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WHEAT RESPONSE TO N APPLICATION METHOD UNDER SOME IRRIGATION SYSTEMS AT NORTH DELTA

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ABSTRACT

A Field experiment was conducted during 2011 - 2012 cultivation season at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate to evaluate the effect of some irrigation systems (surface irrigation "I_1", semiportable sprinkler "I_2", minisprinkler "I_3", floppy sprinkler "I_4", surface drip "I_5" and sub-surface drip "I_6" and N application methods (100 % fertigation "N_1", 75 % fertigation + 25% soil application "N_2", 50 % fertigation + 50% soil application "N_3", 25 % fertigation + 75% soil application "N_4" and 100 % soil application "N_5") on wheat (var. Sakha 93) yield, N uptake, N use efficiency and soil available N remained after harvesting.

The main results could be summarized as follows:

1- Surface irrigation system (I_1) and N_1 treatment achieved the highest values of wheat grain and straw yields, while the lowest values were recorded with subsurface drip irrigation system and N_4 treatment.

2- I_1 and N_2 treatment gave the highest 1000 kernel weight, while I_6 and N_4 treatment gave the lowest value.

3- The highest values of N uptake, and N use efficiency were recorded with I_1 and N_1, while, the lowest values were achieved under I_6 and N_5. The opposite trend was observed with available nitrogen remained in soil after wheat harvest. This means surface irrigation and N fertigation increase the ability of wheat plants to N uptake from the soil and consequently increase yield.

4- The response of wheat grain yield to N application method under surface drip irrigation could be expressed by equations 1 and 2 as follow:-

$Y_{Soil\ app}$ = 3107.4 (N soil app.) + 56.1 (R^2 = 0.9973), (1)

Y_{fert} = 2756.2 (N fert.) + 31.7 (R^2 = 0.9991), (2)

While, equations 3 and 4 summarized the response of grain yield to different N treatments under sub-surface drip irrigation as follow:-

Y_{fert} = 2478.1 (N fert.) - 33.298 (R^2 = 0.9992), (3)

$Y_{Soil\ app}$ = 2064.3 (N soil app.) + 70.15 (R^2 = 0.9913), (4)

Where:

$Y_{Soil\ app}$ = the estimated wheat grain yield (kg fed^{-1}) according to the contribution ratio of N soil application.

Y_{fert} = the estimated wheat grain yield (kg fed^{-1}) according to the contribution ratio N fertigation method.

N soil app.= N soil application ratio (%).

N fert = N fertigation ratio (%).

From equation 1, 2, 3 and 4 it could be concluded that nitrogen fertilizer is preferable to add as soil application with surface drip irrigation, while N fertigation method has to be used with sub-surface drip irrigation.

Keywords: Wheat grain yield, surface drip, sub-surface drip irrigation, N soil application and N fertigation.

INTRODUCTION

Egypt is suffering from a great gap between wheat production and consumption as well as water scarcity (CAGMS, 2003 and (EAS, 2005), consequently, great efforts have to be directed to raise the use efficiency of water, land and fertilizer units. The problem of surface irrigation system is approximately half of the applied irrigation water is lost (Sonbol *et al*., 2011). There are several methods for applying irrigation water; for instance surface irrigation, semi portable sprinkler, minisprinkler, floppy sprinkler, surface drip and subsurface drip. In this respect Abo-Soliman *et al* (2005) stated that surface irrigation achieved the highest maize and barley grain yields and their components followed by mini-sprinkler and gun irrigation methods. Surface drip resulted in increasing the seed yield of soybean by 18.54, 37.68, 17.39, 11.59 and 4.35% compared with semi portable, gun, mini sprinkler, floppy and subsurface drip (Saied *et al*, 2008).

On the other hand, Soil fertility continues to decline because of agricultural intensification and cultivating the land many times a year. Therefore, nitrogen which is an essential plant nutrient is the most commonly deficient and reduces the crop yield throughout the world (Mkhabela *et. al*., 2001). Therefore, Faizy *et al*. (2012) revealed that increasing the level of nitrogen significantly increased wheat grain yield and the highest yield (2.25 tons /fed) was obtained with 120 kg N fed^{-1} . Also, the grain and straw yields of wheat were significantly increased with increasing N level up to 90 $kgfed^{-1}$. in field experiments (Allam , 2005). El-Desouqi (2000) found that the grain and straw yields as well as 1000-grain weight were increased by increasing the N levels from 100 to 150 kg fed^{-1}. Also, El- El-Naggar ad El-Ghamry (2004) found that the maximum grain yield was 20.85 ardab fed^{-1}. with 131.89 kg N fed^{-1} application. Silber *et al*. (2003) stated that, nutrient use efficiency is increased under fertigation over soil application of nutrients.

Drip irrigation has been gained wide spread popularity as an efficient method for fertigation because both time and rate of nutrients can be controlled to meet the requirements of a crop at each physiological growth stage. Fertigation enables the application of fertilizer uniformly and more efficiently (Patel and Rajput, 2000). Drip fertigation places nutrients in active root zone besides maintaining favorable soil moisture level resulting in much greater movement of phosphorus and potassium in areca nut rhizosphere (Bhat *et al*, 2007). Drip irrigation along with soil application of 100% NPK (control) registered yield of 3574 $kgha^{-1}$ which was at par with drip fertigation treatment. However, estimation of economic feasibility based on annuity value approach revealed that drip fertigation is highly profitable due to considerable saving in input, labor and energy costs to the tune of 54% over conventional method of cultivation (Bhat and Sujatha, 2006).

So, the objectives of this study were to evaluate the effect of some irrigation systems and N application methods on wheat yield, N uptake, N use efficiency and soil available N remained after harvesting, as well as determining the general trend of wheat response to N application methods under surface and sub-surface drip irrigation systems.

MATERIALS AND METHODS

A Field experiment was conducted during 2011-2012 cultivation season at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate to evaluate the effect of some irrigation and N application methods on wheat production. Split plot design was used; main plots were arranged for irrigation methods namely:

I_1 = surface irrigation , I_2 = semi portable sprinkler

I_3 = minisprinkler , I_4 = floppy sprinkler

I_5 = surface drip , I_6 = subsurface drip

Sub plots were subjected to nitrogen application methods namely:

N_1 = 100% fertigation + 0 % soil application

N_2 = 75 % fertigation + 25 % soil application

N_3 = 50% fertigation + 50 % soil application

N_4 = 25% fertigation + 75 % soil application

N_5 = 0 % fertigation + 100 % soil application

Wheat (var. Sakha 93) was planted on November 15th, 2011 and all agronomic practices were conducted according to the standard recommendation for North Delta.

Soil samples were taken before planting from four depths namely; (0-15), (15-30), (30-45) and (45-60) cm for some chemical and physical analysis according to Page *et al*. (1982). Mechanical analysis for soil was carried out using the pipette method as described by Dewis and Fartias (1970).The data are shown in Tables 1 and 2.

Plant samples were taken at the end of season and prepared for determination of total nitrogen according to the method described by Faithfull (2002).

The crops yield and yield components were statistically analyzed according to procedures outlined by Cochran and Cox (1960).

Table 1: Some chemical properties of the soil of the experimental field.

Depth (cm)	O.M. %	$CaCo_3$ %	C.E.C. meq /100 g soil	pH*	EC** (dS m^{-1})	Soluble cations (meq L^{-1})				Soluble anions (meq L^{-1})				SAR
						Na^+	K^+	Ca^{++}	Mg^{++}	Co_3^-	HCO_3^-	Cl^-	SO_4	
0-15	1.48	2.13	48.5	8.08	1.68	11.4	0.16	3.53	2.01	0.0	3.0	8.0	6.1	6.9
15-30	1.23	2.05	45.0	8.16	1.73	11.9	0.17	3.68	2.1	0.0	3.5	8.3	6.1	7.0
30-45	1.05	1.86	44.0	8.21	1.92	13.1	0.19	4.03	2.3	0.0	4.0	9.1	6.5	7.4
45-60	0.95	1.71	42.5	8.29	2.01	13.8	0.20	4.22	2.41	0.0	4.5	9.6	6.5	7.6

*** pH was determined in soil suspension (1:2.5) ** EC was determined in saturated soil paste extract.**

Table 2: Some physical properties of the soil of the experimental field.

Depth cm	Particle size distribution				FC %	Permanent wilting point%	Available water %	Bulk density, g cm^3
	Sand %	Silt %	Clay %	Texture class				
0-15	21.59	35.76	42.65	Clay	43.70	23.96	19.74	1.24
15-30	21.10	32.15	46.75	Clay	39.00	21.20	17.80	1.36
30-45	20.61	29.71	49.68	Clay	37.10	20.11	16.99	1.39
45-60	18.13	30.50	51.37	Clay	36.20	19.67	16.53	1.47

RESULTS AND DISCUSSION

1) Effect of irrigation system and N application methods on wheat yield:

The obtained results in Table 3 show high significant effects of irrigation system on wheat grain and straw yields. Surface irrigation method gave the highest grain and straw yields (3894 and 4117 kg fed $^{-1}$, respectively); while the lowest yields were obtained under sub-surface drip irrigation system (2307.9 and 2241.2 kg fed $^{-1}$, respectively). Data also indicated that the weight of 1000-kernel is highly significantly affected by irrigation system methods. The surface irrigation system (I_1) gave the highest 1000-kernel weight (74.60 gm), while sub-surface drip irrigation system recorded the lowest value (65.40 gm).This trend may be attributed to the proper amount of water applied or stored in the effective root zone with surface irrigation. The tendency of these results is similar to those obtained by Omar *et al*. (2008), El-Hendawy *et.al.* (2008), Abo Soliman *et. al* (2005) and Saied *et al*. (2008).

Table 3: Effect of irrigation systems and nitrogen fertilization on wheat grain and straw yields and 1000 kernel weight.

Treatments	Grain yield (kg fed $^{-1}$)	Straw yield (kg fed $^{-1}$)	1000- kernel Weight (g.)
Irrigation system (I)			
I_1	3894.00 a	4117.00 a	74.60 a
I_2	2720.04 e	3299.40 d	65.48 d
I_3	3536.26 b	3368.40 c	69.98 b
I_4	2793.70 d	3450.00 b	67.34 c
I_5	2907.40 c	2873.00 e	65.60 d
I_6	2307.90 f	2241.20 f	65.40 d
F-test	**	**	**
LSD 0.05	7.04	9.60	1.51
0.01	10.02	13.65	2.16
Nitrogen application method (N)			
N_1	3158.36 a	3445.44 a	67.13 ab
N_2	3146.86 b	3413.66 b	69.40 a
N_3	3000.19 d	2994.22 d	67.37 c
N_4	2699.66 e	2908.66 e	65.95 d
N_5	3127.66 c	3362.16 c	68.48 b
F-test	**	**	**
LSD 0.05	9.90	9.72	0.89
0.01	13.21	12.96	1.19
Interaction			
IXN	**	**	**

The data reveal also that nitrogen application methods resulted in highly significant effect on wheat yield, where the highest grain and straw yields are obtained under N_1 treatment (3158.36 and 3445.44 kg fed^{-1}, respectively), while the lowest grain and straw yields (2699.66 and 2908.66 kg fed^{-1}, respectively) are achieved under N_4 treatment. Regarding the effect of nitrogen fertilization methods on the weight of 1000-kernel, the results show highly significant differences, where N_2 gave the highest 1000-kernel weight (69.4 g) while N_4 gave the lowest one (65.95 g). This trend may be attributed to that fertigation application method (N_1) is more effective in filling the kernels than soil application method as in N_4 treatment.

The interaction between irrigation system and N addition method has highly significant effects on grain and straw yields as well as on the weight of 1000-kernel.

The effect of the interactions between irrigation systems and N application methods on grain yield is shown in Table 4 and Fig 1. The data show that the combination between I_3 and N_3 treatments is more effective interaction since it achieved the highest grain yield (3997 kg fed^{-1}), while the lowest yield (2045 kg fed^{-1}) is recorded with the interaction between I_6 and N_5 treatments.

Table 4: Wheat grain yield (kg fed^{-1}) as affected by the interaction between irrigation and N application methods

N application method	Surface irri. (I_1)	Semi portable (I_2)	Meni-sprinkler (I_3)	Floppy sprinkler (I_4)	Surface drip irri. (I_5)	Sub-surface drip irri. (I_6)
N_1	3894	2436.0	2623	2072.0	2771	2467.5
N_2	3894	2499.0	3560	2877.0	2778	2425.0
N_3	3894	2604.0	3997	3139.5	2919	2365.5
N_4	3894	3097.5	3770	2982.0	2940	2236.5
N_5	3894	2992.5	3733	2898.0	3129	2045.0

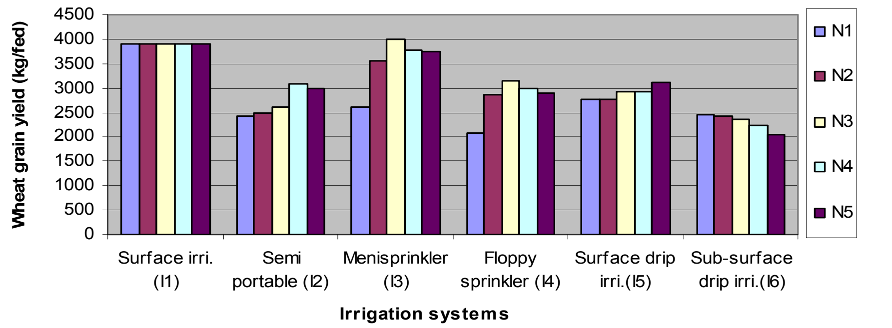

Fig 1: The interaction effect of irrigation systems and N application methods on wheat grain yield

In spite of that the interaction between irrigation and nitrogen treatments has high significant effect on wheat grain yield, general trend of the effect of N treatments under different irrigation systems could be seen only with surface drip irrigation (I_5) and sub - surface drip irrigation (I_6) as shown in

Table 4 and Fig 1. It seems from the data that wheat grain yield is increased under surface drip irrigation and decreased under sub-surface drip irrigation with increasing of N ratio that applied by soil method. This observation could be clarified as follow: there are two factors affecting wheat grain yield, namely: N fertigation application method with 5 decreasing sharing ratios namely: 100 %, 75 %, 50 %, 25 % , and 0.0 %, and soil application method with 5 increasing sharing ratios namely: 0.0 %, 25%, 50 % , 75 % , and 100 %. Consequently, wheat grain yield could be distributed according to the contribution of the N applied through either fertigation or soil application methods for each N treatment under both surface and subsurface drip irrigation methods as shown in Tables 5 and 6. For example wheat grain yield of the third N ratio (2919 kg fed^{-1}) under surface drip irrigation could be distributed according to the contribution ratio of (50% N soil application and 50% N fertigation). So, N soil application method shares in producing 1459 kg grain /fed, while N fertigation shares in producing 1459 kg grain fed^{-1}). Table 5 summarizes the distribution of wheat grain yield under surface drip irrigation method according to the sharing of both N addition methods. Fitting a linear equation between N soil application and N fertigation ratio and their sharing in wheat grain yield give equations 1 and 2, respectively as shown in Fig 2. From equation 1, N soil app. coefficient (3107.4) is greater than that of N fert. coefficient (2756.2) obtained from equation 2. This means that nitrogen fertilizer is preferable to add as soil application fertilizer with surface drip irrigation.

$$Y_{Soil\ app} = 3107.4\ (N\ soil\ app.) + 56.1 \qquad (R^2 = 0.9973), \qquad (1)$$
$$Y_{fert} = 2756.2\ (N\ fert.) + 31.7 \qquad (R^2 = 0.9991), \qquad (2)$$

Where:

$Y_{Soil\ app}$ = the estimated wheat grain yield according to the contribution ratio of N soil application.

Y_{fert} = the estimated wheat grain yield according to the contribution ratio of N fertigation method.

N soil app. = N soil application ratio (%).

N fert = N fertigation ratio (%).

Table 5: The distribution of wheat grain yield under surface drip irrigation method according to N application method sharing.

N application methods	Grain yield ($kgfed^{-1}$)	N fertigation ratio (%)	N fertigation share in grain yield ($kgfed^{-1}$)	N soil application ratio (%)	N soil application share in grain yield ($kgfed^{-1}$)
N_1	2771	**100%**	2771	**0%**	0
N_2	2778	**75%**	2083.5	**25%**	694.5
N_3	2919	**50%**	1459.5	**50%**	1459.5
N_4	2940	**25%**	735	**75%**	2205
N_5	3129	**0%**	0	**100%**	3129

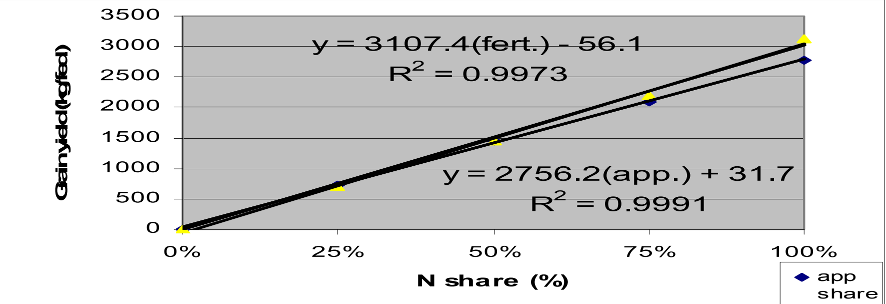

Fig 2: Wheat grain yield response to N application under surface drip irrigation

On the other hand, equations 3 and 4 could be produced by applying the same steps under sub-surface irrigation as shown in Table 6 and Fig 3. From equation 3, N fert. coefficient (2478.1) is greater than that of N soil app. coefficient (2064.3) obtained from equation 4. This means that N fertigation method is preferred to be used with sub-surface drip irrigation.

Y_{fert} = 2478.1 (N fert.) - 33.298 (R^2 = 0.9992), (3)

$Y_{Soil\ app}$ = 2064.3 (N soil app.) + 70.15 (R^2 = 0.9913), (4)

Table 6: The distribution of wheat grain yield under sub-surface drip irrigation method according to N application method share.

N Appli. methods	Grain yield (kgfed^{-1})	N fertigation ratio (%)	N fertigation share in grain yield (kg fed^{-1})	N soil application ratio (%)	N soil application share in grain yield (kg fed^{-1})
N_1	2467.5	100%	2467.50	0%	0
N_2	2425.0	75%	1818.75	25%	606.25
N_3	2365.5	50%	1182.75	50%	1182.75
N_4	2236.5	25%	559.125	75%	1677.38
N_5	2045.0	0%	0	100%	2045.00

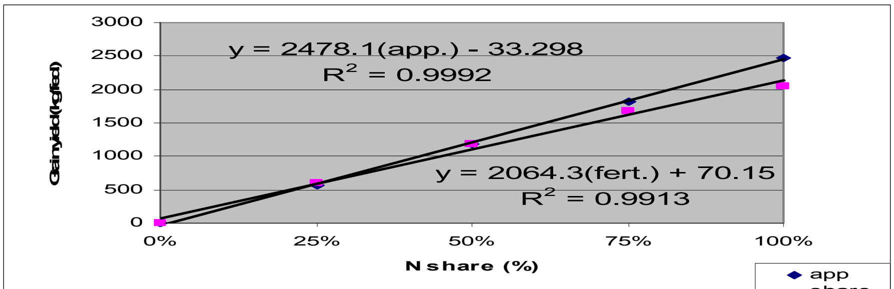

Fig 3: Wheat grain yield response to N application under sub-surface drip irrigation

From the above mentioned result, it could be concluded that nitrogen fertilizer is preferable to add as soil application fertilizer with surface drip irrigation, while N fertigation method has to be used with sub-surface drip irrigation.

2) Effect of irrigation system and nitrogen application methods on N uptake, N use efficiency and available nitrogen (mg kg^{-1}) remained in soil after wheat harvest.

Data presented in Table 7 show that the N uptake, N use efficiency and available nitrogen (mg kg^{-1}) remained in soil after wheat harvest was affected by both of irrigation systems and N application methods.

I) Irrigation system effect: The highest values of N uptake, and N use efficiency by grain (62.09 kg fed^{-1} and 45.55 kg/N unit, respectively) were recorded with surface irrigation system. While, the lowest values (29.06 kg fed^{-1} and 25.67 kg/N unit, respectively) were achieved under subsurface drip. The opposite trend was observed with available nitrogen remained in soil after wheat harvest where the highest value (63.61 mg kg^{-1}) was found under subsurface drip and the lowest value (39.45 mg kg^{-1}) was recorded with surface irrigation systems.

Table 7: Effect of irrigation system and nitrogen fertilization on N uptake (kg fed^{-1}), N use efficiency (kg/N unit) and available N in soil after wheat harvest:

Irrigation System	Nitrogen application Methods	Nitrogen uptake (kg fed^{-1})		Nitrogen use efficiency (kg / N unit)		Available nitrogen after wheat harvest (mg kg^{-1})
		Grain	Straw	Grain	Straw	
Surface irrigation	**N5**	62.09	14.03	45.55	42.84	39.45
Semi portable sprinkler	**N1**	42.75	14.78	35.59	38.35	70.18
	N2	42.13	13.25	34.28	34.30	61.17
	N3	35.70	9.78	29.43	29.31	55.35
	N4	34.02	8.92	28.11	28.95	51.18
	N5	31.21	8.61	27.33	28.43	43.92
Mean		37.16	11.07	30.98	31.87	56.36
Mini sprinkler	**N1**	67.13	18.22	46.84	40.50	73.15
	N2	62.96	17.12	44.00	37.88	64.43
	N3	61.99	13.50	43.54	35.25	58.17
	N4	55.87	11.02	41.38	27.38	55.75
	N5	40.85	9.58	29.66	22.65	45.18
Mean		57.76	13.89	41.08	32.73	59.34
Floppy sprinkler	**N1**	49.54	15.04	36.12	43.65	68.21
	N2	43.85	14.80	34.15	42.03	59.17
	N3	40.28	14.75	33.10	32.63	51.47
	N4	37.76	11.81	32.84	26.23	49.38
	N5	27.33	9.21	22.78	24.23	41.65
Mean		39.75	13.12	31.79	33.75	55.13
Surface drip	**N1**	49.54	11.78	35.98	29.48	75.25
	N2	43.85	11.17	33.63	28.43	67.18
	N3	40.28	10.40	33.30	27.90	59.35
	N4	37.76	9.33	31.60	24.23	57.11
	N5	27.02	8.67	31.51	22.66	46.43
Mean		39.69	10.27	33.22	26.54	61.06
Subsurface drip	**N1**	30.23	9.55	27.72	28.88	78.84
	N2	29.92	6.90	27.19	17.55	69.38
	N3	29.84	6.65	26.44	16.41	61.68
	N4	28.66	6.52	24.83	15.30	58.51
	N5	26.66	6.50	22.44	15.06	49.62
Mean		29.06	7.22	25.67	18.64	63.61

II) Nitrogen application methods effect: The highest values of grain N uptake and N use efficiency (67.13 kg fed^{-1} and 46.84 kg / N unit, respectively) were observed with N_1 treatment under Mini sprinkler irrigation system. While the lowest values of grain N uptake, and N use efficiency (26.66 kg fed^{-1} and 22.44 kg / N unit, respectively) were recorded with N_5 under subsurface drip irrigation system. The highest value (78.84 mg kg^{-1}) of available nitrogen remained in soil after wheat harvest was recorded under N_1 for subsurface drip irrigation system and the lowest value (39.45mg kg^{-1}) was achieved under N_5 for surface irrigation system.

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استجابة محصول القمح لطريقة إضافة الأسمدة النتروجينية تحت بعض نظم الري في منطقة شمال الدلتا

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حيث أنه توجد في مصر فجوة كبيرة بين إنتاج واستهلاك القمح وأن مصر أصبحت من الدول الفقيرة مائيا، فإنه يجب أن توجه مجهودات كبيرة للاستفادة من كل قطرة مياه ومن كل وحدة سماد متاحة. لذلك تهدف هذه الدراسة إلى تقييم تأثير بعض نظم الري (٦ معاملات) وكذا طرق إضافة الأسمدة الآزوتية (٥ طرق) على محصول القمح (صنف سخا ٩٣) وكذا محتواه من النيتروجين وكفاءة استخدام الاسمدة النتروجينة. أقيمت هذه التجربة خلال الموسم الزراعي ٢٠١١ / ٢٠١٢ بمزرعة محطة البحوث الزراعية بسخا- كفر الشيخ .

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

١- حقق نظام الري السطحي ومعاملة التسميد مع مياه الرى (N_1) أعلي محصول قمح بينما كانت أقل القيم تحت نظام الري بالتنقيط تحت السطحي والمعاملة N_4 (٢٥% تسميد مع مياه الري + ٧٥% تسميد أرضي).

٢- سجلت أعلي قيمة لوزن ١٠٠٠ حبة تحققت تحت نظام الري السطحي والمعاملة N_2 (٧٥% تسميد مع مياه الري + ٢٥% تسميد أرضي) بينما أعطى نظام الري بالتنقيط تحت السطحي والمعاملة N_4 (٢٥% تسميد مع مياه الري + ٧٥% تسميد أرضي) أقل قيمة.

٣- سجلت اعلى قيمة للنيتروجين الممتص وكفاءة استخدام السماد النيتروجينى تحت الرى السطحى والتسميد مع مياه الرى (N_1) بينما تم الحصول على اقل القيم عند الرى بالتنقيط تحت السطحى وكذلك تحت استخدام التسميد الارضى (N_5). وقد اخذت قيم النتروجين الميسر المتبقى فى التربة بعد حصاد القمح اتجاها معاكسا لقيم النيتروجين الممتص وكفاءة استخدامه. مما يعنى ان الرى السطحى والتسميد مع مياه الرى يزيد قدرة النبات على امتصاص النيتروجين الميسر من التربة وبالتالى زيادة المحصول.

٤- يمكن تقدير استجابة محصول حبوب القمح لطريقة إضافة السماد الآزوتي (تسميد أرضي أو تسميد مع مياه الري) تحت نظام الري بالتنقيط السطحي عن طريق استخدام المعادلتين ١ و ٢:

$Y_{Soil\ app}$ = 3107.4 (N soil app.) + 56.1 (R^2 = 0.9973), (1)

Y_{fert} = 2756.2 (N fert.) + 31.7 (R^2 = 0.9991), (2)

بينما تحت نظام الري بالتنقيط تحت السطحي يمكن استخدام المعادلتين ٣ و ٤ :

Y_{fert} = 2478.1 (N fert.) - 33.298 (R^2 = 0.9992), (3)

$Y_{Soil\ app}$ = 2064.3 (N soil app.) + 70.15 (R^2 = 0.9913), (4)

حـــــيث:

$\mathbf{Y_{Soil\ app}}$ = محصول القمح المقدر نتيجة مشاركة السماد النيتروجينى المضاف ارضيا.

Y_{fert} = محصول القمح المقدر نتيجة مشاركة السماد النيتروجينى المضاف مع مياه الري.

N soil app = نسبة السماد النيتروجينى المضاف ارضيا (%).

N fert. = نسبة السماد النيتروجينى المضاف مع مياه الري (%).

من المعادلات ١،٢، ٣ و ٤ يمكن استنتاج أنه: يفضل إضافة النتروجين بطريقة التسميد الأرضي (**soil application**) في حالة استخدام نظام الري بالتنقيط السطحي بينما يوصي بإضافة النتروجين بطريقة التسميد مع مياه الري (**fertigation**) في حالة استخدام طريقة الري بالتنقيط تحت السطحي.

قام بتحكيم البحث

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