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THE RESPONSE OF WHEAT CROP TO FERTILIZATION UNDER SPRINKLER IRRIGATION SYSTEM IN SANDY SOILS

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ABSTRACT

Field experiment was carried out on newly reclaimed sandy soil at Abdul-Moneam Reyad village, Bustan site during wheat growing season of 2012- 2013 to asses the response of the grain yield and biological yield of two wheat cultivars (MISR I & MISR II) under different irrigation treatment and under different of fertilization levels and also to determine of the main effect of studied treatmentson the some yield attributes.The obtained data revealed that, the fertilization treatments improve the productivity of the wheat crop under sprinkler irrigation system as compared with farmer's practice in sandy soil. The obtained results also indicated that, the fertilization treatments significantly effect on both wheat grain yield and biological yield than the irrigation treatments and variety of wheat crops. Also it was observed, the variety MISR II recorded the highest grain yield (2.650 ton/fed.) and biological yield (7.595 ton fed) under irrigated treatment I_1 (2528 m^3/fed.) and fertilization level of 120 kg N (F_1) over studied treatments. Moreover, it can be concluded that the wheat cultivar(MISR II) is more suitable for sandy soil than cultivar MISR I.

Keywords: Fertilization; Sprinkler Irrigation; Grain yield; Biological yield; Water regime; Water use efficiency.

INTRODUCTION:

The rapidly growing population of Egypt, and limited water and soil resources,so it can not cape with the continuous increase in food demand. It is imperative to force theagriculture sectorcontinuously for increasing its products. So the planted area of wheat (asthe first strategic crop in Egypt) has greatly increased from 11.9% in 1980 to 17.7% of cropped area in 2007. On the other hand, wheat yield have doubled from around 1.86 ton/fed. in 1980 to 2.72 ton/fed. in 2007. Moreover, wheat is grown in Egypt on the area of 2.89 million feddan (a feddan= 0.42 hectare) with total annual production of about 8.4 million tons with an average yield of 2.9 tons/fed. (FAO, 2011).

Methods of efficient fertilizer and water use, singly or combined (fertilization) are developed by agricultural researches and used by majority of growers. Moreover, improving both the efficiently of irrigation method and that of fertilizer use to maximum possible economic extent would allow for an appreciable expansion of the cultivated area of wheat and contribute a great deal to increasing crop yield. Where thus water use efficiency can't be considered apart from the moisture and yield situation.The period necessary for sandy soil to reach the productivity stage varied from 6 to 10 year. However at the present time by introducing the technology of fertilization this period was considerably reduce to 2-3 years.

Only deltaic along soils are suitable for level basin irrigation, while the sandy soil and very coarse desert soils which represents over 77% of the total area of some 2.33 million feddan will be irrigated by sprinkler or drip systems.Mounting pressure in old land areas, an newly reclaimed areas and Egypt's growth population all encouraged increasing or uprising the water use efficiency by improving agricultural inputs and practices and introducing the new techniques specially in sand soils (250% of cultivated land in Egypt).The new available technology for developing sandy soil stimulates the possibility to reclaim and develop . These soils using the different types of suitable irrigation technologies such as sprinkler and drip irrigation with different types of them. Although one of the advantages of using sprinkler or drip systems for irrigation is the possibility to use the system for fertilization. Modern irrigation technology (fertilization) will undoubtly play an important role in the future unique agronomic benefits that address many of the challenges facing irrigated agriculture (Heikal, et al 2008). Yet the small farms andsome of the big farmers still use hand or machine for fertilizingtheircrops. It is estimated that 40 to 60 of the present sandy soils irrigated by sprinkler or drip have the equipment for fertilization or are using fertilization technique.

El-Sayed and El-Araby (1998), stated that the cost of chemigation is generally less than when applying chemicals through traditionalirrigation method, farmers can be save up to 35% of their chemical bills if appropriately used.

Sayed and Bedaiwy (2011), conducted two year experiments in the Nobaria region (sandy soil) to study the effect of applying fertilizer and other agronomic chemicals through sprinkler irrigation system(a technique referred to as chemigation) on wheat grain yield. They stated that by applying chemigation the grain yield increased significantly, ranging between 9.9% and 50% with an average of 43.2% and 14.5% over the first and the second season (2006 and 2007) respectively. Also chemigation resulted in more uniform distribution of nitrate – nitrogen through the root zone with nitrate levels within safe limit.When combined with an efficient irrigation system both nutrients and water can be manipulated and managed to obtain the maximum possible yield of marketable production from given quantity those inputs (New Dep. of primary Industries, 2005). Continuous small applications of soluble nutrients, particularly in sandy soils result in none uniform distribution of added nutrients and other chemicals around plant roots and enhance the rate of nutrient uptake by plants (Keeny, 1983, and Pitter and Chrenside, 1987).Kassem and Suker (2009), found that fertilization method affected all of this study uniformity coefficient of water ,CUW; uniformity coefficient of nitrogen. (CUN); productivity, water use efficiency,(WUE); and nitrogen use efficiency,(NUE). Injection pump method then venture method had the highest values of CUW, CUN, productivity, WUE and NUE of wheat and barley.

Fertilizers should be applied in a form that become reliable in soil with crop demand for maximum utilization of nitrogen from fertilizers. The method of application is one of the among of several factors that affects fertilizer use efficiency (Mahmoud et al, 1999). Feigin and Jerrell(1982) reported that fertilization (combined irrigation and fertilizer) is the most efficient method of fertilizer application. The hypothesis is that nitrogen use efficiency can be influenced by a fertilization scheme, because movement and transformations of fertigated nitrogen are affected by applications (Cole et al, 2003).Fertilization enables the application of soluble fertilizers and other chemicals along with irrigation water, uniformly and more efficiency (Patel and Rajput, 2000).

The major disadvantages associated with the use of injection pump are high initial cost, greater maintenance and consequently high cost of production. However pressure differential method which operating on the principle of pressure differential generated by means of valves or venture causeshead loss in operation pressure (Narda and Chawla,2002). Fertigation devices can be affected on the uniformity of water and fertilizer, pressure differential tank decrease the uniformity of water and fertilizer in drip irrigation system (Bakeer, 2002).Abdelraouf et. al (2013) found that decreasing of fertigation levels from 100% to 50% NPK of the recommended fertilizer doses significantly decreased most studied elements, yield and yield attributes, protein and carbohydrate contents, while water use efficiency increased. So the treatment 100% NPK of recommended fertilizer +100% irrigation requirement recorded the highest value of studied grown characters, spike length, seed index and biological yield per fed.Latif and Iqbal (2002) stated that the potential advantages of the fertilization include improved fertilizer use efficiency, flexibility in timing of fertilizer use in relation to crop demand,increased crop yields, improved quality of production and saving in labors.

Rain Bird corporation (2009) classified water use distribution, Du; as follows: Du ranging between 70- 90% is considered good, Du> 90% excellent and Du < 70% is poor, where distribution uniformity, Du is a measure of low eventually water is applied across a field during irrigation. Poor Du means that either too much water is applied increasing cost production or low applied water is used, causing in stress crops.

This experimental work aims at evaluate the main effect of fertilization techniques, applied irrigated water in terms of water requirement (IR) at two wheat cultivars (MISR I & MISR II) and sprinkler irrigation system on some yield attribute in sandy soil.

MATERIALS AND METHODS:

A field experiment was carried out on newly reclaimed sandy soil at Abdul Moneam Reyad village, Bustan site, Behera governorate (the west of Nile Delta) during wheat growing season of 2012 – 2013 to assess the effect of two cultivars of wheat; (Misr I and Misr II) , different levels of irrigated water applied and fertigation levels on some yield attribute under sprinkler irrigation system.

Soil samples were taken and collected from the experimental area of successive depth of 0-30, 30-60 and 60-120 cm.The physical and chemical analysis are shown in Tables (1 and 2). Meanwhile, water samples were taken also from the source of irrigation water for water chemical analysis(Table 3).

Table (1): Some physical properties of the sandy soil at Bostan site

Soil depth, cm	Particle size distribution (%)				Soil texture	Bulk density, $kg.m^{-3}$
	Coarse sand	Fine sand	Silt	Clay		
0 - 30	52.8	41.4	4.1	1.7	Sandy	1680
30- 60	50.02	43.5	5.0	1.5	Sandy	1726
60 – 120	52.0	42.0	4.3	1.7	Sandy	1628
Average	51.6	42.3	4.47	1.63		16.78

Table (2): Some chemical analysis of the sandy soil at Bostan site

Soil depth (cm)	pH (1:2.5)	EC (dS/m)	Soluble cations (meq/l)				Soluble anions (meq/l)			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Co_3^{-2}	Hco_3	Co_4^{-2}	Cl^{-}
0-30	8.2	1.27	2.9	2.8	5.1	0.6	--	3.6	2.0	5.8
30-60	8.3	1.22	2.9	2.1	5.2	0.7	--	3.7	2.1	5.1
60-120	8.3	1.30	3.0	2.0	5.4	0.7	--	4.3	2.4	4.4
Average	8.26	1.26	2.93	2.93	5.23	0.66	--	3.87	2.17	5.1

Table (3); Some chemical analysis of water source at Bostan site

pH	EC dS/m	Cations (meq/l)				Anions (meq/l)			
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Hco_3^{-2}	Co_4^{-2}	Cl^{-}	So_4^{-2}
7.9	0.58	2.1	1.4	1.9	0.45	1.5	--	2.03	2.25

The experiments were arranged in a split-split plot design with three replications. Three were two wheat cultivars as main plots, four levels ofirrigated water as sub-plots and three levels of nitrogen rates, through irrigation water (fertigation) as sub-sub plots. The control treatment was designed to simulate typical irrigation regime (I_0), with fertilizer application broadcast on the field as used by farmers in the area of study (F_0). Fertilization was applied each four days using sprinkler irrigation system. The rotary sprinkler of 0.7 m^3/h discharge at 2.5 bar nozzle pressure with spacing of 8 * 8 m between laterals and sprinklers.

A differential pressure tank was connected to the sprinkler irrigation system to inject fertilizer via irrigation water. The fertigation rate was determined according to irrigation system operation water supply in terms of irrigated time), concentration of the fertilizer element in the tank stock solution and discharge of the fertilizer. Nitrogen fertilizer was added in the form of ammonium nitrate (33.5 % N) in rates of 100%, 83% and 70%) as recommended fertilizer rates of amounia nitrate (120 Kg N) namely F1, F2 and F3; respectively. Nitrogen fertilizer applied in equal doses every four days till 50 days after sowing.

Total irrigation requirements IR (m^3/fed/season) were estimated according to the metrological data of Central Laboratory for Agricultural Climate (CLAC)depending on FAO equation (1973)as shown in Fig(1). The calculated seasonal water irrigation applied was502 m^3/fed.The irrigation treatments were: 120% IR, 100% IR, 90% IR and 70% IR manly I1, I2, I3 and I4, respectively.

At harvest a random sample of 1 m* 1m (1/100 of plot area approximately) was taken from each plot to determine grain, straw and calculate biological yield in ton/fed.

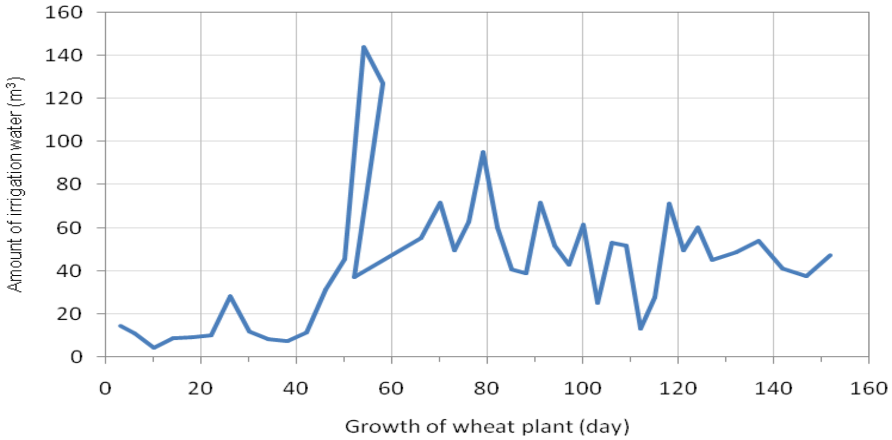

Fig (1); Relation between growth of wheat plant and amount of irrigation water.

Water use efficiency (WUE): The WUE was calculated according to James (1988) as follow:

WUE= Grain yield (kg/fed) / Total application irrigation water (m^3/fed/season)

Water distribution uniformity (DU): was measured in the field and calculated by the following equation (Merriam & Keller 1978):

DU= Average low quarter catch water / average all catching water

Data analysis: Data were subjected to analysis of variance according to Gomez and Gomez, (1976). Main values of recorded data were compared by using the LSD, 0.05.

RESULTS AND DISCUSSION

A correctly designed irrigation system will supply adeguate amount of water needed each day of the year. This amount will depened upon the area to be watered, kind of crop grown, weather condilionns, time of the day, and time of the year.

Soil texture and sprinkler distribution uniformity, DUsp.:

The data presented in Table (1) show that the soil is desert sandy soil contains 90% and sand bulk density greater than 1500 kg m^{-3}, so this soil is characterized with low water holding capacity, low available soil moisture and markedly high steady infiltration rate, (FAO, 1973). On the other hand, the sandy soil is imperative to follow a strict irrigation scheduling policy. So, the use of sprinkler irrigation systems which deliver adequate amount of water to the localized soil.

Results of DUsp tests of the sprinkler irrigation system indicate that the average value low quarter is 0.567 L and overall catching water average is 0.659 L. ,so the values of DUsp is 80% approximately. This value of DUsp is good according to Rain Bird Corporation (2009). This means that good watering performance of the system. On the other sense, there is a balanced application of irrigated water through root zone of the crop which reflects a good uniform movement of added fertilizer into the soil profile.

Main effect fertigation (F), water requirement (I), and wheat cultivars (C) on grain yield and biological yield.

It is important to mention that, the control treatment is designed to simulate a typical wheat irrigation regime with fertilizer application broadcast on the field as conventionally used by the growers in the area of study.

For control treatment, grain yield, and biological yield of cultivars MISR I were reach about 1.26 ton/fed., 4.682 ton/fed., and 4.712 ton/fed. respectively. With respect of cultivar MISR II these values were 1.64 ton/fed., and 5.576 ton/fed, respectively.

Table (4): The main effect of fertigation levels, irrigation levels and two wheat cultivars on grain yield and biological yield.

Treatment	Grain yield Ton/fed.	Straw yield Ton/fed.	Biological yield Ton/fed.
Fertilization levels			
F_1	2.168	4.707	6.669
F_2	2.004	4.290	6.195
F_3	1.910	4.036	5.945
LSD	0.55	0.61	0.64
Irrigation levels			
I_1	2.203	4.468	6.644
I_2	2.139	4.363	6.519
I_3	1.961	4.366	6.198
I_4	1.807	4.157	5.958
LSD	0.58	0.71	0.66
Cultivars			
MISR I	1.818	3.935	5.753
MISR II	2.236	4.687	6.925
LSD	0.22	0.79	0.74

Data presented in Table (4) illustrated that the main effect of two wheat cultivars (MISR I &MISR II), irrigation treatment and fertilization levels and the cultivars on the grain yield, and biological yield are significant. This means that the fertigation levels have the highest effect on both of grain yield and biological yield followed by irrigation levels and the wheat cultivar.Accordingly, the grain yield, and biological yield of MISR I under average fertilization levels increased by 30.69%, and 18.09%, respectively, as compared with control whereas treatment, Where as the percentage of grain yield, straw yield and biological yield for the cultivar Misr under average fertilization levels increased by 26.65%, and 19.98% compared with control treatment, respectively.Also, from Table (4), it is clear that reducing fertigation levels from F_1 to F_3(from 100% to 70% N as recommended fertilizer) significantly decreased the grain yield, and biological yield. The highest values of the studied various yields were recorded by F_1(100% N as recommended fertilizer) without significant differences with treatments F_2 and F_3except and biological yield of F_3.

Regarding to irrigation treatments, reducing irrigation scheduling from 1.2 IR to 0.7 IR, the grain yield, and biological yield decreased significantly. The highest values of grain yield, and biological yield were recorded by using treatment I_1 (1.2 IR) without significant differences between averages of treatment except biological yield.

These results also shown that the water stress treatment (I_4) reduced the grain yield, straw yield and biological yield by 17.98%, 9.20% and 10.33% of treatment (I_1)respectively.

With respect to the studied cultivars (common cultivars in the studied area), the C_2 (MISR II) has been recorded the significantly higher grain yield, straw yield and biological yield than C_1(MISR I) with significant differences between them. The grain yield, and biological yield of $C_2$are increased by 18.7% and 16.9% as compared with the yield of $C_{1,}$ respectively. Also, the yield of all studied treatments surpass the yield of control treatment (treatment's farmer).

Effect interaction between crop cultivars and applied irrigation water on yield attributes:

Data listed in Table (5) showed the interaction between changing the crop cultivars from C_1(MISR I)to C_2 (MISR II) and reducing the applied irrigated water from $I_1$to I_4(1.2 IR to 0.7 IR) on grain yield, and biological yieldton/fed. A significant differences between grain yield and biological yield for irrigation treatment $I_1$and I_4 (water stress) were observed. While, the differences between grain yield and biological yield for irrigation treatments ($I_1$and I_4) were not significant with both wheat cultivars (Misr I and Misr II). This Table also revealed that, the highest grain yield (2.461 ton/fed) and biological yield (7.120 ton/fed) were achieved with irrigation treatment $I_1$for cultivar $c_{2.}$ Whereas, the lowest grain yield (1.622 ton/fed) and biological yield (5.434 ton/fed) occurred with irrigation treatment I_4 (water stress) for cultivar $c_{1.}$

Table (5): Effect of interaction between crop cultivars and applied irrigated water on grain yield, straw yield and biological yield, ton/fed.

Crop cultivars	Irrigation treatment	Grain yield ton/fed.	Straw yield ton/fed.	Biological yield ton/fed.
C_1	I_1	1.940	4.100	6.043
	I_2	1.908	4.027	5.928
	I_3	1.764	3.844	5.614
	I_4	1.602	3.772	5.434
C_2	I_1	2.461	4.870	7.120
	I_2	2.366	4.742	7.110
	I_3	2.138	4.600	6.74
	I_4	1.951	4.541	6.471
LSD 0.05		0.22	0.18	0.19

Effect interaction between cultivars and fertigation levels on yield attributes:

The effect of wheat crop varieties and reducing fertilization levels on grain yield and biological yield is summarized and listed in Table (6). It evident by showed that, the highest grain yield(2.425 ton/fed) and biological yield (7.283) ton/fed) were achieved by variety c_2 (Misr II) with frtigation level F_1 (100% N as recommended fertilizer level). While, the lowest values of grain and biological yields occurred by crop variety c_1 with fertilizer level F_3 (60% N as recommended fertilizer level).

Table (6): Effect of the interaction between wheat crop varieties and fertigation levels on grain yield, straw yield and biological yield.

Crop cultivars	Fertigation treatment	Grain yield ton/fed.	Straw yield ton/fed.	Biological yield ton/fed.
C_1	F_1	1.898	4.548	6.450
	F_2	1.803	3.690	5.498
	F_3	1.739	3.569	5.308
C_2	F_1	2.425	4.771	7.283
	F_2	2.199	4.690	6.887
	F_3	2.086	4.002	6.577
LSD 0.05		0.29	0.27	0.26

Effect of interaction between applied irrigated water treatments and fertigation levels on some yield attributes:

The effect of reducing irrigation water amount from 1.2 to 0.7 IR and fertilization levels from 100 % N to 70% N on grain biological yield is listed in Table (7). It clearly clarifies that, the highest values of grain yield (2.332 ton/fed) and biological yield (7.159 ton/fed) were realized with irrigation manipulate I_1 (1.2IR) and fertigation level F_1 (100% N). Whereas, the lowest values of grain yield (1.703 ton/fed) and biological yield (5.551 ton/fred) occurred with irrigation treatment I_4(0.7IR) and fertilization level (70% N).

Table (7) Effect of applied irrigation water amount and fertigation levels on grain yield, straw yield and biological yield.

Irrigation treatment	Fertigation treatment	Grain yield ton/fed.	Straw yield ton/fed.	Biological yield ton/fed.
I_1	F_1	2.332	4.828	7.159
	F_2	2.170	4.307	6.417
	F_3	2.107	4.221	6.326
I_2	F_1	2.284	4.796	7.060
	F_2	2.160	4.286	6.424
	F_3	1.992	4.092	6.073
I_3	F_1	2.109	4.631	6.740
	F_2	1.929	4.150	6.079
	F_3	1.895	4.476	5.821
I_4	F_1	1.965	4.578	6.516
	F_2	1.755	4.038	5.792
	F_3	1.703	3.854	5.531
LSD 0.05		NS	NS	NS

Table (8): Water use efficiency (WUE) for the two wheat varieties as affected by irrigation and fertigation treatment

Treatment		MISR I		MISR II	
Applied irrigated water m^3/fed.	**Fertigation Levels kg N/fed.**	**Grain yield, kg/fed.**	**WUE kg/m^3**	**Grain yield kg/fed.**	**WUE Kg/m^3**
Control I_0 2015	F_0 (120% N)	1260	0.599	1640	0.780
I_1 2528	F_1 (120% N)	2013	0.796	2650	1.048
	F_2 (100% N)	1940	0.707	2400	0.949
	F_3 (80% N)	1880	0.794	2333	0.923
WUE average			0.792		0.973
I_2 2015	F_1 (120% N)	1960	0.931	2507	1.192
	F_2 (100% N)	1923	0.914	2397	1.140
	F_3 (80% N)	1820	0.865	2163	1.029
WUE average			0.903		1.120
I_3 1896	F_1 (120% N)	1867	0.985	2350	1.239
	F_2 (100% N)	1737	0.916	2120	1.118
	F_3 (80% N)	1687	0.890	2003	1.056
WUE average			0.930		1.138
I_4 1474	F_1 (120% N)	1783	1.210	2153	1.461
	F_2 (100% N)	1633	1.108	1877	1.273
	F_3 (80% N)	1570	1.055	1823	1.237
WUE average			1.124		1.324

Water use efficiency for two wheat crop cultivars:

Water use efficiency (WUE) was determined for the two wheat varieties (MISR I and MISR II) and listed in Table (8). It evidently shows that, the water use efficiency (WUE) was high for all fertilization manipulates and irrigation treatments as compared with control treatment. It also reveals that, the high WUE was reflected its effect on the production of higher biological yield and grain yield for the two varieties. The annual average WUE for the three different levels of fertilization (F_1, F_2 and F_3) and four different irrigation treatments, respectively, were 0.792, 0.903, 0.930 and 1.24, while it was 0.599 for control unit under wheat varieties MISR I. Whereas, these averages were 0.973, 1.120, 1.136 and 1.324for treatments I_1, I_2, I_3 and I_4 and 0.780, for control treatment under wheat verities MISR II. These obtained data were in general agreement with those reported by Sayed and Bedaiwy (2011).

CONCLUSION

This study was conducted in El-Nubaria province, Egypt to assess the effect of different fertigation treatmentsand two wheat varieties (MISR I and MISR II) grown in sandy soil using sprinkler irrigation system. It was also examined the different irrigation treatments and different fertigation levels on grain yield and biological yield of two wheat varieties. The obtained data revealed that the fertilization manipulates using sprinkler irrigation system improved the productivity of wheat crops as compared with cpnventional system that applied in sandy soil. The results also clarified that, the fertigation manipulates had have a significant greater effect on both grain and biological yield of wheat crop than the irrigation treatments and varieties of wheat crop. Also obviously that, the varieties MISR II recorded the highest grain yield (2.650 ton/fed.) and biological yield (7.595 ton fed) under irrigation treatment I_1(2528 m^3/fed.) and fertigation level of 120 kg N (F_1) over studied treatments. Finally it can be concluded that, the wheat suitable for the sandy soil than varieties MISR I.

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إستجابة محصول القمح للري الكيماوي تحت نظام الري بالرش في الأراضي الرملية

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أجريت هذه التجربة في أرض رملية مستصلحة في قريةعبد المنعم رياض،بمنطقة البستان– منطقة غرب النوبارية خلال موسم القمح ٢٠١٢ لتقييم استجابة محصول الحبوب والمحصول البيولوجى لصنفين من القمح (MISR I & II MISR) تحت معاملات ري مختلفةوتحت مستويات مختلفة من التسميد لتحديد تأثير هذه المعاملات المختلفة على بعض الصفات الإنتاجية. أدت عملية التسميد مع مياه الرش إلى تحسين إنتاجية محصول القمح. وأشارت النتائج إلى أن الصنف مصر٢ سجل أعلى محصول حبوب (٢.٦٥٠ طن / فدان) والعائد البيولوجي (٧.٥٩٥ طن) تحت I1 معاملة الري I1 (٢٥٢٨ م٣/فدان) ومستوى التسميد ١٢٠ كجم(F1) N . لذلك فإن صنف القمح مصر ١ هوأكثر ملاءمة للتربة الرملية من الصنف الآخر. وأوضح تحليل النتائج أن محصول القمح تأثر جوهرياً بكمية السماد النيتروجيني مع معاملة (الري الكيماوي) أكثر من الصنف نفسه. كما أن إنتاجية الري الكيماوي بمستوياته المختلفة أعلى من إنتاجية المزارع في هذه المنطقة لكلا الصنفين (مصر ١، مصر ٢).