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EVALUATION OF SOME PERFORMANCE PARAMETERS ON PRESSURIZED IRRIGATION SYSTEMS UNDER FIELD CONDITIONS IN DUHOK GOVERNORATE (IRAQI KURDISTAN)

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ABSTRACT

The study was conducted in May–October 2021 at Duhok University, Iraq, where the land adjacent to the College of Agricultural Engineering Sciences, in “Seajay” village fields, latitude 36^0 55’28’’N, longitude 42^0 52’ 36’’E and 640 (m.a.s.l), the objectives of the current study are to assess the pressurized irrigation system's efficiency in applying water, intending to lessen irrigation water and managed , a set of performance guidelines and recommendations for the design to attain the highest uniformity and efficiency in water application in the field condition through selecting some parameters (Water depth, D), System coefficient of uniformity, CUS), and (radius of throw, R), a layout of (144 m^2) was designed according to the length of lateral lines, 36 catch cans were positioned in a grid of (2m) apart, a single nozzle type (5mm) was used under operating pressures of (1.0 - 2.0) bar and riser heights of (1.0 - 2 m), during two- daily runs (morning &evening), and two time periods (May and June-July 2021), statistically using RSBD and (ANOVA) table with LSD test was applied , It was observed that there was a highly significant effect (P> 0.01) of the riser height and operating pressure on the water depth (mm) in the catch cans, while, it was observed a highly significant effect between the means of CUS % value (P> 0.01) at the riser height parameter, maximum mean of wetted radius among (36 catch cans) was (13.833 m), recorded in the morning with a riser height of (2m) and operated pressure,2 bar in May, 2021,It is not suggested to run the sprinkler irrigation system at wind speeds more than (2.2 - 3.0 ms^{-1}).

KEYWORDS: Evaporation, losses, performance, pressure, riser, radius throw, sprinkler

1 INTRODUCTION:

In the past, irrigation has been essential to the growth of agriculture [1]. In times of insufficient precipitation, irrigation provides the water required for agricultural development. The demand for food production to feed an increasing population is driving a quick evolution in irrigation. Surface irrigation is the primary irrigation technique used globally. When compared to pressurized systems like sprinklers and drip irrigation, the labor required for this technology is relatively significant. In this system, water is applied in such a way, that the loss of water is very slow [2]. They have excellent efficiency, little water loss, and little labor requirements as referred to that by [3]. By using sprinkler irrigation (35%) of water can be saved, which is otherwise wasted in the surface method [4]. According to [5] it’s critical to apply the correct amount of water to the field and distribute it evenly throughout. The allowable lengths of irrigation runs are significantly influenced by the uniformity of water distribution made feasible by a given soil and irrigation management strategy.

A sprinkler system's water distribution application is more affluent and more efficient than a surface irrigation system [6]. In order to the cost of irrigation and water losses, it is necessary to enhance the way the sprinkler irrigation system operates [7] and [8]. Field test losses were reported by [9] and [10] to range usually from (10 to 20%). In contrast, losses under a moderate evaporative state should not exceed (5 to 10 percent) [11]. In addition to being a direct loss of water, droplet evaporation during spray irrigation has a substantial impact on microclimate. It improves the microclimate of the irrigated region by lowering temperature and vapor pressure deficit, which reduces transpiration and soil evaporation [12]. Evaporation losses are influenced by environmental parameters (air temperature, air friction, relative humidity, solar radiation, and wind speed) and equipment-related factors (nozzle size, operating pressure, and height of the sprinkler riser). The evaporation losses were hardly impacted by operating pressure. On high wind speed, sometimes produces transient dry zones close to the sprinkler laterals. Clam winds can occasionally aid with uniformity, according to some writers, the wind is the primary environmental factor influencing sprinkler effectiveness [8], [13], [14]. The effectiveness of a sprinkler irrigation system is frequently assessed using data from a variety of measurement tools, such as rain gauges, and catch cans which measure water uniformity coefficients [15].

The objectives of the current field study are to assess the pressurized irrigation system's efficiency in applying water and reducing water waste by examining the performance of the sprinkler irrigation system (solid sets) by selecting some parameters (Water depth, D), System coefficient of uniformity, CUS), and (radius of throw, R) at different riser heights, and operating pressures in the different time period and field conditions, intended to lessen irrigation water and managed.

2 MATERIAL AND METHODS

The study was carried out on the land adjacent to the College of Agricultural Engineering Sciences, in the fields of the “Seajay” village Duhok Governorate-Iraq contrary, the geographical coordination is as follows latitude 36^0 55’978’’N and longitude 42^0 52’ 836’’E and640((m.a.s.l).The annual maximum and minimum rainfall in the area range between (450 - 500 mm), yearly means maximum and minimum temperatures in the study site are 34.5°C and 8.3 °C respectively. The field has an area of (12 m * 12 m). The vegetation of the field was cleared and mapped out with pegs to form a grid as shown in Fig. 1 . The current study evaluates the 1- Water depth (D), 2- System Coefficient of Uniformity (CUS), and 3- The radius of the throw (R). Measuring the water volume applied by different combinations of operating pressure, riser height, and test time. Two levels of operating pressure (1.0 and 2.0. bar), and two riser heights (1.0 and 2.0 m), with one sprinkler nozzle diameter (5.0 mm) applied, and all tests data collection were applied at two-daytime (Morning and Evening) and, at two times periods (May and June –July 2021).

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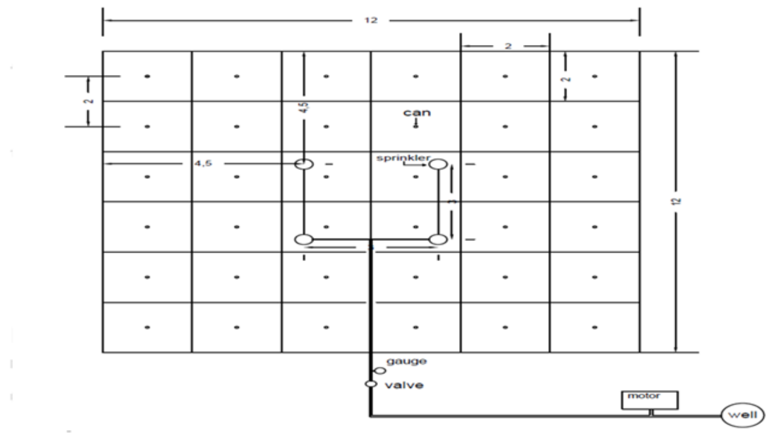

Fig. 1. Layout of the field experiment 12*12 m^2 Area, pattern soled sits sprinkler irrigation 3*3m^2

2.1 Experimental design and Statistical analysis:

The field experiment is a (Two way) randomized completely block design (RCBD), using (ANOVA) table. The comparison between means was carried out according to the LSD test using a computerized Microsoft Excel program under probability levels ($P < 0.05$) and ($P > 0.01$).

The sprinkler irrigation system has about 20 m of mainline light with a 50 mm diameter. Two lateral lines have (25 mm) diameter with 3m light, pattern solid site squared sprinkler irrigation 3*3m2, and the sprinkler irrigation system conveys water from the well through the main and lateral lines to the sprinkler nozzle which sprays the water in the form of rainfall to the field. The square pattern of the “solid site sprinkler” was used in the current study for irrigating testes the square-shaped regions because it has equal distances between the four sprinkler sites Fig. 2. In the current study (36 Catch Cans) were used to measure the collected water volume from four applied sprinklers, the diameter and height of the catch can be (114.5 and 100 mm) respectively, and the total volume is about (1000 cm^3) capacity.

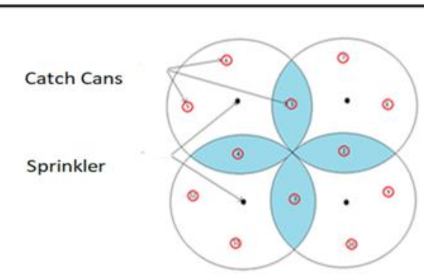

Fig. 2. Square pattern sprinkler irrigation system spacing.

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Used devices:

1. Water Pump to convey and suctions water from the well to the field study site ,

2. The pitot instrument: to measure sprinkler discharge by using the following formula

   $q=a*c\ (2*g*H)^{0.5}$ ....(1)

   Where q is the water discharge from the single nozzle (m^3/sec)

   a, the area of the nozzle orifice in m^2

   c, is Constance= 0.96.

   g, and H are accelerated gravity (9.81) and head pressure (m) .

3. Pressure gauge instrument, it is used to measure the operating pressure of the sprinkler system

4. Tape: A 50 m linen tape was used to measure the field borders layout, spacing of the catch cans, and wetted diameter.

5. Volumetric cylinder: The cylinder was used to measure the water caught by the catch cans. It has a capacity of 500 cm^3, but a plastic cylinder with the same volume is more provable to prevent breaking.

6. Computerized weather station (Data logger) returning to Agricultural Engineering Sciences College (Type Davis)

3.2 Evaporation and drift losses in Sprinkler irrigation:

The optimum equation for forecasting the evaporation and drift losses from the sprinkler technique using field weather date and riser height (m) as a variable according to [16]as proposed by Drapper and Smith (1966) [17]

$E\ (\%) = 4.506 - 0.518\ Ln\ D + 0.703\ LnH + 0.137\ Ln\ U - 0.04\ Ln\ RH + 0.022\ LnT$.......... (2)

Where:

E= Evaporation and drift losses, (%).

D = Nozzle diameter, (m).

H = Riser height, (m).

U = Wind velocity, (km/h).3-2

RH = Relative humidity, (%).

T = Air temperature, (°C).

3.3 Weather information:

As reported in Table1, and 2, meteorological data were acquired from the field weather station. Each test involved of, air temperature (°C), relative humidity (percent), Pan

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evaporation (mm/day), vapor pressure (kpa), wind speed (m/sec), and direction during the study period (May and June-July, 2021).

TABLE 1: Means of weather information from the field weather station during the test times in May 2021.

Time	Test Run	Temperature (C°)	Relative Humidity (%)	Evaporation Pan (mm/hr.)	Vapour pressure (kpa)	Wind speed (m/sec)	Wind direction
Morning	1	34.43	11.2	0.019	4.927	0.71	NE
	2	30.00	23.06	0.033	4.53	0.22	NE
	3	32.06	15.1	0.053	2.75	1.07	NE
	4	25.00	28.2	0.031	2.28	2.18	SE
Evening	1	34.80	13.76	0.034	4.856	1.43	SE
	2	34.97	15.70	0.034	3.95	1.75	NE
	3	34.60	18.36	0.025	4.53	2.24	NE
	4	28.73	24.03	0.027	3.00	3.10	SE

Pressure: Riser=1:1, 2:1, 2:2, 1:2

TABLE 2: Means of weather information from the field weather station during the test times in (June and July 2021).

Time	Test Run	Temperature (C°)	Relative Humidity (%)	Evaporation Pan (mm/hr.)	Vapour pressure (kpa)	Wind speed (m/sec)	Wind direction
Morning	1	33.66	16.06	0.036	4.39	0.75	NW
	2	30.20	25.13	0.030	3.21	1.09	NW
	3	32.76	17.90	0.032	4.07	1.73	NW
	4	35.73	8.76	0.038	5.38	1.94	NW
Evening	1	37.66	17.10	0.042	5.71	2.15	NW
	2	37.43	12.10	0.040	5.66	3.49	NW
	3	38.83	8.90	0.063	6.35	2.86	NW
	4	26.83	9.30	0.035	5.87	1.93	NW

Pressure: Riser=1:1, 2:1, 2:2, 1:2

3.4 Some selected performance evaluation parameters:

1. Water depth

Water volume caught by the net of (36 catch cans) in an area (144 square meters) the distance from each can and other was (2m) Fig.(1). The required water volume should be collected in the center catch cans by using a class cylinder shown in previous research, by dividing the total volume of collected water from each catch can contender on its base (103 cm3) be capable to measure the average depth of each irrigated run.

2. System Coefficient of Uniformity (CUS),[11]as:

$$CUS = CU \times 1/2[1 + (\sqrt{Pn}/\sqrt{Pa})] \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

CU = coefficient of uniformity measured by [18]

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Pn = the minimum sprinkler pressure (kpa)

Pa = the average sprinkler pressure (kpa)

3. Radius of throw(R).

The wetted radius of the throw for each sprinkler was calculated using the boundary sprinklers of the experimental setup. The solid site sprinklers were operated at different pressures and the throw radius was measured using a measuring tape, average of this was calculated to give the effective radius of the throw, and changes in the profiles of sprinklers as reported by [19]. The wetted radius is inversely related to wind speed and riser's height, but directly related to operating pressure.

4 RESULT AND DISCUSSION:

The sprinkler system's on-field effectiveness has been evaluated using three parameters, water depth (D), system coefficient of uniformity(CUS), and radius of the throw(R) were evaluated under different levels of riser height and operating pressures and at two-day time , in a period of (May, June –July 2021). Table 3, shown as operating pressure is constant and the riser height was taken into account the evaporation and drift losses descended from (10.2 to 8.57%), when the riser height increased from (1.0 to 2.0 m), this up-normal result was illustrated due to a decrease in temperature about(27.39%)and increase of relative humidity (60.3%)at the morning run in May 2021, whereas the result shown increased in evaporation and drift losses from (8.47 to 13.02%) when riser height increased from (1.0 to 2.0 m) at morning in (June –July 2021) due to increase in temperature (6.1%) and decreased in relative humidity at the rate of (45.4%)as showed in table 2. The forecasting equations of the evaporation and drift losses percentage of the sprinkler technique which shown in table 3. (Column7), measured by power equation applied field weather data, and riser height (m) as a variable. To comparison the results obtained by the current study with that obtained by [16], as proposed by [17] (Column 8). It was clear that results in current study ranged between (8.47-13.02%), in time results obtained by [17] successive ranged between (7.35-7.98%). The difference may be due to the mean of calculation equations and diverseness in weather conditions (North of Iraq).

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TABLE 3: The losses of evaporation and drift (%) at (1&2m) riser height and wind speeds in interval period.

Two Period	Time	Riser height	Wind speed (m/sec)	Air temperature (C°)	Relative humidity (%)	Evaporation and drift loss (%)	Drapper & Smith (1966) equation
May,2021	Morning	1	0.71	34.43	11.2	10.20	7.36
		2	1.07	25.00	28.21	8.57	7.86
	Evening	1	1.43	34.80	13.76	11.60	7.45
		2	2.24	28.73	24.03	11.37	7.97
J-J,2021	Morning	1	0.75	33.67	16.07	8.47	7.35
		2	1.94	35.73	8.77	13.02	7.94
	Evening	1	2.15	37.67	17.10	12.62	7.50
		2	1.93	26.83	9.30	10.03	7.99

4.1 Water depth (mm)

Table 4,. showed that the maximum and minimum water depth among (36 catch cans) was (9.877 mm) at morning applied on (2m) riser height and 2bar operating pressure, while the minimum water depth value was (7.880 mm) recorded at the morning too on (1m) riser height and (1bar) operating pressure during the period time (May,2021). Statistically using LSD test, it was observed that there was a highly significant effect ($P> 0.01$) of the riser height and operating pressure on the water depth (mm) in the catch cans, in time, it shown that there was a significant effect ($P < 0.05$) of interaction between run time and riser height on the water depth (mm) in (May 2021). In the second period time (June –July 2021) using an LSD test, In table 5, it was revealed that the maximum value of water depth in the cans was equal to (10.307 mm) tested in the morning applied at (2m) riser height and (2bar) pressure whereas the minimum water depth mm recorded in the evening equal (8.737mm) at (1m) of riser height and (1bar) operation pressure, highly significant effect ($P> 0.01$) of run time and operation pressure was observed on water depth mm in the cans, while, significant different effect ($P < 0.05$) of riser height showed on water depth mm. Finally, the result of the current study was in line with that finding by [20]. Using Tukey simultaneous testing for differences between the means values for water caught, when determined the riser heights of (2, 1.5, and 4 meters) had the most impact on the water in the catch cans. Consequently, the risers have a varying impact on the amount of water caught at a given depth.

4.2 CUS % (System coefficient of uniformity):

Table 4.shown that the system coefficient of uniformity (CUS%) was calculated according to equation (3) ,[11]. the maximum mean CUS% value was achieved from the entire set of tests at a riser height of (1m), and operating pressure of (2 bar) was (76.109%) in the morning, while the minimum value shown equal (64.597%) at a riser height of (2m), and operation pressure (1 bar) at evening. It was observed that there was a highly significant effect between the mean of CUS % value ($P> 0.01$) at the riser height parameter, while the effect between the means of operation pressure on CUS% was significant ($P < 0.05$), using the LSD test, in (May 2021). Concerning the second time period (June-July,2021), table 5. it was seen that CUS % recorded (68.794%) as

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the maximum value in the morning day time, and 52.875% in the evening, LSD test manifested that high significance (P > 0.01) was observed between the means of CUS% values of the each of the following (run time, riser height, operating pressure and the interaction between run time and riser height) in the same lain of that significance effect (P < 0.05)was observed between the means of CUS% values of interaction among (run time, riser height, and operating pressure).

An expected result of the performance CUS% indicator was shown that each of following factors (Run time, riser height, operation pressure, and their interactions) Evidently, were close links with that obtained by [11], and the rationalize was revealed that the riser height operating pressure and run-time have a reasonable effect on the sprinkler irrigation management and reduction of water somewhat in suitable condition and operating techniques.

4.3 The radius of throw (m):

The wetted radius of the throw for each sprinkler was measured for the both riser height (1,2m) and operating pressures (1,2 bar) using a measuring tape. Table 4, was showed that the maximum and minimum mean of wetted radius among (36 catch cans) were (13.833 and 10.333m) respectively, the maximum radius value was recorded in the morning with a riser height of (2m) and the operating pressure,(2 bar) and the minimum radius of throw value was tested in the evening, under (1m) riser height and (1 bar) operating pressures on (May 2021), there were highly significant differences (P > 0.01) between the values of the means (radius m) observed affected by the operating pressure; in time significant differences (P < 0.05) between the means values of (radius m) was observed affected by the run time and riser height using LSD test. In the second period test (June –July 2021), the maximum and minimum mean wetted radius were (15.000 and 9.667 m) respectively, as illustrated in table,5 the maximum radius value was recorded in the morning with a riser height of (2m) and operated pressure of (2 bar), and the minimum radius of throw values was observed in the evening, at (1m) riser height and (1 bar) operating pressures. Statistically, it was shown that a highly significant effect (P> 0.01) between the means values of (radius m) affected by the riser height; while, a significantly different (P < 0.05) was observed between the means values of (radius m) affected by the interaction between both time run and riser height, applied LSD test. The previous investigation cites that low pressures with low riser height have a very limited effect on the radius length, while high riser (2m) and high operating pressures (2bar) showed a conspicuous effect on the (radius of throw m), also the radius of throw inversely related to wind speed and directly related to riser height and operating pressure [19].

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TABLE 4: The effect of operating pressures, riser heights, and wind speeds on some selected performance Parameter during test runs in May 2021.

Time	Wind speed (m/sec)	Riser Height (m)	Operation pressure (Bar)	Depth mm	CUS %	Radius m
Morning	0.75	1	1	8.997	57.102	12.000
	1.09	1	2	9.350	62.400	13.667
	1.94	2	1	9.383	66.897	12.000
	1.73	2	2	10.307	68.794	15.000
Evening	2.15	1	1	8.737	52.875	9.667
	3.49	1	2	9.577	55.050	13.833
	1.93	2	1	8.920	59.340	10.000
	2.84	2	2	9.703	61.850	13.600

TABLE 5: The effect of operating pressures, riser heights, and wind speeds on some selected performance Parameter during test runs in (June and July 2021).

Time	Wind speed (m/sec)	Riser Height (m)	Operation pressure (Bar)	Depth mm	CUS %	Radius m
Morning	0.71	1	1	7.880	73.863	11.500
	0.21	1	2	8.617	76.109	13.000
	1.07	2	1	8.770	71.863	12.667
	2.18	2	2	9.877	71.967	13.833
Evening	1.43	1	1	7.973	69.435	10.333
	1.75	1	2	8.697	69.928	12.667
	2.24	2	1	8.143	64.597	12.000
	3.10	2	2	9.003	68.450	12.000

3 CONCLUSION:

At low wind speeds, low temperatures, and high relative humidity, highly efficiencies were obtained. The better test run of sprinkler irrigation was in the morning time due to low temperature, calm wind speed, and high relative humidity. All performance parameters tested under the current study referred to decreases in values in the evening -day and conspicuously lower than those obtained in the morning tests. The strength and direction of the prevailing wind have a significant impact on the effectiveness of sprinkler watering systems. The wind was the main variable that alters sprinkler profiles and reduces throw radius. The uniformity of set-move sprinkler irrigation systems was significantly impacted by wind speed in conjunction with sprinkler spacing. The issue is more severe when the wind speed is greater than 2.2 ms^{-1}. Wind skips, happen when there is a significant change in wind speed. The square design of sprinkler irrigation systems, which is appropriate for irrigating square-shaped regions, has identical distances running between each of the four sprinkler sites. The diagonal space between sprinklers in the corners, which is frequently subject to wind impacts, depends on how strong the wind is, closer spacing is advised to reduce wind effects as design in current study.

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