



Department of Filed crops

College of Agricultural Engineering Sciences

University of Salahaddin-Erbil

Subject: Experimental Design and Analysis

Course Book – *For* (4th year students)

Lecturer's name: Asst. Professor. Bahar J Mahmood

B.Sc. in Field Crops, Salahaddin university

M.Sc. in Field Crops Production.

Academic Year: Academic Year: (2021-2022)

Course Book

1. Course name	Fall semester 2021-2022
2. Lecturer in charge	Asst .professor Bahar Jalal Mahmood
3. Department / College	Field Crops Department ,Agricultural Engineering Science
4. Contact	e-mail: bahar.mahmmod@su.edu.krd Tel: 07504672974
5. Time (in hours) per week	Theory: 2 hours per week Practical: 3 hours per week
6. Office hours	6 hours/week
7. Course code	
8. Teacher's academic profile	<p>The main points in my academic profile can be summarize as follow:</p> <ol style="list-style-type: none"> 1- Teaching B.Sc. M. Sc students. 2- Doing scientific researches. 3- Member of some scientific committees in the field crops department. 4- Supervising a student in (Industrial crops/ oil crops) 5- Contributing in (2) examine committee for MSc 6-Evalution of some researches for scientific journals in Kurdistan and Iraq. 7- Supervising students of research project and seminars of 4th year's students, Field crop department. 8-Doing statistical analysis for numerous post graduate students. 9 –Supervising some researches in Agriculture Research Center, Ainkawa.
9. Keywords	Experimental designs ,Principles of experimental design ,Randomization , relative efficiency ,Multiple range tests.
1. Course name	Practical
2. Lecturer in charge	Asst. lect. Asoz Omer Abdulla
3. Department/ College	Field crops Department / College of Agricultural engineering sciences
	BSc . 2005, Diploma Degree 2010 , MSc. 2015 Salahaddin Univ.-Erbil
4. Contact	Email : asoz.abdulla@su.edu.krd . Tel: 09647504211399
5. Time (in hours) per week	Practical: 3
6. Office hours	10hr/week
7. Course code	

<p>8. Teacher's academic profile</p>	<p>Date of Birth:1/4/1982</p> <ul style="list-style-type: none"> • Sex: Female <p>Nationality: Iraqi Marital Status: Married</p> <p>EDUCATION</p> <p>Scientific Degree: Year / Research Subject / university</p> <ul style="list-style-type: none"> • B.S.C: Year / Research Title / University 2005/ plant production / College of Agriculture/ University of Salahaddin/ Kurdistan Region/ Iraq. <p>Diploma Degree: Year/ Research Title/ University 2010 / Field Crops/ Genetics "Induction of Auto tetraploid Mung bean" (Vigna radiata L .)</p> <ul style="list-style-type: none"> • M.SC : Year/ Research Title / University 2013/ Field Crops/ Plant Breeding " Genetic Analysis and Heterosis in F2 Generation of Bread Wheat using Factorial Mating" / College of Agriculture/University of Salahaddin/ Kurdistan Region/ Iraq College of Agriculture/University of Salahaddin/ Kurdistan Region/ Iraq,
<p>9. Keywords</p>	<p>Designs, Factorial Experiments, principles of experimental design ,Significant tests.</p>
<p>10. Course overview:</p> <p>Experimental design and Analysis is 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.</p> <p>In 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.</p> <p>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.</p>	

The application of the studied experimental design in research projects of 3rd or 4th 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 summarizing 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, 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- Data show and power point.
- 2- White board.
- 4- Lectures.
- 5- Visiting Grdarasha field to show students how design an experiment in field .

14. Assessment scheme

Breakdown of overall assessment and examination:

- 1-Monthly exam 15marks.
- 2-Quizzes 5 marks.
- 3-Present and contributing in scientific discussions 3 marks.
- 4-Seminar 2 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 applicat and examples about factorial experiment. 13th and 14th weeks solving examples about plot design . 15th and 16th weeks comparison between different designs and experiments

16. Course Reading List and References:

* Brown, R.B. (1990). Experimental Design and Analysis. USA.

Clark, G.M. (1980). Statistical and Experimental Design, 2nd ed., UK.

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.

* Li. C.C. (1964). Introduction to Experimental Statistics. New York.

* Milton, J. S. and Arnold, J. C. (1995). Introduction to Probability and Statistics, 3rd ed., Mc Graw-Hill Book company. Singapore.

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

* Montgomery D.C. (1976). Design and Analysis of Experiments.

*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.

احمد, ليلي عزيز. (2002) مقارنة طرائق تقدير القيم المفقودة في تصميم قطاعات العشوائية الكاملة. رسالة الماجستير/ قسم الاحصاء/ جامعة صلاح الدين.

الحقني ، مسعد زكي (1982) تصميم وتحليل التجارب الحقلية. جامعة صلاح الدين.

المحمداوي، فاضل مصلح و مؤيد اليونس. (2000). التجارب الزراعية التصميم والتحليل. جامعة بغداد، العراق.

الراوي، خاشع محمود الراوي (1980) تصميم وتحليل التجارب الزراعية. مطابع جامعة موصل.

الساھوكي، 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 الثابت. رسالة الماجستير في الاحصاء، كلية الادارة و الاقتصاد، جامعة صلاح الدين-أربيل (بإشراف د. أكرم عثمان إسماعيل).

منهم وتحليل البيانات الاحصائية. SPSS الزعبي، 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.

<p>احمد, ليلي عزيز (2002) مقارنة طرائق تقدير القيم المفقودة في تصميم قطاعات العشوائية الكاملة. رسالة الماجستير/ قسم الاحصاء/ جامعة صلاح الدين.</p> <p>حمد، أختار صابر (2000)دراسة مقارنة الطريقة المعلمية واللامعلمية لتحليل التغيرات باستخدام المحاكاة رسالة الماجستير/ قسم الاحصاء/ جامعة صلاح الدين.</p> <p>خماس، قيس سبع (1984) المفاهيم الأساسية في تصميم التجارب. جامعة المستنصرية.</p> <p>بشير، محمد علي ومحمد ممدوح (1983). مقدمة في طرق الأحصاء وتصميم التجارب. جامعة الإسكندرية</p>	
17. The Topics:	Lecturer's name
14 dawamyak nakird	
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.	Asst. Professor: Bahar Jalal (2) hrs 21/9/2020
1-Example about symbols in experimental design	(3) hrs 21/9/2020 Asoz Omer
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.	Asst. Professor: Bahar Jalal (2) hrs 28/9/2020
2- Testing accuracy of data and comparison between systematic and random design practically.	Asoz Omer (3) hrs 28/9/2020
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 ?	Asst. Professor: Bahar Jalal (2) hrs 5/10/2020
3- Examples on CRD in case of equal replication.	Asoz Omer (3) hrs 5/10/2020
4-Comparison between different tests then selecting the suitable one for statistical analysis LSD test.	Asst. Professor: Bahar Jalal (2) hrs 12/10/2020

<p>4-Practical examples about multiple comparison tests LSD test.</p> <p>5-CRD with un equal replication</p> <p>5-Examples on CRD with unequal replication</p> <p>6- Duncan and Duneet test in CRD design</p> <p>6-Some examples in Duncan and Duneet test</p>	<p>Asoz Omer (3) hrs 12/10/2020</p> <p>Asst. Professor: Bahar Jalal 19/10/2020</p> <p>Asoz Omer (3) hrs 19/10/2020</p> <p>Asst. Professor: Bahar Jalal 26/10/2020</p> <p>Asoz Omer (3) hrs 26/10/2020</p>
<p>5-Randomized block design.</p> <p>The goals are:</p> <p>1-Blocking the uniform experimental units in a same block.</p> <p>2-Limiting the direction of blocks</p> <p>3- Comparison between CRD and RCBD.</p>	<p>Asst. Professor: Bahar Jalal (2) h. 2/11/2019</p>
<p>5 Comparison between CRD and RCBD practically in the field and lab.-Solving examples related to field experiments</p>	<p>Asoz Omer (3) hrs 2/11/2020</p>
<p>Examination (first)</p> <p>6-- Missing value in RCBD, causes of missing value and its effect on ANOVA table statistical analysis.</p>	<p>9/11/2020</p>
<p>6- Solving some examples which are having missing value then adjusting ANOVA table and SS treatment..</p>	<p>Asoz Omer (3) hrs 9/11/2020</p>
<p>Examples about LSD</p>	<p>Asst. Professor: Bahar Jalal (2) hrs 16/11/2020</p>

7-Missing values	Asoz Omer (3)h 16/11/2019
8- Latein square design	Asst. Professor: Bahar Jalal (2) hrs 23/11/2020
8-latein square, Examples about LSD	Asoz Omer (3)h 23/11/2020
9- Relative efficiency between designs	Asst. Professor: Bahar Jalal (2) hrs 30/11/2020
9- Solving Practical examples about relative efficiency.	Asoz Omer (3)h 30/11/2020
10-Factorial experiments, Basic terms, Factorial experiment using CRD , The goals include: 1- Explaining the interaction effects of treatments. 2-Construction factorial experiments using different designs.	Asst. Professor: Bahar Jalal (2) hrs 7/12/2020
10- Practical examples	Asoz Omer (3)h (3)h 7,12,2020
11- Factorial experiments, Basic terms RCBD and LS .	Asst. Professor: Bahar Jalal (2) hrs 14/12/2020
11-practic examples	Asoz Omer (3)h (3)h 14/12/2020
12-Split plot design. (Holiday) The goals are: 1-Studing the differences between factorial experiments and split plot design. 2-When this design can be applying?	Asst. Professor: Bahar Jalal (2) hrs 21/12/2020
12-Practical examples about split experiments. (Holiday)	Asoz Omer (3)h (3)h 21,12,2020 and

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 $t_1 = 3$ compare between treatments using $LSD\alpha$, if $tab.t\alpha = 2.8$.df error =30.

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

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

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

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

$100 = 12 + 14 + 16 + \sum t_4 + 18$

$= 100 - 60 = 40$

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

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

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

Mean of $t_1 = 12 / 4 = 3$, Mean of $t_2 = 14 / 4 = 3.5$,

Mean of $t_3 = 16 / 4 = 4$ Mean of $t_4 = 40 / 4 = 10$, Mean of $t_5 = 18 / 4 = 4.5$

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 – LS-Design (3*3) is not allowed.

Typical answer:

1-Because $RLSD_{\infty}$ 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:

(a)=(RCBD)

A	D	C	B
C	A	B	D
D	C	A	B
			ΣΣ

(b) =LSD

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

Type five :Mathematical type for factorial experiments:

Q¹: 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 a₂b₂ and a₁ b₁ using LSD_{0.01}

c- From the following information:

	a₁	a₂
b₁	12	14
b₂	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	$\sum b_2 =33$
	$\sum a_1 =22$	$\sum a_2 =21$	$\sum a_3 =29$	

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

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

$$SSA=[(\sum a_1)^2 + (\sum a_2)^2 + (\sum a_3)^2 \div br]-CF$$

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

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

$$SSB=[(\sum b_1)^2 + (\sum b_2)^2 \div ar]-CF$$

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

$$SSAB=\{[(\sum a_1 b_1)^2 + \dots + (\sum a_3 b_2)^2 \div r]-CF\}-SSA-SSB$$

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

$$SSAB = 6.25$$

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

$$\text{Total}_{SS} = TCSS * 1.2$$

$$\text{Total}_{ss} = 12.5 * 1.2 = 15 \quad \text{Error SS} = \text{Total}_{SS} - SSA - SSB - SSAB$$

$$\text{Or Error SS} = \text{Total}_{SS} - SSA - SSB - SSAB = \text{Error SS} = \text{Total}_{SS} - (SSA + SSB + SSAB)$$

$$\text{Error SS} = \text{Total}_{SS} - TCSS = 15 - 12.5 = 2.5$$

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			

$$LSD_{AB,0.1} = \text{tab. } t_{.01} * \sqrt{2MSE/r} = 2.88 * \sqrt{(2 * 0.14)/4} = 2.41$$

$$\text{Mean of } a_1 b_1 = \sum a_1 b_1 / r = 12/4 = 3$$

$$\text{Mean of } a_2 b_2 = (\sum a_2 b_2) / r = 7/4 = 1.75$$

$$3 - 1.75 = 1.7$$

The difference between them is less than calculated $LSD_{AB,0.1} (2.41)$, 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

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

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

(5-1)(3-1)

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

Approved by Asst. Prof. Bahar Jalal Mahmood.