MISR JOURNAL OF AGRICULTURAL ENGINEERING ISSN-Print: 1687-384X
https://mjae.journals.ekb.eg/ ISSN-Online: 2636-3062

Misr J. Ag. Eng., 40 (4): – DOI:

EFFECT OF SPRINKLER AND FURROW IRRIGATION SYSTEMS ON RICE YIELD AND ITS WATER PRODUCTIVITY

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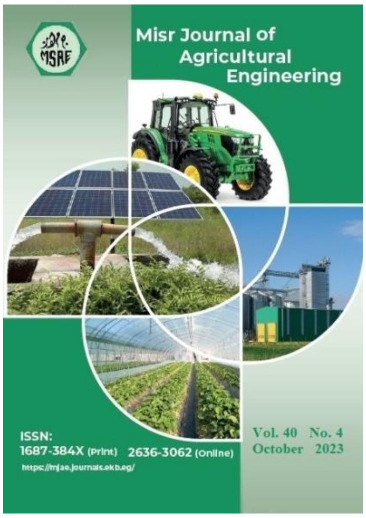

Keywords:
Rice irrigation; Water productivity, Rice varieties.

ABSTRACT

Fixed Sprinkler and furrow irrigation methods considered as the effective irrigation methods for most of field crops. Therefore, it was essential to evaluate of using these methods in irrigation of rice paddy (Oryza sativa L.) instead of the traditional flood irrigation methods which consume large amounts of irrigation water. Also, rice varietal substitutions with new developed short-duration cultivars could be an opportunity to achieve higher crop yield and water saving. From thus points, this work aims to assess the effect of using sprinkler and furrow irrigation systems on rice yield and water productivity of the two rice varieties (Sakha104 and Oraby3) compared with traditional method (basin irrigation). The results indicated that the highest grain yield was obtained under sprinkler irrigation system as the average for the two varieties reached to 10.17ton.ha^{-1}. Oraby3 variety showed higher grain yield than Sakha104 variety. The interaction between two rice varieties and the two irrigation systems indicated that the highest value of grain yield was 10.81ton.ha^{-1} obtained from treatment of Oraby3 variety under sprinkler irrigation system, Also, the highest crop water productivity (1.24 kg.m^{-3}) was recorded under the same treatment.

1. INTRODUCTION

Egypt is facing a challenge of producing more agricultural production with limited irrigation water. In addition to the effect of the climate changes which likely increase irrigation water requirements especially for summer crops. Therefore, a number of measures have been taken in Egypt to reduce the cultivated area for rice crop, in order to conserve water and use it more efficiently in other agricultural and economic sectors. These actions are intended to increase water efficiency in Egypt, promote sustainable development, and lessen the burden on the nation's water resources, as rice cultivation declined by an average of 1.5% and productivity by 0.33% between 2000 and 2020 year **(Abou Mosalam and El Shamy, 2021)**. **Atta (2005)** indicated that strip of furrows of 80 cm apart treatment produced the greatest grain yield (5.01 ton/ fed), followed by strip of furrows of 60 cm apart (4.79 ton/ fed), with insignificant differences between them. Grain yield was exhibited pronounced increases for treatments of strip of furrows of 60 cm apart and strip of furrows of 80 cm apart, where the corresponding relative increase percentages were 9.78 and 13.70 % over the control treatment of traditional transplanting method, respectively. **(He, 2010)** reported that furrow irrigation system outperformed continuous flooding irrigation, reducing water use by 3130 m^3, or 48.1%, as well as increasing grain yield by 13.9% for an early cultivar while reduced water by 2655 m^3, or 40.6%, and increased grain yield by 12.1%, respectively To conserve water resources, reduce water scarcity, and advance sustainable agriculture, it is imperative to increase water productivity and efficiency in water usage **(Zhou et al., 2021).** The authors demonstrated higher water savings under the furrow irrigation system as well as higher yields. WUE was improved by 146.44% due to the significant reduction in water use by 56.8% **(Abdallah et al., 2018). Kahlown et al. (2007)** during 2002–2004 found that sprinkler irrigation increased rice output by 18% while using 35% less water than the conventional irrigation technique and revealed that adopting sprinkler irrigation for rice is a financially viable choice for farmers. According to **Stevens et al., (2009)** sprinkler irrigation uses 28% less water than conventional flooding system.

So the aim of this study was to examine the effect of using furrow irrigation system and sprinkler irrigation for rice crop on grain yield, water productivity and water use efficiency of two rice varieties (Sakha104 and Oraby3) comparing with the traditional basin irrigation method.

2. MATERIALS AND METHODS

1. Site Description

Field experiments were conducted at the Experimental Farm of Faculty of Agriculture, Benha University at Moshtohor – Qalyubia Governorate, Egypt, during the two successive summer seasons of 2020 and 2021. This location represents clay soil conditions of the Nile Delta region. The dominant soil of the experimental site was clay textured throughout the profile as shown in Table **1.**

Table (1) Physical and hydro-physical properties of soil, at Moshtohor, Qalyubia

Physical properties					
Soil depth (cm)	**Sand (%)**		**Silt (%)**	**Clay (%)**	**Textural Class**
	Fine	**Coarse**			
0 – 30	20.95	1.28	27.92	49.85	**Clay**
30 – 60	21.23	1.96	28.19	48.62	**Clay**
hydro-physical properties					
Depth (cm)	**FC (%)**	**P.W.P (%)**	**AW (%)**	**HC (cmh^{-1})**	**BD (gcm^{-3})**
0 – 30	33.50	16.00	17.50	1.19	1.10
30 – 60	38.50	18.50	20.00	0.42	1.15

FC.: Field capacity P.W.P: Permanent wilting point BD.: Bulk density
AW: Available water HC: Hydraulic conductivity

2. Experimental design and layout

The applied statistical design of the experiments used was split plot design with three replicates, where three irrigation systems (basin, furrow and sprinkler irrigation system) were used with two varieties (Sakha104 and Oraby3) as shown in **Fig (1).**

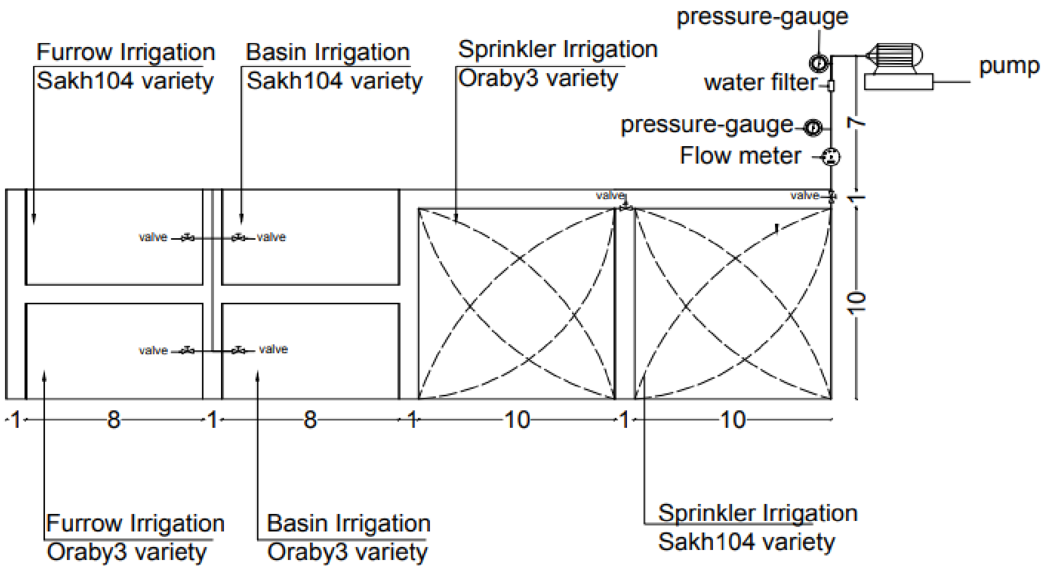

Fig (1) Experimental irrigation system layout

Sprinkler irrigation network (The components of the sprinkler irrigation network were as follows:-

1- A 3 HP electrical centrifugal pump of 50.8mm (2in) suction and delivery pipe sizes had the same diameter. A control gate valve, pressure gage and flow meter were attached on the pump discharge pipe, pumping discharge was24 m^3/h at 27 m operating pressure head.
2- PVC pipelines of 63 mm diameter were used to convey and distribute irrigation water from the source to the sprinklers on the lateral line.
3- PVC pipelines of 19.05 mm diameter were used as lateral lines carried irrigation sprinkler heads.
4- Four rotator sprinkler heads of two nozzles (2.9 * 1.8 mm), 0.6 $m^3.hr^{-1}$ discharge and10 m trajectory radius at 20 m operating pressure were located at the 4 corners of the squire rice basin. Each sprinkler was controlled to irrigate one quarter of the basin. So, average water application rate was 24 mm/h.

Field preparation and practices performed according to the traditional local management. Thirty days rice (Sakha104 (V_{S104}) and Oraby3 (V_{O3})) varieties seedlings were transplanted on flat soil surface at the hills (2 plants) distance of 20 x 20 cm to give the rate of (25 hills/m^2) in both of the two treatments (basin irrigation system (BI) and sprinkler irrigation system (SI), while under furrow irrigation system (FI) (strip of furrows of 80 cm apart, where top of furrow 45 cm (border) and 35 cm for bottom tape. Seedlings were transplanted in hills (2 plants) 10 cm apart in the two rows on the bottoms of furrows (tapes) keeping population the same as in the traditional method (25 hills.m^{-1}) according to **Atta, (2008)**. Fertilization program and weed control was carried out as recommended from Ministry of Agriculture and Land Reclamation (MALR). The growing season for rice extends from May to end of September.

3. Rice crop growth and yield components measurements

Ten plants were selected randomly after flowering from each treatment for measuring plant height, (cm) – flag leaf area (cm^2) - panicle length (cm) - number of panicles /hill. At harvest, 1000-grain weight- grain yield - straw yield- biological yield-harvest index (%).

4. Rice irrigation water requirement

The amount of irrigation water for rice crop was applied by flow meter. Seasonal irrigation water applied for Sakha104 variety were 1501.23 mm under basin treatments (BI), 1005.82mm under furrow treatment (FI) and 1000.22 mm under sprinkler irrigation treatment (SI) and for Oraby3 variety 1234.18 mm under (BI), 826.9 mm under (FI) and 822.79mm under (SI). This data determined after being calculated according to the weekly ETo published data from MALR, and then applied to the equation as follows: **Vermeiren and Jobling, (1980)**:

$$IW = \frac{(ETo \times Kc \times \mathrm{II})}{Ea\,(1 - LR)} \times 10$$

Where (IW = Irrigation water applied, m^3/ha/irrigation, ET_0 = Reference evapotranspiration (mm/day), **II**= Irrigation intervals, day, Ea = Irrigation efficiency of irrigation system (%) and LR = Leaching requirement = 10% of the total amount of water, m^3/ha/irrigation), Kc = Crop coefficient, (for Sakha 104 Variety was 1.16, 1.19 and 1.04 in July, August, and September, respectively **(Darwesh and Hadifa, 2020)** and for Orabi 3 variety, Kc was 0.8 at initial growth stage, 0.99 at development growth stage, 1.06 at mid growth stage and 0.98 at end growth stage **(EL-Sayed and Abd El-Monem, 2017)**).

5. Water use efficiency (WUE) and Crop water productivity (CWP)

Crop scientists express and measure water use efficiency as the ratio of total biomass or grain yield to water supply or evapotranspiration on a daily or seasonal basis (**Sinclair et al., 1984; French and Schultz, 1984)**

Crop Water use efficiency (CWUE) of rice grain yield was accordingly calculated using the following equation:

$$\text{CWUE of rice grain yield (kg/m3)} = \frac{\text{(Y) total rice grain yield (kg/fed)}}{\text{(ETa) seasonal evapotranspiration water } (m^3/\text{fed})}$$

Crop water productivity (CWP) was calculated according to **Michael (1978)** using the following equation:

$$\text{CWP of rice grain yield (kg/m3)} = \frac{\text{total rice grain yield (kg/fed)}}{\text{total irrigation water applied } (m^3/\text{fed})}$$

3. RESULTS AND DISCUSSIONS

1. Effect of irrigation systems on soil moisture distribution pattern

Fig (2) shows soil moisture distribution pattern at vegetative stage under dry basin irrigation system (BId) for drought resistant rice (Oraby3) (V_{O3}). Soil moisture content was 100% under traditional flood irrigation BIt (control system). i.e. soil moisture was uniformly distributed and covering the traditional basin irrigation (for irrigating sakha104 variety), For dry basin where Oraby3 variety (V_{O3}) was irrigated, soil moisture at head of basin was varied vertically. Moisture content at surface soil layer (0-30 cm) was 46.2 % while it was 43.45% at deeper (30-60 cm) soil layer but more or less it was uniform up to the tail end of the basin as shown in Fig 2.

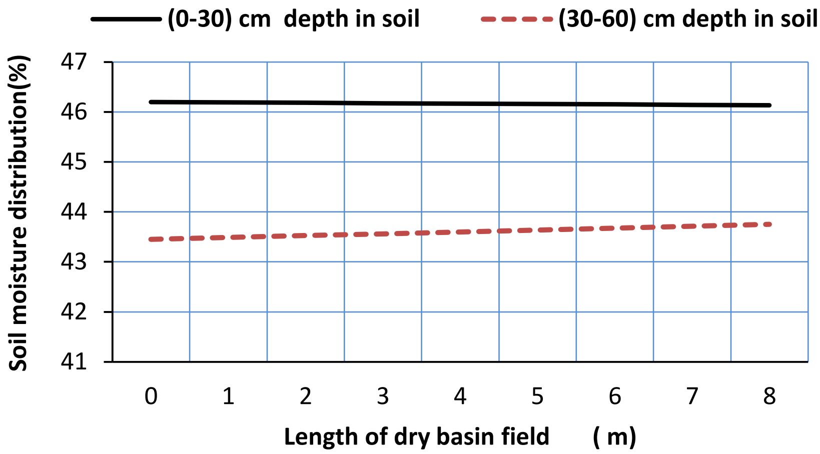

Fig (2): Soil moisture distribution under basin irrigation system for Oraby3

On the other hand, soil moisture content under furrow irrigation system (FI) with Sakha104 variety (V_{S104}) ranged from 45.6 and 44.45 % at (0-30) and (30-60) cm depth , respectively at the head of furrow to 41.73 and 39.75% at the same two soil depths at the tail end of the furrow., while with less irrigation water to be applied for drought variety (Oraby3) furrows, soil moisture distribution pattern showed more uniform than in case of the other variety (Fig3).

Surface horizontal soil moisture distribution pattern under the sprinkler irrigation system (SI) indicated that there was intensive water applied at the middle of the irrigated area higher than that applied at areas near the sprinklers. This may be due to the quarter rotation sprinklers type. Soil moisture throughout the area seems to be ranged from 43% to 37% with high uniformity coefficient (CUC = 97.66%) as will as high Distribution uniformity of low quarter (DUlq = 96.76%).

Similar discussion could be applied on the vertical soil moisture distribution pattern through the soil profile to 60 cm depth as (CUC = 95.39%) (DUlq = 93.37%).. The highest moisture contents located at the middle of area started by 45% and gradually decreased downward to be 37% at the lower depth 60 cm as shown in Fig 4. These agree with **Kamal et al., 2012.**

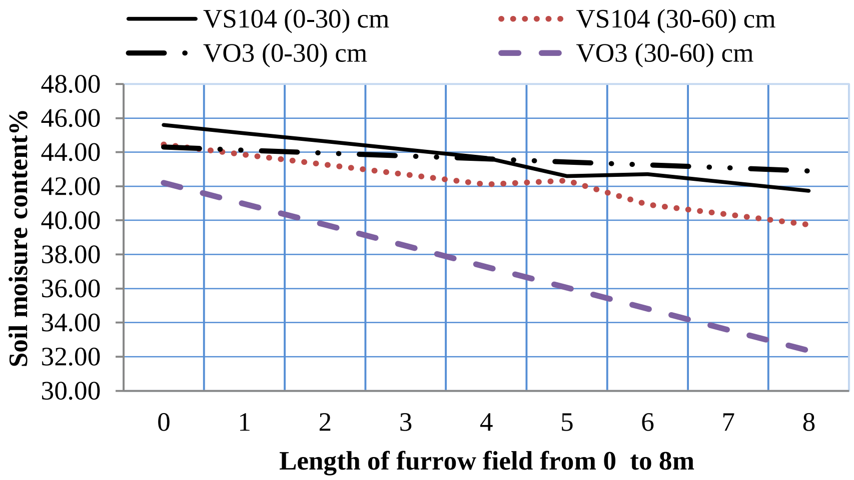

Fig (3): Soil moisture distribution under furrow irrigation system (Sakha104 and Oraby3 rice variety)

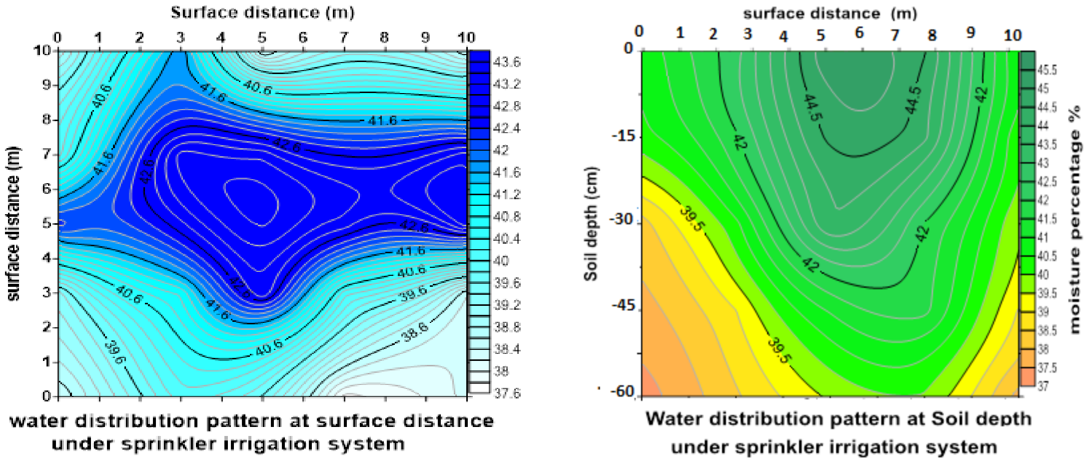

Fig (4): Horizontal and vertical soil moisture distribution patterns of sprinkler irrigation treatment as an average for two varieties

2. Effect of irrigation systems on plant growth parameters

The results indicated that the highest plant height108.5cm, flag leave area23.35cm^2, number of panicles per bed 26.83 and length of panicles 22.6cm were obtained under the control traditional basin treatment (BI) these values were very close to that obtained by sprinkler irrigation treatment, While the lowest plant height, flag leave area and number of panicles per bed was found under furrow irrigation treatment (FI) (**Table 2)**. There were no significant differences between values of flag leave area, number of panicles per bed and length of panicles under sprinkler irrigation treatment (SI) and the control treatment (BI) in spite of the less irrigation water applied in sprinkler treatments the highest number of panicles per bed 31wes obtained with sprinkler treatment. The lowest plant height, flag leave area and number of panicles per bed were obtained under furrow treatments FI, but the length of panicles was the highest in this treatment. There were no significant differences in the length of the panicles per bed in all irrigation. In general, it could be concluded that the traditional basin irrigation (BI) and sprinkler irrigation treatments (SI) as will gave better plant growth parameters than furrow irrigation FI treatments, this result similar to **Chlapecka et al (2021).**

Table (2): effect of irrigation systems on plant growth parameters in 2020 and 2021 seasons.

	Plant height (cm)	Flag leave Area (cm^2)	No. of panicles per bed	Length of panicles (cm)
BI(c)	108.5^a	23.35^a	26.83^a	22.60^a
FI	101.5^b	21.28^b	25.67^a	23.27^a
LSD	1.773	1.167	3.463	2.411
SI	104.10^b	22.68^a	31.00^a	22.52^a
LSD	1.726	0.935	0.925	2.271

Irrigating rice by sprinkler irrigation SI reduced moisture content in the rice field, promoted light penetration and gas exchange, and lowered reduced materials, such as ferrous iron (Fe2+) content in the soil, which in turn led to higher growth rate and rice production. This is reflected by the reduction in the population height and the number of tillers at the early stage of growth, the increases in the quality of tillers and the rate of spike formation, and the reduced occurrence of disease, such as the rice sheath blight. The improvements of rice growth under the SIS system are also evident by higher dry mass weight of different plant components and the higher grain quality. The results agree with **Lu et al., 2000**.

3. Effect of irrigation systems on yield-contributing parameters

The results of rice plant growth parameters shown in table 1 consider to be a clear indication for the results of rice yield and water productivity presented in **Table (3)**. The results indicate that sprinkler irrigation (SI) treatment gave the highest results in all the yield contributing parameters except straw yield and biological yield which were higher in basin (BI) and furrow (FI) treatments. The highest number of grain per panicle 115.20 obtained from SI followed by 114.70 per panicle from FI compared to 110.5 from the control (BI). While there were no significant differences of 1000-grain weight under all irrigation systems. The highest values of grain yield were 10.171 and 9.814 $ton.ha^{-1}$ under SI and FI, respectively and the lowest value was under the control treatment (BI). The highest straw yield was 14.648 $ton.ha^{-1}$ under the control treatment (BI) followed by 12.438 $ton.ha^{-1}$ under furrow (FI) treatment, and the lowest straw yield was 10.781 ton ha^{-1} under SI treatment. Under all irrigation systems, there were no significant differences of biological yield values. However the highest value of harvest index was 48.61% under SI and lowest value was 37.83% under FI and BI treatments. . The highest values of water use efficiency (WUE) and crop water productivity (CWP) were 1.67 and 1.13 $kg.m^{-3}$ obtained from sprinkler irrigation SI treatment followed by 1.61$kg.m^{-3}$ and 1.08 $kg.m^{-3}$ from furrow FI treatment, respectively and the lowest value was 1.41$kg.m^{-3}$ and 0.64 $kg.m^{-3}$under the control BI treatment respectively.

Sprinkler irrigation SI recorded 33.3% water-saving and 33% by furrow FI compared to 1501.23 mm irrigated by BI control method. Although the differences were slight in water conservation between the sprinkler and furrow irrigation systems, the sprinkler irrigation system achieved the highest rice grain production and water productivity. That results similar to **Abdallah et al. (2018); Atta, (2008); Crusciol et al. (2013) and Kahlown et al. (2007)**.

Table (3): effect of surface irrigation systems on yield-contributing parameters

	Number of grain per panicle	1000 grain weight (g)	Grain yield (ton/ha)	Straw yield (ton/ha)	Biological yield (ton/ha)	Harvest index (%)	WUE (kgm^{-3})	CWP (kgm^{-3})
BI(c)	110.5^{b}	23.13^{a}	8.598^{b}	14.65^{a}	23.24^{a}	37.83^{b}	1.41^{b}	0.64^{b}
FI	114.7^{a}	23.59^{a}	9.814^{a}	12.44^{a}	22.25^{a}	37.83^{a}	1.61^{a}	1.08^{a}
LSD	3.702	1.156	0.3475	1.351	1.65	3.027	0.124	0.072
SI	115.20^{a}	23.8^{a}	10.171^{a}	10.78^{b}	20.95^{a}	48.61^{a}	1.67^{a}	1.13^{a}
LSD	2.070	2.374	0.2210	1.026	1.075	2.373	0.1924	0.0786

4. Effect of the interaction between irrigation systems and two varieties of rice on yield - contributing parameters.

Table (4) summarizes the interaction effect of the irrigation systems and the two rice varieties. The data indicate that the number of grain was affected by the method of irrigation for the two varieties. Sprinkler SI and furrow FI gave higher values than the tradition irrigation BI. (131.7 and 131 per panicles) under SI and FI with Oraby3 variety V_{O3} compared to the control (BI) with V_{S104} which recorded 95 per panicles, as shown in **Table (4)**. While the 1000-grain weight didn't effected by irrigation methods, it seems to be depends only on crop variety. 1000 grain weight under all irrigation systems BI, FI, and SI were 25.67, 25.21 and 25.13 g for V_{s104} and 21.05, 21.52 and 22.65 g. for Vo3 which clearly illustrate that no significant effect for the irrigation methods. The highest value of grain yield 10.81 and 10.63 $ton.ha^{-1}$ were recorded with Oraby3 variety (V_{O3}) under SI and FI irrigation methods respectively, while the lowest grain yield 8.193 $ton.ha^{-1}$ was recorded under basin irrigation (BI) with Sakha104 variety as shown in **Fig (5).** The straw yield values were significantly affected, which recorded the highest value 15.576 and 15.26 $ton.ha^{-1}$ with V_{O3} variety under the control (BI) and FI irrigation treatments respectively. while the lowest value was 9.619 $ton.ha^{-1}$ with Sakha104 variety under FI irrigation method and 9.764 $ton.ha^{-1}$ with Oraby3 variety under sprinkler (SI) treatment.

Table (4): The interaction among irrigation systems and two varieties on yield - contributing parameters

		N. of grain per panicle	1000 grain weight (g)	Grain yield ($t.ha^{-1}$)	Straw yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest index (%)	WUE (kgm^{-3})	CWP (kgm^{-3})
BI(c)	V_{S104}	95.00^{b}	25.21^{a}	8.193^{b}	13.719^{ab}	21.912^{ab}	38.17^{b}	1.27^{c}	0.57^{d}
	V_{O3}	126.00^{a}	21.05^{b}	9.000^{b}	15.576^{a}	24.571^{a}	37.50^{b}	1.55^{b}	0.70^{c}
FI	V_{S104}	98.33^{b}	25.67^{a}	8.995^{b}	9.619^{b}	18.614^{b}	48.33^{a}	1.45^{c}	0.98^{b}
	V_{O3}	131.00^{a}	21.52^{b}	10.633^{a}	15.26^{a}	25.881^{a}	41.34^{b}	1.77^{a}	1.19^{a}
LSD		2.507	5.235	1.635	0.4915	1.910	2.332	0.176	0.101
SI	V_{S104}	98.67^{C}	25.13^{a}	9.531^{b}	11.80^{bC}	21.331^{ab}	44.68^{b}	1.51^{c}	1.02^{b}
	V_{O3}	131.7^{a}	22.65^{ab}	10.810^{a}	9.764^{C}	20.573^{b}	52.55^{a}	1.83^{a}	1.24^{a}
LSD		2.927	3.358	0.313	1.452	1.531	3.356	0.101	0.072

Biological yield values indicate that the highest Bio-yield 25.881 $t.ha^{-1}$ was obtained from Oraby3 (V_{o3}) under furrow irrigation (FI). was and the lowest value was 18.614 for V_{s194} variety under furrow (FI)irrigation However harvest index recorded the highest value was under sprinkler irrigation (SI) with Oraby3 variety which reached to 52.55% and the lowest value37.50% was also for Oraby3 but under furrow irrigation (FI) treatment. This result may be attributed to the better growth condition with more nutrients caused high grain weight and tillers number above ground biomass.

The highest values of WUE and CWP were 1.83 and 1.24 $kg.m^{-3}$ respectively obtained from Oraby3 variety under sprinkler irrigation (SI) treatment, while the lowest values were 1.27 and 0.57$kg.m^{-3}$ obtained from Sakha 104 variety V_{S104}. Under traditional basin irrigation (BI) as shown in Table 3 and **Fig (6).** Similar result was reported by **Darwesh et al (2020)**.

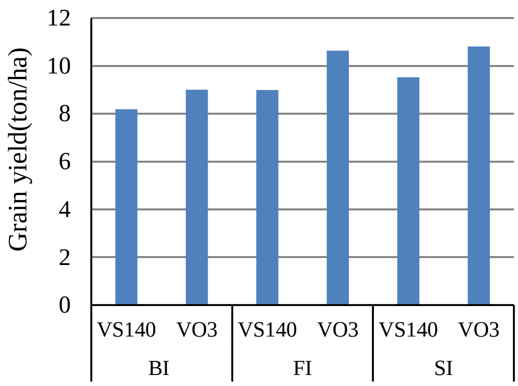

Fig (5) Grain yield (ton.ha^{-1}) under irrigation systems for the two varieties.

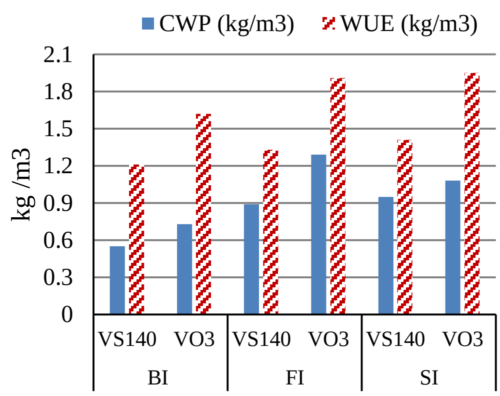

Fig (6) WUE and CWP (kg.m^{-3}) under irrigation systems for the two varieties

4. CONCLUSION

The results indicated that the Oraby3 variety achieved the highest value of grain yield and water productivity for all irrigation systems, while the highest values of grain yield and water use efficiency were under sprinkler irrigation system for the two varieties. The interaction among all treatments caused that grain yield, water use efficiency and crop water productivity under sprinkler irrigation system with Oraby3 variety achieve the highest value. In addition, with Sakha 104 variety, sprinkler irrigation can save 5004.1 $m^3.ha^{-1}$ and furrow irrigation can save 4954 $m^3.ha^{-1}$ compared with traditional irrigation BI. Sprinkler and furrow irrigation methods with Oraby3 rice variety could save 8155.7 $m^3.ha^{-1}$, and 6743.28 $m^3.ha^{-1}$ respectively. As well as, irrigating Oraby3 variety by dry basin (BI) can save 2670.4 $m^3.ha^{-1}$ of irrigation water all compared with traditional irrigation (BI) with Sakha 104 variety .Finally, it is possible to cultivate rice under the sprinkler irrigation system which achieved the highest values of grain yield and water use efficiency and crop water productivity especially for Oraby3 variety.

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تأثيرنظم الري بالرش والرى فى خطوط على محصول الأرز وإنتاجية المائية

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[١] طالبة دراسات عليا - كلية الزراعة - جامعة بنها - مصر.

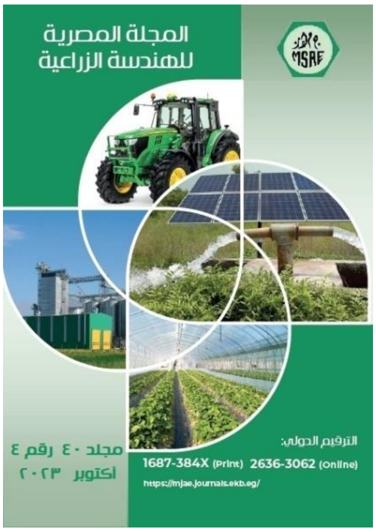
[٢] أستاذ متفرغ الهندسة الزراعية - كلية الزراعة - جامعة بنها - مصر.

[٣] أستاذ مساعد متفرغ الهندسة الزراعية - كلية الزراعة - جامعة بنها - مصر.

[٤] أستاذ الهندسة الزراعية - كلية الزراعة - جامعة بنها - مصر.

الملخص العربى

نظام الري بالرش يعتبر من أكثر الطرق الحديثة والفعالة للري في الزراعة، وهو يحقق العديد من المزايا بما في ذلك توفير استخدام المياه وزيادة الإنتاجية و تعتبر زراعة الأرز(Oryza sativa L.) عادة مرتبطة بالري السطحي حيث يتم تغطية الحقل بطبقة من الماء. ولكن، هذه الطريقة تستهلك كميات كبيرة من الماء، وقد يكون لها تأثير سلبي على البيئة. لذلك تم إجراء هذا البحث لدراسة وتقييم رى الأرز بنظام الرى فى خطوط والرى بالرش مقارنة بنظام الرى فى الاحواض (نظام الرى التقليدى) تحت ظروف الآراضى الطينية القديمة. لذلك أجريت تجربة حقلية بكلية الزراعة جامعة بنها خلال عامى ٢٠٢٠- ٢٠٢١ تدرس انتاجية الارز تحت كلا النظامين مقارنة بالنظام التقليدى فكانت المعاملات زراعة صنفين من الارز احدهما تقليدى (سخا١٠٤) والاخر مقاوم للجفاف (عرابى٣) تحت نظامى الرى بالرش و الرى فى خطوط مقارنة بالرى التقليدى. أوضحت النتائج أن استخدام الرى بالرش لرى محصول الارز في حالة الأرز الجاف الخيار الامثال لأنه يحتاج إلى كميات أقل من الماء مقارنة بالأرز التقليدي. تم الحصول على أعلى انتاج تحت نظام الرى بالرش الصنف الجاف والصنف التقليدى حيث وصل الى ١٠,٨١ طن للهكتار للصنف الجاف وكذلك اعلى قيمة لكفاءة استخدام المياه وصلت الى ١,٨٣ كجم لمتر مكعب من الاستهلاك المائى للمحصول وكانت الانتاجية المحصولية للمياه المضافة الى الحقل ١,٢٤ كجم للمتر المكعب مقارنة بنظام الرى السطحى فى أحواض لصنف سخا١٠٤والذى وصل الانتاج فيه الى ٨,١٩٣ طن للهكتار حيث كانت أقل انتاج للمعاملات وكانت الانتاجية المحصولية للمياه ٠,٥٧ كجم للمتر المكعب من المياه المضافة.



الكلمات المفتاحية:
رى الأرز؛ الانتاجيه المائيه؛ نظم الرى