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ANALYSIS OF FACTORIAL EXPERIMENTS FOR AGRICULTURAL RESEARCH USING DIGITAL TOOL

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ABSTRACT

Factorial experiments involve simultaneously more than one factors and each factor is at two or more levels. Several factors affect simultaneously the characteristic under study in factorial experiments and the researcher is interested in the main effects and the interaction effects among different factors. Digital tool is transforming institutions, learning processes and creating innervates systems. Nowadays digital tool has become a powerful tool to carry out empirical investigation, collection of qualitative and quantitative data for further analysis. Digital tool namely SPSS is a widely used for analysis of factorial experiments for agricultural research like Factorial CRD and Factorial RBD and also for illustration purposes in the classroom teaching as well as for the researchers with interest in factorial experimental designs. The present study will be useful for researchers to know the analysis of factorial experiments for agricultural research using digital tool.

Keywords*: factorial experiments, digital tool, spss, factorial crd, factorial RBD*

INTRODUCTION

In agricultural research, factorial experiments has two or more factors, each with distinct possible levels and whose experimental units take on all possible combinations of these levels across all such factors. Such a research allows the researcher to study the effect of each factor on the dependent variable, as well as the effects of interactions between factors on the dependent variable. For the majority of factorial experiments, each factor has only two levels. Suppose in 2^2 factorial experiments, we have two factors each at two levels, a factorial experiment would have four treatment combinations in total, and is usually called a 2×2 factorial design. In factorial experiments, the interaction between the factors is often the most significant. This applies even to situations where a main effect and an interaction are there. Factorial designs were used in the 19th century by John Bennet Lawes and Joseph Henry Gilbert of the Rothamsted Experimental Station (Yates and Mather, 2009). Fisher, (١٩٢٦) argued in 1926 that "complex" designs such as factorial designs were more efficient than studying one factor at a time. Fisher wrote, "No aphorism is more frequently repeated in connection with field trials, than that we must ask Nature few questions, or, ideally, one question, at a time. The writer is convinced that this view is wholly mistaken." Oehlert, (2000) and Montgomery, (2013) examined the effect of only a single factor or variable. Compared to such one-factor-at-a-time (OFAT) experiments, factorial experiments offer several advantages. The digital tool in this era of globalization has accentuated new modes of knowledge transformation and communication patterns (Parmar, 2016). Digital tool has opened up uncommon opportunities for developing countries in terms of providing low cost access to information. This is the fastest growing tool of communication. Digital tool is transforming institutions, learning processes and creating innervates systems. Nowadays digital tool has become a powerful tool to carry out empirical investigation, collection of qualitative and quantitative data for further analysis. Eliciting reliable data facilitates planning process to be more systematic. Whereas, monitoring and evaluation exercises throw better insights into the functioning of the schemes/ programmes at every stage. In this context, use of digital tool like SPSS will aid the end-user to infer the results in a simple and orderly manner to make quick decisions. The present study will be useful for researchers to know the analysis of factorial experiments for agricultural research using digital tool.

OBJECTIVE

To know the analysis of factorial experiments for agricultural research using digital tool SPSS

METHODOLOGY

Statistical package for the social sciences (SPSS) is the set of modules that are combined together in a single digital tool. SPSS is proprietary digital tool. The basic application of this digital tool is to analyze experimental data

related with the agricultural science. This digital tool can be used for agricultural research, surveys, data mining, etc. User need to import raw data into digital tool SPSS through excel file. Once user imports the data, the SPSS will analyse it. Based on what user want to study, user can give desired commands as per the requisitions in the SPSS tool. SPSS is a sophisticated digital tool originally designed to support analysis and management of experimental data. Factorial ANOVA allows the researcher to test the effectives of two independent factors; hence, this method is called Two-Way ANOVA. Researcher can simultaneously assess the effects of two or more independent factors on a single dependent variable within the same analysis. Factorial ANOVA also allows the researcher to determine the possible combined effects of the independent factors. In two-way ANOVA generates three F-values: one to test the main effects of each factor, and a third to test the combined effect of the two factors. In the two-way ANOVA, four different sets of contributors would be required. If the first factor is Nitrogen and the second factor is Varieties, four combinations would be required to permit a factorial ANOVA (Table 1).

Table 1: Factorial combination of nitrogen and varieties

Nitrogen Varieties	n_o	n_1
p_0	$n_o p_0$	$n_1 p_0$
p_1	$n_o p_1$	$n_1 p_0$

This factorial combination will allow us to compare the n_o vs. n_1 (Nitrogen) and p_0 vs. p_1 (Varieties) on a given dependent variable. This would be the same as if we did two separate studies and conducted two t-tests (one comparing the n_o vs. n_1, and one comparing p_0 vs. p_1). But it would be more economical and efficient, because we would get the same information from one study and one analysis (the 2 x 2 ANOVA). What is crucial to the factorial combination of these two independent variables is that we are also able to assess the possible interaction effect of the two independent variables combined. If $p < .05$ for the main effect of a particular factor then there is a significant effect for that factor. The interpretation of the interaction effect is more complex. If the F-value of the interaction effect is not significant (i.e., $p > .05$), then our conclusion would be that nitrogen differences in varieties did not depend on the level of varieties. If the F-value for the interaction *is* significant ($p < .05$), then we would conclude that nitrogen differences in varieties depend on the level of varieties.

RESULTS AND DISCUSSION

Suppose an experiment was conducted by using factorial RBD with the following details.

Factor	Level
Sowing Dates (S)	s_1,s_2 and s_3
Doses of Nitrogen (N)	n_o,n_1,n_2 and n_3

Procedure for Factorial Design using digital tool SPSS as under:

1 Row data :

Treatment Combination	Replication					
	I	II	III	IV	V	VI
s_1n_0	8.3	10.3	8.0	8.0	6.0	8.5
s_1n_1	9.3	9.0	9.5	11.7	11.3	10.7
s_1n_2	11.3	11.5	11.3	11.7	14.7	15.0
s_1n_3	10.5	15.7	10.5	11.7	10.3	15.0
s_2n_0	5.7	4.5	8.3	8.5	5.3	4.3
s_2n_1	4.7	5.3	8.0	9.3	5.3	6.7
s_2n_2	5.3	5.5	8.0	8.7	8.5	11.3
s_2n_3	6.5	8.3	8.0	9.0	6.3	8.5
s_3n_0	5.0	4.7	1.5	3.0	3.7	4.5
s_3n_1	7.0	8.3	2.5	3.5	6.7	4.5
s_3n_2	3.3	3.3	2.5	1.0	6.3	8.0
s_3n_3	2.7	4.3	1.3	2.5	4.0	7.7

Data Arrangement in SPSS Data Editor Window

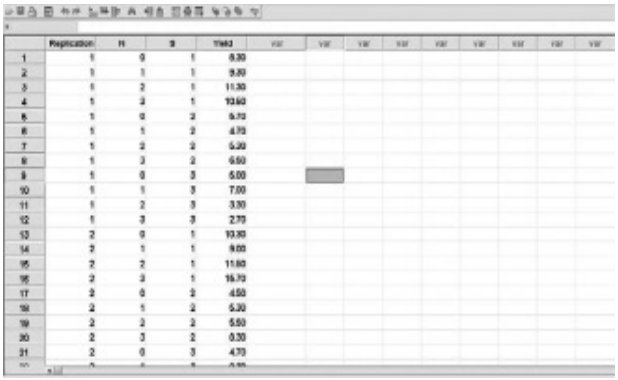

Fig. 1: SPSS data editor window

(1) Open your Two_Factor_RBD.sav file and select Analyze, General Linear Model, Univariate... from the menu

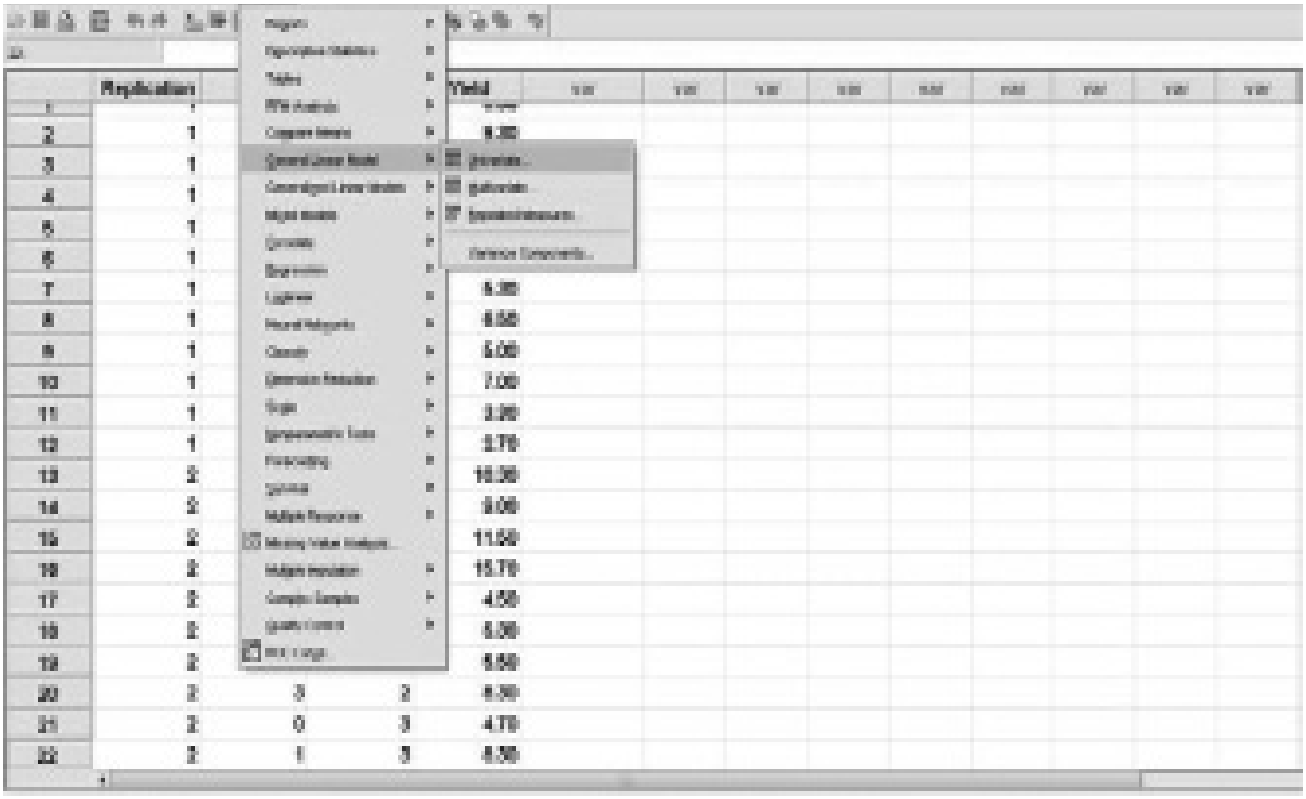

Fig. 2: SPSS "Analyze" menu

A Univariate dialog window will appear (Fig.3). In the left pane, scroll all the way down and select Yield, then move it to the Dependent Variable: box on the right. Next, in the pane on the left, select Replication, Nitrogen (N) and Date of Sowing (S) and move them to the Fixed Factor(s) pane on the right.

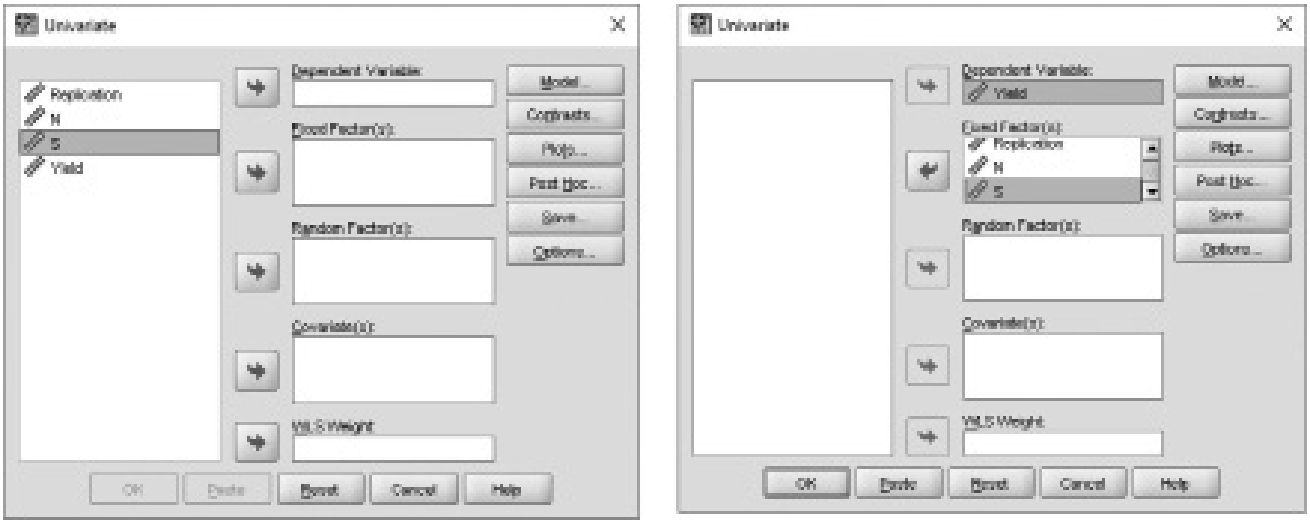

Fig. 3: SPSS univariate dialog window

For 2 Factor RBD, we will customize model. To do this, click the Model… button on the right (Fig. 3). Model → Custom → Select Main Effect → Put Replication, S and N into Model Box → Select Interaction → S*N TO Model → Continue (Fig. 4).

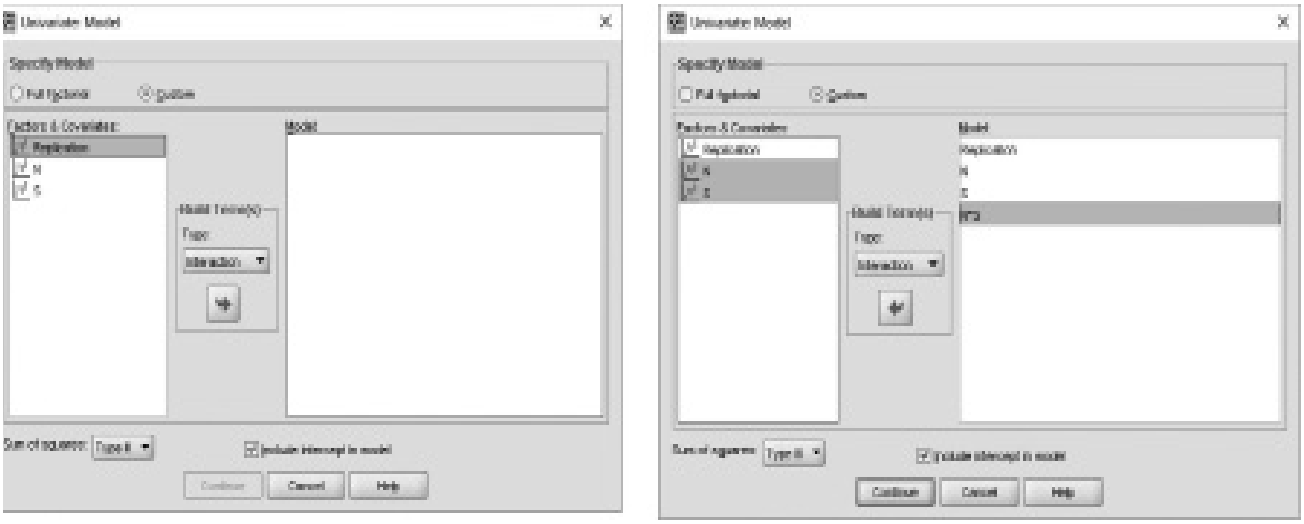

Fig. 4: SPSS univariate model window

The desired ANOVA table will be generated when we click on OK button (Table 2).

Table 2 : Analysis of variance

Dependent variable: Yield

Source	Type III Sum of Squares	D.F.	Mean Square	F	Sig.
~~Corrected Model~~	~~660.001[a]~~	~~16~~	~~41.250~~	~~12.446~~	~~.000~~
~~Intercept~~	~~3922.027~~	~~1~~	~~3922.027~~	~~1183.328~~	~~.000~~
Replication	35.774	5	7.155	2.159	.072
N	50.983	3	16.994	5.127	.003
S	523.444	2	261.722	78.965	.000
N * S	49.799	6	8.300	2.504	.033
Error	182.292	55	3.314		
~~Total~~	~~4764.320~~	~~72~~			
Corrected Total	842.293	71			

a. R Squared = .784 (Adjusted R Squared = .721)

In the result (Table 2), the F-Test indicates that the main effects of sowing dates are significant at 1% and doses of nitrogen at 1% level of significance and interaction (N x S) is significant at 5% level only. The significance of the interaction proves that there are real differential effects of the sowing dates with variation in the doses of nitrogen.

1. Univariate → Post Hoc → select Factors S, N → Post Hoc Test → Duncan → continue → OK

Homogeneous Subsets S

Yield					
Duncan[a,,b]					
S	**N**	**Subset**			
	1	**2**	**3**		
3	**24**	**4.2417**			
2	**24**			**7.0750**	
1	**24**				**10.8250**
Sig.		**1.000**		**1.000**	**1.000**
Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square(Error) = 3.314.					

a. Uses Harmonic Mean Sample Size = 24.000.
b. b. Alpha = 0.05.

Homogeneous Subsets N
Yield

Duncan[a,,b]

N	N	Subset	
		1	2
0	**18**	**6.0056**	
1	**18**		**7.4056**
3	**18**		**7.9333**
2	**18**		**8.1778**
Sig.		**1.000**	**.236**

Means for groups in homogeneous subsets are displayed. Based on observed means.
The error term is Mean Square(Error) = 3.314

a. Uses Harmonic Mean Sample Size = 18.000.
b. Alpha = 0.05

CONCLUSION

Factorial experiment is an experiment whose design consists of two or more factors, each with discrete possible levels. Digital tool (SPSS) is widely useful and user friendly to analyze the data of the factorial experiments for agricultural research like Factorial CRD and Factorial RBD and also for illustration purposes in the classroom teaching as well as for the researchers with interest in factorial experimental designs.

CONFLICT OF INTEREST

"We, The Authors declare that there is no conflict of interest."

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