Kurdistan Region- Iraq
Ministry of Higher Education & Scientific ResearchSalahaddin University- Erbil
College of Administration & Economics
Department of Statistics and Information

FACTORS AFFECTING AGRICULTURAL PEST CONTROL USING FACTORIAL DESIGN

Paper submitted to the Department of Statistics and Information - College of Administration and Economics - Salahaddin University as a partial fulfillmentof the requirements for the B.Sc. degree in statistics

Prepared by
Zhwan Hamad Hamadamin
Sara Sarhang Shekhil

Supervised
by
Assistant professor
Dr. Nabeel George Nacy

April 2023

The Dedication

- To our mothers, who taught us to give without waiting for the return.
- To that great edifice which taught us the generous creation (our fathers are the owner of the great merit).
- To our honorable professor (Dr. *Nabeel G. Nacy*), who taught us that encouraging the lecturer to his student is a strong motivation for him to progress and you have all the praise and appreciation for your precious advice and guidance and the time and effort that put in the way the success of this research and its accomplishment.
- Many thanks to the Mohammed Mohammed Ameen Ahmed who helped us.
- We also extend our sincere thanks and appreciation to all who helped us from near or far to complete this work.

Researchers:
Zhwan Hamad Hamadamin
Sara Sarhang Shekhil

Abstract

Due to the spread of agricultural pests in large areas of our planet, including Iraq and the Kurdistan region, and to combat such pests, the College of Agriculture and Forestry at the University of Mosul conducted an agricultural experiment to determine the efficiency of two types of traps and two different locations for these traps, and to test four different types of food placed inside the trap to attract insects to it; each one placed in a trap. The experiment was conducted in three different locations. We tested and analyzed the data using ANOVA table and concluded that these traps, their locations and feeding have a significant effect on hunting insects, at a significant level $\alpha = 0.05$.

<u>Key words</u>: ANOVA table, Experimental design, Factorial design, trap, insects.

Research goal

The aim of the research is to study the efficiency of two types of traps placed in two different locations between plants and tested four types of feeding, each one placed in a trap and repeated the experiment in three locations. As a simple attempt to control agricultural pests, it can be circulated more widely.

Theoretical Aspect

1.1 Definitions: Researchers conduct experiments in all disciplines of study to learn more about a particular process or to compare the impact of various conditions on various occurrences.

A scientific approach to preparing the experiment must be taken into account if it is to be carried out as effectively as possible. The only objective way of analysis when dealing with problems involving data that are prone to experimental errors is statistical methodology. Therefore, the design of the experiment and the statistical analysis of the data are the two components of any experimental problem.

Experimental design is a methodology for assigning treatments to experimental units, allowing statistical tools to estimate the effects of the treatments.

Experiment This type of inquiry involves the application of various treatments to the experimental units, followed by the measurement of one or more response variables to determine the impact of the treatments on the experimental units.

Treatment is a condition or set of conditions applied to experimental units in an experiment.

Experimental units are the objects of interest in the experiment (people, plants, animals …etc.).

Factor is a variable that the experimenter has selected for investigation (which is an explanatory variable that can take any one of two or more values).

Experimental error (SSE or MSE) is the variance in the reactions of experimental units that are subjected to the same treatment and are observed under the same experimental circumstances. Although zero experimental error would be ideal, this is not attainable for (at least) one or more of the reasons listed below:

- Prior to receiving treatments, the experimental units had inherent differences.
- The instruments used to record the measurements vary.
- There are variations in how the treatments are applied or placed.
- The reaction is influenced by outside variables besides the therapies.

- ***Hypothesis testing:*** A hypothesis is a statement about the values of the parameters of a probability distribution. Suppose we think that the mean yield of an experiment is μ_0. This statement is expressed formally as:

$H_0: \mu = \mu_o$ called null hypothesis.

$H_1: \mu \neq \mu_0$ called a two-sided alternative hypothesis.

Or $H_1: \mu < \mu_0$ or $H_1: \mu > \mu_0$ are called a one-sided alternative hypothesis.

To test a hypothesis, we devise a procedure for taking a random sample, computing an appropriate test statistic, and then rejecting or failing to reject H_0. Part of this procedure is specifying the set of values for the test statistic which lead to rejection of H_0. This set of values is called the rejection region for the test. Two kinds of errors may be committed when testing hypothesis:

α = *Pr (type I error) = Pr (reject* H_0 / H_0 *is true) = Significance level of the test*. β = *Pr (type II error) = Pr (accept* H_0 / H_0 *is false).*

Power of the test = 1 - β *= Pr (reject* H_0 / H_0 *is false).*

Factorial experiment indicates that all potential combinations of the factor levels are looked into in each complete trial or replication of the experiment. Each copy comprises all ab treatment combinations, for instance, if factor A and factor B are present at levels a and b, respectively. It is common to refer to factors as being crossed when they are organized in a factorial experiment. The factorial approach The terms 2k and 3k denote k factors with each having two levels, three levels, and so on.

The change in reaction brought on by a change in a factor's level is referred to as the factor's effect. This is sometimes referred to as a main effect because it discusses the key drivers of interest in the experiment.

In some experiments, the difference in response between the levels of one factor is not the same at all levels of the other factors that mean, there is an *interaction* between the factors.

1.2. *The two – way classification ANOVA:*

Let there are *a* levels of factor *A* and *b* levels of factor *B*, and there are arranged in a factorial design; that is, each replicate of the experiment contains all *ab* treatment combinations. Assume there are *n* replicates of the experiment, and let Y_{ijk} represent the observation taken under the i^{th} level of factor *A* and the j^{th} level of factor *B* in the k^{th} replicate. The order in which the *abn* observations are taken is selected at random, so that this design is a completely randomized design *(CRD)*, as shown below:

Factor A	*Factor B*					
	B_1	B_2	…	B_j	…	B_b
A_1	Y_{111}	Y_{121}	…	Y_{1j1}	…	Y_{1b1}
	Y_{112}	Y_{122}	…	Y_{1j2}	…	Y_{1b2}
	:	:	:	:	:	:
	Y_{11k}	Y_{12k}	…	Y_{1jk}	…	Y_{1bk}
	:	:	:	:	:	:
	Y_{11n}	Y_{12n}	…	Y_{1jn}	…	Y_{1bn}
: :	: :	: :	: :	: :	: :	: :
A_i	Y_{i11}	Y_{i21}	…	Y_{ij1}	…	Y_{ib1}
	Y_{i12}	Y_{i22}	…	Y_{ij2}	…	Y_{ib2}
	:	:	:	:	:	:
	Y_{i1k}	Y_{i2k}	…	Y_{ijk}	…	Y_{ibk}
	:	:	:	:	:	:
	Y_{i1n}	Y_{i2n}	…	Y_{ijn}	…	Y_{ibn}
: :	: :	: :	: :	: :	: :	: :
A_a	Y_{a11}	Y_{a21}	…	Y_{aj1}	…	Y_{ab1}
	Y_{a12}	Y_{a22}	…	Y_{aj2}	…	Y_{ab2}
	:	:	:	:	:	:
	Y_{a1k}	Y_{a2k}	…	Y_{ajk}	…	Y_{abk}
	:	:	:	:	:	:
	Y_{a1n}	Y_{a2n}	…	Y_{ajn}	…	Y_{abn}

The linear statistical model is:

$$Y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + e_{ijk}$$

$$i = 1,2,\ldots,a \quad ; \quad j = 1,2,\ldots,b \quad ; \quad k = 1,2,\ldots,n$$

Where μ is the overall mean effect.

τ_i is the true effect of the i^{th} level of factor *A*.

β_j is the true effect of the j^{th} level of factor *B*.

$(\tau\beta)_{ij}$ is the effect of the interaction between τ_i and β_j .

e_{ijk} is a random error component.

The ANOVA table is:

1) If both factors and their interactions are fixed, then:

$$\sum_{i=1}^{a}\tau_i = \sum_{j=1}^{b}\beta_j = \sum_{i=1}^{a}(\tau\beta)_{ij} = \sum_{j=1}^{b}(\tau\beta)_{ij} = 0$$

S.O.V.	*d.f.*	*S.S.*	*M.S.*	*E(M.S.)*	*F*
treatments	*ab-1*	SS_{tr}	MS_{tr}		
A	*a-1*	SS_A	MS_A	$\sigma_e^2 + nb\sum\frac{\tau_i^2}{a-1}$	$\frac{MS_A}{MS_E}$
B	*b-1*	SS_B	MS_B	$\sigma_e^2 + na\sum\frac{\beta_i^2}{b-1}$	$\frac{MS_B}{MS_E}$
AB	*(a-1) (b-1)*	SS_{AB}	MS_{AB}	$\sigma_e^2 + n\sum\frac{(\tau\beta)_{ij}^2}{(a-1)(b-1)}$	$\frac{MS_{AB}}{MS_E}$
Error	*ab(n-1)*	SS_E	MS_E	σ_e^2	
Total	*abn-1*	SS_T			

2) If both factors are random then:

S.O.V.	*E(M.S.)*	*F*
Treatments		
A	$\sigma_e^2 + n\sigma_{\tau\beta}^2 + bn\sigma_\tau^2$	MS_A / MS_{AB}
B	$\sigma_e^2 + n\sigma_{\tau\beta}^2 + an\sigma_\beta^2$	MS_B / MS_{AB}
AB	$\sigma_e^2 + n\sigma_{\tau\beta}^2$	MS_{AB} / MS_E
Error	σ_e^2	

3) If one of the factor is random, then:

a) *A* is fixed and *B* random:

S.O.V.	*E(M.S.)*	*F*
Treatments		
A	$\sigma_e^2 + n\sigma_{\tau\beta}^2 + bn\sum\frac{\tau_i^2}{a-1}$	MS_A / MS_{AB}
B	$\sigma_e^2 + an\sigma_\beta^2$	MS_B / MS_E
AB	$\sigma_e^2 + n\sigma_{\tau\beta}^2$	MS_{AB} / MS_E
Error	σ_e^2	

b) A is random and *B* is fixed:

S.O.V.	*E(M.S.)*	*F*
Treatments		
A	$\sigma_e^2 + bn\sigma_\tau^2$	MS_A / MS_E
B	$\sigma_e^2 + n\sigma_{\tau\beta}^2 + an\sum \frac{\beta_j^2}{b-1}$	MS_B / MS_{AB}
AB	$\sigma_e^2 + n\sigma_{\tau\beta}^2$	MS_{AB} / MS_E
Error	σ_e^2	

Where:

$$SS_T = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n} Y_{ijk}^2 - CF \quad ; \quad CF = \frac{Y_{...}^2}{abn}$$

$$SS_{tr} = \frac{1}{n}\sum_{i=1}^{a}\sum_{j=1}^{b} Y_{ij.}^2 - CF \quad ; \quad SS_A = \frac{1}{nb}\sum_{i=1}^{a} Y_{i..}^2 - CF$$

$$SS_B = \frac{1}{na}\sum_{j=1}^{b} Y_{.j.}^2 - CF \quad ; \quad SS_{AB} = SS_{tr} - SS_A - SS_B$$

$$SS_E = SS_T - SS_{tr}$$

1.3. ***The simple effects of factor:***

Let factor *A* has two levels a_0 and a_1; and factor *B* has two levels b_0 and b_1, then:

		Factor B		*Simple effects of B at each level of A*
		b_0	b_1	
Factor A	a_0	$a_0b_0 = (1)$	$a_0b_1 = b$	$b - (1)$
	a_1	$a_1b_0 = a$	$a_1b_1 = ab$	$ab - a$
Simple effects of A at each level of B		$a - (1)$	$ab - b$	

Then the main effect of factor $A = ab + a - b - (1) = (a-1)(b+1)$

the main effect of factor $B = ab - a + b - (1) = (a+1)(b-1)$

the main effect of interaction $AB = ab - a - b + (1) = (a-1)(b-1)$

1) <u>*The sign method*</u>:

we can find the sum of squares for factors *A*, *B* and their intersection *AB* as described in the table below:

effects	*treatments*				*C*	$D = n\sum C_i^2$	$SS=C^2/D$
	(1)	*a*	*b*	*ab*			
A	*-1*	*1*	*-1*	*1*	*-(1) + a – b + ab*	*4n*	SS_A
B	*-1*	*-1*	*1*	*1*	*-(1) – a + b + ab*	*4n*	SS_B
AB	*1*	*-1*	*-1*	*1*	*(1) – a – b + ab*	*4n*	SS_{AB}
							SS_{tr}

2) *Yates method:*

We can find the sum of squares for factor *A* , *B* and their interaction *AB* by this method as shown in the table below :

Treatments	*[1]*	*[2]*	$D = n\sum C_i^2$	*SS=[2]/D*
(1)	*(1) + a*	*(1) + a + b + ab = Y…*		
a	*b + ab*	*a - (1) + ab - b*	*4n*	SS_A
b	*a - (1)*	*b + ab - (1) - a*	*4n*	SS_B
ab	*ab - b*	*ab – b – a + (1)*	*4n*	SS_{AB}

1.4. *The general Factorial Experiment:*

The results for the two-way classification *ANOVA* may be extended to the general case where there are a levels of factor *A*, *b levels* of factor *B*, *c* levels of factor *C*, and so on, arranged in a factorial experiment. In general, there will be *abc…n* total observations, if there are *n* replicates of the complete experiment. Once again note that we must have at least two replicates ($n \geq 2$) in order to determine a sum of squares due to error if all possible intersections are included in the model.

The general 2^k design:

The generalized case of a 2^k factorial design, that is, a design with *k* factors each at two levels. The statistical method for a 2^k design would include *k* main effects,C_2^k two-factor interactions, C_3^k three-factor interactions, …, one *k*-factor interaction . That is for a 2^k design the complete model would contain 2^k-1 effects.

The usual approach to the analysis of a single replicate of the 2^k is to assume that certain higher-order interactions are negligible, and then since their mean squares will all have expectation σ^2, they may be combined to estimate the experimental error.

- ***The general 3^k design***: The 3^k factorial design is the case of *k* factors each at three levels (low, intermediate, and high). There are 3^k treatment combinations, with 3^k-1 degrees of freedom between them. These treatment combinations allow sum of squares to be determined for k main effects, each with two degrees of freedom, C_2^k two factor interactions each with four degrees of freedom, …, one k factor interaction with 2^k degrees of freedom . If there are n replicates, there are $n.3^k-1$ total degrees of freedom and $3^k(n-1)$ degrees of freedom for error.

For example, the numbers *0120* represents a treatment combination in a 3^4 design with *A* and *D* at the low level, *B* at the intermediate level, and *C* at the high level.

The size of the design increases rapidly with k. For example, a 3^3 has *27* treatment combinations per replication, the 3^4 has *81*, the 3^5 has *243*, and so on. Therefore, frequently only a single replicate of the 3^k designs is used, and higher – order interactions are combined to provide an estimate of error. As an illustration, if three factor and higher interactions are negligible, then a single replicate of the 3^3 provides 8 degrees of freedom for error, and a single replicate of the 3^4 provides 48 degrees of freedom for error.

Yate's algorithm can be modified for use in the 3^k factorial design.

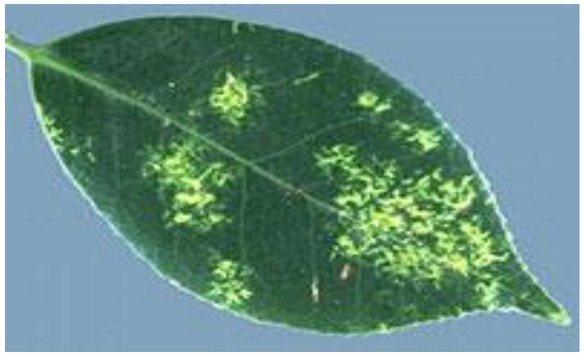
Practical Aspect

Insect pests, diseases and weeds are interlinked and complement each other. Individually, each one of these is responsible for a considerable loss by itself but if one remains neglected, it gives rise to the infestation of the other. Some insects secrete a sugary substance on which fungi develop. Weeds serve as the alternate host for rust and other fungi, and also harbor insect pests. Therefore, for efficient insect pests and disease management, it is necessary to also manage weeds. Regular removal of weeds is a type of preventive control as it minimizes competition of nutrients, prevents hibernating pests, as well as, facilitates proper aeration and application of pesticides. The key behind the success of insect pests, diseases and weed management lies in early and perfect detection of maladies and their management. Eradicating and treating sources of inoculate in the field are important preventive measures. Strengthen the crop by maintaining soil fertility, drainage and aeration check infection from soil, and develop resistance in the crop against pest attack. Infections in the crop may be soil-borne, aerial or seed-borne. Similarly, some insect pests suck the cell-sap of the crop, some chew the foliage and floral parts, some bore into the stems, buds and fruits, while there are insects where their larvae mine the leaves and sometimes even the stems. Each of these problems and infestations need specific approach towards prevention and control. For an effective strategy on pest management, it is essential to gather technical know-how on identification of the pests. This will be useful for appropriate selection of pesticide with its specific dose, method and time of application.

Nature of insect damage

Chewing and cutting tissues of the host These insects have biting and chewing type of mouth parts and may cut, chew and bite the tissues of the host. Infestation of such insect pests is confirmed through this type of damages found on various parts of the host. Mostly larvae and in some cases, adults are responsible for such damages. Larvae of the Lepidoptera (caterpillars) and the Coleopteran (grubs) are well-known damaging stages that cause such type of damage. Maggots and immature stage of flies feed on flowers of chrysanthemum and many other plants. Sunflower maggots infest the stem and cause collapse of the plant. Larvae of painted lady butterfly, yellow woolly bear, checker spot butterfly, diamondback moth, etc., cause such damages to ornamental crops severely.

Mining in the leaf Larvae (maggots) of certain leaf minors by mining get inserted between upper and lower surface of the leaf. Irregular tunnel-like structure over the leaf surface is observed due to the feeding of inside tissues. Such infestation may be observed in ornamentals, such as chrysanthemum, dahlia, dianthus, salvia, verbena, etc. This can be identified by the creamy-yellow lines formed on the leaves due to tunneling.



Spiders are insects in the straight-winged family. There are more than 20,000 different species worldwide, belonging to 28 families. They are found in all habitats except the polar regions They are groups of millions and billions of migrants. The musical sound they make is the result of scratching their wings, and they can fly at speeds of up to 12.87 kilometers per hour (about 13 kilometers).

External appearance

Cockroaches are similar to insects with very strong hind legs that help them jump. The length of their jumps is 20 times their size. Adult cockroaches are between 3-13 cm long, but females are larger than males Chest and abdomen (divided into 11 parts) with 6 legs, like all other arthropods, body covered with a layer of chitin, mouth with sharp teeth and head with two small characteristic mountains used for sensing, two types of mountains according to length, some cuckoos have long wings and others have short ones, and some cuckoos have open colors on their wings that are used to attract females.

Food

These insects are herbivores, active during the day and feed but sometimes at night. Because they are small, they do not eat small amounts of food, but together they can eat 100 tons of plants per kilometer per day Normal can eat 16 times their body weight, and lizards can also eat leaves, flowers, flowers, berries and seeds. Some species eat poisonous plants and then store the poison in their bodies to protect themselves, although lizards are saturated and open in color Because they taste bad, but have many enemies in nature, birds, mice, snakes, lizards and spiders eat them, and is considered a favorite food of most Asian and Arab countries, because this insect is rich in protein, fat and minerals In the grass, whenever caught by humans or other animals, it quickly pulls itself to the ground and jumps into the tall grass to protect itself.

Reproduction and the life cycle

The mating period is between 3-14 hours, after which the females lay their eggs underground, where they first dig a hole with a sharp sword-like tool, then insert the eggs and pour a liquid over them to protect them from the cold The number of eggs is between 95-158 and they can lay eggs more than once in their lives. After about a month of laying, the eggs hatch and go into the developmental stage), and finally the maturation stage, the duration of each stage varies according to the climate.

The main types

Cockroaches are basically classified into two main types, namely nomadic cockroaches and stable cockroaches, but these are examples of the most common cockroach species in the world:

-Desert squirrel: Able to travel long distances, and lives in tropical areas.

-African nomadic lizards.

-Oriental nomadic lizards: Located in Southeast Asia.

-Red squirrels: Located in East Africa.

-Brown lizards: Located in South Africa.

-Egyptian squid.

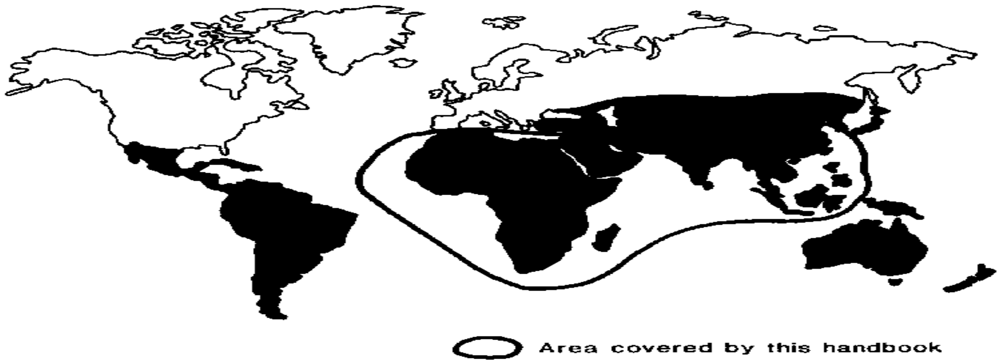
-Australian lizard.

-Tree lizards: Located in Africa and the East.

-Moroccan snails.

Locust and grasshopper distribution

The Figure below indicate the parts of the world where crops may suffer damage caused by locusts and grasshoppers.



World distribution of locusts and grasshoppers of agricultural importance

Damage and losses caused by locusts

Locusts have probably been an enemy of man ever since he began to grow crops. The Desert Locust is mentioned in ancient writings such as the Old Testament of the Bible and the Koran. Carved images of locusts have been found on Sixth Dynasty (2420-2270 BC) tombs at Saqqara in Egypt. Locusts are still a great enemy of the farmer and in some countries they are the determining factor between sufficient food for the people and starvation. Damage is sometimes diffuse and not very obvious, but it can be very severe in many more restricted areas. This depends on whether the swarms are moving about quickly or whether they stay for several days in one area.

The number of people in the world is increasing by about 220,000 every day, so that more and more crops must be grown to feed them. No one wants to grow more crops to feed locusts. Table 1 gives examples of crop losses caused by locusts.

TABLE 1

Year	Country locusts (in £ sterling)	Value of crops destroyed by(in £ sterling)	1986 value
1926-1934	India	400,000 per year	6 million
1928 and 1929	Kenya	300,000 per year	4.5 million
1953	Somalia (Southern Region)	600,000	
1954-1955	Morocco	4,500,000 in a single season	40 million
1949-1957	FAO estimate for only 12 out of 40 affected countries	1,500,000 per year; in 1955 over 5,000,000	45 million

It is even more significant to reckon the losses in terms of quantities of actual food or other crops and the examples in Table 2 show how serious these can be.

TABLE 2

Year	Country	Amount of crops eaten by the Desert Locust
1944	Libya	7,000,000 grapevines; 19% of total vine cultivation
1954	Sudan	55,000 tonnes of grain
1957	Senegal	16,000 tonnes of millet, 2000 tonnes of other crops
1957	Guinea	6000 tonnes of oranges
1958	Ethiopia	167,000 tonnes of grain, which is enough to feed 1,000,000 people for a year
1962	India	4000 hectares of cotton (value £300,000)

Application Aspect

In an agricultural experiment carried out in the College of Agriculture and Forestry at the University of Mosul to study the factors affecting the hunting of agricultural insects, two types of traps and four types of feeding were taken to catch insects, as well as two types of site for setting traps. The experiment was repeated in three different locations as blocks.

block	Trap	Place	food	Insects no.
1	1	1	1	2
1	1	1	2	2
1	1	1	3	2
1	1	1	4	2
1	1	2	1	4
1	1	2	2	2
1	1	2	3	3
1	1	2	4	2
1	2	1	1	2
1	2	1	2	0
1	2	1	3	2
1	2	1	4	0
1	2	2	1	2
1	2	2	2	2
1	2	2	3	2
1	2	2	4	2
2	1	1	1	4
2	1	1	2	1
2	1	1	3	2
2	1	1	4	0
2	1	2	1	5
2	1	2	2	0
2	1	2	3	4
2	1	2	4	1
2	2	1	1	2
2	2	1	2	0
2	2	1	3	1
2	2	1	4	0
2	2	2	1	3
2	2	2	2	0
2	2	2	3	1
2	2	2	4	0
3	1	1	1	4
3	1	1	2	0
3	1	1	3	2
3	1	1	4	1
3	1	2	1	5
3	1	2	2	0
3	1	2	3	2
3	1	2	4	1
3	2	1	1	3
3	2	1	2	0
3	2	1	3	0
3	2	1	4	1
3	2	2	1	2
3	2	2	2	0
3	2	2	3	2
3	2	2	4	1

Source: College of Agriculture and Forestry at the University of Mosul.

The above data can be summarized in the following table:

Trap				I		II	
Place				I	II	I	II
Food	I	Block	I	2	4	2	2
			II	4	5	2	3
			III	4	5	3	2
	II		I	2	2	0	2
			II	1	0	0	0
			III	0	0	0	0
	III		I	2	3	2	2
			II	2	4	1	1
			III	2	2	0	2
	IV		I	2	2	0	2
			II	0	1	0	0
			III	1	1	1	1

The mathematical model is:

$$\boldsymbol{Y_{ijkl} = \mu + \alpha_i + \gamma_j + (\alpha\gamma)_{ij} + \delta_k + (\alpha\delta)_{ik} + (\gamma\delta)_{jk} + (\alpha\gamma\delta)_{ijk} + \beta_l + \varepsilon_{ijkl}}\ ;$$

$$\boldsymbol{i, j = 1, 2};\ \ \boldsymbol{k = 1, 2, 3, 4};\ \ \boldsymbol{l = 1, 2, 3}$$

α_i is the true effect of the i^{th} level of factor *A (trap)* on the whole plots.

γ_j is the true effect of the j^{th} level of factor *B (place)* on the whole plots.

δ_k is the true effect of the k^{th} level of factor *C (food)* on the whole plots.

β_l is the true effect of the l^{th} *block* on the whole plots.

And the others are the interactions between the main factors.

Test of Normality:

Since all the values of the statistics calculated for the Shapiro-Wilk are greater than the level of significance $\alpha = 0.05$. Hence, we accept the null hypothesis that the residuals, for each response variable, follows normal distribution.

According to the test a Kolmogorov-Simonov, we conclude that all values of statistic are greater than $\alpha = 0.05$. Therefore, the null hypothesis is accepting and that residuals of each variable are normally distributed.

Tests of Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
number	.212	48	.090	.879	48	.000

Test of Mullticollinearity:

According to the results shown in the table below, we find that all values of the VIF are less than 10, and thus we can confirm that there is no linear coupling problem among the independent (response) variables involved in the formation of the estimated model.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.088	.231		13.383	.000		
Number	-.357	.108	-.440	-3.322	.002	1.000	1.000

a. Dependent Variable: food

Auto correlation (KMO and Bartlett's Test):

Shows the result for KMO and Bartlett's test for sphericity Table below Sufficiency and suitability test of data KMO for the execution of factor analysis for response variable shows that data set were suitable to execute factor analysis, because the acquired number is greater than 0.5 (0.5). Similarly, the number of significant Bartlett's test equals to 0.002 and is smaller than significant level 0.05 that indicates correlation matrix possesses significant information.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.500
Bartlett's Test of Sphericity	Approx. Chi-Square	9.785
	Df	1
	Sig.	.002

Assume that the hypotheses are

H_0: there is no significant effect of factor Z

$vs.$ H_1: there is significant effect of factor Z

where Z is any factor as A (trap), B(place), C(food), block, or their interaction

Then the ANOVA table is:

Source	*SS*	*df*	*MS*	*F-cal*	*P-Value*	*Sig.*
Blocks	2.042	2	1.021	1.534	.232	NS
Factor_A	11.021	1	11.021	16.566	.000	HS
Factor_B	3.521	1	3.521	5.292	.029	S
Factor_C	48.563	3	16.188	24.332	.000	HS
Interaction AB	.021	1	.021	.031	.861	NS
Interaction AC	2.896	3	.965	1.451	.248	NS
Interaction BC	.729	3	.243	.365	.778	NS
Interaction ABC	2.229	3	.743	1.117	.358	NS
Error	19.958	30	.665			
Total	90.979	47				

From the ANOVA table above, we conclude that:

- The null hypothesis is accepted (don't reject) at the level of significance ($\alpha = 0.05$), because the P-values are (0.232 , 0.861 , 0.248 , 0.778 and 0.358) associated with the calculated F value for the block , interaction AB, interaction AC, interaction BC and interaction ABC, is greater than the specific level of significance, which indicates that there is no significant effect for block, interaction AB, interaction AC, interaction BC and interaction ABC.
- We reject the null hypothesis related to the effect of the levels of significance ($\alpha = 0.05$), because the P-value are (0.00 , 0.029 and 0.00) associated with the calculated F values for the factor A, factor B and factor C, is less than the level of specific significance, which indicates the existence of a significant effect for factor A, factor B and factor C .

Descriptive Statistics					
Factor_A	Factor_B	Factor_C	Mean	Std. Deviation	N
1	1	1	3.33	1.155	3
		2	1.00	1.000	3
		3	2.00	.000	3
		4	1.00	1.000	3
		Total	1.83	1.267	12
	2	1	4.67	.577	3
		2	.67	1.155	3
		3	3.00	1.000	3
		4	1.33	.577	3
		Total	2.42	1.782	12
	Total	1	4.00	1.095	6
		2	.83	.983	6
		3	2.50	.837	6

Descriptive Statistics					
Factor_A	Factor_B	Factor_C	Mean	Std. Deviation	N
		4	1.17	.753	6
		Total	2.13	1.541	24
2	1	1	2.33	.577	3
		2	.00	.000	3
		3	1.00	1.000	3
		4	.33	.577	3
		Total	.92	1.084	12
	2	1	2.33	.577	3
		2	.67	1.155	3
		3	1.67	.577	3
		4	1.00	1.000	3
		Total	1.42	.996	12
	Total	1	2.33	.516	6
		2	.33	.816	6
		3	1.33	.816	6
		4	.67	.816	6
		Total	1.17	1.049	24
Total	1	1	2.83	.983	6
		2	.50	.837	6
		3	1.50	.837	6
		4	.67	.816	6
		Total	1.37	1.245	24
	2	1	3.50	1.378	6
		2	.67	1.033	6
		3	2.33	1.033	6
		4	1.17	.753	6
		Total	1.92	1.501	24
	Total	1	3.17	1.193	12
		2	.58	.900	12
		3	1.92	.996	12
		4	.92	.793	12
		Total	1.65	1.391	48

Conclusions

From the data of the experiment above, we conclude that:

1. There is a significance effect of main factors (trap, place of trap, food put in trap) on hunting insects; at level of significant ($\alpha = 0.05$).

2. There is insignificance effect of interactions of main factors (trap, place of trap, food put in trap) on hunting insects at level of significant ($\alpha = 0.05$).

3. No any significance effect of block on the experiment at level of significant ($\alpha = 0.05$).

References

1. Dean, A.; Voss, D & Draguljić, D. (2017) *Design and Analysis of Experiments*. 2nd Edition. New York. Springer International Publishing AG.
2. Hinkelmann, K. & Kempthorne,O. (2008) *Design and Analysis of Experiments Introduction to Experimental Design.* 2nd Edition. U.S.A. John Wiley & Sons, Inc
3. Montgomery, D.C. (2013), *Design and Analysis of Experiments*. 8th Edition. U.S.A. John Wiley & Sons, Inc.
4. https://zaniary.com/blog/61542ab08fb39/%DA%A9%D9%88%D9%84%D9%84%DB%95

5. https://news.mongabay.com/2022/06/high-tech-early-warning-system-could-/curb-next-south-african-locust-swarms

6. https://english.alarabiya.net/News/gulf/2020/05/31/Saudi-Arabia-says-invasion-of-locusts-almost-over-threat-from-neighbors-remains