University of Salahaddin, Erbil, College of Agricultural Engineering Sciences,
Department of Soil and Water

Subject: Experimental Design and Analysis

Course Book – *For* (3rd year students)

Lecturer's name: Proof. Dr. Akram Othman Esmail

B.Sc. 1980 University of Sulaimani

MSc. 1986 University of Salahaddin

PhD. 1992 University of Baghdad

Academic Year: (2022-2023), Fall semester.

Course Book

1. Course name	Fall semester 2022-2023
2. Lecturer in charge	Prof. Dr. Akram Othman Esmail
3. Departmen t/ College	Soil and Water, Agricultural Engineering Sciences
4. Contact	e-mail: akram.esmail@su.edu.krd Tel: 07504672975

5. Time (in hours) per week	Theory: 2 hours per week Practical: 2 hours per week
6. Office hours	6 hours/week
7. Course code	
8. Teacher's academic profile	The main points in my academic profile can be summarize as follow: 1- Teaching BSc. MSc and PhD students. 2- Doing scientific researches. 3- Member of some scientific committees in the soil and water department. 4- Supervising (15) Ph. D students and 25MSc.studets. 5- Contributing in 170 examine committee for MSc and Ph. D students either as a member or chairman. 6-Evalution of numerous researches for scientific journals in Kurdistan, Iraqi and other countries universities. 8- Supervising students research project and seminars of 4th years students, Soil and Water Sciences department. 9-Doing statistical analysis for numerous post graduate students.
9. Keywords	Experimental designs, Principles of experimental design, Randomization, relative efficiency ,Multiple range tests.

1. Course name	Practical Water resources
2. Lecturer in charge	Lect. Khazin Sarbaz Rajab
3. Department/ College	Soil and water/ College of Agricultural Engineering Sciences.
4. Contact	e-mail: Khazin.rajab@su.edu.krd Tel: (07508821330)
5. Time (in hours) per week	Practical: 2
6. Office hours	6 hr/week
7. Course code	
8. Teacher's academic profile	BSc. (2010), MSc. (2015) Salahaddin University, Erbil

9. Keywords	Experimental units, Designs, Multiple comparison tests.

10. Course overview:

Experimental design and Analysis regard as applied statistics, which includes different design and tests. Selecting the suitable design and test in investigations leads to increase in accuracy of data. The experimental design uses in different field and specializations like agricultural sciences, biological sciences, medical sciences economical sciences…etc. During this course we must refer to the main designs, types of experiments and multiple comparison tests. It is necessary to explain basic terms and steps in experimental design and analysis. Selecting the suitable multiple range test is necessary depending of the type or nature of the research. comparison between designs depending on their efficiency and uses in agricultural experiments and researches.

The application of the studied experimental design in research projects of 4^{th} year students and then conducting statistical analysis for their results using statistical programs like SPSS, SAS and Stat graph.....etc.

Explaining the importance of this subject and its application in different fields especially in agricultural sciences and biological sciences.

Finally, it is necessary to throw light on the role of experimental design and analysis for the staff of agriculture research centers in Kurdistan rejoin.

11. Course objective:
Goals of the course or Goals of studying Experimental Design and Analysis:

The main goals of studying the above subject can be summarize as follow:

1-Studding the basic terms in experimental design and analysis.

2-Studding the basic principles of experimental design then explaining the role of them in decreasing experimental error.

3-To learn the steps for construction complete randomized design (CRD).

4-Studding the steps for construction complete randomized block design (RCBD).

5-To explain the role of blocking and direction on blocks in decreasing experimental error.

6-Comparison between CRD and RCBD, and why RCBD called agricultural design.

7-To study the steps for construction Latin square design, and then why this design is not widely uses in agricultural experiments and researches.

8-Comparison between the mean of treatments in the laboratory and field experiments using different multiple comparison tests.

9-Comparison between simple experiments and factorial experiments.

10- Steps for construction of CRD, RCBD and Latin square design LSD in case of factorial experiments.

11-To compare between factorial experiments and Split Plot Design.

12-Comparison between systematic and Randomized designs.

12. Student's obligation:

The student must have an important role:

1- The students must contribute in the scientific discussions in the class or teaching hall.
2- The students must know the importance of quizzes, homework's, reports and exams.
3- It is necessary to contribute the student in presentation a scientific subject.

13. Forms of teaching:

There are different forms of teaching:

1-Datashow and power point.
2- White board.
3-Lectures.

14. Assessment scheme

Breakdown of overall assessment and examination:

1-Monthly exam 10marks.
2-Quizzes 3 marks.
3-Present and contributing in scientific discussions 1 marks.

4-Seminar 1 marks.

15. Student learning outcome:

Explaining and training on selecting the suitable design and application it at summer training and research project. Doing statistical analysis using hand method or or statistical programs.

The practical part includes the application on different designs and multiple comparison tests: 1st week introduction and symbols. 2nd week construction on CRD practically and solving some examples of CRD .3rd and 4th week solving examples about multiple Comparison tests. 5th and 6th week examples about RCBD and calculating missing value. 7th , 8th and 9th week applications and examples about Latin Square Design , calculating Missing value and relative efficiency between designs.10th, 11th and 12th weeks applications and examples about factorial experiment. 13th and 14th weeks solving examples about split plot design.

16. Course Reading List and References:

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Clewer, A. G. and D. H. Scarisbrick. (2001). Practical Statistics and Experimental Design for plant and crop science.

* Cochran, W. G. and Cox, D. R. (1957). Experimental Design, 2nd ed., Johan Wiley and Sone, Inc., New York, USA.

* Journal of the American Statistical Association No. 411, 442 and 443., (1998).

Kassab, J. Y., (1982). Experimental Design and Statistical Analysis Course. North Waley University.

* Kuehl, R. O. (2000). Design of Experiments .2nd ed.

• Locioru, E. L., Warren, H. L. and A. G. Clark (1962). Field plot Technique. USA.

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* Miller, R. G. (1998). Beyond ANOVA Basics of Applied Statistics .CRD press LIC, USA.

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*Oehlert G.W. (2014) A first course in design and analysis of experiment.USA.2nd ed.

* Rossello, J. M. and de Gorostiza M. F. (1993). Technical Guidelines for field variety Trials.

*Seltman H.J. (2014) Experimental design and analysis.USA.2nd ed.

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الِساهوكي، مدحت و كريم محمد وهيب (1990) تطبيقات في تصميم وتحليل التجارب.

الشواني، أميد صابر عبدالله (2002) دراسة توفر شروط تحليل التباين لبعض التجارب التطبيقية ذات النموذج الثبت. رسالة الماجستير في الاحصاء، كلية الادارة و الاقتصاد، جامعة صلاح الدين-أربيل (بأشراف د. أكرم عثمان إسماعيل).

منهم وتحليل البيانات الاحصائية. SPSSالزعبي، محمد بلال وعباس الطلافي.(2004) النظام الاحصائي

جامعة الدول العربية .(1993). دليل مشاكل تصميم وتحليل التجارب في البحوث الزراعية. المنظمة العربية للتنمية الزراعية.

إسماعيل، أ. ع.، عبدالرحيم، ع. م. و قاسم، ع. ع. (2003) تصميم التجارب وتحليلها. الجزء الاول.

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حمد، أختر صابر (2000)دراسة مقارنة الطريقة المعلمية واللامعلمية لتحليل التغاير بأستخدام المحاكاةز رسالة

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خماس، قيس سبع (1984) المفاهيم الأساسية في تصميم التجارب. جامعة المستنصرية.

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17. The Topics:	Lecturer's name
1-Introduction (definition of experimental design, Basic terms in experimental design,).In this week the students will learn definition and steps of experimental design in additional to some scientific terms.	Dr. Akram Othman Esmail (2) h. 7/9/2022
1-Example about symbols in experimental design	Khazin S. Rajab (2) h. 8,9,2022
2-Basic principles of experimental design, Classification of experimental design in to two types systematic and random design. The goals of these topics to study the role of principles of experimental design in accuracy of data and comparison between systematic and random designs.	Dr. Akram Othman Esmail (2) hrs 14 /9/2022
2- Testing accuracy of data and comparison between systematic and random design practically.	Khazin S. Rajab (2) h. 15,9,2022
3-Complete randomized design (CRD), Multiple comparison tests. The goals are:1-to learn the construction of this design.2-When and where this design can be use?	Dr. Akram Othman Esmail (4) h. 22/9/2022
3- Examples on CRD in case of equal and unequal replicates	Khazin S. Rajab (2) h. 23,9,2022
4-Comparison between different tests then	Dr. Akram Othman Esmail (4) h.

selecting the suitable one for statistical analysis.	28/9/2022 and 5,10,2022
4-Practical examples about multiple comparison tests.	Khazin S. Rajab (2) h. 29,9,2022 and 6,10,2022
5-Randomized block design. The goals are: 1-Blocking the uniform experimental units in a same block. 2-Limiting the direction of blocks.	Dr. Akram Othman Esmail (2) h 12/10/2018
5-Solving examples related to field experiments	Khazin S. Rajab (2) h. 13,10,2022
6--Comparison between CRD and RCBD.	Dr. Akram Othman Esmail (2) h. 19/10/2022
6-Comparison between CRD and RCBD practically in the field and lab.	Khazin S. Rajab (2) h. 20,10,2022
7-Missing value in CRD, causes of missing value and its effect on statistical analysis.	Dr. Akram Othman Esmail (2) h. 26/10/2022
7-Solving some examples which are having missing value.	Khazin S. Rajab (2) h. 27,10,2022
8-Missing value in RCBD, causes of missing value and its effect on AANOVA table statistical analysis.	Dr. Akram Othman Esmail (2) h. 2/11/2022

8-Solving some examples which are having missing value then adjusting ANOVA table and SS treatment..	Khazin S. Rajab (2) h. 3,11,2022
9-Latin Square Design .In this topic the students will learn the reasons of rarely use of this design in the field experiments.	Dr. Akram Othman Esmail (2) h. 9/11/2022
9-Examples about LSD	Khazin S. Rajab (2) h. 10,11,2022
10-Relative efficiency between designs	Dr. Akram Othman Esmail (2) h. 16/11/2022
10- Solving Practical examples about relative efficiency.	Khazin S. Rajab (2) h. 17,11,2022
11-Theoritical exam	**23,11,2022**
Practical exam	**24,11,2022**
12-Factorial experiments, Basic terms, Factorial experiment using CRD, RCBD and LS. The goals include: 1- Explaining the interaction effects of treatments. 2-Construction factorial experiments using different designs.	Dr. Akram Othman Esmail (2) hrs 30/11/2022
13-Practical examples	Khazin S. Rajab (2) h. 1,12,2022
14-Split plot design. The goals are:	Dr. Akram Othman Esmail (2) h. 7,12,2022

1-Studing the differences between factorial experiments and split plot design. 2-When this design can be applying?	
15-Practical examples about split experiments.	Khazin S. Rajab (2) h. 8/12/2022
16-2nd theoretical exam.	**14,12,2022**
2nd Practical exam	**15,12,2022**

17. Examinations:

1-Mathematical type: The pot experiment was conducted to study the effect of 5 levels of moisture on growth radius of fungi(mm) and you are given the following information:

1-$\sum t_1=12$ 2-$\sum t_2=14$ 3-$\sum t_3=16$ 4-$\sum t_5=18$ 5-CF=500

6-mean of t1 = 3 compare between treatments using LSDα, if tab.tα =2.8 .df error =30.

Mean of $t_1=\sum t_1/ r$ $3=12/r$ $r=12/3=4$ it means r=4

$CF = G^2/tr$ $500=G^2/5*4$ $500=G^2/20$ $G^2=500*20=10000$

$G^2=\sqrt{10000}$ G=100

$G =\sum t_1 + \sum t_2 + \sum t_3 + \sum t_4 + \sum t_5$

$100=12+14+16+\sum t4+18$

$=100-60=40$

$\sum t_4= 43$, df error =t(r-1) =5(4-1)=15 MSE =SSE/df error =30/15 =2

$LSD\infty=tab.t *\sqrt{2MSE/r} =2.8*\sqrt{2*2/4} =2.8$. After that we must calculate mean

of treatments then arranging them and calculating all possible differences between means then comparing the results with LSD∞ for testing the significance of them.

Mean of t1=12/4 =3, Mean of t2 =14/4=3.5 ,

Mean of t3= 16/4=4 Mean of t4=40/4 =10 , Mean of t5=18/4=4.5

Means	t_1=3	t_2=3.5	t_3=4	t_5=4.5	t_4=10	
t_4=10	10-3=7*	10-3.5=6.5*	10-4=6*	10-4.5=5.5*	10-10=0	
t_5=4.5	1.5n.s	1.0n.s	0.5n.s	0		
t_3=4	1.0n.s	0.5n.s	0			
t_2=3.5	0.5	0				
t_1=3	0					

2-Type two: Give the reasons for the following:

1- RLSD is more accurate than LSD∞. 2-LSD (3*3) is not allowed.

Typical answer:

1-Because RLSD∞ depends on four parameters (df error, df treat. Calc.F ,level of significance) while, LSD∞ depends on two parameters(df error and level of significance).

2-In Latin square design the df error must be =6 or more, but in the LSD (3x3) the df error =2 .

3-Type three: Differences or comparison type:

a-Compare between CRD and RCBD.

b-Compare between Duncan's test and Dunnett's test.

Typical answer:

a-

CRD	RCBD
1-It uses in laboratory ,pot ,green house experiments.	1-It uses widely in field experiments.

2-The experimental units are uniform.	2- The experimental units are not uniform.
3-Includes randomization and replicates.	3- Includes randomization and replicates and local control.
4-ANOVA table includes treats and error.	4-ANOVA table includes treats and error and blocks.
5-It uses in case of equal and unequal replicates.	5-It uses in case of equal replicates only.
6-Missing value not causes difficulty in statistical analysis.	6-Missing value causes difficulty in statistical analysis.

b-

Duncan's test .	Dunnett's test.
1-There are more than one table values.	1-Thereis only one table value.
2-All possible comparisons could be done.	2-The comparison between treatments and control could be done.
3-Letters are using in comparison.	3-Letters are not use in comparison.
4-LSR=SSR*Sx^{-}	4- DTvalue=tab.Dtα*√2MSE/r

4-Type four: Schemes:

From the following schemes mention the types of designs:

(b)

=LSD

A	B	C	D

(a)=(RCBD)

B	C	D	A
C	D	A	B
A D D C B	A	B	C
C A B D			
D C A B			

Type five :Mathematical type for factorial experiments:

Q[1]: The laboratory experiment was conducted to test the effect of (3) levels of moisture (A factor) and (2) levels of temperature (B factor) on growth radius of fungi (cm) using (4) replicates and you are given the following information.

1- $\sum a_1 b_1 = 12$ $\sum a_1 b_2 = 10$ $\sum a_2 b_1 = 14$ $\sum a_3 b_1 = 13$ $\sum a_2 b_2 = 7$

2- $\sum$ of A factor = 72 3- Total SS = TCSS * 1.2 4- Tab. $t_{0.01} = 2.88$

a- Complete ANOVA table *b- Compare between a_2b_2 and $a_1 b_1$ using $LSD_{0.01}$*

c- From the following information:

	a_1	a_2
b_1	12	14
b_2	10	7

Calculate (Simple effects, main effects and interaction effect)

Steps for solving the example:

1- $\sum$ of A factor =G= $\sum a_1 b_1 + \sum a_2 b_1 + \sum a_3 b_{1+} \sum a_1 b_{2+} \sum a_2 b_2 + \sum a_3 b_2$

2- 72=12+14+13+7+10+ $\sum a_3 b_2$

3- $\sum a_3 b_2$ =72-56=16

preparing the table contains sum of treatment combinations ,levels of factors and factors.

	a_1	a_2	a_3	
b_1	12	14	13	$\sum b_1 = 39$
b_2	10	7	16	$\sum b_2 = 33$
	$\sum a_1 = 22$	$\sum a_2 = 21$	$\sum a_3 = 29$	

$$CF=(G)^2/abr$$

$$CF=(72)^2/2*3*4=(5184)/24=216$$

$SSA=[(\sum a1)^2+(\sum a2)^2+(\sum a3)^2 \div br]-CF$

$SSA=[(\sum 22)^2+(\sum 21)^2+(\sum 29)^2 \div 2*4]-216$

$SSA=[(484+441+841) \div 8]-216=4.75$

$SSB=[(\sum b1)^2+(\sum b2)^2 \div ar]-CF$

$SSB=[(\sum 39)^2+(\sum 33)^2 \div 3*4]-216=217.5-216=1.5$

$SSAB=\{[(\sum a1b1)^2+\ldots\ldots\ldots\ldots+(\sum a3b2)^2 \div r]-CF\}-SSA-SSB$

$SSAB=\{[(12)^2+\ldots\ldots\ldots\ldots+(16)^2 \div 4]-216\}-4.75-1.5$

$SSAB=6.25$

$TCSS=SSA+SSB+SSAB=4.75+1.5+6.25=12.5$

$TotalSS=TCSS*1.2$

Total ss=12.5*1.2=15 Error SS=TotalSS-SSA-SSB-SSAB

Or Error SS=TotalSS-SSA-SSB-SSAB=Error SS=TotalSS-(SSA+SSB+SSAB)

Error SS=TotalSS-TCSS==15-12.5=2.5

S.O.V.	DF	SS	MS	Calc.F	Tab.F
TC		12.5			
A	a-1=3-1=2	4.75	(4.75/2)=2.38	(2.38/0.14)=17	
B	b-1=2-1=1	1.5	(1.5/1)=1.5	(1.5/0.14)=10.7	
AB	(a-1)(b-1)=(3-1)(2-1)=2	6.25	(6.25/2)=3.13	(3.13/0.14)=22.3	
Error	ab(r-1)=3*2(4-1)=18	2.5	(2.5/18)=0.14		
Total	abr-1=3*2*4-1=23	15			

$LSD_{AB.01}=tab.t._{.01}*\sqrt{2MSE/r}==2.88*\sqrt{(2*0.14)/4}==2.41$

Mean of $a_1b_1=\sum a_1\ b_1)/_{r\ =12/4=3}$ Mean of $a_2b_2=(\sum a_2\ b_2)/_r$ ==7/4=1.75

3-1.75=1.7

The difference between them is less than calculated $LSD_{AB.01}$ (2.41), it means there is no significance difference between them.

	a_1	a_2	Simple effects
b_1	12	14	12-14=-2
b_2	10	7	10-7=3
Simple effects	12-10=2	14-7=7	

From the following information calculate missing value:

A =4	B=5	D=5	E=6	C=3
C=6	D=7	……..	B=8	E=6
D=6	A=7	C=4	D=5	B=3

Steps to solve this example is as follow:

Sum of block which contains missing value =6+7+8+6=27

Sum of treatment (A)which contains missing value=4+ 7=11

G=4+5+5+6+3+6+7+8+6+6+7+4+5+3=75

$$X_{ij}=\frac{rR+tT-G}{(t-1)(r-1)}$$

$$X_{ij}=\frac{3*27+5*11-75}{5-1)(3-1)}=7.63$$

1. Compositional: In this type of exam the questions usually starts with Explain how, What are the reasons for…?, Why…?, How….?
With their typical answers
Examples should be provided

18 Extra notes:
Nothing.

19- Peer review Prof. Dr. Esmail Mustafa Maulood.
and
Approved by Prof. Akram Othman Esmail.