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Impact of cropping systems and drip irrigation levels on growth and yield performance of maize (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted on *Zea mays* during the autumn agricultural season on July 22, 2024, in Al-Hawija District, Kirkuk Governorate, Iraq. The experiment was conducted using a Randomized Complete Block Design (R.C.B.D). The highest results for plant height (cm) were recorded in the 93x15 planting system, reaching 249.56 cm. Regarding irrigation systems, the fixed partial irrigation system recorded the highest height (253.89 cm). The effect of the planting systems on leaf area (cm2) was evident, with the highest average for the trait reaching 5684.5 cm2 when planting with the 93x15 planting system. As for irrigation systems in this trait, the highest average was recorded in the alternating partial irrigation system, which amounted to (5668.0) cm2. The number of ear rows in the cultivation systems at a distance of (140x10) amounted to (17.00). As for irrigation systems in this trait, the fixed partial irrigation recorded the highest average with a non-significant difference of (17.22). The alternating partial irrigation system also outperformed with a non-significant difference for the number of grains per row in irrigation systems, which amounted to (35.78). As for the average of 300 grains (g) for the effect of cultivation systems, the cultivation system (93x15) cm recorded the highest average of (64.84) g, while the effect of irrigation systems was significant in the average of the trait, as the fixed irrigation system outperformed, which amounted to (70.57) g. The number of grains per ear was recorded in the agricultural systems in the area (140x10) amounting to (582.00), and the alternate partial irrigation system was superior in the irrigation systems amounting to (600.67). The biological yield kg ha $^{-1}$ showed the average of the agricultural systems and the highest average was in the agricultural system (140x10) amounting to (15453.3) kg ha, while the effect of irrigation systems for this trait was significant as the fixed partial irrigation system was superior with an average of (18753.1) kg ha. While the average grain yield per individual plant g. plant $^{-1}$ for the agricultural systems did not record significant differences as the distance (93x15) recorded (121.82), while the average of irrigation systems for this trait as the fixed irrigation system was significantly superior amounting to (126.72) g.

KEYWORDS: *Zea mays*; Drip irrigation; Fixed partial irrigation; Alternating partial irrigation; Fixed irrigation.

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تأثير أنظمة الزراعة ومستويات الري بالتنقيط في نمو وإنتاجية محصول الذرة الصفراء (*Zea mays* L.)

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الملخص

نفذت تجربة حقلية على محصول الذرة الصفراء في الموسم الزراعي الخريفي في 22/تموز/2024 في قضاء الحويجة التابعة لمحافظة كركوك-العراق. بتصميم القطاعات العشوائية الكاملة (**R.C.B.D**). وسجلت اعلى النتائج لصفة ارتفاع النبات (سم) في نظم الزراعة في المسافة **x1593** بلغت (249.56) اما بالنسبة لنظم الري في هذه الصفة فقد سجل نظام الري الجزئي الثابت اعلى ارتفاعاً (253.89) سم. بينما اظهرت المساحة الورقية(سم2) بتأثير نظم الزراعة فيلاحظ ان اعلى متوسط للصفة عند الزراعة بنظام (**x1593**) بلغت (5684.5) سم2. اما نظم الري في هذه الصفة فقد سجل اعلى متوسط في نظام الري الجزئي المتناوب بلغ (5668.0) سم2.وسجلت صفة عدد صفوف العرنوص في نظم الزراعة عند المسافة (**x10140**) بلغت (17.00) اما نظم الري في هذه الصفة فقد سجل الري الجزئي الثابت اعلى متوسط بفارق غير معنوي بلغ (17.22). كما تفوق نظام الري الجزئي المتناوب بفارق غير معنوي لصفة عدد الحبوب بالصف في نظم الري بلغ (35.78). وان متوسط 300حبة(غم)لتاثير نظم الزراعة فقد سجل نظام الزراعة (**x9315**) سم اعلى متوسط بلغ (64.84) غم، بينما كان تأثير نظم الري معنويا في متوسط الصفة اذ تفوق نظام الري الثابت حيث بلغ (70.57) غم. سجلت صفة عدد الحبوب بالعرنوص في نظم الزراعة في المساحة (**x10140**) بلغت (582.00)، وتفوقت نظام الري الجزئي المتناوب في نظم الري بلغت (600.67). واظهر حاصل البيولوجي كغم هكتار $^{-1}$ لمتوسط نظم الزراعة وقد كان اعلى المتوسطات في نظام الزراعة (**x14010**) بلغ (15453.3) كغم هكتار، بينما اظهرت تاثير نظم الري لهذه الصفة معنوياً اذ تفوق نظام الري الجزئي الثابت بمتوسط بلغ (18753.1) كغم هكتار. في حين ان متوسط حاصل الحبوب للنبات الفردي غم. نبات $^{-1}$ لنظم الزراعة لم يسجل فروق معنوية حيث سجلت المسافة (**93x15**) (121.82)، اما متوسط

نظم الري لهذه الصفة اذ تفوق نظام الري الثابت معنويا بلغ (126.72) غم.
الكلمات المفتاحية: الذرة الصفراء؛ الري بالتنقيط: الري الجزئي الثابت؛ الري الجزئي المتناوب؛ الري الثابت.

INTRODUCTION

Maize (*Zea mays*L.) is one of the most important strategic and economic crops in the world, and is considered the third most important crop in terms of economic importance after wheat and rice. Maize is used for human and animal nutrition(Mohammed and Ismaiel.2025), in addition to many other uses, such as processing(Ismaiel.2023), dye production, and biofuel. It is expected to become an alternative to conventional and other automotive fuels, and is known as the "king of crops" (Abdulhamed, 2020). It is a source of many secondary products such as glucose, starch, oil, and others. It is also one of the most important grain crops in Iraq and is cultivated in vast areas (Alfalahi et al., 2015). Maize is widely cultivated in Iraq. According to the Food and Agriculture Organization (FAO, 2022), the cultivated area reached approximately 82,842 thousand hectares, with a production rate of 5,987 tons ha $^{-1}$, a very low amount, representing 45% of the global production of 10,880 tons ha $^{-1}$. Water resources are critical for agricultural crop production due to the growing demand for food, feed, There is a growing need to increase the use of our natural resources of land, soil, and water. Pressure is increasing on water resources for their widespread use in agricultural production. Therefore, innovative solutions must be found for more efficient irrigation technologies to improve agricultural irrigation management (Iqbal et al., 2020). Water scarcity is one of the most important factors that hinder plant growth and dry matter, which leads to a decrease in product quality and a lack of water, soil, or air often throughout the plant's life cycle. Therefore, there is an urgent need to adopt modern and effective irrigation methods for crop production and to address this problem (Waqas et al., 2018). Drip irrigation can be defined as adding water to the soil in small quantities that only meet the plant's need through drippers (Alcon et al., 2019). Drip irrigation technology has the advantages of conserving water resources and distributing them appropriately, improving crop water and fertilizer use, and increasing crop yield and quality compared to other water-saving irrigation methods (Sun et al., 2020). In a drip irrigation system, the moisture content is highest at the drip source, after which it decreases horizontally and vertically the further away from the drip source (Wang et al., 2022). Partial root zone drying (PRD) irrigation can improve water use efficiency (WUE) without reducing photosynthesis (Hu et al., 2024). Deficit irrigation (DI) is an improvement strategy that requires crops to tolerate a certain level of water deficit. This sometimes results in a decrease in yield, while significantly increasing WUE. Partial root zone drying (DI) is a modified version of deficit irrigation and has been applied to improve water use efficiency by controlling drought stress. In this irrigation method, a spatial separation between dry and wet roots is maintained throughout the growing season. Water stress developed in one part of the root zone generates chemical signals in the form of abscisic acid, which leads to partial closure of the stomatal aperture.

Stomatal closure reduces the rate of transpiration, which in turn increases WUE (Sonawane and Srivastava, 2022). Alternating partial root zone irrigation (APRI) involves irrigating some root zones naturally during all or part of the plant's growth period, while the other zone is subject to a certain degree of water stress. The two root zones alternate after a period (Hui and Luo, 2021). The main advantages of this technique are water conservation, low investment, and ease of implementation (Wang et al., 2021). Rusere et al. (2012) demonstrated that partial irrigation can save 50% of irrigation water without affecting yield and may even improve quality. However, accumulated results on this technique have shown it to be ineffective for water-stress-sensitive crops because reducing water quantity affects photosynthesis. Constant partial root zone irrigation (FPRI) is a new water-saving irrigation technique that may improve water use efficiency (WUE) in crop production without significantly reducing crop yield. He added that the developed technique is based on two theoretical concepts. The first concept is that a portion of the root system in dry soil can react to desiccation by sending a chemical signal, such as abscisic acid (ABA), to the shoots and leaves through the xylem, where the stomata may close to reduce water loss. The second concept is that slightly narrowing the stomatal aperture may significantly reduce water loss with little effect on photosynthesis. In other words, a fixed half of the root system is exposed to desiccation, while the remaining half is naturally irrigated (Kang and Zhang, 2004). Partial root zone irrigation (APRI) involves exposing approximately half of the root system to dry soil while the remaining half is irrigated naturally (Hu et al., 2011). Fu and Kang (2017) reported that alternative partial root zone drip irrigation (ADI) is a water-saving method by providing an alternate wetting-drying cycle for the root zone, potentially reducing irrigation water consumption. The same source confirmed that the APRI system increased the apparent nitrogen recovery ratio of maize by 16.4%, indicating that APRI can improve nitrogen use efficiency compared to conventional irrigation.

MATERIALS AND METHODS

The experimental land was divided into three sectors, each containing (9) experimental units. Each experimental unit included four rows of *Zea mays*. The distance between rows was determined by the experimental planting system, which included (0.70 m) between rows, with plantings taking place at a distance of (0.20 m) between plants. The distance between rows was (0.93 m), with plantings taking place at a distance of (0.15 m) between plants. The distance between rows was (1.4 m), with plants at a distance of (0.10 m). This ensured equal plant densities in the experimental units (71,428 plants per hectare) with different plant distribution systems. Each of them included three departments of drip irrigation systems, each of which included a different irrigation system, including drippers on the corn planting lines, which is considered (full irrigation system). In the second system, drip lines were distributed in the middle of the distance between the planting lines, and irrigation was alternated in them (alternating partial irrigation). In the third section, dripper lines were between two planting lines, and the next two lines were left without drippers, and irrigation was always in them, so it was (fixed partial irrigation).

Traits studied: Ten plants were randomly selected from the two median lines of each experimental unit, and the following data were recorded:

1. **Plant height (cm):**

   Measurements for this trait were taken from the soil surface to the inflorescence node at the top of the plant height for five plants from each experimental unit.

2. **Leaf area:**

   The leaf area under the main ear was calculated by multiplying the leaf length by 0.75, as the cultivated variety had more than 14 leaves, and for five plants from each experimental unit (Elsahookie and Cheyed, 2013).

3. **Number of panicles:**

   The number of panicles was calculated for ten plants randomly selected from the two median lines, and the total number of panicles was then divided by the number of plants.

4. **Number of panicle rows:**

   Ten panicles were randomly selected from the two median lines, and the average number of rows per panicle was calculated.

5. **Number of grains per row:**

   It was calculated by dividing the number of grains per ear by the average number of rows per ear, and as an average of ten earlets from plants randomly selected from each experimental unit.

6. **Number of grains per ear:**

   The number of grains per ear was calculated by randomly selecting the average of ten earlets from the two medians after they were hulled and counting the number of grains.

7. **Weight of 300 grains (g):**

   Thirty hundred grains were counted from each experimental unit from the hulled grains, which were manually hulled and then weighed on a sensor balance after adjusting their moisture content to (15.5). Grain moisture was measured using a moisture meter (Grain Analysis Computer) and adjusted according to the following equation: (weight of sample after adjustment) x weight of dry matter in the sample divided by standard dry matter weight).

8. **Plant Yield:**

   plant yield was calculated by weighing the grain yield of ten plants harvested from the midribs. The grain yield was then weighed and the moisture content was estimated (15.5).

9. **Biological Yield:**

Five plants were randomly selected from each experimental unit from the two midribs. They were then sun-dried, cut, and oven-dried at 70°C for 72 hours in the laboratory of the Technical Institute in Huwayjah. After the weights stabilized, the plants were weighed on a sensitive balance, including (straw yield + ear yield).

Statistical Analysis:

After collecting and tabulating data for the studied traits according to the randomized complete block (R.C.B.D) experimental design, the data were analyzed using SAS software, and the means were tested for significance using Duncan's multiple range test

RESULTS AND DISCUSSION

Plant Height (cm):

Table (1) shows no significant differences in the effect of cultivation systems on plant height. The averages of the traits show that cultivation according to the (93x15) system recorded the highest height, reaching (249.56) cm. The (140x10) system recorded the lowest height, reaching (241.11) cm. Regarding the average trait across irrigation systems, which differed significantly in their effect on average plant height, the fixed partial irrigation system outperformed the average trait, reaching (253.89) cm, with a non-significant difference over the alternating partial irrigation system. The fixed (regular) irrigation system recorded the lowest height, reaching (232.89) cm. As for the interactions between the study factors, significant differences were observed between the averages of the trait, as the (93*15) cultivation system with the fixed partial irrigation system recorded the highest plant height of (258.67) cm, while the (70x20) treatment in the fixed irrigation system had the lowest height of (220.0) cm. The reason may be that in the cultivation systems, despite their lack of significant effect, the difference in plant distribution caused a difference in plant height as a result of their effect on the variation in lighting distribution conditions for maize plants, especially in the lower part of the plants, which may be reflected in the efficiency of photosynthesis, and this enhances the variation in plant growth according to the cultivation systems. The enhancement of growth and plant height in fixed partial irrigation may also be attributed to stimulating plants to synthesize auxin and gibberellins hormones as a result of the signals the plant receives from the roots, feeling thirsty, and this is reflected in the elongation of cells, so the length of the internodes increases and they move upwards, thus increasing the plant height (Ramezani et al., 2011).

Table 1. The effect of agricultural and irrigation systems and their interaction on the average plant height (cm)

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	220.00 b	253.00 ab	255.00 a	242.67 a
93x15	242.67 ab	247.33 ab	258.67 a	249.56 a
140x10	236.00 ab	239.33 ab	248.00 ab	241.11 a
Mean irrigation systems	232.889 b	246.556 ab	235.889 a	

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Leaf Area (cm2):

Table (2) shows no significant differences in the effect of cultivation and irrigation systems on leaf area. It is noted that the highest average was recorded in the alternating partial irrigation system (5668.0) cm2, while the lowest leaf area was recorded in the fixed partial irrigation system (5550.6) cm2. It was found that the drying and wetting cycle, or the complete drying of a portion of the root zone, although it causes partial closure of the stomata, reduces losses resulting from transpiration and leads to the absorption of carbon dioxide, which leads to the formation of glucose in the photosynthesis process. The rate of photosynthesis may be affected by changes that occur during the closing and opening of the stomata, but this was slight, as the plant leaves expand (Rashid et al., 2020; Al-Mafarji & Al-Jubouri, 2023). As for the average trait affected by the agricultural systems, it is noted that the highest average trait when planted with the (93x15) system reached (5684.5) cm2, while the lowest leaf area when planted according to the (70x20) spacing reached (5508.4) cm2. It is noted that there is no significant effect of the interactions between irrigation systems and agricultural systems on the average leaf area, meaning that the leaf area of the plant is close, and the efficiency of the leaf area may be reflected in the production indicators if its efficiency in photosynthesis differs. In this case, the technology of agricultural systems and the drip irrigation system can be adopted, which is the easiest to apply and allows for easy agricultural operations and is the most economically feasible.

Table 2. The effect of agricultural systems, irrigation systems and their interaction on leaf area cm^2

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	5352.9 a	5591.1 a	5581.1 a	5508.4 a
93x15	5588.6 a	5745.9 a	5719.1 a	5684.5 a
140x10	5784.4 a	5667.1 a	5351.7 a	5601.1 a
Mean irrigation systems	5575.3 a	5668.0 a	5550.6 a	

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Number of ear rows (ear row):

Table (3) shows no significant differences in the effect of planting and irrigation systems on the number of ear rows. It is noted that the highest values for the average number of ear rows were achieved under the fixed partial irrigation system (93x15) and (140x10) planting systems, and under the alternating partial irrigation system (70x20). Since the fixed irrigation system is easier to implement, less expensive, and more economical in terms of irrigation quantities, and the (140x10) planting system allows for easy access for machinery when implementing agricultural operations, this combination treatment can be adopted to ensure the highest average for the trait. This can be attributed to the genetic characteristics of the cultivated variety, as the distance between rows and plants does not affect this trait. This is inconsistent with the results of (Sharifi et al., 2009), who indicated that the number of rows increases significantly with increasing distance between rows and plants.

Table 3. The effect of irrigation and agricultural systems and their interaction on the number of rows.

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	16.33 a	17.33 a	17.00 a	16.89 a
93x15	16.67 a	16.67 a	17.33 a	16.89 a
140x10	16.67 a	17.00 a	17.33 a	17.00 a
Mean irrigation systems	16.56 a	17.00 a	17.22 a	

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Number of grains per row (grain per row):

Table (4) shows no significant differences in the effect of planting systems on the number of grains trait. However, the effect of drip irrigation systems was significant, with the highest mean for the trait, with a non-significant difference between them, for the alternating partial and fixed irrigation systems, reaching (35.78) and (34.78) grains per row, respectively. Fixed irrigation yielded the lowest mean for the trait, reaching (32.67) grains per row. As for the interactions of irrigation and cultivation systems, the difference between the averages according to Duncan's test was significant, as the harmonic treatment outperformed when planting according to the cultivation system (70x20) cm and in the alternating partial irrigation system, and recorded the highest average for the trait, amounting to (37.00) grains row $^{-1}$, which did not differ significantly from the harmonic treatments for the cultivation system (140x10) in the alternating and fixed partial irrigation systems, and the cultivation system (93x15) and alternating partial irrigation, while the harmonic treatment for the cultivation system (x14010) cm and in the fixed irrigation system had the lowest average in the number of grains row, amounting to (32.00) grains row $^{-1}$. We conclude from the above, and since there are no significant significant differences between the treatments, the cultivation system at a distance of (140x10) cm and the alternating partial irrigation system may achieve an improvement in the practice of agricultural management in tolerating stress, as competition between plants over available resources is one of the most important indicators for achieving economic production per unit area. It seems that adopting the cultivation system (140x10) and the fixed partial alternating irrigation system ensures plant distribution in the field. This ensures the efficiency of photosynthesis due to the lack of competition between plants, which is reflected in the formation of the number of grains in the row, which is a component that contributes to increasing the number of grains in the ear with the lowest costs of production inputs, ease of agricultural operations, and provision of additional irrigation water. These results are consistent with Josefina et al. (2020), and Brad and Frederick, (2020), who indicated that competition for light leads to the destruction of the auxin hormone at high radiation levels and is reflected in the increase of carbohydrates resulting from the increase in the photosynthesis process through the lack of shading, which contributes to the number of grains in the row and thus in the ear.

Table (4) The effect of irrigation and agricultural systems and their interaction on the number of grains per row

Planting Systems	**Irrigation systems**			**mean agricultural systems**
	Fixed system	**partial alternating system**	**Fixed partial system**	
20x70	33.00 cd	37.00 a	33.67 bcd	34.56 a
93x15	33.00 cd	34.33 bcd	35.33 abc	34.22 a
140x10	32.00 d	36.00 ab	35.33 abc	34.44 a
Mean irrigation systems	32.67 b	35.78 a	34.78 a	

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Number of grains per ear (ear $^{-1}$ grain):

Table (5) shows no significant differences in the effect of cropping systems on the number of grains per ear. However, it is noted that the highest average for this trait in the (140x10) cropping system reached (582.00) g, and the lowest average in the (93x15) plant distribution system reached (577.33) g. The average number of grains in the ear differed significantly due to the effect of irrigation systems, as the alternate partial irrigation and fixed irrigation systems outperformed in the average trait, with a non-significant difference between them amounting to (600.67) and (597.33) grams, while the fixed irrigation system recorded the lowest average amounting to (539.56) grams. It is believed that alternate irrigation helps plants adapt to different weather conditions such as heat or temporary drought, which reduces the effect of abiotic stresses. It may provide a balance in providing water without exposing them to drought or flooding, and contributes to improving soil ventilation, which allows the roots to breathe better and enhances root growth, depth and spread. It is also believed that the roots emit a chemical signal due to the lack of water during alternate irrigation, which may lead to stimulating the plant to close the stomata and thus reduce transpiration from the leaves, which achieves partial inhibition of the stomata. Plants can raise water to the leaves with the continuation of water stress conditions, and raising the water stress results in antioxidants such as enzymes and abscisic acid and accumulation of proline. All of this contributes to plants being superior in alternate irrigation. Regarding the fixed irrigation on the number of ear grains, which is the main component of grain yield (Abdul et al. 2016) and (Al-Kayssi, 2022). Significant differences were observed between the averages of ear grain number due to the interaction between the study factors, as the harmonic treatment of the cultivation system (70x20) cm and the partial alternating irrigation system had the highest average (625.00) ear grains, with a non-significant difference compared to all cultivation systems in the partial alternating or fixed irrigation systems. The harmonic treatment (140x10) cm in the fixed irrigation system had the lowest average of (536.00) ear grains. These results are consistent with what was reached by (Sharifi et al. 2009), that planting at a wide distance between rows as well as between plants led to an insignificant increase in the number of grains in the ear.

Table (5) The effect of irrigation and agricultural systems and their interaction on the number of grains in the ear.

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	33.00 cd	37.00 a	33.67 bcd	34.56 a
93x15	33.00 cd	34.33 bcd	35.33 abc	34.22 a
140x10	32.00 d	36.00 ab	35.33 abc	34.44 a
Mean	32.67 b	35.78 a	34.78 a	

irrigation systems

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Weight of 300 grains (g):

It is noted from **Table (6)** that there were no significant differences in the average of this trait across the cultivation systems. The (93x15) cm cultivation system recorded the highest average of (64.84) g, while the (140x10) cm system recorded the lowest average of (60.82) g. Meanwhile, the effect of irrigation systems on the average of this trait was significant, as the fixed irrigation system outperformed the partial and fixed irrigation systems, which recorded (57.256) and (61.48) g. It is noted that the weight of 300 grains decreased in the treatments that excelled in the number of ear grains (Table 5), as the relationship is inverse, as the average weight of 300 grains decreases as the number of outlets increases. (Al-Kassi, 2022; Al-Jubouri et al., 2024) indicated that the biomass was affected by alternating irrigation, but the root mass increased, which was reflected in the transport of nutrients and the result of enhancing the role of absorption of nutrients, as it facilitates the activity of the high phosphatase enzyme. The averages of the 300-grain weight showed significant differences according to Duncan's test, although they were insignificant according to the F test, which is an indicator that the averages of the two factors behaved similarly. It is noted that the harmonic treatment with a distance of (140 x 10) cm in the fixed irrigation system recorded the highest average of (71.200) g, in contrast to the harmonic treatment with a distance of (140 x 10) cm in the partial alternating irrigation system, which had a lower average of (51.133) g. It is clear from the harmonic treatment averages that there were no significant differences between the treatments of the fixed irrigation system and the fixed alternating irrigation system in the different agricultural systems, which is considered less expensive and more abundant in water. This may be due to the lack of effect on the leaf area and dry matter accumulation during the male inflorescence emergence stage, which was reflected in the plant height. Also, increasing the distance between plants accompanied by a decrease between rows and vice versa may result in higher and similar temperatures (Jones et al., 1981).

Table 6. The effect of irrigation and cultivation systems and their interaction on the weight of 300 grains (g)

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	70.93 a	58.38 ab	61.60 ab	63.63 a
93x15	69.57a	62.27 ab	62.70 ab	64.84 a
140x10	71.20 a	51.13 b	60.13 ab	60.82a
Mean	70.57 a	57.26 b	61.48 b	

irrigation systems

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Biological yield kg ha $^{-1}$:

Table (7) shows no significant differences in the effect of farming systems on the biological yield trait. The highest average was in the (140x10) farming system, reaching (15453.3) kg ha $^{-1}$, while the lowest average was in the (93x15) farming system, reaching (14887.6) kg ha $^{-1}$. Irrigation systems showed a significant effect on the average biological yield, as the fixed partial drip irrigation system was significantly superior with an average of (18753.1) kg ha, while the lowest average for this trait was in the fixed drip irrigation and partial alternate irrigation systems, which reached (13442.7) and (13095.1) kg ha, respectively. This may be due to the fact that the chemical signals issued by the roots due to water deficiency from the drying side may lead to an increase in the proline content in the leaves, including reducing the osmotic potential and the possibility of raising water to the leaves in stress conditions and producing antioxidant systems such as enzymes and a higher production of abscisic acid, which contributes to the possibility of producing plants with a higher dry matter accumulation. This treatment was higher in plant height and the number of grains per row and ear (Tables 1, 4 and 5). The averages of the biological yield showed significant differences due to the interaction effect between the two factors, as the (140 x 10) cm cultivation system outperformed the fixed partial irrigation system and recorded the highest average of (19948.4) kg ha, unlike the combination treatment with the (140 x 10) cm cultivation system and the irrigation system, which recorded the lowest average of (13129.2) kg ha. Therefore, the (140 x 10) cm cultivation system and the fixed partial irrigation system can be adopted when evaluating this trait as a criterion, as it is less expensive and more abundant in water. This is consistent with the results of Abdul et al. (2016), who indicated that in fixed alternating irrigation, which provides 30-50% of irrigation water without a decrease in the biological yield, this is because it increases the efficiency of nitrogen absorption and increases the accumulation of nitrates in the surface soil horizon.

Table (7) The effect of irrigation and agricultural systems and their interaction on the biological yield trait kg ha $^{-1}$

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	13944.9 c	1290.7 c	18000.3 b	14950.0 a
93x15	13254.0 c	13098.2 c	18310.6 b	14887.6 a
140x10	13129.2 c	13282.3 c	19948.4 a	15453.3 a
Mean	13442.7 b	13095.1 b	18753.1 a	

irrigation systems				

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

Grain yield per plant(g/plant)

Table (8) shows no significant differences in the effect of agricultural systems on the plant yield trait. The average grain yield per plant differed significantly due to the effect of irrigation systems, with the fixed irrigation system significantly outperforming the average trait, reaching 126.72 g/plant. The average trait was non-significantly higher in the fixed partial drip irrigation system, reaching 119.39 g/plant. The highest increases were recorded in the irrigation systems, followed by alternating partial irrigation, which recorded the lowest result, 116.233 g/plant. This confirms that full-flow irrigation systems are expensive to use, as their impact is minimal or almost non-existent in increasing the averages of the studied traits compared to other systems with low water consumption. This is often associated with achieving better growth without affecting production, in addition to saving excess water (Rashid et al., 2020; Al-Mafarji et al., 2024). As for the trait averages with the effect of interaction between the two factors, significant differences are observed between them. It is noted that the fixed irrigation system was superior in all agricultural systems, but it was by an insignificant difference compared to the fixed alternating irrigation system and in all agricultural systems as well, and with the partial alternating irrigation system with the (70 x 20) and (93 x 15) cm agricultural systems. Accordingly, the (140 x 10) cm agricultural system and the fixed partial irrigation system can be adopted, which is less expensive, more abundant in water, and easier to apply agricultural operations and the entry of agricultural mechanisms to apply it in the different growth stages. Abdul et al. (2016) found results indicating the possibility of improving the grain yield in alternating irrigation higher than fixed irrigation, and attributed this to the chemical signals emitted by the plant due to the lack of water towards the root exposed to stress, which stimulates the plant to close the stomata and reduce transpiration.

Table (8) The effect of irrigation and agricultural systems and their interaction on the individual plant grain yield characteristic (g/plant $^{-1}$)

Planting Systems	Irrigation systems			mean agricultural systems
	Fixed system	partial alternating system	Fixed partial system	
20x70	126.97 a	121.37 ab	116.80 ab	121.71 a
93x15	126.53 a	118.97 ab	119.97 ab	121.82 a
140x10	126.68 a	108.37 b	121.40 ab	118.81 a
Mean irrigation systems	126.72 a	116.23 b	119.39 ab	

At 5% of DMRT, Averages with the same litters for each factor and interaction do not differ significantly

CONCLUSION:

The fixed partial irrigation system was superior in most of the studied production traits. It contributed to enhancing plant height and grain number per ear, as well as increasing biological yield, reflecting its effectiveness in stimulating photosynthesis. The results showed that the spaced-spaced planting systems were highly compatible with fixed partial irrigation, providing a balanced plant distribution in the field. This helped reduce shading, enhance ventilation, and provide a more suitable growth environment for corn plants, which positively impacted the resulting productivity. The combination of irrigation and planting systems had a significant impact on many traits. It was found that the systems adopted for alternating partial or fixed irrigation with spaced planting spacing provided an ideal environment for reducing competition between plants and achieving better distribution of light radiation, which contributes to enhancing grain formation within the ear. The results indicated that full irrigation was not superior, but rather that over-irrigation may not have a positive impact on most of the studied traits and may constitute a waste of water without clear productivity gains.

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