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Effect of Industrial Effluents Polluting the River Nile on Growth, Metabolism and Productivity of *Triticum aestivum* and *Vicia faba* Plants

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Abstract: The effect of irrigation with industrial effluents was evaluated on growth, uptake of nutrients and yield of wheat (*Triticum aestivum* Giza 164) and faba beans (*Vicia faba* Giza 461) plants. Also, irrigation by industrial effluents in combination with vesicular-arbuscular mycorrhiza (VAM) was used as biological control to overcome the harmful effects of pollution with heavy metals. Irrigation of plants with industrial effluents led to marked changes in growth criteria depending on plant and the stage of growth. Industrial wastewater led also to marked changes in total carbohydrates and nitrogen contents in both shoots and roots. On the other hand, combination of industrial wastewater with VAM caused an increase in the total carbohydrates and total nitrogen in shoots and roots of both wheat and bean plants. The yield components in wheat and bean were significantly increased with industrial effluents, but the biochemical concentrations were different. In wheat, the carbohydrate concentrations were increased, but protein-N and total-N were decreased, however mineral content especially Zn was increased. A reverse response was recorded with VAM. The situation was totally opposite in case of bean. Generally, bean plants were more sensitive to pollution with heavy metals, than wheat plants however this influence might also be overcome using VAM.

Key words: *Triticum aestivum, Vicia faba,* industrial effluents, pollution, vesicular-arbuscular mycorrhiza.,VAM

Introduction

River Nile is known as a clean oligotrophic river. In the last decades it has been subjected to pollution via several and rather complicated routes. Agricultural and industrial effluents constitute a real threat to the River Nile system in Egypt (Abdel Hamid *et al.*, 1993). The potential toxicity of some effluents was partly related to their high content of heavy metals.

Worldwide heavy metal pollution of agricultural soils is one of the most severe ecological problems. The major source of pollution in Dakahlia governorate is the discharges from Talkha manufacture of fertilizers. Vegetable production in this area is highly contaminated with excessive amounts of Zn.

Zn toxicity in many plant species is associated with the inhibition of root growth (Powell *et al.*, 1988), or reduced plant growth and low N uptake due to its negative effects on P-uptake (El-Hamdi *et al.*, 1992). On the other hand, Zn-deficient plants of various species exhibit great permeability of the plasma membrane resulting in significant leakage of organic and mineral components from root cells (Welch and Narvell, 1993). The effect of different concentrations of Zn on growth, plant metabolism and yield have been discussed in recent reviews (Cakmak *et al.*, 1997, Grant and Bailey, 1997; Raghuwanshi *et al.*, 1997; Wheal and Rengel, 1997 and Yilmaz *et al.*, 1997).

The effect of Mycorrhizal symbiosis on the reaction of plants to toxic levels of heavy metals has been studied with various systems. Dixon and Buschena (1988) showed that ectomycorrhizal colonization can protect *Pinus banksiama* seedlings from heavy metal toxicity at low or intermediate soil concentrations. Bradley *et al.* (1981) measured an increased heavy metal resistance in ericoid mycorrhizal *Calluna vulgaris* compared with non-inoculated controls. Shetty *et al.* (1994) stated that plants inoculated with mycorrhizal fungi retained more Zn in roots than in shoots, which may be considered as a mechanism of Zn tolerance. Also, the role of vesicular arbuscular mycorrhiza (VAM) in enhancing the plant growth and yield of many field crops has been well documented (Bolan, 1991).

The present investigation aimed at studying the effects of irrigation with severe heavy metals polluted Nile water on plant growth and yield of *Triticum aestivum* and *Vicia faba* as well as vesicular arbuscular mycorrhizal (VAM) fungi to ameliorate the toxic effect of these metals.

Materials and Methods

Caryopses of wheat (*Triticum aestivum,* Giza 164) and seeds of faba beans (*Vicia faba,* Giza 461) were surface - sterilized by soaking in 1% (w/v) sodium hypochlorite for 5 minutes, then washed thoroughly with distilled water. Twenty caryopses from wheat and ten seeds from faba beans were sown into individual pots each containing 7 kg of sieved loam soil (clay: sand, 2:1). Soil chemical and physical characteristics are given in Table 1.

Table 1: Chemical and physical data for experimental soils.

Component	Values
Chemical analysis	
Organic carbon	0.45%
So_4^{-2}	0.016%
Cl^-	0.078%
HCo_3^-	0.062%
$CaCo_3$	2.6%
k^+	0.49μM/g
Na^+	8.4μM/g
Ca^{2+}	5.99μM/g
pH	7.79
Physical analysis	
E.C.	3.55 m. mhos/cm
Sand	26.2%
Silt	30.8%
Clay	43.0%
Mean Porosity	40.4%
Mean W.H.C.	61%
Mean moisture content	27.3%

Table 1a: Tolerance index of *Triticum aestivum* plant

Phenological stages	Treatment	
	P	P+M
Vegetative	0.96	1.47
Flowering	1.48	1.74
Fruiting	1.63	1.95

P= sole industrial effluent.
P+M= Industrial effluent in combination with VAM.

Table 1b: Tolerance index of *Vicia faba* plant

Phenological stages	Treatment	
	P	P+M
Vegetative	0.85	1.00
Flowering	0.90	0.98
Fruiting	1.13	0.97

P= sole industrial effluent.
P+M= Industrial effluent in combination with VAM.

Table 2: Heavy metal contents of investigated effluents.

Element x 10^{-5} mμ/ml	Control	Effluent
Mn	0.118	0.118
Co	0.00	0.00
Ni	0.319	0.319
Cu	0.036	0.036
Zn	1.4	8.4
Pb	0.00	0.00
Cd	0.0658	0.0987

Pots were divided into three sets, (each set contained 7 replicates). The first set was irrigated with natural Nile water and considered as control with a natural content of Zn about 0.91 ppm (0.14 x 10^{-4} mμ). The second set was irrigated with polluted water containing about 5.5 ppm (0.84x10^{-4}mμ) as shown in Table (2) collected from an industrial discharge point at Besendela bridge far from Talkha manufacture for fertilizers about 10 km. The third set was irrigated with

Table 3: Dry weight of roots, shoots and leaves; length and leaf area of *Triticum aestivum* in three phenological phases as affected by type of irrigation water.

Treatment	Phenological stage	Root	Stem (mg)	Leaves	Root (cm)	Stem ((cm)	Leaf area (cm^2)
Control		9.0	20*	20	4.2*	5.9	5.9
Polluted	1	10.0	20*	10	4.0*	4.6	4.5
Polluted + VAM		7.0	8	7	6.1	4.1	3.6
L.S.D. at 0.05		1.1	2.03	1.5	0.57	1.11	1.5
Control		60.0	410	50	9.3	38.6	11.4
Polluted	2	120.0	700	70	13.8	42.2	14.6
Polluted + VAM		270.0	630	80	16.2	30.1	14.8
L.S.D. at 0.05		8.7	11.5	3.47	1.11	1.25	1.31
Control		70.0	460	40	15.00	53.6*	14.3
Polluted	3	150.0	790	70	15.5	62.4	16.3
Polluted + VAM		330.0	720	60	18.6	54.6*	17.1
L.S.D. at 0.05		9.3	12.8	1.5	0.15	2.35	1.82

* : Non significant as indicated L.S.D. ($P \leq 0.05$).

Table 4: Dry weight of roots, shoots and leaves; length and leaf area of *Vicia faba* in three phenological phases as affected by type of irrigation water.

Treatment	Phenological stage	Root	Stem (mg)	Leaves	Root	Stem (cm)	Leaf area (cm^2)
Control		70	130	70*	6.0*	16.6	21.6
Polluted	1	60	200	70*	5.1	15.4	24.3
Polluted + VAM		130	280	110	6.0*	14.2	38.6
L.S.D. at 0.05		8.7	10.3	4.3	0.31	0.15	1.08
Control		270	113	130	10.1*	36.8*	39.7*
Polluted	2	280	820	90	9.1	39.7	30.4
Polluted + VAM		340	980	190	10.0*	37.1*	39.7*
L.S.D. at 0.05		9.1	11.5	15.8	0.13	0.35	0.15
Control		740	231	210	12.3*	67.0	48.2
Polluted	3	102	260	270	14.0	74.0	51.7
Polluted + VAM		196	240	220	12.0*	71.1	49.3
L.S.D. at 0.05		15.8	5.4	7.3	0.41	0.73	0.25

* : Non significant as indicated L.S.D. ($P \leq 0.05$).

Table 5: Effect of industrial effluents (Polluted) and mycorrhiza (Polluted + VAM) on different yield attributes of *Triticum aestivum* and *Vicia faba*. Each value is the mean of 5 replicates.

Treatment Parameter	*Triticum aestivum*				*Vicia faba*			
	Control	Polluted	Polluted+VAM	L.S.D. at 0.05	Control	Polluted	Polluted+VAM	L.S.D. at 0.05
Plant height (cm)	58.6	67.4	59.6	0.51	70.0	88.0	75.1	2.88
Plant weight (g)	1.1*	1.6	1.2*	0.15	60.1	73.5	58.2	1.95
Crop weight (g)	0.7*	1.0	0.7*	0.05	12.7	20.4	14.4	0.85
No. of grain/plant	12.0	18.0	11.0	0.43	4.0	3.0	3.0	0.31
Straw wt./P/(g)	0.4	0.6	0.5	0.03	2.5*	2.8	2.6*	0.15
Grain wt./P/(g)	0.6*	0.9	0.6*	0.01	2.0	5.0	3.6	0.45
Weight of 100 grains (g)	4.7*	5.6	4.7*	0.03	50.0	166.2	120.0	4.7
Mobilization index	1.5	1.6	1.4	0.08	5.0*	7.2	5.5*	0.65
Harvest index	128.4	136.7	118.6	2.1	77.9	176.1	136.8	8.75
Crop index	0.6*	0.6*	0.5	0.04	0.4	0.6	0.6	0.11

* : Non significant as indicated L.S.D. ($P \leq 0.05$).

Table 6: Simple correlation coefficients between different yield attributes in *Triticum aestivum*. ** and * indicate significance at p-level 1% and 5% respectively.

Parameter	Plant height (cm)	Plant weight (g)	Crop weight (g)	No. of grain/plant	Straw wt. /P/G.	Grain wt. /P/G	Weight of 100 grains (g)	Mobilization index	Harvest index	Crop index
Plant height (cm)	1.000									
Plant weight (g)	0.996**	1.000								
Crop weight (g)	0.999**	0.994**	1.000							
No. of grain/plant	0.972**	0.949**	0.978**	1.000						
Straw wt./P/(g)	0.961**	0.981**	0.954**	0.871**	1.000					
Grain wt./P/(g)	0.998**	0.996**	0.997**	0.964**	0.966**	1.000				
Weight of 100 grains (g)	0.109	0.025	0.134	0.338	-0.167	0.089	1.000			
Mobilization index	0.493*	0.418*	0.515*	0.683**	0.235	0.472*	0.918**	1.000		
Harvest index	0.777**	0.722**	0.793**	0.903**	0.575*	0.761**	0.709**	0.930**	1.000	
Crop index	0.754**	0.697**	0.770**	0.884**	0.547*	0.734**	0.722**	0.934**	0.993**	1.000

Table 7: Simple correlation coefficients between yield attributes and other measured parameters in *Vicia faba* plants. ** and * indicate significance at p-level 1% and 5% respectively.

Parameter	Plant height (cm)	Plant weight (g)	Crop weight (g)	No. of grain/plant	Straw wt. /P/G.	Grain wt. /P/G	Weight of 100 grains (g)	Mobilization index	Harvest index	Crop index
Plant height (cm)	1.000									
Plant weight (g)	0.987**	1.000								
Crop weight (g)	0.987**	0.948**	1.000							
No. of grain/plant	-0.547**	-0.403**	-0.673**	1.000						
Straw wt./P/(g)	0.961**	0.904**	0.993**	-0.756**	1.000					
Grain wt./P/(g)	0.871**	0.780**	0.938**	-0.887**	0.973**	1.000				
Weight of 100 seeds (g)	0.930**	0.858**	0.977**	-0.816**	0.995**	0.991**	1.000			
Mobilization index	0.990**	0.953**	1.000**	-0.661**	0.991**	0.933**	0.973**	1.000		
Harvest index	0.834**	0.733**	0.911**	-0.918**	0.954**	0.998**	0.978**	0.905**	1.000	
Crop index	0.766**	0.652**	0.859**	-0.957**	0.914**	0.983**	0.949**	0.851**	0.994**	1.000

Table 8: Effect of industrial effluents and mycorrhiza (Polluted + VAM) on chemical composition in grains of *Triticum aestivum* and seeds of *Vicia faba*.

Treatment Parameter		*Triticum aestivum*				*Vicia faba*			
		Control	Polluted	Polluted + VAM	L.S.D. at 0.05	Control	Polluted	Polluted + VAM	L.S.D. at 0.05
Carbohydrates (mg glucose/g DW)									
Glucose		0.045	0.020	0.031	0.001	0.182	0.052	0.106	0.02
Sucrose		1.540	0.533	0.720	0.05	5.762	1.374	3.364	0.15
Polysaccharides		703.95	715.04	790.32	7.33	391.810	190.990	229.590	8.35
Total carbohydrates		705.53	715.59	791.07	6.15	397.760	192.420	233.060	13.9
Nitrogen (mg NH_4-N/g DW)									
Ammonia-N		0.430	0.950	0.790	0.25	4.460	6.130	5.110	0.38
Total soluble-N		2.660	4.140	3.110	0.53	25.63	27.62	26.11	0.11
Protein-N		116.00	110.500	128.370	3.5	30.820	27.760	31.890	0.15
Total-N		118.66	114.64	131.48	2.7	56.45	55.35	58.00	0.43
Elements (m mole/g DW)									
Potassium	m mole g^{-1}	32.5	25.9	29.3	3.8	0.1	0.06	0.06	0.005
Sodium	m mole g^{-1}	6.0*	16.2	7.8*	1.9	0.15	0.03	0.03	0.002
Calcium	m mole g^{-1}	2.2*	1.2	2.0*	0.31	0.05	0.02	0.02	0.001
Magnesium	μ mole g^{-1}	11.9*	9.1*	16.4	3.1	37.2	9.9	12.7	2.31
Iron	μ mole g^{-1}	0.3	0.04	0.2	0.05	2.9	1.4	0.15	0.53
Zinc	μ mole g^{-1}	1.5*	4.5	1.8*	0.53	17.9	0.8	10.54	1.45

* : Non significant as indicated L.S.D. ($P \leq 0.05$).

polluted water after inoculating the soil with vesicular arbuscular-mycorrhizal (VAM). VAM inoculum was prepared as recommended by Abdel-Fattah (1997).

Irrigation was carried out by equal amounts of water keeping the water holding capacity at 60%. Plants were exposed to normal day length with natural illumination in a greenhouse of Faculty of Science in Mansoura during winter season. The photoperiod was approximately 10 hours and the day/night temperature was about 20/14 ± 2°C.

Throughout the growth of plants, sampling was carried out at three successive stages, phenological stages referred to as vegetative (for wheat and faba bean 32 days after emergence); flowering (for wheat after 83 days and for faba bean after 56 days of emergence) and fruiting (for wheat after 154 days and for bean after 106 days) stages. At the time of sampling, plants were collected from each pot and separated into shoots and roots to measure their growth parameters, as well as for chemical analyses. At harvest, carbohydrate, nitrogen and ionic concentrations were determined, in the seeds.

The full data of growth responses under all treated sets as well as the results of the chemical analyses of harvested seeds were statistically analyzed, and comparison among means was carried out by calculating the least significant difference (LSD) at 5% level (Snedecor and Cochran, 1980).

Determination of yield and yield attributes: As described by Hassanein (1987), ten plants were taken at random to record the data of yield components which included the following :

1- Plant height (cm).
2- Plant weight (g).
3- Crop weight/plant.
4- No of grains or seeds/plant.
5- Straw weight/plant (g).
6- Grains or seeds weight/plant (g).
7- Weight of 100 seeds or grains (g).
8- Harvest index
9- Mobilization index
10- Crop index

Determination of ion contents: Dried plant samples were digested in concentrated nitric acid and perchloric acid (4:1 v/v) and made up to a fixed volume with deionized water as described by Chapman and Pratt (1978). Flame emission Spectrophotometry was used for determining K and Na while Ca, Mg, Fe and Zn were measured by atomic absorption spectrophotometry.

Determination of nitrogen: Nitrogenous constituents were extracted from the dried powdered tissues by the method of Yemm and Willis (1956). Ammonia-N and total soluble-N was determined in the extracts and total-N in dry tissues by the conventional micro-Kjeldahl method. Subtraction of total soluble-N from total-N gave the value for protein-N.

Determination of carbohydrates: Sugars were extracted by overnight submersion in 10 cm^3 of 80% (v/v) ethanol at 25°C with periodic shaking. Glucose and sucrose were determined using modifications of the procedures of Feteris (1965) and Handel (1968) respectively.

Estimation of glucose: A 1.0 cm^3 aliquot of the alcoholic extract was heated with 5.0 cm^3 O-toluidine reagent (60 cm^3) and 2.0 gm thio-urea to 1.0 dm^3 with glacial acetic acid) for 15 min at 97°C. Absorbance was measured with a Bausch and lomb spectronic 20 spectrophotometer at 630 nm.

Estimation of sucrose: Sucrose content was determined by first degrading reactive sugars present in 0.1 ml extract with 0.1 ml of 5.4 N KOH at 97°C for 10 min. Three ml of freshly prepared anthrone reagent (150 mg anthrone +100 ml of 72% H_2SO_4) was then added to the cooled reaction product and the mixture was heated at 97 °C (for 5 min, cooled and read at 620 nm).

Estimation of polysaccharides: Polysaccharides were determined in dry residue after alcohol extraction as described by Younis *et al.* (1969), its reducing power estimated as mentioned above.

Results and Discussion

Growth response and yield components: Throughout the experimental period, irrigation with industrial effluents induced marked changes in the measured growth parameters of *T. aestivum* and *V. faba* plants. In general, treatment with industrial effluents in combination with VAM variably enhanced the growth of *Triticum aestivum* (Table 3). This enhancement was more pronounced in case of treatment with VAM than with sole industrial effluents.

Comparing growth of plant root in the presence of potential toxic metals with its growth in a control gives values known as a tolerance index (TI). (TI = root growth in treatment solution/root growth in control solution, Jowett, 1958) as shown in Table 1a and b.

TI increased throughout the growth period and the magnitude of increase in TI appeared to be higher under industrial effluents irrigation in combination with VAM than with sole industrial effluents.This is in accordance with the results of Piola *et al.* (1995), who found that, development of root system was concomitantly accompanied by an enhancement of shoot growth due to effect of ectomycorrhizal fungi of hybrid larch. *Vicia faba* plants appeared to be more sensitive to irrigation with industrial effluents than wheat, as it appears from the results given in Table 4. All growth parameters in general were, either significantly decreased or non-significantly changed by irrigation with industrial effluents with and without VAM respectively during both vegetative and flowering stages. This result is in accord with those obtained by El-Hamid *et al.* (1992). Meanwhile significant increases in growth parameters were exhibited during fruiting stage. Tolerance index (TI) in *V. faba* plants increased throughout the growth period under irrigation with industrial effluents, while a reverse situation was displayed when industrial effluents irrigation was associated with VAM in Table 2.

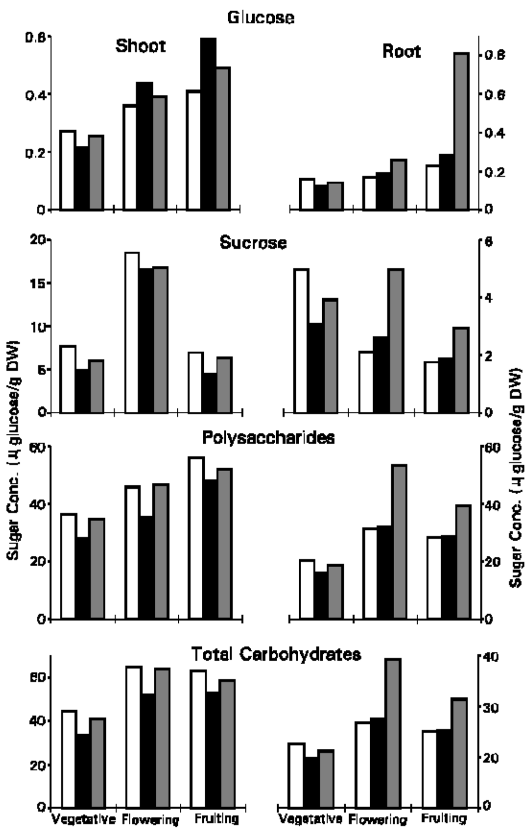

Fig. 1: Effect of irrigation with Nile water (control), industrial effluents (p) and VAM (P+M) on carbohydrate concentration in *Triticum aestivum* plants at three development stages.
The bars with the same letter are not significantly different at p-level=5% (LSD) test.

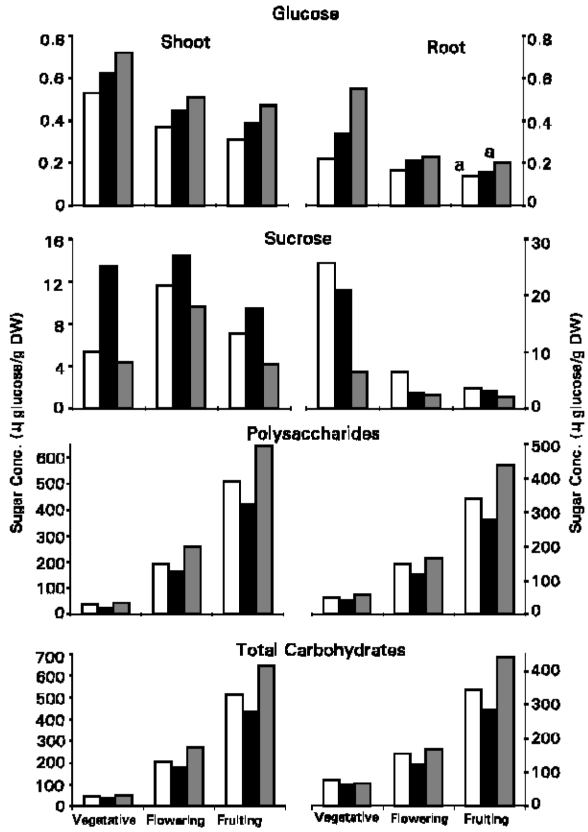

Fig. 2: Effect of irrigation with Nile water (control), industrial effluents (p) and VAM (P+M) on carbohydrate concentration in *Vicia faba* plants at three development stages.
The bars with the same letter are not significantly different at p-level=5% (LSD) test.

Yield and yield components: Comparing yield components of wheat and bean plants (Table 5), irrigation with industrial effluents in association with VAM appeared to induce changes more or less comparable with those gained for growth parameters. Grain or seed weight per plant and weight of 100 grains or seeds (seed index) were significantly increased by irrigation with industrial effluents. The same pattern was recorded in mobilization index, harvest index and crop index. Thus, in wheat plants irrigated with industrial effluents in the presence of VAM, grain weight/plant was affected non-

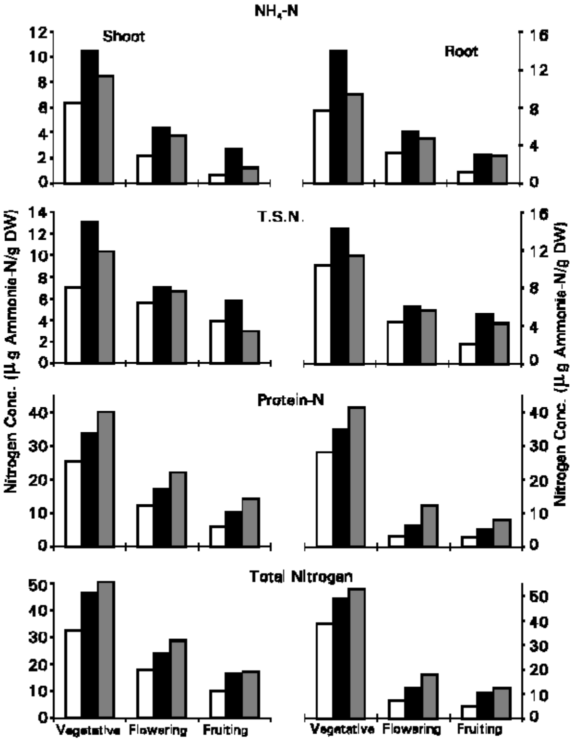

Fig. 3: Effect of irrigation with Nile water (control), industrial effluents (p) and VAM (P+M) on carbohydrate concentration in *Triticum aestivum* plants at three development stages.
The bars with the same letter are not significantly different at p-level=5% (LSD) test.

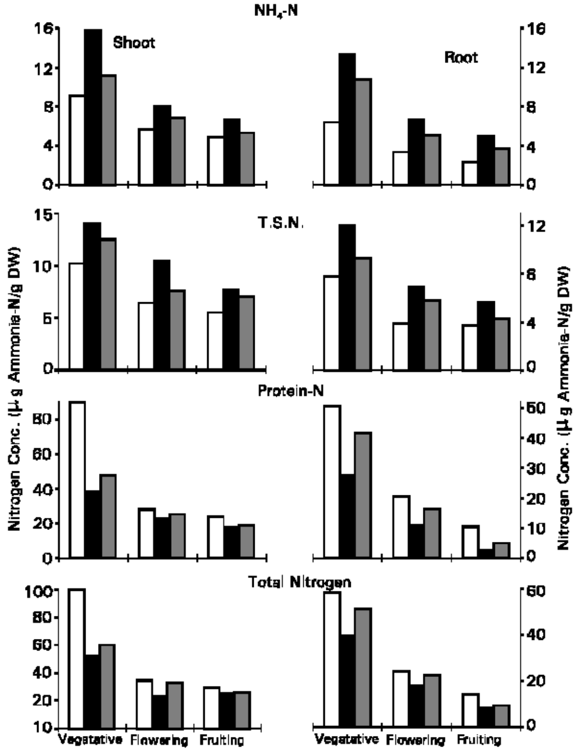

Fig. 4: Effect of irrigation with Nile water (control), industrial effluents (p) and VAM (P+M) on carbohydrate concentration in *Vicia faba* plants at three development stages.
The bars with the same letter are not significantly different at p-level=5% (LSD) test.

significantly but number of grains/plant, mobilization index, harvest index and crop index were significantly decreased. For faba bean plants, number of seeds per plant was significantly decreased.

It is apparent from the results in Table 6 that, there was a significant positive correlation between grain weight/plant and other yield attributes in wheat plant. For faba bean seeds, the same behaviour was apparent except a negative correlation was recorded between number of seeds/plant and other yield attributes (Table 7). In this connection, Raghuwanshi *et al.* (1997) using wheat plants, found that, the application of Zn and 5, 10 gave higher yield. Furthermore Yilmaz *et al.* (1997) found that application of Zn at 0.12 mg kg^{-1} significantly increased grain yield in all cultivars of wheat. These results are in accordance with those obtained by Modaihsh (1997) and Cakmak *et al.* (1996) on wheat.

Changes in carbohydrates: Figs. (1&2) show that, irrigation of wheat and faba bean plants with industrial effluents either alone or with VAM led to increase the total soluble carbohydrates in both shoots and roots. For sucrose in wheat, there was a significant decrease in its amount in both shoots and roots. Polysaccharides and total carbohydrates contents significantly decreased under irrigation by industrial effluents but showed a tendency of increase with VAM in shoots and roots of wheat. In faba bean plants, sucrose, polysaccharides and total carbohydrates were significantly decreased in shoot under industrial effluents irrigation and increased when plants were treated with VAM. Generally, in root, there were significant increases in sucrose, polysaccharides, and total carbohydrates (Abbas and Shukry, 1993 and Abbas, 1986) on *Zea mays*. As Zn plays an important role in carbohydrate metabolism (Vallee, 1976) the increases recorded in soluble sugars in presence of Zn point to the increase in enzymes activities responsible for sugar synthesis in maize (Powell *et al.*, 1986).

Changes in Nitrogen metabolism: Results presented in Figs. (3&4) clearly indicate that the irrigation with industrial effluents associated with VAM, displayed an increase in ammonia-N, total soluble-N, protein-N, thus a net increase total nitrogen was obvious (Abbas, 1986 and Powell *et al.*, 1986). A significant increases in ammonia-N, total soluble-N in shoot and root were observed throughout the growth period of faba bean plants, however protein-N and total-N were decreased in response to irrigation with industrial effluents even when associated with VAM, where Wallander (1996) found that, host carbohydrates allocated to the mycorrhizal fungus are used in growth processes and as carbon skeleton and energy sources in the process of ammonium assimilation. The assimilated N is either used in growth processes by the fungus, stored as amino acids or protein in the fungal mantle and or returned to the host in the form of amino acids. A number of studies have shown that the formation of ectomycorrhizae alters the characteristics of nitrogen acquisition and assimilation depending on the fungus and host plant species (Chalot *et al.*, 1994).

Biochemical composition of seeds:

a- Carbohydrate content: In the harvested wheat grains and faba bean seeds, there was a significant decrease in reducing sugars and sucrose with an increase in polysaccharides and total carbohydrates, in response to irrigation with industrial effluents and inoculation with VAM. This might be due to the enhanced effect of industrial waste water on synthesis and accumulation of carbohydrates. On the other hand the reserve losses from shoot (Figs. 3&4) were gained by grains of wheat or seeds of faba bean as shown in Table 8, most of which appeared to come from translocation of current assimilate, where Zn plays an important role in carbohydrate metabolism (Abbas, 1986; Powell *et al.*, 1986 and Vallee, 1976).

b- Nitrogen content: The pattern of changes in nitrogen constituents is shown in Table 4. The observed general decrease in protein-N was accompanied by an increase in total soluble-N in wheat grain in response to irrigation industrial effluents, which might be attributed to the promotive effects on the proteolytic activity. On the other hand, there was a significant increase in protein-N in response to inoculation with VAM whereas a reverse situation was obtained in faba bean seeds.

c- Mineral content: Data presented in Table 6 indicate that, K,Ca, Mg and Fe contents were significantly decreased in wheat grains under irrigation with industrial effluents and in combination with inoculation with VAM except for Mg ions which were significantly increased with VAM treatment.

Concerning the contents of Na and Zn ions in wheat grain, they were significantly increased under industrial effluent irrigation where non significant changes were exhibited under inoculation with VAM.

Regarding the effect of irrigation with industrial effluents on ion content of faba bean seeds, the results revealed that all tested elements (K, Na, Ca, Mg, Fe and Zn) were significantly decreased in both treatments. In accord with these results Wolswinkel (1992) emphasized that most nutrient enter the developing fruit via the phloem. Indeed much work has been reported on the pathway by which carbohydrates and macro nutrients enter the developing fruit (Wolswinkel, 1987, 1992). The pathway used by micronutrients to enter into developing seeds has generally been assumed to be similar to that of macro nutrients, that is transported via phloem (Longnecker and Robson, 1993) Zn ions are thought to be only partially mobile in the phloem (Kochian, 1991) and are remobilized from leaves during grain or seed development (Pearson and Rengel, 1994) where it is mobilized in the phloem as organic complexes with citrate or malate (Longnecker and Robson, 1993).

Conclusions: It seems that growth criteria of wheat and faba bean plants subjected to irrigation with industrial wastewater and inoculation with VAM throughout the growth of both plants led either to a significant increase in growth (in faba bean) or non significant change (in wheat). The tolerance index in wheat was higher than that in faba bean. This was accompanied by an increase in total carbohydrates and total nitrogen in shoots and roots of wheat plant. On the other hand, total carbohydrates and total nitrogen in faba bean plants were either significantly decreased or did not display any significantly change in combination with VAM. This means that industrial effluents might be used for irrigation, considering that faba bean plants are more sensitive to irrigation with polluted water, while wheat plants were less sensitive to heavy metals in polluted water. The presence of VAM ,however, enhance plant growth and increase the tolerance to these heavy metals in faba beans.

The number of grains/plant and the weight of 100 caryopses were significantly increased in wheat and faba beans in response to irrigation with industrial effluents i.e. the quality of grains or seeds were significantly increased. However the quantity of carbohydrates in wheat were increased although the nitrogen contents were decreased and increased respectively in response to irrigation with polluted water and with VAM. For faba beans, total carbohydrates were decreased. Although total-N was significantly decrease with polluted water and increased with VAM inoculation.

The ionic content of grains revealed that wheat grain contained a high amount of Zn in response to irrigation with industrial effluents, but in faba beans, a decrease in Zn content was attenuated i.e. wheat grains contain high amounts from carbohydrates and Zn, and are low in protein. A reverse situation in faba bean plants. This lead us to consider that wheat plants (as monocot) can tolerate these pollutants where (1) Zn deficiency is a critical nutritional problem in Egypt substantially limiting wheat production. (2) high level of Zn in wheat grains help in solving the problem of widespread occurrence of Zn deficiency in Egyptian children whose diets are dominated by cereals-based food with a protein content. These were in case irrigation with industrial effluents. On the other hand faba beans (Dicot) which is more sensitive to industrial effluents, can be grown and irrigated with industrial effluents but in combination with VAM.

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