THE INFLUENCE OF PERLITE AND IRRIGATION MANAGEMENT ON THE PROPERTIES OF POTATOES IN GYPSIFEROUS SOIL

Article *in* Fresenius Environmental Bulletin · March 2021

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THE INFLUENCE OF PERLITE AND IRRIGATION MANAGEMENT ON THE PROPERTIES OF POTATOES IN GYPSIFEROUS SOIL

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ABSTRACT

A field experiment is carried out in Anbar province for the spring of 2018 in a gypsiferous soil with a sandy clay loam to study the effect of perlite (PL), quantity and intervals of irrigation (IQ & IT) on the consumption and efficiency of water use (WC & WUE) and total yield (TY) of potatoes. PL is added at 0, 4 and 8% of soil volume (SV). IQ is added at 100 and 50% of net depth of irrigation (NDI) are applied. Two ITs every 3 and 6 days are applied. The treatments are distributed according split-split plots system within the design of completely randomized blocks (RCBD) with three replications. The irrigation is scheduled based on the American evaporation basin Class A. PL of 8% of SV led to the WUE of 22.78 kg.m-3 at 50% NDI and IT every 3 days, while it is less WUE when compared to control treatment, reaching 7.15 kg.m-3 at 100% IQ every 6 days IT. The addition of PL of 8% SV achieved the highest TY of 29 tons.ha-1 at the level of 100% IQ and every 3 days IT compared to control treatment, where it gave the lowest TY of 11.2 tons.ha-1 at IQ of 50% NDI with IT every 6 days. The stabilization of the perlite addition factor with 50% NDI and IT of 3 days have led to save (987.875 m3. ha-1) of irrigation water.

KEYWORDS:
Perlite, Irrigation intervals, Yield, Growth, Potato plant

INTRODUCTION

The gypsiferous lands consist 20% of the total area of Iraq; which have formidable physical and fertility problems, such as low agricultural production capacity [1] .Water is the most important determinant of agricultural production in gypsiferous soils. The increasing water demands due to the high population density makes people use many approaches to mitigate the aquatic scarcity, including the reduction of hydraulic inputs during the season by scheduling irrigation [2]. The lack of water available to plants leads to a reduction in production and quality of yield with increasing the disease infestation [3], therefore, water use management and rationalization of irrigation is essential. Iraq suffers from water scarcity due to the shortage of annual hydraulic flow incomes of the Tigris and Euphrates rivers[4]. In all of the world, several procedures followed to reduce crop water consumption by creative scientific methods, such as deficit irrigation, which adds less water than actual requirements [5]. The decreased yield of crops is related to the quantity of available water for irrigation [6] In addition, water stress and reduced irrigation cause insignificant drop in yield [7]. In modern agriculture, precise application and management of irrigation and water requirements of crops is critical successful cropping program. The soil and plant properties, as well as climatic factors controlled the process of hydrous transfer in rhizosphere [8]. Thus, many organic and inorganic compounds if applied to soil can significantly change and improve soil water holding capacity and water use efficiency by cropping systems [9] , for example perlite granules that are produced under high (1500 0C) temperature, can reach a 4-20 times of their original size and generally a 430% increase in their volume that can better hold water and support plant roots particularly under deficit irrigation conditions, also perlite is the optimal germination medium sterilized and free from weeds, pathogens and other shrubs [10].

Potatoes are widely grown in the world because they are highly nutritious and energy-rich, and despite the increase in the area under cultivation, Their production in Iraq still fails to meet their local needs [11], where the area of potato cultivation in Iraq is 40,000 hectares [12]. It worth noting that the potato crop endures the deficit irrigation without a decrease in the quality or quantity of yield during the period preceding the tubers composition [13].Badr et al. [14] showed that drip-irrigated potatoes at 40, 60, 80 and 100 % of evaporated water have led to a significant rise in growth indicators and tubers with increasing irrigation levels. Water stress-sensitive crops such as potatoes need a structured program to manage the irrigation cycle [15]. The main objective of the study is to investigate the influence of perlite addition, the amount of irrigation and the intervals on the consumption and use efficiency of water for the potato crop.

MATERIALS AND METHODS

This study is done as field experiment in Al-Anbar Province/Heet City (180 km to the west of Baghdad) that lies on 42.842597o E longitude, 33.637479o N latitude, at 34 m elevation above sea level during the period from February till May 2018, in a gypsiferous soil. The soil physical and chemical properties are presented in (table 1). The soil saturation capacity, permanent wilting point and volumetric moisture are determined in laboratory [82].

Study Treatments: The experiment included three factors:

1. Perlite treatment in three levels (PL): 0, 4 and 8% of soil volume mixed with soil particles for 30 cm width [17].
2. Irrigation water quantity (IQ): 50% and 100% of the net irrigation depth (NDI) counted from the US evaporation pan class A.
3. Irrigation intervals (IT): Two irrigation intervals of 3 and 6 days.

Experimental Design: Distribution of treatments are done according to the Split – Split Plot Pattern within Randomized Complete Block Design (RCBD) with three replicates. ITs treatment placed in the main plots. Every main plot divided into two sub-plots that irrigated randomly. Every sub-plot partitioned to three lines; in which, PL application distributed randomly. Treatment number reached 2 x 2 x 3 = 12.

Farm Preparation And Cultivation: The farm tilled, leveled and separated into three blocks. Each block divided into plots as defined in the experimental design and the split plots also divided into lines with a length of 10 m and a width of 0,75 m. Diammonium phosphate (DAP) and potassium sulphate fertilizers applied as 300 kg P_2O_5 and K_2O per hectare in respective; the addition of half potassium was before cultivation and the other half after 45 days of cultivation with urea fertilizer, which used as 300 kg per hectare[18] . The cultivation of (Riviera) potato cultivar tubers at a depth of 8 cm and a space of 0.4 m between plants after soaking in a fungicide called (Aggressive) with a concentration of 250 ml/100L of water for 10 minutes. The tubers were then added to the gibberellic solution as a single disk per 200 L of water to stimulate the growth of the tubers.

Scheduling Of Irrigation: All treatments irrigated as 40 mm deep for germination. Irrigation then scheduled to compensate vaporized water from the American evaporation class A pool every 4 and 6 days using 50 % and 100 % NDI. The NDI computed after that by the following equations:

1. Calculation of evaporation reverse transpiration by the equation mentioned by Al-Hadithi and Al-Kubaisi [23].

$$ET_0 = K_p \times E_{pan} \quad \ldots\ldots\ldots\ldots(1)$$

TABLE 1
Some of the physical and chemical characteristics of farm soil

Soil properties		Units	Value
Hydrogen potential pH		---	8.0
Electrical Conductivity (I : I)		$dS.m^{-1}$	2.5
Available Nutrients	Nitrogen	$mg.kg^{-1}$	60
	Phosphorus		30
	Potassium		220
Organic Matter		$g.kg^{-1}$	9.6
$CaSO_4$			180
$CaSO_3$			80
Soil Separates	Sand	$g.kg^{-1}$	528
	Silt		232
	Clay		240
Soil Texture			Sandy Clay Loam
Volumetric Moisture at Saturation		%	44.88
Volumetric Moisture at Field Capacity			29.74
Volumetric Moisture at Wilting Point			940
Bulk Density		$Mgm.m^{-1}$	1.27

Where:

ET0: evapotranspiration potential (mm.day-1).

Epan: evapotranspiration measured in the pan (mm.day-1).

Kp: evaporation pan's specific coefficient, that differs according to pan's type, vegetative cover surrounding the pan, and soil surface nature, as mentioned by Allen et al [37]. The value 0.8 was depended here depending on meteorological conditions of study area according to the method mentioned by ÇETIN et al [24] .

Calculating the actual evapotranspiration that equals the practical water consumption of potato crop irrigated superficially and by spraying; according to the following equation:

$$ET_a = K_c \times ET_0 \ldots\ldots\ldots \quad (2)$$

Where:

ETa: actual evapotranspiration (mm.day-1).

Kc = Crop coefficient

Values 0.75,1.15,1.00 and0.80 that are listed by Shiri-e-Janagrad et al [21] were desired to represent crop coefficient values for the durations (03/7 – 03/27), (27/03 – 04/16), (04/16 – 05/11) and (05/11 –05/20) successively.

Water balance equation was based on the calculation of water consumption:

$$\mathrm{ETa} = (\mathrm{P} + \mathrm{Ir}) - (\mathrm{D} + \mathrm{R} + \mathrm{In} + \Delta\mathrm{s}) \quad (3)$$

Where:

Eta is water consumption (ml), P is water quantity, D is deep percolation, R is superficial flow, In is water blocked by plant, ΔS is soil moisture difference; and if we suppose that both superficial flows, water blocked by plant and deep percolation are zero, then; the equation becomes as follows:

$$\mathrm{ETa} = (\mathrm{P} + \mathrm{Ir}) - \Delta\mathrm{s} \quad (4)$$

Water quantity that should be applied for saline leaching according to the equation of[22] which is special for the drip irrigation system was estimated as below:

$$LR = \frac{\mathrm{Ecw}}{(2\mathrm{Max\ Ece})} \times 100 \ \ldots\ldots\ldots \quad .(5)$$

Where L.R represents leaching requirements (%), Ecw is the electrical conductivity (dS. m-1) and Max ECe is the maximum electrical conductivity (dS. m-1) of the cultivated soil when the crop yield is zero, it's a tabulated value that differs with the crop; it equals 10 for potato crop[19] .

Drip irrigation systems have been used for droppers that discharge 4 liters. hour-1 and the irrigation water was applied according to the dual application system to split the quantity of water introduced into two bursts that are separated with 6 hours[20]. The irrigation time was calculated according to the equation mentioned in (AL – Hadithi, 2002).

$$\mathrm{q} \times \mathrm{t} = \mathrm{a} \times \mathrm{d} \ \ldots\ldots \quad (6)$$

Where:

q: discharge is given for the lateral lines (m3.hr-1), t: irrigation time (hour), a: the cultivated area (m2) and d: applied water depth (m).

Total yield (TY) for each treatment (average treatment area for three replicates in m2) separately and related to hectare using the equation mentioned by AL – Zobaie [26] as in the following:

$$TY = \frac{Experimentunityield\ (kg)}{Experimentunityield\ (m^2)} \times 10000 \quad (7)$$

Water use efficiency (WUE) or water productivity (WP) was estimated by Hillel[27] by dividing the total crop (kg.ha-1) to the added water volume (m3.ha-1) as mentioned by Doorenbos [25] .

$$WUE\ (\mathrm{kg.m^{-3}}) = \frac{TotalYied\ (kg.ha^{-1})}{Addedwaterquantity\ (m^3.ha^{-1})} \ldots \quad (8)$$

Data have been analyzed according to the followed experimental design and averages were tested according to the least significant difference (L.S.D.) test with probability level 0.05 [28] using GenStat Program.

RESULTS

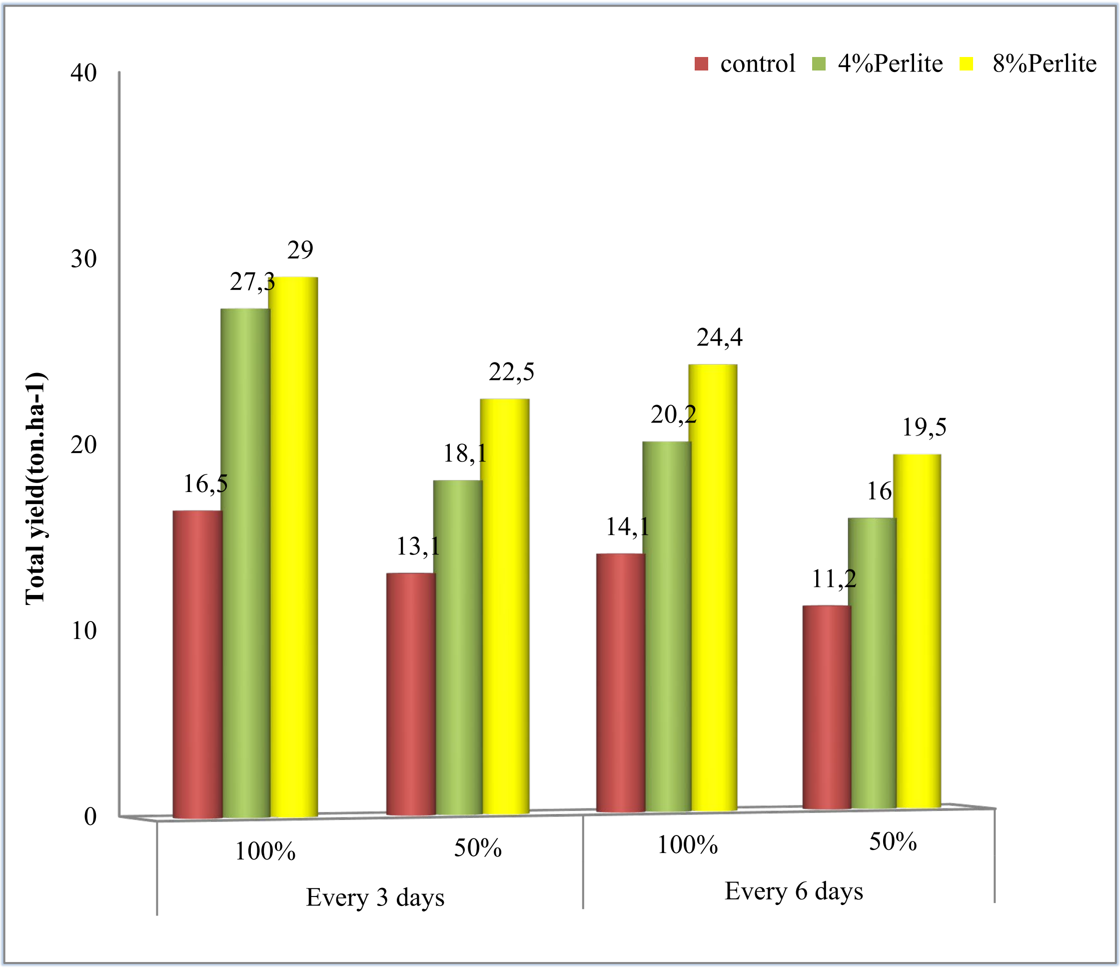
Water Consumptive (Wc): Table 2 displays the LR-free WC values of the potato crop for germination and the other four phases of development for 3-and 6-day IT and 50 % and 100 % NDIs. During the growing season, the WC hit 235.595, 235.995, 471.19 and 471.99 mm respectively for the above listed IT and NDI. Escalation in water consumption for 100 % deep irrigation treatment attributed to increase of plant transpiration and soil evaporation which is consistent with several workers [29,5]. The highest ETa recorded in complete irrigation compared to zero irrigation treatment. It has been shown that cultivation and fertilization can significantly affect plant water uptake [30,31].

At the vegetative growth stage, WC values increased to 64.63 and 54.13 ml for 50 and 100 % NDIs. In addition, the progressive growth of the plant continued to increase to 148.66 and 130.26 ml water consumption at the nodulation stage, reaching 133.2 and 124.2 ml during the nodule swelling stage. In order to meet the nodulation requirements and also because of the rise in temperature during the growing season as a result of climate change, the cause of this continuous increase can be attributed to the extreme irrigation and nutritional needs of plants with decreased leaf area. At the end of the season, the WC values dwindled to 105 and 103.1 mm during the maturation phase. The diminished plant need for water could be due to end of developmental stage and senescence, as most areas of the plant have dried.

Total Yield (Ty) (Ton. Ha^{-1}): Figure 1 shows how research treatments impact TY quantity. The addition of PLs shows high variations in TY. Where the highest value for other additional NDIs can be seen at 8% PL compared to 0 and 4% PL. The lowest TY values for levels 0 and 4 % PLs are 11.2 and 16 ton.ha^{-1} compared with 19.5 ton.ha^{-1} for 8 % PL.

TABLE 2
Water Consumption of Potato Crop mm.season-1

Growth Stage	Stage Duration (day)	Water Consumption (WC) (mm) Irrigation Interval (IT) (day): 3 Irrigation Level 100 %	3 Irrigation Level 50%	6 Irrigation Level 100 %	6 Irrigation Level 50%	NDI ($m^3.ha^{-3}$)
Germination	27	40	20	40	20	167.44
Vegetative Growth	20	54.13	27.065	64.63	32.315	226.588 270.541
Nodulation	20	148.66	74.33	130.26	65.13	622.290 545.268
Tuber Swelling for Two Rains (16 and 20) mm	25	124.2	62.1	133.2	66.6	519.901 557.575
Maturity	10	105	52.5	103.1	51.55	439.53 431.576
Grand Total		471.99	235.995	471.19	235.595	1975.75 1972.4



L.S.D 0.05	A	B	C	A*B	A*C	B*C	A*B*C
	2.966	**2.532**	**1.949**	**2.800**	**2.727**	**2.980**	**3.924**

FIGURE 1
Perlite application and irrigation interval effect on total yield (ton.ha-1)

This result is because of perlite properties of covering soil particles with hydration shells which encourage the penetration of the roots to increase the ability of plants to retain free water. The penetration of roots in the soil will create more spaces for water movement which reduces its bulk density. This reduction will positively reflect vegetative growth characteristics; improve the yield and its components. The PLs can enhance soil structure and boost aggregate stability to increase water permeability. The perlite plays positive role in enhancing both physical and chemical properties of the soil. Furthermore, PL has a large surface area that would improve the retention of water in the soil. The increase in yield could also be attributed to the slight evaporation of water in soil body, The increasing of excessive water content in soil as well as the availability of stored water in the soil caused by perlite application will, therefore, cause more vegetative growth and for all of this, the yield will increase [32].

The results of Figure 1 shows significant differences in the TY values caused by the difference in the irrigation intervals for any PL added. At 3 days IT, they reached the highest values of 16.5, 27.3 and 29 ton.ha^{-1}. Whereas they were 14.1, 20.2 and 24.4 ton.ha^{-1} for PLs 0, 4 and 8% respectively for 6 days IT. This drop in TY values could be attributed to the extensive irrigation intervals as well as the reduced content of water in [33] .

Figure 1 reveals that 100 % of deep NDIs are significantly higher than 50 % NDIs. Since 100 NDI for 3 and 6 ITs improved the TY value significantly relative to 50 % NDI for 6 days IT. The values reached 14.1, 20.2 and 24.4ton.ha^{-1} for NDI of 100% if irrigated every 6 days; compared to 11.2, 16.0 and 19.5 ton.ha^{-1} for 50% deep NDI with 6 days of IT with PLs of 0, 4 and 8% in successive. The reduction of TY values for 50% NDI, 6 days IT treatments in comparison with 100% NDI for 3 and 6 days ITs could be attributed to the effect of water stress on tubers crop which agreed with El-Latif et al. [34] . They found that water stress is the main reason of yield reduction that could be 50% or more.

Water Use Efficiency (Kg.M^{-3}) (Wue): Figure 2 demonstrates the impact of research treatments on WUE values that ranged from PLs to achieve a peak value of 8 % PL relative to 0 and 4 % for any NDIs applied but they have reached the lowest values of 13.82 and 8.35 kg.m^{-3} for 0 and 4% PLs compared with 14.86 kg.m^{-3} for 8% PL. This results maybe because of the increased yield and its components due to perlite addition, which reduce evaporation losses along with increased excess water in soil after the addition of perlite. The increased water storage raises the vegetative growth of branches that increase tubers' yield and its components .

Figure 2 shows significant variations between WUE values by various ITs for every application of PLs, where they reach their top values for IT of 3 days and 50% IQ and recorded 13.26 ,18.32 and 22.78 kg.m-3 in comparison with IT of 6 days, 50% IQ where they were 11.36, 16.22 and 19.77 kg.m-3 for PLs of 0, 4 and 8% successively. WUE declined with high levels of irrigation where the maximum WUE existed in treatment with the lowest IQ [35].

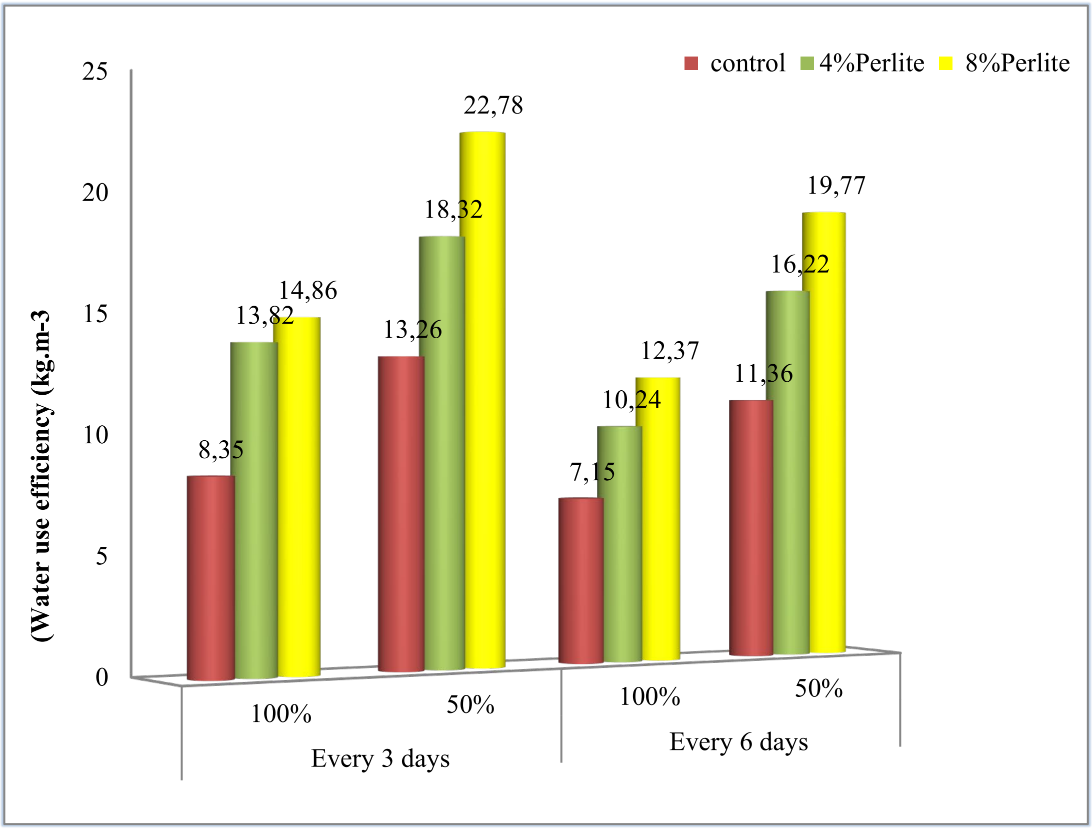
Results cited in Fig. 2 stated that irrigation at 50 % IQ increased the WUE values significantly compared to 100 % IQ during 6 days IT, where it reached 11.36, 16.22 and 19.77 kg.m-3 for 50% IQ by 6days IT compared with 7.15, 10.24 and 12.37 kg.m-3 for 100% IQ at 6 days IT for PLs 0, 4 and 8% successively. The increasing WUE values could be attributed to the few IQs added to the farm. The reduced WUE resulting from increased supply of IQ water due to the lack of aeration of roots caused by increased soil moisture In addition to the increased loss of nutrients by percolated water and the reduction of their concentration and therefore the reduction in productivity in relation to the overall IQ water, The listing of 50 % added IQ influences WUE and water reserves that irrigated additional areas to expand farmland [36].

CONCLUSIONS

This study shows the evident improvements in soil characteristics due to perlite addition, which increased soil's water holding capacity, saved more water volumes and reduced water requirements of plant to increase irrigation intervals; Irrigation at 50 % of NDI together with 3-day IT saved (987,875 m3. ha-1) irrigation water with stabilization of perlite factor, and this led to the possibility of cultivation in gypsiferous soils and partial reclamation and correction of their physical properties.

ACKNOWLEDGEMENTS

This research was funded by the University of Anbar Grant Vote no. 9442500. The authors would like to thank all, who provided the insight and expertise that greatly assisted in the research. The authors also appreciate the efforts of academic and support staffs of the Department of Soil and Water Resources - College of Agriculture, in providing all the required assistance and materials in conducting this research .In addition, the authors would like to thank the University of Jordan for help in publishing this research.



L.S.D	A	B	C	A*B	A*C	B*C	A*B*C
0.05	2.275	1.915	1.518	2.130	2.111	2.287	3.028

FIGURE2

Effect of perlite addition and irrigation brake level on water use efficiency(kg.m-3)

REFERENCES

[1] Saliem, K.A. (2001) The Effect of Irrigation Water Quality and Application on The Properties Gypsiferous Soils for AL-Dour Area. College of Agriculture University of Baghdad.Iraq.

[2] Oweis, T., Zhang, H.and Pala, M. (2000) Water use efficiency of rainfed and irrigated bread wheat in a Mediterranean Environment. Agronomy Journal. 92(2), 231–238.

[3] Pereira, A.B.and Shock, C.C. (2006) Development of irrigation best management practices for potato from a research perspective in the United States. Sakia. Org e-Publish. 1(1), 1–20

[4] Al-Shahrabali, Q. (2009) Surface water resources in Iraq current and future senarios. Iraq Soil Salinity and Water Management. 7, 15-17.

[5] Ati, A.S. (2009) Effect of irrigation deficit and addition of corn cobs on consumptive use and yield of wheat Triticum aestivum L. J. Agric. Sci. Mansoura Univ. 34 (6), 7103–7113.

[6] Geerts, S.and Raes, D. (2009) Deficit irrigation as an on-farm strategy to maximize crop water productivity in dry areas. Agricultural Water Management. 96(9), 1275–1284.

[7] Al-Najim, H.J.M. (2013) The Impact of Irrigation water Salinity Water Magnatization and Soil Available Moisture Depletion Percent on Some Soil Physical and Potato and Growth. College of Agriculture- University of Al-Anbar Iraq.

[8] Shankar, V., Prasad, K.S.H., Ojha, C.S.P.and Govindaraju, R.S. (2013) Optimizing Water Use in Irrigation-A Review. Journal of the Indian Institute of Science. 93(2), 209–226.

[9] Evans, M.R. (2004) Ground bovine bone as a perlite alternative in horticultural substrates. HortTechnology. 14(2), 171–175.

[10] Hanna, H.Y. (2006) A stir and disinfect technique to recycle perlite for cost-effective greenhouse tomato production. J. Veg. Sci. 12(1), 51-63.

[11] AL-Thalage, A.A. and AL-Najjar, E.Y. (2012) An Analytical study of the reality of the production of potato crop in some Arab countries for the period 1981-2010 (Iraq Model) : A Comparative study. Al- Rafidain Journal. 40(4), 77-91.

[12] FAOSTAT (2013) The Statistics Division of the Food and Agriculture Organization of the United Nations. Rome, Italy .

[13] Shock, C.C., Zalewski, J.C., Stieber, T.D.and Burnett, D.S. (1992) Impact of early-season water deficits on Russet Burbank plant development, tuber yield and quality. American Potato Journal. 69(12), 793–803.

[14] Badr, M.A., El-Tohamy, W.A.and Zaghloul, A.M. (2012) Yield and water use efficiency of potato grown under different irrigation and nitrogen levels in an arid region. Agricultural Water Management. 110, 9–15.

[15] Ayas, S. (2013). The effects of different regimes on potato (Solanum tuberosum L. Hermes) yield and quality characteristics under unheated greenhouse conditions. Bulgarian Journal of Agricultural Science. 19(1), 87–95.

[16] Page, A.L., Miller, R.H. and Keeney, D.R. (1982) Methods of soil analysis. Part 2. Chemical and microbiological properties. Agronomy, No. 9. Soil Science Society of America, Madison, WI. 1159.

[17] Hamdi, G.J. (2017) Effect of perlite in reducing water stress for three genotypes of tomato. M. Sc. Thesis. College of Agriculture. University of Diyala. Iraq.

[18] AL–Fadhiy, J.T.M. (2006) Foliar Application on Growth, Yield and Components of Potato Plants Tubers (Solanum Tuberosum L.). College of Agriculture University of Baghdad.

[19] Ayer, R.S. and Westcot, D.W. (1985) Water quality for agriculture, irrigation and drainage. FAW Irrigation and Drainge Paper No, 29,Rev 1.

[20] AL-Khateeb, B.A.,Yousif, B.M. and Abed Al Rhman, W.F. (2016) Measurement of water consumptive use, growth, and yield of potato(Solanum tuberosum L) under drip irrigation system. AL-Anbar Journal of Agricultural Sciences. 14(2),36-52.

[21] Shiri-e-Janagrad, M., Tobeh, A., Abbasi, A., Jamaati-e-Somarin, S. and Hokmalipour, S. (2009) Vegetative growth of potato (Solanum tuberosum L.) cultivars, under the effects of different levels of nitrogen fertilizer. Research Journal of Biological Sciences. 4(7), 807–814.

[22] Haman, D.Z. and Yeager, T.H. (2000) Foliar Deposits and Stains from Irrigation Water. Citeseer. Fact Sheet ENH 150, a series of Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

[23] Al-Hadithi,I. And Al-Kubaisi,A.(2010). Modern Irrigation Technlogies and Other Issues in Water Issue. (First Edit). Baghdad , Iraq.

[24] Çetin, Ö., Yildirim, O., Uygan, D. and Boyaci, H. (2002) Irrigation scheduling of drip-irrigated tomatoes using Class A pan evaporation. Turkish Journal of Agriculture and Forestry. 26(4), 171–178.

[25] Doorenbos, J. (1975) Guidelines for predicting crop water requirements. Food and Agriculture Organization. Rome, Irrig. Drainage. 24.

[26] AL-Zobaie, A.A.A. (2016) The Effect of Planting date and Spraying of nutrient Organic (Siapton 10 L.) growth and Yield five varieties of Potatoes Solanum Tuberosum L. University of Al-Anbar. MS Thesis. College of Agriculture Iraq.

[27] Hillel, D. (2008) Years of drip irrigation reviewing the past, prospects for the future. Crops Soils. 41, 38–42.

[28] Al-Sahaf, F.H. (1989) Practical Plant Nutrition. Ministry of Higher Education and Scientific Research. Dar Al-Hikma Printing Press. Iraq.

[29] AL–Hadithi, S.A.S. (2002) Deficit irrigation scheduling of Zea mayz L. Ph.D. Dissertation College of Agriculture University of Baghdad.Iraq.

[30] Souri, M.K. and Hatamian, M. (2019) Aminochelates in plant nutrition: a review. Journal of Plant Nutrition. 42(1), 67–78.

[31] Souri, M.K., Neumann, G. and Römheld, V. (2009) Nitrogen forms and water consumption in tomato plants. Horticulture Environment and Biotechnology. 50(5), 377–383.

[32] Salas-Pérez, L., Garcia-Hernández, J.L., Márquez-Hernández, C., Fortis-Hernández, M., Estrada-Arellano, J.R., Esparza-Rivera, J.R. and Preciado-Rangel, P. (2017) Yield and nutraceutical quality of tomato fruits in organic substrates. Ecosistemas y Recursos Agropecuarios. 4(10), 169–175.

[33] Farooq, M., Wahid, A., Kobayashi, N., Fujita, D. and Basra, S.M.A. (2009) Plant drought stress: effects, mechanisms and management. In Sustainable Agriculture. Springer. 153–188.

[34] El-Latif, K.M.A., Osman, E.A.M., Abdullah, R. and El Kader, N.A. (2011) Response of potato plants to potassium fertilizer rates and soil moisture deficit. Adv. Appl. Sci. Res. 2(2), 388–397.

[35] Fouda, T., Elmetwalli, A.and Eltaher, A. (2012) Response of potato to nitrogen and water deficit under sprinkler irrigation. Scientific Papers Series-Management, Economic Engineering in Agriculture and Rural Development. 12(1), 77–81.

[36] Feddes, R.A., Kowailk, P.J. and Zaradny, H. (1978) Simulation of field water use and crop yield, PUDOC, Wangeningen. 189.

[37] Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998) Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage. FAO, Rome. 300(9), 56. D05109.

Received: **16.01.2021**
Accepted: **10.02.2021**

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