New Technique to design Graeco Latin square for odd numbers of treatments

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Abstract

In any laboratory or field experiment, if homogeneity is provided on the experimental units, the Complete Random Design (CRD) is the best design, on the condition that the conditions (assumptions) for the analysis of variance (ANOVA) are available. If the homogeneity is not ensured, to control systematically one source of extraneous variability the Randomized Complete Block Design (RCBD) is the best. In the case of two sources of external variability, the Latin Square Design (LSD) design is best. If three sources of external variability are present, the Graeco Latin Square Design (GLSD) is better, but this design is complicated because of the two conditions available for the (GLSD) which is not to repeat letters for the rows and columns, and every letter must contain one Greek letter. In the case of 6*6 design, we do not feel able to do this. Therefore, I have found a new technique for all designs that have odd numbers of (n) treatments. This method can help researchers in their scientific research.

Keywords: CRD, RCBD, LSD, GLSD, Homogeneity, Normality, Correlation.

1. Introduction

The Graeco-Latin Square Design A Graeco-Latin square is a t × t pattern that permits the study of t treatments simultaneously with three different blocking variables each at t levels. For example, the 4 × 4 Graeco-Latin square shown in Table 1 is an extension of the Latin square design used earlier but with one extra blocking variable added. This is labelled α, β, γ, and δ, could be used to eliminate possible differences between, say four days on which the trials were run. It is constructed from the first two 4 × 4 Latin squares. (Box et al., 2005)

In this arrangement, the treatments are grouped into replicates in three different ways with the consequence that the effects of three different sources of variation are equalised for all treatments. The additional grouping (usually represented by Greek letters) is denoted here by subscripts. Each treatment (A, B,…) appears once in each row and column and once with each index ($\alpha,\beta,\ldots$). (Cochran and Cox, 1957)

Graeco Latin squares are extensions of the basic Latin square designs, consider a t×t Latin square, and superimpose on it a second t×t Latin square in which the treatments are denoted by Greek letters, if the two squares when superimposed have the property that each Greek letters appear once and only once with each Latin letters, the two Latin squares are said to be orthogonal, and the design obtained is called a Graeco-Latin square. An example of a 4×4 Graeco-Latin square is shown in Table 1. (Montgomery, 2017)

Table (1) 4×4 Graeco-Latin square

	Column			
Row	1	2	3	4
1	Aα	Bβ	Cγ	Dδ
2	Bδ	Aγ	Dβ	Cα

3	Cβ	Dα	Aδ	Bγ
4	Dγ	Cδ	Bα	Aβ

2. Materials description

The Graeco Latin square design can be used to control systematically three sources of extraneous variability, that is, to block in three directions. The design allows investigation of four factors (rows, columns, Latin letters, and Greek letters), each at r levels in only r^2 runs. Graeco-Latin squares exist for all r ≥ 3 except r = 6.

The statistical modele is:

$$y_{ijkl} = \mu + \tau_i + \psi_j + \theta_k + \zeta_l + \varepsilon_{ijkl} \qquad \begin{cases} i = 1,2,\ldots,r \\ j = 1,2,\ldots,r \\ k = 1,2,\ldots,r \\ l = 1,2,\ldots,r \end{cases}$$

Where:

y_{ijkl}: is the observation in row j and column k for Latin letters i and Greek letters l,

ψ_j: is the effect of the jth row, τ_i is the effect of Latin letters treatment i,

θ_k : is the effect of Greek letters treatment k,

ζ_l : is the effect of column l, and

ε_{ijkl}: is a NID $(0, \sigma^2)$ random error component. Only two of the four subscripts are necessary to completely identify an observation. (Cox and Reid, 2000) (Montgomery, 2017)

The analysis of variance is very similar to that of a Latin square. Because the Greek letters appear exactly once in each row and column and exactly once with each Latin letters, the factor represented by the Greek letters is orthogonal to rows, columns, and Latin letters treatments. Therefore, a sum of squares due to the Greek letters factor may be computed from the Greek letters totals, and the experimental error is further reduced by this amount. The null hypotheses of equal row, column, Latin letters, and Greek letters treatments would be tested by dividing the corresponding mean square by mean square error. The rejection region is the upper tail point of the $F_{(\alpha;(r-1),(r-3)(r-1))}$ distribution. (Montgomery, 2017)

Table (2) Greek Alphabet

α	β	γ	δ	ε	ζ	η	θ
alpha	beta	gamma	delta	epsilon	zeta	eta	theta
ι	κ	λ	μ	ν	ξ	ο	π
iota	kappa	lambda	mu	nu	xi	omicron	pi
ρ	σ	τ	υ	φ	χ	ψ	ω
rho	sigma	tau	upsilon	phi	chi	psi	omega

(Box et al., 2005)

Table (3) Analysis of Variance for a Graeco-Latin Square Design

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square Error
Latin letters treatments	r-1	$SS_L = \frac{\sum_{i=1}^{r} y_{i...}^2}{r} - \frac{y_{....}^2}{r^2}$	$MS_L = \frac{SS_L}{r-1}$
Greek letters treatments	r-1	$SS_G = \frac{\sum_{l=1}^{r} y_{...l}^2}{r} - \frac{y_{....}^2}{r^2}$	$MS_G = \frac{SS_G}{r-1}$
Rows	r-1	$SS_R = \frac{\sum_{j=1}^{r} y_{.j..}^2}{r} - \frac{y_{....}^2}{r^2}$	$MS_R = \frac{SS_R}{r-1}$
Columns	r-1	$SS_C = \frac{\sum_{k=1}^{r} y_{..k.}^2}{r} - \frac{y_{....}^2}{r^2}$	$MS_C = \frac{SS_C}{r-1}$
Error	(r-3)(r-1)	$SS_E = SS_T - SS_L - SS_G - SS_R - SS_C$	$MS_E = \frac{SS_E}{(r-3)(r-1)}$
Total	r^2-1	$SS_T = \sum_{i=1}^{r}\sum_{j}^{r}\sum_{k}^{r}\sum_{l}^{r} y_{ijkl}^2 - \frac{y_{....}^2}{r^2}$	

(Winer, 1962)

3. Methodology and procedure

Design of odd number of square for any number of squares:

The problematic design in experimental design is Graeco Latin square, for example, in 6×6 we cannot be able to do the design, we discovered this method it is used for any odd number of the square.

The stapes is semi-chess animation:

The 1st step systematic distribution, 2nd step replace the numbers to Greco letters and 3rd step Randomization for rows:

A2	B1	C3
B3	C2	A1
C1	A3	B2

↓

A(β)	B(α)	C(γ)
B(γ)	C(β)	A(α)
C(α)	A(γ)	B(β)

↓

A(β)	B(α)	C(γ)
C(α)	A(γ)	B(β)
B(γ)	C(β)	A(α)

Figure (1) 3*3 Graeco Latin Square Design

After that we do the randomization for the rows and the columns

A2	B1	C3
B3	C2	A1
C1	A3	B2

⇨

B3	C2	A1
C1	A3	B2
A2	B1	C3

⇨

A1	B3	C2
B2	C1	A3
C3	A2	B1

Figure (2) randomisation for 3*3 Graeco Latin Square Design

The first stapes we must distribute the Latin Letters on the table systematically in the first row (A, B, and C) in the second row (B, C, and A) and (C, A, and B) for the last row in 3×3 square. After that we must distribute the Graeco Letters on the Latin Letters the condition must every Latin square must be Receive diffident Graeco Letters, The stapes must be started in the middle of the square (A1) after that the second animation like the knight animation in chess ♘ like the L Letters (A2) after that (A3) the third stapes is Like the Bishop move in the chess ♗ and diagonal moving ↗ and give the new order numbers from 1 to 3 (C1,C2 and C3) after that we do the last stapes it's the Rook moves ♖ to the right (B1) and complete the knight moving to down (B2) and the previous is (B3). Moreover, the below example about 5×5 to 11×11 and we can able to do any odd square by this way.

A4	B3	C2	D1	E5
B2	C1	D5	E4	A3
C5	D4	E3	A2	B1
D3	E2	A1	B5	C4
E1	A5	B4	C3	D2

⇩

A(δ)	B(γ)	C(β)	D(α)	E(ε)
B(β)	C(α)	D(ε)	E(δ)	A(γ)
C(ε)	D(δ)	E(γ)	A(β)	B(α)
D(γ)	E(β)	A(α)	B(ε)	C(δ)
E(α)	A(ε)	B(δ)	C(γ)	D(β)

⇩

A(δ)	B(γ)	C(β)	D(α)	E(ε)
B(β)	C(α)	D(ε)	E(δ)	A(γ)
E(α)	A(ε)	B(δ)	C(γ)	D(β)
C(ε)	D(δ)	E(γ)	A(β)	B(α)
D(γ)	E(β)	A(α)	B(ε)	C(δ)

Figure (3) 5*5 Graeco Latin Square Design

A 4	B 3	C 2	D 1	E5
B 2	C 1	D 5	E4	A 3
C 5	D 4	E3	A 2	B 1
D 3	E2	A 1	B 5	C 4
E1	A 5	B 4	C 3	D 2

⇨

B 2	C 1	D 5	E4	A 3
A 4	B 3	C 2	D 1	E5
E1	A 5	B 4	C 3	D 2
D 3	E2	A 1	B 5	C 4
C 5	D 4	E3	A 2	B 1

⇨

C 1	B 2	A 3	E4	D 5
B 3	A 4	E5	D 1	C 2
A 5	E1	D 2	C 3	B 4
E2	D 3	C 4	B 5	A 1
D 4	C 5	B 1	A 2	E3

Figure (4) two direction randomization for 5*5 Graeco Latin Square Design

A6	B5	C4	D3	E2	F1	G7
B4	C3	D2	E1	F7	G6	A5
C2	D1	E7	F6	G5	A4	B3
D7	E6	F5	G4	A3	B2	C1
E5	F4	G3	A2	B1	C7	D6
F3	G2	A1	B7	C6	D5	E4
G1	A7	B6	C5	D4	E3	F2

A(ζ)	B(ε)	C(δ)	D(γ)	E(β)	F(α)	G(η)
B(δ)	C(γ)	D(β)	E(α)	F(η)	G(ζ)	A(ε)
C(β)	D(α)	E(η)	F(ζ)	G(ε)	A(δ)	B(γ)
D(η)	E(ζ)	F(ε)	G(δ)	A(γ)	B(β)	C(α)
E(ε)	F(δ)	G(γ)	A(β)	B(α)	C(η)	D(ζ)
F(γ)	G(β)	A(α)	B(η)	C(ζ)	D(ε)	E(δ)
G(α)	A(η)	B(ζ)	C(ε)	D(δ)	E(γ)	F(β)

A(ζ)	B(ε)	C(δ)	D(γ)	E(β)	F(α)	G(η)
C(β)	D(α)	E(η)	F(ζ)	G(ε)	A(δ)	B(γ)
E(ε)	F(δ)	G(γ)	A(β)	B(α)	C(η)	D(ζ)
D(η)	E(ζ)	F(ε)	G(δ)	A(γ)	B(β)	C(α)
B(δ)	C(γ)	D(β)	E(α)	F(η)	G(ζ)	A(ε)
F(γ)	G(β)	A(α)	B(η)	C(ζ)	D(ε)	E(δ)
G(α)	A(η)	B(ζ)	C(ε)	D(δ)	E(γ)	F(β)

Figure (5) 7*7 Graeco Latin Square Design

A8	B7	C6	D5	E4	F3	G2	H1	I9
B6	C5	D4	E3	F2	G1	H9	I8	A7
C4	D3	E2	F1	G9	H8	I7	A6	B5
D2	E1	F9	G8	H7	I6	A5	B4	C3
E9	F8	G7	H6	I5	A4	B3	C2	D1
F7	G6	H5	I4	A3	B2	C1	D9	E8
G5	H4	I3	A2	B1	C9	D8	E7	F6
H3	I2	A1	B9	C8	D7	E6	F5	G4
I1	A9	B8	C7	D6	E5	F4	G3	H2

A(θ)	B(η)	C(ζ)	D(ε)	E(δ)	F(γ)	G(β)	H(α)	I(ι)
B(ζ)	C(ε)	D(δ)	E(γ)	F(β)	G(α)	H(ι)	I(θ)	A(η)
C(δ)	D(γ)	E(β)	F(α)	G(ι)	H(θ)	I(η)	A(ζ)	B(ε)
D(β)	E(α)	F(ι)	G(θ)	H(η)	I(ζ)	A(ε)	B(δ)	C(γ)
E(ι)	F(θ)	G(η)	H(ζ)	I(ε)	A(δ)	B(γ)	C(β)	D(α)
F(η)	G(ζ)	H(ε)	I(δ)	A(γ)	B(β)	C(α)	D(ι)	E(θ)
G(ε)	H(δ)	I(γ)	A(β)	B(α)	C(ι)	D(θ)	E(η)	F(ζ)
H(γ)	I(β)	A(α)	B(ι)	C(θ)	D(η)	E(ζ)	F(ε)	G(δ)
I(α)	A(ι)	B(θ)	C(η)	D(ζ)	E(ε)	F(δ)	G(γ)	H(β)

A(θ)	B(η)	C(ζ)	D(ε)	E(δ)	F(γ)	G(β)	H(α)	I(ι)
C(δ)	D(γ)	E(β)	F(α)	G(ι)	H(θ)	I(η)	A(ζ)	B(ε)
D(β)	E(α)	F(ι)	G(θ)	H(η)	I(ζ)	A(ε)	B(δ)	C(γ)
E(ι)	F(θ)	G(η)	H(ζ)	I(ε)	A(δ)	B(γ)	C(β)	D(α)
B(ζ)	C(ε)	D(δ)	E(γ)	F(β)	G(α)	H(ι)	I(θ)	A(η)
H(γ)	I(β)	A(α)	B(ι)	C(θ)	D(η)	E(ζ)	F(ε)	G(δ)
I(α)	A(ι)	B(θ)	C(η)	D(ζ)	E(ε)	F(δ)	G(γ)	H(β)
G(ε)	H(δ)	I(γ)	A(β)	B(α)	C(ι)	D(θ)	E(η)	F(ζ)
F(η)	G(ζ)	H(ε)	I(δ)	A(γ)	B(β)	C(α)	D(ι)	E(θ)

Figure (6) 9*9 Graeco Latin Square Design

A10	B9	C8	D7	E6	F5	G4	H3	I2	J1	K11
B8	C7	D6	E5	F4	G3	H2	I1	J11	K10	A9
C6	D5	E4	F3	G2	H1	I11	J10	K9	A8	B7
D4	E3	F2	G1	H11	I10	J9	K8	A7	B6	C5
E2	F1	G11	H10	I9	J8	K7	A6	B5	C4	D3
F11	G10	H9	I8	J7	K6	A5	B4	C3	D2	E1
G9	H8	I7	J6	K5	A4	B3	C2	D1	E11	F10
H7	I6	J5	K4	A3	B2	C1	D11	E10	F9	G8
I5	J4	K3	A2	B1	C11	D10	E9	F8	G7	H6
J3	K2	A1	B11	C10	D9	E8	F7	G6	H5	I4
K1	A11	B10	C9	D8	E7	F6	G5	H4	I3	J2

A(κ)	B(ι)	C(θ)	D(η)	E(ζ)	F(ε)	G(δ)	H(γ)	I(β)	J(α)	K(λ)
B(θ)	C(η)	D(ζ)	E(ε)	F(δ)	G(γ)	H(β)	I(α)	J(λ)	K(κ)	A(ι)
C(ζ)	D(ε)	E(δ)	F(γ)	G(β)	H(α)	I(λ)	J(κ)	K(ι)	A(θ)	B(η)
D(δ)	E(γ)	F(β)	G(α)	H(λ)	I(κ)	J(ι)	K(θ)	A(η)	B(ζ)	C(ε)
E(β)	F(α)	G(λ)	H(κ)	I(ι)	J(θ)	K(η)	A(ζ)	B(ε)	C(δ)	D(γ)
F(λ)	G(κ)	H(ι)	I(θ)	J(η)	K(ζ)	A(ε)	B(δ)	C(γ)	D(β)	E(α)
G(ι)	H(θ)	I(η)	J(ζ)	K(ε)	A(δ)	B(γ)	C(β)	D(α)	E(λ)	F(κ)
H(η)	I(ζ)	J(ε)	K(δ)	A(γ)	B(β)	C(α)	D(λ)	E(κ)	F(ι)	G(θ)
I(ε)	J(δ)	K(γ)	A(β)	B(α)	C(λ)	D(κ)	E(ι)	F(θ)	G(η)	H(ζ)
J(γ)	K(β)	A(α)	B(λ)	C(κ)	D(ι)	E(θ)	F(η)	G(ζ)	H(ε)	I(δ)
K(α)	A(λ)	B(κ)	C(ι)	D(θ)	E(η)	F(ζ)	G(ε)	H(δ)	I(γ)	J(β)

A(κ)	B(ι)	C(θ)	D(η)	E(ζ)	F(ε)	G(δ)	H(γ)	I(β)	J(α)	K(λ)
B(θ)	C(η)	D(ζ)	E(ε)	F(δ)	G(γ)	H(β)	I(α)	J(λ)	K(κ)	A(ι)
G(ι)	H(θ)	I(η)	J(ζ)	K(ε)	A(δ)	B(γ)	C(β)	D(α)	E(λ)	F(κ)
E(β)	F(α)	G(λ)	H(κ)	I(ι)	J(θ)	K(η)	A(ζ)	B(ε)	C(δ)	D(γ)
C(ζ)	D(ε)	E(δ)	F(γ)	G(β)	H(α)	I(λ)	J(κ)	K(ι)	A(θ)	B(η)
J(γ)	K(β)	A(α)	B(λ)	C(κ)	D(ι)	E(θ)	F(η)	G(ζ)	H(ε)	I(δ)
I(ε)	J(δ)	K(γ)	A(β)	B(α)	C(λ)	D(κ)	E(ι)	F(θ)	G(η)	H(ζ)
H(η)	I(ζ)	J(ε)	K(δ)	A(γ)	B(β)	C(α)	D(λ)	E(κ)	F(ι)	G(θ)
F(λ)	G(κ)	H(ι)	I(θ)	J(η)	K(ζ)	A(ε)	B(δ)	C(γ)	D(β)	E(α)
D(δ)	E(γ)	F(β)	G(α)	H(λ)	I(κ)	J(ι)	K(θ)	A(η)	B(ζ)	C(ε)
K(α)	A(λ)	B(κ)	C(ι)	D(θ)	E(η)	F(ζ)	G(ε)	H(δ)	I(γ)	J(β)

Figure (7) 11*11 Graeco Latin Square Design

A12	B11	C10	D9	E8	F7	G6	H5	I4	J3	K2	L1	M13
B10	C9	D8	E7	F6	G5	H4	I3	J2	K1	L13	M12	A11
C8	D7	E6	F5	G4	H3	I2	J1	K13	L12	M11	A10	B9
D6	E5	F4	G3	H2	I1	J13	K12	L11	M10	A9	B8	C7
E4	F3	G2	H1	I13	J12	K11	L10	M9	A8	B7	C6	D5
F2	G1	H13	I12	J11	K10	L9	M8	A7	B6	C5	D4	E3
G13	H12	I11	J10	K9	L8	M7	A6	B5	C4	D3	E2	F1
H11	I10	J9	K8	L7	M6	A5	B4	C3	D2	E1	F13	G12
I9	J8	K7	L6	M5	A4	B3	C2	D1	E13	F12	G11	H10
J7	K6	L5	M4	A3	B2	C1	D13	E12	F11	G10	H9	I8
K5	L4	M3	A2	B1	C13	D12	E11	F10	G9	H8	I7	J6
L3	M2	A1	B13	C12	D11	E10	F9	G8	H7	I6	J5	K4
M1	A13	B12	C11	D10	E9	F8	G7	H6	I5	J4	K3	L2

A(μ)	B(λ)	C(κ)	D(ι)	E(θ)	F(η)	G(ζ)	H(ε)	I(δ)	J(γ)	K(β)	L(α)	M(ν)
B(κ)	C(ι)	D(θ)	E(η)	F(ζ)	G(ε)	H(δ)	I(γ)	J(β)	K(α)	L(ν)	M(μ)	A(λ)
C(θ)	D(η)	E(ζ)	F(ε)	G(δ)	H(γ)	I(β)	J(α)	K(ν)	L(μ)	M(λ)	A(κ)	B(ι)
D(ζ)	E(ε)	F(δ)	G(γ)	H(β)	I(α)	J(ν)	K(μ)	L(λ)	M(κ)	A(ι)	B(θ)	C(η)
E(δ)	F(γ)	G(β)	H(α)	I(ν)	J(μ)	K(λ)	L(κ)	M(ι)	A(θ)	B(η)	C(ζ)	D(ε)
F(β)	G(α)	H(ν)	I(μ)	J(λ)	K(κ)	L(ι)	M(θ)	A(η)	B(ζ)	C(ε)	D(δ)	E(γ)
G(ν)	H(μ)	I(λ)	J(κ)	K(ι)	L(θ)	M(η)	A(ζ)	B(ε)	C(δ)	D(γ)	E(β)	F(α)
H(λ)	I(κ)	J(ι)	K(θ)	L(η)	M(ζ)	A(ε)	B(δ)	C(γ)	D(β)	E(α)	F(ν)	G(μ)
I(ι)	J(θ)	K(η)	L(ζ)	M(ε)	A(δ)	B(γ)	C(β)	D(α)	E(ν)	F(μ)	G(λ)	H(κ)
J(η)	K(ζ)	L(ε)	M(δ)	A(γ)	B(β)	C(α)	D(ν)	E(μ)	F(λ)	G(κ)	H(ι)	I(θ)
K(ε)	L(δ)	M(γ)	A(β)	B(α)	C(ν)	D(μ)	E(λ)	F(κ)	G(ι)	H(θ)	I(η)	J(ζ)
L(γ)	M(β)	A(α)	B(ν)	C(μ)	D(λ)	E(κ)	F(ι)	G(θ)	H(η)	I(ζ)	J(ε)	K(δ)
M(α)	A(ν)	B(μ)	C(λ)	D(κ)	E(ι)	F(θ)	G(η)	H(ζ)	I(ε)	J(δ)	K(γ)	L(β)

A(μ)	B(λ)	C(κ)	D(ι)	E(θ)	F(η)	G(ζ)	H(ε)	I(δ)	J(γ)	K(β)	L(α)	M(ν)
B(κ)	C(ι)	D(θ)	E(η)	F(ζ)	G(ε)	H(δ)	I(γ)	J(β)	K(α)	L(ν)	M(μ)	A(λ)
H(λ)	I(κ)	J(ι)	K(θ)	L(η)	M(ζ)	A(ε)	B(δ)	C(γ)	D(β)	E(α)	F(ν)	G(μ)
I(ι)	J(θ)	K(η)	L(ζ)	M(ε)	A(δ)	B(γ)	C(β)	D(α)	E(ν)	F(μ)	G(λ)	H(κ)
M(α)	A(ν)	B(μ)	C(λ)	D(κ)	E(ι)	F(θ)	G(η)	H(ζ)	I(ε)	J(δ)	K(γ)	L(β)
G(ν)	H(μ)	I(λ)	J(κ)	K(ι)	L(θ)	M(η)	A(ζ)	B(ε)	C(δ)	D(γ)	E(β)	F(α)
C(θ)	D(η)	E(ζ)	F(ε)	G(δ)	H(γ)	I(β)	J(α)	K(ν)	L(μ)	M(λ)	A(κ)	B(ι)
K(ε)	L(δ)	M(γ)	A(β)	B(α)	C(ν)	D(μ)	E(λ)	F(κ)	G(ι)	H(θ)	I(η)	J(ζ)
D(ζ)	E(ε)	F(δ)	G(γ)	H(β)	I(α)	J(ν)	K(μ)	L(λ)	M(κ)	A(ι)	B(θ)	C(η)
L(γ)	M(β)	A(α)	B(ν)	C(μ)	D(λ)	E(κ)	F(ι)	G(θ)	H(η)	I(ζ)	J(ε)	K(δ)
J(η)	K(ζ)	L(ε)	M(δ)	A(γ)	B(β)	C(α)	D(ν)	E(μ)	F(λ)	G(κ)	H(ι)	I(θ)
E(δ)	F(γ)	G(β)	H(α)	I(ν)	J(μ)	K(λ)	L(κ)	M(ι)	A(θ)	B(η)	C(ζ)	D(ε)
F(β)	G(α)	H(ν)	I(μ)	J(λ)	K(κ)	L(ι)	M(θ)	A(η)	B(ζ)	C(ε)	D(δ)	E(γ)

Figure (8) 13*13 Graeco Latin Square Design

4. Results

The accuracy of the results depends to a great extent on the design and analysis of the experiment. The more accurate results can be obtained, the better the decisions are. The designs used vary according to the nature of the experiment. Each of these designs fits a specific goal. This design or that, and the experience may be simple or complex.

One of the most challenging designs and the creation of the design is the design of the GLSD (Graeco Latine Square Design), because the design requires not to repeat the Latin and Greek letters once in the row, and column with another condition is not to repeat the Latin with Greek letters only once in any experimental unit, it is difficult. In the design 6×6 cannot provide this condition so cannot apply with this design, I managed to find a way to fit all the designs in the case of the number of individual transactions n×n odd number of treatments.

5. Discussion

We can use this technique for any n×n odd number of (rows, columns or treatments (Latin letters or Greco letters)).

In conclusion programming the proposed method in advanced statistical packages, such as Minitab, Matlab, Statgraphics, R, and SPSS.

References :

BOX, G. E., HUNTER, J. S. & HUNTER, W. G. 2005. *Statistics for Experimenters: Design, Innovation, and Discovery*, Wiley-Interscience New York.

COCHRAN, W. G. & COX, G. M. 1957. *Experimental Designs*, John wiley & Sons

COX, D. R. & REID, N. 2000. *The theory of the design of experiments*, Chapman and Hall/CRC.

MONTGOMERY, D. C. 2017. *Design and analysis of experiments*, John wiley & sons.

WINER, B. J. 1962. *Statistical principles in experimental design*, McGRAW-HILL BOOK COMPANY United States of America.

پوختە

لە هەر توێژینەوەیەکی تاقیگەیی یان کێڵگەیی ئەگەر هاوڕێکی تەواو توانرا دابین بکرێت لە سەر یەکەی توێژینەوەکە ئەوا دیزاینی تەواو هەڕەمەکی CRD باشترین دیزاینە بەمەرجێک مەرجەکانی شیکردنەوەی ڤاریەنس بەرجەستە بکرێت، بەڵام ئەگەر هاوڕێکی نەتوانرا بەرجەستە بکرێت وە بەیەک لا جیاوازی هەبوو ئەوا پەنا دەبەینە بەر دیزاینی RCBD وە ئەگەر بوو بە دوو لا لە جیاوازی ئەوا پەنا دەبەینە بەر دیزاینی LSD، وە ئەگەر بوو بە سێ لا لە جیاوازی ئەوا پەنا دەبەینە بەر دیزاینی GLSD بەڵام دیزاین کردنی ئەم مۆدێلەی کۆتاییان ئاسان نیە بگرە لە کاتی (6*6) ئەوا ناتوانرێت بەکار بێت چونکە دیزاین ناکرێت، بۆیە من توانیم تەکنیکیک بدۆزمەوە کە بۆ هەموو بارێکی ژمارەی تریتمێنتەکان تاک بێت بەکاری بهێنین وە دیزاینی بکەین تا (ن) جار، کە ئەمەش دەکرێت لە ئایندەدا زۆر سودی لێ ببینرێت بۆ دیزاینی توێژینەوەی زانستی.

ملخص

في أي تجربة مختبرية أو حقلية اذا تم توفير التجانس على الوحدات التجريبية فان التصميم العشوائي الكامل (CRD) هو أفضل تصميم شريطة توفر شروط تحليل التباين، أما اذا لم يتم توفير التجانس بوجود اختلاف باتجاه واحد فان تصميم القطاعات الكاملة العشوائية (RCBD) هو الافضل، أما في حالة وجود الاختلاف باتجاهين فان التصميم المربع اللاتيني (LSD) هو الاجدر، وفي حالة وجود الاختلاف بثلاث اتجاهات فان تصميم المربع اللاتيني الاغريقي (GLSD) هو الأمثل، لكن التصميم المربع الاغريقي يعد من التصاميم المعقدة للشروط الواجب توفرها على التصميم بحيث يتكرر كل معاملة مرة واحدة في الصف والعمود، ويختار كل معاملة حرف اغريقي واحد، حيث لايتكرر في الصف والعمود ومع المعاملات لهذا السبب ولايمكن تصميم حالة 6*6 لفقدان الشروط المذكورة، لذلك قام البحث بايجاد طريقة مبتكرة للتصاميم التي تكون عدد معاملاتها فردية الى العدد (ن) من المربعات الفردية، وهذه الطريقة يمكن ان تساعد الباحثين في تصميم بحوثهم العلمية والإفادة منها.

Appendix: 3*3 Graeco Latin square design by visual basic in Excel

```
Sub Macro1()
'
' Macro1 Macro
'
' Keyboard Shortcut: Ctrl+q
'
    ActiveCell.FormulaR1C1 = "if t=3"
    Rows("3:5").Select
    Selection.RowHeight = 24.75
    Range("A3:C5").Select
    Selection.Borders(xlDiagonalDown).LineStyle = xlNone
    Selection.Borders(xlDiagonalUp).LineStyle = xlNone
    With Selection.Borders(xlEdgeLeft)
        .LineStyle = xlContinuous
```

```
    .ColorIndex = 0
    .TintAndShade = 0
    .Weight = xlThin
End With
With Selection.Borders(xlEdgeTop)
    .LineStyle = xlContinuous
    .ColorIndex = 0
    .TintAndShade = 0
    .Weight = xlThin
End With
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .ColorIndex = 0
    .TintAndShade = 0
    .Weight = xlThin
End With
With Selection.Borders(xlEdgeRight)
    .LineStyle = xlContinuous
    .ColorIndex = 0
    .TintAndShade = 0
    .Weight = xlThin
End With
With Selection.Borders(xlInsideVertical)
    .LineStyle = xlContinuous
    .ColorIndex = 0
    .TintAndShade = 0
    .Weight = xlThin
End With
With Selection.Borders(xlInsideHorizontal)
    .LineStyle = xlContinuous
    .ColorIndex = 0
    .TintAndShade = 0
    .Weight = xlThin
End With
Range("C4").Select
ActiveCell.FormulaR1C1 = "a"
Range("C4").Select
ActiveCell.FormulaR1C1 = "A1"
Range("A3").Select
ActiveCell.FormulaR1C1 = "A2"
Range("B5").Select
ActiveCell.FormulaR1C1 = "A3"
Range("A5").Select
ActiveCell.FormulaR1C1 = "B1"
Range("B4").Select
ActiveCell.FormulaR1C1 = "B2"
Range("C3").Select
ActiveCell.FormulaR1C1 = "B3"
Range("B3").Select
ActiveCell.FormulaR1C1 = "C1"
Range("C5").Select
ActiveCell.FormulaR1C1 = "C2"
Range("A4").Select
ActiveCell.FormulaR1C1 = "C3"
Range("A3:C5").Select
With Selection
    .HorizontalAlignment = xlCenter
    .VerticalAlignment = xlBottom
    .WrapText = False
    .Orientation = 0
    .AddIndent = False
    .IndentLevel = 0
    .ShrinkToFit = False
    .ReadingOrder = xlContext
    .MergeCells = False
End With
With Selection
    .HorizontalAlignment = xlCenter
    .VerticalAlignment = xlCenter
    .WrapText = False
    .Orientation = 0
    .AddIndent = False
    .IndentLevel = 0
    .ShrinkToFit = False
    .ReadingOrder = xlContext
    .MergeCells = False
End With
```

```
    Range("A3:C5").Select
    Selection.Copy
    Range("F3").Select
    ActiveSheet.Paste
    Range("E3").Select
    Application.CutCopyMode = False
    ActiveCell.FormulaR1C1 = "=RAND()"
    Range("E3").Select
    Selection.AutoFill Destination:=Range("E3:E5"), Type:=xlFillDefault
    Range("E3:E5").Select
    Range("E3:H5").Select
    ActiveWorkbook.Worksheets("Sheet1").Sort.SortFields.Clear
    ActiveWorkbook.Worksheets("Sheet1").Sort.SortFields.Add Key:=Range("E3"), _
        SortOn:=xlSortOnValues, Order:=xlAscending, DataOption:=xlSortNormal
    With ActiveWorkbook.Worksheets("Sheet1").Sort
        .SetRange Range("E3:H5")
        .Header = xlNo
        .MatchCase = False
        .Orientation = xlTopToBottom
        .SortMethod = xlPinYin
        .Apply
    End With
    Range("E3:E5").Select
    Selection.ClearContents
    Range("F3:H5").Select
    Selection.Copy
    Range("F11").Select
    Selection.PasteSpecial Paste:=xlPasteAll, Operation:=xlNone, SkipBlanks:= _
        False, Transpose:=True
    Range("E11").Select
    Application.CutCopyMode = False
    ActiveCell.FormulaR1C1 = "=RAND()"
    Range("E11").Select
    Selection.AutoFill Destination:=Range("E11:E13"), Type:=xlFillDefault
    Range("E11:E13").Select
    Range("E11:H13").Select
    ActiveWorkbook.Worksheets("Sheet1").Sort.SortFields.Clear
    ActiveWorkbook.Worksheets("Sheet1").Sort.SortFields.Add Key:=Range("E11"), _
        SortOn:=xlSortOnValues, Order:=xlAscending, DataOption:=xlSortNormal
    With ActiveWorkbook.Worksheets("Sheet1").Sort
        .SetRange Range("E11:H13")
        .Header = xlNo
        .MatchCase = False
        .Orientation = xlTopToBottom
        .SortMethod = xlPinYin
        .Apply
    End With
    Range("E11:E13").Select
    Selection.ClearContents
    Range("F11:H13").Select
    Selection.Cut
    Range("J3").Select
    ActiveSheet.Paste
    Columns("I:I").Select
    Selection.Insert Shift:=xlToRight, CopyOrigin:=xlFormatFromLeftOrAbove
    Range("K3:M5").Select
    ActiveSheet.Shapes.AddShape(msoShapeStripedRightArrow, 156.75, 60.75, 74.25, 21 _
        ).Select
    Selection.ShapeRange.Duplicate.Select
    Selection.ShapeRange.IncrementLeft 239.25
    Range("K7:M7").Select
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = False
        .Orientation = 0
        .AddIndent = False
        .IndentLevel = 0
        .ShrinkToFit = False
        .ReadingOrder = xlContext
        .MergeCells = False
    End With
    Selection.Merge
    ActiveCell.FormulaR1C1 = "Final Design"
    Range("K3").Select
End Sub
```