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Effect of mulching and deficit irrigation on crop water productivity and energy use efficiency for drip irrigated cucumber

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ABSTRACT

This small-scale study aimed to investigate the effect of rice straw mulch(RM) and gravel mulch (GM) on cucumber crop water productivity (CWP) and energy use efficiency (EUE) of drip irrigation system with deficit irrigation (DI) technique. Variables included three mulching conditions namely RM and GM in addition to no mulching (NM) combined with four levels of applied water 100, 90, 80, and 70% of crop water requirement (ET_c). Results indicated that RM showed the ability to keep soil moisture content for longer time compared to GM and NM. Values of soil temperature showed that RM could reduce the effect of air temperature on soil temperature and provide the required modification whether aeration or warming in high and low air temperature times. There was no-significant difference between obtained cucumber yield at RM treatments while crop yield has significantly affected at GM and NM treatments using 70% ET_c. Reducing amount of applied water from 100 to 70% led to increase the CWP by 23.51% using RM while it decreased by 6.37% and 4.58% for GM and NM, respectively. Results indicated that, GM has lower ability to reduce the effect of DI on crop yield than RM which had the greatest values of EUE compared to GM and NM treatments. The study recommended using RM70 to obtain greatest possible CWP and EUE in addition to maximizing the economic benefits of water unit.

Key words: *Irrigation techniques,soil cover, water conservation, vegetables, yield*

1. INTRODUCTION

Irrigated agriculture contributes to over 40% of global food production. Water and food security are critical concerns under climate change, as both are highly sensitive to fluctuations in climatic conditions **(Misra, A. K., 2014)**. Agriculture is the primary consumer of freshwater, accounting for approximately 70% of global water usage. As the global water scarcity issue intensifies, enhancing agricultural productivity per unit of irrigation water becomes increasingly important to meet the growing food demand and the challenges posed by rapid population growth **(Abdelraouf and Ragab, 2018; Eid and Negm, 2018; Bosco et al., 2022)**. To address these challenges, it is vital to apply all available techniques and technologies to optimize the benefits of water and energy, whether in terms of economic impact or crop yield. One such method is drip irrigation, a modern system that conserves water and boosts crop productivity **(Shareef et al., 2019).** The use of drip irrigation has been shown to increase. Drip irrigation enhances productivity by 27.2%, reduces cultivation costs by 25%, and lowers energy requirements, weed problems, soil erosion, and farming expenses when compared to traditional flood irrigation **(Pawar et al., 2015)**. Drip irrigation increases total yield of cucumber under different water regimes and deficit irrigation techniques **(Rahil and Qanadillo, 2015; Sonnenberg et al., 2016; Hu et al., 2019; Masria et al, 2021)** Mulching, whether with organic or inorganic materials, provides several benefits, such as maintaining soil moisture, preventing salt accumulation, and controlling weeds. Organic mulches, such as rice straw, also help regulate soil temperature, improve the physical and chemical properties of the soil, and promote soil biological activity. Rice straw, in particular, is readily available in the Egyptian agricultural context and can help reduce production costs **(Abo-Ogiala and Khalafallah, 2019).** Rice straw mulch has been shown to reduce grape water requirements by 50%, thanks to its role in conserving soil moisture. Gravel mulch also affects soil physical properties by regulating key hydrological processes like moisture evaporation, infiltration, and runoff **(Zhang et al., 2024; Bonachela et al., 2020; Xia et al., 2018)**. Deficit irrigation (DI), a water-saving technique, involves reducing the water applied to crops at specific growth stages. By carefully managing water supply, DI can improve water use efficiency and increase crop resilience to water stress. While DI is especially necessary in arid regions, it must be carefully regulated to maximize water productivity **(Elnemr and Elmetwalli, 2021)**. Studies have demonstrated that DI leads to higher water use efficiency and reduced production costs **(Nakawuka et al., 2014; Abd El-Mageed and Semida, 2015; Ahmed and Aly, 2017; Al-Ghobari and Dewidar, 2018).** Additionally, energy productivity and use efficiency are significantly higher with straw mulch than without it **(Brar et al., 2019)**. Combining DI with mulching and drip irrigation is expected to enhance water and energy use efficiency, particularly for crops that are highly sensitive to water stress, such as cucumbers. Cucumbers (Cucumis sativus L.) are widely cultivated for their refreshing taste and nutritional benefits **(Aref and El-Beltagy, 2014).** However, their production is often limited by factors like water scarcity, soil degradation, and weed competition **(Farook et al., 2009)**. The objectives of this study are as follows:

1. investigate the effect of organic and inorganic mulching on mitigating the impact of DI on crop yield; 2. assess the impact of mulching and DI techniques on crop water productivity and energy use efficiency.

2. MATERIALS AND METHODS:

2.1 Experiment and site description

In the present study the experiments were conducted in a private house under open air conditions located at 31.42˚ N 31.71˚ E in New Damietta city, Damietta governorate, Egypt, during the summer of the year 2023. The experiment design was split plot design with three replicates of each treatment. The study area average temperature was 33.5 °C, and no precipitation during the study time period. Variables included four levels of applied water namely 70,80,90 and 100% of crop water requirement (ET_c) as main plot and three mulching types as sub-main plot which were rice straw mulching (RM) with abundance of 0.5 kg/m^2, gravel mulching (GM) with 10 cm average thickness with total volume 0.02 m^3/pot in addition to no mulch treatment (NM). Each treatment set in a pot 0.6 m length x 0.3 m width x 0.4 m. height. Each pot filled with sandy soil to 36 cm depth. All pots had four holes in the bottom to assure excess irrigation water drain.

2.2 Soil preparation and crop planting

The experiment applied on cucumber (Hybrid
in 12 Jomana 55 F1); Cucumber seeds were planted
hinned aftertAugust 2023 with three seeds per pot then
rs wereegermination to one plant per pot. Fertiliz
planting, we added manually to the soil surface. Before
il. At firstoadded 0.5 kg/m^2 of organic matter to the s
rs weree20 days, the following amounts of fertiliz
K_2SO_4,fadded 700 g/m^2 of $(NH_4)_2SO_4$, 350 g/m^2 o
and 150 g/m^2 of MgSO4. During Flowering stage an
amount of 300 g/m^2 of NH_4NO_3. .

2.3 Irrigation network layout

Figure 1 presents the layout of the drip irrigation network used. Irrigation network consisted of a 5 cm inner diameter PVC manifold was used to feed 16 mm inner diameter polyethylene laterals with built-in emitters. The network was divided into four parts; each of them works at a certain operation head and consisted of 3 laterals. Treatments were separated by control valves to control water the flow when required. Pressure gauge was fitted after main control valve. T-shaped valves were fitted in the laterals to enable ending irrigation process at desired time for each treatment separately. Laterals were 3 m length with 0.5 m spacing, and 0.3 m space between emitters. The average flow rate of the emitters was 5 l/h at 10 m of water operating pressure head. Tap water pumping process was carried out using 0.38 kW electric pump model TWP137011.

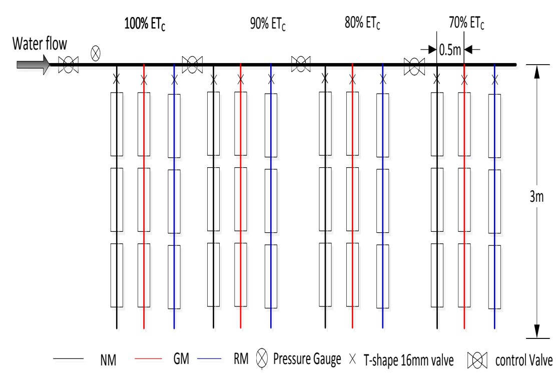

Fig.1: Schematic diagram of the used drip irrigation network

2.2 Measurements

2.2.1 Soil moisture content

In order to investigate how different mulch types, affect water preservation with varying water application amounts, the soil moisture content was measured. The soil moisture content measured at four different times after which were 6, 12, 24 hours, and 48 hours after irrigation which started at 7 am with 72 hours irrigation interval. to investigate the change of soil moisture content and ability of each type of mulching materials to reduce evaporation from soil surface. The moisture content of the soil was measured as volumetric percentage using Smart wave SW220MMT digital soil moisture meter with one digit accuracy provided with 20 cm steel probe. Device probe immersed vertically under the emitter to measure soil moisture content. The root zone moisture was expressed using average values of the soil moisture content for the three replicates.

2.2.2 Soil temperature

The temperature of the soil was measured using a Digital temperature thermometer device Generic TB 300. Soil temperature was compared to air temperature (T_a) which was measured by a wall mercury thermometer Soil temperature was measured at the same times digit accuracy to investigate the ability of each soil type to modify soil temperature according to the change in air temperature. Measuring Soil temperature was at the same times of measuring soil moisture content in addition to taking measures for both air and soil temperatures directly before irrigation.

2.2.3 Crop yield

Total crop yield was expressed as the average of the three replicates of each treatment. Harvesting was after reaching maturity or size commercially acceptable fruit size. Weighing processed using a digital scale with two digits' accuracy. The total yield of each lateral (0.18 m²) was factored to calculate the yield per hectare using $55.6*10^3$ factor.

2.2.4 Crop water productivity (CWP)

The crop water requirements for cucumbers were calculated according to **(FAO,1998)** Based on climate data from the Damietta Meteorological Station for the year 2023. The reference evapotranspiration (ET_0) for the duration of the experiment was determined using the Cropwat 8.0 software. The crop coefficient values were, 0.6, 1.0, and 0.75 for the development, mid-season, and late-season growing periods, respectively **(FAO,1998)**. Crop Water requirement was calculated according to the following formula **(Doorenbos,1977).**

$$ET_c = ET_o . Kc \qquad (1)$$

Where:- ET_c= crop water consumption use; (mm/ day), ET_0 = reference evapotranspiration, (mm/ day); Kc=crop coefficient. Leaching requirement is neglected due to using tap water.

Productivity of cucumber crop per unit of water has been measured to point out the efficiency of water use. Applying the following equation allowed for its determination. **(Jensen,1983).**

$$CWP = \frac{Y}{W_a} \qquad (2)$$

Where:-CWP = crop water productivity, kg/m^3; Y = total yield kg/ha; W_a = total applied water, m^3/ha

2.2.5 Energy use efficiency (EUE)

The crop produced from an energy unit was expressed using the energy use efficiency (EUE) calculation. The equation utilized was as follows:

$$EUE = \frac{Y}{EC} \qquad (3)$$

Where:- EUE = Energy use efficiency, Kg/kW.hr; EC= Energy consumption, kW.hr

$$EC = BP_E . T \qquad (4)$$

Where:- BP_E = Pump brake power, kW ; T= Seasonal operation time, h

$$BP_E = \frac{Pw}{\eta} \qquad (5)$$

Where:-P_w= water pumping power, kW; η = decimal pump efficiency which was assumed 0.7

$$P_w = \omega . Q . H_t \qquad (6)$$

Where: - Q = required discharge at the network, m³/s; H_t= total head, m; ω= water specific weight, KN/ m³. The friction loss inside pipes was neglected because of the short length of both pipes and laterals.

2.2.6 Benefits

In order to determine the revenue per volumetric unit of applied water, total benefits of selling crop yield were divided by total applied water for each treatment. According to the prices of Egyptian market during the experiment time period including currency exchange rate from Egyptian pound (EGP) to US dollar (US$), the average price for selling cucumber from the farm after harvesting was 0.33 US$/kg during the harvesting period.

2.2.7 Statistical analysis

CropStat 7 software was used to perform the statistical analysis to find the significancy of each variable effect on crop yield. and the average of the three replicates was obtained. Duncan's mean comparison test has been carried out referring to Duncan (1955).

3. RESULT AND DISCUSSION

3.1 Soil moisture content

Results listed in Table 1 showed that increasing amount of applied water will lead for more moisture loss. The effect of mulching and DI on the reduction of soil moisture content within 48 hours after irrigation indicated that, RM noticeably has shown greater ability on saving soil moisture. The greatest saving ability was at RM70 while the greatest reduction was at NM100. Using RM will save soil moisture by 26.31% , when the amount of applied water decreases from 100 to 90% of ET_c while this percentage will get lower for GM and NM to be 16.66% and 12.24%, respectively.

Table 1: Reduction in soil moisture content, % from 6 to 48 hours from the end of irrigation.

Amount of applied water, %ET_c.	NM	GM	RM
100	4.9	4.8	3.8
90	4.7	4.4	3.6
80	4.6	4.1	3.2
70	4.3	4.0	2.8

Values of soil moisture were near to the initial ones after irrigation for all the levels of applied water as shown in Figure 1. GM succeed to keep the soil moisture through the time but there was a remarkable loss in the GM70 which did not appear in NM treatments. Increasing amount of applied water led to increase the soil moisture loss. These results clarify the role of DI to reduce soil moisture depletion **Parkash et al., 2023)** and mulching for improving soil) .(moisture retention **(Mkhabela et al., 2019**

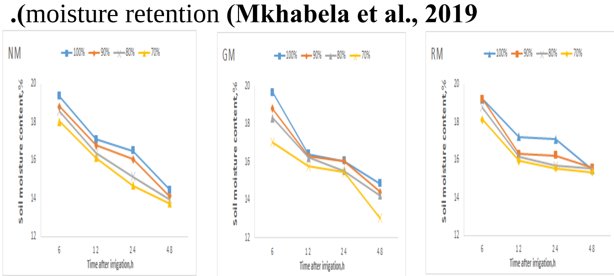

Fig.2: Soil moisture content change after irrigation at different irrigation levels and different mulching

3.2 Soil temperature

Figure 3 shows the values of soil temperature at different day time with 24 hours timing system within time period started from 7 am till first and second next days which represents 7 am after 24 hours from the end of irrigation process (7D1) and 7 am after 48 hours (7D2). Results showed that, RM has the ability of conditioning soil temperature by keeping the soil temperature in a range near to air temperature and lower than air temperature in the hours of sunshine specially at 13 and 19 hours, which were the greatest values of air temperature. RM at low air temperature at 7 am made warming to the soil which appeared in higher temperature than air temperature at all amounts of applied water. On the other hand, GM could not keep the same behavior of RM as soil temperature followed the trend of air temperature whether decreased or increased especially at GM70 which is the least amount of applied. This thermal effect difference is due to the physical nature of the properties of rice straw, where the density is very low due to its intrinsic porosity, which allows the temperature to be transferred to the soil, while the physical properties of gravel make them work to absorb the temperature and not transfer it to the soil, where surface rocks can act as insulators during the hottest part of the day and as a heat source at night **(Pramanik et al., 2015).** In case of NM, the amount 100% ET_c has recorded higher soil temperature than air temperature in the high temperature time periods 13, and 19 h**.** In general, the 70% amount recorded the greatest values of soil temperature and this due to less amounts of water that led to losing the ability to make conditioning for soil temperature.

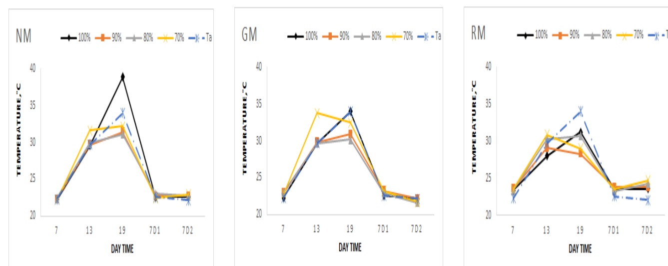

Fig.3: Soil temperature change with air temperature

3.3 Crop yield

Statistical analysis showed that both amount of applied water and mulching type had a highly significant effect on the yield of cucumber while there was no interaction between these variables which means they affect independently on the crop yield as shown in table 2.

Table 2: Analysis of variance for the effect of experimental variables on cucumber crop yield.

S.V	D.F	S.S	M.S	F
Replicates	2	125	63	
Applied water (A)	3	155	52	12.88**
Error(a)	6	24	4	
Type of mulch (M)	2	261	130	7.15**
A.M	6	40	7	0.37ns
Error(b)	16	291	18	
Total	35	896		

**= significant at 1% level, ns= not significant

Cucumber yields generally decreased as the percentage of applied water decreases across all mulching treatments. At 100% applied water, yields were highest for all treatments (21.25, 23.61, and 25.60 Mg/ha for NM, GM, and RM, respectively), indicating that providing the full water requirement maximizes yield potential. At 70% applied water, there is a notable decline in yield, with the lowest values observed across all treatments (13.94 for NM, 15.69 for GM, and 23.43 Mg/ha for RM). This suggests that reduced water availability, negatively impacts cucumber yield, especially under the NM and GM conditions. RM consistently showed the highest yield across most levels of applied water compared to the other mulching conditions. GM performed slightly better than NM, but not as well as RM. For example, at 100% ET_c, GM yielded 23.61 compared to 21.25 for NM, and at 70% ET_c, GM yielded 15.69 compared to 13.94 for NM. Reducing amount of applied water from 100 to 70% of ET_c resulted a reduction of 8.47%, 33.55%, and 34.40% of the maximum yield for RM, GM, and NM, respectively. The results indicated that rice straw mulch is more effective in preserving water and promoting cucumber growth, especially under limited water conditions as shown in table 3. The previous results were confirmed by the mean comparison shown in Table 3 where there was no significant difference between RM treatments while RM and GM could keep the non-significancy till 80% $_c$ while there was significant difference in cucumber yield at 70% percentage at both mulching conditions. The significant difference between RM100 and NM100 treatments clarified that RM has the ability to improve plant growth (**Devasinghe and Sangakkara, 2015; Karki et al., 2020; El-Nemr 2006)** as a result for his ability to keep soil moisture for longer times and keep soil temperature in the required temperature range whether in day or night.

Table 3: Mean cucumber yield comparison (Mg/ha).

Applied water, %ET_c	NM	GM	RM
100	21.25 b	23.61 ab	25.60 a
90	19.81 bc	19.40 bc	25.00 ab
80	19.40 bc	18.84 bc	24.58 ab
70	13.94 c	15.69 c	23.43 ab

L.S. D=3.99 at 0.05 level

3.4 Crop water productivity (CWP)

Table 4 shows the number of days till reaching maturity (D_{mat}), the length of harvesting period (D_{har}), and the total length of the growing season (D_{total}) for all experiment treatments. Results showed that RM helped cucumber fruits to reach maturity stage earlier than NM and GM. Earliest maturity was at RM70 with 38 days while latest was NM70 and NM80 with 48 days. The difference of 10 days is considered long time period of growing season which reached maximum value of 68 days at RM100. This is an indicator to the ability of rice mulching to improve and support the cucumber maturity and increasing yield in longer harvesting period. Crop maturity started earlier with RM followed by GM which showed slight reduction in maturity period but still near to near to NM. As shown in table 4 and figure 4, RM showed higher CWP when compared to GM and NM. The greatest CWP was 9.06 kg/m^3 at RM70 while the least was 5.83 at NM70. Despite the RM70 treatment consumed greater amount of water compared to NM70 and GM70 in addition to longer growing season, it showed higher CWP because of the higher productivity and the decreased effect of DI which has appeared in the non-significant differences between RM treatments' crop yield.

Table 4: Maturity time period (Dmat), Harvesting time period (D_{har}), Seasonal amount of applied water (W_a), m^3/ha, and CWP, kg/m^3

		D_{mat}	D_{har}	D_{total}	W_a	CWP
NM	**100**	45	19	64	3476.05	6.11
	90	46	17	63	3125.55	6.34
	80	48	13	61	2690.10	7.21
	70	48	13	61	2389.44	5.83
GM	**100**	44	19	63	3421.70	6.90
	90	45	18	63	3125.60	6.21
	80	46	16	62	2734.20	6.89
	70	47	15	62	2428.60	6.46
RM	**100**	38	30	68	3693.30	6.93
	90	39	28	67	3324.00	7.52
	80	39	28	67	2954.70	8.32
	70	41	25	66	2585.30	9.06

CWP took the trend of increase till 80% at NM. Greatest CWP with GM was at GM100 followed by GM80 and GM70, respectively, while the least was at GM90. GM did not show the same ability of RM to improve crop yield and decrease the effect of DI on crop yield reduction. Reducing amount of applied water from 100 to 70% led to increase the CWP by 23.51% using RM while it decreased by 6.37% and 4.58% for GM and NM, respectively. When water stress is not severe, DI is a useful technique for increasing CWP (Igbadun et al., 2006; Saad et al., 2018), so when we use mulching especially RM, we can reach the maximum benefit of unit of water.

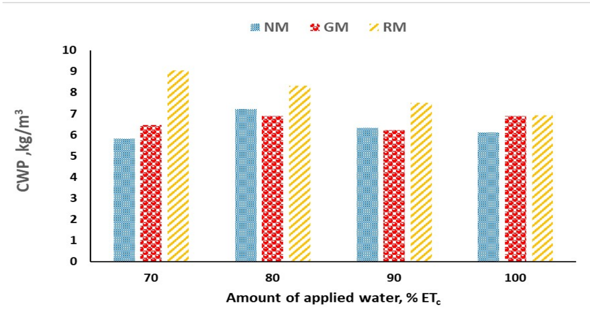

Fig.4: CWP at different amounts of applied water and mulching conditions

3.5 Energy use efficiency (EUE)

Results indicated that, decreasing amount of applied water led to decrease in energy consumption (Enc) as shown in table 5. This is a logic result for the decrease in operation time. The greatest En_c was 52.76 kW.h at RM100 while the least was 34.13 kW.h at NM70. The higher En_c values at RM treatments are due to the longer growing season which resulted in higher cucumber yield. For NM treatments, reducing amount of applied water which is directly related to operation time and energy consumption led to increase EUE till NM70 which recorded the least value of EUE which was 408.3 kg/kW.h. This is due to the significant reduction in crop yield compared to the rest of amounts of applied water as shown previously in table 3. The GM treatments showed the greatest EUE value at GM 80 with 484.5 kg/kW.h while the least was at GM90 with a value of 436.5 kg/kW.h . The greatest value of EUE at RM was 634.4 kg/kW.h at RM70 while the least was 485.3 kg/kW.h.

Table 5: Seasonal operation time, h; Energy consumption, kW.h; and EUE for experiment treatments

	Amount of applied water, % ET_c	Operation time, h	En_c, kW. hr.	EUE, kg/ kW. hr.
NM	100	12.51	49.64	428.1
	90	11.24	44.60	444.3
	80	9.68	38.41	505.0
	70	8.60	34.13	408.3
GM	100	12.30	48.81	483.7
	90	11.20	44.44	436.5
	80	9.80	38.89	484.5
	70	8.70	34.52	454.6
RM	100	13.29	52.76	485.3
	90	11.96	47.45	526.9
	80	10.64	42.21	582.4
	70	9.31	36.93	634.4

Results indicated that, GM has lower ability to reduce the effect of DI on crop yield than RM which had the greatest values of EUE compared to GM and NM treatments. The higher EUE with DI at NM treatments at NM80 and NM90 may is due to the less operation time and the ability of DI to adjust the amount of applied water (Melkie et al., 2024).

Figure 5 shows that, there was a directly proportional relationship between Enc and W_a due to the reduction in operation time. At the same time, EUE had an inverse relationship with W_a just at RM while there were changes in EUE values and did not follow a certain trend according to W_a for both GM and NM. These results indicated the ability of RM compared to GM and NM to reduce the negative effect of DI on EUE and helped to provide better management for system operation when Using DI. Using DI technique showed a positive effect on EUE with limitations of selecting suitable percentage of reducing W_a at each mulching condition to assure obtaining maximum possible EUE. Comparing the maximum obtained values of EUE with the values of full irrigation (100% ETC) at each mulching condition showed that DI increased EUE by 15.23%, 0.17%, and 23.50% at NM, GM, and RM, respectively.

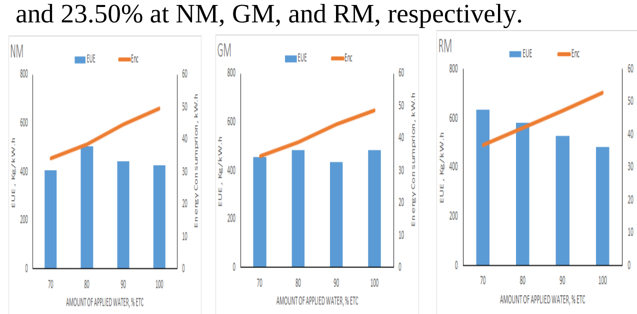

Fig.5: Effect of using different amounts of applied water and mulching conditions on Enc and EUE.

3.6 Benefits

Table 8 shows the values of benefits obtained from volumetric water unit (US$/m^3). The greatest profit was 8534 US$/ha at RM100 while the least one was 4645 at NM70. As a reflection for crop yield, RM showed the highest benefits followed by GM and NM, respectively.

Table 6: benefits per water unit US$/m3 of cucumber crop during the growing season.

	NM				GM				RM			
	100	90	80	70	100	90	80	70	100	90	80	70
Benefits US$/ha	7083	6605	6466	4645	7870	6466	6281	5231	8534	8333	8194	7809
Water benefits, US$/m^3	2.04	2.11	2.4	1.94	2.3	2.07	2.3	2.15	2.31	2.51	2.77	3.02

The greatest water benefit reached 3.02 US$/m^3 at RM70 while the least one was 1.94 at NM70. Obtaining greatest benefit at RM70 is due to the lower amount of applied water with no significant reduction in cucumber crop yield. Increasing amount of applied water at RM led to decrease water benefit which was not the same with GM and RM. The least benefit of water unit for GM was 2.07 Us$/m3 at GM 90 while the greatest was 2.30 at GM100. On the other hand, the greatest benefit of NM was 2.40 at NM80 while the least was 1.94 at NM70 which recorded the least cucumber yield. In general RM treatments showed higher benefits than all facing ones for both GM and NM. Despite the expected increase in total costs due to the additional costs of mulching materials, but the same trend of benefits is still expected because of the low cost of RM mulching material and the decrease in operation time which means lower energy consumption and water use.

4. CONCLUSION

This study aimed to investigate the impact of integration of RM and GM mulching with deficit irrigation on increasing the crop water productivity and energy use efficiency for drip irrigated cucumber. Results indicated that, using mulch led to decrease the effect of DI on reducing total cucumber yield. Using RM showed higher ability than GM in keeping soil moisture and making modification for soil temperature whether by aeration or warming. This ability has been reflected on keeping cucumber yield with non-significant reduction with the least amount of applied water under experiment condition. The study recommends using the treatment RM70 in order to obtain the greatest possible CWP, EUE, and benefits from volumetric water unit. Gravel mulch did not appear as suitable mulching material under experiment condition due to lower ability of saving soil moisture and making required soil aeration at increased air temperature times. Future studies on less amounts of applied water are recommended with other different crops to utilize the features of RM for reaching better irrigation management with DI under drip irrigation operation conditions especially in arid and semi-arid areas where DI is required and acceptable strategy.

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CONFLICTS OF INTEREST:

The authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION

Elnemr and Elmwafy developed the concept of the manuscript, shared writing. All authors checked and confirmed the final revised manuscript.

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الملخص العربى

تأثير التغطية والرى الناقص على إنتاجية المياه وكفاءة استخدام الطاقة لمحصول الخيار المروي بالتنقيط

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تم اجراء تجربه صغيرة النطاق على محصول الخيار المروي بالتنقيط بغرض استقصاء تأثير تغطيه التربة على انتاجيه وحده المياه وكفاءه استخدام الطاقة في حالة استخدام الري الناقص. تم تجربة ثلاث ظروف من التغطية هي التغطية بقش الارز والحصى مقارنه بظروف عدم التغطية، مع أربع كميات من المياه المضافة وهي الري الكامل بالإضافة للنسب ٩٠%، ٨٠%، ٧٠% من الاستهلاك المائي للمحصول. اظهرت النتائج قدره أكبر للتغطية بقش الارز على المحافظة على المحتوى الرطوبي للتربة مقارنه بالتغطية باستخدام الحصى كذلك قدرتها على توفير التهوية والتدفئة لسطح التربة مع تغير درجه حرارة الهواء الخارجي وهو ما لم يتوفر في التغطية بالحصى التي اظهرت ارتفاع في درجه حرارة التربة عن درجة حرارة الهواء الخارجي بشكل مستمر. اوضحت قيم انتاجيه المحصول، ان جميع معاملات التغطية بقش الأرز لم تسجل اي انخفاض معنوي في الإنتاجية مع خفض كميه المياه المضافة على عكس التغطية بالحصى التي اظهرت اختلافا معنويا في الإنتاجية عند النسبة ٧٠%. كنتيجة لقدرة التغطية بقش الارز على الحد من التأثير السلبي للنقص المائي على الانتاج سجلت اعلى انتاجيه من وحده المياه عند النسبة ٧٠% بينما كانت اعلى انتاجيه عند التغطية بالحصى عند استخدام الري الكامل وكانت اعلى نسبه في حاله عدم التغطية عند النسبة ٨٠%. انعكس تأثير الري الناقص على كفاءه استخدام الطاقة مما اظهر امكانيه لزيادتها بنسب ١٥.٣%، ١٧.٠٠، ٢٣.٥٠% مع عدم التغطية والتغطية بالحصى والتغطية بقش الأرز على الترتيب. اوصت الدراسة بإمكانية استخدام الري الناقص حتى ٧٠% من الاحتياجات المائية المحسوبة للنبات مع التغطية بقش الارز لتعظيم انتاجيه وحده المياه وكفاءه استخدام الطاقة وتحقيق اقصى عائد مادي لوحده المياه لمحصول الخيار.