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Application of Factorial Experiments with Asymmetric Responses for Determine Important Factors Affecting on Production of Dates.

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Abstract

The factorial of experiments assume that the response variable is a distributed one with normal distribution, thus, the dependence of the technique of analysis of variance (ANOVA), assumes the response variable are normally distributed. However, there are many situations where the response variable is non-normal. There are many methods that help us process this problem, the log transformation method for the responses due to the fact that distribution of this responses is non-normal. In this paper we are studying the most important factors affecting the production of the Iraqi dates using factorial experiments. The five factors have been described as the following: (Fertilizers, Dates Type, Number of times vaccinate, Watering the Palm, Pesticides) and each factor has two levels. The ways used to determinate the most important factors are the traditional methods (ANOVA) and adaptive Lasso method for determine important factors. We used program R to analyse the data.

Keywords: *Full Factorial Experiment, Adaptive lasso, Production of Dates.*

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1. Introduction

Iraq is one of the oldest countries in the world in which palm trees abound. It is also one of the most suitable geographical areas to cultivate palms. Here the environmental requirements of the palm tree meet the climatic conditions supporting it which are characterized by high temperature and low humidity. Palm trees occupy an advanced position for fruit tree species. The 1995 census of the Central Bureau of Statistics indicates that the number of palm trees is 18.2 million, of which 12.7 million are a fruitful palm. The palm groves cover 382 thousand dunams. Statistical studies indicate that the production of dates in case of continuous decrease due to poor care of the dates and diseases that limit the quality and cause low production.

Our study aims to find out the most important factors affecting the production of dates in Iraq by using factorial experiments when the response variable is distributed according to the exponential distribution (non-normal distribution). Factorial experiments are the most important statistical models used in the study of agricultural phenomena and production, because they study the interactions between these factors as well as the levels of these factors, In the start, we use a method to approximating data to normal distribution, Which is the log transformation method, Which are explained in detail in the section (4-2), We use factorial ANOVA to examine the main effects and interaction effect between the factors. and for the selection of the most important of these factors, our use adaptive Lasso method, to choose the most important factors affecting mainly the productivity of dates, which the described in Section (4-3).

This paper is organized as follows. In Section 2 we present the problem research, and in Section 3 we illustrate briefly the Aims of the research. In Section 4 we introduce briefly the Research Methods that includes the full factorial experiment, Logarithmic Transformation and adaptive lasso method. The fifth section includes the study sample and the obtained results A brief Discussions and conclusion is included in Section 6.

2. Problem Statement

The problem of research can be formulated in a scientific form based on the most important factors affecting the palm production of dates in Iraq. In order to test the scientific hypotheses attempting to explain the problem of research, the study relied on the appropriate statistical methods

for that data in terms of analysis and selection of important factors for this sample of study.

Factorial experiments models are often have been extensively used by experimental researchers in many areas of interest such as agriculture, engineering, medical research, industrial research [7], [18]). In 1999, Bahman Eghball and James F. Power [5], conducted an experiment to determine the effects of fertilization on maize under two ploughing systems in four years (1992, 1993, 1994, and 1995).The plots were distributed according to the design of the random whole sectors with four replicates. The tillage systems were distributed on the main plots. The secondary plots were distributed at the fertilization levels. The results showed that in three years out of four years there was no effect of ploughing in the production. In 2000 Morrison et al., [12] assessed the performance of fourteen varieties of soybean plant grown in Canada in six years for the purpose of identifying changes in plant qualities. He randomized whole sections with four replicates. The varieties represented the treatments. The result of the analysis of the composite variance showed the significance of the varieties as well as the interaction between the varieties and the years for all studied traits. In 2006, Tarakanovas and Ruzgas [15], studied the stability of the 13 type of wheat in four locations and two years by using the factorial experiments. Where the results showed that analysis of variance to (genotype, locations, years) and their interactions were significant at the 99% confidence level. In 2012 Dong et al., [2] use the factorial experiments to study the effects of five fertilization treatments [these were: no fertilizer, rice straw return, chemical fertilizer, organic manure and green manure] on soil pH, soil organic carbon, total nitrogen, ratio and available nutrients contents in the plowed layer of paddy soil from 1998 to 2009 in Jiangxi Province, southern China. Results showed that the organic manure should be recommended to improve soil fertility in this region. Considering the long-term fertilizer efficiency, and also the results suggest that annual straw returning application could improve soil fertility in this trial region .In 2016 Al-Qurashi et al., [1] use the experiments of design to study and analysis the effect of fertilization on yield, fruit quality and nutrient uptake of 'Nabbut-Ahmar' date palm cultivar grown in sandy loam soil. Three fertilization treatments were compared with traditional application. The results showed that in applying of the recommended dose of fertilizers under dry land condition through fertilization maximize yield, quality and fertilizer use efficiency.

In this paper, we studied five factors with two level for each factor to determine their effect on palm productivity of dates in Iraq. We used the

full factorial experiments model. There are 2^5-1= 31 treatments divided according to the following, 5 main factors,10 two-factor interactions, 10 three-factor interactions, 5 four-factor interactions and 1 five -factor interaction. As well as selecting the most important of these factors using variable selection methods (adaptive lasso).

3. Research Questions/Aims of the research

The research seeks to achieve some goals, which are

1-Determine the most important factors affecting on the productivity of dates in Iraq using the factorial of experiments.

2- Determine the best way to choose factors affecting mainly the product

3- Increase the productivity of palm dates in Iraq for the next period after determine factors affecting productivity.

The research assumes that there are technical factors that led to the deterioration of date's production in Iraq at the all levels. Thus Low productivity of dates.

4. Research Methods

The best way to carry out such experiments is by using full factorial experiments [3].These are experiments in which all combinations of factors are investigated in each replicate of the experiment. Full factorial experiments are the only means to completely and systematically study interactions between factors in addition to identifying significant factors. One-factor-at-a-time experiments do not reveal the interaction effects between the factors. Further, in one-factor-at-a-time experiments, full randomization is not possible [14]. The model and analysis of a multi-way factorial are similar to those of a two-way factorial. In this paper, we study factorial experiment type of 2^5. In this type of factorial design we have five factors each at two levels, say, so that there are 2×2x2x2x2=32 treatment combinations in all. Following the notations due to yates and letting the capital letters A, B, C, D and E indicate the names of the five factors under study and the small letters a, b, c, d and e denote one of the two levels of each of the corresponding factors. This can be described mathematically as follows:

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_{12} x_1 x_2 + \cdots + \beta_{15} x_1 x_5 + \cdots + \beta_{23} x_2 x_3 + \cdots + \beta_{25} x_2 x_5 + \beta_{34} x_3 x_4 + \beta_{123} x_1 x_2 x_3 + \cdots + \beta_{12345} x_1 x_2 x_3 x_4 x_5 + e \quad \ldots. (1)$$

4.1. Logarithmic Transformation

The log transformation method, a generally utilized strategy to address skewed data, is a standout method amongst the most prominent transformation utilized as a part of biomedical and psychosocial inquiries. Because of its ease of use and popularity, the log transformation is used into most major measurable programming bundles including SAS, S plus, SPSS and R. [9] considered a suitable processor to transform data to approximate normal distribution. The log transformation method is used in the case of non-homogeneity of variance or in the case of a spread distribution of any non-normal data distribution and skewed variance.

In both cases, the data conversion process helps us to fix variance and convergence data to normal distribution [13], in this paper the data she was the distributed exponential distribution. The response variable y can be converted into log transformation by the following formula:

$$W_{ij} = \log(\mathrm{y}_{ij}) \dots (2)$$

where, $W_{ij} \sim N(\mu_i, \sigma_w^2)$

4.2. Adaptive lasso method

Many studies in agricultural, medical and industrial experimentation contain a large number factors of which believed were relevant in study. But the actual effects of these factors are often few and scattered. The analysis of experiments in which numerous potential variables are examined is driven by the principles of effect Sparse. variable selection strategy are widely used for identifying important factors in practical experiments .The variable selection is the operation of reducing the number of random variables with as little loss of information as possible. It is one of the main solutions to the Reduce voltage, time and cost dimension.

In 2006, Zou [19] introduced a new version of the Lasso [16] based on the adaptive weights which in turn lead different penalization to different coefficients in the ℓ_1 penalty. Adaptive Lasso, as a regularization method, avoids over fitting penalizing large coefficients. Besides, it has the same advantage that Lasso: it can shrink some of the coefficients to exactly zero. Adaptive Lasso estimate [19] is based on Oracle's property that is Consistency in variable selection and asymptotic normality [6]. Zou explained that the lasso cannot be an oracle procedure. However, the asymptotic setup is somewhat unfair, because it forces the coefficients to be equally penalized in the ℓ_1 penalty. Zou has given different weights to different coefficients.

In a linear regression, the Adaptive Lasso seeks to minimize:

RSS (β)+$\lambda \sum_{j=1}^{p} \widehat{w_j}|\beta_j|$ …(3)

Where $\boldsymbol{\lambda}$ is the tuning parameter (chosen through 10-fold cross validation), β_j are the estimated coefficients, existing p of them. Furthermore, we see $\widehat{w_j}$, called Adaptive Weights vector.

The adaptive lasso can be defined as

argmin$\{\sum_{i=1}^{n}(y_i - \sum_{j=1}^{p}\beta_j x_{ij})^2 + \lambda \sum_{j=1}^{p} w_j |\beta_j|\}$ …(4)

Where $(w_1, w_2, , \ldots, w_p)$ are the adaptive weights. Zou has shown that if the weights are efficiently chosen in a data-dependent way then the adaptive lasso can achieve the oracle properties. He suggested the use of estimated weights, $\widehat{w_j}=|\beta_j|^{-\gamma}$, where $\beta = \{bj: j = 1, p\}$ is a root-n-consistent estimator of β and $\gamma > 0$ is a user-chosen Constant.

The smaller the weight on a specific coefficient, the less the size of that coefficient is penalized in the regression, and the less likely it is that the coefficient will fall to 0 as λ increases.

Kraemer and Schaefer [10] have developed an R package, *parcor*, to implement Zou'smethod. The function *adalasso* relies on a Least Angle Regression [4] algorithm to compute the weights in the adaptive lasso expression.

Different λ_k values are then applied to the constrained minimization problem (4) and their corresponding models are tested for accuracy via cross-validation. The λ_k thatproduces.The vector of coefficients $\hat{\beta}_k$ that yield the lowest mean squared error in the test set is selected as the penalty. The adaptive lasso $\hat{\beta}$ is then chosen as the vector of coefficient that solve (4) given λ .Kane and Mandal [8]. They utilized test Kraemer's and Schaefer's adaptive lasso on small samples and examine its effectiveness in designs with complex aliasing via simulations .In this study we can employ adaptive Lasso method in factorial experiment.

5. Findings

5.1 sample study

The sample of study is taken from the Ministry of Agriculture (Agricultural research division) of the Production of Dates in Iraq [17], for orchard made up of 128 palm trees. This experiment was used for a period of one season, in the district of Shafi'ia, for the study. The most important factors that affect the amount of production of the palm one of dates, represent the response variable **(y)**. These factors are, the first factor **"A"** is the Fertilizers type ($\boldsymbol{a_1}$: organic fertilizer, $\boldsymbol{a_2}$:Nitrogen fertilizer),The

second factor "B" is the Dates Type ($\boldsymbol{b_1}$, Hilawi Variety , $\boldsymbol{b_2}$: Zahdi Variety), the third factor **"C"** is the Number of times vaccinate ($\boldsymbol{c_1}$: the twice , $\boldsymbol{c_2}$: three times), the four factor **"D"** is the Watering the Palm($\boldsymbol{d_1}$: Once the season, $\boldsymbol{d_2}$: Twice in the season),the five factor **"E"** is the Pesticides ($\boldsymbol{e_1}$: at one time , $\boldsymbol{e_2}$: the twice). As it is shown below in table (1).

Table (1) Factors & levels

Factors	Factors levels
x_1 =A : Fertilizers type	a_1: organic fertilizer,a_2:Nitrogen fertilizer
$x_2 = B$: Dates Type	b_1:Hilawi Variety , b_1: Zahdi Variety
$x_3 = C$:Number of times vaccinate	c_1: the twice, c_2: three times
$x_4 = D$: Watering the Palm	d_1: Once the season, d_2 : Twice in the season
x_5 = E: Pesticides	e_1: at one time, e_2: the twice

We can describe the model **(1)** based on the factors studied in this research as follows:

y_i : Response variable, the product quantity of dates for one palm.
$A =$ The fertilizers type, this factor his two levels (a_1: organic fertilizer and a_2:Nitrogen fertilizer)
$B=$ The dates Type, this factor his two levels (b_1, Hilawi Variety and b_1: Zahdi Variety)
$C =$ The Number of times vaccinate, this factor his two levels (c_1: the twice and c_2: three times
$D=$ Watering the Palm, this factor his two levels (d_1: Once the season and d_2 :

Twice in the season

E: The Pesticides, this factor his two levels (e_1: at one time and e_2: the twice)

AB=Two – factor interactions between the Fertilizers and the dates type.
AC: Two – factor interactions between the Fertilizers and Number of times vaccinate
AD= Two – factor interactions between the Fertilizers and Watering the Palm
AE=Two – factor interactions between the Fertilizers and Pesticides.
$BC =$Two – factor interactions between the Dates Type and Number of times vaccinate
$BD =$Two – factor interactions between the Dates Type and Watering the Palm.

BE=Two – factor interactions between the Dates Type and Pesticides.

CD=Two – factor interactions between the Number of times vaccinate and Watering the Palm

CE=Two – factor interactions between the Number of times vaccinate and Pesticides

DE =Two – factor interactions between Watering the Palm and Pesticides

ABC=Three –factor interactions between the Fertilizers, the Dates Type and the Number of times vaccinate

ACD=Three –factor interactions between the Fertilizers, Number of times vaccinate and the Watering the Palm

ABD = Three –factor interactions between the Fertilizers, the Dates Type and the Watering the Palm.

BCD=Three –factor interactions between the Dates type, Number of times vaccinate and the Watering the Palm

ACD: Three –factor interactions between the Fertilizers and Number of times vaccinate and the Watering the Palm.

ABE= Three –factor interactions between the Fertilizers, the Dates Type and Pesticides.

ADE: Three –factor interactions between the Fertilizers, the Watering the Palm and Pesticides

BCD=Three –factor interactions between the Dates Type, Number of times vaccinate and the watering.

BCE = Three –factor interactions between the Dates Type, Number of times vaccinate and Pesticides.

BDE = Three –factor interactions between the Dates Type and Watering the Palm and Pesticides.

CDE=Three –factor interactions between the number of time vaccinate, Watering the Palm and Pesticides

$AC\ E$ =Three –factor interactions between the Fertilizers, Number of times vaccinate and Pesticides.

ABCD=four –factor interactions between the Fertilizers, the Dates Type, Number of times vaccinate and the watering.

$ABCE =$ Four –factor interactions between the Fertilizers, the Dates Type, Number of times vaccinate and Pesticides.

ACDE= four –factor interactions between the Fertilizers, the number of time vaccinate, Watering the Palm and Pesticides.

$ABDE =$Four –factor interactions between the Fertilizers, the Dates Type, Watering the Palm and Pesticides.

BCDE=four –factor interactions between the Dates Type, Number of times vaccinate, the watering and Pesticides.

ABCDE= five- factors interaction between the Fertilizers, the Dates Type, Number of times vaccinate, the watering and Pesticides.

5.2 Analysis and results

At the beginning of the analysis, the Kolmogorov-Smirnov test [8] was used to determine the distribution of data. As it turned out, in table (2) it's asymmetric and does not follow the normal distribution, whereas p-value (0.321), is greater than the significant level at (0.05)

Table 2. Results of Kolmogorov-Smirnov test

Test	Statistical test	Degree of freedom	p-value
Kolmogorov-Smirnov	0.5244	32	0.321

Therefore, we used Logarithmic Transformation method, which has been clarified in (4-2) to approximate the data to normal distribution using R program. After the data is rounded to the normal distribution, We used the Analysis of variance (ANOVA) and adaptive Lasso method to determine the effect of important factors on date palm production, The results were as in Table 3 and 4.

Table 3. ANOVA TABLE

Factor	Df	Sum Sq	Mean Sq	F value	Pr(>F
A	1	236.5	236.5	1.256	0.04313 *
B	1	200.9	200.9	1.068	0.0477 *
C	1	265.4	265.4	1.410	0.0022 **
D	1	142.9	142.9	0.760	0.0244 *
E	1	133.5	133.5	0.709	0.0462*
AB	1	139.6	139.6	0.854	0.432

AC	1	0.7	0.7	0.004	0.956
AD	1	150.9	150.9	0.802	0.436
AE	1	2.8	2.8	0.015	0.911
BC	1	145.8	145.8	0.775	0.444
BD	1	116.6	116.6	0.620	0.489
BE	1	222.4	222.4	0.804	0.356
CD	1	630.5	630.5	2.923	0.01132 *
CE	1	550.1	550.1	2.644	0.186
DE	1	394.9	394.9	1.908	0.03424 *
ABC	1	359.0	359.0	1.308	0.261
ACD	1	267.0	267.0	1.907	0.04158 *
ABD	1	197.2	197.2	1.048	0.381
BCD	1	701.9	701.9	3.103	0.00847 **
ABE	1	604.4	604.4	3.212	0.171
ADE	1	311.0	311.0	1.653	0.289
BCE	1	54.0	54.0	0.287	0.629
BDE	1	296.9	296.9	1.578	0.298
CDE	1	0.6	0.6	0.003	0.958
ACE	1	574.1	574.1	8.730	0.1442
ABCD	1	415.3	415.3	2.033	0.03075 *
ABCE	1	382.5	382.5	2.010	0.249
ACDE	1	103.2	103.2	0.549	0.513
ABDE	1	0.1	0.1	0.001	0.980
BCDE	1	125.5	125.5	0.673	0.342
ABCDE	1	148.76	148.76	1.049	0.278

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 4. Estimation and selection of factorial experiment coefficient using the adaptive Lasso method

Factor	Coefficient	Factor	Coefficient
A	2.95261	ABD	0.000
B	1.64746	ABE	0.84775
C	2.83764	ADE	0.0000
D	1.96461	BCD	0.73663
E	0.47737	BCE	0.0000
AB	0.74377	BDE	0.0000
AC	0.0000	CDE	0.63544
AD	0.6523	ACD	0.0000
AE	0.7365	ACE	0.0000
BC	0.0000	ABCD	0.43287
BD	0.0000	ABCE	0.0000
BE	0.763553	ACDE	0.86532
CD	0.28474	ABDE	0.0000
CE	0.49883	BCDE	0.76353
DE	0.000	ABCDE	0.98524
ABC	0.73466		

6. Discussions

Through the results of Table (3) we note that the main effects, as follows, were the number of times vaccinate (C) was the first and has a significant effect on the productivity of dates. It can be clearly seen that the p-value (0.0023) had its least of significant level at (0.05). This evidence that the factor (C) has a significant effect. Factor (D) came second, the p-value (0.0244) having least of significant level at (0.05). This is evidence that the factor (D) has a significant effect. Third came the fertilizers type factor (A), with the p-value (0.04313), having the least of significant level at (0.05). It had a significant effect.

The pesticide factor (E) came fourth with the p-value (0.0462) and least of significant level at (0.05). The factor date type (B) came at the end, it can be seen that the p-value (0.0477) with the least of significant level at (0.05). This evidence showed that the factor (B) had a significant effect.

As for the effect of interactions between factors on the productivity of dates, we note as follows, were the Three –factor interactions between the Dates type, Number of times vaccinate and the Watering the Palm (BCD), was the first and had a significant effect on the productivity of dates. The p-value (0.00847) had its least of significant level at (0.05). This was evidence that the factors (BCD) had a significant effect.

Two – factor interactions between the number of times vaccinate and Watering the Palm (CD) had the p-value (0.01132), and the least of significant level at (0.05), having significant effect. Third came the four – factor interactions between the Fertilizers, the Dates Type, Number of times vaccinate and the watering (ABCD), where that the p-value (0.03075), it's least of significant level at (0.05), having a significant effect. Two – factor interactions between Watering the Palm and Pesticides (DE) came fourth with the p-value (0.03424) and the least of significant level at (0.05). Three– factor interactions between the Fertilizers and Number of times vaccinate and the Watering the Palm (ACD) came at the end, where that the p-value (0.04158) had its least of significant level at (0.05). This was evidence that the factors (ACD) had a significant effect.

The results in Table (4) indicated, (adaptive lasso method) unimportant covariates in building the factorial design model. The results of the estimation of some factors emerged as zeros (detailed below):

AC: Two – factor interactions between the Fertilizers and Number of times vaccinate

BC:Two – factor interactions between the Dates Type and Number of times vaccinate

BD: Two – factor interactions between the Dates Type and Watering the Palm.

DE: Two – factor interactions betweenWatering the Palm and Pesticides**.**

ABD: Three –factor interactions between theFertilizers, the Dates Type and the Watering the Palm.

ADE: Three –factor interactions between theFertilizers, the Watering the Palm and Pesticides

BCE: Three –factor interactions between the Dates Type, Number of times vaccinate and Pesticides.

BDE: Three –factor interactions between the Dates Type and Watering the Palm and Pesticides.

ACD: Three –factor interactions between the Fertilizers and Number of times vaccinate and the Watering the Palm**.**

AC E: Three –factor interactions between the Fertilizers, Number of times vaccinate and Pesticides**.**

ABCE:Four –factor interactions between the Fertilizers, the Dates Type**,** Number of times vaccinate and Pesticides**.**

ABDE:Four –factor interactions between the Fertilizers, the Dates Type**,** Watering the Palm and Pesticides.

7. Conclusions

In this work, we studied the some factors that affect the date's production in Iraq by using factorial experimental design. The case of study has five factors described as; Fertilizers (A), Dates Type (B), Number of times vaccinate (C), Watering the Palm (D), and Pesticides (E) ,To determine the main factors we used two methods the (ANOVA) method and variable selection (adaptive lasso method). Through the results obtained. We concluded that factors have had a significant effect on palm production of dates. Where the first factor Number of times vaccinate (C) came, the second the Watering the Palm factor (D), the third the fertilizer Type factor (A), Fourthly the pesticide factor (E), and finally the dates type factor (B). The ANOVA method gave us only five interactions among factors that had a significant effect on the product. The remaining interactions (21), did not have a significant effect on the product of dates.

As for the adaptive lasso method, the results showed that the main factors had a significant effect. The interactions between the factors were 14 interaction between the factors have a significant effect, and the remaining twelve interactions did not have a significant effect on the product. This

means that the adaptive Lasso method gave better results. For the purpose of overcoming the problems facing dates production, we recommend the provision of pesticides and fertilizers, As well as to provide adequate water for the palm and number of vaccination times, to protect the production of dates. We also recommend using the adaptive Lasso method, to determine the important factors and effects on production, as they have demonstrated better results than conventional methods.

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