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EFFECT OF METHODS AND LEVELS OF IRRIGATION AND FARMING SYSTEMS ON WATER PRODUCTIVITY, GROWTH AND YIELD OF CUCUMBERS (*CUCUMIS SATIVUS* L.) AND ZUCCHINI (*CUCURBITA PEPO* L.)

Dergham Munther Jalil[1,*], A. Saleh Atee[2] and Hammed Kadhum Abd-Al-Ameer[1]

[1*]Al- Mussaib Technical College, Al-Furat Al-Awsat Technical University, Babylon Province, Iraq.
[2]College of Agricultural Engineering sciences, Baghdad University. Baghdad province, Iraq.

Abstract

Three field experiments were conducted in Al-Buamer region, Al-Yousifiya sub-district, Baghdad province during the agricultural season 2019. The study aims to know the effect of three methods of irrigation, which are surface irrigation, drip irrigation, surface drip irrigation, subsurface drip irrigation, and three levels of humidity (35, 50, 65%) and their interaction with two farming systems (single and intercropping) for both cucumber and zucchini crops. The treatments of each experiment were cultivated separately using Split-Plot Design according to The Randomized Complete Block Design (RCBD), with three replicates. cucumber seed (Ghzeer cultivar) and zucchini seeds (Fouadi cultivar) were cultivated on 1/4/2019 and the irrigations of germination were given by surface irrigation on 1-15 / 4/2019 and the first harvest was on 5/15/2019 and the harvests continued to the date of 7/15/2019 for zucchini by the single farming system and to date 1/8/2019 for cucumber by the single farming system and by the single and intercropping farming system for cucumber and zucchini. The process of evaluating the soil moisture content has been conducted continuously throughout the experiment period, while the moisture content of the soil indicates to the depletion of 35, 50, and 65% of the available water. Irrigation is conducted by adding the depth of water needed to reach the moisture content at the field capacity for the field soil using the moisture tension curve of the soil and by the gravimetric method. The efficiency of water productivity and leaf area ($dm^2.plant^{-1}$), plant lengths (cm) and the number of branches($branches.plant^{-1}$) were estimated, and the total fruit yield ($Mag.ha^{-1}$) for all experimental unit and with cumulatively, the results showed the following: 1. The best water consumption rate in the single farming system for cucumber plants amounted to (325, 297, 264 $mm.season^{-1}$) for the treatments of surface irrigation, drip irrigation, and subsurface irrigation, and for the zucchini plant amounted to (299, 270, 239 $mm.season^{-1}$) and for the same above irrigation treatments respectively. 2- The intercropping farming system for cucumber and zucchini gave the highest water consumption rate amounted to (308, 283, 252 $mm.season^{-1}$), respectively for surface irrigation, drip irrigation, and subsurface irrigation. 3. The best average of water productivity by the single farming system for the cucumber plant amounted to (4.97 $kg.m^{-3}$) at a moisture level of 35% of available water. As for the zucchini plant, it amounted to (6.68 $kg.m^{-3}$) for the same farming system and the same level of moisture depletion. 4. The treatment of subsurface drip irrigation gave the highest water production efficiency for cucumber plants at the single farming system amounted to (4.97 $kg.m^{-3}$) at the level of moisture depletion 35% of the available water. The same treatment and the same moisture level for zucchini gave the highest rate amounted to (6.68 $kg.m^{-3}$).

Key words : surface irrigation, drip irrigation, subsurface irrigation, zucchini, and cucumber.

Introduction

Water is considered the specified component of agricultural development, and agriculture is the largest consumer of water and because micro-irrigation is the most important vital field in the development of agriculture in the world today, the main driver for using modern technologies in irrigation is the need to increase global food production, adding new lands and reducing Water wastes and increasing the efficiency of using irrigation water. These modern technologies for irrigation methods

***Author for correspondence :** E-mail: dhurgham.9870@gmail.com

require a high level of culture, skill, ability, and good management to control irrigation operations in order to face the scarcity of water. Irrigation methods are divided into traditional irrigation methods such as surface irrigation and modified irrigation methods such as spraying irrigation, surface drip irrigation, and subsurface drip irrigation. Surface irrigation is considered a popular and easy method with low starting costs, It is preferable to use it for soil that has good water storability and has a low permeability such as clay soil and loam. However, due to what is happening from wasting water through runoff, evaporation, and deep percolation, this makes it of low use efficiency. The drip irrigation system provides a greater possibility to control the added water than surface irrigation, where Stykers, (2001) described that the drip irrigation system is characterized by reducing the amount of water loss or the occurrence of runoff because the rate of added water is less than the Infiltration rate. surface irrigation is considered one method of storing water, with low permeability, easy and with low starting costs. It is used for irrigation soil with good water storability and low permeability, as well as environmental conditions appropriate for the region. The irrigation scheduling has an important role in determining the amount of water added during the season to achieve when to irrigate and how much to irrigate in order to obtain an appropriate irrigation separator and the appropriate amount of water according to the stages of plant growth. Irrigation practices in the field aim to provide the appropriate quantities of water in the soil to provide the plant with its water needs and to deliver the moisture content in the soil to the limits of field capacity by adopting the moisture description curve to make it accessible to the plant. The degree of yield and productivity of the crop depends on the homogeneous distribution of soil moisture in the root zone. Testing the homogeneity of irrigation water distribution and irrigation efficiency requires identifying the distribution of moisture in the soil due to the fact that adding small amounts of water is not sufficient to deliver soil moisture to the limits of field capacity, making the plant benefit from it limited. intercropping farming is the cultivation of two or more crops on the same land simultaneously. Among the benefits of nested cultivation is the dynamic interaction between interfering crops, which leads to more efficient use of energy and building resources. It also benefits such agricultural systems in controlling the weeds and diseases associated with crops. It also aims to improve the quality and nutritional value of the total crop. in addition to increasing the economic returns from the land unit, which increases the income of farmers and encourages them to use this system of agriculture (Malezieux *et al.*, 2009). Soil and water management programs are considered an important aspect in this field, in particular choosing the appropriate irrigation method that achieves water use and maintains good physical properties of soil as well as providing appropriate conditions for plant growth ‘in addition to choosing the method of cultivation and crop. Due to the lack of applied field studies, this study was conducted by adopting three methods of irrigation, namely, surface irrigation and subsurface drip irrigation and three levels of moisture (depletion of available water) and their interaction with single and intercropping farming systems for both cucumber and zucchini crops, the study was conducted to achieve the following objectives:

1. Measuring the water consumption for cucumber and zucchini crops under the surface irrigation system, drip irrigation, and subsurface drip irrigation, the levels of irrigation (depletion of available water), and single and intercropping farming system.
2. Determining the best irrigation system and the most appropriate level of irrigation to obtain the best growth and yield and calculating water productivity under farming systems.

Materials and Methods

Location and study soil

Three field experiments were conducted in Al-Buamer region, Al-Yousifiya sub-district, Baghdad province (44 18 ‘75’ ‘E and 33 07’84' N; 34.1 m above sea level) during the agricultural season 2019. Field soils were described as morphology and then classified using the USDA system which classified under the Great group (Typic Torrifluvent) according to (Soil Survey Staff, 2014).

Preparing land and cultivation

The experiment was conducted on a land area with the area (1155 m^2), its dimensions are (105 m x 11 m). The land plowed with moldboard plow, perpendicular tillage with a depth of 0.25 m. The treatments of irrigation method (surface irrigation, surface drip irrigation, and subsurface drip irrigation with a depth of 20 m) occupy main plots, the level of depletion in sub-plot, and the farming method occupy sub-sub-plot. The specific area of the experiment was divided into three main sectors and each sector represents the implementation of an independent experiment for the irrigation system. The single sector was divided into three sectors, each of which represents the level of moisture depletion, which is 65%, 50%, and 35% of available water, and each level of depletion contains three replicates and each replicate contains three experimental units representing the farming method. The area of one experimental unit (the terrace) amounted to 3 m (1 m width x 3 m length), leaving a distance of 2 m between one sector and another and 2 m between one replicate and another and 1 m between one experimental unit and another to prevent the depletion treatments from overlapping with each other. Thus, the number of experimental units is 81 experimental units. cucumber seed (Ghzeer cultivar) and zucchini seeds (Fouadi cultivar) were cultivated on 1/4/2019 and the irrigations of germination were given by surface irrigation on 1-15 / 4/2019. The seeds were planted on the two terrace lines in the case of single farming for the same crop and on two lines, one of which represents the cucumber crop and other the zucchini on both sides of the terrace at the intercropping farming system, the distance from one plant to another is 0.40 m. The weeding process was performed manually and periodically for all treatments, and the control was conducted with Acaricide and downy mildew pesticides (100 ml / 50 L of water with two batches), 80 kg.ha-1of TSP (P 20%) was added in one batch before planting by pruning. Urea fertilizer (46% N) was added in one batch with a fertilizer recommendation of 50 kg.ha^{-1} (Ali, 2012). The first harvest was on 5/15/2019 and the harvests continued to the date of 7/15/2019 for zucchini by the single farming system and to date 1/8/2019 for cucumber by the single farming system and by the single and intercropping farming system for cucumber and zucchini.

Describing the drip irrigation system

The irrigation system consisted of a 100 m^3 water tank that draws water from the tank using a gasoline-powered water pump followed by the control unit, which contains valves to open and close the water and it controls the drainage of water and devices for measuring pressure and water meters. The drip irrigation system used in the study consisted of:

1. 2 horsepower water pump
2. Filter to filter water from impurities
3. Water withdrawal and drainage pipes
4. The operating pressure reading gauge is attached to the system main tube
5. The distribution network consists of:

A. Main tube: It is a plastic tube with a diameter of 1.5 inches to distribute water to the experimental units.

B. Drip pipes to distribute water within experimental units (plots) with a diameter of 0.5 inches, on which GR type spots are distributed, the distance from one drop to another 0.40 m, in order to obtain the required plant density.

4. Describing the surface irrigation system

The surface irrigation system consisted of:

1. 2 horsepower water pump
2. Main tube: It is a tube with a diameter of 1.5 inches
3. Sub-tubes: They are plastic tubes with a diameter of 1.25 inches, for easy transport between experimental units in order to control the amount of added water.

Irrigation water productivity

Water productivity was calculated according to the formula mentioned in (Allen *et al.,* 1998).

Water productivity (kg.m^{-3}) = Yield / the depth of added irrigation water

Results and Discussion

Table 1 indicates the effect of irrigation methods and levels of moisture depletion on the seasonal consumption values for the cultivated cucumber plant with a single farming system, where it is observed that there are noticeable differences in the seasonal water consumption values for the cucumber plant under different irrigation methods, where the highest water consumption of the cucumber plant was at the treatment of surface irrigation which amounted to (325 mm.season^{-1}) followed by the treatment of surface drip irrigation amounted to (297 mm.season^{-1}), then the treatment of subsurface drip irrigation amounted to (264 mm.season^{-1}) and the percentage of decrease in seasonal water consumption was 8.62% and 18.77% at the method of drip irrigation and subsurface drip irrigation, respectively compared to the surface irrigation system.

Table 2 indicates the effect of irrigation methods and levels of moisture depletion on the seasonal consumption values for the cultivated zucchini plant with a single farming system, where it is observed that there are noticeable differences in the seasonal water consumption values for the zucchini plant under different irrigation methods, where the highest water consumption of the zucchini plant was at the treatment of surface irrigation which amounted to (299 mm.season^{-1}) followed by the treatment of drip irrigation amounted to (270 mm.season^{-1}), then the treatment of subsurface drip irrigation amounted to (239 mm.season^{-1}) and the percentage of decrease in seasonal water consumption was 9.70% and 20.07% at the method of drip irrigation and subsurface drip irrigation, respectively compared to the surface irrigation system.

Table 3 indicates the effect of irrigation methods and levels of moisture depletion on the seasonal consumption

Table 1: Effect of irrigation methods and moisture depletion on the seasonal water consumption for cucumber plants with a single farming system.

Irrigation methods	Moisture depletion	The seasonal water consumption	Average
Surface irrigation	35%	360	325
	50%	330	
	65%	286	
Drip irrigation	35%	342	297
	50%	285	
	65%	263	
Subsurface drip irrigation	35%	295	264
	50%	254	
	65%	243	

Table 2: Effect of irrigation methods and moisture depletion on the seasonal water consumption for zucchini plants with a single farming system.

Irrigation methods	Moisture depletion	The seasonal water consumption	Average
Surface irrigation	35%	342	299
	50%	294	
	65%	261	
Drip irrigation	35%	316	270
	50%	253	
	65%	241	
Subsurface drip irrigation	35%	263	239
	50%	234	
	65%	221	

Table 3: Effect of irrigation methods and moisture depletion on the seasonal water consumption for zucchini plants with an intercropping farming system.

Irrigation methods	Moisture depletion	The seasonal water consumption	Average
Surface irrigation	35%	353	308
	50%	302	
	65%	269	
Drip irrigation	35%	327	283
	50%	267	
	65%	256	
Subsurface drip irrigation	35%	279	253
	50%	246	
	65%	234	

values for the cultivated zucchini and cucumber plant with an intercropping farming system, where it is observed that there are noticeable differences in the seasonal water consumption values under different irrigation methods, where the highest water consumption of the zucchini plant was at the treatment of surface irrigation which amounted to (308 $mm.season^{-1}$) followed by the treatment of surface drip irrigation amounted to (283 $mm.season^{-1}$), then the treatment of subsurface drip irrigation amounted to (253 $mm.season^{-1}$) and the percentage of decrease in seasonal water consumption was 8.12% and 17.86% at the method of drip irrigation and subsurface drip irrigation, respectively compared to the surface irrigation system.

The efficiency of water productivity varied according to the irrigation treatment and the levels of moisture depletion as shown in table 4, the subsurface drip irrigation treatment gave the highest efficiency of water productivity amounted to (4.97 $kg.m^{-3}$) at the level of depletion 35% of the available water followed by the surface irrigation treatment, which amounted to (4.26 $kg.m^{-3}$), then the treatment of surface drip irrigation was 3.28 $kg.m^{-3}$ at the same level of moisture depletion (35%) of the available water. The results also show a decrease in water productivity by increasing the level of moisture depletion, where water productivity decreased from 4.26 to 3.82 and 4.04 $kg.m^{-3}$ when increasing the level of moisture depletion from 35% to 50% and 65% of available water at surface irrigation treatment. while water productivity decreased from 3.28 to 2.93 and 2.95 $kg.m^{-3}$ when increasing the level of moisture depletion from 35% to 50% and 65% of available water at surface drip irrigation treatment and the values were similar in the decrease at the treatment of subsurface drip irrigation from 4.97 to 4.63 and 4.34 $kg.m^{-3}$ when increasing the level of moisture depletion from 35% to 50% and 65%, respectively.

The efficiency of water productivity varied according to the irrigation treatment and the levels of moisture depletion as shown in table 5, the subsurface drip irrigation treatment gave the highest efficiency of water productivity amounted to (6.68 $kg.m^{-3}$) at the level of depletion 35% of the available water followed by the surface irrigation treatment, which amounted to (539 $kg.m^{-3}$), then the treatment of surface drip irrigation was 4.01 $kg.m^{-3}$ at the same level of moisture depletion (35%) of the available water. The results also show a decrease in water productivity by increasing the level of moisture depletion, where water productivity decreased from 5.39 to 5.22 and 4.08 $kg.m^{-3}$ when increasing the level of moisture depletion from

Table 4: Effect of irrigation methods and moisture depletion levels on the efficiency of water productivity for cucumber plants with a single farming system.

Irrigation methods	Moisture depletion	The volume of added water	Total yield	The efficiency of water productivity
Surface irrigation	35%	3600	15340	4.26
	50%	3300	12670	3.84
	65%	2860	11560	4.04
Drip irrigation	35%	3420	11210	3,28
	50%	2850	8340	2.93
	65%	2630	7770	2.95
Subsurface drip irrigation	35%	2950	14660	4.97
	50%	2540	11760	4.63
	65%	2430	10540	4.34
LSD				1.122

Table 5: Effect of irrigation methods and moisture depletion levels on the efficiency of water productivity for zucchini plants with a single farming system.

Irrigation methods	Moisture depletion	The volume of added water	Total yield	The efficiency of water productivity
Surface irrigation	35%	3420	18440	5.39
	50%	2940	15340	5.22
	65%	2610	10660	4.08
Drip irrigation	35%	3160	12670	4.01
	50%	2530	10440	4.13
	65%	2410	7380	3.06
Subsurface drip irrigation	35%	2630	17560	6.68
	50%	2340	14460	6.18
	65%	2210	10220	4.62
LSD				1.133

Table 6: Effect of irrigation methods and moisture depletion levels on the efficiency of water productivity for zucchini plants with an intercropping farming system.

Irrigation methods	Moisture depletion	The volume of added water	Total yield	The efficiency of water productivity
Surface irrigation	35%	3530	16770	4.51
	50%	3020	13870	4.60
	65%	2690	12940	4.81
Drip irrigation	35%	3270	12880	3.94
	50%	2670	9800	3.67
	65%	2560	8940	3.49
Subsurface drip irrigation	35%	2790	15560	5.58
	50%	2460	12440	5.06
	65%	2340	11860	5.07
LSD				1.121

35% to 50% and 65% of available water at surface irrigation treatment. while water productivity decreased from 4.01 to 3.06 kg.m^{-3} when increasing the level of moisture depletion from 35% to 65% of available water at surface drip irrigation treatment and the values were similar in the decrease at the treatment of subsurface drip irrigation from 6.68 to 6.18 and 4.62 kg.m^{-3} when increasing the level of moisture depletion from 35% to 50% and 65%, respectively.

The efficiency of water productivity varied according to the irrigation treatment and the levels of moisture depletion as shown in table 6, the subsurface drip irrigation treatment gave the highest efficiency of water productivity amounted to (5.58 kg.m^{-3}) at the level of depletion 35% of the available water followed by the surface irrigation treatment, which amounted to (4.51 kg.m^{-3}), then the treatment of surface drip irrigation was 3.94 kg.m^{-3} at the same level of moisture depletion (35%) of the available water. The results also show a decrease in water productivity by increasing the level of moisture depletion, where water productivity decreased from 394 to 3.67 and3.49 kg.m^{-3} when increasing the level of moisture depletion from 35% to 50% and 65% of available water at surface irrigation treatment, respectively. the values were similar in the decrease at the treatment of subsurface drip irrigation from 5.58 to 5.06 and 5.07 kg.m^{-3} when increasing the level of moisture depletion from 35% to 50% and 65%, respectively. Water productivity increased from 4.51 to 4.60 and 4.81 kg.m^{-3} when the level of moisture depletion increased from 35% to 50 and 65% of available water at surface irrigation treatment. The reason is due to the non-significantly lower productivity of the surface irrigation method compared to the other irrigation method. The results showed that the highest water productivity was at the subsurface drip irrigation method, the surface irrigation method, and then the drip irrigation method. The results also show that the values of efficiency of water productivity decrease with increasing levels of depletion of available water, that is, the low moisture content in the soil. The reason for the increase in the efficiency of the subsurface drip irrigation method compared to the efficiency of surface irrigation and surface drip irrigation is due to the lack of water consumption and high irrigation efficiency. In addition to the homogeneity of irrigation efficiency through the accurate addition to the root zone in each location drip irrigation treatments. Or the reason is due to an increase in production yield versus low water added irrigation, which increases water productivity when cultivating crops and increases production per square meter. Also, it greatly reduces irrigation losses, which will save millions of cubic meters of water annually, so we can say that the relationship between modern messages used in agriculture requires conducting studies that prove the impact of these methods on the field reality and in order to be successful, they must be distinguished in terms of production yield and then economic and studying its effect on productivity (International Telecommunication Union, 2015).

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