Manufacture and Testing an Automatic Sprinkler Riser in the Fixed Sprinkler Irrigation System Using Smart Irrigation and its Impact on the Performance of the System and Zea Maize Yield

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Abstract

A field experiment was carried out with the aim of designing and manufacturing an automatic sprinkler riser for fixed sprinkler irrigation system and evaluated its impact on the system performance and the growth and production of Zea maize at Al-Raad Research Station located in the Akerkov area, 1 km north of the highway (Baghdad - Anbar) in silt clay loam soil for the agricultural season of 2021. Riser type included a regular straw, and a self-propelled riser with an inner tube, and a self-propelled riser with an external tube, and operating pressure included 1, 1.5 and 2 bar. Were used in this experiment., sprinkler discharge, sprinkler service area, plant height and plant yield. Were studied in this research Nested deign with a randomized complete block design (RCBD) with three replications, were used the least significant difference was used under the probability level of 0.05 ($LSD_{0.05}$) for comparison in the averages of the coefficients of the experiment, the results showed the following an automatic sprinkler riser with the outer tube was significantly superior in obtaining the highest the highest moisture content of 37.29% and the highest value of the sprinkler service area amounted to 247.98 m^2 and the highest yield of the crop was 6.38 tons.ha^{-1}, while the self-propelled riser with inner tube outperformed in obtaining the highest value of plant height amounted to 189.67 cm, and it was noted that there was no significant difference between the risers used in the value of sprinkler discharge .The superiority of the operating pressure of 2 bar in obtaining the highest value of the highest value of the moisture content was 37.97, and the highest value of the sprinkler discharge was 33.07 liters. Min^{-1} and the highest value of the sprinkler service area was 367.71 m^2, the highest plant height was 190.11 cm and the highest yield of the crop was 6.46 ton. ha^{-1} compared with other pressure. The interaction between the self-propelled riser with inner tube and the operating pressure of 2 bar was superior to obtaining the highest moisture content of 38.13%, and the highest discharge of the sprinkler was 33.40 liters.min^{-1} while the bilateral interaction between the self-propelled riser with an external tube and the operating pressure of 2 bar exceeded the highest value of the highest value of the sprinkler service area amounted to 377.69 m^2, the highest height of the plant was 194.67 cm, and the highest yield of the crop was 6.89 ton. ha^{-1}. The success of using the locally designed and manufactured an automatic sprinkler "self-rising" riser according to the plant's height and used in the fixed sprinkler irrigation system to irrigate the maize crop. 180

Key Words: Automatic Riser, Zea Maize Yield, Moisture Content, Sprinkler Irrigation, Smart Irrigation.

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Introduction

Modern irrigation mechanization, especially sprinkler irrigation systems, is one of the modern and advanced irrigation systems that are widely used in various countries of the world, whether developed or developing, to exploit the available water resources and invest them in ideal ways with the aim of saving water in the quantities required for the expansion of agriculture and filling the needs of the agricultural sector of water and raising the efficiency of irrigation in terms of the water resource and increasing agricultural production (Jasim and Nafawa, 2017).

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Agricultural mechanization is one of the most important indicators of the transfer of traditional agricultural operations to modern agricultural operations, as it is an important factor in regularity and speed (Al-Banna, 1990).

Researchers and scientists have been interested in studying the effect of fixed sprinkler irrigation systems on the growth and production of maize crop and some physical properties of soil through knowledge of water productivity and efficient use of available water, (Kirda, 1996) and (Jasim et al., 2009).

The main objective of using the fixed sprinkler irrigation system is to deliver water in an efficient and sufficient manner suitable for the field without wasting the quantities of irrigation water, and this lies through the use of suitable operating pressure for the sprinklers to cover an area and suitable quantities for the soil and the crop, and this leads to reducing energy waste and reducing the quantities of irrigation water (Al Kubaisi, 2001).

It is necessary to use the smart irrigation system in countries that suffer from a scarcity of irrigation water, where water is a precious resource, as these areas must use water carefully and efficiently due to its scarcity. However, irrigation systems are still wasting water due to the use of traditional irrigation methods that result in waste of water and energy used in pumping water. In order to achieve effective management of water use and energy consumption of irrigation systems, this can be done with modern irrigation methods and the use of a smart irrigation system that relies on environmental information to determine when and where irrigation is required. The system consists of a microcontroller, sensors, and water pumps. A program has been developed to help the system determine irrigation durations Based on the environment information collected, the sensors determine where irrigation is required. In this way, water is given to dry sites in the field and irrigation of wet sites is stopped, and this leads to an increase in the efficiency of water use (Masaba, et al., 2016).

The operating pressure is one of the main factors responsible for the consistency of the water distribution in the sprinkler. The correct performance of the sprinkler requires breaking, dispersing and spreading the water extrusion into droplets that cover the land in consistency and reduce the relatively large droplets. The good feature of the large droplets is that they move in the air for a longer time and reach a longer distance. The optimum operating pressure varies depending on the size of the sprinkler nozzle and wind speed (Mohamed, et al., 2019).

Zea Maize corn is one of the most important agricultural crops in the production of food and industrial grains in multiple regions in the world. The extent of the crop's use has been estimated at 150 uses and Plants can used as green fodder. As for grains, they are used in preparing a concentrated diet for poultry and cows and grains can also use as food for humans through grinding. Its grains are used to obtain flour that is used in the manufacture of bread, biscuits, pasta and sweets, as well as in preparing food for children (Diederichsen, et al., 2007), (FAO, 2013).

In view of the importance of this system, a self-rising riser was designed according to the height of the maize plant without the need to replace the riser during the plant growth period, and knowing its impact on the performance of the system and plant growth came this study.

Advancements in communications technology dedicated to farm machinery have helped the agriculture industry cultivate more land and manage water resources more effectively in order to meet the food productions needs of a growing world population. A controller area network (CAN) binary unit system (Bus) tracks the performance and efficiency of agricultural machinery units on a continuous, real-time basis on flat, uphill, and downhill lands (Al-Aani, et al., 2018).

Materials and Methods

A field experiment was carried out with the aim of designing and manufacturing an automatic sprinkler riser for fixed sprinkler irrigation system and evaluated its impact on the system performance and the growth and production of Zea maize at Al-Raad Research Station located in the Akerkov area, 1 km north of the highway (Baghdad - Anbar) in silt clay loam soil for the agricultural season of 2021.

Use two factors: The type of sprinkler riser includes three levels: A – regular riser B – riser Locally manufactured "containing an external tube (self-propelled) C - a locally manufactured riser containing an inner tube (automotive) and the operating pressure of the system included three levels: A - pressure of 1 bar, B - pressure of 1.5 bar and C - pressure of 2 bar

The following characteristics were studied: sprinkler filtering, liters.min^{-1}and sprinkler service area, m^2, the plant height cm and yield of yellow corn, the total of the experimental units was 27 experimental units. The area of the experiment field was 3888 m^2. It is 108m long and 36m wide.

Design and Manufactured Riser

The riser was made in the form of aluminum rings, one inside the other according to the size (telescopic), meaning the small ring is inside the large ring according to the size. The dimensions of the rings, starting from the big ring to the small one, were 27 cm, 24 cm, 21 cm, 18 cm, 15 cm. The rings move by means of rails installed on the rings. Two types of riser are designed, the first is the internal sprinkler feeding tube, and the second design is the external sprinkler feeding pipe. The rings were also connected to each other using sliding rails that were installed in the ribs to install the ring from four sides and to give the cane more durability and for easy movement of the rings during the height of the sprinkler cane to the top. Also, all the rings were installed on a wooden base of an area of 1.225 m^2. Two types of bronchi were designed, the first to be with an internal sprinkler feeding tube and the second to be an external sprinkler feeding tube. An Ultrasonic sensor was used, which is a sensor that can be measured by means of ultrasound, HC-SR04-Sensor, which measures the distance with high accuracy and at a distance of 2.5 m. It is not affected by water and the sensor was connected to the Arduino to complete the electrical circuit by giving the required command to the device to start the rising process, (Carullo and Parvis, 2001). 35cm 15 cm 35cm 18 cm 21 cm 180 cm 27 cm 24 cm 35cm 27 cm.

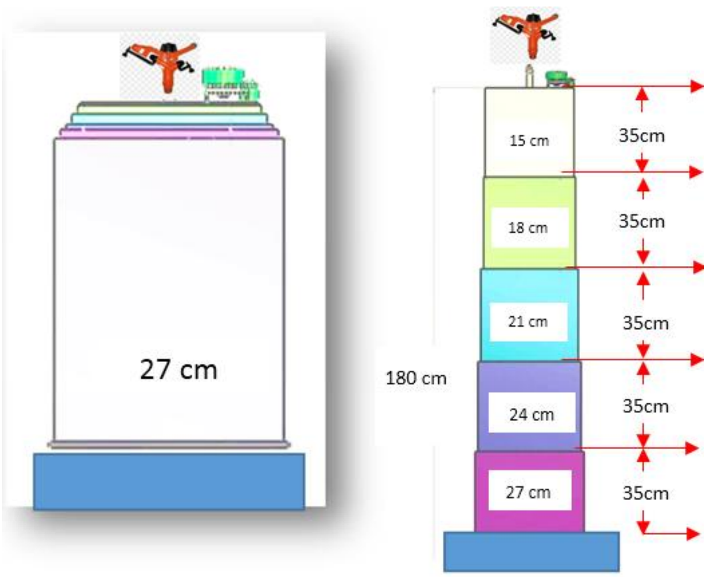

Figure 1. Dimensions of the manufactured riser

Agricultural Operations and Crop Service

The maize crop, Oryx variety, was planted on 15/7/2021. The planting was carried out using the Gaspardo seed of Italian origin with four lines. The seed was calibrated before the sowing process, with a distance of 75 cm between one line and another and 25 cm between the hollows, after which the germination process was carried out by keeping one plant. Each hole has a plant density of 53,333 plants per hectare-1The control of the bush was carried out manually and the control of infection with the corn riser borer was carried out using the granular pesticide diazinon and in two doses, the first after germination by 25 days and the second after the first dose by 20. Phosphate fertilizer (triple super phosphate by 46%) was added at once before the planting process at a rate of 200 kg / hectare and manure Nitrogenous (urea at 46% N) at a rate of 200 kg / hectare and the second batch after planting a month (Al-Ma'ini and Al-Sahoki, 1987) and the irrigation process was determined after the soil was depleted 25% of the ready water after determining the volumetric moisture content of the soil at the field capacity and the volumetric moisture content at the point of withering, and then the amount of ready water for the irrigation process was determined. The moisture content of the soil was measured using the gravimetric method to calculate the moisture content by taking daily soil samples and diluting them in the drying oven located in the station laboratory for 24 hours at a temperature of 105 degrees Celsius.

Smart Irrigation System

A smart irrigation system was manufactured and worked locally by linking the parts of the irrigation system between themselves wirelessly and between the smart irrigation system used via the Internet, meaning that the secondary parts (A, C) send the reading of the moisture sensors to the main system (B) wirelessly and after analyzing the information (moisture content) by the main smart irrigation system that is equipped with an internet service (SIM, GSM) through which all parts of the system are connected with the user by downloading the (BLYNK) application located on the two mobile systems (APPLE STORE) for iPhone and Android phones (GOOGLE). PLAY) and through the application, the level of moisture is controlled and the soil reaches it so that the pump is turned off or the pump signal is given to work to conduct the irrigation process. Where water was added accordingly according to the depletion of 25% of the prepared water by finding a relationship between the reading of the sensor and the volumetric moisture content and finding an equation between them by taking p Daily data of the soil and measuring the volumetric moisture content of the soil and comparing it with the sensor reading by determining the field capacity and wilting point.

The Smart Irrigation System Used consists of Three Parts

1. The main system (B): It is the main part responsible for receiving information from the secondary systems, as well as sending the system commands to start and stop the pump, and the connection is wireless, in addition to the presence of the Internet service to ensure communication between it and the user through the application, in addition to the presence of sensors distributed in the central part In the field to measure the moisture content of the main system. The main system is fed with energy using solar energy, a charger and a 12-volt battery, as shown in Figure (1).
2. Secondary system (A): It is the secondary part whose location is at the beginning of the field. It contains sensors that measure the moisture content and send it to the main system (B). This part is fed with energy by a 5-volt lithium battery charged by a portable battery every week. Figure (2).
3. Secondary system (C): It is the secondary part whose location is in the last part of the field. It also contains sensors that measure the moisture content and send it to the main system (B). This part is fed with energy by a 3.7-volt lithium battery charged by a portable battery each a week. 183
4. Pump switch-off and operation system: It is the part of the signal receiving part of the main system for the operation of turning off the pump, and it is connected to the pump, and the badge can be secured between it and the main part (B) 200 m, Figure (3).

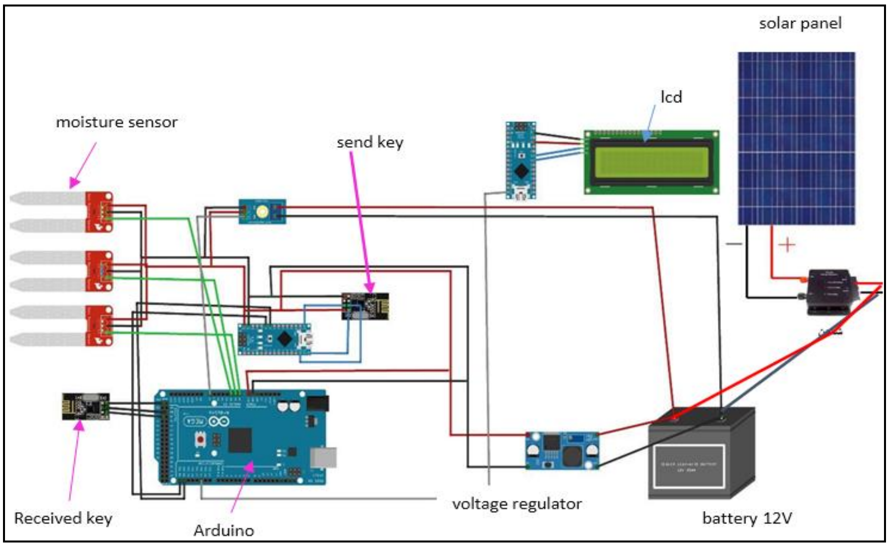

Figure 1. The main smart irrigation system (B)

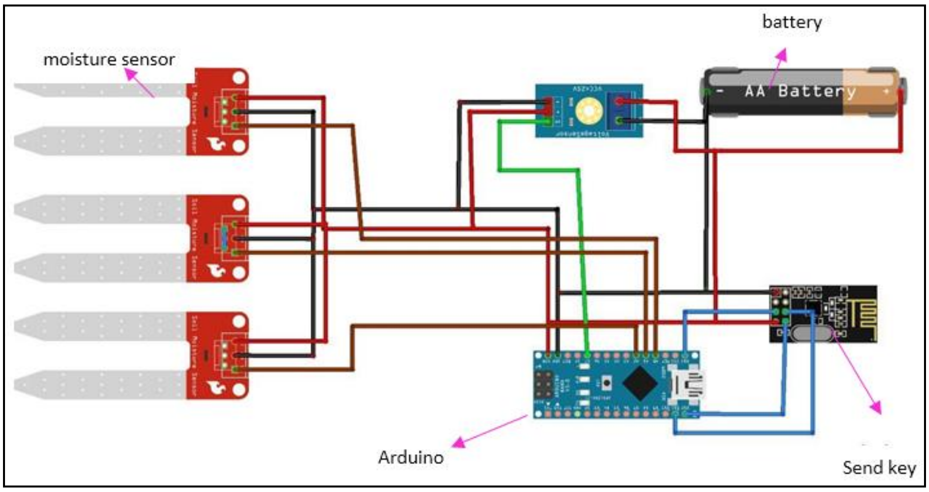

Figure 2. The secondary smart irrigation system (A, C)

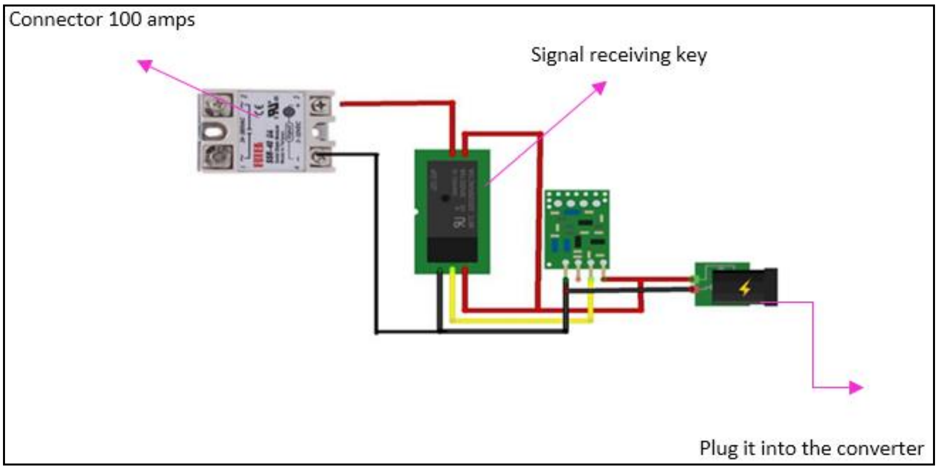

Figure 3. Pump operating system

Studied Traits

1. Soil Moisture Content %

Soil moisture content was measured using gravimetric method was used to calculate the moisture content which is the direct method by taking samples of wet soil and drying them in the oven for 24 hours at a temperature of 105 degrees Celsius, and then weighing while it was dry using the following equation used by (Gardner, 1965), and suggested by (Jasim and Nafawah, 2017)

$$Pw = ((Msw - Ms)/Ms) \times 100$$

The volumetric moisture content was calculated using the following equation and suggested by (Hillel, 1980).

$Pv = Pw \times Pp$

$d = Pv \times D$

$Q = dxa$

Since:

Pw = (%) weight moisture content

Pv = (%) Volumetric moisture content

Msw = wet soil mass

Ms = Dry soil mass

Pp = Soil Bulk Density

d = Irrigation water depth, cm

D = Root zone depth, cm

Q = Amount of water used for irrigation, m^3

A = field area, m^2

2. Sprinkler Discharge

The discharge of sprinklers is a function of the rate of water addition (perfusion rate) in the fixed sprinkler irrigation system, as the sprinkler discharge was calculated using the following equation proposed by (Jasim and Nafawa, 2017)

$$\mathbf{Q = CA\sqrt{2gh}}$$

Since:

Q = Sprinkler discharge l/sec = Q

C = Sprinkler modulus constant (ranging from 0.95 - 0.98) = C

A = Orifice area, cm^2

G =ground acceleration, cm/s^2

Also, the discharge of each sprinkler was calculated by (hydrometer) according to the required pressure, and the pressure was controlled by using the water lock.

3. **The sprinkler service area:** The sprinkler service area was calculated according to the following equation and suggested by (Jasim and Nafawa, 2017)

   $R = 1.35 \sqrt{d} * h$

   whereas:

   R=Radius of wetting area

   d = Discharge l/min

   h = Pressure applied to the sprinkler opening
4. **Plant height cm:** Ten plants were selected from the middle areas of the experimental units after leaving the guard lines at random from the sprinkler service area, marking them and measuring their height after the flowering stage was completed, starting from the base of the plant at the surface of the soil to the top node of the plant and taking the average heights for each experimental unit (Al-Sahoki, 1990).
5. **Zea mayz crop yield, ton. ha^{-1}:** Ten plants were selected from the middle areas of the experimental units within the limits of the sprinkler service area after leaving the guard lines at random, and then they were harvested on 11/23/2021 and the weight of the seeds was calculated (gm/ per 10 plants) after the nubs were neglected for each experimental unit. Production per hectare, and then weight was adjusted on the basis of 15.5% moisture, according to the following equation (Al-Sahoki, 1990):

Weight at 15.5% humidity = ((100 - original humidity) / 84.5) x original weight

Results and Discussion

Soil Moisture Content %

Table (1) shows the effect of the riser used on the moisture content, as it turns out that the type of riser had a "significant" effect on the moisture content of the soil, as the average riser recorded the lowest soil moisture content of 36.52%, while the average of the self-moving riser with an external tube was recorded on the highest Its value for the average homogeneity coefficient amounted to 37.29%, and the reason may be due to the increase in moisture content in the designed riser s as a result of the uniformity and homogeneity of irrigation water distribution within the sprinkler service area, and these results may agree with the results obtained (Khedr, 2020).

It also appears from the results that there are no significant differences between the averages of the automatic self-moving riser s with inner and outer tubes in the moisture content amounted to 37.28% and 37.29%, respectively. The table also shows that the operating pressure had a significant effect on the moisture content, as the value of the average moisture content increased from 36.2, 36.92 and 37.97% for the operating pressures 1, 1.5 and 2 bar, respectively, and the reason may be due to the dispersion and spread of water extrusion into droplets Covers the territory uniformly and reduces of relatively large droplets, and these results may agree with the results obtained (Mohamed, et al., 2019).

It is also noted from the table that the bilateral interaction between the type of riser and the operating pressure did not have a "significant" effect, as the self-propelled riser with an external tube at a pressure of 2 bar outperformed in obtaining the highest value of the moisture content, which amounted to 38.13%, while the regular riser scored 1 Bar with the lowest moisture content valued at 35.50%. 185

Table 1. The effect of the riser used, the operating pressure used and the interactions between them on the content soil moisture%

Riser type (R)	Operational Pressure (P)			Mean riser type	
	1 bar	1.5 bar	2.0 bar		
Normal	35.5	36.37	37.7	36.52	
automatic inner tube	36.48	37.23	38.13	37.28	
Automatic external tube	36.63	37.17	38.07	37.29	
LSD 0.05	N.S			LSD 0.05	0.40
Operational Pressure mean	36.2	36.92	37.97		
LSD 0.05	0.43				

Sprinkler Discharge Liter. min^{-1}

It is noted from Table (2) the effect of the riser used to drain the sprinkler, as it was found that the type of riser did not have a "significant" effect on the sprinkler discharge, where the average value of sprinkler discharge increased from 23.73, 27.38 and 33.07 liters.min^{-1} for operating pressures of 1, 1.5 and 2 bar, respectively. This may be due to the fact that the discharge rate of sprinklers is strongly affected by the operating pressure of the system, as

the discharge rate increased with the increase in operating pressure and these results may agree with the results obtained (Khedr, 2020).
It is also noted from Table (2) that the bilateral interaction between the type of straw and the operating pressure had a "significant" effect, as the self-propelled riser with an inner tube at a pressure of 2 bar outperformed in obtaining the highest value of the sprinkler discharge, which amounted to 33.40 liters.min^{-1} While the self-propelled riser with an external tube of 1 bar recorded the lowest value for the sprinkler discharge amounted to 23.20 liters.min^{-1}.

Table 2. The effect of the used riser and the operating pressure used and the interactions between them in the discharge Sprinkler L.min^{-1}

Riser type (R)	Operational Pressure (P)			Mean riser type	
	1 bar	1.5 bar	2.0 bar		
Normal	24.60	27.60	32.80	28.33	
Automatic inner tube	23.40	27.00	33.40	27.93	
Automatic external tube	23.20	27.53	33.00	27.91	
LSD 0.05	0.90			LSD 0.05	N.S
Operational Pressure mean	23.73	2.76	2.67		
LSD 0.05	0.49				

3. Sprinkler Service Area m^2

It was shown from Table (3) that the type of riser had a "significant" effect on the sprinkler service area, as the average riser recorded the lowest area for the sprinkler service was 233.8 m^2 While the averages of self-propelled riser s with an external tube recorded the highest value of the average sprinkler service area of 247.98 m^2 The reason may be due to the fact that increasing the height of the riser helps to increase the service area of the sprinkler by not impeding the plants to distribute water because the riser is higher than the plant. These results agree with the results obtained (Abd El-Wahed, et, al., 2015).

The table also shows that the operating pressure had a significant effect on the value of the sprinkler service area, as the value of the average sprinkler service area increased from 130.49, 226.05 and 367.71 m^2 The operational pressures are 1, 1.5 and 2 bar, respectively. The reason may be that increasing the operating pressure helps push the water to a greater distance, which increases the sprinkler service area. These results may be consistent with the results obtained (Montero, 2000). The binary interaction between the type of straw and the operating pressure had a "significant" effect, as the self-propelled riser with an external tube at a pressure of 2 bar outperformed in obtaining the highest value of the sprinkler service area, which amounted to 377.69 m^2 While the normal straw 1 bar recorded the lowest value for sprinkler discharge, which was 129.33 m^2.

Table 3. The effect of the used riser and the used operating pressure and the interactions between them in a service space sprinkler m^2

Riser type (R)	Operational Pressure (P)			Mean riser type	
	1 bar	1.5 bar	2.0 bar		
Normal	129.33	219.75	352.32	233.8	
Automatic inner tube	129.33	224.9	373.12	242.45	
Automatic external tube	132.77	233.49	377.69	247.98	
LSD 0.05	4.48			LSD 0.05	2.11
Operational Pressure mean	130.48	2.76	2.67		
LSD 0.05	2.97				

4. Plant Height

Table (4) shows that the type of riser had a "significant" effect on plant height, as the inner tube riser achieved the highest plant height of 189.67 cm, while the regular riser achieved the lowest value for plant height of 173.78 cm. It is also noted that there are no significant differences between the averages of the two risers. With the inner and outer tubes, which achieved plant heights of 189.67 cm and 189.22 cm, respectively. The reason may be due to the increase in plant height in the designed risers by increasing the homogeneity of the moisture content of the soil through the regular distribution of water and in turn providing good moisture for plant growth. These results may agree with the results obtained On it (Maazou, 2016). It is also noted from the table that "there are significant differences between the average pressures used, as the pressure exceeded 2 bar by achieving the highest plant height of 190.11 cm, While the operating pressure of 1 bar achieved the lowest plant height of 177.44 cm. The reason may be due to the fact that the regulation of the operating pressure led to an increase in the moisture content of the soil, which increased the growth of the plant. These results may agree with the results obtained (Montazar and Sadeghi, 2008).

It is also noted from Table (4) that the bilateral interaction between the type of riser and the operational pressure had a "significant" effect, as the self-propelled riser with the inner tube at pressure 2 bar outperformed in obtaining the highest value of plant height of 194.67 cm, while the regular riser recorded 1 The lowest value for plant height was 163.33 cm.

Table 4. The effect of the riser used and the operating pressure used and the interactions between them on the height of the plant

Riser type (R)	Operational Pressure (P)			Mean riser type	
	1 bar	1.5 bar	2.0 bar		
Normal	163.33	176	182	173.78	
Automatic inner tube	185	190.33	193.67	189.67	
Automatic external tube	184	189	194.67	189.22	
LSD 0.05	3.63			LSD 0.05	2.30
Operational Pressure mean	177.44	185.11	2.67		
LSD 0.05	2.24				

5. Zea Mayz crop yield, ton. ha-1

Table (5) shows that the type of riser had a significant effect on the yield of maize grains, as the riser with automatic inner tube achieved the highest yield of maize, which reached 6.38 tons. hectare-1, while the regular riser achieved the lowest grain yield, which reached 5.61 tons. hectare-1. These results are in agreement with the results obtained (Mansour et al., 2019). The results showed no significant differences between the averages of the two inner and external tubes, which achieved the yield of maize 6.34 and 6.38 tons. hectare-1.

It is also noted from the table that there is a significant difference between the operation pressures used, as the pressure 2 bar outperformed by achieving the highest yield of maize 6.46 tons. hectare-1. While the operating pressure of 1 bar achieved the lowest yield of maize yield, which reached 5.80 tons. These results are in agreement with the results obtained by (Warda, 2014).

The results showed a significant two-way interaction between the type of riser and the operational pressure, as the automatic external tube at a pressure of 2 bar outperformed in obtaining the highest value of the maize yield of 6.89 tons. hectare-1, while the regular riser with 1 bar, produced the lowest yield of maize at 5.34 tons. hectare-1.

Table 5. The effect of the riser used, the operating pressure used, and the interactions between them on the yield yellow corn crop

Riser type (R)	Operational Pressure (P)			Mean riser type	
	1 bar	1.5 bar	2.0 bar		
Normal	5.34	5.59	5.89	5.61	
Automatic inner tube	6.00	6.42	6.60	6.34	
Automatic external tube	6.05	6.20	6.89	6.38	
LSD 0.05	0.130			LSD 0.05	0.070
Operational Pressure mean	5.80	6.07	6.46		
LSD 0.05	0.080				

Conclusions and Recommendations

We conclude the success of using the designed riser s in the self-height fixed sprinkler irrigation system, where the outer-tube riser excelled in the highest moisture content and the highest value for the sprinkler service area, while the self-propelled riser with the inner tube outperformed in obtaining the highest value for plant height,, Also, The two-way interaction between the self-propelled reed with an inner tube and the operating pressure of 2 bar was superior in obtaining the highest moisture content and the highest discharge of the sprinkler, while the bilateral interference between the self-propelled reed with the outer tube and the operating pressure 2 bar was superior to the highest value of the homogeneity coefficient and the highest value of the service area. Sprinkler and higher plant height. We therefore recommend the use of designed risers and appropriate operating pressure.

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