Special Topic

APPLICAL, RANDOMA, and MULTSTAT—Three Microcomputer Utilities for Managing Field Trial Experiments

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Evaluation of treatments in field trials is an important activity for many plant pathologists, agronomists, weed scientists, entomologists, and horticulturists. At any one time, a scientist may have several experiments, each consisting of many treatments. The time spent in paperwork for the setup and analysis of each experiment can be considerable. Although computer software has been available for management of such information (e.g., Pesticide Data Management Program, Micro Simplified, Inc., Indianapolis, IN), we found no single set of programs with the capacities and simplicity to suit our needs for the setup and analysis of uncomplicated experiments. Therefore, three programs were developed at Ohio State University to handle activities common to many field and greenhouse trials. APPLICAL is used to calculate chemical mix rates for spray trials and generate application rate summaries. RANDOMA generates randomizations for assignment of treatments to plots in experiments of completely randomized or randomized complete block design. MULTSTAT generates one-way and two-way ANOVA tables, Bartlett's test for homogeneity of treatment variances, and two types of multiple comparison analyses: Duncan's new multiple range test (2) and the Waller-Duncan k-ratio t test (3).

The three programs were written and compiled with Turbo Pascal version 5.0 (Borland International, Scotts Valley, CA) for IBM (IBM Corporation, Boca Raton, FL) or IBM-compatible computers with at least one disk drive. The programs require DOS 2.0 or higher and at least 256 kilobytes of random access memory. All three programs will work with standard text or graphics monitors. A printer is desirable but not essential.

APPLICAL, a utility for calculating spray rates

APPLICAL was designed to aid researchers in calculating spray rates for testing of fungicides, insecticides, herbicides, etc. APPLICAL can be configured to work in units of measure most commonly used for spray trials (Table 1). For example, the application rate can be specified in ounces of product per acre and the resultant mix units expressed as grams of product per milliliter of carrier or diluent (e.g., water). APPLICAL also has the ability to express application rates as amount of product or active ingredient per 1,000 ft^2, a convention widely used in the turfgrass industry. Any configuration can be saved in a disk file, allowing the program to be customized.

The program calculates the amount of product and carrier needed in the mix for each treatment. Calculations are determined from the user-specified plot size, number of replications, amount of carrier, formulation, and application rate (Table 2). APPLICAL can be instructed to increase the carrier amount to a convenient user-specified volume.

Calculations from APPLICAL are shown on the computer monitor (Table 3). In addition, the user can assign names to the experiment and the individual treatments, and a summary can be sent to a printer (Table 4) or to a computer disk as a standard ASCII file for further modification with word processor software.

RANDOMA, a utility for generating randomizations

A common task in setting up field or greenhouse experiments is the randomization of treatments among experimental units. Customary techniques for obtaining random numbers include drawing numbered objects from a container or referring to a table of random numbers (6).

RANDOMA is a program designed to simplify the task

Table 1. Units of measurement available for use in APPLICAL

Plot area	Carrier	Container	Active ingredient and dry product	Liquid product
ft^2	gal/1,000 ft^2	ml	oz	fl oz
m^2	L/1,000 ft^2	L	lb	gal
1,000 ft^2	gal/acre	pt	g	ml
acre	L/ha	gal	kg	L
ha				

Table 2. APPLICAL menu for modification of spray trial parameters[a]

Parameter	Amount	Units
1 Number of plots per treatment	4	
2 Plot area	16.0	sq ft
3 Amount of carrier	3.0	gal/1,000 ft^2
4 Maximum capacity of spray container	1,800.0	ml
5 Round up spray volume	100	ml

Q NO MORE CHANGES

Choose a selection ?

[a] Selection of options allows the current parameters to be changed to suit the experiment. This example is appropriate for setting up a demonstration trial for chemical evaluation on small turfgrass plots.

Table 3. APPLICAL results for hypothetical chemical and spray trial setup[a]

Formulation: Liquid 2.00 lb a.i./gal, 239.88 gm a.i./L

Application rate
0.500 oz a.i./1,000 ft^2
2.000 fl oz product/1,000 ft^2
0.032 fl oz product/plot

Product	Carrier	Number of plots
3.78 ml	726.7 ml	4
4.17 ml	800.0 ml	4.40

[a] In this example, APPLICAL determined that 3.78 ml of product should be added to 726.7 ml of carrier to cover four plots. If the carrier amount is increased to the nearest whole 100 ml, the amount of product to use is 4.17 ml, sufficient for 4.40 plots.

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Table 4. Portion of a typical spray mix prescription produced by APPLICAL for a field evaluation of turf fungicides for treatment of Bipolaris/Drechslera leaf spot

Treatment Formulation	a.i./ 1,000 ft^2	Product/ 1,000 ft^2	Product/ 800 ml for 4.4 plots	Interval
1. CHIPCO 26019 2F 2.00 lb a.i./gal	0.50 oz	2.00 fl oz	4.2 ml	21 days
2. CHIPCO 26019 50WP 50.00% a.i.	1.00 oz	2.00 oz	4.5 gm	21 days

Table 5. Sample run for acquisition of random numbers from RANDOMA for a six-treatment experiment with five replications per treatment

```
Number of treatments   ? 6
Number of replications ? 5

Randomizing replications . . .

Replication number
1   2   3   4   5
5   6   4   1   5
3   1   6   5   4
1   2   5   4   2
4   4   3   2   6
2   5   2   3   3
6   3   1   6   1
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Table 6. Sample analysis by MULTSTAT of disease severity ratings from a fungicide trial for control of Bipolaris/Drechslera leaf spot

<table>
<tr><th colspan="10">Waller-Duncan k-ratio (LSD) test—completely random design</th></tr>
<tr><th>No. treatment (LSD = 16.8100)</th><th>Mean</th><th colspan="8">Group</th></tr>
<tr><td>13 SDS 66518</td><td>13.00</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>15 PRCL. CR17217 (1.88 a.i.)</td><td>16.00</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12 DCNL 500F (3.13 a.i.)</td><td>17.25</td><td>|</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>14 DCNL 90DF</td><td>22.25</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11 DCNL 500F (1.56 a.i.)</td><td>23.00</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10 SN 832 (2.5 a.i.)</td><td>23.50</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3 VRLN (0.5 a.i.)</td><td>24.75</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>16 PRCL. CR17217 (1.25 a.i.)</td><td>28.00</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>19 CHECK—No N</td><td>28.75</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>2 FNG-VRLN (0.5 a.i.)</td><td>29.50</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>1 FNG-VRLN (0.25 a.i.)</td><td>29.50</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>9 SN 832 (1.5 a.i.)</td><td>34.00</td><td></td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td></tr>
<tr><td>18 CHECK—2 lb N</td><td>37.50</td><td></td><td></td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td></tr>
<tr><td>5 SN 619 (0.07 a.i.)</td><td>38.50</td><td></td><td></td><td>|</td><td>|</td><td>|</td><td>|</td><td></td><td></td></tr>
<tr><td>4 CHPC 2FL (0.5 a.i.)</td><td>39.50</td><td></td><td></td><td></td><td>|</td><td>|</td><td>|</td><td>|</td><td></td></tr>
<tr><td>6 SN 619 (0.1 a.i.)</td><td>41.50</td><td></td><td></td><td></td><td></td><td>|</td><td>|</td><td>|</td><td></td></tr>
<tr><td>17 PRCL CR18742</td><td>48.25</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td>|</td><td></td></tr>
<tr><td>7 SN 619 (0.1 a.i.—28 days)</td><td>48.50</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td>|</td><td></td></tr>
<tr><td>20 CHECK—3 lb N</td><td>56.00</td><td></td><td></td><td></td><td></td><td></td><td></td><td>|</td><td>|</td></tr>
<tr><td>8 SN 619 (0.13 a.i.)</td><td>70.50</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>|</td></tr>
</table>

Means followed by the same line are not significantly different ($k = 100$).

Analysis of variance—randomized complete block design

Source of variation	df	SS	MS	*F*
Blocks	3	1319.037	439.679	3.350**
Treatments	19	15791.237	831.117	6.333**
Error	57	7479.712	131.223	
Total	79	24589.987		

**Significant at $P = 0.01$.

Bartlett's test for homogeneity of treatment variances: Calculated value 21.1121, tabular value 30.14 at $P = 0.05$. → Accept hypothesis that treatment variances are homogeneous.

of acquiring random numbers for any number of blocks or treatments. The program utilizes a seed number from the internal clock of the computer for initialization of the random number generator. Thus, each new randomization is, for practical purposes, unique. The user, in response to the computer prompt, enters the number of treatments and number of replications and receives the randomization (Table 5). Reading the table across the columns results in a completely randomized design. Reading the table down the columns results in a randomized complete block design.

MULTSTAT, a program for analyzing data in simple experiments

Use of MULTSTAT is appropriate for situations where the experimental design is simple (completely random or randomized complete block design) and no data are missing. Data can be entered by keyboard or from a DOS text file on disk. Data can be edited within the program and saved in a disk file. MULTSTAT generates one-way or two-way analyses of variance and two types of multiple comparisons of means: Duncan's new multiple range test (2) and the Waller-Duncan k-ratio t test (1,3). Of the two, the k-ratio t test is generally more desirable because Duncan's new multiple range test has a higher rate of type II errors (4). Assessment of the appropriateness of multiple range procedures in a given situation is left to the user (4).

MULTSTAT computes Bartlett's test for homogeneity of treatment variances as a guide as to whether a pooled error should be used to compare treatment means. Five types of transformation—arcsin(sqrt(x)), sqrt(x), sqrt($x + 0.5$), log(x), and log($x + 1$)—are available for stabilization of treatment variances. MULTSTAT can accommodate at least 50 treatments with at least 10 replications.

Table 6 shows the results from a sample analysis by MULTSTAT. In all tests to date, MULTSTAT has produced results identical with those obtained by the ANOVA and multiple comparison procedures of the mainframe statistical package SAS, Release 5.18 GLM (5).

MULTSTAT has its limitations. Complicated statistical designs or experiments with missing data cannot be analyzed with the current version of MULTSTAT. The advantages of MULTSTAT are that only a microcomputer is needed, and the program offers both the Bartlett and the Waller-Duncan statistical tests, which are not generally available in low-cost statistical packages for microcomputers.

Summary

APPLICAL, RANDOMA, and MULTSTAT have been very valuable in the setup and analysis of field and greenhouse experiments at Ohio State University. Inexperienced computer users have been able to use all three programs successfully with very little instruction. The programs execute quickly on a standard IBM XT—less than 2 sec for APPLICAL and RANDOMA, less than 10 sec for MULTSTAT, using a moderate-sized data set (25 treatments, four replications) and excluding printing time.

The three utility programs and user guide can be obtained by sending a 5.25-in. diskette and mailing envelope to the first author.

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