IMPACT OF APPLIED IRRIGATION WATER SYSTEM ON THE DISTRIBUTION PATTERN OF BOTH MOISURE AND SALTS IN A SANDY SOIL AS RELATED TO WHEAT PRODUCTIVITY

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ABSTRACT:

The main objective of this work was to investigate the impact of using two irrigation systems, *i.e.,* modified surface irrigation with cement gated passers (flooding) and sprinkler irrigation on the pattern distributions of soil moisture and salts as related to plant characteristics and grain yield of wheat (*Triticum aestivum* L., Sakha 93 cv.) grown on a desert sandy skeletal soil at Inshas area that was reclaimed and cultivated since 1959 A.D.

The obtained results showed that irrigation water was classified as C1S1, *i.e.,* EC_{iw} value = 0.35 dS/m or 0.75 dS/m and SAR 1.42 or < 6, indicate that the used irrigation water have no soil salinity or sodicity problems are expected. Also, the studied soil is characterized by a relatively coarse texture grade. *i.e*., sandy loam that characterized by low capacity to retain either soil moisture or nutrients to the grown plants. By using a parametric evaluation system for irrigated agriculture land, it was found that soil texture represents a limiting factor for its productivity as well as the studied soil belongs to a moderately suitable class (S2) in both current and potential conditions. Meanwhile, it could be evaluated as marginally (S3) and moderately (S2) suitable adaptations for winter wheat at the current and potential conditions, respectively.

It was also showed that the actual consumed value of irrigation water required for the grown wheat plants under the prevailing conditions of the experimental soil was 1775.5 m^3 fed^{-1} vs 2683.0 under modified surface irrigation and 2104.7 m^3 fed^{-1} under sprinkler systems, with water saving of about 21.55 % in irrigation water for the later one. That was true, since such saving of water is more attributed with the water efficiency use values that were 66.18 and 78.47 % for modified surface irrigation and sprinkler, respectively.

Moreover, the data indicated that the soil salinity levels were liable to seasonally change with different efficiencies of salts removed reached about 22-25 vs 16-19 % throughout soil profile layers under the modified surface and sprinkler irrigation systems, respectively. Practically, soil moisture contents reached almost values of wilting point at the eleventh and fifth days after irrigation under the applied irrigation systems of modified surface irrigation and sprinkler, respectively. Consequently, the corresponding best irrigation intervals were 11 and 5 days under the prevailing environmental conditions of the current experiment, respectively.

Wheat vegetative growth parameters, *i.e.,* plants intensity in m^2, plant height, No. of tillers/plant and dry weight/plant as well as harvest parameters, *i.e*., spike length and No. of grains/spike, grain and straw yields were affected by both applied irrigation systems, with successfully parameters for plants irrigated with sprinkler system. This was more attributed with the uniformity of soil-water distribution a certain stage of germination and seed response, may be due to easily irrigation water flow among whole field with high efficiency use in short time with low losses either by down movement under such relatively coarse textured soil or evaporation under hot-arid climate.

Key words: Soils of Inshas area, wheat, modified surface and sprinkler irrigation systems.

INTRODUCTION:

One strategy to increase the horizontal expansion as well as available water resources for the reclaimed desert sandy soils on both sides of the Nile Valley and Delta are more affected by the traditional farming systems and a pronounced shortage of the fresh Nile water for irrigation, and in turn such soils started to represent problems. So, many questions have been raised concerning the safe limits of water hazard for each soil or plant, the dual between both fresh Nile water and the low quality one, the relevant robust crops and finally the dispersed of soil properties must be leafed behind. Water resources of Egypt are limited and insufficient for coping the designed agricultural development projects and other water uses. Therefore, Egypt is facing increasing water needs for recover growing population demands, more food and other basic needs. Such forefront issue represents the main constraints for any future agricultural expansion **(FAO, 1992)**.

Inshas area represents one of the promising desert reclaimed projects at the rim of the south-east Nile Delta. However, the irrigation water supplied to the area by El-Ismailia Canal, which is actually fresh water derived from the Nile River. The use of such good quality of irrigation water for irrigating a relatively coarse textured soil under the arid zone needs to be managed through applying a suit irrigation system in order to prevent losses in such limited water source as well as salt build up in irrigated desert soils that affects the crop yield and the environment **(Ahmed, 2010)**.

The aforementioned statements are confirmed by **Singh *et al.* (2002)** who evaluated sprinkler irrigation system on a loamy sand soil as compared with the conventional check basin method of irrigation for chilli crop. They found that the micro-sprinklers achieved a 52 % water saving as well as growth attributes, i.e., plant height, number of leaves, stem girth and leaf area were all found to be higher for micro-sprinkler than for check basin. As for yields the micro-sprinklers also achieved a 43 % improvement In this connection, **Brennan (2008)** reported that the benefits of a more uniform sprinkler was associated with reduced water application when application is uniform. An empirical analysis of the economics of lettuce production, grown using sprinkler systems under the windy conditions of the Swan Coastal plain in Western Australia is presented, where the yield response to water exhibits eventual declining marginal productivity. The optimal per-crop water application for the least efficient system was up to double the application rate of the most efficient system.

That is why this research's objective was to discuss the associated seasonally changes in soil moisture and salts as related to soil characteristics as well as wheat growth and yield under the applied modified surface and sprinkler irrigation systems.

MATERIALS AND METHODS

The present work was carried out at a desert pilot area located adjacent to the southern-east portion of The Nile Delta, *i.e.,* an experimental farm of Inshas, El-Sharkia Governorate, Egypt, which was reclaimed since 1959 A.D., and located at a distance of about 45 km from Cairo. The feeding irrigation was derived from El-Wastania sub-canal that supplied its water from Ismailia main-canal. The soil relief is almost flat and it occupies a promising area for agriculture utilization. The climatic conditions characterized by a long hot rainless summer and short mild winter, with scare amounts of rainfall according to the main climatic data are presented in Table 1.

Table 1. Climatological data of the studied area, as recorded during the winter season of 2007-2008 (Meteorological data of Inshas Station).

Month	Temperature, °C			Relative humidity,%	Evaporation, mm/day	Rainfall, mm	Possible sun shine, wat/h
	Mini.	Maxi.	Mean				
November	13.9	26.5	20.2	64.3	2.0	0.0	10.5
December	9.3	21.5	15.4	65.7	3.4	0.2	10.3
January	6.5	17.8	12.2	67.3	6.1	4.7	10.3
February	7.8	19.8	13.8	68.3	1.1	3.2	11.0
March	13.7	27.3	20.5	57.0	1.8	0.0	11.8
April	15.3	29.8	22.6	55.3	1.7	0.1	12.5

It is noteworthy to mention that the mean annual soil temperature could be considered as less than 22° C and the differences between mean summer and mean winter is more than 5° C. Using the US Soil Taxonomy System bases (1975), the soil temperature regime of the studied area could be defined as thermic, and soil moisture regime as torric.

The soil of the experimental farm of Inshas has a special feature for each of soil texture, structure, percolation and drainage, in addition to climatic conditions of the studied area. Based on these criteria, two irrigation systems or methods were chosen for the winter field crop of wheat, *i.e*., improved or modified irrigation with cement gated passers, in addition to another one of sprinkler, which are used to irrigate wheat plants that were grown into two basins.

The modified surface irrigation system, with cement gated passers, is used as field distributors. The system needs a low-pressure high flow pump unit. It is connected to elevate irrigation cemented passers for reducing losses to great extent on farm level as well as it is easy to determine water discharge in front of each cement gated passer directly by using a Water-Gagger. To tillage the land and to be smoothed divided into basins, and then leveled by laser (with or without slope). Water movement inside any strip is governed by inlet discharge (with or without slope), soil roughness, soil infiltration and shape of waterway. The cement gated passers are fixed on foundations and the gates provided by movable graduated gates to control their discharge. The cement gated passer has orifice discharges ranged from 2.5-3.5 m3/hr.

Meanwhile, sprinkler irrigation system depends on using pressure to convey irrigation water to soil surface on the shape of spray spread in the air and falls over the soil similar to natural rainfall. This system is suitable for most plants and land types. Also, it conveys water with suitable quantities and required rates for any peace in the field with a high degree of control and high efficiency of irrigation water to the root zone. As for the used sprinkler irrigation system, it is of a sprinkler type "T.N.T.-30c-Rain bird", and it was constructed at a space of 12 x 12 m, with a sprinkler discharge of 3.5 m^3/h and an operating pressure of 3 bars.

Both the aforementioned irrigation systems were used for irrigating the annual field crop of winter wheat (Triticum aestivum L., Sakha 93 cv.). In order to define the soil properties of the experimental site as affected by irrigation water quality under the applied irrigation system. A study was carried out on monitoring irrigation water quality parameters, however, water samples were taken from El-Wastania irrigation canal, and were analyzed to identify their suitability for irrigation. In addition, soil samples were collected at three depths (0-20, 20-40, 40-60 cm). In this respect, site Nos. 1 and 2 were chosen to represent soils irrigated with improved surface irrigation and sprinkler irrigation systems, respectively. The soil samples were taken from each soil site layers for a period of immediately just soil was irrigated up to eleven days after irrigation for the investigated two irrigation systems to monitor the disturbed pattern of either soil moisture contents or salinity levels. The collected soil samples were air dried, crushed, sieved to pass a 2mm sieve and preserved for determining the following main soil physical and chemical properties.

The analytical data of the available irrigation water source could be obtained by determining the chemical characteristics such as pH, ECiw and soluble ions were determined using the standard methods described by **Page *et al.* (1982)**.

The analytical data of the experimental soil were determined as; particle size distribution **(Bauder, 1986),** bulk density **(Klute, (1986)**, soil moisture retention curves **(Topp *et al*., 1993)**, and in turn to identify soil total porosity, field capacity and permanent wilting point, using pressure Cooker and pressure membrane method. Available water was calculated as the difference between soil moisture at field capacity and permanent wilting point, electrical conductivity (ECe in dS/m), soluble cations and anions in soil paste extract, soil pH was measured in 1:2.5 soil water suspension **(Richard, 1954)**. Water requirements including the leaching fractions were calculated according the equations after **Droonbos and Pruitt (1977)**.

In each of the studied periods, irrigation water was measured by using a Flow Meter. Crop water use efficiency is the weight of marketable crop produced per volume unit of water consumed by plant of the evapotranspiration quantity. The crop water use efficiency treatments by dividing the yield (kg) on units of evapotranspiration expressed as cubic meters of water **(Abd El-Rasool *et al*., 1971)**. Field water use efficiency is the weight of marketable crop produced per the volume unit of applied irrigation was expressed as cubic meter of water **(Michael, 1978)**. Some vegetative growth parameters of wheat (plant height, dry weight, No. of tillers and leaves/plant) and harvest ones (spike length, No. of kernels, grain and straw yields) were investigated. As for maize, the parameters of vegetative growth (plant height and leaves dry weight), ear (length and diameter) and harvest (grain and straw yields) were measured.

The obtained data of plant parameters were statistically analyzed according to the methods suggested by **Gomez and Gomez (1984)** using the L.S.D. values at 0.05 level of significance.

RESULTS AND DISCUSSION:

I. Chemical characteristics of the used irrigation water:

Data presented in Table (2) showed that the used irrigation water of El-Wastania Canal was characterized by pH value of 7.89, which still laying within the suitable category for irrigation **(Ayers and Westcot, 1985)**. The water salinity as expressed by ECiw ranged 0.35 dS/m, and according to the salinity classes of **Ayers and Westcot (1985)**, this low quality water lies within the first (ECiw=< 0.75 dS/m) and denoting no problems of soil salinity are expected from using such water quality. In general, the distribution pattern of soluble cations follows an ascending order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$, vs $HCO_3^- > Cl^- >> SO_4^{2-}$ for anions. Also, the dominated Na^+, Ca^{2+} vs HCO_3^- and Cl^-, denoting that NaCl and $Ca(HCO_3)_2$ are the probable dominated soluble salts in the studied irrigation water.

Table 2. Chemical characteristics of the used irrigation water.

Water pH	ECiw, dS/m	Soluble ions (mmolc L^{-1})							SAR
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	
7.89	0.35	1.25	0.70	1.40	0.20	1.45	1.30	0.80	1.42

The SAR value ranged 1.42, and according to the criteria after **Ayers and Westcot (1985)**, the calculated SAR value lying within the first class (SAR=<6), denoting no hazard problems are expected for soil sodicity.

II. A general view on the soil of the studied area:

a. Physico-chemical properties:

Inshas area represents a part of the old reclaimed desert sandy soils, where artificial irrigation canal of Ismailia irrigation an agricultural development was continued and sustained. The chosen soil site is not only characterized by a relatively coarse texture grade in nature (sandy loam) and low contents of CaCO3, gypsum and organic matter % among the studied experimental area but also throughout soil profile layers, as shown in Table 3. Some other characteristics of the selected soil samples are presented in Tables 4 and 5, which showed an almost homogeneous soil material entire the studied soil profile layers and low capacity to retain soil moisture. Such severe conditions get more attention for soil supplying an efficient water use to plants through selecting more suitable irrigation systems.

That is true, since such unfavourable conditions for soil moisture characteristics are more attributed to soil siliceous in nature, and in turn the associated hydrophysical properties, *i.e*., infiltration rate, hydraulic conductivity, field capacity, wilting point and available water ranged between (8.74-12.67 cm h-1), (5.91-9.25 cm h-1), (13.14-20.99 %), (4.35-7.62 %) and (8.79-13.37 %), respectively. The relatively narrow differences in the aforementioned categories of the studied soil hydrophysical properties, in general, are responded greatly to the identified soil texture grade.

Table 3. Particle size distribution, $CaCO_3$, gypsum and organic matter contents of the studied soil site.

Applied irrigation system	Soil depth (cm)	Particle size distribution %			Textural class	$CaCO_3$ %	Gypsum %	Organic matter %
		Sand	Silt	Clay				
Improved surface	0-20	78.1	7.6	14.3	Sandy loam	1.25	0.87	0.34
	20-40	75.3	8.2	16.5		0.97	0.75	0.26
	40-60	71.7	9.0	19.3		0.82	0.64	0.19
Sprinkler system	0-20	78.3	9.7	12.0		1.18	0.90	0.28
	20-40	76.4	9.7	13.9		0.91	0.83	0.22
	40-60	74.1	11.2	14.7		0.78	0.70	0.15

Table 4. Soil bulk density, total porosity, and moisture constants of the studied soil site.

Applied irrigation system	Soil depth (cm)	Bulk density ($g\ cm^3$)	Total porosity %	Soil moisture content % per weight at		
				Field capacity	Wilting point	Available water
Improved surface	0-20	1.45	45.28	16.12	5.67	10.45
	20-40	1.42	46.45	18.26	6.54	11.72
	40-60	1.38	47.92	20.99	7.62	13.37
Sprinkler system	0-20	1.53	42.25	13.14	4.35	8.79
	20-40	1.50	43.40	15.71	5.50	10.21
	40-60	1.47	44.50	17.18	6.13	11.05

Table 5. Soil salinity, sodicity, infiltration rate and hydraulic conductivity of the studied soil site.

Applied irrigation system	Soil depth (cm)	Soil salinity (ECe, dS/m)	Soil sodicity (ESP)	Infiltration rate ($cm\ h^{-1}$)	Hydraulic conductivity ($cm\ h^{-1}$)
Improved surface	0-20	2.05	5.60	10.50	8.35
	20-40	2.46	6.15	9.13	7.40
	40-60	3.35	6.70	8.74	5.91
Sprinkler system	0-20	2.79	7.42	12.67	9.25
	20-40	3.84	8.95	10.95	8.14
	40-60	3.15	6.90	9.64	7.30

The pronounced changes in water flow under either unsaturated (infiltration rate) or saturation (hydraulic conductivity) conditions of the studied soil sites may be attributed to the creation of both conductive and micro-pores. That was true, since soil permeability refers to the readiness with which the soil conducts or transmits fluids, while infiltration rate is influenced by many soil factors, particularly distribution of soil moisture throughout its layers.

In general, the magnitudes of soil field capacity, wilting point, and then available water range showed a positive response towards the soil mechanical fraction of clay, while the reverse was true soil infiltration rate and hydraulic conductivity. In this connection, the values of soil bulk density and total porosity took place the same trend and emphasized by the fact that the colloid materials are capable for binding soil particles or aggregates as well as can absorb more water molecules, thereby increases the soil moisture retention. In addition, such inorganic colloidal particles not only improve the soil structure parameters but also the properties of solid-liquid system interface due to the change in the contact angle of the soil particle with water **(Sadek *et al*., 1992)**.

As a general view about soil salinity and sodicity conditions, the initial data reveal that such area was surveyed as non-saline and non-sodic soil, as shown in Table 9. However, the ECe values were ranged 2.05-3.84 dSm^{-1}, *i.e.*, < 4.00 dSm^{-1} as well as the ESP values ranged 5.60-8.95 %, *i.e.*, < 15.00 %.

b. Evaluation for agricultural irrigated land and its suitability to specific crops:

By using a parametric system undertaken by **Sys and Verheye (1978)**, the intensity degrees of limitations for soil productivity were calculated as well as suitability class of the studied soil for irrigated agriculture land at most of the chosen soil sites, as shown in Table 6.

Table 6. Soil limitations and rating indices for the evaluation of the studied soil sites.

Suitability condition	Topography (t)	Wetness (w)	S				Soil salinity/ Alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
			Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)				
Current	100	100	65	100	95	90	100	55.57	S2	S2s1s3s4
Potential	100	100	65	100	95	90	100	55.57	S2	S2s1s3s4

The obtained data show that soil texture (s_1), $CaCO_3$ (s_3) and gypsum (s_4) represent the main limitations for soil productivity, with an intensity degree of moderate (65 %), for soil texture and slight (> 90 %) for the other ones. Also, the suitability conditions in both current and potential classes of the studied soil could be categorized as moderately suitable for irrigated agriculture land (S2), with a suitability index rating (Ci) of 55.57 %.

Some soils may be suitable for a specific crop and unsuitable for another, however, the ideal approach for land evaluation is based on evaluating the land for utilization types which used as guides for the most beneficial use for a specific productivity by replacing a less adapted land utilization type by another promising one, and was applied in this study according to **Sys (1991)**. Evaluation indices of land characteristics could be done by rating the used values of soil variables as well as specifying their limitations for grown crops by matching the calculated rating with the crop requirements in different suitability levels as proposed by **Sys *et al.* (1993)**, Table 7.

In the studied area, the obtained either current or potential land suitability classes were achieved by matching charts of soil suitability for specific certain crops. This level was designed to be guide charts for the best land utilization alternatives giving a possible maximum output, as follows:

* *Marginally suitable (S3) adaptations* will be dealing with the current condition of soil site, which are suitable for wheat.

* *Moderately suitable (S2) adaptations* will be dealing with the potential condition of soil site, which are suitable for wheat.

Table 7. Current and potential soil suitability for wheat crop.

Suitability condition	Topography (t)	Wetness (w)	S				Soil salinity, ECe (n)	Soil sodicity, ESP	Rating (Ci)	Suitability class	Suitability subclass
			Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)					
Current	100	100	50	100	100	100	90	100	45.0	S3	$S3s_1n$
Potential	100	100	50	100	100	100	100	100	50.0	S2	$S2s_1$

The aforementioned discussion refers to the conclusion: a) An importance for soil texture or structure on soil physical properties such as pore size distribution…etc, which reflect on the water behaviour throughout soil profile, *i.e.*, infiltration rate, hydraulic conductivity and soil moisture constances, and b) The infiltration rate can be controlled by the infiltration capacity of the soil or the rate at which water is applied at the surface.

III. Irrigation water required for the grown crops under different applied irrigation systems:

Irrigation water required divided into the irrigation numbers for each of the seasonal crops of winter wheat were calculated under the different applied irrigation systems and environmental conditions of Inshas area, and are presented in Table 8. The obtained data reveal that the irrigation water value consumed in m^3 fed^{-1} for wheat under the prevailing environmental conditions of the experimental area was 1775.5 m^3 fed^{-1}, however, the applied irrigation water amount under the improved or modified surface irrigation with cement gated passers system reached 2683.0 m^3 fed^{-1}. On the other hand, the corresponding irrigation water amount under the sprinkler irrigation system was 2104.7 m^3 fed^{-1}. That means, water saving was about 21.55 % in irrigation water required under the applied sprinkler irrigation system as compared to the modified surface irrigation with cement gated passer system for wheat crop.

That was true, since it is evident that differences between irrigation water amounts for both applied irrigation systems are more attributed to the water use efficiency for each of them, which reached 66.18 and 78.47 % for improved or modified surface irrigation with cement gated passers and sprinkler, respectively. These findings indicate that the available soil moisture content increased as the water efficiency use increased. Also, such findings are also in harmony with those obtained by **Demian *et al.* (1998)**. It is noteworthy to mention that irrigation water required for the grown wheat plants under different applied irrigation systems was calculated and applied on the basis of actual water required for each crop plus leaching fraction to remove salts built up from each of the previous irrigation.

Table 8. Monthly-applied water amounts (crop water required + leaching fraction) for winter wheat under the two irrigation systems.

Month	Consumption use, m^3 fed^{-1}	Improved surface irrigation system			Sprinkler irrigation system		
		Amount of irrigation water, m^3 fed^{-1}	Loss in irrigation water, m^3 fed^{-1}	Loss in irrigation water %	Amount of irrigation water, m^3 fed^{-1}	Loss in irrigation water, m^3 fed^{-1}	Loss in Irrigation water %
November	23.2	35.3	9.7	27.48	27.6	4.8	17.39
December	68.4	98.4	30.9	31.40	77.2	15.5	20.08
January	121.8	185.8	56.8	30.57	145.8	28.3	19.41
February	240.9	373.5	122.5	32.79	293.0	61.2	20.89
March	445.5	680.9	229.6	33.72	534.2	114.7	21.47
April	621.0	932.4	325.7	34.93	731.4	162.6	22.23
May	254.7	376.7	132.3	35.12	295.5	66.1	22.37
Total	1775.5	2683.0	907.5	33.82	2104.7	453.2	21.53
Water use efficiency %		66.18			78.47		

***IV. Soil properties as affected by irrigation water quality under the applied two irrigation systems*:**

a. Soil salinity and sodicity:

The response of irrigated soil characteristics to either positive or negative effects depends on it initial characteristics as well as both chemical characteristics and applied amounts of water used under the used irrigation systems, *i.e.*, modified surface irrigation with cement gated passers (flooding) and sprinkler irrigation systems for seasonal field crop of wheat,. From this point of view, the current study was carried out to clarify the accompanied changes in soil salinity and sodicity levels, which were associated with the salinity and sodicity levels of the used irrigation water as well as the native source of the irrigated soil during the fixed period under the applied different irrigation systems.

So, controlling the soluble salts concentration in the applied irrigation water is a must, however, it must be also mobile into the root zone. Also, soil characteristics, moisture status, discharge rate and irrigation interval affect the status of the salts built up in the soil under the applied irrigation systems. According to the values of soil salinity (ECe) and sodicity (ESP) for the initial data in Table 5 and at harvest of wheat in Table 9, it could be noticed that the levels of soil salinity liable to seasonally change with different efficiencies of salts removed reached about 22-25 % throughout soil profile layers under the modified surface irrigation system with cement gated passers (flooding) as compared to that under sprinkler system, which reached about 16-19 %. Also, it is noteworthy to mention that there was an accumulation salt tendency in the subsurface layer under the applied sprinkler irrigation system.

Table 9. Salinity and sodicity conditions of the studied soil sites as related to the applied irrigation systems at harvest of wheat.

Depth (cm)	pH	EC (dS/m)	Soluble cations, mmolc L^{-1}				Soluble anions, mmolc L^{-1}				SAR	ESP
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{--}	HCO^{-}	Cl^{-}	SO_4^{--}		
Improved surface irrigation system with cement gated passers												
0-20	7.45	1.60	3.97	4.73	7.15	0.20	0.00	2.50	7.65	5.90	3.44	6.48
20-40	7.60	1.89	4.76	5.64	8.45	0.25	0.00	2.60	9.50	7.00	3.71	7.09
40-60	7.71	2.53	7.15	8.35	9.80	0.30	0.00	2.75	13.50	9.35	3.52	7.55
Sprinkler irrigation system												
0-20	7.64	2.35	5.40	6.95	11.00	0.25	0.00	2.65	12.50	8.45	4.43	8.32
20-40	7.75	3.20	7.49	9.11	15.30	0.45	0.00	2.70	16.40	13.15	5.31	9.49
40-60	7.83	2.64	6.70	8.80	10.65	0.35	0.00	2.90	13.75	9.85	3.83	7.80

In this concern, the values of sodicity parameter (ESP), Tables 5 and 9, showed also an opposite parallel trend like ECe values among either studied soil sites or profile layers. This is true, since Na^{+} can be easily replacement by other exchangeable cations during removed the soluble Na^{+} form. In addition, the dominance of soluble Na^{+} as well as the released Na from the inert weathered components accelerate and enhance the ESP slightly increased in the studied soil sites. That means the modified surface irrigation system with cement gated passers (flooding) surpassed the sprinkler one for removing soluble salts. That was true, since the continuous water flow in a way to a long-term use under modified surface irrigation system enhancing salts removing. Moreover, this means irrigating with elevated uniformity coefficients, where the water intercepted horizontally on the soil surface is taken into account. These parameters explain the later distribution of soil water, which is more important for practical purposes of either salt dissolved or removed out.

b. Soil moisture content:

In contrast, the best strategy of the irrigation water supply would be avoidance of moisture stress in the root zone for grown plants at emergence stages of plant growth. In addition wheat was found to be responsive to water stress at different stages of growth. **Klar *et al.* (1990) and Mahdy and Teama (2000 a)** mentioned that irrigation of wheat plants at all stages of growth caused a highly significant increase in grain yield and yield components as compared to drought treatments. So, modern agricultural practices as well as modern irrigation systems largely rely on high inputs of available soil moisture to achieve high yield. Data presented in Table 10 showed the distribution pattern of soil moisture contents, as a mean value for all the applied irrigations, throughout the studied two soil sites under the applied two irrigation systems.

As clearly shown, the irrigation process aims to achieve enough available soil moisture content for overcome the water needs of the grown plants to complete their growth stages from germination to harvest. It was also noticed that soil moisture contents just after irrigation were relatively high under the applied sprinkler irrigation system as compared to the modified surface irrigation one. After that, soil moisture content was tended to decrease with increasing time as well as soil depth under both the applied two irrigation systems, but with different rates.

Table 10. Soil moisture contents % at irrigation intervals per day of the studied soil sites as related to the applied two irrigation systems (as a mean value for all the applied irrigations).

Depth (cm)	Soil moisture content % at irrigation intervals per day										
	1	2	3	4	5	6	7	8	9	10	11
Improved surface irrigation system with cement gated passers											
0-20	32.36	30.45	26.47	25.67	23.17	21.27	17.69	16.50	14.15	9.78	6.12
20-40	37.30	33.37	30.53	28.50	26.50	21.13	18.00	15.10	14.38	11.69	7.35
40-60	43.60	38.94	37.05	35.61	32.62	29.43	24.15	19.85	15.90	12.15	7.96
Sprinkler irrigation system											
0-20	19.76	16.85	12.63	9.89	5.42	--	--	--	--	--	--
20-40	25.50	20.33	17.42	10.17	7.11	--	--	--	--	--	--
40-60	17.42	5.60	11.19	9.34	7.38	--	--	--	--	--	--

Practically, the soil moisture contents tended to gradual decrease up to almost values of moisture contents for wilting point or slightly more, that was occurred at the eleventh and fifth days after irrigation under the applied irrigation systems of modified surface irrigation and sprinkler, respectively. That means the irrigation process should be executed on the twelfth and sixth days for the applied irrigation systems of modified surface irrigation and mini sprinkler, respectively. Consequently, 5 and 11 days represent the best irrigation intervals for sprinkler and modified surface irrigation systems under the prevailing environmental conditions of the current experiment, respectively.

V. Wheat growth and yield as affected by the applied irrigation systems:

Under such desert conditions, a field experiment was carried out on a sandy loam soil of the Experimental Agric. Res. Farm at Inshas during the winter season of 2007-2008 by applying modified surface irrigation with cement gated passers and sprinkler systems to irrigate a relatively coarse textured soil cultivated with the tested wheat plants (*Triticum aestivium* L., Sakha 93 cv.) to identify the impact of both irrigation systems on soil moisture distribution as related to wheat yield and its components.

Data in Table 11 showed wheat vegetative growth parameters (*i.e.*, plants intensity in m^2, plant height, No. of tillers/plant and dry weight/plant) under both applied irrigation systems. The successful diagnosis of plants intensity in m^2 of any crop is a function of the relationship between uniformity of soil water distribution a certain stage of germination and seed response. The magnitudes of the wheat plants intensity of an area in soil were accompanied with the beneficial effects of available soil moisture that enhanced seed ability to germinate. This is true, since the increments in available water encouraged their uptake by wheat seeds and in turn positively supported the studied growth parameters, which were also resulted from increasing the net photosynthesis and transpiration rate when wheat plants were subjected to the prevailing best conditions **(Naire and Khuble, 1990)**.

Moreover, the obtained data showed that the applied sprinkler system was found to be more effective than modified surface irrigation one, in general with insignificant differences, for increasing the studied growth and harvest parameters of wheat, *i.e.*, spike length and No. of grains/spike as well as the grain and straw yields. This is explained on the bases of sprinkler irrigation system makes maximum use of available water among whole irrigated area, may be due to easily water flow among whole field with high efficiency in short time with low losses either by down movement under such relatively coarse textured soil or evaporation under arid hot climate.

Table 11. Plants intensity, vegetative and harvest parameters of wheat as affected by irrigation water systems at the studied Inshas area.

Nos. of plants/m^2	Vegetative growth parameters				Harvest parameters			
	Plant height, cm	No. of tillers/ plant	No. of leaves/ plant	Dry weight/ plant, g	Spike length, cm	No. of grains/ spike	Grain yield, kg/fed	Straw yield, kg/fed
Improved surface irrigation system								
780..47	79.50	4.85	14.75	5.65	10.44	49.50	2025.85	4978.50
Sprinkler irrigation system								
843.56	82.76	5.34	15.17	6.28	11.37	52.00	2572.75	4254.92
Statistical analysis of L.S.D. at 0.05								
70.58	3.89	0.76	0.65	0.70	1.12	3.20	324.54	215.70

Note: The value of each plant parameter represents a mean of seven replicates

The aforementioned data are confirmed by **Singh *et al.* (2002)** who evaluated micro-sprinkler irrigation on a loamy sand soil as compared with the conventional check basin method of irrigation for chilli crop. They found that the micro-sprinklers achieved a 52 % water saving as well as growth attributes, *i.e.*, plant height, number of leaves, stem girth and leaf area were all found to be higher for micro-sprinkler than for check basin. As for yields the micro-sprinklers also achieved a 43 % improvement In this connection, **Brennan (2008)** who reported that the benefits of a more uniform sprinkler was associated with reduced water application when application is uniform. An empirical analysis of the economics of lettuce production, grown using sprinkler systems under the windy conditions of the Swan Coastal plain in Western Australia is presented, where the yield response to water exhibits eventual declining marginal productivity. The optimal per-crop water application for the least efficient system was up to double the application rate of the most efficient system.

In here, the net biological yield of wheat (grain and straw yields) under the applied two irrigation systems was a function of some criteria of water efficiency use among both wheat and irrigated field under the prevailing conditions of the studied area, as shown in Table 12. This magnitude of wheat plants confirmed the fact that plant life represents a continuous or complete life cycle. However, the relatively higher values were observed with best growth parameters, while the usefulness ones were associated with relatively low water efficiency use. The results clearly showed also that biological yield of wheat (grain and straw) takes a parallel trend of dry weight/plant. That means that dry weight can be used as a criterion for identifying wheat yield. These results are in agreement with those obtained by **Gomaa (1997)** who pointed out that grain yield was highly correlated with the development of vegetative growth as well as dry matter accumulation.

Table 12. Some criteria of water use efficiency among both wheat and irrigated field under the prevailing conditions of the studied area.

Applied irrigation system	Amount of irrigation water, $m^3 fed^{-1}$	Efficiency of applied irrigation water %	Water use efficiency for crop (kg m^{-3})	Water use efficiency for field (kg m^{-3})
Improved surface irrigation system	2683.0	66.18	0.76	1.18
Sprinkler irrigation system	2104.7	78.47	1.22	1.55

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تأثير نظام الرى المستخدم على نمط توزيع كلا الرطوبة والأملاح
فى تربة رملية وعلاقته بانتاجية القمح

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الهدف الرئيسى من هذه الدراسة هو إستبيان مدى تأثير إستخدام نظامى رى هما الرى السطحى المعدل (الغمر) باستخدام ممرات وبوابات أسمنتية وكذا الرى بالرش على نمط توزيع كلا رطوبة وملوحة التربة وعلاقة ذلك بخصائص نباتات ومحصول القمح (*Triticum aestivum* L.) صنف سخا ٩٣ النامية فى تربة صحراوية رملية هيكلية بمنطقة أنشاص المستصلحة والمنزرعة منذ عام ١٩٥٩م.

وتشير النتائج المتحصل عليها إلى أن مياه الرى المياه تصنف على أنها جيدة الصلاحية (C1S1)، حيث أن EC_{iw} value = 0.35 dS/m or 0.75 dS/m and SAR 1.42 or < 6، مشيرا إلى أن مياه الرى المستخدمة لا ينتج عنها مشاكل متوقعة لملوحة أو صودية التربة. كما وأن التربة تحت الدراسة تتصف بالقوام الخشن نسبيا (طميى رملى) ذات القدرة الضعيفة فى الإحتفاظ بالرطوبة الأرضية والمغذيات للنباتات النامية. باستخدام نظام التقييم الرقمى للأراضى الزراعية المروية، إتضح أن قوام التربة يمثل عاملا محددا لإنتاجيتها، كما وأن التربة تحت الدراسة تنتمى إلى رتبة متوسطة الصلاحية (S2) فى صورتيها الحالية والمستقبلية، بينما تقيم عل أنها هامشية (S3) أو متوسطة الصلاحية بالنسبة لزراعتها بالقمح الشتوى فى صورتيها الحالية والمستقبلية على الترتيب. ولقد إتضح أيضا أن الكمية الفعلية من مياه الرى التى تحتاجها نباتات القمح النامية تحت الظروف السائد للتجربة كانت ١٧٧٥.٥ م^3/فدان مقابل ٢٦٨٣.٠ م^3/فدان فى حالة نظام الرى السطحى المعدل، ٢١٠٤.٧ م^3/فدان فى حالة الرى بالرش، بوفر بلغ ٢١.٥٥٪ من مياه الرى فى حالة نظام الرى الأخير. وهذا حقيقى، حيث أن مثل هذا الوفر من مياه الرى يرتبط لحد كبير بكفاءة إستخدام المياه والتى سجلت ٦٦.١٨، ٧٨.٤٧ ٪ فى حالتى الرى السطحى المعدل والرى بالرش على الترتيب.

علاوة على أن النتائج تشير إلى أن مستويات ملوحة التربة قد إستجابت للتغير الموسمى بكفاءات مختلفة للتخلص من الأملاح وصلت إلى حوالى ٢٢-٢٥ مقابل ١٦-١٩٪ خلال طبقات القطاع الأرضى تحت نظامى الرى السطحى المعدل والرى بالرش على الترتيب. عمليا، وصل المحتوى الرطوبى للتربة إلى حدود نقطة الذبول عند اليوم الحادى عشر والخامس من الرى تحت نظامى الرى السطحى المعدل والرى بالرش على الترتيب، وبالتالى فان أفضل فترات الرى المقابلة هى ١١، ٥ يوم تحت الظروف البيئية السائدة للتجربة الحالية على الترتيب.

ولقد تأثرت قياسات النمو الخضرية للقمح ممثلة فى كثافة النباتات/م^2، طول النبات، عدد التفريعات/نبات، الوزن الجاف/نبات وكذلك قياسات الحصاد ممثلة فى طول السنبلة، عدد الحبوب/ سنبلة، محصولى الحبوب والقش بكلا نظامى الرى المستخدمين. مع أفضلية لقياسات النباتات التى تروى بظام الرى بالرش. وهذا يرتبط بتجانس توزيع الرطوبة الأرضية خلال مرحلة الإنبات وإستجابة البذور، وذلك لسولة تدفق مياه الرى على مستوى أركان الحقل بكفاءة إستخدام عالية فى وقت قصير وبفقد أقل سواء بالتسرب لأسفل تحت ظروف القوام الخشن للتربة أو بالبخر تحت المناخ الحار الجاف.