Analysis of the variance water distribution of pivot sprinkler irrigation on the productivity of the potato plant in El Oued region of Algeria

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Subject Area: Agriculture

Abstract

This study aimed to determine the extent different of distribution of the axial sprinkler water as a method of irrigation, and the effect of this on the quantity and quality of potato plant production in different areas along the axis sprinkler in the sandy soil of Eloued region in Algeria. For this, we relied on a sample of data consisting of 150 observations distributed over 10 areas according to the length of the axis. statistically we used oneway-analysis of variance after ensuring its statistical validity. Accordingly, we concluded that despite the significant statistical significance of the difference in the distribution of irrigation water(and the time taken and flow strength) along the axis, the difference in the amount of water supplied in the tenth area (tail region) reached a maximum of 57,58 % relative to the reference area (the fourth region), which recorded at 42,42 % of what the reference area obtained, and at least 21,60 % was obtained in the eighth area relative to the reference region, which obtained 78,40 % of what the reference area obtained. However, according to the tests of our study, this had no significant effect on the difference, quantity and quality of production along the radius at the 5 % level. In light of these results, we concluded that the productivity of the irrigation water component fundamentally differs between the areas along the axis, which means that this irrigation method is not economical in sandy soils.

Keywords: axial irrigation, potato production, the analysis of variance, sandy soil

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I. Introduction

The region of Eloued is distinguished by its sandy soil, which is poor in nutrients, as well as its dependence on Groundwater as a source of irrigation by pumping from wells using pivot sprinkler technology and drip irrigation technique. The first experience of pivot sprinkler technique was adopted in March 1995 in Qamar area using a traditional pivot sprinkler made locally. Then it spread throughout the area and expanded until the total area irrigated by pivots In the entire region, 31,351 hectares, of which 81,425 hectares are dedicated to potato cultivation, according to statistics issued by the Directorate of Agricultural Services of El Oued Province for the year 2019.(**2001** ،ريان)

Despite all the technical improvements to the sprinkler pivot in order to overcome the problem of the different amount of water provided along its length, mainly caused by the time it takes for the pivot sprinkler water to remain above the crop, which may affect its productivity in both cases:

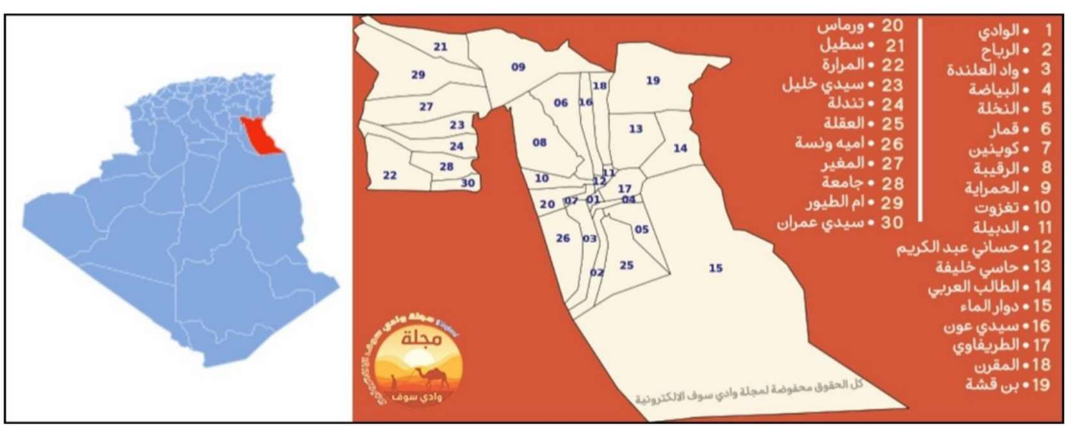
- The first: When the amount of water is provided according to the needs of the center pivot area, the end regions of the pivot will receive a less amount than the crop needs, which reduces its production.
- The second is that if the amount of water is provided according to the tail area (the end of the axis), then the center area gets quantities that exceed the crop's need, and accordingly the productivity of the water element decreases.

In this context, we can pose the problem as follows:

To what extent does the distribution of center pivot irrigation water vary? And how does this affect the productivity of the potato crop in sandy soils in the eloued region of algeria?

II. Method and materials;

The region of Eloued is located between longitudes 6° and 8° and latitudes 30° and 34° north. It is located geographically in the southeast of Algeria, north of the Great Eastern Erg. and Wadi Rig) and from the west it ends with the flat lands of the Wadi Rig region, but from the southern side it extends to the depths of the great eastern race, ending with the appearance of the red sand dunes of the Ouargla region, and from the eastern side it reaches the Tunisian Chotts region (Shatt El Jerid and Al Gharsa) as shown in next Figure.(2019 ،سالم)



1- Experiment site:

The experiment was carried out in one of the farms belonging to the municipality of Taghazout, in the farm of Mr. Hedfi Selim, which is located 10 km from the northern side of the city of El-Wadi. As show in the following Figure.

2- characteristics of natural potato production factors in Eloued region

In this section, we will discuss an overview of the characteristics of natural potato production factors from water, Soil and climate, and the most important components of these factors that characterize the Eloued region, and we will also discuss the pivot sprinkler irrigation method used in the region by means of a traditional pivot irrigation device invented locally, and we will review its components, and study the method of operation and distribution of water along its axis, through two requirements The first requirement includes natural potato production factors in Eloued region, and the second requirement includes the method of pivot irrigation in the region

The region mechanism is a part of the northern desert that hides in its interior large reserves of water present in the aquifers superimposed on the surface (phréatique nappe la) called the free surface tablecloth, and the deeper tablecloth called the alpine tablecloth (Fig. (25-01). The city of Eloued and its surroundings draw water from deep aquifers.(أيوب، 2011)

The region consists of two sub-regions, Wadi Souf and Wadi Rig, each of which has different soils, Wadi Souf have sandy soil and large pebbles and wide pores, which makes it very permeable to water, and there are some limestone and stone flats in some areas.As for the soil of Wadi Righ, it is clay soil, its pebbles are small, and its pores are narrow, so it is not permeable. The region of eloued is 390 km from the sea, and the average height of the region is from the surface. to 74 ° C, and a cold, dry winter (2) The temperature sometimes reaches 23°C. (**Nacira**, 2018)

3- the method of spraying and the components of the traditional pivot in Eloued region:

3-1 Components of conventional pivot sprinkler

Conventional irrigation pivots consist of a single-diameter large sprinkler pipe, consisting of lightweight steel tubes suspended above the ground by long metal structures, and by cables attached to movable towers on wheels. The pipe is connected to a pivot mechanism located in the center of the intended area and the entire tube rotates around the axis, the rate of use of water dispensers varies between the lowest values near the axis, and the highest values towards the other end, and this is done through nozzles of different diameters along the tube. (Mohammed, 2018)

3-2 Distribution of rainfall along the traditional irrigation axis:

Dispersive factors in the uniformity of the spatial distribution of water are characterized by:

- Disturbances due to fluctuations in wind direction and speed.
- Operating pressure varies over the particle size spectrum of the selected sprinkler.
- The relative arrangement of the sprinklers depends on the operating pressure and the quality of the sprinklers, by calculating the overlap that shows an acceptable distribution uniformity.

According to a study conducted on traditional irrigation axes in Eloued region by Aishush. M, Deyyah A.A., Ghadir.A.M.A. 0201-0208), the distribution of precipitation was measured under different nozzles installed in a fixed position, according to different criteria (flow rate, pressure, wind, etc.) according to three axes were chosen to represent This difference, knowing that there are two types of traditional irrigation axes used in the region, axes of 72 m and 22 m, and there is a big difference in the positions of the nozzles. (**HANAFI**, 2011)

4- sampling features:

In this study, several tools and methods were used, the most important of which is a traditional locally manufactured sprinkler pivot, unlike the modern sprinkler pivots used in the irrigation of large agricultural areas such as wheat cultivation. Some other methods for water and yield measurements.

4-1 Characteristics of the used spray axis:

With regard to the components of the traditional irrigation axle used in this research, it was detailed in the first chapter of the theoretical part, and these are some of its characteristics:

- The diameter of the pivot sprinkler tube is 21 mm

- The length of the pivot sprinkler tube is 51.23 m

The peristaltic spray cycle takes 10 hours

- **Axial sprinkler tube:** It is the part along which the sprinklers are placed and through which the irrigation water passes, and it rotates around the central unit during irrigation.
- **The central unit of the pivot sprinkler**: it is the part on which the pivot rests during its rotation, and it is located in the center of the irrigation circle.
- **The mobile tower of the pivot sprinkler**: its role is to assist the pivot to move in a circular motion, by means of two wheels equipped with an electric motor that is adjusted according to the time taken for one rotation of the pivot.
- **Distribution of sprinklers:** After we measured the distances between the sprinklers, we obtained their distribution along the sprinkler pipe, which is detailed in Table below.

Number	Sprinkler No.	Distance between sprinkler	Number	Sprinkler No.	Distance between sprinkler
1	0-1	6.8	12	11-12	2.55
2	1-2	2.37	13	12-13	2.25
3	2-3	2.65	14	13-14	1.98
4	3-4	1.1	15	14-15	179
5	4-5	3.7	16	15-16	1.62
6	5-6	3.5	17	16-17	1.48
7	6-7	3.35	18	17-18	1.23
8	7-8	3.18	19	18-19	0.97
9	8-9	2.97	20	19-20	0.69
10	9-10	2.74	21	20-21	1.32
11	10-11	2.68	**Total**		**50.92**

4-2 Characteristics of the pumping system:

The characteristics of the pumping system are represented in the elements shown in Figure (2-09), which are:

- The capacity of the pump is 5.5 horsepower

- The pipe connecting between the pump and the pivot sprinkler is 20 m long, 21-001 mm in diameter.

- The length of the well pipe from the surface to the bottom (sund) is 30 m

4-3 Tools and means used in the field:

The tools and means used in the field are summarized in the following table:

Tuber size measurement device	**-**
Utensils to collect water (paint bucket)	**Diameter 21 cm, height 25 cm**
long tape	**5 m**
Marking sticks	**0m-0.5m**
Plastic bottles to direct water from the sprinkler into the bucket	**-**
A graduated glass tube for water	**250 ml**
Long thread for education	**greater than 51 m**
drilling tool	**-**
Tuber weighing scale	**-**
Chronometer (small watches for keeping time)	**-**
Plastic bags for collecting tubers	**-**
Wire to tie the bottles	**-**
Camera	**-**

III. Results and discussion:

Through presenting the statistical summaries of the study data and the form of its distribution, we will analyze the variance of differences, test the validity of the model, and discuss the results.

1- descriptive summary of the study data

In this requirement, we will present the descriptive statistical summaries (arithmetic mean, After entering the data collected from the field and processing them automatically using the SPSS version we can view the summaries as in the following table:

	Number of observations	Minimum value	Maximum value	The mean	The variance
The distance from the center of pivot	150	2.50	47.5	25	14.40
The amount during one circle	150	378	891	590.35	152.62
The time period during one circle	150	9.21	29.33	14.87	6.00
Plant production quantity	150	100	700	345.33	145.90
Plant production quality	150	9.87	28.40	18.14	3.80

Through the descriptive statistics table, we have 051 observations (N), distributed evenly in 10 regions, the middle of each of them is far from the center of the axis with different distances, the lowest is 3.5 m and the maximum is 17.5 m, with an average of 35 m and a contrast equal to 01.11. located on the ground during one cycle, its maximum is 220 mm and its minimum is 272 mm, with an average equal to 521.25 mm and a variance equal to 053.02.

For the time it takes for water to fall on the ground during one cycle, the maximum value recorded It is equal to 32.22 minutes and the lowest is 2.30 minutes, with an average equal to 01.27 and a variance equal to 0. We also record the maximum value of the amount of tree production 711g and the lowest 011g with an average equal to 215.22 and a variance equal to .015.21.

As for the quality of production, represented by calculating the tuber circumference estimator, the maximum value is equal to 32.11 cm and the minimum value is 2.27 cm, with a mean of 0.01 and a variance of 2.

2- Analysis of the variance of differences and testing the validity of the model:

In this requirement, we will present the results obtained through the one-way analysis of variance (ANOVA) table, test the validity of the model hypotheses, and finally discuss the results of the study.

2-1 One-way analysis of variance (ANOVA) table:

After entering the data collected from the field and processing them automatically in the one-way analysis of variance program, we obtained the results summarized in the following ANOVA table:

The variables	Source of variance	Degrees of freedom	Sum of squares	Mean sum of squares	F-ratio	P-value
The amount of water per plant during one circle	**Between groups**	3473370.375	9	385830.42	∞	0.00
	Within groups	0.000	140	0.0000		
	The Total	3473370.375	149			
The time period during of water per plant during one circle	**Between groups**	5379.428	9	597.714	∞	0.00
	Within groups	000000	140	0.000		
	The Total	5379.428	149			
Plant production quality	**Between groups**	105066.667	9	11674.074	0.533	0.849
	Within groups	3066666.667	140	21904.762		
	The Total	3171733.33	149			
Plant production quantity	**Between groups**	229.350	9	25.483	1.858	0.063
	Within groups	1920.409	140	13.717		
	The Total	2149.759	149	-		

2-2 Testing the validity of the model assumptions:

We tested the validity of the model hypotheses by examining the following tests:

Group independence test:

As indicated in the yield measurements, we took samples randomly for each region (05 samples per region) independently of the others, and this means that each group of samples is independent of the rest of the groups and does not affect each other.

5- Testing the normal distribution of the data of the study population:

By applying the Test Bera-J statistic

$$JB = \frac{n}{6}(\beta_1^2 + \frac{(\beta_2 - 3)^2}{4})$$

So that 1B and 2B are respectively the skewness and kurtosis coefficients according to the sample values.

$$\beta_1 = \frac{\hat{\mu}_3}{\hat{\sigma}^3} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^{3/2}}$$

$$\beta_2 = \frac{\hat{\mu}_4}{\hat{\sigma}^4} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^2},$$

- **for the amount of water:**

  We get the calculated JBC result: JBC = 6902.69832

- **For the time taken:**

  We get the calculated JBC result: JBC= 18823.8111

- **With regard to the quantity of production:**

  We get the calculated JBC result : JBC=56.24446316

- **With regard to production quality:**

  We get the calculated JBC result: JBC=26.66083709

Through the statistical table (Square-Chi) and the degree of freedom k = 10 corresponding to the distribution of the square, we get a value of JBt = 0044, which is less than the JBC values calculated for each of the water quantity, time taken, production quantity and production quality, therefore the null hypothesis is rejected The normal distribution is not accepted. Since the evidence is balanced and the size of the samples in all regions is equal and equal to 50, the normal distribution is not considered a necessary condition for the validity of the analysis of variance test model.

6- Test the equality of variance of the data of the study population:

Applying Levine's test statistic:

$$W = \frac{(N-k)}{(k-1)} \cdot \frac{\sum_{i=1}^{k} N_i (Z_{i\cdot} - Z_{\cdot\cdot})^2}{\sum_{i=1}^{k} \sum_{j=1}^{N_i} (Z_{ij} - Z_{i\cdot})^2}$$

$$Z_{ij} = \begin{cases} |Y_{ij} - \bar{Y}_{i\cdot}|, & \bar{Y}_{i\cdot} \text{ is a mean of the } i\text{-th group,} \\ |Y_{ij} - \tilde{Y}_{i\cdot}|, & \tilde{Y}_{i\cdot} \text{ is a median of the } i\text{-th group.} \end{cases}$$

- **for the amount of water:**
  We obtained the result of the calculated W = 0.1438
- **With regard to the time taken:**
  We obtained the result of the calculated W = 0.1565
- **With regard to the quantity of production:**
  We got the result of W calculated 0.039079853 = W
- **Regarding production quality:**
  We obtained the result of W calculated as 0.000815064 W = 0.000815064

through the statistical table and degrees (1.12, 12, 1.11), we obtained a value of 5.05 = Ft from the table, which is greater than the values of W calculated for each of the amount of water, the time spent, as for the quantity of production and the quality of production, we get on the value of Ft = 5047, which is greater than the values of W calculated for each of them, therefore we accept the null hypothesis and the normal distribution is accepted. It was found from the previous tests that all hypotheses of the analysis of variance model were fulfilled (the independence of the samples, (the balance of the data), a normal distribution, and the odds of variance).

3- Discussing the results:

Through the above table of one-way analysis of variance for data collected from the field, we will discuss what follows:

3-1 The amount of water that falls on the ground during the cycle

We note from the analysis of variance table that the significant value of F is equal to 1, or 1 percent, which is less than the significance level of 15 percent. Therefore, we reject the null hypothesis, and accept the alternative hypothesis that

There are at least two averages that are not equal, meaning that the amount of water located on the ground is not equal between at least two regions, that is, there are clear statistical differences between the regions, so we will calculate the relative difference in the averages of the amount of water located on the ground between regions, and take the highest average amount The water obtained in the fourth area, which equals 220 ml, is estimated as a reference using the following relationship:

$$\textbf{Relative difference}\ (\%) = \frac{\boldsymbol{region\ average\ of\ water\ amount\ per\ plant}}{\boldsymbol{forth\ region\ average\ of\ water\ amount\ per\ plant}} \times \mathbf{100}$$

Relative differences for the average amount of water on land (%) = Percentage of relative difference in the average amount of water on land (%) - 011 (%)

We get the results summarized in the following table:

Ref. region	**average of water amount per plant**	**Relative difference**	**Absolut difference**	**Average of time**	**flow power**
1	580	65.10	34.90	29.33	19.77
2	646	72.50	27.50	22.07	29.26
3	698	78.34	21.66	15.48	45.06
4	891	100.00	000	15.15	58.80
5	611	68.57	31.43	13.19	46.32
6	420	47.14	52.860	12.16	34.52
7	591	66.33	33.67	11.37	51.96
8	698.5	78.40	21.60	11.33	61.64
9	390	43.77	56.23	9.37	41.58
10	378	42.42	57.58	9.20	9.20

Through this table, we notice the relative difference in the average amount of water falling The land in the nine regions compared to the average amount of water for the fourth region is randomly different, and this is due to several factors, including the condition of the old sprinkler axis where some sprinklers do not work or the water flow from them is very weak, due to the accumulation of salts on them with the passage of time, and this is what we noticed while measuring The water flow of the pivot sprinkler from the center to the end, and there are other factors that we touched upon in the theoretical part of the raw topic, including operating pressure, wind speed and the relative arrangement of the sprinklers.

Accordingly, we found that the difference in the amount of water supplied in the tenth region (the tail region) reached a maximum of 57.58% relative to the reference region. (the fourth region), which obtained 42.42% of what was obtained in the reference region, and at least 30.01% in the eighth region in relation to the reference region, which obtained 72.11% of what was obtained in the reference region.

3-2 The time it takes for water to fall on the ground during one cycle:

Note the previous case because the significant value of F is equal to 1, and therefore we say that the time taken for water to fall on the ground during one cycle is equal between at least two regions. That is, there are clear statistical differences between the regions, so we will calculate the relative difference in the averages of the time it takes for water to fall on the ground during one cycle between the regions, and take the average time for the initial region close to the center of the axis as a reference using the following relationship:

$$\textbf{proportion of Relative difference} = \frac{\boldsymbol{average\ of\ time\ period\ per\ plant}}{\boldsymbol{first\ region\ aaverage\ of\ time\ period\ per\ plant}} \times \mathbf{100}$$

We have the average time for water to fall on the ground in the first region = 29.3316 minutes.

We get the results summarized in the following table.

Ref. region	average of time period per plant	proportion of Relative difference
2	22.07	75.26
3	15.48	52.81
4	15.15	51.66
5	14.15	44.97
6	13.19	41.48
7	12.16	38.78
8	11.33	38.63
9	9.37	31.92
10	9.20	31.38

Through the table, we notice an increase in the percentage of relative difference in the averages of the time taken for water to fall on the ground as we approach the center, and Akka is correct, with the exception of areas 2 and 7 with a slight difference, which is a logical result because the circular distance traveled by the spray axis is shorter as we approach the center. The arrival time of the water is faster than my colors, and the time it takes to the end of the water's departure for my colors is longer, and the reverse is true.

3-3 The amount of tree production in the region:

Unlike the previous two cases, we notice in this case that the significant value of F is equal to 0.849, i.e. 21.21 percent, which is greater than the significance level of 15 percent to 10 percent. Therefore, we reject the alternative hypothesis, and accept the null hypothesis that there are no differences between the averages, meaning that according to the number of these arithmetic differences of the averages, they do not show any statistical differences, and this means that the amount of production per tree is close. There is a difference between the regions in terms of the amount of water dumped on them, and this is due to the fact that the tree is sufficient for the lowest amount of water on the ground in each of the ten regions.

It is the amount of water located in the tenth region (the tail region), which equals 272 ml, in other words, this amount meets the water needs of the potato tree during one cycle of the axis used in this research and in the climatic conditions in which the experiment was conducted, and the quality of The soil on which it was applied, which is sandy soil, amounts in excess of this quantity are considered a waste of water because the tree does not benefit from it and is lost in the depths of the soil and causes it to leak organic fertilizers, as it descends below the level of the roots of the plant and does not benefit from it, and it shows symptoms of nutritional deficiency This forces the farmer to replace it by using chemical fertilizers, and this is considered a waste of effort and money, in addition to that excess water is harmful to the cultivation of potatoes, because it prevents the flow of oxygen to the underground parts of the plant, which reduces growth, especially in clay soils with poor permeability, It is good for the roots and causes rotting of the newly formed tubers. The region is fortunate that it has sandy soil with great porosity and permeability to water. Therefore, each tree takes its water needs equally in all regions, and the rest is lost in the depth of the soil. Therefore, we note that the amount of production for the tree is not affected in this respect. This explains the convergence of production quantities of the tree between different regions.

3-4 Quality of tree production in the region:

In this case, we took the significant F value less than 10 percent instead of 15 percent because it Significant, we note from the analysis table that the significant F value is equal to 0.063, or 0.21 percent, which is less than the significant level of 10 percent, and thus we say that the quality of tree production in the region is not equal between at least two regions, which are statistically weak differences.

Based on the above discussion, we calculated the amount of water drained from the shaft during one cycle by collecting the quantities of water from the ten regions, The amount that was spent from the wipe, which = 5903.5 ml, then we calculated the amount of water that was supposed to be drained from the axis during one cycle, by multiplying the amount of the tail region (the tenth region, which is the least amount that meets the needs of the plant) by ten areas, and we get: The amount that is supposed to be drained from the axis = 3780 ml By dividing the second quantity by the first, i.e. the following relation:

$$\frac{\textbf{the supposed water amount in axis}}{\textbf{the real water amount in axis}} \times \mathbf{100} = \frac{\mathbf{3780}}{\mathbf{5903.5}} * \mathbf{100} = \mathbf{64}\%$$

This means that we can reduce the amount discharged from the axle during one cycle by 20 percent

IV. Conclusion

The obtained results showed that there are clear statistical differences between regions, and a relative difference in the average amount of water on the ground between regions.

The averages of the amount of water located on the ground in the nine regions compared to the largest average amount of water located in the fourth region are randomly different, that is, the first hypothesis was not fulfilled.

In contrast to the previous two cases, the results obtained showed that there are no statistical differences between the averages, meaning that the average percentage of the amount of production of one tree is similar between the regions despite the difference in the amount of water dumped on it, and that the percentage of averages of the amount of production of one tree for the areas close to the center of the spraying axis is similar. With its counterpart for the tail areas, and this proves the invalidity of the third hypothesis, the further we move away from the center of the axis, the lower the amount of potato tree production.

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