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The Effect of the Use of Subsurface Water Retention Technology (SWRT) in the available content of nutrients in the soil under the subsurface drip irrigation system and for different Management Treatments*

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Abstract

Field experiments were carried out during the 2016 spring season to evaluate the effect of using subsurface water retention technology (SWRT) on the available nutrients content of the soil under the subsurface drip irrigation system and for different Management treatments at the Palm Textile Research Station of the Ministry of Agriculture in Najaf Governorate (Al-Najaf desert island). The field soil was classified as a Sandy loam texture Classified under Group Sandy loam; Strong fine , Typic, Torrifluvents. he results showed the superiority of SWRT technology in increasing the soil content of available nitrogen, phosphorous and potassium in the middle and end of the season compared with other treatments than it was at the beginning of the season. The content of available nitrogen at the end of the season reached 30.20, 30.21 and 31.67 mg N kg-1 for depths 15, 30 and 45 cm, respectively. While the content of available phosphorous at the end of the season was 13.64, 14.92 and 13.84 mg P kg-1 for depths of 15, 30 and 45 cm, respectively, while the values of available potassium content at the end of the season were 138.22, 138.57 and 138.44 mg K kg-1 for depths 15, 30 and 45 cm, respectively. With a significant increase of 7.90, 29.31 and 16.44% for the depth of 15 cm and with a percentage increase of 7.22, 29.43 and 15.84% for the depth of 30 cm and an insignificant increase of 7.63% and with a significant increase of 27.77 and 17.02% for depth 45 cm compared with the O.M, T and N treatments .T and straight. Also, O.M treatment gave an increase in the soil content of nitrogen, phosphorous and available potassium compared with T. and N.T treatments, respectively.

Keywords: SWRT technology , available nitrogen , subsurface drip irrigation system.

تأثير استخدام تقانة احتجاز الماء تحت السطحي *SWRT* في المحتوى الجاهز من العناصر الغذائية في التربة تحت نظام الري بالتنقيط تحت السطحي ولمعاملات ادارية مختلفة*

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الخلاصة

نفذت تجارب حقلية خلال الموسم الربيعي 2016 لتقييم تأثير استخدام تقنية احتجاز الماء تحت السطحي SWRT في المحتوى الجاهز من العناصر الغذائية للتربة تحت نظام الري بالتنقيط تحت السطحي ولمعاملات ادارية مختلفة في محطة بحوث النخيل النسيجية التابعة لوزارة الزراعة في محافظة النجف (جزيرة النجف الصحراوية) صنفت تربة الحقل بانها رملية ذات نســجة مزيجة رملية مصنفة تحت مجموعة ;Sandy loam. moderate medium, Typic, Torripsammentsتضمنت الدراسة اربع معاملات وهي معاملة SWRT ومعاملة المادة العضوية و معاملتي الحراثة و عدم الحراثة ووزعت المعاملات وفق تصميم القطاعات الكاملة المعشاة RCBD بواقع اربعة مكررات. زرعت بذور الذرة الصفراء وتم تحديد موعد وكمية مياه الري في كل رية بعد استنزاف 50% من الماء الجاهز اعتماداً على المعطيات الرطوبية لمتحسسات نوع GS3-Soil Moisture Sensorلمراقبة المحتوى الرطوبي الحجمي عند الاعماق 15 و30 و45 سم باستعمال اجهزة Data Logger لتخزين وتمثيل البيانات كل اربعة ساعات وعلى طول موسم النمو. اظهرت النتائج تفوق تكنولوجيا SWRT في زيادة محتوى التربة من النيتروجين والفسفور و البوتاسيوم الجاهز في منتصف ونهاية الموسم مقارنة مع المعاملات الأخرى مما هو عليه في بداية الموسم، بلغ محتوى النيتروجين الجاهز في نهاية الموسم 30.20 و30.21 و31.67 مغم N كغم-1 للأعماق 15 و30 و45 سم على التوالي. في حين محتوى الفسفور الجاهز في نهاية الموسم 13.64 و14.92 و13.84 مغم P كغم-1 للأعماق 15 و30 و45 سم على التوالي، في حين بلغت قيم محتوى البوتاسيوم الجاهز في نهاية الموسم 138.22 و138.57 و 138.44 مغم K كغم-1 للأعماق 15 و30 و45 سم على التوالي. وبنسبة زيادة معنوية 7.90 و29.31 و16.44% للعمق 15 سم وبنسبة زيادة 7.22 و29.43 و15.84% للعمق 30 سم وبنسبة زيادة غير معنوية 7.63% وبنسبة زيادة معنوية 27.77 و17.02% للعمق 45 سم مقارنة مع معاملات O.M و Tو N.T وعلى التوالي. كما أعطت معاملة O.M زيادة في محتوى التربة من النيتروجين والفسفور والبوتاسيوم الجاهز مقارنة مع معاملتي .T و N.T وعلى التوالي.

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.1. Introduction

Water resources are an important determinant of the agricultural development program in Iraq, one of its most important pillars and one of the most important determinants of the exploitative pattern of agricultural lands and the possibility of vertical and horizontal expansion. The Tigris and Euphrates rivers, in addition to the border rivers with Iran, constitute the main source of water resources in Iraq, while rain comes in the second place to meet the need for water uses, especially for agricultural purposes, while groundwater occupies the third place, as it constitutes a small percentage and that most of its uses are limited for drinking purposes, especially In desert areas (2). Through good water management, water is controlled and used for optimal food or yield and fodder. This management is represented in using and utilizing all natural, chemical, biological and social resources to supply crops with their water needs to obtain food and fodder to achieve predetermined goals without harming the environment. The amount of water needed and the time of irrigation depend on the prevailing climatic conditions, the type and degree of growth of the crop. The properties of the soil also affect the irrigation process and the water needs of plants and the amount of water lost by evaporation - transpiration because it affects the movement of water in the soil towards the surface and this determines the amount of water consumed by the plant (1).

In recent years, farmers in developed countries have turned to using modern irrigation methods, and these methods have become widely used in arid and semi-arid areas where water is a limiting factor due to a water deficit. Also, adopting modern methods of crop irrigation can increase the soil's water-holding capacity, increase its permeability, reduce water lost to surface runoff and secure the water needs of plants.

SWRT technology as a water retention system under the surface of sandy soil in order to improve its water physical properties and reduce losses to the least possible and increase the productivity of these soils (7). SWRT technology is developed to maintain the volumetric moisture content in the root zone of plants. According to Aoda (5), field studies and greenhouse studies have proven that the use of this technology leads to doubling the capacity of the soil to conserve water. SWRT technology improves the root environment by conserving water and nutrients, and then improves soil water qualities and productivity. These environmental and hydrological effects of SWRT technology can increase production in quantity and quality for both vegetable and grain crops, while using less water and fertilizers. Experiments at the University of Michigan have proven that installing polyethylene films at a depth of 30 cm led to an increase in the water capacity of the root zone by twice as much compared to not using this technology (7).

Materials and Methods

Field experiments were carried out at the Palm Textile Research Station of the Ministry of Agriculture in Najaf Governorate (Al-Najaf desert island) during the spring season 2016. This site is located at latitude 37.80” 0732º North, and longitude 44.7” 19” 44º East. The soil of the field is classified as sandy. It has a sandy mixture texture (Sandy loam; moderate medium, Typic, Torripsamments) according to what was mentioned in (12) Random samples were taken from several separate locations of the soil of the site at three depths 0-0.30, 0.30-0.60 and 0.60- 0.90 m, then samples of each depth were mixed together and a representative composite sample was obtained from it, the soil samples were air dried, then ground and sieved with a sieve with a diameter of 2 mm. These samples were used to estimate the physical and chemical properties of soil before planting and as shown in Tables 1 and 2.

Table 1: Some physical properties of field soil before planting for the study

Other physical properties				Soil depth (m)			Soil Separators	
Total Porosity	Particles Density	Bulk Density	Location	0.9-0.6 م	0.6-0.3 م	0.3-0.0 م		
	Mgm.m^{-3}			785	734	673	gm.kg^{-1}	Sand
0.41	2.72	1.61	Al-najaf	193	234	242		Silt
				22	33	85		Clay
				Loamy Sand		Sandy Loam	Texture Class	

Table 2: Some chemical properties of field soil before planting for the study

Chemical characteristic		Soil depth (m) 0.0−0.3	0.3−0.6	0.6−0.9
pH		7.41	7.34	7.52
EC dSm^{-1}		3.27	3.66	3.78
Ca^{++}	(mmeq.L^{-1})	12.67	15.67	14.46
Mg^{++}		6.15	6.38	5.72
Na^{+}		17.56	20.31	19.18
K^{+1}		0.13	0.22	0.23
SO_4^{2-}		12.76	12.76	13.32
Cl^{1-}		14.37	14.27	13.21
HCO_3^{1-}		3.97	3.67	3.16
NO_3^{1-}		0.27	0.20	0.15
PO_4^{2-}		0.03	0.04	0.05
SAR (mgL^{-1})$^{-1/2}$		5.72	6.12	6.04
CEC (Cmol kg^{-1})		15.45	14.13	15.32
O.M.	(g kg^{-1})	13.22	11.09	10.18
Gypsum		2.32	2.56	2.62
$CaCO_3$		145.05	226.00	218.12

Experimental parameters and statistical design:

The study included four treatments, namely:

1) Plowed soil treatment with the use of subsurface water retention technology (**SWRT**): To implement the SWRT system, it was necessary to use a type of plastic membranes, Membranes, with special specifications, made of polyethylene. The plastic was installed and planted under the surface of the soil by placing these strips at a depth of 0.50 m from the

middle, and with a side depth of 0.10 m, with a lateral curvature of 3:1, while it was The height of the plastic from the side edges is 0.15 m and the bottom base of the soil is 0.20 m, and in a geometrical style with a trapezoidal shape. And because there is no machine for growing plastic under the surface of the soil, it was necessary to open a manual trench with dimensions of 0.5 x 0.35 x 14 m^3 (depth x width x length) for each experimental unit and to raise the treatment soil.

2) Treatment of plowed soil with organic matter added to a depth of 35 cm. Organic Mater (**O.M**.): To apply the organic fertilizer treatment, it was necessary to manually open a trench with dimensions of 50.3 x 0.30 x 14 m^3 (depth x width x length) for one experimental unit and raise the soil of the treatment, and then add the organic matter in the form of a layer with a thickness of 0.05 m, width 0.3 m, at a depth of 0.35 m.

3) Plowed soil treatment and considered as control treatment (**T**.)

4) No Tillage Treatment (**N.T**).

The field was leveled for the open house, whose dimensions are 56 x 9 m^2, and the area specified for the experiment was divided into terraces. The length of the terrace was 14 m, the width of 0.90 m, and the height of 0.10 m, and the distance between one terrace and another was 1.0 m. Each repeater was divided into 4 terraces for cultivation with four treatments and a distance of one meter was left longitudinal and crosswise in order to prevent the overlapping of irrigation treatments with each other, and the number of treatments in the experiment was sixteen experimental units. The experiment was designed according to the RCBD randomized complete block design with four replications, with the use of a subsurface drip irrigation system for all treatments. The yellow corn seed cultivar 5018 was cultivated by the Yellow Corn Research Center in an open field system. The data were analyzed using Genstat Discovery Edition 4 program, and the least significant difference at the 0.05 level was tested to compare the arithmetic means of the coefficients.

Subsurface drip irrigation system (SDIS):

The sub-surface drip irrigation system consisted of a water basin, a water pump, a fertilizer, a water meter, a pressure gauge, and a filter to purify the water connected to each other on main and secondary pipes to transfer water to the Ro-Drip-Drip Tape field irrigation pipes of the JOHN DEERE company with a diameter of 16 mm As in Figure 1. The tape tubes contain drippers that work according to the principle of water perfusion under the influence of low water pressure. They are self-cleaning, resistant to rupture and shock, and do not allow dust and plant roots to enter the drippers and are resistant to clogging. The discharge of these droppers is low, about 1.37 liters per hour-1 for the dropper. The experimental units for the subsurface drip irrigation treatment were equipped with a tape tube for each experimental unit at the specified design depth of 0.3 m below the soil surface, the length of each tube is 14 m. The number of dots in one tape tube reached 140 dots, as the distance between one dotted and another is 0.10 m. The subsurface drip irrigation system was arranged in its experimental units according to the open system in order to facilitate the cleaning process as well as control the irrigation process with high efficiency (6). Several tests were also conducted to evaluate the coefficient of homogeneity of the distribution of the water droppers at different operating pressures, and one bar pressure achieved the highest efficiency of the homogeneity coefficient of 97.37%.

Figure 1. Ribbon subsurface drip irrigation pipe Ro-Drip-Drip Tape type

Monitoring moisture content and irrigation method:

The crop was irrigated during the first two weeks using the surface drip irrigation system due to the limited root system at the beginning of planting for the two seasons. Then the subsurface drip irrigation system was relied on based on the reading of the GS3 type sensors (Fig. 2), which were placed at depths of 15, 30 and 45 cm, and connected with the Data Logger device (as in Figure 3) to take the volumetric moisture content readings in the form of Continuous and represented using computer programs that support these devices. When the moisture content of the soil indicates the depletion of 50% of the available water, then irrigation is carried out by adding the depth of water necessary to reach the moisture content at the field capacity of the field soil using the soil moisture description curve for the values of field capacity and reading the sensors, i.e. when the volumetric moisture content reading reaches 0.20 $cm.cm^{-3}$ For the effective depth of the root zone, according to the stage of growth, at which time the irrigation takes place.

The irrigation process is carried out with two balls: 1) The first mechanism, in which the irrigation process is carried out for each treatment according to its need (after draining 50% of the prepared water) according to its moisture reading from the sensors in order to estimate and know the effect of the amount of irrigation water for the SWRT treatment compared to other treatments and this mechanism was applied in the season the first. 2) The second mechanism, in which the irrigation process is carried out and for all treatments according to the humidity data for the SWRT treatment, and water is added to all the treatments with the same amount added to the SWRT treatment in order to simulate the permaculture and the possibility of using this technique in it. This method is applied in the second season.

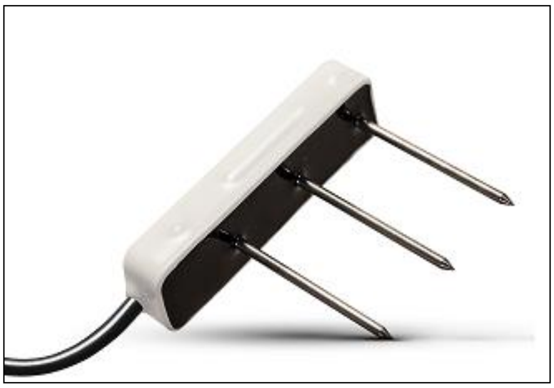

Figure 2. Sensor type GS3

Figure 3. Data Logger Em50

Irrigation time is calculated on the basis of drainage and the amount of water needed by the plant per irrigation (m^3 hour^{-1}). The equation proposed by (4) was also used in calculating the depth of water to be added to compensate for the depleted moisture, as follows:

$$d = (\theta_{f_c} - \theta_w) \times D$$

Results and discussion

Available content of nutrients in the soil

Available Nitrogen Content:

The results of Table 3 show the effect of different treatments on the available content of nitrogen, phosphorous and potassium in the soil at the beginning, middle and end of the growing season and for three depths. The results show the superiority of the SWRT treatment in increasing the soil content of available nitrogen in the middle and end of the season compared to other treatments than it was at the beginning of the season.

The mid-season values were 33.83, 33.73 and 33.65 mg N kg-1 for depths of 15, 30 and 45 cm, respectively. With a significant increase of 12.39, 24.51 and 18.08% for depth of 15 cm and a percentage increase of 15.20, 26.24 and 21.07% for depth of 30 cm and a significant increase of 13.57, 22.54 and 16.32% for depth of 45 cm compared with O.M treatments. and T. and N.T. Straight. O.M.'s treatment also outperformed. About the treatment of T. and N.T. In the increase of the soil content of available nitrogen with a non-significant increase of 10.78 and 5.06% for a depth of 15 cm and a significant increase of 9.58% and an insignificant increase of 5.10% for a depth of 30 cm and a significant increase of 7.90% and an insignificant increase of 2.42% for a depth of 45 cm in the middle of the season .

While the values at the end of the season were 30.20, 30.21 and 31.67 mg N kg-1 for depths of 15, 30 and 45 cm, respectively. And with an insignificant increase of 5.23% with a significant increase of 11.32% and an insignificant increase of 7.21% for a depth of 15 cm and a significant increase of 4.06, 11.15 and 9.85% for a depth of 30 cm and an increase of 8.76, 14.21 and 13.47% for a depth of 45 cm compared with treatments O.M. and T. and N.T. Straight. She also gave the treatment of O.M. Significant increase in soil content of available nitrogen compared with T. and N.T. treatments. And with a non-significant increase of 5.79 and 1.88% for depth of 15 cm and an insignificant increase of 6.81 and 5.56% for depth of 30 cm and an insignificant increase of 5.01 and 4.34% for depth of 45 cm at the end of the season.

Table 3: The effect of study parameters on the available content of nitrogen, phosphorous and potassium (mg/kg-1) in the soil

L.S.D	Treatments				Depth (cm)	Element	appointment
	N.T	T	O.M	SWRT			
3.14	29.62	27.83	32.59	28.40	15	N	Beginning of season
2.34	31.20	27.88	32.92	29.54	30		
1.94	29.45	29.05	33.06	30.28	45		
2.04	11.36	10.79	14.19	13.13	15	P	
2.03	12.53	11.73	13.47	12.73	30		
1.32	11.48	10.83	13.61	11.52	45		
11.46	126.20	126.10	157.30	133.70	15	K	
8.09	127.80	125.20	158.60	131.00	30		
8.35	129.20	126.00	158.90	136.70	45		
3.20	28.65	27.17	30.10	33.83	15	N	Mid season
2.29	27.86	26.72	29.28	33.73	30		
1.83	28.93	27.46	29.63	33.65	45		
2.41	10.33	09.34	11.76	14.47	15	P	
1.27	10.78	10.51	11.81	15.93	30		
1.88	10.60	10.01	11.41	14.24	45		
9.14	125.40	113.90	138.00	151.40	15	K	
8.41	126.90	116.60	138.90	148.90	30		
5.64	125.11	113.61	142.32	153.42	45		
2.46	28.17	27.13	28.70	30.20	15	N	End of the season
2.16	27.50	27.18	29.03	30.21	30		
1.97	27.91	27.73	29.12	31.67	45		
1.30	08.92	09.69	12.04	13.64	15	P	
1.49	08.55	09.17	12.10	14.92	30		
2.11	09.04	08.95	11.54	13.84	45		
4.62	118.70	106.89	128.10	138.22	15	K	
5.68	119.62	107.06	129.24	138.57	30		
3.92	118.30	108.35	128.63	138.44	45		

available phosphorous content:

The results in Table 3 show the superiority of the SWRT treatment in increasing the soil content of ready phosphorous in the middle and end of the season compared to other treatments than it was at the beginning of the season. The mid-season values were 14.47, 15.93 and 14.24 mg P kg-1 for depths of 15, 30 and 45 cm, respectively. With a significant increase of 23.04, 54.93 and 40.08% for a depth of 15 cm and a significant increase of 34.89, 51.57 and 47.77% for a depth of 30 cm and a significant increase of 24.80, 42.26 and 34.34% for a depth of 45 cm compared with the O.M treatments. and T. and N.T. Straight. O.M.'s treatment also outperformed. About the treatment of T. and N.T. In the increase of the soil content of ready-made phosphorous with a non-significant increase of 25.91 and 13.84% for a depth of 15 cm and an increase of 12.37 and 9.55% for a depth of 30 cm and a non-significant increase of 13.99 and 7.64% for a depth of 45 cm in the middle of the season.

While the values at the end of the season were 13.64, 14.92 and 13.84 mg P kg-1 for depths of 15, 30 and 45 cm, respectively. With a significant increase of 13.29, 40.76 and 52.91% for the depth of 15 cm and a percentage increase of 23.31, 62.70 and 74.50% for the depth of 30 cm and a significant increase of 19.93% and an insignificant increase of 54.64 and 53.10% for the depth of 45 cm compared with the O.M treatments. and T. and N.T. Straight.

She also gave the treatment of O.M. An increase in the soil content of ready phosphorous compared with T and N.T treatments. In increasing the soil content of ready-made phosphorous with a significant increase of 24.25 and 34.98% for a depth of 15 cm and a significant increase of 31.95 and 41.52% for a depth of 30 cm and an insignificant increase of 28.94 and 27.65% for a depth of 45 cm at the end of the season.

available Potassium Content:

The results in Table 3 show the superiority of the SWRT treatment in increasing the soil potassium content in the middle and the end of the season compared to other treatments than it was at the beginning of the season. The mid-season values were 151.40, 148.90 and 153.42 mg K kg-1 for depths of 15, 30 and 45 cm, respectively. With a significant increase of 9.71, 32.92 and 20.73% for depth of 15 cm and a percentage increase of 7.20, 27.70 and 17.34% for depth of 30 cm and a significant increase of 7.80, 35.04 and 22.63% for depth 45 cm compared with O.M treatments. and T. and N.T. Straight. O.M.'s treatment also outperformed. About the treatment of T. and N.T. In increasing the soil content of ready potassium, with an insignificant increase of 21.16 and 10.05% for a depth of 15 cm and an insignificant increase of 19.13 and 9.46% for a depth of 30 cm and a significant increase of 25.27 and 13.76% for a depth of 45 cm in the middle of the season.

While the values at the end of the season were 138.22, 138.57 and 138.44 mg K kg-1 for depths of 15, 30 and 45 cm, respectively. With a significant increase of 7.90, 29.31 and 16.44% for the depth of 15 cm and a percentage increase of 7.22, 29.43 and 15.84% for the depth of 30 cm and an insignificant increase of 7.63% and a significant increase of 27.77 and 17.02% for the depth of 45 cm compared with the O.M treatments. and T. and N.T. Straight. She also gave the treatment of O.M. An increase in the soil content of ready potassium in comparison with the two treatments T. and N.T. And with an insignificant increase of 19.84 and 7.92% for depth of 15 cm and a non-significant increase of 20.72 and 8.04% for depth of

30 cm and a significant increase of 18.72% and a non-significant increase of 8.73% for depth of 45 cm at the end of the season.

Reasons for the effects of study coefficients on the prepared content of nutrients in the soil:

The results showed the contribution of SWRT technology to increasing the availability of nitrogen, phosphorous and potassium in the middle of the growing season compared to the beginning of the growing season, while it was noted that the availability of these elements for other treatments decreased at the middle and end of the growing season compared to the beginning of the growing season, due to the role played by plastic films for technology SWRT in keeping fertilizers and nutrients within the root zone of plants and reducing their loss. The availability of these elements decreased at the end of the growing season compared to the middle of the growing season, due to the large vegetative total, as well as the root system and its extension, and the increased need of plants from the elements, thus depleting it from the soil by plants, which reduces its content at the end of the growing season.

In light of the above-mentioned results from Table 3, it was clear that SWRT treatment was superior to other treatments in increasing the availability of nitrogen, phosphorous and potassium elements in the soil. The reason for this is due to the role of the membranes used for this technology in preserving fertilizers and nutrients and preventing their loss by leaching. Therefore, the SWRT treatment kept high amounts of nitrogen, phosphorous and potassium in the soil, although the fertilizer additions to it were less by about half compared to the rest of the other treatments and this It agrees with findings (3) and (11). In addition, the role of SWRT-treated films in maintaining good moisture content is highlighted.

It was also found (8) that it was possible to improve the biological-chemical condition of the plant environment with coarse sandy soils with low organic matter by means of fixed membranes in a suitable shape and depth, as well as increasing soil carbon storage and reducing hydrological losses. It depends on moisture and lowering the temperature in the root zone, which makes the conditions suitable for the plant to absorb water and nutrients, and this is consistent with what it has found (3). It is also due to the increased readiness of these elements for O.M. To the role of organic matter in improving the physical and chemical properties of the soil, as it constitutes an important source of nutrients needed for growth and increases the soil's ability to conserve water and improve its structure (9). In addition to what organic manure contains of organic acids and its role in increasing the readiness of nutrients in the soil by reducing the degree of interaction and reducing the retention of nutrients (7).

Conclusions:

1) The use of SWRT technology led to an increase in the availability of nutrients in the soil despite reducing the fertilizer additions to them by half compared to other treatments.

2) Providing water and nutrients within the root zone of plants in light of water retention by special plastic membranes planted below the surface of the soil and at a certain depth, while improving the use of fertilizers and raising their efficiency when added with the subsurface drip irrigation system (Fertigation) in order to add fertilizers and preserve nutrients within the root zone.

3) SWRT technology contributed to an increase in the soil content of nitrogen, phosphorous and potassium ready in the middle and end of the season compared to other treatments than it was at the beginning of the season. It also resulted in the use of the O.M transaction. There was a significant increase in the soil content of nitrogen, phosphorous and ready potassium compared with T and N.T treatments. at the end of the season.

Recommendations:

1) To generalize the use of SWRT technology in desert farming applications for coarse and medium textured soils in arid and semi-arid areas.

2) Using sensors to monitor moisture changes, fertility, nutritional and hydration needs.

3) Inviting the relevant government institutions and agricultural production companies to invest in this technology.

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