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RESEARCH ARTICLE

WATER SAVING OF RICE CROP USING INNOVATIVE TECHNIQUE FOR SOIL MANAGEMENT, SWMR

Mohamed Elhagarey
Irrigation and Drainage Unit, Soil Conservation and Water Resources, Dept. Desert Research Center, Cairo, Egypt

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Abstract

The trial was conducted in, 2019 and 2020; Kafr-El Sheikh Governorate, Egypt, Rice (Sakha 104) was cultivated under two methods, traditional method (WTF3) and modified innovative method in furrow bottoms, soil and water management for rice cultivation (SWMR). The cross section of furrows is such as a zigzag shape using a soil management and soil bed preparation (soil surface shape) using innovative machine to soil bed preparation to harvest irrigation water. Without any reduction of rice intensity, and rice transplants at 40 ×40 cm in both of two cultivation methods. Besides, three treatments of nutrients (50, 75 and 100% of recommended doses and called WMF1, WMF2 and WMF3 respectively), irrigation system are traditional system for the first method and furrow irrigation systems for the modified innovative method, applied water amount and nutrients was measured, productivity parameters, economic and energy analysis. The results show that applied water in 2019 are 13104 and 6897 m3/ ha while in 2020 are 12510 and 6724 m3/ha, for the traditional and modified cultivation methods, Respectively. Rice yield in 2019 is 7589, 8282, 8987 and 8580 in 2020 is 7392, 8366, 8770 and 8376 kg/ha. For both of WMF1, WMF2, WMF3 and WTF3, respectively, finally, every parameters engaged with irrigation water is influenced according to the water foot print of rice is cut to half. SWMR technique can save about 20% of irrigation water will be saved in world.

Introduction:-

Rice (Oryza sativa L.) is a staple food of more than 50% of the world's population **(Fageria, 2007),** Rice (Oryza sativa) is one of the main field crops and a major staple food in most parts of the world. More than 160 million ha of arable land dedicated to its production, and more than 730 million tons produced in 2012. The top producers in the world are China, India, and Indonesia **(El-Shahway et al. 2016).** Flooding/Basin irrigation is the most common pattern for irrigating rice; it is always called paddies or paddy basins. Basin irrigation is useful if leaching is requiredto remove salts from the soil, Rice crop is stunningly diverse and unique because of its ability to grow in wet ecosystems, while other crops cannot survive. Rice paddies are estimated by a large portion of the wetland ecosystem; mainly in Asian countries [3]. It is the most broadly grown under irrigation **(FAO, 2003)**. Paddy soils are featured by high organic material inputs with rather a low decomposition rate under anaerobic conditions, which favors organic matter accumulation **(Zhang et al., 2017)** , As the rice being the staple food of most Egyptians, its local consumption rate is 35–40 kg/capita/annum **(Ahmed ,1998).**

Corresponding Author: - Mohamed Elhagarey, elhagarey@gmail.com
Address**: -** Desert Research Center, 1 Mathaf AlMatarya St. AlMatarya, Cairo, Egypt. B.O.X. 11753.

Egypt relies on the Nile for 97% of its water requirements. The expected scenario of water deficiency in Nasser lake due to the Grand Ethiopian Renaissance Dam construction, with pulling of deficiency from Dam Lake; is emphasizing on wasting approximately 1.7 million ha of Egypt's cultivated area. As well, the expected high scenarioof a relative sea level rise in Egypt; especially Nile Delta increases the amount of land that lying under risk from inundation in the north Nile Delta by 300 km^2, which estimated by one-fifth of the total agricultural land in the northeast Nile Delta only. Also, all crops are projected to have a decrease in yields and an increase in irrigation needs. Thus; all these challenges will increase the stresses on rice production and decrease soil C storage in Egypt asa result of climate change and water shortage due to establishing GERD. Therefore, the changing in rice management practice; such as decreasing ploughing, creating another alternative to rice straw burning and balanced fertilizer application; will lead to mitigating of greenhouse gases emission from rice cultivation and improving soil organic matter (SOM) stocks, subsequently soil quality and productivity. **(Omran and Negm (2020)**

Rice is highly water consumed specially under the conventional irrigation method, thus saving the water isbecoming decisive factor for agricultural expansion. At the same time, a shortage of fresh water for irrigation therequirement of the rice crop was to vary from 75 to 250 cm. On average, tall Indian rice require about 1.25 cm ofwater every day **(Dastane et al., 1971).** Rice is one of the most important strategic crops in the world. It ranks thethird in terms of cultivated area after wheat and maize. It is food for half of the world's population and it consumes40% of the world's irrigation water and it is one of the most important food and export crops in Egypt. During thepast ten years, demand for water consumption has increased, either from inhabitants or the different economicsectors, at an alarming rate, while water supply resources remain constant and are likely to decline in the future. Thehigh rates of population growth and urbanization, as well as the expected increase in economic activities, particularly in the industrial, agricultural and tourism sectors accompanied by unsustainable patterns of production and consumption in the water sector, continued to put pressure on an already scarce resource. In 2004, per capita water was 950 m 3 / capita, and by 2025, per capita water is projected to reach 600 m^3 / capita and 350 m^{3}per capita by 2050. There are about 150 million hectares of rice land worldwide, which provides about 550- 600million tons of raw rice annually **(Maclean et al., 2002).** The annual cultivated area increased from 0.45 to 0.702million hectares, and grain yield increased from 3.14 to 5.80 million tons. The average grain yield reached 1.32 tons / ha, **(Ghonimey and Rustom, 2002)** on the other side of publications of the Ministry of Agriculture in Egypt (2007). Nitrogen is a key component of many organic compounds. Irrigation also plays a pivotal role in increasing the productivity of rice. The efficiency and productivity of irrigation water is quite low owing to percolation losses and high water requirement. There is an urgent need to save water and increase its efficiency in rice production. Various agronomic practices like proper land leveling **(Jat et al., 2009),** without applied nitrogen, the crop yield should be limited by the available nitrogen within the soil. Nitrogen application can improve the root system, so that water and nutrient absorption are facilitated. (**Yoshida, 1972).**

According to the water poverty in Egypt, where the water share of one person is between 650 and 700 cubic meters, while the world average is 1200 cubic meters, there are strict legislations and laws on farms that growrice in violation of the laws that farmers may be subject to a fine up to 756 pounds Per hectare for flow irrigation (gravity irrigation) and 1176 hectares for irrigation pumping by the government, although there are 700,000 hectaresof cultivated rice, this means 70% of the area of rice from the area allowed 0.45 million hectares. The cultivated areas that violate laws are about 4 billion cubic meters of water. Precise leveling reduces the amount of water needed for cleaning and flooding, and it greatly facilitates subsequent management of posture, weed control, and field drainage for harvesting **(Williams, 2004),** Water efficiency is affected by the different methods of cultivation. The method of cultivation achieved the highest value (0.50 kg / m^3 of water that reaching the field) **(El-Mowelhy, 1995)** The main objectives of this paper are as follows: conservation of irrigation water for rice paddy and fertilizers, taking into account the regulations of the ecosystem, economic considerations the aim of this study is investigate, modified and approve the new innovative technique of rice cultivation (SWMR) which release on the soil and water management by rice transplanting on the furrows bottoms to save both of water and nutrients.

List of Abbreviations

WTF3	=	Traditional method + 100% of nutrients doses.
SWMR	=	Soil and water management for rice cultivation
WMF1	=	SWMR method + 50 of nutrients doses.
WMF2	=	SWMR method + 75of nutrient doses.
WMF3	=	SWMR method + 100 of nutrients doses.
Yield	=	the rice crop yield/ha, kg/ha,
IWP	=	Irrigation water productivity, kg/ m^3,
EAE	=	Pumping energy-applied efficiently, kg/kW.h,

ICPU	=	Irrigation cost of production unit LE/kg,
EEI	=	Economic efficiency of irrigation, EEI, %. And
EWP	=	Economic water productivity, (value of produce per unit ofwater consumed; EGP per m^3).

Materials and Methods:-

Field description:

Rice was cultivated seasons 2019 and 2020 using two methods – a traditional method (WMF3) and the modified innovative method, in furrow bottoms. Soil management and soil bed preparation (soil surface shape) were done using an innovative machine to prepare the soil bed to harvest irrigation water without any reduction of rice intensity. Rice was transplanted manually at 01 × 01 cm for both of the cultivation methods. Three treatments of mineral nutrients were applied (50%, 75% and 100% of recommended doses for the modified method, called WMF1, WMF2 and WMF3 respectively). The statistical design was completely random blocks. A traditional surface irrigation system was used in the first method and furrow irrigation systems for the modified innovative method. The amount of irrigation water applied was measured and calculated as well as the amounts of mineral nutrients, both nutrient and water productivity, and an economic and energy analysis was also carried out.

Innovative soil and water managemnegt for rice cultivation technique (SWMR):

The SWMR technique depends on the cultivating of rice transplants in the furrows bottoms and replacing of some parts of rice paddy basin by soil instead of water, subsequently, the desired size of water for fill the field size will decrease, where the rice paddy needs to 15 to 25 cm of water head above the soil surface, in this case the applied water size equals the head water multiplying cultivated area (cuboid), and drainage water approximately every three days to the field drainages, where the water losses and the other additions with it such as, nutrients, pesticides and soil conditioners. The last scenario happens the traditional method of rice cultivation, when the paddy basin (cuboid) is filled complete with water, on the contrary soil and water management of rice cultivation technique (SWMR) which depends on the rice transplanting in the furrow bottoms and replacing the applied water size in traditional methods by the soil furrows, it can be calculated the desired water size in SWMR technique, the applied water sizein SWMR technique is equal the head water multiplying the half of triangle or (cross section of furrows trenches) multiplying the number of lines. It's important to mention that, the soil porous of soil furrows will be filled in the first irrigation and stayed saturated along the rice season for both of the two methods, according to the rice does not tolerate any drought so the saturated soil size is considered a solid size and will not fill with water in two methods - except the first irrigation - so the desired size of applied water for two methods is just for the volume of space size above the surface of the soil.

The specifications and design of SWMR tools of soilbed reformation:

Soil and water managements for rice cultivation using an innovative technique SWMR is done during the soil surface (seed bed) reformation by using the machine in this study was used to carry out Bottoms of furrow system and preparing the soil surface to transplant rice seedlings in the furrows, Photographic view and sketched back and side views. It is a mounted SWMR machine hitched to the tractor using the three points hitching system. The machine components were manufactured locally. The total weight, length, width and height of the machine were about of 650 Kg, 2500 mm, 1600 mm and 900 mm respectively. The machine consisted of the frame manufactured from 100 mm L shapes iron, a three point hitching system manufactured from 20mm thickness iron at the height of an upper hitch point of 600mm and lower hitch point spread of 650mm, In addition to, forming the surface of ridges, inclined in one direction, inclined in one direction and bending, three diggers with six shanks (20 mm thickness and 300 mm width) to dig the furrows. And inside the iron frame contains the iron roller which is all-round the movable axe where this axe is center on the frame and the iron role is moving on bearings on the frame, the surface of iron spikedroller takes the furrows shape to print the furrows shape to limit the soil erosion by water irrigation and prepare the soil-bed to be more stable during the rice cultivation season. Figs (1, 2 and 3).

Table (1):- Tractor specofcations:

Tractor New Holland Diesel engine - Model	4x4TT4.90
Net rated power	90 hp at 2300 rpm
Number of cylinders	4 cylinders
Weight, kg 3000	Weight, kg 3000
Power take-off shaft	450 rpm
Front tire	13.6 - 24
Rear tire	16.9 -34

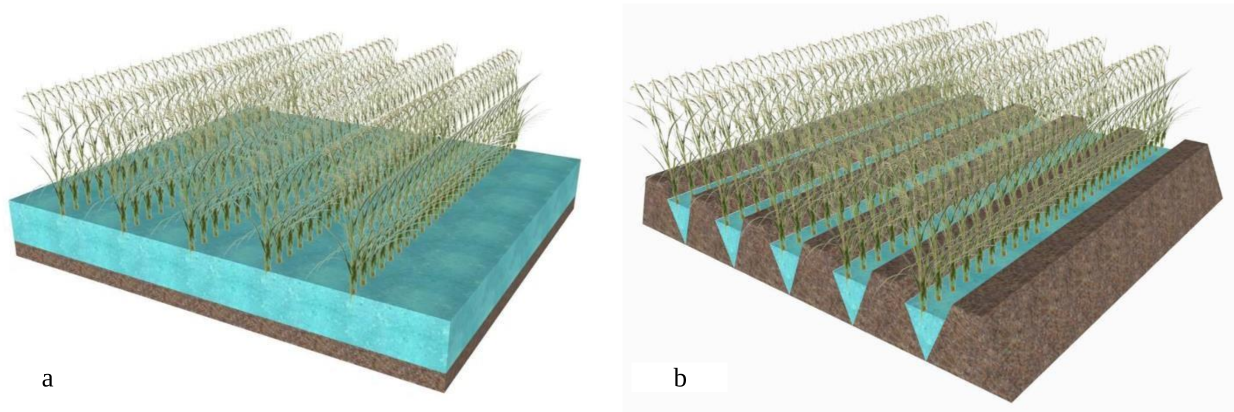

Fig .1:- (A) Isometric view of paddy section (water flow area) for traditional vs (B) Isometric view of paddy section(water flow area) modified rice furrow irrigation, innovative SWMR technique.

Irrigation requirements:

Irrigation water requirements for the rice were calculated according to the local climate station data at Kafr El-Sheikh Governorate, the Central Laboratory for Agricultural Climate (C.L.A.C.), Ministry of Agriculture and Land Reclamation. Irrigation was done after the calculation of crop consumptive use (mm/day), Water requirements for the rice crop were calculated according to **(Doorenobs and Pruitt, 1977).**

Measurements and calculations:

Irrigation water saving percentage:

$$\text{Water saving} = (I_f - I_n) / I_f \times 100,$$

Where:

I_f = Water use for control treatment (m^3/ha); and

I_n = Water use of various treatments (m^3/ha);

Advanced and recession phases of water movements.

The water advance and recession times were recorded for each 12.5 m length during the irrigation time. Using signsand recoding the water movements per time, the total flow time T including the times of the water advance.

Crop measurements:

Total cash crop yield (ton/ha.), crop quality, field water productivity (kg/ m^3), field nutrient productivity (Kg/ m^3).

The nutrients productivity:

The nutrient productivity is calculated by the ratio of rice yield and the nutrients in N for one hectare(NP, kg rice yield per kg N): NUE = (Rice yield / Nutrients, N).

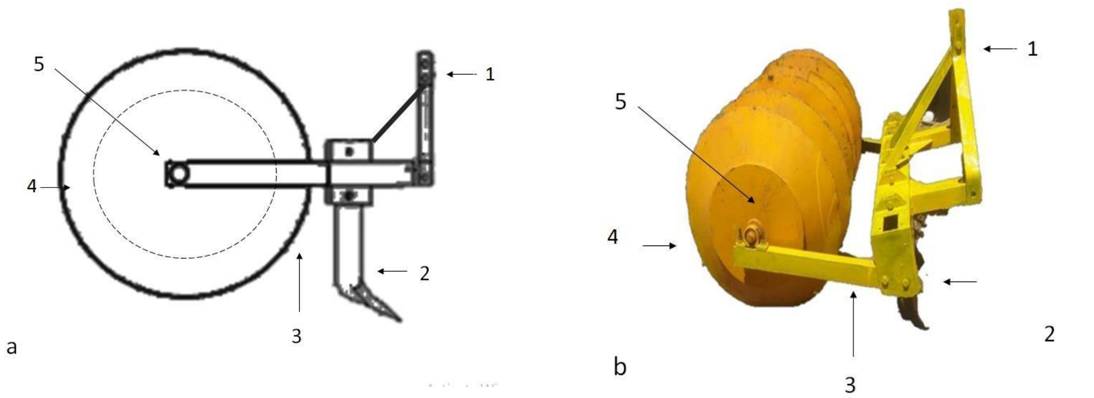

Fig .2:- (a) The side view of SWMR machine and (b) the photography of SWMR machine. Where 1- Points hitch, 2= Chisel plow, 3 = frame of machine 4 = spiked roller, and 5= bearing.

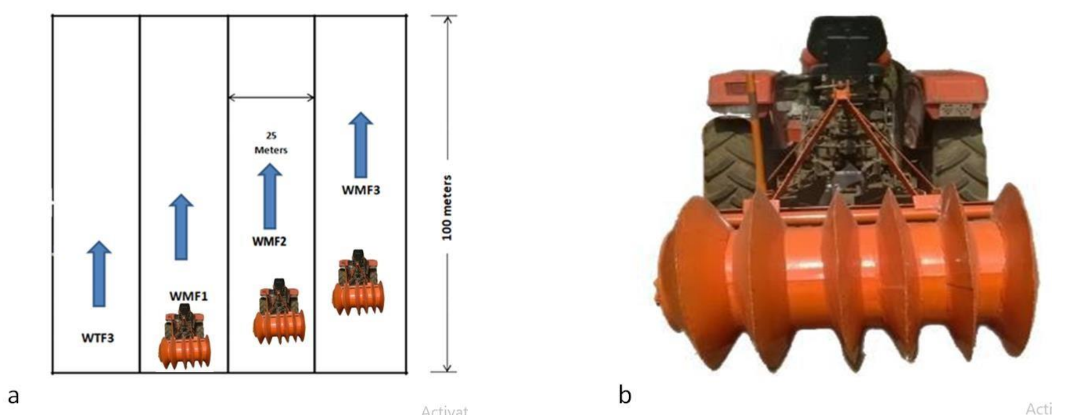

Fig .3:- (a) Statically design of experiments shows the cultivation methods and fertilizer treatments. (B) Soil performed machine which hanging on tractor in new rice planting technique in the furrows bottom.

1– Initial cost (IC):

Initial cost (IC) (LE. ha^{-1}.) = Irrigation systems price **(**LE**)** × Item quantity per ha.

2– Annual fixed cost (F):

Fixed annual cost (LE. $year^{-1}$) invested in the irrigation system was calculated according to the following equation:

$$F = D + I + T$$

Where:

F = Fixed annual cost (LE. $year^{-1}$),
D = Depreciation rate (LE. $year^{-1}$),
I = The interested (LE. $year^{-1}$), and
T = Taxes and overhead ratios (LE. $year^{-1}$) taken 1.5% of the initial cost. According to (**UC DANR 1976)**

Depreciation rate cost was calculated using the following equation:

$$D = (I.C - D.C) \times (E.L)^{-1}$$

$$I = (I.C + D.C) \times 0.5IR$$

Interest on initial was calculated as follows:

Where:

I.C = Initial cost (LE. ha^{-1}),
D.C = Price after depreciation (LE),
E.L = Expected life (year), and
IR = Interest rate per year (taken 14%).

Taxes and overhead ratios were taken as 1.5 % of the initial cost.

3– Operating cost (O):

Annual operating cost (LE. $year^{-1}$) of the capital investment in the irrigation system was calculated as follows:

$$O = L + E + (R \& M)$$

Where:

O = Operating cost,

L = Labor cost (LE. $year^{-1}$),

E = Energy cost (LE. $year^{-1}$),

R & M = Repair and maintenance costs (LE. $year^{-1}$), R & M costtaken as 3 % of the initial cost, and Labor cost was calculated for the soil and cultivation process by labors. Beside Maintenance and repair costs were calculated based on a percentage of the initial cost of system components, and the useful lives assumed for the major system components according to (**Jensen 1983**), **(The UC Committee of Consultants 1988)** and **(the San Joaquin Valley Drainage Program 1989).**

Energy cost was calculated as follows:

$$\mathbf{Bp} = \frac{\mathbf{Q} * \mathbf{TDH}}{\mathbf{K} * \mathbf{E}}$$

Where:

Bp = Brake horsepower (HP),

Q = Discharge rate (L. h^{-1}),

TDH = Total dynamic head (m),

K = Coefficient to convert to energy unit, 1.2, and

E = The overall efficiency, 55% for pump driven by an internal combustion engine.

The power cost of diesel type source was calculated using the following formula:

$$E.C = 1.2\ Bp\ H * S * F.C$$

Economic and Cost Feasibility analysis:

Cost analysis to evaluate for traditional and innovative SWMR method, cost analysis were computed according to (**Worth and Xin, 1983),** Fixed and operation costs are calculated according to market price level of 2019/2020 for equipment and operating irrigation process, cost analysis is based on one hectare.

Where:

E.C = The energy cost of diesel (LE.Hp^{-1}),

H = Annual operating hours (h),

S = Specific fuel consumption (LHp^{-1}. h^{-1}),

F.C = Fuel price (LE), and

1.2 = Factor accounting for lubrication.

4–Total annual cost (LE. $year^{-1}$) = F + O

5- Unit production irrigation cost (LE.kg^{-1}) = [Annual irrigation cost (LE.m^{-3})] ÷ [FWUE (kg.m^{-3})]
Water use efficiency (WUE, kg. m^{-3}).

This crop water use efficiency was defined as the percentage of yield and its ratio or irrigation water requirements. In practice irrigation water use efficiency would be more conveniently expressed as mass of marketable crop per unit volume of water (kg. m^{-3}) as it has been done by many others over the past two decades, onthe other hand the field water use efficiency was defined as the percentage of yield and applied water that's mean water consumption plus water losses or by other mean, it's the water consumption multiply irrigation system efficiency. But this very important, the water use efficiency is may become deceptive value, by believing in its good wherever it becomes high, but that's not true because it's may be high value according to the saving and reducing water applied with having a yield value which is being less that the economic yield of hectare in this case, the water use efficiency becomes so deceptive value so, it's very necessary to use it under the economic yield of a hectare **(Michael, 1978).**

On the other side there another definitions of Bio-physical water productivity is conventionally also referred to as Water Use Efficiency (WUE), and is crop- and location-specific. For common field crops (food grains, forage crops, fibers, sugar) the relationship between biomass (yield) and water consumption (transpiration - T) is essentiallylinear **(Howell, 1990; Fereres and Soriano, 2007; Steduto et al., 2012)** over a wide range of intermediate yield levels.

Economic efficiency of irrigation systems (EEIS, %).

The economic efficiency of irrigation systems was defined as the percentage of actual yield and typical yield per hectare.

Results and Discussions:-

Firstly, it's important to mention that the water head is ranged from 7-15 cm above the soil surface during the irrigation process, for that water amount of the traditional method is lower than the common average water amount of one hectare. According to the rice farmers to excessive water as a believing in the more water means more crop.

Irrigation water saving percentage:

The investigation results show that the amounts of irrigation water applied are 13,104 and 6,897 for 9102 season in addition to 12510 and 6724 m3/ha for 9191 season for both of the traditional and modified methods of rice cultivation respectively. This means that the percentage of irrigation water saved in the innovative method (SWMR) compared to the traditional method is 47 and 53 % for seasons 2019 and 2020 respectively, the saved water amounts are results to reduction infiltration rate in furrow irrigation compared with basin irrigation, but the most saved water is according to the saved water which is replaced by soil furrow along paddy. It's important to mention that the soil size replaced the same size of water and saved this water size, whatever the soil porosity is ranged from 30-60% according the soil texture, it's memorable to report that these porosity are filled for first one time according to the rice season the soil surface must be flooded by water for 7-15 cm above soil surface so that the soil is completely saturated, (see Fig.4 and 5).

EEIS = (Actual yield ÷ typical yield) per ha

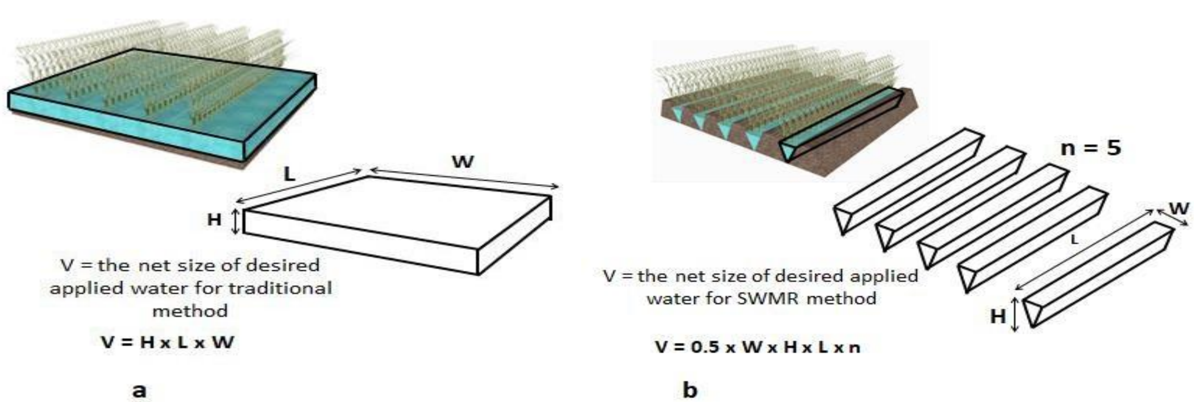

Fig .4:- The net desired volume of applied water of traditional methods and SWMR methods where: V= water volume, H= water head, L= length of filed in water flow direction, W = width of water surface, n= the number of furrows.

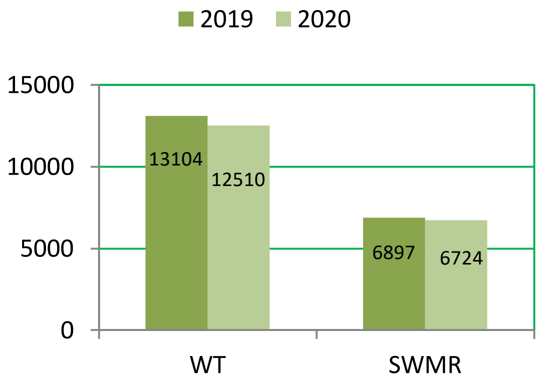

Fig .5. The amounts of applied water (m^3/ha)

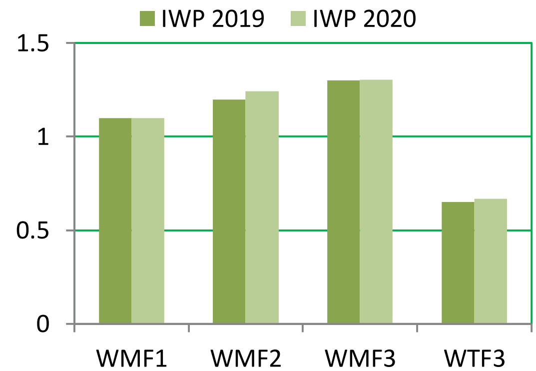

Fig .6. Irrigation water productivity (kg/ m^3).

Advanced and recession phase of water movement:

There are two shapes of irrigation stream cross section, the first one is for strip and this only for this trial but in common rice paddy the shape is for basin, and the second in trial is V shape for SWMR technique method. In other crop irrigation systems, the recession of water movement is very high for furrow and may be causes runoff but in rice paddy the paddy borders is higher than traditional to prevent water runoff and help to fill paddy by water to reach to the desired water head above soil surface,

In SWMR V shape the water velocity is higher than the cross strip shape according the short of time water advanced, as it clear in advanced and recession curves, in addition to the soil compaction of SWMR machine whichreduce the soil fraction forces where resistances the water movements on the other hand, in the traditional method, the uncompact soil cause water movement resistance by soil fraction forces. the irrigation time of SWMR is 68 Minutes while the irrigation time of traditional method is 163 Min, it' mean that the traditional time of irrigation process to finish for traditional method is more than SWMR technique by three times, according to essential two influences the first one is the shape of cross section of water movement stream, and the second is the amount of applied water which cuts off to half for SWMR technique.

Crop measurement:

For first season, the rice crop yield of one hectare is 7,588.8, 8,282.4, 8978.4, and 8,580, kg/ha for WMF1, WMF2, WMF3 and WTF3 (traditional), respectively, by the same token for 2020 season, the rice crop yield of one hectare is, and for second season, 7392, 8366.4, 8769.6 and 8376, kg/ha for WMF1, WMF2, WMF3 and WTF3.

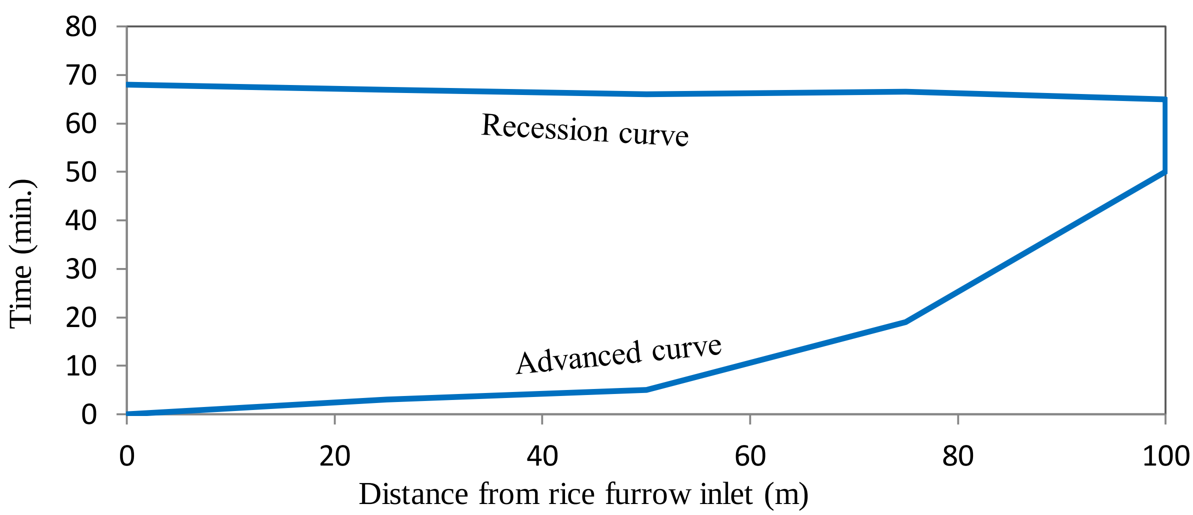

Fig .7. Water advance and recession curves for rice SWMR furrow (innovative method).

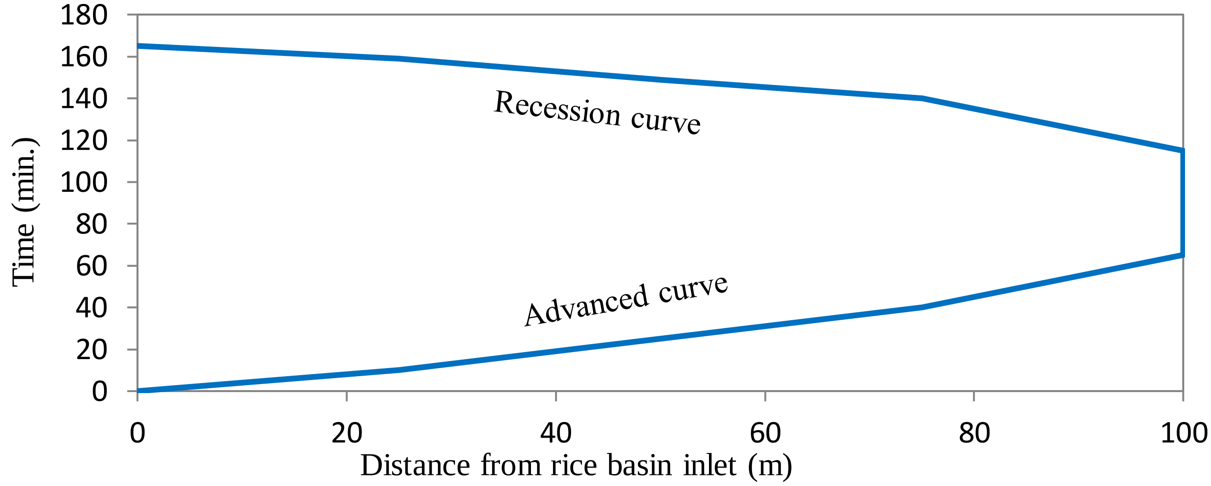

Fig .8. Water advance and recession curves for rice paddy (traditional method).

(traditional), respectively, it's important to mention that the half of recommended doses of rice paddy nutrients is very significant results but the yield of this treatment under SWMR technique produced yield is lower than full doses under traditional methods by 11.6 and 11.7% for 9102 and 9191 seasons respectively, by the same token the three quarter of recommended dosed under SWMR technique produced rice yield which is lower that the full doses under traditional by 3.5 and 0.12 % for 9102 and 9191 seasons respectively, Finally, the full doses under SWMR technique produced a yield which is more that the full doses and traditional method by 4.6 and 4.7% for both of applied water amounts which cuts off to half for SWMR technique. (See Fig. 7 and 8).9102 and 9191 seasons respectively. These results need to economic evaluation according to the global and national market for both of rice and fertilizers to determine the SWMR economic feasibility under global ecosystems criteria. (See Fig. 9)

The irrigation water productivity:

The water productivity refers to the one kg of rice yield is produced by one cubic meter of consumed irrigation water, as it is clear, For first season, the irrigation water productivity is 1.1, 1.2, 1.3 and 0.65 and for second season, 1.1, 1.2, 1.3 and 0.67 kg/m3 for WMF1, WMF2, WMF3 and WTF3 (traditional), respectively. In other interpreted data, the under SWMR technique, the half doses of nutrient, the irrigation water productivity is more than traditional method by 69 64% for 2019 and 2020 seasons, respectively, where its more than tradition by 85% for both of 2019 and 2020 seasons respectively, and finally, for full doses its, more than traditional by 100 and 94% for 2019 and 2020 seasons respectively, the irrigation water productivity increased significantly according to save the irrigation water amounts under a new technique SWMR. The last results are agreements with **(Ya-Juan et al., 2012) and (P. Belder et al., 2005).** (Fig. 10).

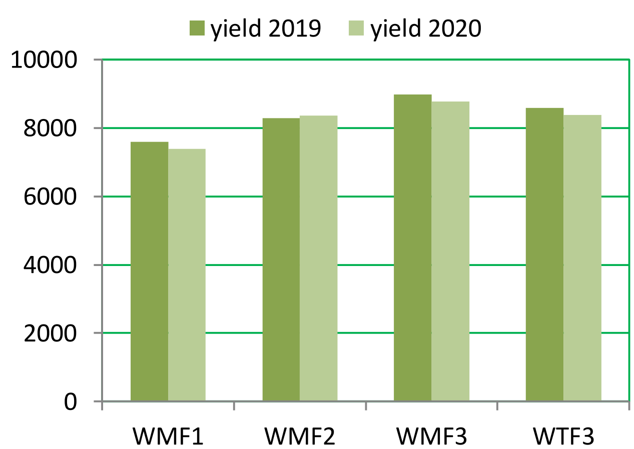

Fig .9. Rice crop yield (kg/ha).

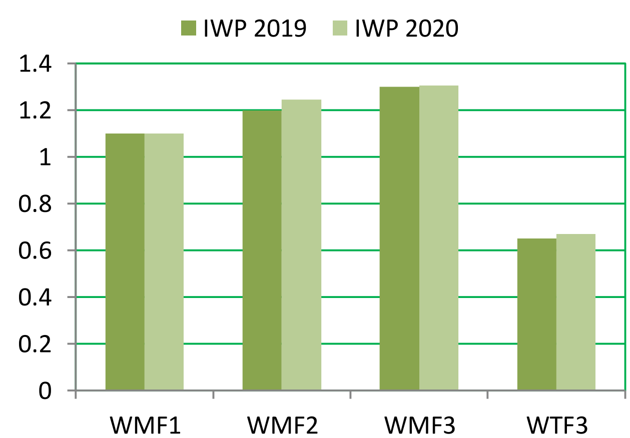

Fig .10. Irrigation water productivity (kg/m^3).

The nutrient productivity:

For first season, the nutrient productivity is 42.2, 30.7, 24.9 and 23.8, for seconded season 41.1, 31, 24, and 23 kg rice yield per kg N for WMF1, WMF2,WMF3 and WTF3 (traditional), respectively . Data clear that the nutrient productivity for SWMR technique is higher than traditional methods, for half doses and SWMR, NP is higher than traditional method by 76 and 79% for 2019 and 2020 seasons respectively, where for three quarters of doses, NP values is higher than traditional method by 29 and 35% for 2019 and 2020 season respectively, by the same token,, NP values is higher than traditional by 5 and 6% for 2019 and 2020 seasons respectively. The increasing of NP regards to the saving of applied amount of nutrients, according to the trials treatment, moreover, SWMR technique saved the half of applied water which increase the nutrients concentration of irrigation water, and the same thing for any additions to the water, this rich solution by nutrients elements introduce the good nutrients need to rice plant, by other mean, SWMR harvest the irrigation water and elements all-round the rice plant which give the chance to plant to be had its enough needed from nutrients, on the other hand the irrigation water of rice paddy is drainage for 3 days, that's mean losses of all of amount of water and nutrients on drainage, Accordingly, the drainage water is polluted by chemical additions and need to a lot of money to treat for reusing which burn a more challenges in water and environments issues but in SWMR technique the last amount is cut off to half which save a lot of last challenges. The last results of nutrient productivity are agreements with **(Ya-Juan et al., 2012) and (P. Belder et al., 2005).** (Fig. 11).

Energy-Applied efficiency:

The energy-applied efficiency is refer to the final calculation of pumping energy, operating hours and yield, Regardless to calculated data, the energy-applied efficiency, under SWMR technique and half doses of nutrients is higher than traditional treatment by 68 and 64% for 2019 and 2020 respectively, and increased according to the yield increasing for three quarters doses of nutrients to become higher that traditional treatment by 83 and 86% for 2019 and 2020 seasons respectively, and come to the highest values to be higher traditional for full doses by 99 and 95% for 2019 and 17 seasons respectively. For first season, The energy-applied efficiency of pumping (EAE, kg/kW.h) of the rice crops are, 40.38, 44.07, 47.77 and 24.03 Subsequently, for second season 40, 46, 48 and 25 kg/kW.h for , WMF1, WMF2, WMF3 and WTF3 respectively.

The higher of applied energy efficiency means the reduction of applied pumping energy and labor in addition to the reduction of operating hours to half, as result to the reduction of applied water amounts of SWMR technique. The happened reduction of energy is translated to reduction of greenhouse gases (GHG), which led to reduce the negative hazardous impacts on environment and support the SDG of United Nations during enchantment of sustainable developments in agriculture. The last results are garmented with **(Faidley, 1992, Schroll, 1994, Dalgaard et al., 2001, and Nasso et al., 2011).** (Fig. 12).

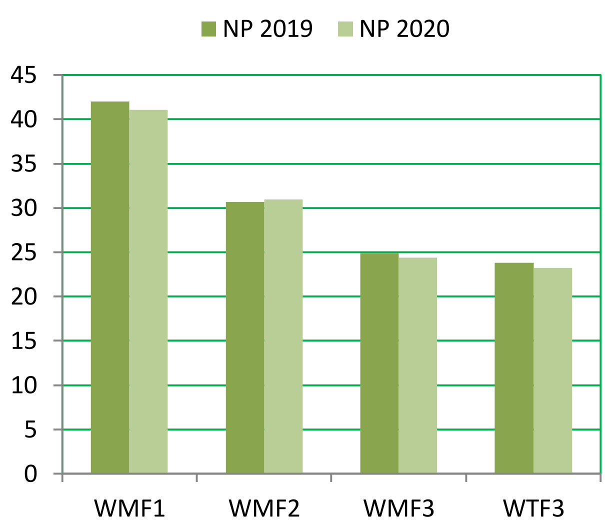

Fig .11. Nutrients productivity (kg yield/ kg urea 140 N)

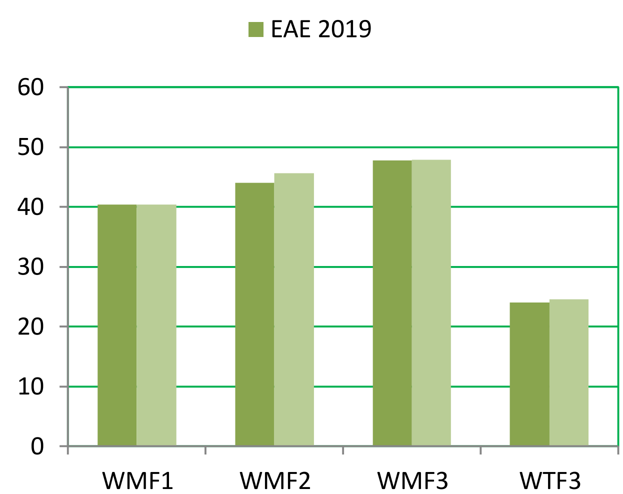

Fig .12. Energy-applied efficiency (EAE), (kg/ (kW.h).

Irrigation cost of production unit LE/kg:

Irrigation cost of production unit (LE/Kg) refers to the ration of the irrigation cost and the one kg of yield to determine the economic feasibility of irrigation system. For first season, Irrigation cost of production unit LE/kg is0.23, 0.21, 0.19 and 0.4 Subsequently for second season 0.23, 0.2, 0.19 and 0.4 for WMF1, WMF2,WMF3 and WTF3 (traditional), respectively. (Fig. 14)

Under SWMR technique, and the half doses of nutrients the Irrigation cost of production unit is lower than traditional and full doses of nutrients by 41 and 43% for 2019 and 2020 seasons respectively, by the same token, the three quarters doses of nutrients under SWMR technique is lower than traditional method and full doses by 46 and 50% for 2019 and 2020 seasons respectively, and finally the full doses of nutrients under SWMR is lower than traditional method and full doses by 50 and 51% for both of 2019 and 2020 seasons respectively. The happened reduction of irrigation cost of production unite returns to the reduction of amount of irrigation applied water including all of the joined cost parameters of water such as pumping costs, labor costs, repair & maintained costs and capital depreciation rate. These results are logic according to with **(Gonzalez et al., 2006).** (Fig. 13).

The economic efficiency of irrigation (EEI, %):

the economic efficiency of irrigation (EEI, %) refers to the ratio between the actual yield and the typical yield in the same conditions according to the location and environmental factors, the economic fficiency of irrigation (EEI, %) for first season is, 88, 96 and 104 and 99 % then for second season 86, 97, 102 and 97. for WMF1, WMF2, WMF3 and WTF3 respectively. For that., it's clear under SWMR technique and half doses of applied nutrients the economic efficiency of irrigation is lower than the traditional method and full doses by 11% for both of 2019 and 2020 seasons whatever, with the three quarters of applied nutrients the economic efficiency of irrigation is lower than traditional method by 3 for 2019 season and equal to the typical yield in 2020 season. Finally, the economic efficiency of irrigation for full doses under SWMR technique is higher than the traditional method and full doses by 5% for both of 2019 and 2020 seasons. Although the reduction of applied water to half in SWMR technique but under full applied doses of nutrient give the highest yield which increase the economic efficiency of irrigation, but it's important of mention that the reduction of economic efficiency of irrigation under 50 and 75% doses of applied nutrients introduces little economic efficiency but it still economic, by considering the direct costs of saved water and nutrients in addition to the indirect costs which will be according to the pollution of drained water and the increasing of greenhouse gases of pumping water….etc. In addition to, the other parameters' of applied water to irrigate rice paddy, (see Fig. 14)

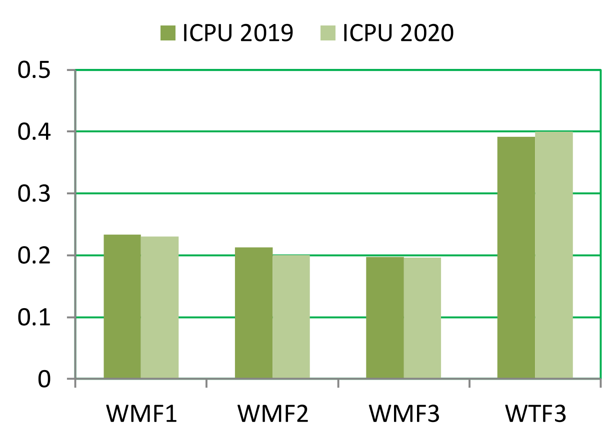

Fig .13. Irrigation cost of production unit (LE/Kg).

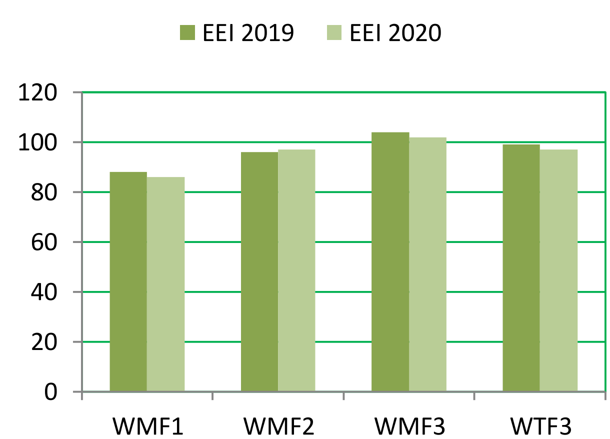

Fig .14. Economic efficiency of irrigation (%).

Economic water productivity, EWP, (EGP/m^3):

Economic water productivity according to FAO is defined as the monetary value generated from each unit of water consumed (EGP / m^3). Economic water productivity has been used to relate water use in agriculture to nutrition, jobs, welfare and the environment.; It means growing more food or gaining more benefits with less water.; Unit of biomass produced per unit of water applied.; The ratio of net benefits and the volume of water consumed when producing these benefits, it is illustrated the highest economic productivity is WMF3, WMF2, WMF1 and WTF3 for both two seasons 2019 and 2020 and this results to the water amount save by using innovative SWMR technique.

Where the highest value is 6.56 EGP/m^3 for WMF3 for 2020 season and the lowest value is 1.66 EGP/m^3 for 2019 season. As it clear the value of economic water productivity increases with the saving of applied water.

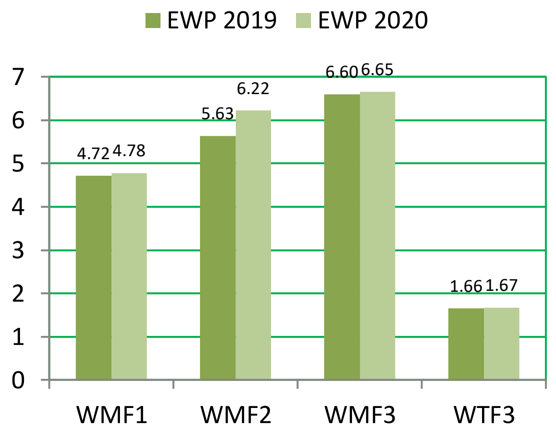

Fig .15. Economic water productivity, (value of produce per unit of water consumed, EGP per m^3).

Fig .16. The field site show the transplanted rice by traditional method on the right and SWMR technique on the right, the rice under SWMR is more healthy plants and green is very clear.

Statically explanations of results:

Data clear the significant influence of four treatments of SWMR technique with three treatments of applied nutrientsdoses and the half amount of water, which clears the significant influence navigate from A to D according to (Table:2).

Table 2: The significant influence of treatment of rice production parameters.

	yield		IWP		NP		EAE		ICPU		EEI	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
WMF1	7.5D	7.4D	1.06C	1.07B	41.8A	41.3A	40.3C	40.4C	0.2B	0.2B	87.5D	86.4C
WMF2	8.3C	8.4C	1.21B	1.24A	30.8B	30.9B	44.5B	45.4B	0.2C	0.2C	96.2C	96.8B
WMF3	8.9A	8.7A	1.30A	1.29A	24.7C	24.5C	47.8A	47.84A	0.19D	0.19D	103.5A	102.4A
WTF3	8.5B	8.4B	0.65D	0.67C	23.6D	23.2D	24.2D	24.4D	0.4A	0.4A	98.5B	97.4B

WTF3 = Traditional method + 100% of nutrients doses.

WMF1 =SWMR method + 50 of nutrients doses.

WMF2 = SWMR method + 75of nutrient doses.

WMF3 = SWMR method + 100 of nutrients doses.

Yield = The rice crop yield/ha, kg/ha,

IWP = Irrigation water productivity, kg/m^3,

NP = nutrient productivity, kg rice yield per kg N,

EAE = Pumping energy-applied efficiently, kg/kW.h,

ICPU = Irrigation cost of production unit LE/kg, and

EEI = Economic efficiency of irrigation, EEI, %.

All 4 means are significantly different from one another.

Financial feasibility:
The modified method is more economical than traditional methods, only requiring 53% as much irrigation water to be applied (saving 47%) in addition to save about 25% of the applied nutrient of rice paddy, which equal about 10 billion USD costs of saved nutrients.

Socioeconomic impact:

1) Maximizing rice water productivity and the outputs of water units;
2) Increasing the farmer's final income;
3) Decreasing the law's potential which streets on rice farmers;
4) Solving – even partially – the unemployment problem in the area of the new rice cultivation, and
5) Improving management rice irrigation systems and increasing reclamation of land.

The environmental impact:

1) Reducing weeds, which compete with rice for water and nutrients;
2) Reducing nutrient loss through drainage water and pollution of underground water;
3) Increasing the water drainage salinity:
4) Having enough irrigationwater for rice, which takes up 20-30% of the total water requirement in Egypt; and
5) Reduction of greenhouse gas emission according to save pumping the half of applied water.

Recommendations:-

Financial support of this investigation will develop the strengths and reduce weaknesses of a modified method of rice crop cultivation. A generalization of a new method of cultivation (SWMR), encouraging the use of the new innovative machine for soil and water management of rice crops by stakeholders near the agricultural stations, which belong to the Ministry of Agriculture and Land Reclamation, and other stations, which belong to the Ministry of Water Resources and Irrigation. Establishment of workshops to discuss SWMR .and raises the awareness of stakeholders and manages their inquiries and requests to develop and use this new method of rice cultivation.

Conclusions:-

The main conclusions of this investigation are summarized in the next points:

Irrigation water is saved in the modified method of rice paddy cultivation, which harvests both water and nutrients around the rice transplanting in the bottom of v shape of the furrowed irrigation. This benefits the rice plants and reduces water loss by evaporation and runoff. It also reduces the environmental hazards of the traditional method, which presents a full surface of irrigation water, therefore presenting a perfect environment for mosquitoes and weeds. The modified method reduces the surface water and so would result in a reduction of weeds, mosquitoes, and water evaporation. Data clear that the modified method of rice cultivation soil and water management of rice crops (SWMR) could have a positive influence on the parameters of rice crop production. The values are calculated as follow (rice crop yield of one hectare). As shown above, the water applied to the modified method is lower than the traditional method by 47 and 53 %, for two seasons, in addition to for first season, For first season, the yields percent for the modified method are 88, 97 and 105 % and for second season are 88, 100 and 105 % of the traditional method yield for WMF1, WMF2 and WMF3 respectively. Water for rice paddy is saved by 50%irrigation water requirements, and when it's known that rice paddy consumed about 40% of global irrigation water, it's will revolution to save about 20% of global irrigation water, just when SWMR technique will improved and spread in all over the world irrigated rice paddy Nutrient for rice paddy is saved by 25% of recommended doses, it's important to mention that, Fertilizer requirements of Million hectares of rice paddy (Urea 140 N) are 114.85 million ton nutrient for 132.84 million hectares of rice paddy, the saved cost of 25% saved nutrients is 10 Billion USD for global area of rice paddy. SWMR technique is chosen by the UN office as a solution for water crisis and service the next SDC of UN as follow: (1. No poverty, 2. Zero Hunger, 8. Decent Work and Economic, 9. Industry, Innovationand Infrastructure, 13. Climate Action), under themes of Agriculture, Environment, Innovation,

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