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EFFECT OF INOCULATING N-FIXING BACTERIA (A CEREALINE) ON WHEAT (*TRITICUM AESTIVUM*) GROWTH AND NUTRIENT CONTENTS

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ABSTRACT : **A pot experiment was carried out under greenhouse conditions at the Faculty of Agriculture, Zagazig University, during winter season of 2002-2003 in order to study the effect of inoculation with the biofertilizer (Cerealine) containing N-fixing bacteria and chemical N-fertilizers of ammonium sulphate (AS) and ammonium nitrate (AN) on growth, yield and chemical composition of wheat (*Triticum aestivum*), variety Sakha 69. There were two experiment, one on the sand soil from El-Khatara and the other on the clay soil from Al-Ibrahimiya (Sharkia Governorate). Each experiment was factorial in a randomized complete block design which involved 3 factors i.e. inoculation (I), N-source (S) and N-level (L). Inoculation was in 3 i.e. none; inoculation at a low rate, and inoculation at a high rate (7 g Cerealine/kg seeds, and 14 g/kg seeds). Levels of N application were 0, 75, 105 and 135 mg N /kg soil).**

The clay soil received 10 irrigations while the sand soil received 15 irrigations. The leachates were collected three times after nitrogen additions and before harvest and subjected to NO^-_2, NO^-_3 analysis.

The present study revealed that dry weight of plant after 55 days from seeding increased slightly, by seed inoculation in the clay soil, but significantly in the sand soil.

The straw yield was positively significantly affected by inoculation alone or with chemical fertilizers and the interactions between inoculation, N-source and levels (I x S x L) were reached to the level of highly significant on the sand soil. The effect of interactions between cerealine, N-source and rates (I x S x L) was highly

significant as regards to N-uptake by plants in the clay and sand soils and the greatest value of N-uptake was obtained from the clay soil. The interaction between cerealine and N-source and level occurred on P-uptake. The effect of AS was more pronounced and much greater than AN in the clay soil. Values of (NO_2 + NO_3)-N in leachates increased by increasing N-rate in all leachates (1, 2 and 3) and N-source and inoculation. Values were greater with AN than those with AS at biofertilizer comparing the values of leached nitrate and nitrite nitrogen than the lower level of inoculation.

Key words : Wheat, biofertilizers, cerealine, yield, chemical fertilizers, loss of nitrogen (NO_2^- + NO_3^-).

INTRODUCTION

"Biofertilizers" are preparations containing live or latent cells of efficient strains of microorganisms used for application to seeds, soil composts used to increase availability of plant nutrients. They include organic resources (manures) for plant growth, Subba Rao (1982). Sharief *et al.*, (1998) found that inoculation of wheat grains with Azospirillum and Azotobacter in a form of biofertilizer called (Cerealine) increased spike weight, number of grains / spike, 1000-grain weight, grain and straw yield. Abd El-Rasoul *et al.*, (2003) investigated sources of fertilizers and inoculation with the biofertilizer Cerealine and found a significant effect on yield of wheat and its components. Amara and Dahdoh (1997) stated that inoculation with Cerealine (a mixture of Azotobacter plus Azospirillum) increased the uptake of N, P and K in straw of wheat. Ibrahim (1998) showed that inoculated wheat seeds with Cerealine significantly increased phosphorus and potassium content in grains.

El-Maddah *et al.*, (2005) indicated that nitrogen content and uptake were significantly increased in wheat plants inoculated with Azotobacter chroococcum combined with mineral nitrogen fertilizer. Harris and Rose (1992) estimated losses of mineral N at 100 to 150 kg N/ha, constituting 15 to 29% of the applied N-fertilizers. Meshref *et al.*, (2000) reported that significant decreases in leached NO_3^- and NH_4^+ in drainage water were recorded due to biofertilizers and organic manure application. Their results illustrate the beneficial effect of bio and organic fertilization on reducing the adverse impacts of inorganic nitrogen in agro-ecosystem.

Aims of study : 1) the effects of seed inoculation using Cerealine (free living N_2-fixing bacteria); 2) how to minimize the levels of N to obtain maximum yield under different concentrations of microbial inoculation; 3) the interaction effects between different microbial inoculation, chemical fertilizer source and levels, and 4) the loss of some macro and micro-nutrients from the soil which is affected by bio- and chemical fertilization and soil characteristics.

MATERIALS AND METHODS

A pot experiment was carried out under greenhouse conditions at the Faculty of Agriculture, Zagazig University, during winter season of 2002 – 2003 in order to study the effect of a biofertilizer (trade name of Cerealine) and chemical nitrogen fertilizers (ammonium sulphate and ammonium nitrate) on growth, yield and chemical composition of wheat (*Triticum aestivum*) c.v. Sakha 69 grown in two different soils, i.e., sandy from El-Khatara farm and the clay from Al-Ibrahimiya area.

Plastic pots were filled with 8 kg fine earth. The pots were 15 cm diameter and 20 cm depth.

Biofertilizer

Cerealine is a biofertilizer supplied by the General Organization of Equalization Fund (GOEF), Ministry of Agriculture, Egypt. It contains efficient strains for nitrogen fixation, mainly Azospirillum and Azotobacter.

Chemical Fertilizers

Two sources of nitrogen fertilizers were used, i.e., ammonium nitrate (AN) (33.5% N) and ammonium sulphate (AS) (21%N) at 4 levels. N was applied in two equal doses, the first before the first irrigation. The second before the second irrigation. Potassium was applied at 20 mg K /kg soil as potassium sulphate (40% K), before the first irrigation.

Experimental Design

The experiment was executed in a randomized complete block design, factorial, involving 3 factors as follows :

Factor A : Inoculation; 3 treatments, inoculated at 7 g/kg seeds and 14 g/kg seeds and non-inoculated.

Factor B : N-source; 2 sources of N, ammonium sulphate (AS) and ammonium nitrate (AN).

Factor C : N-rate (level); 4 levels, 0, 75, 105, and 135 mg N/kg soil. These rates are equivalent to 50, 70 and 90% the recommended rate.

The experiment was done on the sand soil as well as on the clay soil.

Preparation of Wheat Grain with cerealine Inoculant

Rats of Cerealine application were 0, 7 g/kg, and 14 g/kg seeds (recommended dose is 7 g/kg, as stated by the Cerealine manufactures i.e. one bag "500 g" per amount of seeds per faddan (70 kg). Each pot was seeded with 25 seeds. Inoculation was done by wetting the seeds with Arabic gum 5% in water. The wet seeds were well mixed with the Cerealine biofertilizer then air dried for 30 minutes in shade.

Sowing

Wheat (*Triticum aestivum*) variety Sakha 69, at the rate of 25 seeds/pot, were sown and irrigated immediately. The sowing date was 24-11-2002 and the harvesting date was 17-5-2003. Plant were thinned so as to leave 20 seeding/pot.

Soil analysis

Soil material for the expect was taken from 0 – 30 cm depth, air dried and ground to pass through a 2 mm sieve. Soluble cations and anions, pH, organic matter, calcium carbonate, electrical conductivity and available N, P and K were determined as follows:

The international pipette method was used to determine the particale size distribution as described by Piper (1950); the chemical analysis of soil samples were carried out according to Jackson (1967); pH by pH-meter, EC in saturated extract, organic matter, by Walkey and Black were determined according to Hesse (1971). Calcium carbonate by calcimeter Piper (1950); available nitrogen in the soil was extracted using 2.0 M KCl according to Hesse (1971) and determined by macro-kjeldahl apparatus. Available phosphorus in the soil was extracted by 0.5 M $NaHCO_3$ (pH 8.5) and determined by spectrophotometer (Jackson, 1967). Available potassium was extracted using 1.0 N ammonium acetate (pH 7) and determined by flamephotometer (Hesse, 1971).

Data of physical and chemical soil properties are in Table 1.

Plant Growth Studies

Dry matter

Dry matter of wheat plants was recorded after 55 days from sowing and at harvest. In both stages, 5 plants were taken at random from each pot and air dried at 70 °C till constant weight, and expressed as g/plant.

Yield and Yield Components

Grain, straw yields and weight of 1000 grains were determined.

Plant analysis

Plant analysis was determined using the oven dry plant samples. The plant samples were well ground and were digested with conc. Sulphuric, perchloric acid mixture for P and K analysis. Nitrogen was determined by the Kjeldahl method (Chapman and Pratt 1961, and Peterburgski, 1968).

Leachate analysis

The clay soil received 10 irrigations while the sand soil received 15 irrigations. The irrigation was adopted at 75% of the maximum water holding capacity to assure receiving the leachate quantity. The leachates were collected three times after nitrogen additions and before harvest and subjected for NO_2^-, NO_3^-, determination.

Statistical analysis

The statistical analysis of the obtained data was carried out according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

Plant Dry Weight, Straw, Grain Weight and 1000 Grains Weight of Wheat Plant

Plant dry weight-55 days, straw, grains weight and 1000 grains weight as affected by different levels of Cerealine, N-fertilizers and their interactions for clay soil are presented in Table 2, for sand soil Table 3.

Table 1. Some physical and chemical properties of the studied soils

Soil type	Clay	Sand
Physical properties :-		
Particle size distribution		
Sand %	26.1	71.3
Silt%	33.2	13.5
Clay%	40.7	15.2
Textural Class	clay	sand
Chemical properties :-		
$CaCO_3$ %	2.15	3.12
Organic matter %	1.4	0.02
pH	8.15	7.75
EC (dSm^{-1})	1.96	0.66
Soluble ions (mmol/L) :-		
Ca^{++}	1.46	1.50
Mg^{++}	1.30	0.5
Na^{++}	18.00	2.98
K^{++}	0.26	0.33
CO_3^{--}	0.00	0.00
HCO_3^{-}	2.60	2.60
Cl^{-}	15.42	2.30
SO_4^{--}	3.00	0.41
Available nutrients :-		
Macronutrients		
P (mg/kg)	8.6	4.9
K (mg/kg)	989.0	176.40
Micronutrients (mg/kg)		
Fe	5.53	0.85
Mn	3.46	0.11
Zn	0.98	0.35

P. Ulsen extract; K (NH_4 acetate; Fe, Mn and Zn (DTPA)

Dry weight of plant

Tables 2 and 3 show that dry weight at the 55-day plant was increased, but non-significantly, by seed inoculation in the clay soil. However, this effect was highly significant in the sand soil. There was an interaction with source of N and level of N. Dry matter under ammonium sulphate was greater than with ammonium nitrate.

These results may be attributed to N-fixation by free living N_2-fixing bacteria which are reported to produce growth, promoting substances Rabie *et al.*, 1995 and Amara and Dahdoh, 1997.

Kaloosh and Koreish (1995) concluded that biofertilizers increase wheat growth due to increased available N.

Straw yield

Tables 2 and 3 present the effect of biofertilizer and chemical fertilizers on straw yield of wheat plants. Greater highly significant yields were obtained with ammonium sulphate (AS) than ammonium nitrate (AN) in the clay soil than the sand soil. Generally, the straw yield was significantly affected by inoculation either alone or in combination with N fertilizers under all nitrogen levels. These results are in harmony with those obtained by Vallejo *et al.*, (1993) Ahmed (1995), El-Aita and Abou Seeda (1996) and El-Aila (1998).

Grain yield

Tables 2 and 3 reveal that grain yield increased by inoculation. This increase occurred in both soils.

Regarding the effect of N-source, AS was superior to AN and this is attributed to the ability of the soil to retain ammonium ions more than NO_3 which is usually leached from the soil.

From the data of grain yield, it seems that inoculation at the high rate combined with the 75 mg N/kg gave maximum obtained grain yield, weight of 1000 grains. Thus, this treatment is considered the most efficient treatment to produce maximum grains yield because it : 1) saves about 40% of mineral N-fertilizer used; 2) gives the greatest grain yield of each wheat plant and 3) minimizes the environmental pollution through reduction of chemical fertilizers.

There was an positive interaction between biofertilizer inoculation and N-source and level which was significant in case of

Table 2. Plant dry weight, 55 days after seeding, straw and grain yield and 1000-grain weight at harvest as affected by different inoculation with Cerealine and N-fertilizers in the clay soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization		Plant* dry weight (g/plant)	Straw yield (g/plant)	Grain yield (g/plant)	1000-grain weight (g)
	Source	Levels (mg N/kg soil)				
0	AS	0	0.61	1.73	1.00	36.48
		75	0.78	1.77	1.21	42.13
		105	0.59	1.97	1.15	41.66
		135	0.48	1.73	1.38	33.38
	AN	0	0.61	1.73	1.00	36.48
		75	0.81	1.57	1.07	41.19
		105	0.92	1.83	1.20	42.53
		135	0.65	1.60	1.27	40.07
0.5	AS	0	0.77	1.90	1.07	41.50
		75	0.57	1.77	1.30	42.80
		105	0.58	1.23	1.25	41.34
		135	0.40	1.0	1.20	42.25
	AN	0	0.77	1.90	1.07	41.50
		75	0.34	1.07	1.23	45.12
		105	0.49	1.12	1.50	39.76
		135	1.17	1.70	1.18	38.23
1	AS	0	0.76	2.17	2.07	41.36
		75	0.78	3.20	2.00	38.91
		105	0.93	2.57	1.31	39.93
		135	0.86	2.30	1.10	35.39
	AN	0	0.76	2.17	2.07	41.36
		75	0.42	2.57	1.74	40.91
		105	0.31	1.37	1.20	38.62
		135	0.69	1.43	0.93	40.41
LSD						
(I) : inoculation			N.S	0.072**	N.S	1.957**
(S) : N-source			N.S	0.042**	N.S	N.S
(L) : N-level			0.052**	0.078**	N.S	1.566**
I × S			0.083**	0.073**	N.S	N.S
I × L			0.089**	0.135**	0.34**	2.714**
S × L			0.073**	0.110**	N.S	N.S
I × S × L			0.127**	0.191**	N.S	3.84*

* after 55 days from sowing

Table 3. Plant dry weight, 55 days after seeding, straw and grain yield and 1000-grain weight at harvest as affected by different inoculation with Cerealine and N-fertilizers in a sand soil

Inoculation of Cerealine rate (mg/kg seed)	Nitrogen fertilization Source	Nitrogen fertilization Levels (mg N/kg soil)	Plant* dry weight (g/plant)	Straw yield (g/plant)	Grain yield (g/plant)	1000-grain yield (g)
0	AS	0	0.15	0.43	0.10	21.32
		75	0.20	0.53	0.03	34.14
		105	0.19	0.60	0.04	40.66
		135	0.14	0.57	0.07	41.09
	AN	0	0.15	0.43	0.01	21.32
		75	0.28	0.50	0.06	39.02
		105	0.19	0.60	0.09	36.83
		135	0.18	0.37	0.05	42.33
0.5	AS	0	0.19	0.47	0.15	38.78
		75	0.14	0.63	0.07	44.39
		105	0.10	0.40	0.02	41.49
		135	0.11	0.40	0.04	40.22
	AN	0	0.19	0.47	0.14	38.79
		75	0.11	0.53	008	43.55
		105	0.09	0.50	0.20	39.62
		135	0.27	0.53	0.12	29.98
1	AS	0	0.20	0.60	0.11	29.19
		75	0.23	0.57	0.18	48.45
		105	0.19	0.50	0.10	32.56
		135	0.22	0.63	0.10	32.33
	AN	0	0.20	0.60	0.10	29.19
		75	0.23	0.53	0.10	28.57
		105	0.17	0.47	0.11	41.11
		135	0.22	0.50	0.12	33.36
LSD						
(I) : inoculation			0.014**	N.S	0.025**	1.079**
(S) : N-source			0.015*	0.025*	0.013**	1.022**
(L) : N-level			0.026**	N.S	N.S	1.345**
I × S			N.S	0.044*	0.022**	1.770*
I × L			0.046**	0.078**	0.038**	1.423**
S × L			0.037*	N.S	0.029**	1.977**
I × S × L			0.064**	0.110**	0.053**	3.427**

* after 55 days from sowing

sandy soil in particular. Such soil enhances the biofertilizer activity due to the soil conditions.

1000-grains weight

Tables 2 and 3 show the effect of different levels of Cerealine and N-fertilizers (source and levels) on 1000 grain weight in clay and a sand soil. They indicate high-significance regarding inoculation, N-source and levels and their interactions. These results were recorded by El-Moursy (1998) and Abo Grab and Darwich (1998).

Nutrients Concentrations and Uptake by Wheat Plant :

Nitrogen concentration and uptake :

N-concentrations and uptake by whole plant (55-days) and by straw and grains as affected by inoculation and N-fertilizers and rates are shown in Table 4 (clay soil) and Table 5 (sand soil). It is obvious that N-concentrations in wheat grains and straw were affected significantly by inoculation. Also, there were positive interactions between inoculation and N-source and rates. No much difference was detected in respect to the effect of N-source on N-concentration and uptake.

These results agree with those of Zambra *et al.*, (1984) and Ishac *et al.*, (1986). Therefore, it could be concluded that inoculation with Cerealine could minimize the rate of mineral-N to produce appropriate wheat yield.

In spite of the greater values of N-concentrations and uptake obtained from the clay soil, still the values of sand soil are highly significant.

Data of N-concentration and uptake as affected by inoculation are in agreement with those obtained by El-Hawary *et al.*, (1998) and Kotb (1998).

The present investigation shows that supply of N to wheat plant at late stage of growth combined with biofertilizer inoculation could be used with moderate rate of chemical N-fertilizer. This may result positively vigorous growth and yield of wheat. Such results are in agreement with those obtained by El-Mancy *et al.*, (1998).

It is interesting to note that N-concentrations and uptake by grains was greater than those in straw. At maturity stage, translocation of N is pronounced from the roots and shoots to grains.

Table 4. N-concentration and uptake in the whole plant 55 days after seeding, straw and grain yield at harvest as affected by different inoculation with Cerealine and N-fertilizers in the clay soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization Source	Levels (mg N/kg soil)	N %* in plant)	N % in straw	N % in grain	N* uptake plant (mg/plant)	N uptake straw (mg/plant)	N uptake grain (mg/plant)
0	AS	0	1.52	0.37	4.65	09.1	6.4	46.6
		75	2.25	0.38	5.3	17.3	6.8	64.2
		105	2.81	0.39	4.70	16.7	7.7	54.0
		135	2.27	0.38	4.57	11.00	6.6	62.8
	AN	0	1.52	0.37	4.65	09.1	6.4	46.6
		75	3.46	0.30	4.63	28.1	4.7	49.0
		105	1.74	0.19	4.25	15.9	3.5	51.5
		135	3.26	0.37	3.89	21.2	5.9	49.2
0.5	AS	0	2.45	0.18	5.39	18.8	3.4	58.1
		75	1.85	0.14	4.05	10.6	2.5	52.7
		105	2.4	0.55	4.93	13.8	6.8	61.8
		135	3.45	0.4	5.36	14.1	3.9	64.8
	AN	0	2.45	0.18	5.39	18.8	3.4	58.1
		75	2.52	0.6	5.86	08.7	6.4	72.5
		105	1.85	0.33	5.47	09.0	3.8	81.4
		135	3.3	0.43	5.74	38.7	7.3	67.6
1	AS	0	3.01	0.79	4.38	22.9	17.1	90.8
		75	4.08	0.73	4.07	3.17	23.3	81.0
		105	3.32	0.59	2.85	3.07	15.2	37.4
		135	2.20	0.56	2.9	1.89	12.9	31.9
	AN	0	3.18	0.79	4.38	2.42	17.1	90.8
		75	3.40	0.23	4.21	1.45	5.9	73.2
		105	1.98	0.49	4.32	0.62	6.7	51.9
		135	1.92	0.49	6.31	2.05	7.1	55.3
LSD								
(I) : inoculation			0.0307**	0.085**	0.329**	0.257**	1.04**	N.S
(S) : N-source			N.S	N.S	0.308**	N.S	1.08**	N.S
(L) : N-level			0.221**	N.S	N.S	0.195**	N.S	N.S
I × S			0.089**	0.103*	0.533**	0.336**	1.87**	10.66*
I × L			0.382**	0.138**	N.S	0.338**	2.67**	18.17**
S × L			0.310**	N.S	N.S	0.76**	2.17**	N.S
I × S × L			0.539**	0.195**	0.990**	0.478**	3.56*	N.S

* after 55 days from sowing

Table 5. N-concentration and uptake in the whole plant 55 days after seeding, straw and grain yield at harvest as affected by different inoculation with Cerealine and N-fertilizers in the sand soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization Source	Levels (mg N/kg soil)	N%* in plant	N% in straw	N% in grain	N* uptake plant (mg/plant)	N uptake straw (mg/plant)	N uptake grain (mg/plant)
0	AS	0	1.46	0.39	0.1	02.2	1.7	1.00
		75	1.23	0.56	4.73	02.5	3.00	1.6
		105	1.79	0.4	5.06	03.3	2.4	2.3
		135	1.53	0.22	4.76	02.2	1.2	3.2
	AN	0	1.46	0.39	0.1	02.2	1.7	1.0
		75	1.55	0.66	6.43	04.5	3.3	3.9
		105	1.42	0.67	4.88	02.7	4.1	4.6
		135	1.42	0.36	4.37	02.5	1.3	2.2
0.5	AS	0	1.32	0.19	7.86	02.6	0.9	11.9
		75	1.14	0.52	8.72	01.6	3.3	6.4
		105	1.47	0.76	6.58	01.4	3.0	1.3
		135	1.37	1.28	6.12	01.5	5.1	2.5
	AN	0	1.32	0.19	7.86	02.6	0.9	11.4
		75	1.62	1.00	5.76	01.7	5.4	4.8
		105	1.62	0.28	5.82	01.5	1.4	11.6
		135	1.51	0.06	4.99	04.1	0.3	6.2
1	AS	0	1.68	0.12	4.47	03.4	0.7	5.1
		75	1.35	0.78	4.66	03.1	4.9	8.4
		105	1.73	0.07	4.81	03.2	0.4	4.8
		135	1.72	0.07	6.21	03.8	0.5	6.2
	AN	0	1.68	0.12	4.47	03.4	0.7	4.5
		75	1.33	0.06	5.77	03.1	0.3	0.58
		105	2.40	0.06	4.95	04.1	0.3	5.3
		135	2.49	0.09	5.68	05.4	0.5	6.8
LSD								
(I) : inoculation			0.225*	0.072**	0.294**	00.38**	0.53**	1.63**
(S) : N-source			0.131*	0.028**	0.239*	00.48*	0.32**	0.86**
(L) : N-level			0.109**	0.046**	0.393**	N.S	0.41**	N.S
I × S			0.227*	0.049**	0.419**	N.S	0.55*	1.49**
I × L			0.189**	0.078**	0.680**	00.90**	0.72**	2.84**
S × L			N.S	0.066**	N.S	00.75*	0.57**	2.35**
I × S × L			0.267**	0.113**	0.961**	0.127	1.00**	N.S

* after 55 days from sowing

Phosphorus concentration and uptake

Phosphorus concentrations and uptake by whole plant (55-days), and by straw and grains as affected by inoculation and N-fertilizer are shown in Table 6 for the clay soil, and Table 7 for a sand soil. P-concentration in wheat grains and straw were affected significantly by inoculation. No much difference was detected in respect to the effect of N-source on N-concentration and uptake in clay soil and in straw in sand soil.

Although there was greater values of P-concentration and uptake, obtained in the clay soil, the values of a sand soil were significant, and was pronounced in case of P-uptake by straw.

There was an significant effect of interaction between inoculation or N-source and levels on P-concentrations and uptake. The effect of AS was more pronounced and the values is much greater than AN. This difference may be due to a possible residual acidity produced due to AS application.

In general, application of 75 mg N/kg along with the high rate of inoculation gave more response than 105 mg N/kg along with the low rate of inoculation. However, Tables 6 and 7 present the effect of different levels of inoculation and fertilizers on P-concentration and uptake by whole plant in the clay and a sand soils. It indicates that the treatment of 105 mg N/kg. along with the high rate of inoculation gave the maximum effect.

The present findings are in agreement with those of El-Mancy *et al.,* (1998).

The data revealed that P-concentration and uptake in grains and straw increased significantly with inoculation and N-fertilizers (source and levels). P-concentrations and uptake by straw was greater than by grains unlike N-concentrations and uptake. This result indicates that high growth of wheat plants due to sufficient nitrogen level is able to uptake more phosphorus in shoots. Such results suggest that nitrogen level is very important to be taken into consideration to enhance plant production in favour of P translocation in grains more than straw.

Potassium concentration and uptake

Potassium concentrations and uptake by whole plant (55-days), and by straw and grains as affected

Table 6. P-concentration and uptake in the whole plant 55 days after seeding, straw and grain yield at harvest as affected by different inoculation with Cerealine and N-fertilizers in the clay soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization Source	Levels (mg N/kg soil)	P* (μ g/g) in plant	P (μ g/g) in straw	P (μ g/g) in grain	P* uptake plant (mg/plant)	P uptake straw (mg/plant)	P uptake grain (mg/plant)
0	AS	0	3290	3120	1280	2.008	5.408	1.28
		75	5560	3610	1340	4.341	6.42	1.63
		105	5560	3120	1220	3.303	6.12	1.40
		135	3390	2900	1390	1.639	5.027	1.91
	AN	0	3290	3120	1280	2.008	5.408	1.28
		75	6190	2650	1340	5.002	4.170	1.43
		105	2780	1830	1380	2.548	3.35	1.66
		135	6010	1830	1240	3.257	2.92	1.57
0.5	AS	0	5910	1980	1720	4.551	3.76	1.84
		75	3190	2020	1460	1.829	3.57	1.87
		105	7240	2400	1330	4.175	2.96	1.68
		135	7220	2590	1400	2.864	2.54	1.67
	AN	0	5910	1980	1720	4.551	2.76	1.84
		75	330	2330	1320	1.142	2.48	1.63
		105	2250	1980	1370	1.097	2.21	2.07
		135	4070	2080	1360	4.779	3.54	1.61
1	AS	0	2660	1850	1140	2.014	4.05	2.36
		75	3890	2160	1310	3.021	6.94	2.63
		105	5070	2090	1300	4.72	5.38	1.72
		135	2950	1260	1250	2.533	2.90	1.38
	AN	0	2660	1850	1140	2.014	4.05	2.36
		75	5450	1610	1330	2.273	4.16	2.33
		105	3890	1160	1260	1.224	1.58	1.55
		135	5030	1580	1380	3.544	2.27	1.23
LSD								
(I) : inoculation			40**	10**	80**	N.S	0.314**	N.S
(S) : N-source			10**	10**	N.S	0.295*	0.263**	N.S
(L) : N-level			20**	10**	N.S	N.S	0.332**	0.263*
I × S			20**	20**	N.S	0.511**	0.456**	N.S
I × L			50**	20**	10**	0.614**	0.574**	0.456**
S × L			40**	10**	N.S	0.501**	0.470**	N.S
I × S × L			70**	30**	N.S	0.869*	0.812**	N.S

* after 55 days from sowing

Table 7. P-concentration and uptake in the whole plant 55 days after seeding, straw and grain yield at harvest as affected by different inoculation with Cerealine and N-fertilizers in a sand soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization Source	Levels (kg N/fad soil)	P* (µ g/g) in plant	P (µ g/g) in straw	P (µ g/g) in grain	P* uptake plant (mg/paant)	P uptake straw (mg/plant)	P uptake grain (mg/plant)
0	AS	0	4860	883	460	0.745	0.37	0.046
		75	5680	1190	837	1.137	0.64	0.025
		105	5710	1830	933	1.06	1.10	0.038
		135	4160	1330	960	0.59	0.76	0.067
	AN	0	4860	883	450	0.74	0.37	0.046
		75	4390	1330	1300	1.21	0.66	0.078
		105	4290	1400	1130	0.78	0.85	0.106
		135	5270	1550	1280	0.93	0.56	0.062
0.5	AS	0	4400	1260	9.0	0.86	0.58	0.148
		75	4510	760	1090	0.65	0.49	0.080
		105	5400	930	880	0.52	0.37	0.018
		135	5330	1980	850	0.58	0.82	0.034
	AN	0	4450	1260	970	0.86	0.58	0.141
		75	4780	1120	1070	0.510	0.59	0.086
		105	6090	1280	1110	0.546	0.64	0.223
		135	5070	1520	933	1.36	0.81	0.111
1	AS	0	5300	1260	1000	1.08	0.75	0.114
		75	6870	1150	927	1.56	0.65	0.167
		105	6530	1260	857	1.25	0.63	0.086
		135	5390	1230	1080	1.20	0.78	0.108
	AN	0	5300	1260	1000	1.08	0.75	0.100
		75	5710	1120	1290	1.32	0.59	0.129
		105	4480	1050	1240	0.75	0.49	0.134
		135	5240	1080	1080	1.13	0.54	0.130
LSD								
(I) : inoculation			30**	0.9*	80*	0.13**	N.S	0.030**
(S) : N-source			10**	N.S	50**	N.S	N.S	0.017**
(L) : N-level			20**	10**	80**	0.116**	1.02*	N.S
I × S			20**	N.S	N.S	0.117**	N.S	0.030*
I × L			30**	20**	10**	0.202**	1.77**	0.045**
S × L			20**	N.S	10**	0.165**	N.S	0.037**
I × S × L			50**	20**	20**	0.285*	N.S	N.S

* after 55 days from sowing

by Cerealine, levels, N-fertilizers and rates in the clay soil are in Table 8 and those in the sand soil are in Table 9. It is obvious that in the sandy soil K-concentration in grains and K-uptake in straw responded to inoculate significantly positively. The lowest values of K-concentration and uptake were obtained in grains and also in sand soil.

The effect of inoculation on K-concentration and uptake in the clayey one was not significant except K-concentration in straw. In general, 75 mg N/kg in the form of AS combined with the high rate of inoculation gives higher uptake as regards to K-concentrations and uptake by wheat plants. These results are in harmony with those obtained by Vallejo et al., (1993) and El-Aila (1998). Inoculation of N-fixing micro-organisms combined with N-fertilizers enhances the absorption of K. This result can be attributed to the effect of bacteria of biofertilizer to save N through fixing process and ultimately reduces N-losses from the soil.

Greater content of encourages greater plant growth and hence nutrients uptake including potassium (Kaloosh and Koreish, 1995).

Leached NO_2^--N, NO_3^--N, as Affected by Cropping Under Different Levels of Cerealine, N-Source and N Level in Clayey and Sandy Soils

$(NO_2^- + NO_3^-)$-N

$(NO_2^- + NO_3^-)$-N values as shown in Table 10 were clearly affected by the tested treatments. In the clay soil, results show that values $(NO_2^- + NO_3^-)$-N increased by increasing N-rate at all leachate Nos (1, 2 and 3) and all N-sources. In addition inoculation significantly decreased leached $(NO_2^- + NO_3^-)$-N, and the values were greater with AN than those with AS at all levels of Cerealine biofertilizer. Comparing the values the low level of Cerealine with the higher level, results show that the high level gave higher values of leached nitrite and nitrate nitrogen. This trend was clear particularly in the leachate No. 1 and No. 2, while I n the leachate No. 3 the trend was clear but not with all cases. Significant differences were observed due to the treatments of inoculation, N-source, N-level and their interactions for each $NO^-{}_{,2}$-N and NO_3^--N, separately. In most cases, leached $(NO_2^- + NO_3^-)$-N decreased with time of leaching where the values in the leachate No. 3 were lower than those in the first or the second ones.

Table 8. K-concentration and uptake in the whole plant 55 days after seeding, straw and grain yield at harvest as affected by different inoculation with Cerealine and N-fertilizers in the clay soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization Source	Levels (mg N/kg soil)	K* (mg/kg) in plant	K (mg/kg) in straw	K (mg/kg) in grain	K* uptake (mg/plant) plant	K uptake (mg/plant) straw	K uptake (mg/plant) grain
0	AS	0	2.50	1.01	2.83	0.0152	0.0176	0.0275
		75	2.15	0.950	0.739	0.0167	0.0168	0.00901
		105	2.42	0.616	0.724	0.0144	0.0121	0.00829
		135	2.38	0.748	0.656	0.0115	0.0129	0.00890
	AN	0	2.50	1.01	2.83	0.0152	0.0176	0.0275
		75	2.55	1.11	0.750	0.0207	0.0175	0.0079
		105	2.37	0.866	0.712	0.0219	0.0159	0.0085
		135	2.82	1.41	0.651	0.0183	0.0225	0.00822
0.5	AS	0	2.31	0.971	0.495	0.0177	0.0184	0.00534
		75	2.34	1.36	0.599	0.0134	0.0243	0.00750
		105	2.45	0.840	0.642	0.0140	0.0103	0.00804
		135	2.33	0.846	0.798	0.0091	0.0085	0.00958
	AN	0	2.31	0.971	0.495	0.0177	0.0184	0.00534
		75	2.29	1.14	0.752	0.0078	0.0121	0.00929
		105	2.04	1.20	0.608	0.0098	0.0135	0.00901
		135	2.48	1.05	0.558	0.0291	0.0180	0.00662
1	AS	0	2.58	0.943	0.419	0.0197	0.0203	0.00869
		75	2.24	0.838	0.502	0.0174	0.0267	0.0109
		105	2.54	0.674	0.717	0.0235	0.0173	0.00942
		135	2.31	0.482	0.717	0.0198	0.0110	0.00788
	AN	0	2.58	0.943	0.419	0.0197	0.0203	0.00869
		75	2.68	0.676	0.797	0.0111	0.0173	0.0137
		105	2.84	0.659	0.750	0.0089	0.0090	0.00924
		135	2.91	0.997	0.820	0.0202	0.0141	0.00757
LSD								
(I) : inoculation			N.S	0.138**	N.S	N.S	N.S	N.S
(S) : N-source			0.095**	0.130*	N.S	N.S	N.S	N.S
(L) : N-level			N.S	0.140*	N.S	0.01172**	0.00236**	N.S
I × S			0.165**	N.S	0.078*	0.00241**	N.S	N.S
I × L			N.S	0.244*	1.23*	0.00298**	0.00415*	N.S
S × L			0.219**	0.199**	N.S	0.00243**	0.00338**	N.S
I × S × L			N.S	N.S	N.S	0.00422**	N.S	N.S

* after 55 days from sowing

Table 9. K-concentration and uptake in whole plant 55 days after seeding, straw and grain yield at harvest as affected by different inoculation of Cerealine and N-fertilizers in the sand soil

Inoculation rate of Cerealine (mg/kg seed)	Nitrogen fertilization Source	Levels (mg N/kg soil)	K* (mg/kg) in plant	K (mg/kg) in straw	K (mg/kg) in grain	K* uptake (mg/plant) plant	K uptake (mg/plant) straw	K uptake (mg/plant) grain
0	AS	0	2.41	1.56	0.09	0.0037	0.0067	0.00009
		75	2.28	1.69	0.703	0.0045	0.0090	0.00021
		105	2.74	1.71	0.847	0.0050	0.0010	0.00030
		135	2.31	1.27	0.779	0.0033	0.0073	0.00047
	AN	0	2.41	1.56	0.09	0.0037	0.0067	0.00009
		75	2.05	1.93	1.00	0.0059	0.0096	0.00060
		105	2.23	1.58	0.851	0.0042	0.0093	0.00079
		135	2.38	1.56	1.00	0.0042	0.0057	0.00047
0.5	AS	0	2.26	1.67	1.50	0.0043	0.0078	0.00225
		75	2.38	1.49	1.48	0.0034	0.0096	0.00099
		105	2.45	1.44	2.26	0.0023	0.0057	0.00045
		135	2.37	1.59	2.36	0.0026	0.0064	0.00094
	AN	0	2.26	1.67	0.150	0.0043	0.0078	0.00215
		75	2.41	1.42	2.39	0.0025	0.0076	0.00196
		105	2.55	1.31	1.15	0.0022	0.0064	0.00230
		135	2.41	1.73	1.58	0.0065	0.0092	0.00205
1	AS	0	2.41	1.60	0.829	0.0048	0.0096	0.00093
		75	2.53	2.00	0.628	0.0057	0.0113	0.00113
		105	2.46	2.07	0.538	0.0047	0.0103	0.00053
		135	2.49	1.77	1.00	0.0055	0.0112	0.00101
	AN	0	1.74	1.60	0.829	0.0034	0.0096	0.00082
		75	1.76	1.50	0.713	0.0039	0.0079	0.00071
		105	1.80	1.48	1.39	0.0027	0.0068	0.0144
		135	2.57	1.72	2.28	0.0055	0.0086	0.0274
LSD								
(I) : inoculation			N.S	N.S	0.210**	N.S	0.00055**	N.S
(S) : N-source			N.S	0.066*	0.092**	N.S	0.000432**	0.00033**
(L) : N-level			N.S	0.100**	0.154**	N.S	N.S	0.00030**
I × S			N.S	0.114**	0.160**	N.S	0.00074**	0.000175**
I × L			N.S	0.173**	0.266**	N.S	0.00176**	N.S
S × L			N.S	0.141**	0.218**	0.00139**	N.S	0.00062**
I × S × L			N.S	N.S	0.377**	0.00113**	N.S	0.00050**

* after 55 days from sowing

Table 10. NO_2^- and NO_3^- concentrations (ppm) of the leachates at different intervals, as affected by Cerealine, N-fertilizers and their interactions in clay soil

Inoculation rate of Cerealine (mg/kg)	Nitrogen fertilization Source	Levels (mg N/kg)	Leachate 1 NO_2^-	Leachate 1 NO_3^-	Leachate 1 NO_2^- + NO_3^-	Leachate 2 NO_2^-	Leachate 2 NO_3^-	Leachate 2 NO_2^- + NO_3^-	Leachate 3 NO_2^-	Leachate 3 NO_3^-	Leachate 3 NO_2^-+ NO_3^-
0	AS	0	2.33	13.3	15.63	0.35	14.3	14.65	0.30	12.33	12.63
		75	6.20	18.0	24.2	0.80	42.0	42.8	8.60	20.0	28.6
		105	8.20	28.0	36.2	0.50	51.0	51.5	7.50	64.0	71.5
		135	11.8	28.0	39.8	0.40	54.0	54.4	4.50	36.0	40.5
	AN	0	3.00	10.0	13	2.00	11.0	13	0.30	9.0	9.3
		75	1.90	66.0	67.9	0.30	54.0	54.3	5.20	34.0	39.2
		105	3.20	70.0	73.2	0.70	45.0	45.7	4.00	37.0	41
		135	2.70	66.0	68.7	1.20	69.0	70.2	0.06	40.0	40.06
0.5	AS	0	0.20	36.0	36.2	0.30	14.0	14.3	0.07	15.0	15.07
		75	0.30	30.0	30.3	0.10	13.0	13.1	0.05	16.0	16.05
		105	0.20	25.0	25.2	0.10	16.0	16.1	0.05	40.0	40.05
		135	0.20	26.0	26.2	0.10	12.0	12.1	0.06	45.0	45.06
	AN	0	0.20	26.0	26.2	0.30	14.0	14.3	0.07	15.0	15.07
		75	0.20	47.0	47.2	0.10	13.0	13.1	0.40	11.0	11.4
		105	1.00	50.0	51	0.10	13.0	13.1	0.60	13.0	13.6
		135	3.50	52.0	55.5	0.40	42.0	42.4	0.10	12.0	12.1
1	AS	0	0.10	42.0	42.1	0.20	45.0	45.2	0.40	13.0	13.4
		75	0.30	50.0	50.3	0.40	30.0	30.4	0.50	12.0	12.5
		105	3.00	50.0	53	1.50	36.0	37.5	0.60	12.0	12.6
		135	3.40	66.0	69.4	0.60	60.0	60.6	0.20	16.0	16.2
	AN	0	0.10	42.0	42.1	0.20	45.0	45.2	0.50	13.0	13.5
		75	2.50	38.0	40.5	0.30	27.0	27.3	0.37	18.0	18.37
		105	5.80	62.0	67.8	1.00	87.0	88	0.27	25.0	25.27
		135	2.80	66.0	68.8	0.30	75.0	75.3	0.20	27.0	27.2
LSD											
(I) : inoculation			0.189**	0.946**		0.095**	0.946**		0.019**	0.946**	
(S) : N-source			0.136**	0.678**		0.068**	0.678**		0.013**	0.678**	
(L) : N-level			0.159**	0.798**		0.078**	0.798**		0.009**	0.798**	
I × S			0.235**	1.177**		0.118**	1.177**		0.024**	1.177**	
I × L			0.276**	1.381**		0.138**	1.381*		0.016**	1.381**	
S × L			0.227**	1.128**		0.112**	1.128**		0.013**	1.128**	
I × S × L			0.390**	1.952**		0.195**	1.952**		0.023**	1.952**	

Table 11. NO_2^- and NO_3^- concentrations (ppm) of the leachates at different intervals, as affected by cerealine, N-fertilizers and their interactions in the sand soil

Inoculation rate of Cerealine (mg/kg)	Nitrogen fertilization Source	Levels (mg N/kg)	Leachate 1 NO_2^-	Leachate 1 NO_3^-	Leachate 1 NO_2^- + NO_3^-	Leachate 2 NO_2^-	Leachate 2 NO_3^-	Leachate 2 NO_2^- + NO_3^-	Leachate 3 NO_2^-	Leachate 3 NO_3^-	Leachate 3 NO_2^- + NO_3^-
0	AS	0	0.39	8.00	8.39	0.34	1.93	2.27	0.43	10.0	10.43
		75	1.00	46.0	47	0.10	1.90	2	4.30	25.0	29.3
		105	0.80	55.0	55.8	0.80	2.30	3.1	3.30	70.0	73.3
		135	0.60	57.0	57.6	0.80	3.0	3.8	3.90	40.0	43.9
	AN	0	0.06	15.0	15.06	0.01	1.60	1.61	0.10	10.0	10.1
		75	2.0	58.0	60	0.30	10.9	11.2	2.80	39.0	41.8
		105	4.50	48.0	52.5	3.10	9.50	12.6	2.00	40.0	42
		135	0.30	71.0	71.3	0.60	5.00	5.6	0.03	45.0	45.03
0.5	AS	0	0.50	17.0	17.5	0.10	8.90	9.0	0.04	19.0	19.04
		75	0.30	15.3	15.6	0.03	2.2	2.23	0.02	18.0	18.02
		105	0.40	22.7	23.1	0.10	3.20	3.3	0.02	42.0	42.02
		135	0.40	23.7	24.1	0.40	15.4	15.8	0.02	98.0	98.02
	AN	0	0.50	17.0	17.5	0.10	8.90	9	0.04	19.0	19.04
		75	0.30	14.7	15	0.10	20.3	20.4	0.20	13.0	13.2
		105	2.50	22.0	24.5	1.0	0.50	1.5	0.30	15.0	15.3
		135	4.00	46.0	50	0.20	1.50	1.7	0.50	16.0	16.5
1	AS	0	0.20	48.0	48.2	2.00	1.00	3	3.00	14.0	17
		75	0.50	35.0	35.5	1.70	7.50	9.2	2.00	13.0	15
		105	4.50	38.0	42.5	0.40	1.00	1.4	0.20	17.3	17.5
		135	5.00	64.0	69	0.30	1.00	1.3	0.10	17.0	17.1
	AN	0	0.20	48.0	48.2	2.00	1.00	3	3.00	14.0	17
		75	5.00	34.0	39	0.60	3.00	3.6	0.20	20.0	20.2
		105	9.50	90.0	99.5	1.40	9.00	10.4	0.02	28.0	28.02
		135	8.50	77.0	85.5	1.90	12.5	14.4	0.02	29.0	29.02
LSD											
(I) : inoculation			0.095**	1.771**		0.095**	0.095**		0.095**	0.946**	
(S) : N-source			0.068**	0.353**		0.068**	0.068**		0.068**	0.678**	
(L) : N-level			0.086**	1.128**		0.080**	0.079**		0.080**	0.798**	
I × S			0.118**	0.613**		0.118**	0.118**		0.118**	1.177**	
I × L			0.138**	1.949**		0.138**	0.138**		0.138**	1.381**	
S × L			0.112**	1.599*		0.112**	0.112**		0.112**	1.128**	
I × S × L			0.195**	2.759**		0.195**	0.195**		0.195**	1.952**	

In general, inoculation with Cerealine decreased (NO_2 + NO_3) – N in the clay soil particularly with higher rates of nitrogen added. Meshref *et al.* (2000) reported that inoculation with Cerealine and manure application decreased (NO_2^- + NO_3^-)-N in the clay soil.

In the sand soil, results of leached (NO_2^- + NO_3^-)-N as shown in Table 11 shows similar trend in the first leachate with those in the clay soil. In the second and third leachates, the trend was not clear. Comparing the values of leached ($NO^-_{,2}$ + $NO^-_{,3}$) -N in the three leachates, the values decreased in the second leachate, then again increased in the third leachate in most cases. Statistical analysis showed significant differences between treatments of inoculation, N-source, N-level and their interactions for NO_2- N and NO_3-N. Data also reveal that using biofertilizer (cerealine), resulted in a decrease in (NO_2 + NO_3) – N. These results are in agreement with those of Meshref *et al.* (2000) and Mohammed (2002).

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تأثير التلقيح بالبكتيريا المثبتة للنيتروجين (السيريالين) على نمو القمح ومحتوى العناصر المغذية

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أجريت تجربة أصص على نبات القمح خلال الموسم الشتوى ٢٠٠٢/٢٠٠٣ بصوبة كلية الزراعة جامعة الزقازيق بهدف تأثير دراسة الأسمدة الحيوية (السيريالين) المحتوية على الكائنات الدقيقة المثبتة للنيتروجين والأسمدة النيتروجينية الكيماوية (سلفات الأمونيوم ونترات الأمونيوم) على نمو ومحصول القمح صنف سخا ٦٩ وكذلك محتواه من العناصر المغذية فى تجربتين الأولى باستخدام أراضى رملية من مزرعة الخطارة الخاصة بكلية الزراعة والثانية باستخدام أراضى طينية من منطقة الإبراهيمية محافظة الشرقية واحتوت كل تجربة على ثلاثة عوامل (التلقيح بالسيريالين ، مصادر النيتروجين ومستوى إضافة النيتروجين حيث تم التلقيح بثلاث معدلات (صفر ، منخفض ٧ جم سيريالين لكل ١ كجم حبوب ومرتفع ١٤ جم سيريالين لكل ١ كجم حبوب) وتم إضافة سماد النيتروجين على صورة سلفات أمونيوم ونترات أمونيوم فى أربع معدلات صفر ، ٧٥ ، ١٠٥ ، ١٣٥ ملليجرام نيتروجين / ١ كجم تربة على دفعتين والتجربة عاملية كاملة العشوائية أما بالنسبة للرى فتم إعطاء الأراضى الطينية عشر ريات والأراضى الرملية ١٥ رية وتم تجميع الراشح ثلاث مرات الأولى والثانية بعد إضافة النيتروجين والثالثة بعد الحصاد وتم تقدير النترات والنيتريت فى الراشح.

وقد أظهرت النتائج ما يلى :

زاد وزن النباتات بعد ٥٥ يوم من الزراعة زيادة طفيفة في حالة التلقيح بالسيريالين فى الأراضى الطينية بينما كانت الزيادة معنوية فى الأراضى الرملية.

بالنسبة لمحصول القش فقد زاد زيادة معنوية سواء فى حالة التلقيح بالسيريالين فقط أو مع التسميد الكيماوى بالنيتروجين وكان تأثير التداخل بين الثلاث عوامل معنوى موجب في الأراضى الرملية وبالنسبة للنيتروجين الممتص سواء فى الأراضى الطينية أو الرملية فقد كانت الزيادة عالية المعنوية وكانت الزيادة الأكبر فى الأراضى الطينية.

وقد أثر التداخل بين العوامل الثلاثة تحت الدراسة تأثيراً معنوياً على امتصاص النيتروجين. لوحظ أن تأثير سلفات الأمونيوم كان أفضل من نترات الأمونيوم فى الأراضى الطينية. وقد زادت قيم النترات والنيتريت فى الراشح فى الثلاث مرات بزيادة معدلات إضافة النيتروجين وكانت القيم أكبر فى حالة نترات الأمونيوم عنها فى حالة سلفات الأمونيوم فى حالة التلقيح بالسماد الحيوى (السيريالين) ، وكانت قيم النترات والنيتريت فى هذه الحالة أكبر منها فى حالة التلقيح بالسيريالين بالمعدل المنخفض.