Tikrit Journal for Agricultural Sciences (2024) 24 (2): 54-71
DOI: https://doi.org/10.25130/tjas.24.2.5

TJAS

IRAQI Academic Scientific Journals

العراقية
المجلات الأكاديمية العلمية

ISSN:1813-1646 (Print); 2664-0597 (Online)
Tikrit Journal for Agricultural Sciences
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq

TJAS
Tikrit Journal for Agricultural

Effect of deficit irrigation and partial root zone drying on the water consumptive use, growth and yield of faba bean (*vicia faba* L.) in a gypsiferous soil

Awss Mamdouh Khairo

Department of Soil Science and Water Rescores, Agriculture College, Tikrit University, Tikrit, Iraq

**Corresponding E-mail*: awsskhairo@tu.edu.iq

KEY WORDS:
deficit irrigation; partial root zone drying; faba bean; water consumption use; gypsiferous soil.

Received: 02/01/2024
Revision: 18/03/2024
Proofreading: 05/04/2024
Accepted: 20/04/2024
Available online: 30/06/2024

© 2024.This is an open access article under the CC by licenses http://creativecommons.org/licenses/by/4.0

cc BY

ABSTRACT

To evaluate the effect of deficit irrigation and partial root zone drying on the water consumptive use, growth and yield of faba bean (*vicia faba* L.) in a gypsiferous soil, a field experiment was conducted using a completely randomized block design with three replications. The study included seven irrigation treatments (full irrigation as a comparison treatment (F), adding 25% of the water requirement when depleting 50% ($DI_{25\%}$), adding 25% of the water requirement when depleting 75% ($DI_{50\%}$), adding 25% of the water requirement when 50% is depleted on both sides of the root system ($FP_{25\%}$), adding 25% of the water requirement when 75% is depleted on both sides of the root system ($FP_{50\%}$), adding 25% of the water requirement when 50% is depleted, alternating on both sides of the root system ($AP_{25\%}$), and adding 25% of the water requirement when 75% is depleted, alternating on both sides of the root system ($AP_{50\%}$). The seeds of the faba bean crop (Barcelona variety) were planted for the season on 16/10/2021, and the experimental treatments were applied immediately after emergence. The experimental plants were harvested on April 2, 2022, and some growth and yield traits of faba bean crop were measured. The results showed that partial drying of the alternating roots $AP_{50\%}$ used the lowest water consumption of 245 mm and gave a seed yield of 5186.3 kg ha^{-1} while the $DI_{50\%}$ deficient irrigation treatment gave the highest dry weight of the root system of 25.6 g $plant^{-1}$. The results of this experiment will help increase farmers' awareness of water resource management and contribute to rationalizing consumption.

تأثير الري الناقص والتجفيف الجزئي للمنطقة الجذرية في الاستهلاك المائي ونمو حاصل الباقلاء في تربة جبسية

أوس ممدوح خيرو

قسم علوم التربة والموارد المائية ، كلية الزراعة ،جامعة تكريت ، العراق

الخلاصة

لتقييم تأثير الري الناقص والتجفيف الجزئي للمنطقة الجذرية في الاستهلاك المائي ونمو وحاصل الباقلاء في تربة جبسية، اجريت تجربة حقلية باستعمال تصميم القطاعات العشوائية الكاملة وبثلاث مكررات. تضمنت الدراسة سبع معاملات للري (ري كامل كمعاملة مقارنة (F) واضافة 25% من الاحتياج المائي عند استنزاف 50% ($DI_{25\%}$) واضافة 25% من الاحتياج المائي عند استنزاف 75% ($DI_{50\%}$) واضافة 25% من الاحتياج المائي عند استنزاف 50% على جانبي المجموع الجذري ($FP_{25\%}$) واضافة 25% من الاحتياج المائي عند استنزاف 75% على جانبي المجموع الجذري ($FP_{50\%}$) واضافة 25% من الاحتياج المائي عند استنزاف 50% بالتناوب على جانبي المجموع الجذري ($AP_{25\%}$) واضافة 25% من الاحتياج المائي عند استنزاف 75% بالتناوب على جانبي المجموع الجذري ($AP_{50\%}$)). زرعت بذور محصول الباقلاء (صنف برشلونة) للموسم بتاريخ 2021/10/16 وطبقت معاملات التجربة بعد الانبات مباشرة. حصدت نباتات التجربة بتاريخ 2022/4/2 وقيست بعض صفات النمو والحاصل لمحصول الباقلاء. اظهرت النتائج ان التجفيف الجزئي للجذور المتناوب $AP_{50\%}$اقل استخدام في استهلاك الماء 245 مم واعطى حاصل بذور بلغ 5186.3 كغم .هـ$^{-1}$ في حين أعطيت معاملة الري الناقص $DI_{50\%}$ اعلى وزن جاف للمجموع الجذري بلغ 25.6 غم .نبات$^{-1}$. نتائج هذه التجربة ستساعد في زيادة وعي المزارعين في ادارة الموارد المائية وتسهم في ترشيد الاستهلاك.

الكلمات المفتاحية : الري الناقص ، التجفيف الجزئي للمنطقة الجذرية ، الباقلاء ، الاستهلاك المائي ، الترب **الجبسية**

INTROUCTION

The deficit in water resources constitutes one of the most important and biggest challenges facing irrigated agriculture in the world with the increase in demand and cultivated area in the world in most cases, the amount of available water is not sufficient to cover crop requirements (Ingrao *et al.*, 2023). So, in order to solve the problem of water lack, it is essential to think of new techniques that help in the optimal use of water resources, for instance partial root-zone drying (PRD),and the deficit irrigation (DI) (Iqbal *et al.*, 2020 and Jebril *et al.*, 2023). Deficit Irrigation is conceded as one of the important methods used to increase water use efficiency (WUE) (Zou *et al.*, 2020). That's a higher production per unit of irrigation water added by exposing the plants to certain levels of water stress during a stage of growth or at all stages of plant growth to reduce the number of irrigation units or reduce the amount of water per irrigation without significant impact on yield reduction (Kirda, 2002; Abdulmageed, 2023). Fereres and Soriano (2007) identified irrigation as the method by which optimum economic production can be obtained when water is scarce, it is the method by which the maximum yield can be found with the least quantity of irrigation water. Partial root-zone drying, PRD, method is rationalizing the consumption of irrigation water, Which was developed by deficit irrigation, and the mechanism of this method depends on irrigating part of the root zone while leaving the other part dry or adding water to a part of the root zone in the first irrigation and the other part in the next watering and keeping the wetting and drying process continuous alternately (English, 1990; Dry *et al.,* 1999). Li et al, (2007) also emphasized that partial drying is a new technology aimed at saving water and increasing water use efficiency without negatively affecting yield production. Faba Beans (*Vicia faba* L.) are a leguminous seed crop (Dhull *et al.*, 2022 and kudury *et al.*, 2023). It is grown for its nutritional importance, primarily for protein content (The percentage of protein in the seeds is about 28 to 35%, carbohydrates, oils, and mineral salts, especially calcium, iodine, fiber, and vitamins, including A, B_1, and B_2 (Meng *et al.,* 2021). In addition to human food use, it is also used in the food industry, the roots of the plant have a certain role in improving soil fertility through the process of nitrogen fixation in the soil by Rhizobia bacteria (Youseif *et al.,* 2017, Altai *et al.,* 2022; Kader et al.,2023). Some studies mentioned that the bean crop responds to a lack of irrigation by up to 50% without affecting yield significantly (Uwanyirigira *et al*, 2023; Al-Obaidy *et al.*, 2023). Hirich and Choukr-Allah (2014) showed that the application of deficit irrigation with 50% of the crop water requirement during the vegetative growth stage gave the highest yield and the highest water productivity compared to the full irrigation treatment, and it also provided 17% in the amount of water.

Gypsum is considered a rock-forming mineral that also occurs in soils. In arid and semi-arid environments, gypsum can be a significant soil component (Kamal and Rashid, 2020). Gypsiferous soils are defined as soils in which gypsum ($CaSO_4.2H_2O$) accumulates, so that it has a significant effect on plant growth (Farhan and Muhawish, 2022). Gypsum soils cover large tracts of land in the center and north of the Iraq sedimentary plain (Al-Jumaily *et al.,* 2022). Most of these lands suffer from multiple problems affecting their agricultural productivity (Ismaeal, 2022). Gypsiferous soils are characterized by low water retention and nutrients, this depends on the characteristics of gypsum minerals (Al-Kayssi, 2022). The decline in land productivity resulting from drought conditions and unplanned human activities that lead to soil pollution and deterioration of its quality, increased calls for the application of water management methods that have proven their efficiency in irrigating different crops (Sobreiro *et al*.,2023). Therefore, this research aims to study the effect of (DI) and (PRD) on the efficiency of water consumption use, growth, and yield of Faba bean in gypsiferous soil.

MATERIAL AND METHODS

A field experiment was carried out to study the effect of deficit Irrigation and partial root zone drying on the efficiency of water consumptive use, growth, and yield of faba bean (*Vicia faba* L.) cultivar Barcelona of Spanish origin during the 2021-2022 winter season in the fields of Agriculture College, Tikrit University, which is located on Latitude 49° 40′ 34″ North and Longitude 40° 38′ 43″ East At an altitude of 129 m above sea level. Soil samples for a depth of 0-0.3 m were taken from five sites of the field designated for the study before planting. The soil samples were air dried and passed through a sieve of 2 mm diameter to estimate some physical and chemical properties of the soil according to Bremner (1965) and Black (1965) as shown in table 1. The land was plowed and the field was leveled and divided into three main sectors. The experiment's field was plowed and divided into three main blocks, and divided into planks with dimensions of 3 × 3 m. Seeds were planted at distance 0.25 m between plants and 0.50 m between two rows. Planting date was the 16th of October 2021 by using two seeds in each hole. The two plants were thin two weeks after emergence. NPK fertilizer was added as urea (46% N), Super Phosphate (21% P), and potassium sulfate (43% K) at a rate of 50,100 and 60 kg K ha^{-1} respectively, for all treatments when planting, manual weeding was conducted periodically for all treatments.The experiment included seven irrigation coefficients, as shown in table 2. Randomized Complete Block Design was used with three repetitions. The data were statistically analyzed and the means were compared to the least significant difference (L.S.D) test at the 5% level.

Table 1. Some physical and chemical characteristics of gypsiferous Soil that used in the experiment.

Soil traits	**Unit**	**Quantity**
Volumetric moisture content at 33 kPa		0.32
Volumetric moisture content at 1500 kPa	$cm^3\ cm^{-3}$	0.13
available water		0.19
bulk density	$Mg\ m^{-3}$	1.45
EC, electrical conductivity	$dS\ m^{-1}$ at 25ºC	2.77
pH		7.18
Available P	$mg\ kg^{-1}$	26.45
Organic Matter		5.34
$CaSO_4.2H_2O$	$g\ kg^{-1}$	180.46
$CaCO_3$		179.25
Mg		2. 65
Na		3.38
K		1.91
Ca		5.26
Cl	$meq\ L^{-1}$	4.21
$SO^{=}_4$		4.54
$CO^{=}_3$		Nil

Table 2. Experiment coefficients and treatments description

Treatment	**Description Treatment**
FI	This treatment is irrigated when 50% of the prepared water is completely drained
$DI_{25\%}$	This treatment is irrigated when 50% of the prepared water is drained by adding 25% of the water needs (decreasing 25% of the water needs)
$DI_{50\%}$	This treatment is irrigated when 75% of the prepared water is drained by adding 25% of the water needs (decreasing 50% of the water needs)
$FP_{25\%}$	This treatment is irrigated when 50% of the prepared water is drained by adding 25% of the water needs (decreasing 25% of the water needs) Irrigation water is added to one side of the root zone throughout the growing season
$FP_{50\%}$	This treatment is irrigated when 75% of the prepared water is drained by adding 25% of the water needs (decreasing 50% of the water needs) Irrigation water is added to one side of the root zone throughout the growing season
$AP_{25\%}$	This treatment is irrigated when 50% of the prepared water is drained by adding 25% of the water needs (decreasing 25% of the water needs) Irrigation water is added to one side of the root zone with other alternative throughout the growing season
$AP_{50\%}$	This treatment is irrigated when 75% of the prepared water is drained by adding 25% of the water needs (decreasing 50% of the water needs) Irrigation water is added to one side of the root zone with other alternative throughout the growing season

Calculation of irrigation water:

The irrigation amount was calculated by measuring the water that added to the field during growth season using the following equation

$$I = \left(\frac{PWF.C - PWPWP}{100}\right) Pb \times Md \times d \times AW \qquad (1)$$

Where: It was the amount of irrigation water that added to the field during growth season (mm)

PW F.C was gravimetric moisture content at field capacity (%)

PWPWP was gravimetric moisture content at permanent wilting point (%)

Pb was bulk density (Mg m^{-3})

Md was Moisture depletion rate (%)

D was root zone depth (mm)

AW was wetted area ratio (%)

AW was calculated from the following equation:

$$AW = \frac{Sw}{Sl} \times 100 \qquad (2)$$

Where: Sw was the diameter of the wetted area, which reached 0.40 m (the width of the wet strip, and it may be measured in the field)

Sl was the interval between drip lines 0.75 m

As per the time required for operation from the following equation::

$$T = \frac{I \times Se \times Sl}{Q} \qquad (3)$$

I was total irrigation depth (mm)

T was Operating time (hours) per dripper

Se was interval between the drippers along the drip tube (m)

Sl was separator between drip tubes

Q was Dripper discharge (L h^{-1})

The field water use efficiency (WUE_f) was calculated using the following equation (Hansen *et al.*, 1980):

$$WUEc = Y / ET_a \qquad (4)$$

Where,

WUE_c was crop water use efficiency (kg m^{-3}).

Y was grain yield (kg).

ET_a was evapotranspiration - actual (M^3 season $^{-1}$).

RESULTS AND DISSCUSION

The amount of water consumptive use decreased with treatment in order FI, $DI_{25\%}$, $DI_{50\%}$, $FP_{25\%}$, $FP_{50\%}$, $AP_{25\%}$, $AP_{50\%}$, respectively, and it showed in figure 1. The highest amount was 635 mm in treatment FI. The other treatment reduced by 30, 43, 45, 54, 53, 61 % for $DI_{25\%}$, $DI_{50\%}$, $FP_{25\%}$, $FP_{50\%}$, $AP_{25\%}$, $AP_{50\%}$ compared with FI treatment respectively, so the Indemnity for water add to treatment was reduced in order showed above. The application of the partial drying method of the root zone gave the lowest values of the water added depth in addition to reducing the number of irrigation during the growing season, which led to a reduction in the total depth of the added water compared to other treatments of incomplete irrigation or full irrigation, this can be attributed to the drying to which part of the root zone is exposed leads to plant water stress and this leads to the occurrence of sending physiological signals from the root system to the leaves, Via stem through abscisic acid, cytokinin, and ethylene. This leads to the partial closure of the stomata and decreases Transpiration from plant leaves (Schachtman and Goodger, 2008). At the same time, the other part of the root system continues to supply the plant with water growth, the application of a drying and mutual wetting system increases the efficiency of this method and regulates the water consumption of the crop (Hu *et al.*, 2011).

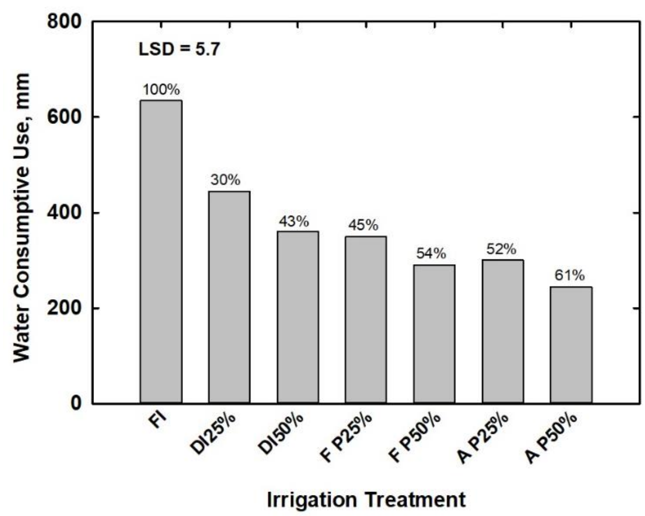

Figure 1. Effect of deficit irrigation and partial root-zone drying on the water consumptive use of faba bean (*Vicia faba* L.) in a gypsiferous soil

Even the FI and AP25% had a higher plant highest, there were no significant different among all the treatments (figure 2A). The increase in plant height when applying alternate partial drying compared to other treatments can be attributed to the effect of partial alternating drying on increasing abscisic acid secretion in the roots, which subsequently works to reduce water loss from the plant by partially closing the stomata and reducing the negative effect of stress. Water on plant growth (Kang and Zhang, 2004). Also, the decrease in the average plant height was significant when applying deficient irrigation can be explained by the fact that the bean length is affected by the water stress resulting from irrigation lack (Galvão *et al.*, 2019; Mahdii *et al.*, 2023).

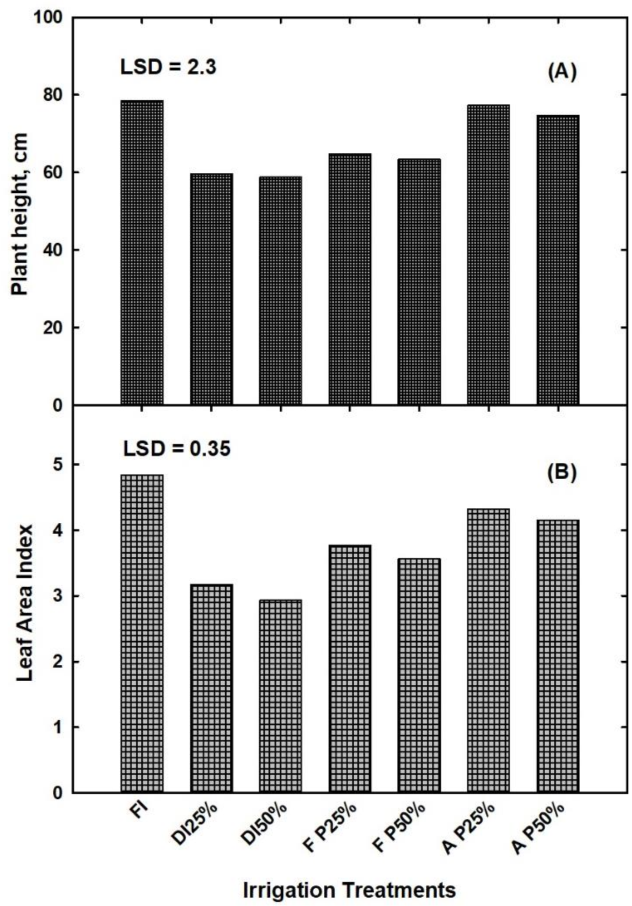

Figure 2. Effect of deficit irrigation and partial rootzone drying on (A) plant height (cm), (B) leaf area index of faba bean (*vicia faba* L.) in a gypsiferous soil

Also, the FI treatment achieves the highest leaf area index (4.83 cm^2) superior to all other treatments, by 11.80, 16.38, 18.11, 35.67, 52.67, and 59.93% compared to A P25%, A P50% F P25%, F P50%, DI25%, and DI50% respectively(figure 2B). The decrease in leaf area index for other treatments may be attributed to the greater effort of plants to extract water once soil water content was less, and this situation causes the consumption of part of the output of photosynthesis and energy in the plant to face this stress and extract water, this reduces the plant capability to build new cells in the leaf and expand, and later reducing the paper space and leaf area index (Burroughs *et al.*, 2023). The decrease in the leaf area with the decrease in the level of irrigation can be attributed to the lower level of irrigation than covering the water needs of the crop, as well as the environmental conditions and the gypsum soil conditions, which affect the increase in the water needs of the plant. This exposure plant to water stress, and leads to weak plant growth, with low leaf area (Seleiman *et al.*, 2021). Number of pods plant^{-1} was affected by irrigation treatment. The A P25% treatment achieved 7.96 pods plant^{-1} highest superior to all other treatments except FI treatment, which also increased by 16.09, 31.38, 28.11, 51.30, 52.67, and 67.38% compared to, A P_{50}%, FP_{25}%, FP_{50}%, DI_{25}%, and DI_{50}% respectively, (figure 3A). The alternate drying of the root zone is one of the important means to increase plant production and its components when water resources are scarce (Iqbal et al, 2020).

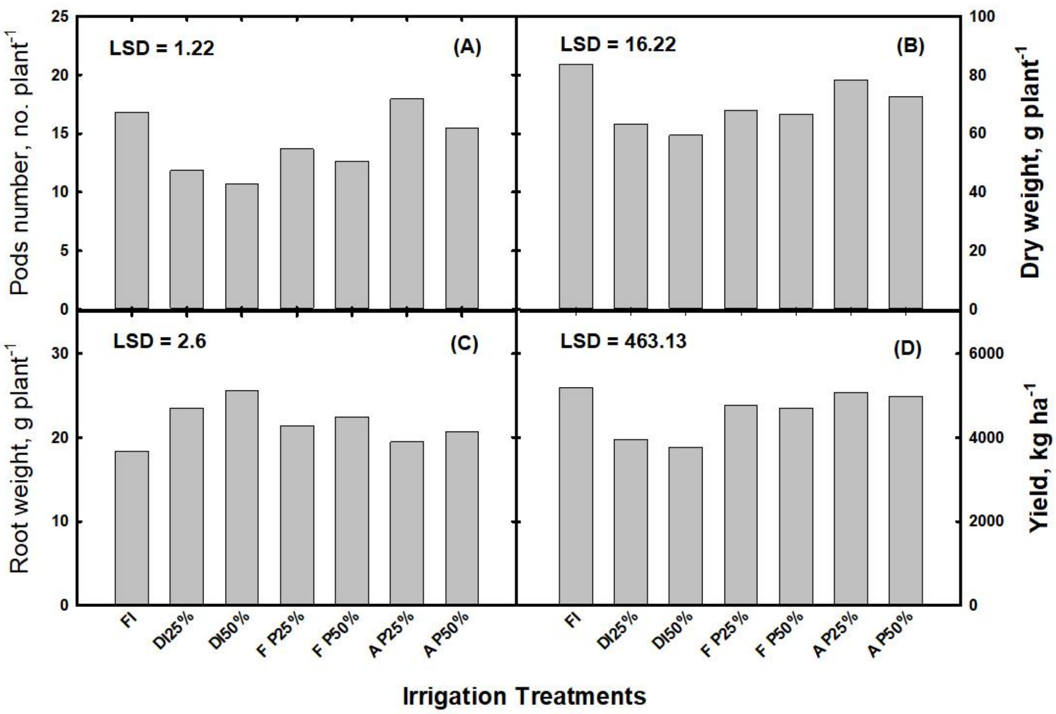

Figure 3. Effect of deficit irrigation and partial rootzone drying on (A) pods no. plant^{-1}, (B) dry weight, g plant^{-1}, (C) root weight g plant^{-1}, (D) yield kg ha^{-1}, of faba bean (vicia faba L.) in a gypsiferous soil.

Figure 3B showed the dry weight of plant shoots. FI treatment achieves the highest value with 83.62 g plant^{-1} and it was superior to the other treatments except A P25%, which also increased by 15.16, 23.26, 25.61, 32.01, and 40.82% compared to A P50 F P25 F P50 DI25 and DI50% respectively. The dry weight of the shoot decreased significantly with the decrease in the level of water irrigation. The treatment of deficit irrigation DI50 % achieves the lowest average dry matter weight with 59.38 g plant^{-1}. This can be attributed to the fact that the level of irrigation water is too shallow to meet the crop's water requirements and lead to a decrease in dry matter accumulation by photosynthesis (Ulyanych *et al.,* 2021). Also, the application of partial drying increased the efficiency of the rootstock to use available irrigation water in an optimal manner (Yazar *et al.,* 2017).

As shown in figure 3C, dry weight of the root system increased significantly with the decrease in irrigation level. The treatment of deficit irrigation and fixed partial drying outperformed the weight of the plant root system while full irrigation treatment (figure. 3), gave the lowest average weight of the dry root system, with 18.4 g plant^{-1}, and DI50 % deficit irrigation treatment chives 25.6 g plant^{-1}. This can be attributed to the fact that the root system contains less tissue when compared to the vegetative group because it needed less amount of photosynthesis products. Therefore, the effect of lack of irrigation on the level of water requirements for the plant and the increase in water stress to which the plant is exposed affect the root system less than the vegetative group. Also, water decrease can lead to stimulated roots to elongate and spread to search for moisture. This was known as hydrotropism. This elongation and separation of the root system leads to an increase in the dry weight of the roots (Sperry *et al.,* 1998).

Figure 3D presented that the yield decreased significantly as the level of irrigation decreased too. The highest value was 5186.3 kg ha^{-1} with full irrigation treatment while deficit irrigation treatments DI25% and DI50% were achieved. 3959.2, and 3774.8 kg ha^{-1}, respectively. This can be attributed to the effect of water stress created by a lack of irrigation, which reduced vital processes and leads to a reduction of the accumulated matter from the photosynthesis process, which consequently leads to a decrease in the seed yield (Essa *et al.,* 2023). The application of partial drying of the root zone conduces to an increase in the yield compared to the deficit irrigation treatments, where the alternating partial drying treatment A P25% achieves a seed yield of 5070.6 kg ha^{-1}. This can be attributed to the fact that the plants under the partial drying system were not exposed to water stress compared to the deficient irrigation treatments. Therefore, the seed yield was not affected significantly and it gave better results (Belachew *et al.,* 2019).

For the Crop Water Use Efficiency (WUEc) it showed in figure 4 that values of crop water use efficiency (WUEc) increased significantly as the level of irrigation decreased. The water use efficiency reached the highest value of 0.2 kg m-^{3} in $AP_{50\%}$. Partial drying treatments generally gave lower values in this research. This result was related to the amount of water consumed by the crop compared to the crop close to the full irrigation treatment. Also, the obtained results can be attributed to the fact that the reduced amount of irrigation water below the level of the crop water requirements possibly stimulates the root system to absorb the largest possible amount of irrigation water which leads to an increase in the efficiency of water use (Phene *et al.,* 1990).

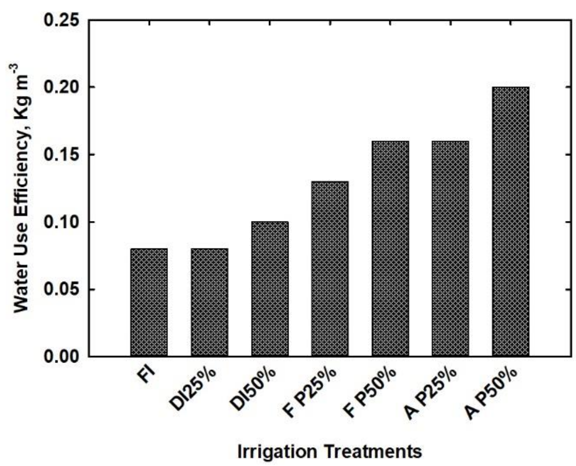

Figure 4. Effect of deficit irrigation and partial rootzone drying on the Crop Water Use Efficiency (WUEc) of faba bean (*Vicia faba* L.) in a gypsiferous soil

Uptake the elements of N, P, and K mg kg^{-1} in the dry matte weight with different irrigation treatments were showed in figure 5 (A, B, and C), the highest values were 1240, 210, and 1782 mg kg^{-1} N, P, and K nutrients, respectively in AP25% treatment with a significant increase compared to all treatments. This can be attributed to the fact that the application of partial drying, increased the ability of the plant to absorb nutrients from the soil (Etemadi *et al.,* 2019). $DI_{50\%}$ treatment recorded the lowest value by 930, 122, and 1356 mg kg^{-1} for N, P, and K nutrients uptake because the lack of added irrigation water led to less movement of water and nutrients to the plant (Awadalla *et al.,* 2018 and Ghanem *et al.*,2023).

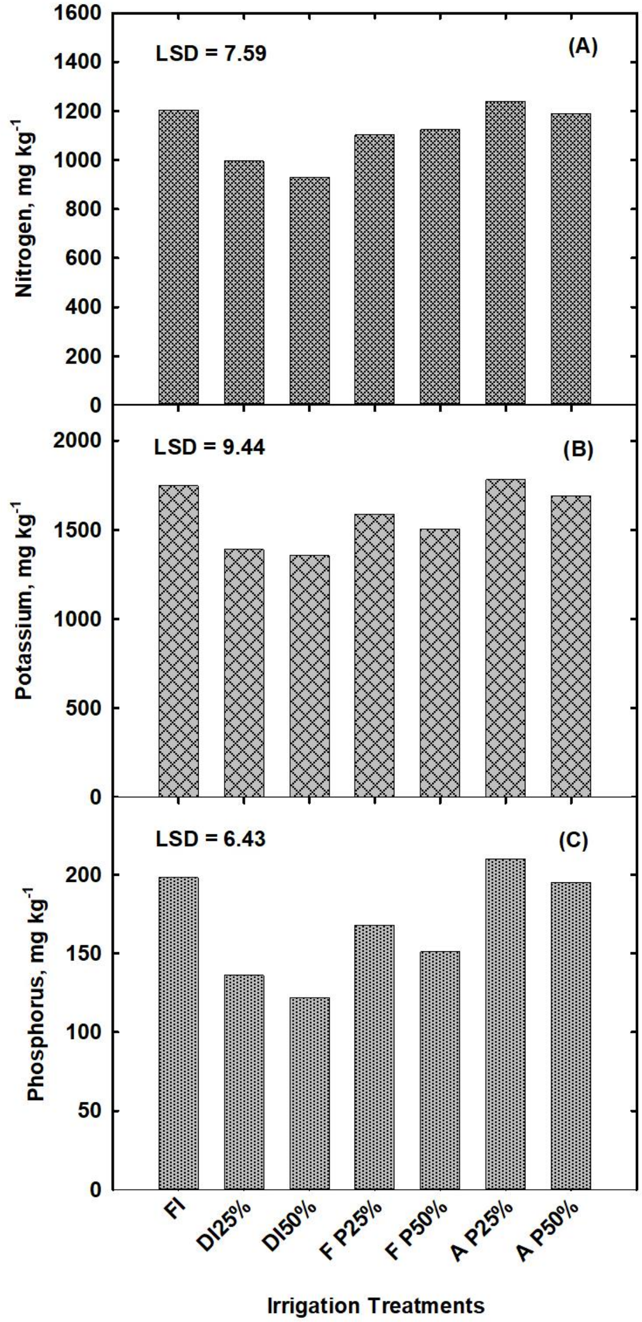

Figure 5. Effect of deficit irrigation and partial rootzone drying on the uptake (A) N mg Kg^{-1}, (B) K mg Kg^{-1}, and (C) P mg Kg^{-1} of faba bean (*Vicia faba* L.) in a gypsiferous soil.

Faba bean is one of a central crop that counted as source of protein for animal and human consumption. Irrigation treatment can modify the amount of protein in faba bean seed. Figure 6 showed the effect of deficit irrigation and partial root-zone drying on the protein percentage in seeds, the amount of protein decreased with increasing irrigation treatment amount. The higher protein amount was observed when irrigation treatment was $AP_{25\%}$.

These results may be due to the fact that protein is considered one of the indicators of plant tolerance to water deficiency because a sufficient amount of water can cause hydrolysis and catabolism of proteins and the secretion of proline as well as amino acids and ammonia. (Fayed *et al.*, 2018; Al-Badri, 2023).

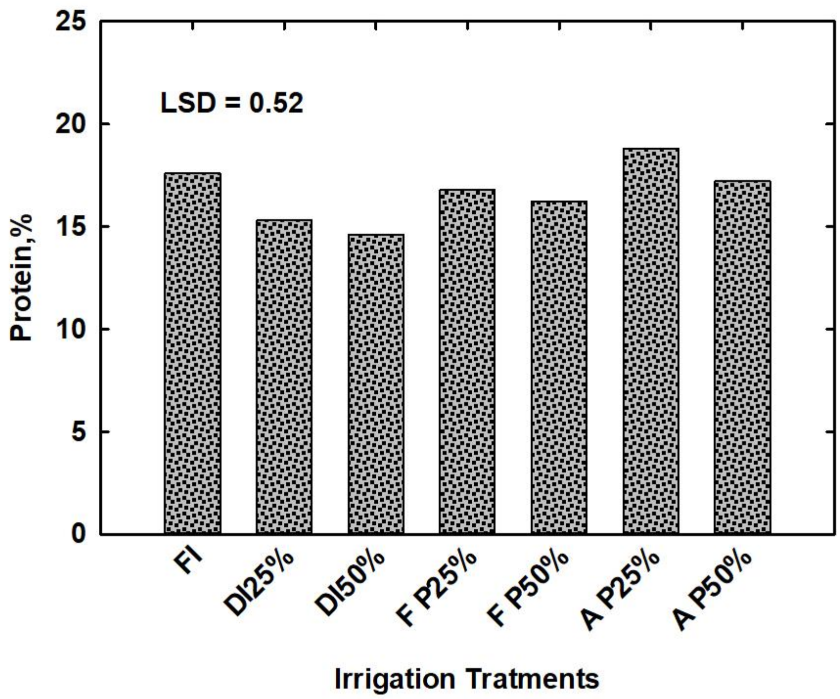

Figure 6. Effect of deficit irrigation and partial rootzone drying on the proten % of faba bean (*Vicia faba* L.) in a gypsiferous soil.

CONCLUSION

We concluded through this study that the application of deficit irrigation and partial drying of the root zone had reduced water consumption and increased water use efficiency. These two applications achieve the goal of this study, which was to increase the productivity of the water unit, especially partial root zone drying, but full irrigation gave higher yield.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the staff of the [College of Agriculture in the University of Tikrit] for their technical and general support.

REFRANCES

Abdulmageed , H., L. (2023). Study of Morphological and Physiological Characteristics of Some Types of Fungus Aspergillus Spp.. *Anbar Journal of Agricultural Sciences*, *21*(2), 386-395. doi: 10.32649/ajas.2024.143268.1083.

Al-Badri , B., S. (2023). An analysis study of some agricultural wastes and their impact on the environment. *Anbar Journal of Agricultural Sciences*, *21*(2), 309-318. doi: 10.32649/ajas.2023.141036.1047

Al-Jumaily, M. M., Al-Hamandi, H. M., Al-Obaidi, M. A., and Al-Zidan, R. R. 2022. Quantity-intensity ratio of potassium in gypsiferous soils in Iraq1. *Pesquisa Agropecuária Tropical*, 52. doi.org/10.1590/1983-40632022v5271620

Al-Kayssi, A. W. 2022. Quantifying soil physical quality by using indicators and pore volume-function characteristics of the gypsiferous soils in Iraq. *Geoderma Regional*, 30, e00556. doi.org/10.1016/j.geodrs.2022.e00556

Al-Obaidy , Sh., G., Abdulrahman , F., M., & Alobaidy , Sh. J., B. (2023). Future Trends For Green Environmental Applications Of Nanotechnology: A Review. *Anbar Journal of Agricultural Sciences*, *21*(1), 133-147. doi: 10.32649/ajas.2023.179725

Altai, S. H. M., Khalefah, K. M., & Amin, E. A. M. (2022). Isolation and identification of Rhizobium bacteria from Faba bean (Vicia faba L.) roots grown in gypsiferous soil and testing their efficiency in production growth regulate (IAA) and siderophorses. Tikrit Journal for Agricultural Sciences, 22(4), 96-105. doi:10.25130/tjas.22.4.12

Awadalla, A., Morsy, A. S. M., and Sherif, M. M. M. 2018. Performance of faba bean plants under different irrigation regimes and foliar application of certain growth regulators in Toshka area, Egypt. *Journal of Plant Production,* 9(10), 821-83 doi:10.21608/JPP.2018.36438

Belachew, K. Y., Nagel, K. A., Poorter, H., and Stoddard, F. L. 2019. Association of shoot and root responses to water deficit in young faba bean (*Vicia faba* L.) plants. *Frontiers in Plant Science*, 10, 1063. doi.org/10.3389/fpls.2019.01063

Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E., Clark, F.E. (Eds.), 1965. Methods of Soil Analysis, Part I. *Agron. Monogr*. 9. ASA, Madison, WI

Bremner, J. M. (1965). Methods of Soil analysis Part 2. Chemical and microbiological properties. Ed. CA Black. *Amer. Soc. Agr. Inc. Publisher Agro. Series*, (9).

Burroughs, C. H., Montes, C. M., Moller, C. A., Mitchell, N. G., Michael, A. M., Peng, B and Ainsworth, E. A. 2023. Reductions in leaf area index, pod production, seed size, and harvest index drive yield loss to high temperatures in soybean. *Journal of Experimental Botany*, 74(5), 1629-1641. doi.org/10.1093/jxb/erac503

Dhull, S. B., Kidwai, M. K., Noor, R., Chawla, P., & Rose, P. K. 2022. A review of nutritional profile and processing of faba bean (*Vicia faba* L.). *Legume Science*, 4(3), e129. doi.org/10.1002/leg3.129

Dry, P. R., Stoll, M., Mc Carthy, M. G., and Loveys, B. R. 1999. Using plant physiology to improve the water use efficiency of horticultural crops. *In III International Symposium on Irrigation of Horticultural Crops* 537: 187-197. doi.org/10.17660/ActaHortic.2000.537.19

English, M. 1990. Deficit irrigation. I: Analytical framework. *Journal of Irrigation And Drainage Engineering*, 116(3), 399-412. doi.org/10.1061/(ASCE)0733-9437(1990)116:3(399)

Essa, S. M., Wafa, H. A., Mahgoub, E. S. I., Hassanin, A. A., Al-Khayri, J. .) cultivars for drought stress tolerance through molecular, morphological, and physiochemical parameters. *Sustainability*, 15(4), 3291. doi.org/10.3390/su15043291

Etemadi, F., Hashemi, M., Barker, A. V., Zandvakili, O. R., and Liu, X. 2019. Agronomy, nutritional value, and medicinal application of faba bean (*Vicia faba* L.). *Horticultural Plant Journal*, 5(4), 170-182. doi.org/10.1016/j.hpj.2019.04.004

Farhan, M. J., and Muhawish, N. M. 2022. Effect of blended triple superphosphate with urea on N, P concentrations in plant and growth of broad bean in a gypsiferous soil. Iraqi *Journal of Agricultural Sciences*, 53(4), 931-940. doi.org/10.36103/ijas.v53i4.1605

Fayed, T. B., Abdrabbo, M. A., Hamada, M. M., Hashem, F. A., and Hegab, A. S. 2018. Irrigation requirements of faba-bean under two climatic locations in Egypt. *Egyptian Journal of Agricultural Research*, 96(2), 653-664. doi:10.21608/EJAR.2018.135777

Fereres, E., and Soriano, M. A. 2007. Deficit irrigation for reducing agricultural water use. *Journal of experimental botany*, 58(2), 147-159. doi.org/10.1093/jxb/erl165

Galvão, Í. M., dos Santos, O. F., de Souza, M. L. C., de Jesus Guimarães, J., Kühn, I. E., and Broetto, F. 2019. Biostimulants action in common bean crop submitted to water deficit. *Agricultural Water Management*, 225, 105762. doi.org/10.1016/j.agwat.2019.105762

Ghanem, A., S., & G. Ibrahim, A. (2023). Variation in parent material and its effect on the properties and development of soil profiles in the northern part of the coastal region (lattakia - syria). *Anbar Journal of Agricultural Sciences*, *21*(2), 480-493. doi: 10.32649/ajas.2024.144257.1095

Hansen, V. E., Israelson, O. W., & Stringham, G. E. 1980. Irrigation principles and practices. Irrigation principles and practices. *4th edition*.

Hirich, A., and Choukr-Allah, R. 2014. Faba bean (*Vicia faba* L.) production under deficit irrigation with treated wastewater applied during vegetative stage. *Desalination and Water Treatment*, 52(10-12), 2214-2219. doi.org/10.1080/19443994.2013.804452

Hu, T., Kang, S., Li, F., and Zhang, J. 2011. Effects of partial root-zone irrigation on hydraulic conductivity in the soil–root system of maize plants. *Journal of Experimental Botany*, 62(12), 4163-4172. doi.org/10.1093/jxb/err110

Ingrao, C., Strippoli, R., Lagioia, G. and Huisingh, D., 2023. Water scarcity in agriculture: An overview of causes, impacts and approaches for reducing the risks. *Heliyon*, (9) doi:10.1016/j.heliyon.2023.e18507

Iqbal, R., Raza, M.A.S., Toleikiene, M., Ayaz, M., Hashemi, F., Habib-ur-Rahman, M., Zaheer, M.S., Ahmad, S., Riaz, U., Ali, M. and Aslam, M.U., 2020. Partial root-zone drying (PRD), its effects and agricultural significance: a review. *Bulletin of the National Research Centre*, 44, pp.1-15. doi: 10.1186/s42269-020-00413-w

Ismaeal, A. S. 2022. Diagnostics and Characterization of Micro morphological Features of some Soil Series in Baiji City, Central Iraq. *Tikrit Journal for Agricultural Sciences*, 22(2), 132-147. doi.org/10.25130/tjas.22.2.15

Jebril , T., N., Boden, R., & Braungardt, C. (2023). Remediation Technique For Cadmium Contaminated Groundwater: A Systematic Review. *Anbar Journal of Agricultural Sciences*, *21*(1), 1-18. doi: 10.32649/ajas.2023.178800

Kamal, A. M., and Rashid, A. A. 2020. The nature of iron oxide distribution in some calcareous and gypsiferous soils. *Tikrit Journal for Agricultural Sciences*, 20(2), 107-119.

Kang, S., and Zhang, J. 2004. Controlled alternate partial root-zone irrigation: its physiological consequences and impact on water use efficiency. *Journal of Experimental Botany*, 55(407), 2437-2446. doi.org/10.1093/jxb/erh249

Kirda, C. 2002. Deficit irrigation scheduling based on plant growth stages showing water stress tolerance. Food and Agricultural Organization of the United Nations, *Deficit Irrigation Practices, Water Reports*, 22(102).

kudury , K.; S., Abed , A., I. & Mahdii, A. B. (2023). Microbial Fertilizers Existence And Its Relationship To Heavy Metals In Some Sustainable Agricultural Fields In Anbar Governorate. *Anbar Journal of Agricultural Sciences*, *21*(1), 44-53. doi: 10.32649/ajas.2023.179714

Li, F., Liang, J., Kang, S., and Zhang, J. 2007. Benefits of alternate partial root-zone irrigation on growth, water and nitrogen use efficiencies modified by fertilization and soil water status in maize. *Plant and Soil*, 295, 279-291. doi.org/10.1007/s11104-007-9283-8

Mahdii , A., B., K. Imran, F., & J. Sultan, L. (2023). The Efficiency Of Microbiology In The Process Of Pesticide Biodegradation. *Anbar Journal Of Agricultural Sciences*, *21*(1), 105-113. doi: 10.32649/ajas.2023.179720

Meng, Z., Liu, Q., Zhang, Y., Chen, J., Sun, Z., Ren, C. and Huang, Y. 2021. Nutritive value of faba bean (*Vicia faba* L.) as a feedstuff resource in livestock nutrition: *A review. Food Science & Nutrition*, 9(9): 5244-5262. doi.org/10.1002/fsn3.2342

Phene, C. J., Itier, B., and Reginato, R. J. 1990. Sensing irrigation needs. In Visions of the future-Proceedings of the 3rd National Irrigation Symposium-ASAE Pub. *American Society of Agricultural Engineers*.429-443.

Schachtman, D. P., and Goodger, J. Q. 2008. Chemical root to shoot signaling under drought. *Trends in plant science*, 13(6), 281-287. doi.org/10.1016/j.tplants.2008.04.003

Seleiman, M. F., Al-Suhaibani, N., Ali, N., Akmal, M., Alotaibi, M., Refay, Y, and Battaglia, M. L. (2021). Drought stress impacts on plants and different approaches to alleviate its adverse effects. *Plants*, 10(2), 259. doi.org/10.3390/plants10020259

Sobreiro, J., Patanita, M. I., Patanita, M., and Tomaz, A. 2023. Sustainability of high-density olive orchards: Hints for irrigation management and agroecological approaches. Water, 15(13), 2486. doi.org/10.3390/w15132486

Sperry, J. S., Adler, F. R., Campbell, G. S., and Comstock, J. P. 1998. Limitation of plant water use by rhizosphere and xylem conductance: results from a model. *Plant, Cell & Environment*, 21(4), 347-359.doi.org/10.1046/j.1365-3040.1998.00287.x

Ulyanych, O., Poltoretskyi, S., Liubych, V., Yatsenko, A., Yatsenko, V., Lazariev, O., and Kravchenko, V. 2021. Effect of surface drip irrigation and cultivars on physiological state and productivity of faba bean crop. *Agraarteadu*s, 32(1):139–149. doi.org/10.15159/jas.21.14

Uwanyirigira, J., Owido, S. F., and Lelei, J. J. 2023. Influence of irrigation levels and mulching types on growth and yield of bean in drought prone area of Bugesera, Eastern Rwanda. *American Journal of Agriculture*, 5(1), 22-41. doi.org/10.47672/aja.1368

Yazar, A., Mart, D., Çolak, Y. B., & Kaya, Ç. İ. 2017. Yield response of faba bean to various irrigation strategies in the Mediterranean region. *International Journal of Research in Agriculture and Forestry*, 4(7), 9-19.

Youseif, S. H., Abd El-Megeed, F. H., and Saleh, S. A. 2017. Improvement of faba bean yield using Rhizobium. Agrobacterium inoculant in low-fertility sandy soil. *Agronomy*, 7: (1), 2. doi.org/10.3390/agronomy7010002

Zou, Y., Saddique, Q., Ali, A., Xu, J., Khan, M.I., Qing, M., Azmat, M., Cai, H. and Siddique, K.H., 2021. Deficit irrigation improves maize yield and water use efficiency in a semi-arid environment. *Agricultural Water Management*, 243, p.106483. doi.org/10.1016/j.agwat.2020.106483