WATER CONSUMPTION, WATER USE EFFICIENCY AND POTATO YIELD UNDER THE INFLUENCE OF MOISTUER DEPLETION AND ADDITION METHOD

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ABSTRACT

Field experiment was conducted at AL Ramadi – Anbar province in western Iraq. far fall season 2020 in sandy clay loam soil which has 58.90 gm Kg $^{-1}$ gypsum, to study the effect of water depletion, addition method in water consumption and water use efficiency. Irrigation was at depletion rates 40, 50 and 60% of available irrigation water, with three ways: Complete addition of irrigation depth, half addition included adding half of irrigation depth and adding another half after 6 hours, third addition division to three parts at duration of 6 hours, treatments distributed according spilt plot design in RCBD with three replicates. Potato planted in 13.09.2020. Evaporation pan Class A used to scheduling the irrigation. Water consumption calculated by equivalent it of added water depth. Results showed increasing in water consumptive with decreasing in depletion rate, highest value of water consumptive reached 324.13 mm at 40% depletion of available water, while decreased to 293.61 mm at 60% depletion with decreasing rate reached 9.41 %, Total yield rate prevailed at 40% depletion of water available which reached 22.73 t h $^{-1}$, Also total yield and water use efficiency prevailed significantly at triple addition which reached 23.90 t h $^{-1}$, 14.17 kg m^{-3} respectively.

Key word: desert Soils, potato crop, gypsum, water stress.

الاستهلاك المائي وكفاءة استعمال المياه وحاصل البطاطا تحت تأثير استنزاف رطوبة التربة واسلوب الإضافة

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المستخلص

اجريت تجربة حقلية في مدينة الرمادي / محافظة الانبار غرب العراق في تربة صحراوية ذات نسجة مزيجة طينية رملية Sandy Clay loam تحتوي على 58.9 غم كغم$^{-1}$جبس خلال الموسم الخريفي2020 ، لدراسة تأثير مستوى واسلوب الاضافة في الاستهلاك المائي و كفاءة استعمال المياه وحاصل البطاطا. تم الارواء عند نسب استنزاف 40%و50% و60% من الماء الجاهز, تم اضافة عمق الرية بثلاث اساليب وهي اضافة كامل عمق الرية واضافة نصفية تضمنت اضافة نصف عمق الرية وبعد 6 ساعات اضيف النصف الاخر واضافة ثلاثية تضمنت تقسيم عمق الرية الى ثلاث دفعات تفصل بين كل دفعة والدفعة التي تليها مدة 6 ساعات. وزعت المعاملات وفق القطع المنشقة بتصميم القطاعات العشوائية الكاملة وبثلاث مكررات. زرعت تقاوي البطاطا صنف سافران بتاريخ 2020/9/13 تم جدولة الري باستعمال حوض التبخر صنف A اعتمدت رطوبة التربة المقاسة حقلياً في حساب حجم المياه وتوقيت الري باعتماد بيانات حوض التبخر. حسب الاستهلاك المائي والحاصل الكلي وكفاءة استعمال المياه. أظهرت النتائج زيادة في استهلاك المياه مع انخفاض نسبة استنزاف رطوبة التربة ، اذ بلغت أعلى قيمة للاستهلاك المائي 324.13 مم عند نسبة استنزاف 40٪ من الماء الجاهز. بينما انخفض إلى 293.61 مم عند استنفاد 50٪ و 60٪ بمعدل تناقص بلغ 9.41٪ . بلغ معدل الإنتاج الإجمالي عند استنفاد 40٪ من المياه المتاحة 22.73 طن هكتار$^{-1}$، كما بلغ معدل الإنتاج الكلي وكفاءة استخدام المياه عند الاضافة ثلاثية 23.90 طن هكتار$^{-1}$، 14.17 كغم م -3 على التوالي.

الكلمات المفتاحية: ترب صحراوية, محصول البطاطا, ترب جبسية, جهد الماء

Received: 28/6/2022, Accepted:4/9/2022

INTRODUCTION

Water resources occupy a privileged place among natural resources and play an essential role in human life and environment. Water is the determinant of agricultural production in many regions of the world where water resources are scarce, and the shortage and limited availability of arable water sources are a major problem in providing food security requirements to meet the increase in the population census (15). The development of modern irrigation methods and techniques to bridge the gap between freshwater availability and food security, on the other hand, requires that the use of available water is a real goal to focus on in order to exploit the largest area of arid and semi-arid region in the development of agriculture (9). The importance of water consumption studies in Iraq is highlighted by the fact that it falls within the arid and semi-arid region, as irrigation is more important because of the inadequacy of rainwater falling under conditions of arid and semi-arid region and water scarcity, which negatively affects the water resources needed to meet crop requirements, so water exploitation requires efficient and effective utilization as much as possible, and the identification of the water needs of different crops is the first and important stage of planning for optimum management of available water. The limited and availability of freshwater has prompted researchers to work on ways and practices in the field of irrigation (14). Water consumption is defined as the total amount of water consumed by the plant system lost from the soil surface by the evaporation process, lost from the vegetative part of the plant by the transpiration process, and the amount of water used to construct the plant's own fabric), and can to say that water consumption is equivalent to evapotranspiration (ET) when the amount of water in the plant at the end of the season does not exceed 1% of the total loss by evaporation and transpiration over the season, and water consumption can be estimated in direct and indirect ways (18). The introduction and investment of new land in agriculture requires estimating the actual water requirements of crops (1). There was a variation in the rate of water consumption of the potato plant planted in autumn season and for different stages of growth, calculated relying on evaporation from the evaporation pan (2). The amount consumed by the plant at the beginning of the growth season was low compared to the progress of the plant growth stages and then decreased with water consumption at the end of the season, with water consumption at the beginning of the growth season of 106.52 mm month of October represents a total of 26 days, while it reached 197.91 mm 1-month November represents a total of 27 days, either in a December the water consumption rate reached 162.12 mm represents a total of 28 days (7, 8, 19). Sodigand Al-Skibli Found differences in the water consumption rate of the potato 216.7, 213.2 and 211.6 mm for the treatment of incomplete irrigation at the stage of vegetative growth emergence of tubers and bulging tubers as sequence compared with the treatment of full irrigation received the highest water consumption rate of 220.9 mm (16). This study was aimed to calculate the water consumption of potato under impact of moisture depletion and irrigation management on potato yield and water use efficiency.

MATERIALS AND METHOD

A field experiment was carried out at desert soils with sandy clay loam containing 58.9 g kg^{-1} gypsum during the autumn season 2020, in AL Ramadi district/Anbar province/ western Iraq. The soil described morphology and was classified under the great group Typic Haplo, Gypsid by American Classification System (20). Samples of the field's soil were taken from different regions and randomly and at a depth of 0-0.30 m physical and chemical analysis (table 1) according to the standard methods mentioned in (10).

Table 1. Some physical and chemical properties of the soil before planting

No.	property	Quantity	Units	No.	Property		Quantity	Units
1	Sand	528	$gm.Kg^{-1}$	11	pH		8.1	$Ds.m^{-1}$
2	Silt	232		12	EC		3.5	
3	Clay	240		13	Dissolved Cation	Ca^{2+}	5.125	$Meq .L^{-1}$
4	Texture	Sandy Clay Loam				Mg^{2+}	3.25	
5	Bulk Density	1.28	$Mgr.m^3$			Na^+	7.04	
6	saturated water conductivity	7.28	$cm.h^{-1}$			K^+	0.61	
7	Wet soil moisture content 33 kpa	24.74	%	14	Dissolved Inion	SO_4^{2-}	7.25	
	Wet soil moisture content 1500 kpa	9.56				HCO_3^-	2.0	
8	Available Water	15.18				CO_3^{2-}	Nill	
9	Gypsum ($CaSO_4$)	58.9	$gm.Kg^{-1}$			Cl^-	10.0	
10	Lime ($CaCO_3$)	175						

properties of irrigation water were estimated according to the methods proposed by the American Salinity Laboratory and were show in table (4).

Table 2. Chemical properties of irrigation water

EC $Ds.m^{-1}$	pH	Dissolved Ion $meq.L^{-1}$ Ca^{+2}	Mg^{+2}	Na^+	K^+	Cl^-	SO_4^{-2}	HCO_3^-	$CO_3^=$	NO_3^{-2} Ppm	SAR	Class
1.25	7.5	1.0	4.0	3.86	0.14	4.0	5.4	2.0	0.0	2.10	2.44	C_3S_1

The experiment included the study of water stress and the method of addition of irrigation water, which used three water depletion 40, 50 and 60% depletion, irrigation was scheduled based on aus class A pan evaporation, and irrigation water was added with three methods is complete addition of irrigation depth, half addition included adding half of irrigation depth and adding another half after 6 hours and third addition division to three parts at duration of 6 hours The experiment was carried out at a land of 35 x 22 m, with adjustment processes, then the Earth ploughed by the tipper plough (moldboard) and the soil Grace, the field section to three blocks 10 × 19.3 m and leave a distance of 2.5 m (guard area) between blocks and another, Divide each blocks to three main plot with dimensions of 10 × 5.1 m, leaving a distance of 2 m between one piece and the other distributed the soil moisture depletion ratios randomly, divided each major plot into three beds length 10 m and width of 0.7 m and Left a distance between the bed and another 1.5 m distributed coefficients of random addition on the plot. Potato tubers have been planted (*Solanum tuberosum L.*) Safrane Average early grade A in 13/9/2020 at 0.08-0.10 m depth. After being immersed for 15 minutes with a revanol solution with a concentration of 100 ml/100 liters of water as a sterile substance for tubers against fungal infections (5). At the rate of 25 tubers for the experimental unit, 0.4 m between one to another tubercle and at a interval of 2.2 m between the planting line and the other, to become total number of tubers 675 tuber and equivalent to 11363 h^{-1}gave of germination date 13/9/2020 to deliver soil moisture to the field capacity limits use the A-class evaporation pan to schedule irrigation. Fertilizer was added according to the recommendation (11) at the rate of 240, 120 and 400 kg ha^{-1} N, p and K in respectively, where it was added in two stages, including the first stage on the entire recommendation of the phosphorus element and 50% of the recommendation of nitrogen before planting mixing with the surface layer of the soil, and the whole potassium recommendation and the remainder And Jan was added a month after the dawning. The management were conducted by chemically removing the bushes before dawning using the Roundup 50 ml^{-1} once, and then by manually at a rate of once every two weeks according to (6). Irrigation has been scheduled for all experiment treatments since the start of the vegetative growth phase on 2020/10/14 based on the stages of potato plant growth, and each treatment has received the amount of water calculated on the basis of the proportion of soil moisture deficit for each treatment. indirectly by relying on the depth of water evaporated from the pan evaporation and reverse from the calculation of the depth of water to be drained from the soil (d) for any depletion ratio to the value (E pan) to be evaporated from the pan to tell which rewards the moisture consumed in a way that is not directly and as explained in the following equations:

$$\boldsymbol{\theta wi = (\theta fc - (\theta Aw * dp)) \ldots\ldots\ldots\ldots (1)}$$

As that:

Ɵwi = soil volumetric moisture in irrigation(%). Ɵ AW = available water for plant(%).

Dp = moisture depletion(%). Ɵ fc = soil volumetric moisture at field capacity (%).

The depth of the water to be added to the soil (d) was calculated as follows:

$$\boldsymbol{d = \frac{\theta f.c - \theta wi}{100} * D \ldots\ldots (2)}$$

As:

d = depth of water to be added to the soil (cm), which is equivalent to actual water consumption (Eta).

D = effective depth of the root group (cm).

reference Evapotranspiration (ET_0) was calculated according to the equation mentioned in (2) as follows:=

$$\boldsymbol{ETo = \frac{ETa}{Kc} \ldots\ldots\ldots (3)}$$

As:

reference Evapotranspiration, mm^{-1} day. and **ET_a**: actual Evapotranspiration, ======mm^{-1} day.

: The coefficient, and the values 0.75, 1.15, 1, and 0.8 mentioned in (17) were used to represent the yield coefficient of the vegetative growth stage, growth of tubers, bulging tubers and maturity respectively. The irrigation was timed by finding the value of Epan, which is equivalent to the required drain rate according to equation (1):

$$\boldsymbol{Epan = \frac{ETo}{Kp} \ldots\ldots\ldots (4)}$$

As:

E_{pan}: Depth of the water (mm) to be evaporated from the evaporation pan until watered, which represents moisture depletion.

Kp: coefficient for evaporation pan and varies according to the type of pan, the vegetation surrounding the pan and the nature of the soil surface (3). The value of 0.8 was adopted in this study, according to what mentioned (6). The stages of crop growth were divided according to what he mentioned (19) into four stages.Then the total yield after the harvest was calculated on 29/12/2020. The results were statistically analyzed using the (Genstat) program, according to the method of analysis of variance and according to the significant differences between the treatments at the level of significance 0.05 for the least significant difference (L.S.D).

RESULTS AND DISCUSSION

Water consumption rate (mm)

Figure 1 shows the effect of the ratio of moisture depletion on the water consumption rate of the potato during the growth season, as the rate of water consumption decreased with increased water stress and reached the highest value for water consumption of 324.13 mm per plant when treatment of drain 40% of available water and reached 300.32 and 293.61 mm per plant at 50% and 60% in respectively, when comparing treatment we find that the rate of water consumption in the treatment of 50% depletion of available water decreased by 7.34% compared to 40% depletion and decreased when 60% of the available water was depleted by a decrease of 9.41 % compared to a 40% depletion treatment as water consumption decreased from 300.32 mm per plant when treating a 50% depletion to 293.48 mm per plant when a 60% depletion rate was treated with a decrease of 2.23% and this corresponds to (4), due to the increase in the moisture depletion rate has led to an increase irrigation interval and other resulting in a reduction in the number of irrigation during the season when treated the drain 50 and 60% table 3 compared to the number of the rats when treatment drain 40% (16).

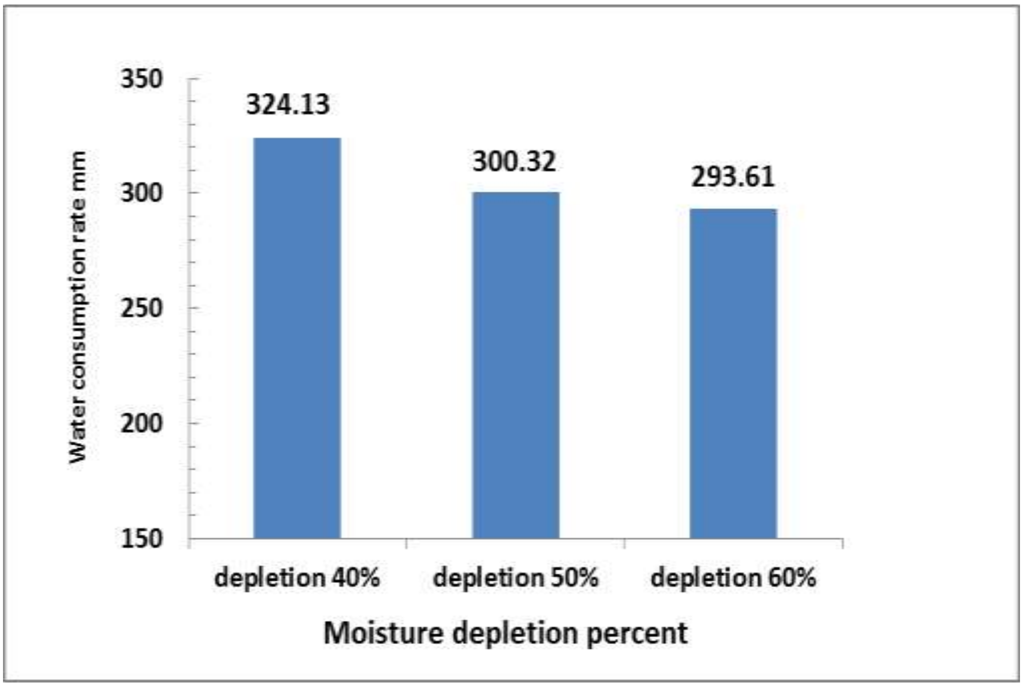


Figure 1. Effect of study moisture of depletion rate on the water consumption (mm per plant)

To note from table 3 that irrigation when draining 50% of the ready water resulted in a quantity of irrigation water reached 132.93 m^3 compared with the treatment of irrigation at the depletion of 40% and an increase of 8.04%, this water can be exploited in other areas of 0.080 ten h^{-1} and rewards total productivity of up to 1.53, 1.71 and 1.9 1 ton ha^{-1}. If these water is added in a complete addition, a half addition and a triple addition, the results of the statistical analysis proved the morale of this productivity, while the treatment of draining 60% of the irrigation water amounted to 170.53 m^3 compared with a 40% depletion treatment with an increase of 10.55% as can be yields in an area of 0.105 hectares rewards total productivity of up to 1.99, 2.15 and 2.29 tones ha^{-1}, When these water is added in a complete addition, a half addition and triple addition respectively, and by morale differences according to the results of the statistical analysis, also provided a treatment depletion 60% of the water of irrigation reached 37.60 m^3 compared to a 50% depletion treatment with a 2.32% increase to exploit a new area of up to 0.023 $hectares^{-1}$, equivalent to a total productivity of 0.44, 0.47 and 0.50 t ha^{-1}, when added with complete addition and double and triple addition respectively.

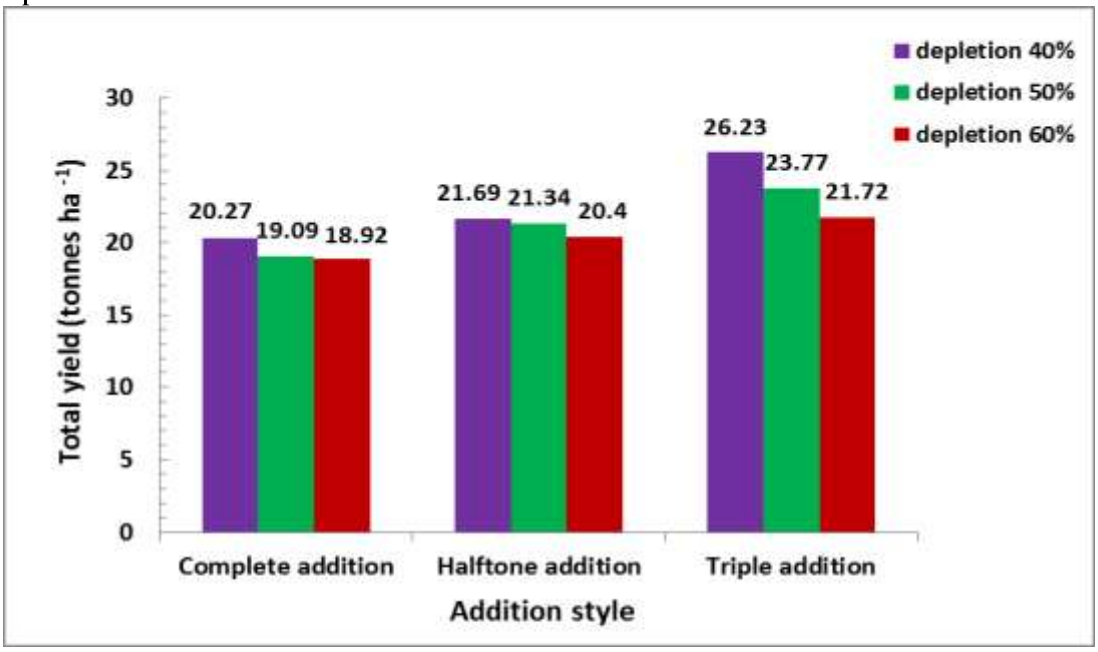
Total yield (t. ha^{-1})

Fig. 2 refers to the effect of water stress on yield values, as the overall yield decreased by increasing water stress and the total yield rate was 22.73 ton ha^{-1} when 40% of the available water was drained and 21.40 tons ha^{-1} were depleted at 50% and 20.34 tons ha^{-1} when 60% of the pain was drained Ready, perhaps because of the closeness of the moisture depletion ratios to each other, as well as limiting the role of plant life (the average of early), thus saving the size of irrigation water at high attrition rates without a moral decline in total yield.

Table 3. Depths and volumes of added water according to stages of growth with depletion ratios (60,50,40%).

Stage	Duration of the stage (day)	Depletion ratio	Root depth (cm)	Added water depth	depth of leaching requirements (mm)	number of irrigations	Volume of added water (m^3. ha^{-1})
From agriculture to field emergence	30	50%	12	11.60	0.72	13	820.43
growth Vegetative	17	40%	20	15.66	0.97	2	174.57
		50%		19.58	1.22	2	217.54
		60%		23.49	1.46	2	260.51
emergence of tubers	20	40%	25	19.74	1.23	2	220.22
		50%		24.67	1.54	2	273.94
		60%		29.61	1.85	2	330.34
Bulging tubers	27	40%	30	24.40	1.52	3	406.88
		50%		30.51	1.90	2	341.08
		60%		36.61	2.28	1	204.11
Maturity	7	40%	35	29.33	1.83	1	163.82
		50%	—	—	—	—	—
		60%	—	—	—	—	—
Total	91	40%		324.13	20.15	21	1785.92
		50%		300.32	18.68	19	1652.99
		60%		293.61	18.26	18	1615.39

Figure 2 Indicates the effect of the addition method on the total yield values, as the overall yield increased morally by the adoption of the depth of the deorbit, and the highest rate for the total holder was 23.90 tons ha^{-1} at the triple addition of 21.14 tons ha^{-1} in the Half addition, and decreased to 19.42 tons ha^{-1} in the complete addition methods coefficients Full, the reason for the efficiency of the triple and half way addition is due to the rationalization of water and the giving of the best physical qualities the recipes of growth and the melting of nutrients throughout the period between the rate and thus increased productivity (13).

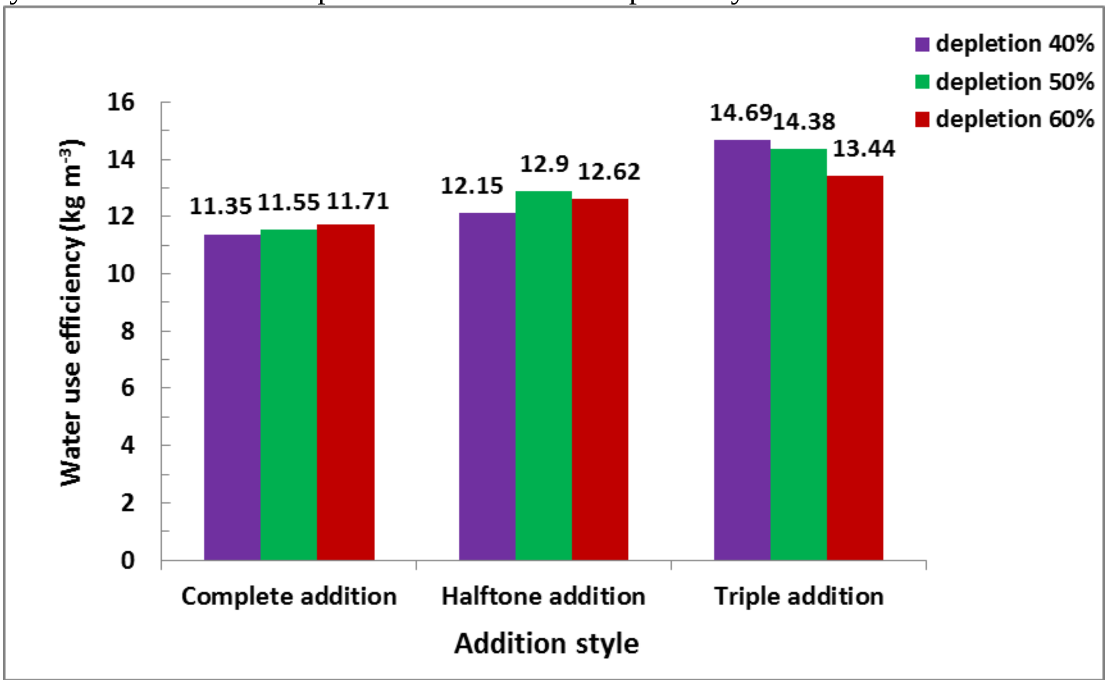


interference	Addition style	Depletion ratio	L.S.D
NS	1.351	1.368	0.05

Figure 2. The effect of water addition method and depletion rate on the total quotient (tons h^{-1}).

Water use efficiency

Figure 3 shows the effect of the study treatments on the water use efficiency values as it is clear that efficiency of water use has increased significantly with the increase in the percentage of moisture depletion at the two methods of complete and clear addition only, as the lowest value reached 11.35 and 12.15 kg m^3 when the depletion of 40% of the available water reached 11.55 and 12 .90 kg m^3 when depleting 50%, while the highest values reached 11.71 and 12.62 kg m^3 when depleting 60% of the water available for complete and half addition method in respectively, while the opposite occurred in the triple addition method, as the highest value when depletion reached 40% and then reduced Efficiency of water use morally with increased moisture depletion, as it reached 14.69, 14.38 and 13.44 kg m^{-3} The depletion rates are 40%, 50% and 60% in succession, and the reason for this is due to the decrease in the volumes of added water by the increase in the depletion rates of moisture during this season in the case of complete and clear addition (11), but in the case of triple addition, which received the same volume of added water at my full and cleared method as It reached a maximum of 14.69 kg m^{-3} when depleting 40%, while it decreased to 14.38 and 13.44 kg m^{-3} when depleting 50% and 60%, respectively. It gave the highest productivity (1) and consequently high water use efficiency, so at comparison of the increase in the rate of productivity increase in the triple addition treatment when treating a depletion of 40% with its values when the drain 50 and 60% reached 10.34% and 20.76% respectively. The increase in the production rate exceeded between the depletion rates of 40 and 60% to twice that of the depletion between 40 and 50% . While we find the percent of increase in productivity in the treatment of complete addition when depleting 40% compared to its values when depleting 50 and 60%, it reached 6.18% and 7.13%, respectively.



interference	Addition style	Depletion ratio	L.S.D
0.1961	0.1220	0.1328	0.05

Figure 3. The Effect of water addition method and depletion rate on Water Efficiency (kg m^{-3})

Figure 3 shows a significant increase in water use efficiency, as the highest values were 14.69, 14.38 and 13.44 kg m^{-3} for the triple addition and the lowest values were 11.35, 11.55 and 11.71 kg m3 - at full addition, while at the half addition 12.12 and 12.90 and 12.62 kg m^{-3} for depletion rates of 40%, 50 and 60% respectively, due to the efficiency of the half and triple addition method in maintaining an appropriate level of soil moisture throughout interval of irrigation. water rationalization and availability of nutrients, thus increasing productivity (1). This is in addition to the increase in moisture retention for a longer period, which reduces the stress strength of the soil structure dominated by the tubers, which gave a greater opportunity for the tubers to grow and increase their size better compared to the full addition, which made the triple addition treatment superior to giving the highest rate of any deficit rate. Results included highest water consumption when irrigated reached 40% of the available water, while the lowest water consumption when using the depletion treatment reached 60% of the available water. Irrigation when the depletion reached 60% saved from the irrigation water compared to the treatment of depletion of 40 and 50% of the water available for the plant. We recommend to the irrigation when 40% is depleted in gypsum soils, not to expose the plant to water stress, and adopting a three-way additive method for the net irrigation depth, because of the moisture it provides for a longer period and not wasting added water.

REFERENCES

1. Al-Ani, M. Y. 2016. Estimating the Water Consumption by Different Methods of Calculating the Growth and Yield of Potatoes Under the Drip Irrigation System. M.Sc. Thesis, Dept. of Soil Science. and Water Resources. Colle of Agri., Univ. of Anbar. pp.116.

2. Al-Dulaimi, N. H. A, and N. J. K. Al-Amri.2020. Impact of *Conocarpus erectus* L. fertilizer ,and some micronutrients on growth and production of potato . Iraqi Journal of Agricultural Sciences. 51(3):865-873. https://doi.org/10.36103/ijas.v51i3.1041

3 Al-Hadithi, I. K, A. M. Al-Kubaisi and Y. Khudair. 2010. Modern Irrigation Technologies and other Topics in the Water Issue. Ministry of Higher Education and Scientific Research. Coll. of Agri., Univ.of Anbar.

4. Al-Janabi, K. H. 2012. Effect of Drip Irrigation, Organic Fertilizing and Covering on Potato Growth and Yield (*Solanum tuberosum L*). Ph.D. Dissertation. Dept. of Soil Scie. and Water Resources., Coll. of Agric., Univ. of Baghdad. pp 162

5. Al-Jodhury, Y. 2011. The Effect of Fertilizer Sources and Levels, Irrigation Methods and Growth Potato Holder (*Solanum tuberosum L.*). Ph.D. Dissertation. Dept. of Soil Scie. and Water Resources .,Coll. of Agric., Univ. of Baghdad pp.95

6. Al-Muhammadi, M. H. 2011. The Effect of Spotting Drainage and Salinity of Irrigation Water on Some Physical Properties of Soil, Saline Distribution, Potato Growth and Yield. PhD Dissertation. Dept. of Soil Science. and Water Resources., Coll. of Agric., Univ. of Anbar.pp 112

7. Al-Rubaie; A. H. S. and K. D. H. Al-Jubouri. 2023. Effect of tocopherol, trehalose and soil improvement in water productivity and industrial potatoes under water stress. Iraqi Journal of Agricultural Sciences, 54(4):979-995. https://doi.org/10.36103/ijas.v54i4.1787

8. Al-Rubaie; A. H. S. and K. D. H. Al-Jubouri. 2023. Response of growth and yield of industrial potatoes to soil improvement and spraying with tocopherol and trehalose under water stress. Iraqi Journal of Agricultural Sciences, 54(4):963-978. https://doi.org/10.36103/ijas.v54i4.1786

9. Al-Shamari, M. F B. A. A. H. Alkhateb, and S.A.W.Mahmoud. 2020. Role of compost and irrigation water quantity on some physical properties of soil under surface , subsurface drip irrigation . Iraqi Journal of Agricultural Sciences, 51 (5) 1300-1307. https://doi.org/10.36103/ijas.v51i5.1137

10. Black, C.A. and et .al .1965. Methods of soil analysis, part (1). Agron. No. 9. Am. Soc. Agron, Madison, WI (USA).

11. Fadli, J. T Mahmoud. 2006. The Effect of Adding P K N to Soil and Spraying on Potato Growth, Yield and Components .M.Sc. Thesis. Dept. of Soil Scie. and Water Resources. Coll. of Agri., Univ. of Baghdad. pp 175

12. Fouda, T. A. and E. ALI. 2012. Response of potato to nitrogen and water deficit under sprinkler irrigation. Scientific papers Series Management, Economic Engineering in Agriculture and Rural Development Vo.12 :77-82

13. Hisham, B. A. A and et.al. 2016. Measurement of water consumptive use, growth, and yield of potato (*Solanum tuberosum* L) under drip irrigation system. Anbar Journal of Agricultural Sciences. 14(2): 36-52

14. Mehmdy. M , and et.al . 2020. Performance field evaluation of drip irrigation

systems under conditions of desert region in western Iraq. Iraqi Journal of Agricultural Sciences, 51(1):392-400. https://doi.org/10.36103/ijas.v51i1.938

15. Qadir, M et al. 2006. Agricultural Water Management. (In press).

16. Roderick, M. L. and G. D. Farquhar. 2002. "The cause of decreased pan evaporation over the past 50 years". Science 298 (5597): 1410-1411.

17. Sadiq, M. H and T. Y. Al-Shibli. 2013. The effect of under irrigation on water consumption and growth. Potato holder, Solanum tuberosum L., Al Furat Journal of Agricultural Sciences. 5(4): 120-134

18. Shiri-e-Janagrad, M. A. and et.al. 2009. Potato Response to drip irrigation regimes and plant arrangements during growth periods. Asian J. of Plant Sciences. V (8). Issue: 6 P: 390-399.

19. Taif, N.I. and I. K. Al-Hadithi. 1988. Irrigation basics and applications. Ministry of Higher Education and Scientific Research .University of Baghdad - College of Agriculture.pp 241

20. Thomas, F. S; F. Dave, L. James, L. Art, A. Dwight, A; Duane, and A. P. Duane, 1999. Growing irrigated Potatoes. NDSU. University of Minnesota, East Grand Fork, MN.