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INFLUENCE OF MOISTURE PRESERVATIVES AND IRRIGATION LEVEL ON GROWTH AND YIELD OF CUCUMBER

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Abstract

This experiment was carried out at a loamy sand soil for the spring season 2019, to know the effect of moisture preservatives under the root zone on the growth of the cucumber crop. The experiment included three preservatives, nylon, zeolite and organic fertilizer, three irrigation levels are 25, 50 and 75% of the field capacity humidity in addition to the control treatment. The experiment was factorial according to Randomized Completely Block Design (RCBD), with three replicates. Preservatives were placed below the soil surface with a depth of 0.30 cm. The results showed that the treatment of nylon exceeded the irrigation level by 75% in most yield characteristics (plant length, leaf area, crop yield and chlorophyll content), qualitative characteristics of the vitamin C and total soluble solids, no significant differences appeared between the 50 and 75% irrigation with the treatment of nylon in some of the yield characteristics. Treatment of the irrigation level exceeded 50% of the field capacity with the presence of nylon at the bottom of the root zone on water productivity and recorded the highest average of 31.99 kg m^{-3}, compared to all treatments. Possibility to cut irrigation in half to obtain the same production when placing nylon under the crop root.
***Keywords*:** moisture preservatives, irrigation, cucumber

Introduction

Sandy soil occupies 19% of the arable land in Iraq, it has weak physical properties due to its low water and nutrient retention and tip rate (Al-Rawi, 2016). This soil is distinguished in central and southern Iraq, used for vegetable production, produced when sufficient water humidity is available (Nedawi, 1988). Due to the scarcity of water in Iraq, the imports of the Tigris River decreased by 45% of its annual imports (Al-Badri, 2009), Euphrates River to 30% of its annual revenue (Al-Jabri, 2013). Therefore, the need for adopting moisture preservation techniques in sandy soil has emerged, providing the plant with controlled shares to increase irrigation efficiency, reducing water addition rate to improve crop productivity (Sun *et al*., 2000). SWRT Subsurface Water Retention Technology has been used below the root zone of sandy soils, to increase water holding, and improve the readiness of nutrients, reducing irrigation water by 3-5 times (Smacker *et al.,* 2009), polyethylene is considered as a membrane to hold water in the root zone, provided irrigation water by 20-80% (Smacker *et al*., 2010). Miller and Smacker (2015) explained that this technique is effective in multiplying the moisture content in the root zone by 2.25 million liters of water per hectare annually. Al-Salhi and Al-Tamimi (2017) noted the superiority of the SWRT plastic films over all other treatments, contributed to reducing the amount of irrigation water and increasing the yield of bile. Zeolite (a high-capacity interchangeable mud mineral with broad channels for irrigation water) (Nozari *et al*., 2013), to increase the susceptibility of soils to holding ready water for the plant and raising the readiness of nutrients in the root zone (Sepaskhah and Yoesefi, 2007). The mineral used to improve the susceptibility of the soil to drought resistance by adsorbing water particles in the internal cavities and increasing the nutrients (Pisarovic *et al*., 2003). Use cucumber crop as a growth indicator when using these materials, preparing the soil with different irrigation levels, this study aims to demonstrate the role of moisture preservatives under the root zone in improving the soil's ability to prepare water for plants under different irrigation levels on the growth of the cucumber crop.

Material and Methods

This experiment was carried out at a loamy sand soil for the spring season 2019, to know the effect of moisture preservatives under the root zone on the growth of the cucumber crop. The experiment included three preservatives, nylon, zeolite and organic fertilizer, three irrigation levels are 25, 50 and 75% of the field capacity humidity in addition to the control treatment. The experiment was factorial according to Randomized Completely Block Design (RCBD), with three replicates. Preservatives were placed below the soil surface with a depth of 0.30 cm. The experiment land after plowing, smoothing, and leveling were divided into lines with a length of 3 meters and a width of 0.40 m and a separation of 2.5 m between the lines in all directions. The seeds of a local variety option were cultivate at 23/3/2019 with holes and the distance between holes and another 0.3 m. A full irrigation was given throughout the germination period, then relaxed until after the fourth real paper appeared, the process of preparing the irrigation according to the irrigation levels started, fertilizer plants with mineral fertilizer NPK 20-20-20 according to the fertilizer recommendation of the Iraqi Ministry of Agriculture, and the use of pesticides and fungi to protect plants from injuries, Mix the samples well to obtain a composite sample, it was air dried, sifted from a 2 mm sieve, analyzes of some chemical, physical and biological properties were performed (Table 1).

Table 1: Chemical, Physical and Biological Properties of Soil Samples before Sowing.

Parameters		Unit	Amount
pH			7.43
ECe		$ds.m^{-1}$	3.64
CEC		$Cmol.Kg^{-1}$	6.34
O.M		%	0.75
$CaCO_3$		%	36.01
Dissolved ions	Calcium	mmol/*l*	27.01
	Magnesium		16.3
	Sodium		5.16
	Potassium		1.31
	Bicarbonate		2.51
Available nitrogen		$ml.kg^{-1}$	28.01
Available phosphorus			3.90
Available potassium			223.12

Crop water consumption calculated (evaporation - reference yield), using the modified Bellini-Kredel equation by FAO (Doorendos and Pruitt, 1975), the formula proposed by Shuttleworth (1993) gives the preferred model for this equation, weather forecast data were used for the period from 2004-2016 (Dhi-Qar Governorate), to Determine Evapotranspiration- Refer to Reference Months (March-June), was 3.68, 5.59, 8.70, and 10.65 mm on -1 in succession, crop Coefficient KC 0.40-0.95 depending on the growth stages of (Doorendos and Pruitt, 1975), the irrigation interval was determined 4 days from one irrigation to another at 100% irrigation, determine the depth of irrigation water according to soil moisture measurements using the THREE-WAY METER device, volumetric analysis of soil separators was performed to find the tissue by absorbent method (Day, 1965) described in Black *et al.* (1965). The estimated bulk density in a way cylinder Core Sample, the degree of soil reaction was measured in a 1: 1 suspension of soil: water using a pH-meter (PTR 79) according to Jackson (1958). The electrical conductivity was estimated in the Ece saturated paste extract using the Conductivity Meter according to the method mentioned in Page *et al.* (1982). Cation exchange capacity (CEC) saturation was estimated by sodium acetate (1 mol) and ammonium acetate (1 mol) extraction (Black *et al*., 1965). The organic matter was estimated using the wet digestion method according to the Walky and Black method mentioned in Black, (1965). Ready nitrogen was extracted with potassium chloride solution (2 NM), estimated using the microwave device according to the method described in Page *et al.* (1982). Ready phosphorous was extracted with sodium bicarbonate solution at (pH = 8.5), the color was developed using ammonium molybdate and ascorbic acid as a reducing agent, determined by a Spectrophotometer (Libra S5) biochrom, along a wavelength of 882nm. Ready potassium was extracted with ammonium acetate solution (1 standard), estimated using the AFP100 Flame photometer according to the method described in Page *et al*. (1982). The length of the plant was measured from the stem-contact area to the soil to the top of the plant by means of a tape measure of five plants randomly taken from each experimental unit at the end of the season, the total leaf area was measured for five leaves and five plants randomly taken from each experimental unit at the end of the season, the scanner was used (CI-202 LASER AREA METER). The chlorophyll content in the leaves was determined by the Chlorophyll meter, type SPAD- 502, water productivity was calculated from the following formula:

Water productivity = cucumber crop $kg.\ ha^{-1}$ / volume of added water $m^3.\ ha^{-1}$

The total result ($ton.\ ha^{-1}$) was calculated from the following formula:

$$\text{Total yield}\left(\text{ton.ha}^{-1}\right)=\frac{\text{experimental unit yield}(\text{kg})\times\text{Hectare area}\left(10{,}000\,\text{m}^2\right)}{\text{Experimental unit area}\left(\text{m}^2\right)}$$

The yield of one plant was calculated from the following equation:

$$\text{Yield of plant}(\text{g})=\frac{\text{Experimental unit yield}(\text{kg})}{\text{The plants number in experimental unit}}$$

Statistical Analysis

Data were collected and analyzed statistically using the split-plot arrangement according to Randomized Completely Block Design (RCBD), with three replicates, using SPSS program3, the mean of the treatments was compared using the lowest significant difference LSD at a probability level of 0.05.

Results and Discussions

Plant length (cm. plant^{-1})

The results (Table 2) indicate a significant difference between the irrigation levels, as the irrigation level scored 75%, the highest average was 169.79 cm. plant^{-1}, significantly outperformed the irrigation level 25%, the lowest average score was 72.50 cm. plant^{-1}, while did not notice significant differences between him and the level 50%, recorded an average of 169.48 cm. plant^{-1}, the reason for the increase in the trait of the plant's length may be due to the presence of irrigation water in sufficient quantities, creates a good moisture balance in the root system, nutrients were provided with irrigation water, reflects on the root system, vegetative and increased growth (Mos-hab and Al-Masraf, 2019). As for the soil moisture preservatives, gave the nylon treatment the highest average of 141.47 cm. plant^{-1}, demonstrated superiority over all other treatments, with an increase of 4.39% compared to the comparison treatment, no significant difference was observed between the treatment of zeolite, organic matter, and comparison, which recorded the following rates 136.04, 135.74 and 135.52 cm. plant^{-1}, respectively, the superiority of the treatment of nylon may be due to a course in improving water conditions, by holding water and reducing waste, reducing water losses and homogenizing the moisture distribution in the root zone, the treatment of nylon also contained high levels of nutrients, trapping it within the root zone, agreed with Smucker *et al*., (2015) and Al-Rawi (2016). As for the interaction, the combination between the irrigation level 50% and the treatment of nylon gave the highest mean (175.90 cm. plant^{-1}), no differences were observed between the other combinations, while the mixture between the irrigation level was 25% and the organic matter was the lowest average (72.10 cm. plant^{-1}), it may be attributed the reason for the superiority of this combination, all physiological processes of the plant are affected by the moisture content, readiness of water in the stages of plant growth, the water balance in the soil that makes the absorption process good in the plant, has a significant effect on plant growth and vegetative growth, the presence of the nylon preservative by creating barriers that impede the movement of water down the root zone, increases the soil's ability to retain water (Issa *et al*., 2016).

Table 2 : Effect of irrigation levels and soil moisture preservatives on plant height cm.plant^{-1}.

Irrigation levels	Treatment				Mean
	Zeolite	Nylon	Organic matter	Control	
75%	167.72	175.44	168.20	168.27	169.79
50%	166.97	175.90	168.20	166.87	169.48
25%	72.33	73.87	71.71	72.10	72.50
Mean	135.52	141.47	136.04	135.74	
L.S.D0.05	irrigation levels 1.124		Treatment 1.298	irrigation× Treatment 2.248	

Leaf area (dm^2.Plant^{-1})

The results (Table 2) indicate that there are significant differences between the mean levels of the leaf area, the irrigation level gave 75% the highest rate (20.84 dm^2.Plant^{-1}), which significantly exceeded the irrigation level 25%, recorded the lowest rate (13.92 dm^2.Plant^{-1}), did not differ significantly with the level 50%, recorded an average of 20. dm^2.Plant^{-1}, the reason may be attributed to the level 75%, to a good moisture content in which the plant did not experience water stress, which is reflected in the root system, increased vegetative growth and increasing leaf area. As for the treatments, the treatment of the nylon preservative achieved a significant superiority, recorded the highest average (20.21 dm^2.Plant^{-1}), with an increase of 13.14% compared to the comparison treatment, which recorded the lowest average (17.52 dm^2.Plant^{-1}), did not record any difference between it and other treatments, gave the following averages 17.95 and 317.9 dm^2.Plant^{-1} respectively. The reason for the increase in leaf area may be attributed to the treatment of nylon, sufficient moisture content in the root zone, as well as increasing the readiness of water, also, increased readiness of nutrients compared to other treatments, positively affects the growth of the plant and its vegetative group, increase the leafy area of the plant, whereas, the paper-field values decrease for other coefficients, due to the effect of water readiness on the different stages of plant growth, all physiological processes of the plant are affected by the moisture content, amount and time of addition of water, therefore, the leaf area is affected, due to reduced photosynthesis and the manufacture of amino acids, which reduces the rate of protein formation from those acids, increased hydrolysis to change these physiological processes in the plant, reflects on the average paper area, agreed with Issa *et al.* (2016) and Al-Shami (2018). As for the interaction, the combination between the irrigation level of 75% and the nylon preservative gave the highest mean (23.18 dm^2.Plant^{-1}), without a significant difference between a number of combinations at the same level, as for the combination between the irrigation level of 25% and the organic matter, gave the lowest rate (13.61 dm^2.Plant^{-1}), the reason may be attributed to the role of the nylon preservative in preserving the amount of water rated, reducing water losses by treating sandy soil, which feature high water conductivity, improved water retention capacity (Erickson *et al*., 1971).

Table 3 : Effect of Irrigation Levels and Soil Moisture Preservatives on leaf area dm^2.Plant^{-1}.

Irrigation levels	Treatment				Mean
	Zeolite	Nylon	Organic matter	Control	
75%	20.00	23.18	20.05	20.12	20.84
50%	19.62	23.05	19.99	20.06	20.68
25%	13.84	14.39	13.81	13.61	13.91
Mean	17.82	20.21	17.95	17.93	
L.S.D0.05	irrigation levels 0.4108		Treatment 0.4744	irrigation× Tre8217311	

Chlorophyll content (mg.cm^{-2})

The results of Table (4) indicate the presence of significant differences in the level of chlorophyll content in the leaves, the irrigation level was 50% above the mean average of 0.0255 mg.cm^{-2}, significant superiority at the level of irrigation 25%, the lowest mean record was 0.0178 mg.cm^{-2}, while it did not differ significantly from the level of irrigation 75%, recorded an average of 0.0254 mg.cm^{-2}, the reason for the irrigation level may be 50%, to provide a good growth and transfer rate of nutrients, contributed to a better chlorophyll than other levels, and good water and nutritional balance of the crop. As for the treatments, the treatment of nylon was significantly superior, gave the highest average (0.0247 mg.cm^{-2}) compare with other treatments, with an increase of 12.78% , compared to the comparison treatment, the lowest rate (0.0219 mg.cm^{-2}), which did not give any significant difference between it and other treatments organic matter and zeolite (0.0225 and 0.0223, mg.cm^{-2}), respectively. As for the interaction between irrigation levels and preservatives, the combination between the 50% irrigation level and the nylon preservative was highest (0.0282 mg.cm^{-2}), as for the combination between the irrigation level of 25% and the comparison is less average (0.0176 mg.cm^{-2}), the reason may be attributed to the availability of nutrients, contributed to the creation of nylon treatment, they provide adequate nutrition to the plant, which contributed to the increase in vegetative growth, the amount of chlorophyll in leaves increases, agreed with Muhammad and Asifu (2012) and Al-Rubaie (2015).

Table 4 **:** Effect of irrigation levels and soil moisture preservatives on total chlorophyll content in leaves mg.cm^{-2}.

Irrigation levels	**Treatment**				**Mean**
	Zeolite	**Nylon**	**Organic matter**	**Control**	
75%	0.0242	0.0280	0.0247	0.0246	0.0254
50%	0.0239	0.0282	0.0247	0.0251	0.0255
25%	0.0176	0.0180	0.0177	0.0178	0.0178
Mean	0.0219	0.0247	0.0223	0.0225	
L.S.D0.05	irrigation levels 0.00060		Treatment 0.00069	irrigation× Treatment 0.00121	

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

The results of Table (5) show that a significant differences between irrigation levels, as the irrigation level scored 75%, the highest average (20,185 ton. ha^{-1}), significantly outperforming the irrigation level 50% (18,297 ton. ha^{-1}), they significantly exceeded the irrigation level by 25%, which recorded the lowest average (7.756 ton. ha^{-1}), the reason for the superiority may be attributed to the irrigation factor, the important environmental factors in influencing the characteristics and quality , irrigation affects the stages of formation and growth of plant parts and growth, the water increases the readiness of the elements and the growth and development of plant cells and their division, increase the process of photosynthesis, in addition to being a solvent and a transport medium for materials manufactured in the leaves to various parts of the plant (Al-Sahuki *et al*., 2009). as for the soil moisture preservatives, the nylon preservative treatment was the highest average (19.218 ton. ha^{-1}), significantly superior to the rest of the treatments, with an increase of 36.97, 36.52 and 34.14%, compared to zeolite treatment, comparison and organic matter, respectively, no significant differences were observed between the other treatments, zeolite, organic matter, and comparison, recorded the following averages 14.030, 14.326 and 14.077 ton. ha^{-1}, respectively. The superiority of nylon treatment may be attributed to other treatments, to the quantities of irrigation water added and the extent of the root zone with a ready moisture content, the ability of this treatment to prevent water from running out of the root zone and the availability of nutrients, plant growth is a result of the intertwining of physiological and plant growth factors, agreed with Smucker *et al*. (2010); Al-Rawi *et al*. (2016); Al-Shami (2018) and Al-Salhi (2017). As for the interaction, the irrigation 75% and the nylon preservative the highest average (25.706 ton. ha^{-1}), no significant differences were observed between the other combinations at the same level, the combination of the irrigation level 50% and the nylon preservative gave an average (23.904 ton. ha^{-1}), compatible with other combinations at the same level, which scored the following averages for organic matter, comparison and zeolite 16,879, 16,297 and 16,108 ton. ha^{-1}, the combination of the irrigation level was 25% and the zeolite was the lowest average (7617 ton. ha^{-1}), the reason for the superiority of the combination between the irrigation level is 75% and the nylon, the nylon material was one of the techniques used, to treat sandy soils by holding water, prevent its penetration to the bottom of the root zone, as well as reducing the water deficit during the growth period, prevented exposure to water stress (Smucker *et al*., 2010).

Table 5 : Effect of Irrigation Levels and Soil Moisture Preservatives on Total yield Kg. experimental unit.

Irrigation levels	**Treatment**				**Mean**
	Zeolite	**Nylon**	**Organic matter**	**Control**	
75%	18.221	25.706	18.364	18.451	20.185
50%	16.297	23.904	16.108	16.879	18.297
25%	7.713	8.044	7.617	7.649	7.756
Mean	14.077	19.218	14.030	14.326	
L.S.D0.05	irrigation levels 485.6		Treatment 560.7	irrigation× Treatment 971.1	

Yield plant g.plant^{-1}

The results of Table 6 indicate that there were significant differences between irrigation levels, the irrigation level scored 75%, the highest average (1596.5 g.plant^{-1}), it significantly exceeded the irrigation level 50%, which recorded an average 1447.1 g.plant^{-1}, significant superiority at the level of irrigation 25%, which recorded the lowest average (613.4 g.plant^{-1}), the reason may be attributed to the level 75%, to the amount of water added, contributed to providing moisture content in the root zone, the plant is not exposed to stress, increased vegetative growth, increasing the yield of the plant, as well as the role of nylon treatment in preserving moisture and nutrient content, agreed with Mos-hab and Al-Masraf (2019). as for preservatives transactions, the nylon treatment gave a significant advantage over all treatments, recorded the highest average of 1520.0 g.plant^{-1}, with an increase of 36.98 and 36.51 34.14%, compared to other treatments zeolite, comparator and organic matter, which recorded 1109.6, 1133.1 and 1113.4 g.plant^{-1}, respectively, the reason for the significant differences between preservative treatments and the superiority of nylon treatment, perhaps it is due to the quantities of added irrigation water, the root zone remains with effective moisture content, the ability of this treatment to prevent water from running out of roots, the availability of nutrients, the plant growth is a result of the intertwining of physiological and environmental growth factors from the life of the plant, reflected on giving the highest yield per plant under the influence of nylon treatment, agreed with Issa *et al* (2016) and Al-Rawi *et al.* (2016). As for the interaction, the combination between the irrigation level of 75% and the nylon preservative gave the highest average (2033.1 g.plant^{-1}), no significant differences were observed between the other combinations at the same level, the reasons for its superiority may be attributed to the role of nylon membranes in preserving water and foodstuffs, which have a fundamental role in vegetative growth and growth.

Table 6 : Effect of Irrigation Levels and Soil Moisture Preservatives on yield Plant g.Plant^{-1}.

Irrigation levels	**Treatment**				**Mean**
	Zeolite	**Nylon**	**Organic matter**	**Control**	
75%	1441.1	2033.1	1452.4	1459.3	1596.5
50%	1288.9	1890.6	1274.0	1335.0	1447.1
25%	610.1	636.2	602.4	605.0	613.4
Mean	1113.4	1520.0	1109.6	1133.1	
L.S.D0.05	**irrigation levels** 38.40		**Treatment** 44.34	**irrigation× Treatment** 76.81	

Water productivity kg m^{-3}

The results of Table 7 indicate that there were significant differences between the studied irrigation levels, preservatives parameters, and the interaction, as the irrigation level scored 50%, the highest average for this capacity was 24.49 kg m^{-3}, a significant difference at the level of irrigation, which was 75%, which recorded an average of 20.16 kg m^{-3}, outperforming the irrigation level 25%, which recorded the lowest average of 15.73 kg m^{-3}, the reason for the irrigation level may be 50%, the nylon preservative contributed to reducing water losses by leaching to the bottom of the root spot and maintaining water content with low tension, with increased horizontal spreading of the wet area at the membranes to increase absorption, root growth and water use efficiency, to obtain the highest productivity of the plant, the exhausted water constantly replaces sufficient irrigation water stored over the plastic membranes providing moisture with capillary properties, achieved by continuously increasing the moisture content in the area of the active root domain that extends above the moisture-protecting membranes, the treatment of nylon reduced evaporation from the surface due to the retention of water under the roots, reflect on the amount of water already added, increased availability of moisture appropriate for the growth and penetration of roots in the soil, due to the increase in water reserves in the soil (Foday *et al*., 2012). As for soil moisture preservatives, the highest average treatment of nylon, at 24.66 kg m^{-3}, showed significant superiority over all other studied treatments, with an increase of 32.93%, by comparison, the comparison treatment recorded an average of 18.55 kg m^{-3}, perhaps the reason for the significant differences in the irrigation levels studied in this capacity, to control the quantities of added water and the length of time from one irrigation to another, which gave a clear moral difference between water productivity rates, this result may have been due to the efficient use of field irrigation water in the treatment of nylon, because of the waterproofing membranes of this technique, maintains moisture levels close to field capacity in the plant's effective root zone, at the same rate of adding low water and higher plant yields, shows that this technique has increased the effectiveness of adding water through the number of irrigation carried out in the experiment, the quantity of wastewater decreased and the productivity of the crop increased, the treatment of nylon gave the highest efficiency in the use of field irrigation water, agreed with Issa *et al* (2016); Al-Rawi (2016) and Al-Shami (2018). As for the interaction between irrigation levels and preservatives, the combination of the irrigation level showed 50% with the highest average nylon treatment for this quality (31.99 kg m^{-3}), significantly superior to all combinations between irrigation levels, preservatives, organic matter, comparison and zeolite, the combination of the irrigation level was 25% and zeolite, the lowest average was 15.45 kg m^{-3}at the same level, the reason may be attributed to the fact that the treatment of nylon with different irrigation levels gives a balanced processing of moisture contents and nutrients, by giving activity and vitality to the plant, makes it achieve the best productivity, increase the overall yield, and have a high water use efficiency, likewise, the nylon preservative retains water in the root zone and sandy soils, which increases the efficiency of use and productivity of water, agreed with Al-Salehi and Al-Tamimi (2017).

Table 7 : Effect of Irrigation Levels and Soil Moisture Preservatives on Water productivity kg m^{-3}.

Irrigation levels	**Treatment**				**Mean**
	Zeolite	**Nylon**	**Organic matter**	**Control**	
75%	18.20	25.68	18.34	18.48	20.16
50%	21.81	31.99	21.56	22.59	24.49
25%	15.64	16.31	15.45	15.51	15.73
Mean	18.55	24.66	18.45	18.84	
L.S.D0.05	irrigation levels 0.577		Treatment 0.667	irrigation× Treatment 1.155	

References

Al-Badri B.H. (2009). The effect of scarce water resources on irrigated agriculture in Iraq, Journal of Administration and Economics, College of Administration and Economy, Al-Mustansiriya University, (80): 118-135.

Al-Jabri A.A.R. (2013). Hydrology and geomorphology of the course of the Euphrates and the factors affecting it in central and southern Iraq. PhD thesis. faculty of Agriculture. , University of Basra, Iraq.

Al-Rawi, S.S.; Al-Tamimi, M.I.; Aati, A.S. and Smoker, A. (2016). Salt case study using SWRT technology in sandy soils and its impact on tomato production, Iraqi Journal of Soil Science. 16(1): 31-49.

Al-Rawi, S.S.M. (2016). The conditions of heat and salinity in coarse soils using SWRT technique and their effect on tomato and hot pepper productivity. PhD thesis, College of Agriculture, University of Baghdad, Iraq.

Al-Rubaie, B.C.H. (2015). The effect of potassium fertilization and spraying with compost and salicylic acid on the growth and yield of Courgettes. Ph.D. thesis, Department of Horticulture and Gardening Engineering, College of Agriculture, University of Baghdad, Iraq.

Al-Sahuki, M.M.; Al-Falahi, A.O. and Al-Muhammadi, A.F. (2009). Management of Crop, Soil and Breeding for Drought Tolerance, Iraqi Agricultural Science Journal. 40(2): 1-28.

Al-Salhi, Z.K.K. (2017). The saline state in the root zone under the SWRT system and some administrative processes in rough and medium-textured soils and the effect of this on the growth and production of sorghum, Master Thesis, College of Agriculture, University of Baghdad, Iraq.

Al-Salhi, Z.K.K. and Al-Tamimi, M.I.O. (2017). The effect of using the SWRT system on the salt accumulation of the subsurface drip irrigation system in two different textured soils compared to other administrative treatments, Iraqi Journal of Soil Science. 17(1): 16.

Al-Shami, Y.A. (2018). Using two different methods to add irrigation water to test the effectiveness of SWRT technology and different soil management treatments and the effect of this on the growth and yield of maize (*Zea mays* L.), Ph.D. thesis, College of Agriculture, University of Baghdad, Iraq.

Black, C.A.; Evans, D.D.; Whit, J.L.; Ensminger, L.E. and Clark, F.E. (1965). Methods of soils analysis. Amer. Soc. of Agro. Inc. USA.

Day, P.R. (1965). Particle fractionation and particle size analysis. In C.A. Black (ed.). Methods of soil analysis part 1, Agron. Ser. Am. Soc. Agron: Madison, WI. 9: 545-567.

Doorendos, J. and Pruitt, W.O. (1975). Guidelines for predicting crop water requirements, Irrigation and Drainage No. 24 (4theds). Food and Agriculture Organization of the united Nations, Rome, Italy.179 p.

Erickson, A.E.; Tiedje, J.M.; Ellis, B.G. and Hansen, C.M. (1971). A barriered landscape water renovation system for removing phosphate and nitrogen from liquid feedlot waste. In Proceedings of International Livestock Waste Conference, Columbus, Ohio. American Society of Agricultural Engineers.

Foday, T.I.; Xing, W.; Shao, G. and Hua, C. (2012). Effect of water use efficiency on growth and yield of hot pepper under partial root-zone drip irrigation condition. International journal of scientific and engineering, 3(1): 2229-5518.

Issa, H.A. and Odeh, M.I.; Alvin, J.M.S. (2016). The effect of using SWRT on water conservation and water use efficiency WUE and tomato and pepper yields, Iraqi Journal of Soil Science. 16(1): 244-249.

Jackson, M.L. (1958). Soil Chemical Analysis Prentic Hall. Inc. Englewood Cliffs, N. J. USA. P: 558

Miller S.A. and Smucker, A.J.M. (2015). A new soil water retention technology for irrigated highly permeable soils. An ASABE Meeting Presentation. Paper Number: 152147252. Written for presentation at the Emerging Technologies for Sustainable Irrigation. A joint ASABE / IA

Mos-hab, F.S. and Al-Masraf, S.A. (2019). Sub-surface water retention is a technique for increasing values of field use efficiency and water storage for cucumber plants, University of Baghdad, Engineering Journal. 25(9): 54-61.

Muhammad, A.S. and Asifu, J.S. (2012). The effect of variety, levels and date of spray with marine extract (1SeaForce) on vegetative growth and productivity of squash gourd, *Cucurbitapepo* L., Kirkuk Journal of Agricultural Sciences, 3(1): 8-17.

Nedawi, D.R. (1988). The movement of water and salts in sandy soil under the surface and subsurface drip irrigation system and tomato crop growth response, Ph.D. thesis, University of Basra, Iraq.

Nozari, R.; Moghadam, H. and Zahedi, H. (2013). Effect of cattle manure and zeolite applications on physiological and biochemical changes in soybean (*Glycine max* L. Merr.) grown under water deficit stress.

Page, A.L.; Miller, R.H. and Keeney, D.R. (1982). *Methods of soil analysis.* Part (2). 2nd. ed. Madison, Wisconson, USA; PP: 1159.

Pisarovic, A.; Filipan, T. and Tisma, S. (2003). Application of zeolite based special substrates in agriculture-ecological and economic justification. Periodicum Biologorum, 105(3): 287-293.

Sepaskhah, A.R. and Yoesefi, F. (2007). Effects of zeolite application on nitrate and ammonium retention Of a loamy soil under saturated conditions, Australian journal of soil research. 45(5): 368-373.

Smucker, A.J.M.; Schultink, G. and Thelen, K. (2009). SWRT enhancement of water use efficiency and economics of irrigated low water holding capacity sandy soils. Abstract for American Society of Soil Science. Pittsburgh, Pennsylvania, November, 2009.

Smucker, A.J.M.; Wang, W.; Kravchenko, A.N. and Dick, W.A. (2010). Forms and Functions of Meso and Micro-niches for Carbon within Soil Aggregates. Journal of Nematology. 42: 84-86.

Sun, H.; Li, K.; Zhao, A. and Zhang, X. (2000). Infiltration characteristics of clay pots in sandy soil. Water Saving Irrigation 2: 26-29.