A Study on Neutrosophic Completely Randomised Design

Srishti Kumari, Azarudheen. S, Jincy James

Department of StatisticsDepartment of StatisticsDepartment of StatisticsCHRIST(Deemed to be University) CHRIST(Deemed to be University) CHRIST(Deemed to be University)

Bangalore, IndiaBangalore, IndiaBangalore,

Indiasrishti.kumari@res.christuniversity.in,azarudheen.s@christuniversity.in,joy.paulose@christuniversity.in

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Abstract

In contemporary practical situations, there are uncertainties, ambiguities and inaccuracies. It is most important to analyse these phenomena instead of focusing on the traditional logic system. Neutrosophic logic is the mathematical model to bring clarity to these uncertain, ambiguous, and inaccurate situations. The design of experiments is a multi-purpose tool that can be used in different cases to identify important input factors (input variables) and how they relate to outputs (response variable). It is a structured and efficient approach for collecting data and making discoveries. In this article, the neutrosophic completely randomised design is introduced, which is a generalisation of the completely randomised design. Further, this article studies the flexible way of handling imprecise elements in completely randomised design.

Keywords: Neutrosophic, Design of Experiment, Completely Randomised Design, Neutrosophic Completely Randomised Design

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I. INTRODUCTION

The real world is vague, unclear and full of ambiguity, and are inevitable. The classical statistics disregards the extreme, aberrant, uncertain values, and hence a new appropriate tool had to surface.

Neutrosophy is a field of philosophy introduced by Smarandache F [3, 4], an extension of fuzzy logic and intuitionistic logic that demonstrate knowledge about neutral accidents. Smarandache F [2, 3, 8] and Salama A.A [5, 8] have presented the fundamental concepts of neutrosophy and neutrosophic sets respectively. Smarandache F extended the fuzzy set to the neutrosophic set [6, 8], introducing the neutrosophic components T, I, F which represent the membership, indeterminacy, and non-membership values respectively .It studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra. It lays the basis for neutral logic, neutral probabilities, neutral sets and neutral statistics. Neutrosophic logic provides mathematical models of uncertainty, ambiguity, inaccuracy, undefined, unknown, incompleteness, redundancy, and contradiction.

Experimentation is a necessary basis for inventions and innovations. Design of Experiments(DOE) is used to identify cause and effect of relationships and employs three basic principles of experimental designs which are replication, randomization and local control. DOE is a branch of applied statistics that deals with a systematic way of experimenting by controlling the input variables and moderating the changes in the output variable. However, this classical method can be employed with precise input and output variables. Lotfi A and Howarth M [1] focused on the generalisation of the experimental design methods by replacing the levels of experimental design with their equivalent fuzzy labels. The experimental procedure was formulated into a fuzzy rule base system and a complete interaction surface was generated between the different parameters. Aslam M [10] focused on overcoming the limitations of classical ANOVA when the data is imprecise. In this study, to reduce the hostility levels among the university students, psychologist carried out the Hostility Level Test(HLT) to measure the data from different students. For this experiment, twelve students were selected, out of which four students were treated with Method 1, Method 2 and Method 3 each. Some of these scores were recorded in the neutrosophic interval and were analysed. It was concluded that the suggested NANOVA is more effective method than other methods.

In DOE, there are single and two-factor experimental designs depending on, observing the effect of number of factor(s) on output variable as a primary interest. Among all the single factor experimental designs, Completely Randomised block design (CRD) is the simplest and flexible design. In this design, treatments are randomly allocated to the experimental units over the entire experimental material. Each treatment is repeated to increase the efficiency of the design. CRD is more appropriate to use when the data is homogenous. The other single factor experimental designs are Randomised Block Design (RBD) and Latin Square Design (LSD). Both the designs are used when the data is heterogeneous in nature, RBD ensures one way blocking and LSD ensures two way blocking in data. Gnanapriya K [11] mainly focused on the statistical analysis of RBD through fuzzy ranking method using the location of median value in support of cardinality under exponential trapezoidal fuzzy numbers. The proposed numerical examples were very close to the real numbers. This method can be used in any kind of real-time calculations for exponential trapezoidal fuzzy numbers. Prathiban S [9] mainly focused on the problem of LSD with trapezoidal fuzzy numbers. The proposed test is analysed under various types of trapezoidal fuzzy models such as alpha cut interval, membership function, ranking function, total integral value and graded mean integration representation. Finally a comparative view of the conclusions obtained from various test is given. Moreover, two numerical examples having different conclusions have been given for a concrete comparative study.

After exploring the literature, we propose CRD under the Neutrosophic situation, called Neutrosophic Completely Randomised Design (NCRD). The proposed NCRD is applicable to uncertain situations. It is expected that the suggested NCRD will be more pliability, effective and explanatory than CRDfor the testing of effect of treatments on various groups under the uncertain situations

II. NEUTROSOPHIC COMPLETELY RANDOMISED DESIGN

A neutrosophic completely randomized design (NCRD) is the simplest design for comparative experiments, as it uses only two basic principles of experimental designs: randomization and replication. In NCRD, the treatments are allocated to the experimental units in a completely random manner. In this design, impreciseness is observed either in one or more elements of the design like levels of factor, sample size and output response.

A. MATHEMATICAL MODEL

Consider that a neutrosophic random variable (NRV) $X_N \in [X_L, X_U]$ selected from a neutrosophic normal distribution with neutrosophic mean, say $\mu_N \in [\mu_L, \mu_U]$ and neutrosophic standard deviation (NSD), say $\sigma_N \in [\sigma_L, \sigma_U]$, respectively.

The mathematical model for NCRD is as follows

$Y_{Nij} = \mu_N + \alpha_{Ni} + e_{Nij}$ - (1)

i = 1,2 ,3, 4,…….k_N and j = 1, 2, 3, …r_{Ni}

Y_{Nij} : neutrosophic response from the j^{th} unit receiving the i^{th} treatment
μ_N : general effect mean
α_{Ni} : the effect due to i^{th}neutrosophic treatment
e_{Nij}: neutrosphic error effect
k_N : neutrosophic number of treatments
r_{Ni} : neutrosophic number of times i^{th} treatment is repeated
n_N: total neutrosophic number of experimental units
SSTN: neutrosophic sum of squares between treatments
SSEN : neutrosophic sum of squares within treatments
NTSS: neutrosophic Total sum of squares.

B. ASSUMPTIONS

The assumptions of the NCRD are given below

1. Neutrosophic random sample is selected from the neutrosophic normalpopulation.
2. Neutrosophic variance is the same in neutrosophic normal population.
3. Also, $\sum_{i=1}^{n_N} r_{Ni}\alpha_{Ni} = 0$.
4. e_{Nij} is identically and independently normally distributed N_N (0, σ_{Ne}^2).

C. TEST PROCEDURE

Step-1: Stating the hypotheses

Null hypothesis

$H_0 : \alpha_{Ni} = 0$ There is no additional effect due to treatments.

Alternative hypothesis

$H_1 : \alpha_{Ni} \neq 0$ There is additional effect due to treatments.

Step-2: Construction of Test Statistics i.e Neutrosophic F test:

$F_{TN} = \frac{s_{TN}^2}{s_{EN}^2} \sim F_{TN} \in [F_L, F_U]$

where

$S_{TN}^2 = \frac{SSTN}{K_N - 1}$; $S_{TN}^2 \in [S_{TL}^2 , S_{TU}^2]$

$S_{EN}^2 = \frac{SSTE}{n_N - K_N}$; $S_{EN}^2 \in [S_{EL}^2 , S_{EU}^2]$

Step-3 : NANOVA table for NCRD

Table 1

Sources of Variation	**NSS**	**df_N**	**NMS**	**F_N ratio**
Between Treatments	SST + ut I	k_N-1	$\frac{SSTN}{K_N - 1}$	$F_{TN} = \frac{s_{TN}^2}{s_{EN}^2}$
Within Treatments (Error)	SSE + ue I	$n_N - k_N$	$\frac{SSTE}{n_N - K_N}$	
Total		n_N - 1		

Step - 4: Decision Rule

The following decision is taken using p value approach [7]

1. If $\max\{neutrosophicP\text{-}value\} \leq \alpha$, then reject H_0 at level α.

2. If $\min\{neutrosophicP\text{-}value\} > \alpha$, then do not reject H_0 at level α.

3.If $\min\{neutrosophicP\text{-}value\} < \alpha < max\{neutrosophicP\text{-}value\}$ then there is an indeterminacy. Thus

(i) $\frac{(\alpha\text{-min}\{\text{neutrosophicP-value}\})}{\text{max}\{\text{neutrosophicP-value}\}\text{-min}\{\text{neutrosophicP-value}\}}$ is the chance of rejecting H_0 at level α,

and

(ii) $\frac{(\text{max}\{\text{neutrosophicP-value}\}\text{-}\alpha)}{\text{max}\{\text{neutrosophicP-value}\}\text{-min}\{\text{neutrosophicP-value}\}}$ is the chance of not rejecting H_0 at level α.

III. APPLICATIONS

Case Study 1:

The research collected the primary data from salem district, Tamil Nadu, India[11]. The data collected was the yield (kilogram per hectare) of four varieties of paddy crops [ADT45, White Ponni, PBT 5204, TKM 13]. While collecting the data, impreciseness in the yields of paddy crops were observed.

Table 2

ADT 45	**White Ponni**	**PBT 5204**	**TKM**
[59,68]	[22,27]	[22,27]	[43,54]
[43,54]	[31,40]	[12,20]	[12,20]
[5,13]	[31,40]	[22,27]	[12,20]

Null hypothesis

$H_0 : \alpha_{Ni} = 0$ There is no additional effect on yields due to different varieties of paddy crops

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Alternative hypothesis

$H_1 : \alpha_{Ni} \neq 0$ There is additional effecton yields due to different varieties of paddy crops

Conclusion

Let p_N-value signify the p value for the neutrosophic statistics. According to the decision rules, the null hypothesis will be accepted if min{p_N-value} $\geq \alpha$, where α is a level of significance. From table 3, min{p_N-value = 0.59} $\geq$ 0.05, we accept the null hypothesis and conclude there is no significant difference in the yields due to the varieties of paddy crops.

Table 3

Source of Variation	**NSS**	**df_N**	**NMS**	**F_N**	**P_N-value**
Treatment (Types of Fertilizer)	**(493.67,653.67)**	**3**	**(164.56,217.67)**	**(0.57,0.68)**	**(0.59, 0.65)**
Error	**(2300,2550)**	**8**	**(287.5,318.75)**		
Total	**(2793.67,3203.67)**	**11**			

Case Study 2:

A professor of a certain college wishes to determine whether there is significant difference in teaching methods: I, II and III. To do this, 15 students were selected at a random and assigned to different group and each group were taught by different methods. The same examination is then given to all the students, and the grades are given in the table below. While collecting the data, it was unclear that one of the student was either taught using method I or method II.

(75) I , (62) I , (81)II, (71) I , (73)III, (79) III,
(58) I, (85) II, (68) II, (60) III, (92) II, (75) III,
(90) II, (81) III, (73) I or II

Table 4

Methods	**Marks (out of 100)**
I	**59 71 [73] 75 62**
II	**68 81 85 92 90 [73]**
III	**60 73 79 77 75**

Null hypothesis

$H_0 : \alpha_{Ni} = 0$ There is no additional effect on marks due to different teaching methods.

Alternative hypothesis

$H_1 : \alpha_{Ni} \neq 0$ There is additional effect on marks due to different teaching methods.

Table 5

Source of Variation	**NSS**	**df_N**	**NMS**	**F_N**	**P_N-value**
Treatment	(548.28,603.73)	2	(274.14,301.87)	(3.90,4.59)	(0.033,0.045)
Error	(787.6,843.05)	14	(65.63, 70.25)		
Total	1391.33				

Conclusion

According to rules, the null hypothesis that there is additional effect of teaching methods will be rejected if max{p_N-value} $\leq \alpha$, where α is a level of significance. From table 5, max{p_N-value = 0.045} < 0.05, we reject the null hypothesis and conclude that there is additional effect on marks due to teaching methods.

IV. CONCLUSION

In this paper, neutrosophic completely randomised design is proposed which is a generalisation of the CRD and ANOVA under classical statistics. The proposed procedure can be applied effectively on uncertain situations than the existing classical designs. It is observed that neutrosophic completely randomised design can be employed when output variable or sample size is imprecise in nature. Generally, this method can be used in any kind of real-time data with impreciseness.

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