Effect of two types of sprayers nozzles on the yield traits and its components for cultivars of flax and evaluating the fixed spraying irrigation systems

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ABSTRACT

A field experiment was conducted at the Daquq Research Station located 40 km south of Kirkuk at longitude 28-44 ° east and latitude 8-35 ° north for the 2019 winter season, starting from 11/15/2019 to 5/15/2020. The study included two factors: the first was two types of sprayer nozzles (Canadian and Turkish) and the second factor was seven cultivars of flax. The experiment was applied using The Randomized Complete Block Design (RCBD) according to the split-plot system, with three replicates. The main plots included two types of sprayers nozzles, while the subplots included seven cultivars of flax. The experiment aimed to test and evaluate the fixed spraying irrigation system for the two types of sprayers nozzles and to determine the best combination of the sprayer nozzles and the type of cultivar with study the response of flax cultivars to the conditions of Kirkuk province. The results showed that the Canadian sprayer nozzle has excelled over the Turkish sprayer nozzle in the studied traits related to the evaluation of the fixed spray irrigation system. The Canadian sprayer nozzle has excelled to that of the Turkish sprayer nozzle in influencing the traits related to the flax yield. Sakha 4 cultivar has excelled in most of the characteristics, including the yield and its components due to the suitability of the environmental conditions of the Kirkuk provinces to this cultivar. The results were as following:

The Canadian sprayer nozzle has excelled in the traits of distribution uniformity for the lower quarter, the efficiency of adding water, the overall efficiency of the system, and the uniformity coefficient of water distribution which gave averages amounted to (62.43%, 73.00%, 56.24%, and 77.40%), respectively. The Sakha 4 cultivar has excelled in most of the traits, including the number of secondary branches per plant, the number of capsules per plant, the seeds yield per plant, and the biological yield of the plant which gave averages amounted to (13.31 branch.plant^{-1}, 53.95 Capsule.plant^{-1}, 3.30g, and 11.30g), respectively. the superiority of the Syria/Erbil cultivar in the traits of plant height and the weight of 1000 seeds by giving averages amounted to (80.26 cm and 11.13 g), respectively. The Syria/Anbar cultivar also excelled in the trait of the number of seeds per capsule by giving an average amounted to (9.10 Seed.capsule^{-1}), the Giza-10 cultivar has excelled in the trait of harvest index per the plant by giving an average amounted to (40.48%).

Keywords: sprayers nozzles, the efficiency of water addition, the uniformity coefficient, flax, cultivars.

Research Paper from the master's thesis for the first articles

تأثير نوعين من رؤوس المرشات في صفات الحاصل ومكوناته لأصناف من الكتان وتقييم منظومة الري بالرش الثابت

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الملخص

أجريت تجربة حقلية في محطة أبحاث داقوق الواقعة على بعد 40 كم جنوب كركوك على خط طول 28-44° شرقاً وخط عرض 8–35° شمالاً للموسم الشتوي 2019 بدأ من 2019/11/15 الى 2020/5/15، شملت الدراسة عاملين: الأول نوعان من رؤوس المرشات (كندي وتركي) والعامل الثاني (7) أصناف من الكتان، طبقت التجربة بتصميم القطاعات الكاملة المعشاه (RCBD) وفق نظام الالواح المنشقة وبثلاثة مكررات، تضمنت الالواح الرئيسية نوعين من رؤوس المرشات بينما شغلت الالواح الثانوية (7) أصناف من الكتان، هدفت التجربة الى اختبار وتقييم لمنظومة الري بالرش الثابت لنوعي رؤوس المرشات وتحديد أفضل توليفة لراس المرشة ونوع الصنف مع دراسة استجابة أصناف من الكتان لظروف محافظة كركوك، استنتج من البحث تفوق راس المرشة الكندي على راس المرشة التركي في الصفات المدروسة التي تتعلق بتقييم منظومة الري بالرش الثابت. تفوق راس المرشة الكندي على راس المرشة التركي في التأثير على الصفات المتعلقة بمحصول الكتان. ملائمة الظروف البيئية لمحافظة كركوك للصنف سخا 4 لتفوقه في اغلب الصفات ومنها الحاصل ومكوناته. كانت النتائج:

تفوق راس المرشة الكندي في صفات تجانس التوزيع للربع الأقل بمتوسط بلغ 62.43% وكفاءة الإضافة للمياه بمتوسط بلغ 73.00% والكفاءة الاجمالية للنظام بمتوسط بلغ 56.24% ومعامل الانتظام لتوزيع المياه بمتوسط بلغ 77.40%. تفوق الصنف سخا 4 في اغلب الصفات منها عدد الافرع الثانوية بالنبات بمتوسط بلغ 13.31 فرع.نبات$^{-1}$ وعدد الكبسولات بالنبات بمتوسط بلغ 53.95 كبسولة.نبات$^{-1}$ وحاصل البذور بالنبات بمتوسط بلغ 3.30 غم والحاصل البيولوجي بالنبات بمتوسط بلغ 11.30 غم، تفوق الصنف سوري / أربيل بصفة ارتفاع النبات بمتوسط بلغ 80.26 سم ووزن 1000 بذرة بمتوسط بلغ 11.13 غم، تفوق الصنف سوري / انبار بصفة عدد البذور بالكبسولة بمتوسط بلغ 9.10 بذرة.كبسولة$^{-1}$، تفوق الصنف جيزة 10 بصفة دليل الحصاد بالنبات بمتوسط بلغ 40.48%.

الكلمات المفتاحية: رؤوس المرشات، كفاءة اضافة المياه، معامل الانتظام، الكتان، الأصناف.

1. INTRODUCTION

The spraying irrigation system is considered one of the modern irrigation systems that has an effective role in increasing production due to its high effectiveness in increasing the efficiency of water distribution and saving the amount of water added to the unit area compared to the traditional method of surface irrigation where spraying irrigation is known as the irrigation method in which water is pumped into a network of the pipes of different diameters end with fixed holes or rotating sprayer from which water flows into the air in the form of drops that fall on the ground resembling rain (1). Zhang et al., (21) observed that the productivity of the crop and the efficiency of the water addition are more efficient than the traditional surface irrigation system in wheat fields, such as the trait of plant height, area of flag leaf, length of spike, number of grains per spike, weight of 1000 seeds, number of spikes and grain yield. Mahdi and Hussein (10) explained that there is the possibility of increasing agricultural production when using spraying irrigation systems because they are characterized by high efficiency and homogeneity for water distribution in addition to their different pressures for operation and economy in supplying water, and they are characterized by little water losses unlike other traditional irrigation systems. Cultivation of suitable cultivars is considered one of the important factors for obtaining high productivity of plants from the required economic yield (oil or fiber), so the cultivar alone is considered insufficient to give high productivity to achieve this. The necessary improvements must be introduced in agricultural technology, which is the application of necessary agricultural processes such as crop service operations and pest control, the agricultural and weeds associated with the crop and the use of modern methods of irrigation, such as irrigation by constant spraying and irrigation by axial spraying to

stimulate the plant to show its genetic and physiological capacity so that the cultivar expresses itself in its agricultural environment (18), in agreement with many researchers who showed there is a possibility to increase the yield traits and components of flax cultivars when preparing the appropriate conditions for plant growth, including (7, 14, 16, 20, 6, 17).

2. MATERIALS AND METHODS

A factorial experiment was conducted at the Daquq Research Station located 40 km south of Kirkuk at longitude 28-44° east and latitude 8-35° north for the 2019 winter season, starting from 11/15/2019 to 5/15/2020. The study included two factors: the first was two types of sprayer nozzles (Canadian and Turkish) and the second factor was seven cultivars of flax. The experiment was applied using The Randomized Complete Block Design (RCBD) according to the split-plot system, with three replicates. The main plots included two types of sprayers nozzles, while the subplots included seven cultivars of flax. The chemical fertilizer was added in the recommended quantities at an average of (90 kg $N.ha^{-1}$) in two batches, the first was at planting and the second was after one and a half months from the first batch with an average of (120 kg $P.ha^{-1}$) (9).

2.1 The used fixed spraying irrigation system and its specifications.

1- A centrifugal pump with a drainage of (400 $m^3.h^{-1}$) connected to a fuel-powered engine (kerosene) with a horsepower (60 horsepower) and a number of cycles (1800 rpm).
2- The suction tube for the pump is with a diameter of (12.7) cm, the pumping tube for the pump is with a diameter of (12.7) cm.
3- Main and auxiliary pipes with a diameter of (12.7 - 6.35 cm), respectively, m and a length of (6) for one pipe.
4- Main locks are installing on the mainline with a diameter of (12.7 cm) and a diameter of (6.35) for the side of the branch pipe (3 number) to control the opening and closing of the branch pipes of the system.
5- Two types of sprayers nozzles are of Canadian and Turkish origin, with a number of (18 sprayers) for each type that has two holes with drainage for the first type at a pressure of (2 bar 1.32 $m3.h^{-1}$), and for the second type at a pressure of (2 bars 1.20 $m3.h^{-1}$) with a spraying diameter for the first type at a pressure of (2 bar 15.24 m) and for the second type at pressure (2 bars 16.60 m), the diameter of the large hole for the first type is (4.4 mm), the small hole is (2.4 mm), and for the second type, the large hole is (3.8 mm) and the small hole is (2.3 mm), and the height of the holder of sprayer nozzle is (100 cm) with a diameter of (3 cm).

2.2 Installing a fixed spraying irrigation system.

The fixed spraying irrigation system consists of three lines that connect vertically with the mainline, the distance between the lines is (12 m) with a rate of (12 sprayers per line) divided into two types (6) sprayers nozzles for the Canadian type and (6) sprayers nozzles for the Turkish type, the distance between the sprayers nozzles is (12 m), leaving a distance of (12 m) for the beginning of each type, and with three replicates, so that the arrangement of the sprayers nozzles is square in shape with dimensions of (12 x 12 m^2) as shown in Figure (1).

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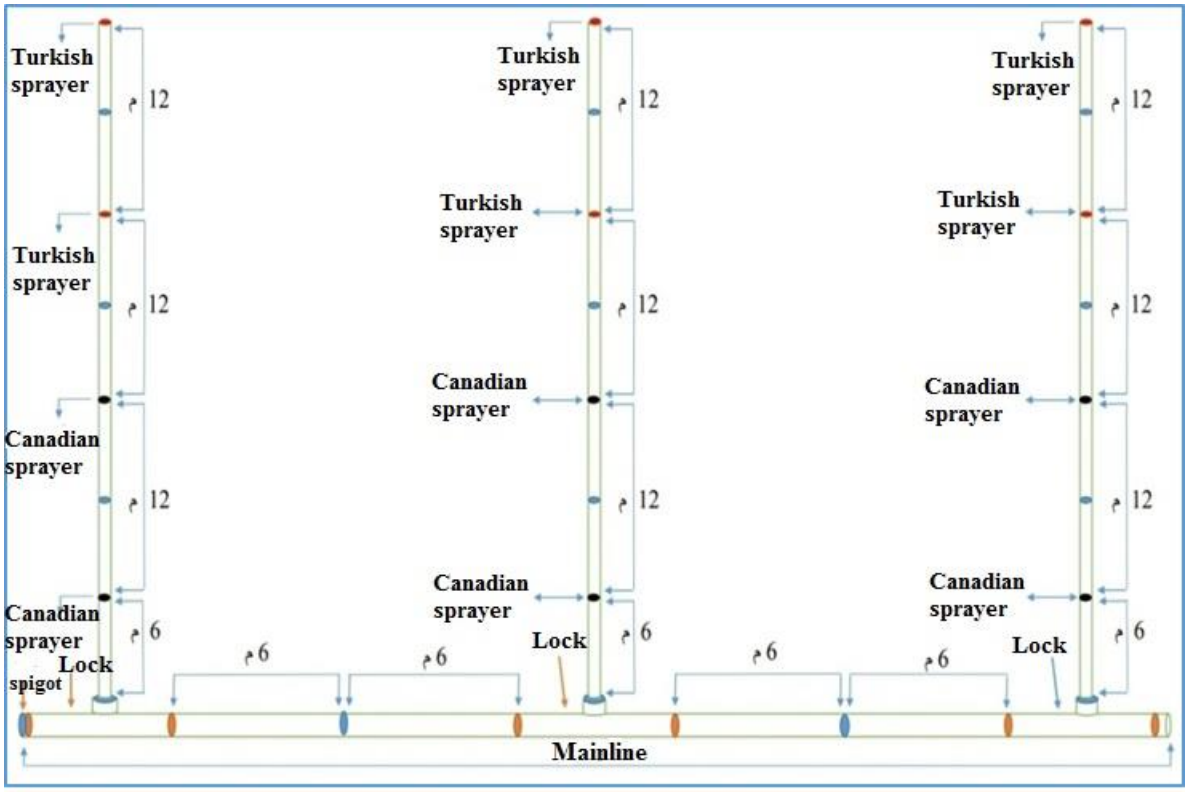

Figure 1: Designing the experiment in the field for a fixed Spraying Irrigation System.

The Studied traits.

1- fixed Spraying Irrigation System.

1-1- The distribution uniformity for the lower quarter (Du).

The measurement is done using the following equation (3).

$$Du\ (1/4) = \left(\frac{Dig}{Dac}\right) \times 100$$

where:

Du (1/4) = distribution uniformity for the lowest quartile (%).

Dac = mean water depths accumulated in cans (mm).

Dig = mean water depths accumulated in cans with lowest drained for a quarter of 25 cans (mm).

1-2- Efficiency of Water Addition (Ea).

The measurement is done using the following equation (10).

$$Ea = \left(\frac{Ds}{Da}\right) \times 100$$

Da is calculated by applying the following equation

$$Da = \frac{(q \times Ta \times 100)}{(Si \times Sm \times 60)} \times 1000$$

where:

Ea = efficiency of water addition (%).

Ds = mean depth of water stored within the area (mm)

Da = mean absolute water depth (mm),

q = sprayer drainage ($L.h^{-1}$).

Ta = addition time (h).

Si = distance between sprayer (m).

Sm = the distance between the lines (m).

1-3- overall system efficiency (Oe).

The measurement is done using Equation (8).

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$$OE = \frac{UC \times Ea}{100}$$

where:

OE = overall system efficiency (%).

UC = uniformity coefficient (%).

Ea = water addition efficiency (%).

1-4- Uniformity coefficient of water distribution (UC).

The uniformity coefficient is measured by collecting a certain volume of water falling from the sprayer at fixed distances and a certain system (11).

$$UC = \left(1 - \frac{\sum_1^n (xi - \bar{x})}{n\bar{x}}\right) \times 100$$

where:

UC = uniformity coefficient of water distribution (%).

xi = depth of water added for a single reading.

$\bar{x}$ = average depth of added water.

n = number of reads.

Traits of flax

Plant height (cm):

The average plant height was measured by a manual measuring machine (metal tape measure) from the soil surface to the top of the plant after appearing signs of maturity and before the harvest phase and for ten plants randomly from the guarded midlines of the experimental unit.

The number of secondary branches (branch.plant^{-1}):

The average number of secondary branches per plant was measured after appearing signs of maturity and before the harvest phase for ten plants randomly taken from one of the guarded midlines of the experimental unit.

Number of capsules per plant (capsule.plant^{-1}):

The average number of capsules per plant was measured for ten plants taken from the guarded midlines randomly for the experimental unit.

Number of seeds per capsule (seed.capsule^{-1}):

The average number of seeds per capsule was measured by taking 20 capsules randomly for ten plants taken from the guarded midlines of the experimental unit.

The weight of 1000 seed (g):

the average weight of 250 seeds was measured randomly from the experimental unit and multiply the result by the number 4.

Seed yield in plant (gm):

The average seed yield per plant was measured for ten plants randomly taken from the guarded midlines of the experimental unit.

Biological yield in Plant (g):

The average biological yield of plants for the rootstock of ten plants was measured randomly before the harvest phase from one of the guarded midlines of the experimental unit.

Harvest Index in plants (%):

It was measured according to the following equation:

$$\textbf{Harvest Index (\%)} = \frac{\textbf{Seed yield in plant}}{\textbf{Biological yield in Plant}} \times \textbf{100}$$

3. RESULTS AND DISCUSSION

The effect of spraying irrigation system with two types of sprayers nozzles (Canadian CA and Turkish TU) on some traits related to system.

1- the distribution uniformity for the lowest quarter

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Table (1) shows when conducting the T-Test for a comparison between the Canadian and Turkish sprayers nozzles, a significant superiority of the Canadian sprayer nozzle on the Turkish sprayer nozzle which gave averages amounted to (62,432 and 53.491%), respectively. The reason is that the homogeneous square-shaped area leads to homogeneity of the interaction of the irrigation water coming out of the sprayer, leading to an increase in the distribution uniformity for the lowest quarter. This result agrees with (3).

2- Efficiency of water addition

Table (1) shows when conducting the T-Test for a comparison between the Canadian and Turkish sprayers nozzles that the Canadian sprayer nozzle has excelled over the Turkish sprayer nozzle which gave an average amounted to (73 and 70.454%), respectively. It is observed that the efficiency of adding water is considered one of the most important factors affecting the growth of plants and it is considered one of the factors affecting the optimal growth of the plant and increasing the yield (12).

3- The overall efficiency of the system

Table (1) shows when conducting the T-Test for a comparison between the Canadian and Turkish sprayers nozzles that there is a significant superiority for the Canadian sprayer nozzle on the Turkish sprayer nozzle which gave an average amounted to (56,248 and 48.75%), respectively. The reason for the superiority of the Canadian sprayer nozzle is with the large diameter of the holes, which led to the dispersion of water droplets leaving and decrease their speed in the air and the droplets falling with a wider spread of the service area of four sprayers. These results agree with (10).

4- The uniformity factor of the water distribution.

Table (1) shows when conducting the T-Test for a comparison between the Canadian and Turkish sprayers nozzles that the Canadian sprayer nozzle has excelled over the Turkish sprayer nozzle which gave an average amounted to (77.402 and 68.628%), respectively. The reason is due to the superiority of the Canadian sprayer nozzle with all the studied traits above. This led to the superiority of the same sprayer by giving the highest uniformity of water distribution, which indicates that the square shape gives the best uniformity coefficient of water distribution. It is worth noting that the uniformity of water distribution directly affects the increase in growth and productivity for crops. These results agree with (13, 5).

Table 1: The effect of spraying irrigation system with two types of sprayers nozzles (Canadian CA and Turkish TU) on some traits related to system.

No	Traits	Type of sprayer nozzle		The calculated T-value	p-value
		CA	TU		
1	* distribution Uniformity for the lowest quarter% (Du)	62.432	53.491	4.06	0.0067
2	* Efficiency of Water Addition % (Ea)	73	70.454	7.00	0.0004
3	* efficiency of Total system % (Oe)	56.248	48.75	7.66	0.0003
4	* Uniformity coefficient% (UC)	77.402	68.628	7.35	0.0003

***It is referred to the presence of significant differences between the two averages.**
The tabular value of the T-test corresponding to the degree of freedom 4 and the probability level of 0.05 = 2.77.
P significant differences in T-test at the probability level of 0.05.

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Figure (2) shows that the pattern of water distribution for the Canadian sprayer nozzle is close to the triangular shape. Figure (3) shows that the pattern of water distribution for the Turkish sprayer nozzle is close to the oval shape, and by comparing the two patterns, we notice that the Canadian sprayer nozzle represents an ideal pattern in water distribution more than The Turkish sprayer nozzle, Whenever the water distribution is homogeneous, it approaches the ideal pattern, this is reflected on the traits of the yield and its components of the plant, as in the following tables, and this agrees with (2, 3, 5, 8).

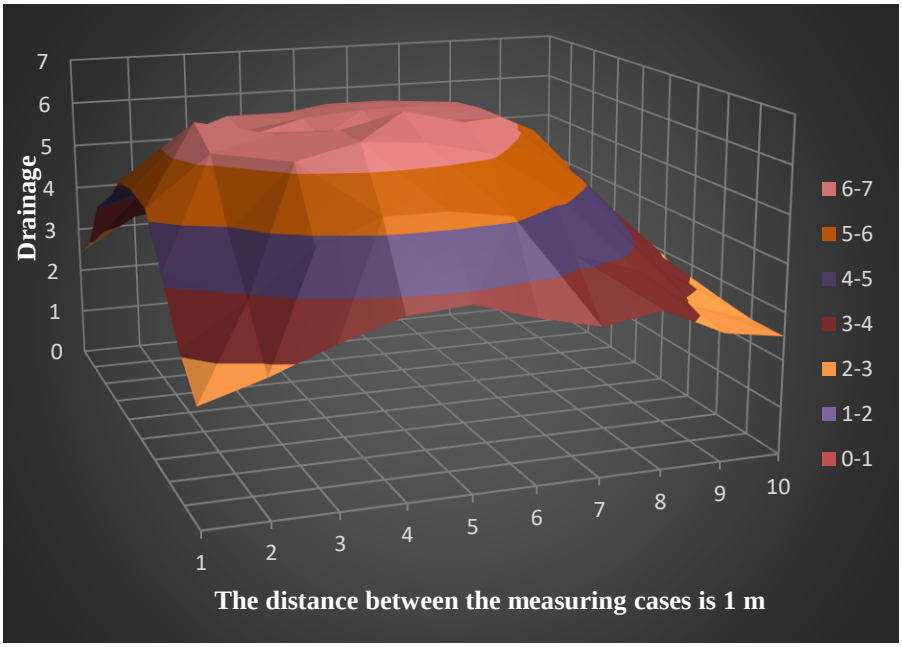

Figure 2: the pattern of water distribution under the service area for one sprayer of the Canadian type.

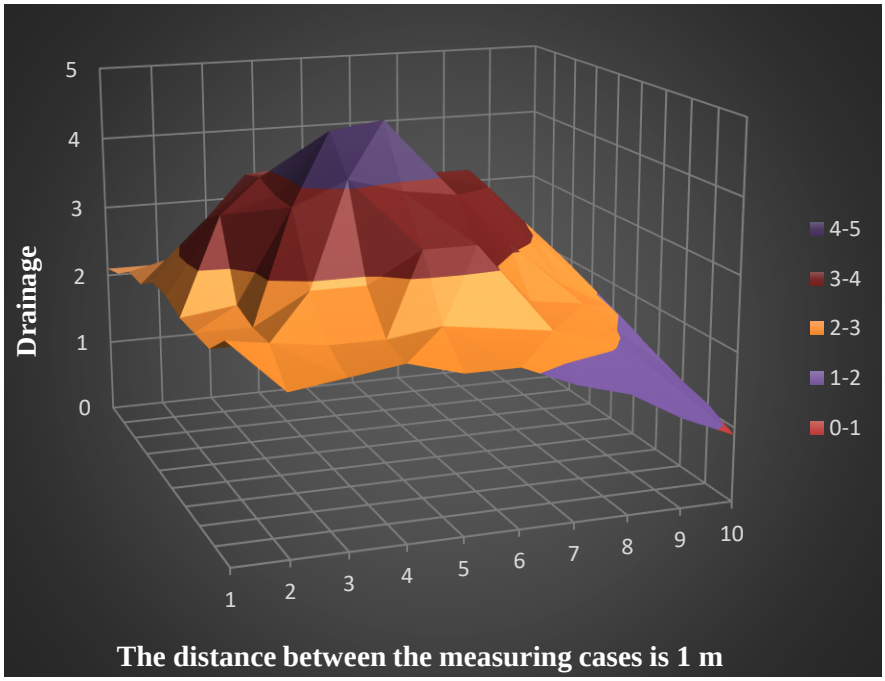

Figure 3: the pattern of water distribution under the service area for one sprayer of the Turkish type.

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2- The effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the yield traits and their components.

2-1- Plant height (cm).

Table (2) shows the effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the trait of plant height. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle at the 5% level by giving averages amounted to (69.75 cm, 67.15 cm), respectively. Table (1) also shows that there is a significant excelling of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the efficiency of adding water. As for the cultivars, the Syrian / Erbil cultivars were significantly excelled by giving it the highest plant height at levels 5 and 1% amounted to (80.26 cm) while the Syrian / Baghdad cultivar gave the lowest plant height amounted to (58.73 cm). The difference in plant height between flax cultivars is due to the genetic nature of the cultivar and its ability to express itself in the environmental conditions prevailing in the area of cultivation. The results agree with (7, 18). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Sakha 4 cultivar was significantly excelled by giving it the highest plant height at the levels 5 and 1% amounted to (81.53 cm) while the interaction treatment between the Turkish sprayer nozzle and the Syrian / Baghdad cultivar gave the lowest average amounted to (58.13 cm). Table (1) shows a significant superiority of the Canadian sprayer nozzle over the Turkish sprayer nozzle for the trait of the efficiency of adding water, leading to a decrease in the temperature of plants, providing favorable conditions for plant growth, which reflected positively on the period of vegetative growth for the stem and the availability of water and nutrients for the plant during the photosynthesis process, which led to the superiority of cultivars under the service area of the Canadian sprayer nozzle. This result agrees with (15).

Table 2: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of plant height.

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	62.46	59.76	61.11	sprayers nozzles = 2.49
Syrian / Baghdad	59.33	58.13	58.73	cultivar = 4.51
Giza 10	59.46	58.30	58.88	sprayers nozzles x cultivar = 6.39
Sakha 4	81.53	75.96	78.75	
Syrian / Anbar	73.56	68.83	71.20	$LSD_{0.01}$
Poland	70.66	69.76	70.21	sprayers nozzles = 5.74
Syria / Erbil	81.23	79.30	80.26	cultivar = 6.12
Average of sprayers nozzles	69.75	67.15		sprayers nozzles x cultivar = 8.66

2-2- The number of secondary branches per the plant (branch.plant^{-1}).

Table (3) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the number of secondary branches per the plant. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle at the levels of (1, 5%) by giving it averages amounted to (11.33 and 9.29 branches.plant^{-1}), respectively. Table (1) also shows that there is a

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significant excelling of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the trait of the distribution uniformity for the lowest quarter. As for the cultivars, the Sakha 4 cultivars were significantly excelled by giving it the highest number of secondary branches per the plant at levels 5 and 1% amounted to (13.31 branches.plant^{-1}) on the Giza 10 cultivar which gave the lowest number of secondary branches per the plant amounted to (7.70 branches.plant^{-1}). The reason for the superiority of the Sakha 4 cultivar in the number of secondary branches per plant is due to the superiority of the same cultivar in the trait of the number of the main branches per plant. This led to the stimulation of the lateral buds and the apical meristem to stimulate the plant to form a greater number of secondary branches in the plant and the response of the cultivar to environmental conditions led to an increase in the number of secondary branches per plant (20). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Poland cultivar was significantly excelled by giving it the highest number of secondary branches per the plant at the levels 5 and 1% amounted to (16.03 branches.plant^{-1}) while the interaction treatment between the Turkish sprayer nozzle and the Giza 10 cultivar gave the lowest average for the trait of the number of secondary branches per the plant amounted to (6.36 branches.plant^{-1}). Because the Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle for the trait of the distribution uniformity for the lowest quarter, it reflected positively on the vegetative growth stages of the plant, which led to the superiority of the cultivars under the Canadian sprayer by increasing the number of secondary branches per the plant as shown in Table (1). These results agree with (4).

Table 3: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the number of secondary branches per the plant.

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	9.60	8.86	9.23	sprayers nozzles = 0.74
Syrian / Baghdad	9.60	8.36	8.98	cultivar = 1.02
Giza 10	9.03	6.36	7.70	sprayers nozzles x cultivar = 1.45
Sakha 4	13.70	12.93	13.31	
Syrian / Anbar	11.73	10.66	11.20	The lowest significant difference at 1%
Poland	16.03	9.33	12.68	sprayers nozzles = 1.71
Syria / Erbil	9.63	8.53	9.08	cultivar = 1.39
Average of sprayers nozzles	11.33	9.29		sprayers nozzles x cultivar = 1.96

2-3- the number of capsules per plant (capsule.plant^{-1})

Table (4) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the number of capsules per plant. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle in the trait of the number of capsules per plant at the level of (5%) by giving it averages amounted to (48.81 and 36.88 capsules.plant^{-1}), respectively. Table (1) also shows that there is a significant excelling of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the trait of the overall efficiency of the system. As for the cultivars, the Sakha 4 cultivars were significantly excelled by giving it the highest

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number of capsules per plant at levels 5 and 1% amounted to (53.95 capsules.plant^{-1}) on the Giza 10 cultivar which gave the lowest number of capsules per plant amounted to (30.98 capsules.plant^{-1}). The reason for the increase in the number of capsules per plant for the Sakha 4 cultivar, as a result of the superiority of the same cultivar in the trait of the number of secondary branches per plant as shown in Table (3), this led to an increase in the leaves' content of manufactured nutrients, thus increasing the number of capsules per plant, this result agrees with (6). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Poland cultivar was significantly excelled by giving it the highest number of capsules per plant at the levels 5 and 1% amounted to (62.70 capsules.plant^{-1}) while the interaction treatment between the Turkish sprayer nozzle and the Giza 10 cultivar gave the lowest average for the trait of the number of capsules per the plant amounted to (23.83 capsules.plant^{-1}). The reason may be due to the superiority of the Canadian sprayer nozzle for the trait of the overall efficiency of the system on the Turkish sprayer nozzle, which is positively reflected on the trait of the number of capsules per plant, which led to the superiority of the Poland cultivar by giving it the highest average as shown in Table (1). This result agrees with (5).

Table 4: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the number of capsules per the plant.

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	43.53	35.23	39.38	sprayers nozzles = 6.67
Syrian / Baghdad	38.16	37.83	38.00	cultivar = 8.86
Giza 10	38.13	23.83	30.98	Sprinkler heads x items = 12.53
Sakha 4	58.30	49.60	53.95	
Syrian / Anbar	57.73	42.73	50.23	The lowest significant difference at 1%
Poland	62.70	39.53	51.11	sprayers nozzles = 15.39
Syria / Erbil	43.10	29.40	36.25	cultivar = 12.01
Average of sprayers nozzles	48.81	36.88		sprayers nozzles x cultivar = 16.98

2-4- Number of seeds per capsule (seeds.Capsule^{-1}).

Table (5) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the number of seeds per capsule. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle in the trait of the number of seeds per capsule at the level of (5%) by giving it averages amounted to (8.92 and 7.93 seed.Capsule^{-1}), respectively. Table (1) also shows that there is a significant excelling of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the trait of the uniformity coefficient of water distribution. As for the cultivars, the Syrian/Anbar cultivars were significantly excelled by giving it the highest number of seeds per capsule at levels 5 and 1% amounted to (9.10 seeds.capsule^{-1}) on the Giza 10 cultivar which gave the lowest number of seeds per capsule amounted to (7.85 seeds.capsule^{-1}). The reason for the differences in the number of seeds per capsule between cultivars is due to genetic differences between cultivars and the different response of cultivars to environmental conditions prevailing in the cultivation area. this result agrees with (7). As for the interaction between the two types of sprayers nozzles and the cultivars, the

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interaction treatment between the Canadian sprayer nozzle and Syrian / Anbar cultivar was significantly excelled by giving it the highest number of seeds per capsule at the levels 5 and 1% amounted to (9.60 seeds.capsule^{-1}) while the interaction treatment between the Turkish sprayer nozzle and the Poland cultivar gave the lowest average for the trait of the number of seeds per capsule amounted to (7.33 seeds.capsule^{-1}). Table (1) shows the significant superiority of the Canadian sprayer nozzle for the trait of the uniformity coefficient of water distribution on the Turkish sprayer nozzle, which was positively reflected on the number of seeds per capsule for the cultivars under the service area of the Canadian sprayer nozzle compared to the same cultivars under the service area of the Turkish sprayer nozzle, which led to the superiority of the Syrian / Anbar cultivar by giving it the highest Average number of seeds per capsule. This result agree with (2).

Table 5: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the number of seeds per capsule.

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	8.53	7.90	8.21	sprayers nozzles = 0.72
Syrian / Baghdad	8.76	7.46	8.11	cultivar = 0.34
Giza 10	8.30	7.40	7.85	Sprinkler heads x items = 0.49
Sakha 4	8.63	8.16	8.40	
Syrian / Anbar	9.60	8.60	9.10	The lowest significant difference at 1%
Poland	9.40	7.33	8.36	sprayers nozzles = 1.67
Syria / Erbil	9.23	8.70	8.96	cultivar = 0.47
Average of sprayers nozzles	8.92	7.93		sprayers nozzles x cultivar = 0.66

2-5- Weight of 1000 seeds (g)

Table (6) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the weight of 1000 seeds. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle in the trait of the weight of 1000 seeds at the level of (5%) by giving it averages amounted to (11.32 and 9.05 g), respectively. As for the cultivars, the Syrian/Erbil cultivars were significantly excelled by giving it the highest weight of 1000 seeds at levels 5 and 1% amounted to (11.13 g) on the Poland cultivar which gave the lowest weight of 1000 seeds amounted to (8.71 g). The increase in the weight of 1000 seeds of the Syrian / Erbil cultivar is due to the small number of capsules per plant as shown in Table (4) led to an increase in the seeds' access to the largest amount of (metabolic) nutrients, which led to an increase in the weight of the seeds, this result agrees with (14, 17, 19). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Giza 10 cultivar was significantly excelled by giving it the highest weight of 1000 seeds at the levels 5 and 1% amounted to (12.10 g) while the interaction treatment between the Turkish sprayer nozzle and the Poland cultivar gave the lowest average for the trait of the weight of 1000 seeds amounted to (6.83 g). The reason may be due to the superiority of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the trait of the uniformity coefficient for water distribution reflected on the cultivars under the service area of the Canadian sprayer nozzle positively. This led to the superiority of Giza 10 cultivar on the rest of the cultivars with a weight of 1000 seeds to provide suitable growth conditions for plant growth as shown in Table (1). This result agrees with (5).

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Table 6: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the weight of 1000 seeds (g).

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	11.73	8.33	10.03	sprayers nozzles = 4.27
Syrian / Baghdad	11.40	8.73	10.06	cultivar = 1.46
Giza 10	12.10	8.90	10.50	Sprinkler heads x items = 2.07
Sakha 4	11.63	10.13	10.88	
Syrian / Anbar	10.46	9.56	10.01	The lowest significant difference at 1%
Poland	10.60	6.83	8.71	sprayers nozzles = 9.87
Syria / Erbil	11.63	10.90	11.13	cultivar = 1.98
Average of sprayers nozzles	11.32	9.05		sprayers nozzles x cultivar = 2.81

2-6- seed yield per plant (g)

Table (7) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the seed yield per plant. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle in the trait of the seed yield per plant at the level of (5%) by giving it averages amounted to (2.97 and 2.32 g), respectively. Table (1) also shows that there is a significant excelling of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the trait of the uniformity coefficient of water distribution. As for the cultivars, the Sakha 4 cultivars were significantly excelled by giving it the highest seed yield per plant at levels 5 and 1% amounted to (3.30 g) on the Giza 10 cultivar which gave the lowest seed yield per plant amounted to (2.32 g). The superiority of Sakha 4 cultivar in the seed yield of the plant due to its superiority in the number of secondary branches of the plant and the number of capsules per plant as shown in Table (3, 4), which led to an increase in the nutrient accumulated inside the seeds, which led to an increase in the weight of the seed, thus an increase in the yield of seeds in the plant in addition to the extent of the genetic cultivar in expressing itself in the environmental conditions prevailing in the cultivation area. This result agrees with (7, 19). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Sakha 4 cultivar was significantly excelled by giving it the highest seed yield per plant at the levels 5 and 1% amounted to (3.60 g) while the interaction treatment between the Turkish sprayer nozzle and the Giza 10 cultivar gave the lowest average for the trait of the seed yield per plant amounted to (1.70 g). The superiority of the Canadian sprayer nozzle for the trait of the uniformity coefficient for the distribution of water on the Turkish sprayer nozzle had a positive effect on the Sakha 4 cultivar grown under the service area of the Canadian sprayer nozzle for the same cultivar grown under the service area of the Turkish sprayer nozzle as the seed yield of the plant as shown in Table (1), This result agrees with (13).

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Table 7: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the seed yield per plant (g).

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	2.76	2.66	2.71	sprayers nozzles = 0.04
Syrian / Baghdad	2.60	2.10	2.35	cultivar = 0.33
Giza 10	2.83	1.70	2.26	Sprinkler heads x items = 0.48
Sakha 4	3.60	3.00	3.30	
Syrian / Anbar	3.03	2.43	2.73	The lowest significant difference at 1%
Poland	3.20	2.10	2.65	sprayers nozzles = 0.09
Syria / Erbil	2.80	2.26	2.53	cultivar = 0.46
Average of sprayers nozzles	2.97	2.32		sprayers nozzles x cultivar = 0.65

2-7- Biological yield per plant (g)

Table (8) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the Biological yield per plant. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle in the trait of the Biological yield per plant at the level of (5%) by giving it averages amounted to (9.38 and 7.21 g), respectively. Table (1) also shows that there is a significant excelling of the Canadian sprayer nozzle on the Turkish sprayer nozzle for the trait of the efficiency of adding water. As for the cultivars, the Sakha 4 cultivars were significantly excelled by giving it the highest Biological yield per plant at levels 5 and 1% amounted to (11.30 g) on the Giza 10 cultivar which gave the lowest Biological yield per plant amounted to (5.61 g). The reason for the increase in the biological yield of plants for the Sakha 4 cultivar is due to its superiority in the traits of growth and the yield, the number of secondary branches in the plant as shown in Table (3), the number of capsules per plant, and the seed yield of the plant as shown in Table (4 and 7), which led to an increase in the biological yield of the plant, this result agrees with (6). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Sakha 4 cultivar was significantly excelled by giving it the highest Biological yield per plant at the levels 5 and 1% amounted to (12.36 g) while the interaction treatment between the Turkish sprayer nozzle and the Giza 10 cultivar gave the lowest average for the trait of the Biological yield per plant amounted to (4.56 g). The reason for the increase in the biological yield of the cultivars grown under the service area of the Canadian sprayer nozzle on the same cultivars grown under the service area of the Turkish sprayer nozzle because the Canadian sprayer nozzle was superior in the efficiency of adding water, which led to an increase in the bioactivity represented by an increase in the vegetative growth of plants leading to an increase in dry weight and an increase in biological yield as shown in Table (1), This result agrees with (21).

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Table 8: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the Biological yield per plant (g).

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	8.76	6.80	7.78	sprayers nozzles = 1.79
Syrian / Baghdad	7.46	6.76	7.11	cultivar = 0.86
Giza 10	6.66	4.56	5.61	Sprinkler heads x items = 1.22
Sakha 4	12.36	10.23	11.30	
Syrian / Anbar	9.03	7.30	8.16	The lowest significant difference at 1%
Poland	12.20	6.50	9.35	sprayers nozzles = 4.13
Syria / Erbil	9.20	8.36	8.78	cultivar = 1.17
Average of sprayers nozzles	9.38	7.21		sprayers nozzles x cultivar = 1.66

2-8- Harvest index in plant (%).

Table (9) shows the effect of the two types of sprayers nozzles, the cultivars, and the interaction between them on the trait of the Harvest index. The Canadian sprayer nozzle was significantly excelled on the Turkish sprayer nozzle in the trait of the Harvest index at the level of (5%) by giving it averages amounted to (36.35 and 32.31 %), respectively. As for the cultivars, the Giza 10 cultivars were significantly excelled by giving it the highest Harvest index at levels 5 and 1% amounted to (40.48 %) on the Poland cultivar which gave the lowest Harvest index amounted to (32.13 %). The reason for giving Giza 10 the highest average for the harvest index in plant may be due to the fact that the Giza 10 cultivar took the lowest average in the two traits of the seed yield of the plant and the biological yield of the plant as shown in tables (7 and 8), which was reflected in this trait as a result of the plant's transition from the vegetative stages to the reproductive stages faster than The rest of the cultivars led to the superiority of the cultivar by giving it the highest harvest index, this result agrees with (7, 18, 19). As for the interaction between the two types of sprayers nozzles and the cultivars, the interaction treatment between the Canadian sprayer nozzle and Giza 10 cultivar was significantly excelled by giving it the highest Harvest index at the levels 5 and 1% amounted to (42.66 %) while the interaction treatment between the Turkish sprayer nozzle and the Poland cultivar gave the lowest average for the trait of the Harvest index amounted to (29.26 %). The reason for the increase in the Harvest index of the cultivars grown under the service area of the Canadian sprayer nozzle on the same cultivars grown under the service area of the Turkish sprayer nozzle because the Canadian sprayer nozzle was superior in the efficiency of adding water, which is reflected in the superiority of the Giza 10 cultivar grown under the service area of the Canadian sprayer nozzle with the highest harvest index as shown in Table (1), This result agrees with (15, 12).

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Table 9: The effect of the two types of sprayers nozzles and the cultivars and the interaction between them on the traits of the harvest index of plant (%).

Cultivar	Type of sprayer nozzle		Average of cultivar	$LSD_{0.05}$
	CA	TU		
local	37.86	31.76	34.81	sprayers nozzles = 7.30
Syrian / Baghdad	35.86	34.00	34.93	cultivar = 3.68
Giza 10	42.66	38.30	40.48	Sprinkler heads x items = 5.21
Sakha 4	34.40	30.36	32.38	
Syrian / Anbar	33.10	32.70	32.90	The lowest significant difference at 1%
Poland	35.00	29.26	32.13	sprayers nozzles = 16.85
Syria / Erbil	35.56	29.76	32.66	cultivar = 4.99
Average of sprayers nozzles	36.35	32.31		sprayers nozzles x cultivar = 7.06

CONCLUSIONS AND RECOMMENDATIONS

1. **Conclusions**.

1- The Canadian sprayer nozzle achieved the best water distribution model over the Turkish sprayer nozzle, and the effect was clear on the yield trait of the plant.

2- The suitability of the environmental conditions for the Kirkuk province for the Sakha 4 cultivar for its superiority in most of the traits, including the yield and its components.

3- 3. The interaction response of the Canadian sprayer nozzle factor with the Sakha 4 cultivar was superior in most of the studied traits.

2. Recommendations

1- Conducting further experiments using different levels of operating pressure for the Canadian and Turkish fixed spraying irrigation systems.

2- Conducting further experiments on other types of agricultural crops under the constant spray irrigation system and evaluating other sprayers nozzles available in the local market.

3- Conducting extensive studies on fertilization, planting distances and other operations on the Sakha 4 cultivar for being superior in most of its traits.

4- The introduction of the Sakha 4 cultivar in cross-breeding programs to transfer its desired traits to other cultivars.

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