

|  |  |  |
| --- | --- | --- |
| **Republic of Iraq** |  | **University of Duhok** |
| **Kurdistan Region / Iraq** |  | **College of Agriculture** |
| **Ministry of Higher Education** |  | **Field Crops Department** |
| **And Scientific Research** |  |  |

**PRINCIPLES AND PROCEDURES OF STATISTICS AND EXPERIMENTAL**

**DESIGNS**

**Compiled by**

**Dr. K. M. D. Al-Zubaidy**

**Professor of Crop Breeeding**

**College of Agriculture**

**And Foresty, Mosul University**

**Dr. M. A. H. Al-Falahy**

**Professor of Crop Breeeding**

**College of Agriculture**

**Duhok University**

**About the Authors**

* **Dr Khalid Mohammad Dawod Al-Zubaidy**
* Was born in Mosul, Iraq in 1953
* Graduated from Al-Rafidin Primary School in 1965
* Graduated from Al-Hekma Intermediate School in 1968
* Graduated from Al-Gharbia Secondary School in 1971
* Awarded B. Sc. 1975 in Field Crops, College of Agric. and Forestry, Mosul Univ., Iraq
* Awarded M. Sc. 1980 in Crop Production, College of Agric. and Forestry, Mosul Univ., Iraq
* Employed in 1980 as Assistant lecturer at Field Crops Dept., College of Agric. and Forestry, Mosul Univ., Iraq
* Awarded Ph. D. 1986 in Crop Breeding, College of Agric. and Forestry, Mosul Univ., Iraq
* Promoted to Assistant Professor in 1989
* Promoted to Professor in 24 November, 2001
* Published 130 scientific research papers in Local, Arabic and International Journals
* Director of Student Training, Presidency of Mosul University, from 1980 – 1983
* Deputy Head of Dept. of Field Crops, College of Agric. and Forestry from 1986 – 1988
* Head of Dept. of Field Crops, College of Agric. and Forestry from 1988 – 1996
* Director, Center for Agriculture Research, Mosul University from 1986 – 1998
* Executive Director for the Cultivation of Cotton Development Program in Iraq, Ministry of Agriculture (Placement), from 1998 – 2002
* Dean of the College of Agriculture and Forestry, Mosul University, from 2001 – 2003
* Shared in publication of the books " Statistical Procedures for Agricultural Researches", 1990 and "Design and Analysis of Genetically Experiments", 2015
* Supervised six M. Sc. and eight Ph. D. graduate students at Mosul University
* Attended numbers of conferences, meetings, seminars and training courses in Iraq and abroad
* Chairman of the editorial board of the Iraqi Journal of Agricultural Science (quarterly scientific journal published by the College of Agriculture and Forestry, University of Mosul, 10/1/2002 to 26/5/2003.

Dr. Mohammed Ali Hussain Al-Falahe, Born in Baghdad, Iraq, 1953.

* Awarded B.Sc. 1977 in the field crops – college of Agric. Baghdad University, Iraq.
* Awarded M.Sc. 1979 in plant breeding, college of Agric. Baghdad University, Iraq.
* Awarded Ph.D 1998 in crop breeding, college of Agric. Baghdad University, Iraq.
* Promoted to assistant professor 2000
* Promoted to professor 2014
* Moved to work in Duhok University college of Agriculture 2006.
* Published 90 scientific research paper in local, Arab and international journals.
* Shared in publication of the books, plant breeding / partical part testing and reproduction seed.
* Supervised six M.Sc. graduate student at Duhok and under university.
* Attended about 5 conferences meeting symposium and workshop in Iraq and Arab countries.
* Prize of Arab organization for Agricultural development 1998.
* Prize of Ma Baina Alnahrain 1999.
* Prize of Agricultural scientific 2000.
* Registration and release – maize hybrid – 3001 – 2000.
* Registration and release – maize hybrid – 3003 – 2001.
* Registration, maize hybrid – 2052 – 2001.
* Registration release – green glam variety – 2002.

**بسم الله الرحمن الرحيم**

 **رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ اَّلتِي أَنْعَمْتَ عَلَيَّ وَعَلى وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحاً تَرْضَاهُ وَأَدْخِلْنِي بِرَحْمَتِكَ فيِ عِبَادِكَ الصَّالِحِين َ**

**صدق الله العظيم**

**سورة النمل – الأية 19**

**DEDICATION**

**TO OUR FAMILIES WHOM THE WORK WAS ACCOMPLISHED ON THE EXPENSE OF THEIR REST**

**Dr. Kh M. D. Al-Zubaidy Dr. M. A. H. Al-Falahy**

*Copy right©2016 – Duhok Uneversity press; all right are for Duhok Uneversity , as subsidized the puplication of this book for the beneft of students .*

*Central Library -Duhok – card Number : D – 2039 / 16*

**ACKNOWLEGEMENTS**

 **We wish to express our sincere appreciation to the Dean of the Faculty of Agriculture and Forestry, Duhok University, for his support and encouragement to finish this work and bring it to light.**

 **Our thanks are also due to the presidency of Duhok University for their assistance in publishing this book.**

 **The efforts of the reviewers have to be greatly appreciated, so a word of thanks is also forwarded to them.**

**Preface**

 As a result of the increasing role of statistics in all scientific fields and in view of the great important occupied by Applied Scientific Agricultural Research, it has become equally important to provide sources that deal with other statistical method for agricultural research and related sciences for the benefit of students and researchers in universities.

 This book comes a continuation of previous works in this area in order to enrich universities libraries and statistical publications. This book includes many statistical method for the analysis of data obtained from tests performed on scientific bases and for the illustration of experiments results. This is in order to able many researches in agricultural and non-agricultural fields to take appropriate decisions.

 In compiling this book, the authors relied on their teaching experience and many local and international scientific references.

 Thanks first and foremost go to a Almighty God. We also thank the university of Duhok for giving the permission to compile this work.

 We hope that this book is useful to collegians, to our colleagues and students, in the relevant faculties.

 The authors

**CONTENTS**

|  |  |
| --- | --- |
| Subject | Page |
| Preface | VII |
| Chapter 1: Chapter 1 | 1 |
|  (1-1) Nature of Statistics | 1 |
|  (1-2) History of Statistics | 2 |
|  (1-3) The Role of Statistics in the way of Scientific Research | 4 |
|  (1-4) Meaning of some Statistical Notations | 6 |
|  (1-5) Exercises for Chapter 1 | 6 |
| Chapter 2: Nature of Data and Statistical Notations | 7 |
|  (2-1) Nature of Statistical Data | 7 |
|  (2-2) Variable and Types of Variables | 7 |
|  (2-3) Population and Sample | 8 |
|  (2-4) Statistical Notations | 9 |
|  (2-5) Important Rules in Summation | 11 |
|  (2-6) Exercises for Chapter 2 | 15 |
| Chapter 3: Tabular and Graphical Presentation | 17 |
|  (3-1) Tabular Presentation | 17 |
|  (3-1-1) Frequency Table | 17 |
|  (3-1-2) General Rules For Constructing Frequency Table | 21 |
|  (3-1-3) Cumulative distributions | 25 |
|  (3-2) Graphical Presentation | 30 |
|  (3-2-1) Graphical Representation for the Frequency Distribution Table | 30 |
|  (3-2-2) Graphical Representation for Cumulative Distributions Tables | 33 |
|  (3-3) Exercises for Chapter 3 | 35 |
| Chapter 4: Measures of Central Tendency | 38 |
|  (4-1) Introduction | 38 |
|  (4-2) The Arithmetic Mean | 38 |
|  (4-3) The Geometric Mean | 45 |
|  (4-4) The Harmonic Mean | 47 |
|  (4-5) The Quadratic Mean | 48 |
|  (4-6) The Median | 49 |
|  (4-7) The Mode | 52 |
|  (4-8) Exercises for Chapter 4 | 57 |
| Chapter 5: Measures of Dispersion or Variation | 59 |
|  (5-1) Introduction | 59 |
|  (5-2) The Range | 59 |
|  (5-3) The Mean Deviation | 60 |
|  (5-4) The Variance and Standard Deviation  | 61 |
|  (5-5) The Variance of the Mean and Standard Error | 67 |
|  (5-5-1) The Variance of the Mean | 67 |
|  (5-5-2) The Standard Error (Standard Deviation of the Mean) | 67 |
|  (5-6) The Coefficient of Variability | 68 |
|  (5-7) Standardized Scores | 69 |
|  (5-8) Exercises for Chapter 5 | 71 |
| Subject | Page |
| Chapter 6: Elementary Probability Theory | 74 |
|  (6-1) Introduction | 74 |
|  (6-2) Some Statistical Definitions | 74 |
|  (6-3) The Probability | 78 |
|  (6-4) Probability Theory | 81 |
|  (6-5) Rules of Probability | 81 |
|  (6-6) The Probability and Combinatorial Analysis | 84 |
|  (6-7) Exercises for Chapter 6 | 86 |
| Chapter 7: Test of Hypothesis | 89 |
|  (7-1) Introduction | 89 |
|  (7-2) Steps of Test Hypothesis | 92 |
|  (7-3) t – Distribution | 92 |
|  (7-3-1) The Tests Concerning One Mean | 93 |
|  (7-3-2) The Tests Concerning the Difference Between Two Means  (unpaired observations) | 96 |
|  (7-3-3) The Test Concerning to the Difference Between Two Means  (paired observations) | 101 |
|  (7-4) Exercises for Chapter 7 | 104 |
| Chapter 8: Chi – Square Distribution | 107 |
|  (8-1) Introduction | 107 |
|  (8-2) Application of chi – Square | 107 |
|  (8-3) Test of Hypothesis for Population Variance | 108 |
|  (8-4) Test of Expected Percent | 110 |
|  (8-4-1) Application of chi – Square for One Degree of Freedom | 110 |
|  (8-4-2) Application of chi – Square for More Than One Degree of  Freedom | 111 |
|  (8-5) Test of Goodness of Fit | 113 |
|  (8-6) Test of Independence (or Test of Association) | 116 |
|  (8-7) Exercises for Chapter 8 | 118 |
| Chapter 9: F – Distribution | 120 |
|  (9-1) Introduction | 120 |
|  (9-2) Nature of F – Distribution | 120 |
|  (9-3) Test For the Equality of Two Variances | 123 |
|  (9-4) Limit intervals for Percent Treatment Among Two Variances σ12/ σ22 | 125 |
|  (9-5)Test of Hypothesis About the Differences Among Three or More  Population Means | 127 |
|  (9-6) Exercises for Chapter 9 | 137 |
| Chapter 10: Regression and Correlation | 140 |
|  (10-1) Introduction | 140 |
|  (10-2) Simple Linear Regression | 140 |
|  (10-2-1) Description of Data | 141 |
|  (10-2-2) Graphical Representation | 141 |
|  (10-2-3) Linear Model | 142 |
|  (10-2-4) Assumptions of Analysis | 143 |
| Subject | Page |
|  (10-2-5) Estimation of Regression Parameters | 144 |
|  (10-2-6) Drawing Regression Line | 146 |
|  (10-2-7)Determination of Confidence Interval for Regression  Coefficient (CI) | 147 |
|  (10-2-8) Testing Significant of Regression | 148 |
|  (10-2-9) Determination Coefficient | 150 |
|  (10-3) Test of Linear Model Fitness | 151 |
|  (10-3-1) Errors Analysis Method (or Residual Analysis)  | 151 |
|  (10-3-3) Lack of Fit Method (L. O. F.) | 154 |
|  (10-4) Simple Non Linear Regression | 158 |
|  (10-4-1) Description of Data | 158 |
|  (10-4-2) Estimation of Regression Parameters | 159 |
|  (10-5) Simple Correlation | 163 |
|  (10-5-2) Testing Significant of Correlation Coefficient | 166 |
|  (10-5-3) Relationship Between Regression and Correlation  Coefficients | 167 |
|  (10-6) Exercises for Chapter 10 | 169 |
| Chapter 11: Principles of Agricultural Experiments | 172 |
|  (11-1) Introduction | 172 |
|  (11-2) Terminology Contributed to Experimental Design | 172 |
|  (11-2-1) The Experiment | 172 |
|  (11-2-2) The Factor | 173 |
|  (11-2-3) The Treatments | 174 |
|  (11-2-4) The Experimental Unit | 174 |
|  (11-2-5) The Design Experiment | 174 |
|  (11-2-6) The Experimental Error | 179 |
|  (11-2-7) The Analysis | 180 |
|  (11-3) Exercises for Chapter 11 | 181 |
| Chapter 12: Single Factor Experiments | 183 |
|  (12-1) Introduction | 183 |
|  (12-2) Completely Randomized Design (CRD) | 183 |
|  (12-2-1) Definition, Advantages and Disadvantages | 183 |
|  (12-2-2) Method of Planning Experiment Using this Design | 184 |
|  (12-2-3) Data Collection and Organization by Symbols | 185 |
|  (12-2-4) Statistical Analysis | 187 |
|  (12-3) Randomized Complete Block Design (RCBD) | 195 |
|  (12-3-1) Definition, Advantages and Disadvantages | 195 |
|  (12-3-2) Method of Planning Experiment Using this Design | 196 |
|  (12-3-3) : Data Collection and Organization by Symbols | 197 |
|  (12-3-4) Statistical Analysis | 198 |
|  (12-3-5) Estimation of Relative Efficiency of RCBD as Compared with CRD (RE%) | 204 |
|  (12-3-6) Estimation of Missing Observation | 204 |
|  (12-4) Latin Square Design (LSD)  | 206 |
| Subject | Page |
|  (12-4-1) Definition, Advantages and Disadvantages | 206 |
|  (12-4-2) Method of Planning Experiment Using this Design | 207 |
|  (12-4-3) Data Collection and Organization by Symbols | 208 |
|  (12-4-4) Statistical Analysis | 209 |
|  (12-4-5) Estimation of Relative Efficiency of LSD as Compared with  CRD and RCBD (RE%) | 215 |
|  (12-4-6) Estimation of Missing Observation | 216 |
|  (12-4-7) Estimation of Components of Variance | 217 |
|  (12-5) Randomized Incomplete Block Designs (BIBD)  | 219 |
|  (12-5-1) Balanced Incomplete Block Design | 220 |
|  (12-5-2) Youden Square Design | 225 |
|  (12-6) Exercises for Chapter 12 | 231 |
| Chapter 13: Two Factors Experiments | 236 |
|  (13-1) Introduction | 236 |
|  (13-2) Interaction Among Two Factors | 236 |
|  (13-3) Factorial Experiments | 239 |
|  (13-4) Completely Randomized Design | 241 |
|  (13-5) Randomized Complete Block Design | 248 |
|  (13-6) Split Plots Deigns | 258 |
|  (13-7) Split Block Deign | 267 |
|  (13-8) Identify the Nature of the Interaction Between the Two Factors  Graphically  | 275 |
|  (13-9) Exercises for Chapter 13 | 275 |
| Chapter 14: Three Factors Experiments | 279 |
|  (14-1) Introduction | 279 |
|  (14-2) Interaction Among Three Factors | 279 |
|  (14-3) Completely Randomized Design | 283 |
|  (14-4) Randomized Complete Block Design | 294 |
|  (14-5) Split-Split Plot Deigns | 301 |
|  (14-6) Factorial Experiment Within Split Plots | 314 |
|  (14-7) Split Plots Within Factorial Experiment | 320 |
|  (14-8) Exercises for Chapter 14 | 328 |
| Chapter 15: Comparison Between Treatment Means | 331 |
|  (15-1) Introduction | 331 |
|  (15-2) Methods of Comparison Between the Treatments Means | 331 |
|  (15-2-1): Tests Identified Before Implementation of Experiment  (Group Comparisons) | 331 |
|  (15-2-1-1): Simple Experiments | 331 |
|  (15-2-1-2): Factorial Experiments | 343 |
|  (15-2-2): Tests Adopted After Implementation of Experiment and  Data Analysis | 359 |
|  (15-3) Exercises for Chapter 15 | 371 |
| References | 375 |
| Appendices  |  |