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Improvement of wheat productivity in newly reclaimed soil in Egypt

ABSTRACT. Two field experiments were carried out in the experimental farm, in El-Khattara region, Sharkia Governorate, Egypt during 1997/98 and 1998/99 seasons. The first experiment studied the effect of three nitrogen fertilizer leavels and Cerealin (N-biofertizer) on growth and grain yield of three wheat cultivars (*Triticum aestivum* L.). The second experiment investigated the influence of three micronutrients (Fe, Zn, and Mn) as well as their combinations and Nutrichem (foliar fertilizer) on some yield attributes and grain yield of wheat (Sakha 8 cultivar). In the first experiment Gemmeiza 3 cultivar recorded the highest dry weight of plant, largest flag leaf area and produced the highest grain yield in comparison with Sakha 69 and Sakha 8 (the last cultivar had the lowest values of analized traits). Irrespectively of cultivars, N-fertilization significantly increased dry weight of plants, flag leaf area and yield of grain (up to dose of 238 kg N/ha). In all cultivars the N-biofertilizer (Cerealin) showed positive effect on plants dry mass weight, flag leaf area, and grain yield. In the second experiment addition of Fe + Zn + Mn as well as foliar application of Nutrichem increased significantly 1000 grain weight and grain yield.

KEY WORDS: wheat, N fertilization, micronutrients, grain yield.

In Egypt, raising wheat production through increasing the productivity of unit area together with expanding the cultivated area in newly reclaimed land is the most important national target. Increasing the productivity of unit area could be achieved by cultivating high yielding cultivars in parallel with improving agronomic practices. Especially an optimal supply of nitrogen is required to be

maintained throughout crop growth. Sharief et al. [1998] pointed out that raising nitrogen fertilizer level from 107 to 143 and 178 kg N/ha caused a significant increase in plant height, flag leaf area and grain yield. Sarhan et al. [1999] stated that N fertilization even up to 250 kg N/ha increased of grain yield. According to Fares [1997] microbial inoculation of creal crops by certain free living N_2 fixing bacteria minimizes the amount of chemical fertilizers applied and reduces soil pollution. Sharief et al. [1998] found that inoculation with Azotobacter and Azosprillum enhanced wheat flag leaf area and grain yield. Regarding the effect of micronutrients on growth and yield attributes of wheat, Mourad et al. [1992] reported a significant increase in dry matter accumulation, LAI as well as grain yield, due to spraying wheat plants with Zn, Mn and Fe. Sharief et al. [2000] found that foliar nutrition with mixture of Mn, Fe and Cu significantly increased the number of grains per spike, 1000 grain weight and grain yield per area unit.

METHODS

Two separate field experiments were carried out at the Experimental Farm Zagazig University El-Khattara region, Sharkia Governorate, Egypt during two successive winter seasons 1997/98–1998/99. The first experiment aimed to study the effect of three nitrogen fertilizer levels (119, 178 and 238 kg/ha) and Cerealin (N-biofertilizer) on the growth and yields of three wheat cultivars: Sakha 8, Gemmeiza 3 and Sakha 69. The split-split plot design with three replications was followed. Wheat cultivars occupied the main plots, whereas nitrogen fertilizer levels and biofertilization were allocated on the first and second order sub-plots, respectively. In both experiments basic fertilization with phosphorus and potassium was assured (P – 56.7 kg/ha, K – 94.7 kg/ha). The second experiment investigated the influence of three micronutrients (Fe, Zn and Mn) as well as their combination and Nutrichem on growth, yield attributes and yield of wheat cultivar Sakha 8. Randomized complete block design with three replications was used. The experimental field soil was sandy in texture.

In both experiments, wheat seeds were hand sown in a row 20 cm apart at the rate of 400 grains per m^2 on November 27^{th} and 22^{th} in the first and second seasons, respectively. Dry weight of plants was recorded on 45, 60 and 75 days after sowing. Flag leaf area was measured at heading time. At harvest, the following characteristics were determined: number of grains per spike, 1000 grain weight and grain yield (kg/ha). Statistical analysis of numerical values was performed.

RESULTS

From among the cultivars compared, Gemmeiza 3 accumulated more dry matter than Sakha 69 and Sakha 8 (Table 1). Variation in dry matter of plants between wheat cultivars was reported by Kishk et al. [1994] and Ibrahim et al. [1994]. As concerns nitrogen fertilization it is obvious that higher application resulted in increasing the weight of dry mass of plants at every date of measurement, the greatest difference being at the last date. A similar effect of N fertilization was reported by Sarhan et al. [1999].

Inoculation with Cerealin significantly increased the total dry weight of plants, too. Fares [1997] came to the same results. There was no correlation found between the level of nitrogen and Cerealin. Application of the micronutrients (Zn, Mn and Fe) as single or in combinations positively affected dry weight of plants but the differences did not reach the level of significance (Table 2). Similar results were reported by Abo Khadrah et al. [1983].

The tested cultivars differed in flag leaf area (Table 3): Gemmeiza 3 and Sakha 69 significantly surpassed Sakha 8. Increasing N-fertilization was accompanied by a significant increase of flag leaf area. A positive effect of nitrogen on this feature was recorded by Sharief et al. [1998] and Saleh [2000]. A marked increase of flag leaf' area resulted from inoculation with biofertilizer Cerealin, too (increase by 11.7%). Sharief et al. [1998, 2000] in their experiments observed similar effects of Cerealin.

Micronutrients play an important role in processes of cell division, affecting the leaf area. Amberger [1990] found out that spraying wheat plants with Fe at low concentration in semiarid regions of Egypt leads to the increase of leaf area (high concentration reduced it). In our experiment the positive effect of Zn, Mn and Fe was greater when they were applied in combination of two or three. Nevertheless, the increase of the leaf area was not statistically significant (Table 4). The effect of Nutrichem was comparable to Zn, Mn and Fe applied in conjunction. Micronutrients and Nutrichem had a similar effect on the number of grains in a spike (Table 5). In this case the effect of Nutrichem was greater than that of three microelements applied together. In the experiment by Salem and El-Beshbeshy [1995] on reclaimed sandy soil microelements caused an essential increase of grain numbers.

Particular micronutrients had only a slight effect on a development of the grain (weight of 1000 grain). The effect increased when they were applied in combination of two or three. In the last object as well as in the object with Nutrichem the weight of 1000 grains was significantly higher as compared with control (Table 6). The favourable effect of different nutrients on 1000-grain wheat weight was documented by Sarhan and Hammad [1995].

Table 1. Total dry weight (g per plant) of wheat as affected by cultivars, nitrogen levels and Cerealin (N-biofertilizer)

Treatment	1997/1998			1998/1999			Mean		
	Days after sowing								
	45	60	75	45	60	75	45	60	75
Wheat cultivars (C)									
Sakha-8	0.13c	0.71c	1.36c	0.51c	0.71c	1.37c	0.32c	0.71c	1.37c
Gemmeiza-3	0.20a	0.83a	1.75a	1.02a	1.89a	2.68a	0.61a	1.36a	2.22a
Sakha-69	0.17b	0.742b	1.46b	0.87b	1.07b	1.77b	0.52b	0.91b	1.62b
F-test	**	**	**	**	**	**	**	**	**
Nitrogen fertilizer kg N/ha (N)									
119	0.14c	0.62c	1.38c	0.45c	0.78c	1.46c	0.30c	0.70c	1.42c
178	0.17b	0.82b	1.50b	0.78b	1.10b	1.98b	0.47b	0.96b	1.74b
238	0.20a	0.83a	1.69a	1.172a	1.79a	2.39a	0.69a	1.31a	2.04a
F-test	**	**	**	**	**	**	**	**	**
Cerealin (N-biofertilizer (B)									
Uninoculated	0.13b	0.66b	1.45	0.68b	1.13b	1.72b	0.41b	0.90b	1.58b
Inoculated	0.21a	0.86a	1.60	0.92a	1.31a	2.17a	0.56a	1.08a	1.88a
F-test	**	*	ns	**	**	**	**	**	**
Interaction									
C x N	**	**	**	**	**	**	**	**	**
C x B	ns	ns	ns	ns	**	**	*	ns	**
N x B	ns	ns	ns	*	**	**	ns	ns	*

Table 2. Effect of Fe, Zn and Mn micronutrients and their combinations as well as Nutrichem on dry weight of wheat plants

Treatment	1997/1998			1998/1999			Mean		
	Days after sowing								
	80	95	110	80	95	110	80	95	110
	g								
Control	1.3	2.2	3.1	2.6	3.0	3.1	1.9	2.6	3.1
Fe	1.4	2.3	3.3	2.7	3.1	3.3	2.1	2.7	3.3
Zn	1.5	2.6	3.5	2.7	3.3	3.5	2.1	2.9	3.5
Mn	1.6	2.6	3.5	2.9	3.3	3.6	2.2	3.0	3.5
Fe + Zn	1.9	2.6	3.6	2.9	3.6	3.6	2.4	3.1	3.6
Fe + Mn	2.0	2.7	3.7	3.1	3.9	3.7	2.5	3.3	3.7
Zn + Mn	1.9	2.9	4.1	3.0	3.9	3.9	2.5	3.4	4.0
Fe + Zn + Mn	2.0	3.0	4.6	3.3	4.0	4.8	2.6	3.5	4.7
Nutrichem	2.0	3.3	4.5	3.1	4.0	3.9	2.5	3.7	4.2
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 3. Wheat flag leaf area at heading (75 DAS) as affected by cultivars, nitrogen levels and Cerealin

Treatment	1997/1998	1998/1999	Mean
	cm^2		
Wheat cultivar (C)			
Sakha – 8	19.32b	22.74	21.03b
Gemmeiza – 3	23.29a	24.17	23.73a
Sakha – 69	23.01a	23.72	23.36a
F-test	**	Ns	**
Nitrogen kgN/ha (N)			
119	19.12c	22.53	20.83c
178	21.34b	23.32	22.33b
238	25.15a	24.78	24.96a
F-test	**	Ns	**
Cerealin (N-biofertilizer) (B)			
Uninoculated	19.59b	22.91	21.25b
Inoculated	24.15a	24.18	24.16a
F-test	**	ns	**
Interaction			
C x N	ns	ns	ns
C x B	ns	ns	ns
N x B	ns	ns	ns

Table 4. Effect of Fe, Zn and Mn micronutrients and their combinations as well as Nutrichem on wheat flag leaf area at heading

Treatment	1997/1998	1998/1999	Mean
	cm^2		
Control	21.48	21.72	21.60
Fe	21.93	22.06	21.99
Zn	21.99	22.30	22.14
Mn	22.91	22.73	22.82
Fe + Zn	23.48	23.88	23.68
Fe + Mn	23.22	23.16	23.19
Zn + Mn	24.50	24.63	24.56
Fe + Zn + Mn	25.51	25.02	25.26
Nutrichem	25.32	24.89	25.10
F-test	ns	ns	ns

Table 5. Effect of Fe, Zn and Mn micronutrients and their combinations as well as Nutrichem of number of grains per spike

Treatment	1997/1998	1998/1999	Mean
	Grains/spike		
Control	39.0	38.4	38.7
Fe	40.0	39.2	39.6
Zn	41.0	40.6	40.8
Mn	41.0	40.2	40.6
Fe + Zn	41.7	41.2	41.4
Fe + Mn	41.5	41.4	41.4
Zn + Mn	41.4	40.8	41.1
Fe + Zn + Mn	43.6	44.1	43.8
Nutrichem	42.1	42.8	42.5
F-test	Ns	ns	ns

The yield of grain in both experiments dependend upon experimental factors (table 7). In the first experiment, on average, Gemmeiza 3 surpassed two other cultivars (the smallest yield was given by Sakha 8). Increasing nitrogen fertilization caused significant increment in the grain yield of every cultivar tested. This probably resulted from the promoting effect of nitrogen on metabolic processes in plant and increased dry matter accumulation (visible earlier in the form of

larger flag leaf area). The positive response of grain yield to N-ferlilization in newly reclaimed sandy soil was reported by Saleh [2000].

Table 6. Effect of Fe, Zn and Mn micronutrients and their combinations as well as Nutrichem on 1000-grain weight

Treatment	1997/1998	1998/1999	Mean
	g		
Control	30.8c	30.2	30.5c
Fe	31.1c	32.5	31.8c
Zn	31.3c	34.8	33.0c
Mn	31.3c	34.6	33.0c
Fe + Zn	32.3bc	77.5	34.9bc
Fe + Mn	32.3bc	37.2	34.8bc
Zn + Mn	33.2bc	36.3	34.8bc
Fe + Zn + Mn	38.9a	39.5	39.2a
Nutrichem	36.5ab	39.1	37.8ab
F-test	**	Ns	**

Table 7. Grain yield (kg/ha) of wheat as affected by cultivars, nitrogen fertilizer levels and Cerealin

Treatments	1997/1998	1998/1999	Mean
	kg/ha		
Wheat cultivars (C)			
Sakha	3262c	3523c	3392c
Gemmeiza-3	3832a	3985a	3909a
Sakha-69	3707b	3557b	3632b
F-test	**	**	**
Nitrogen fertilizer kg N/ha (N)			
119	3169c	3442c	3305c
178	3747b	3668b	3708b
238	3885a	3954a	3919a
F-test	**	**	**
Cerealin (N-biofertilizer) (B)			
Uninoculated	3344b	3515b	3429b
Inoculated	3857a	3862a	3859a
F-test	**	**	**
Interaction			
C x N	**	**	**
C X B	**	**	**
N x B	**	**	**

Table 8. Effect of Fe, Zn and Mn micronutrients and their combinations as well as Nutrichem on grain yield (kg/ha)

Treatment	1997/1998	1998/1999	Mean
Control	2652h	2940g	2796
Fe	2969g	3438f	3204h
Zn	3013f	4016e	3515
Mn	3096e	4018e	3557f
Fe + Zn	3132d	4095d	3614e
Fe + Mn	3585c	4120c	3852d
Zn + Mn	3727b	4120c	3923c
Fe + Zn + Mn	4493a	4482a	4488a
Nutrichem	3732b	4386b	4059b
F-test	**	Ns	**

The effect of inoculation with Cerealin depended upon cultivar and level of N fertilization, on average resulting in a significant increase of grain yield (by 428 kg/ha). These results are similar to those obtained by Fares [1997] and Sharief et al. [1998 and 2000]. As concerns micronutrients, in both seasons they had a significant effect on the yield of grain. The highest yields were obtained when three microelements (Fe, Zn and Mn) were applied together and in the object where Nutrichem was used. A positive response of wheat to micronutrients on newly reclaimed sandy soil was observed by Mourad et al. [1992] and Sarhan and Hammad [1995]. The significant effect of micronutrients in these conditions could be explained by severe microelements deficiency in the soils.

CONCLUSIONS

1. Increasing N-fertilization (119, 178, 238 kg N/ha) on reclaimed sandy soil positively affected the dry mass of plants and flag leaf area during vegetation as well as the number and development of grain in spike, resulting in a significant increase of grain yield of all three wheat cultivars tested.

2. Irrespectively of wheat cultivar and the level of N-fertilizations, N-biofertilizer (Cerealin) had a possitive effect on plants traits measured and – in consequence – on the yields of grain.

3. Micronutrients (Fe, Zn, and Mn and compound fertilizer – Nutrichem) did not markedly infuence the leaf area and the number of grain in spike, significantly affecting, however, the weight of 1000 grain and the yield of grain.

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