented in each strip. The RCBD accounts for some of the variability from one area of the field to the next, thus reducing the effects of spatial (or temporal) variability. While it is possible to include many treatments in an RCBD, the IHARF Data Analysis Tool (v1.1) can only accommodate two treatment experiments. If more treatments are necessary simply use the tool to compare all possible treatment pairs individually. Prepare field plans ahead of time if setting up an RCBD in a single field (Fig. 1) and arrange the treatments randomly within each strip. Use single values (i.e. mean yield) for each treatment within each strip.



**Fig. 1. Typical layout for an on-farm field trial with the treatments arranged in a Randomized Complete Block Design (RCBD).**

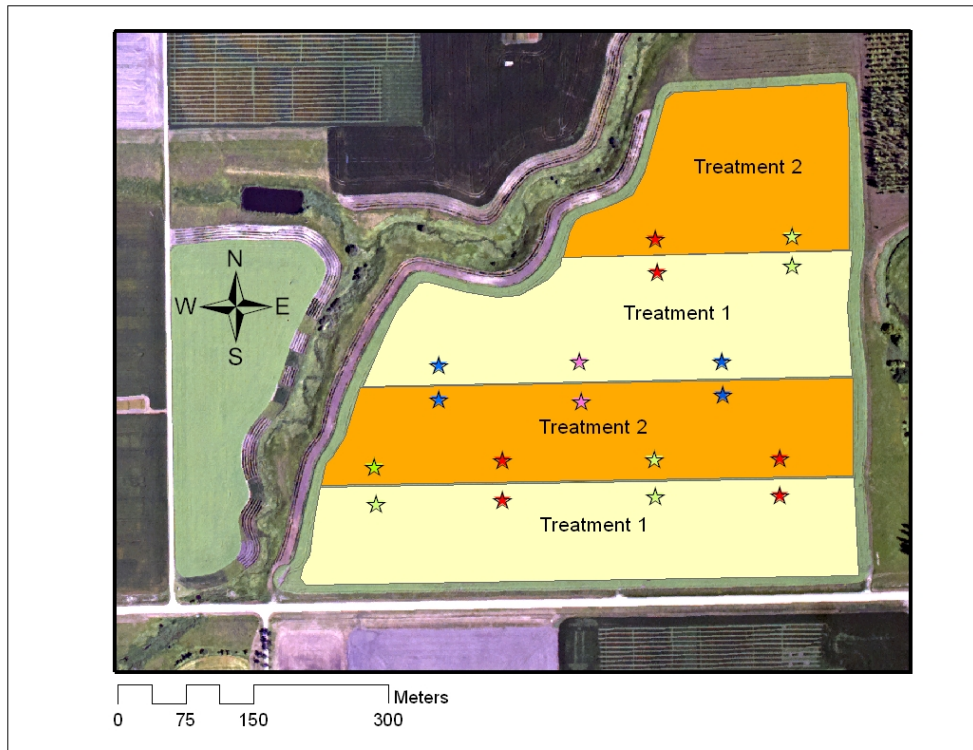
## Paired T-Test

For some experiments, it may not be practical to use an RCBD and an alternative, the paired T-test option, is also available in the Data Analysis Tool (v1.1). The paired T-test is more flexible than the RCBD with regard to how the treatments are arranged. Setting up an experiment for this type of analysis may be as simple as leaving a couple of check strips throughout your field/farm during application (Fig. 2) or splitting a field into two or more large blocks (Fig. 3). For this type of test, data are collected from each treatment at several similar locations and the treatments at each location are directly compared. The premise is simply that conditions at nearby locations are more likely to be similar than for locations spaced farther apart.



**Fig. 2. Possible layout for an on-farm field trial consisting of three check strips randomly located in the field. In this case, one of the two treatments would be no different from the rest of the field. The stars represent data collection points where the two treatments would be directly compared with on another in a paired T-test.**

The design illustrated in Fig. 2 would likely be most suitable for testing products such as foliar fungicides, topdressed fertilizer or pod-sealants. For fertility studies where separate nutrient rates are applied, how you set up your trial may depend on your equipment – if separate blends are required, then the design in Fig. 3 may be more appropriate than that in Fig. 2. Other examples of trials where it might make sense to use the design in Fig. 3 include harvest management studies comparing swathing with straight harvesting or studies that compare two separate cultivars or methods of fertilizer placement.



**Fig. 3.** Possible layout for an on-farm field trial when it is not practical to switch treatments from one pass to the next. The stars represent data collection points where the two treatments would be directly compared with on another in a paired T-test.

### **III: Implementation and Data Collection**

The following are a few general guidelines to consider when planning and carrying out your experiment.

#### **Location**

Always locate trials in representative areas of the field and try to choose fields that are most representative of the farm. For either of the two analysis methods provided in the Data Analysis Tool (1.1), observations from multiple fields and years can be combined. It is generally preferred to avoid field edges and other non-representative locations such as headlands, previous yard sites, old fencelines, saline areas, etc.

#### **Replication**

Increasing the number of times each treatment is replicated raises the experiment's power of detecting differences between the treatments. A minimum of three replications is recommended and, as previously mentioned, data from different fields or years may be combined to increase replication. When the paired T-test is used, the number of replicates can be increased by simply increasing the number of pairs; however it is desirable to include more than one check strip in each field and the location of the strips should be chosen carefully.

#### **Avoid Systematic Error**

Be sure to treat both treatments the same in every respect except for the factor being tested. For instance, for experiments involving post-emergent fungicide or topdressed fertilizer applications, this may mean driving over the untreated area with the booms off

to equalize the effects of wheel tracks. If testing two different rates of fertilizer, the rates of all nutrients except that which being tested should be held constant, which might require preparing a separate blend ahead of time depending on equipment configuration.

### **Plot Size**

The width of each plot, or pass, will be a multiple of the piece of equipment used to apply the treatment. Make each pass at least two times the width of the swather or combine which will be used for the field to ensure one harvest pass entirely within the plot.

The plot length will often be the entire length of the field but does not have to be so. Depending on whether you are measuring grain yield with a yield monitor or a weigh wagon, you would not necessarily use yield data from the entire length of the pass.

### **Locating Treatments**

It is essential that the treatments can be located at harvest time and, if using yield monitor data, identified on the yield map. For weigh wagons, flags or stakes and a corresponding field plan and datasheet may be sufficient; however, make sure the flags are tall enough to not be hidden when the crop is mature and check them periodically to ensure they remain standing. Global Positioning System (GPS) coordinates that can be superimposed over the yield map are strongly recommended if using yield monitor data. The GPS locations can be recorded as-applied maps from the implement used to apply the treatments, handheld GPS locations, or by physically flagging the treatments then electronically doing so during the harvest operation. Always have a field plan so that you have a record of which treatments correspond to which physical markers (or GPS locations). Trials should ideally be harvested using a single machine and it is important for yield monitoring equipment to be properly calibrated.

### **Data Collection**

Data collection should be completed as systematically as possible and without bias. If using the paired T-test, select the sampling locations from random locations along the pass or passes. Generic data sheets which can be printed off and used to record your data and general observations are provided in Appendix A.

## ***IV: Data Analysis and Interpretation***

The IHARF Data Analysis Tool (v1.1) has two separate options for analyzing data and the statistics that are produced vary depending on the method that is chosen. Screenshots of the two worksheets appear in Appendix B and detailed instructions for entering data are provided directly in the spreadsheet.

### **Method #1 – Paired T-Test**

1. Transfer data from worksheets or directly from yield maps into the appropriate cells of the “Observations” table.
2. Look at the overall mean difference between the two treatments and the corresponding p-value. The p-value is an indication of the probability that an observed difference was due to random variability, or chance, as opposed to a treatment effect (a p-value of 0.1 means that there is 10% probability that the observed difference was due to chance and not the treatment). The lower the p-value, the more confident we are that an observed difference was a result of the treatment effect. For most scientific experiments, the p-value must be lower than 0.05 to be

considered significant; however, 0.1 can also be used and is sometimes recommended for landscape-scale experiments. A p-value of 0.1 is certainly worth taking note of, but the experiment should probably be repeated the following year. Descriptive statistics including the means, standard deviations and 95% confidence intervals are also reported in the results table for the Paired T-test option.

#### **Method #2: Randomized Complete Block Design (RCBD)**

1. Transfer data from worksheets or directly from yield maps into the appropriate cells of the “Observations” table.
2. Compare the observed difference between treatments with the least significant difference (LSD) at the desired probability level ( $P=0.05$  or  $P=0.10$ ). If the observed difference is larger than the LSD, it is considered significant – if the observed difference is smaller than the LSD, conclude that there was no difference between the treatments. Descriptive statistics include the overall mean and standard deviation as well as the treatment means.

#### ***V: Summary & Disclaimer***

The purposes of this document and the IHARF Data Analysis Tool are to serve as aids to growers who wish to conduct on-farm research trials. Feedback from anybody who uses this information is encouraged and will be considered for updated versions. Comments should be forwarded to Chris Holzapfel (Email: [chris.holzapfel@agr.gc.ca](mailto:chris.holzapfel@agr.gc.ca)). Both this document and the Data Analysis Tool may be updated in the future so check periodically to ensure that you have the most recent version ([www.iharf.ca](http://www.iharf.ca)).

The Indian Head Agricultural Research Foundation (IHARF) accepts no responsibility for the use of this spreadsheet and assumes no responsibility or liability for any errors, inaccuracies, or omissions. The user accepts all responsibility for results and interpretations arising from this tool and use of these materials constitutes full acceptance and understanding of these disclaimers.

**Appendix A: Generic Data Collection Sheets**

Year: \_\_\_\_\_

Study Name: \_\_\_\_\_

Treatment 1 Name: \_\_\_\_\_


Treatment 2 Name: \_\_\_\_\_

Data Collection: \_\_\_\_\_

<b>Rep / Pair</b>	<b>Treatment 1</b>	<b>Treatment 2</b>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

**NOTES:**

**Appendix B: IHARF Data Analysis Tool (v1.1) Screen-Shots**



**On-Farm Research – Data Analysis Tool (v1.1): Paired T-test**

Study: Canola Fungicide      Year: 2008      Measurement: Grain Yield

Observations (Inputs)			
Pair #	Treatment		Difference
	1	2	(1-2)
1	1543	1544	-1
2	1576	1650	-74
3	1500	2100	-600
4	1740	1890	-150
5	1567	1798	-231
6	1700	1600	100
7	1590	1680	-90
8	1456	1789	-333
9	1621	1680	-59
10	1570	1976	-406
11			0
12			0
13			0
14			0
15			0
16			0
17			0
18			0
19			0
20			0
21			0
22			0
23			0
24			0

Results (Outputs)		
Statistic	Treatment	
	1	2
<i>n</i> (# of samples)	10	10
<i>Mean</i>	1586.3	1770.7
<i>Standard Deviation</i>	84.9	175.6
<i>95% Confidence Interval</i>	52.6	108.8
<b>Paired T-test</b>		
<b>p-value<sup>z</sup></b>		
Mean difference (1-2)	-184.4	
Probability > T	0.022	

Notes:

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Questions or Feedback?      [Email: chris.holzapfel@agr.gc.ca](mailto:chris.holzapfel@agr.gc.ca)      Phone: (306) 695-4200

**Fig. 4. Screen-shot of IHARF Data Analysis Tool (v1.1) Paired T-Test worksheet.**





**On-Farm Research - Data Analysis Tool (v1.1): Randomized Complete Block Design (RCBD)**

Study: Canola Fungicide      Year: 2008      Measurement: Grain Yield

Observations (Inputs)		
Treatment		
Rep#	1	2
1	1974	2123
2	2340	1900
3		
4		
5	1745	2000
6		

Results (Outputs)			
# of Plots	6		
# of Reps	3		
Overall Average	2013.7		
Overall Std. Dev.	202.6		
Means Comparison			
Treatment	1	2	Difference
Mean	2019.67	2007.67	<b>12.0</b>
LSD (P = 0.05)	809.1		
LSD (P = 0.10)	549.4		

Notes \_\_\_\_\_  
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Figure 5. Screen-shot of IHARF Data Analysis Tool (v1.1) Randomized Complete Block Design (RCBD) worksheet.