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EFFECT OF SEWAGE SLUDGE, PHOSPHORINE INOCULATION, AND CULTIVARS ON GROWTH, YIELD, AND ELEMENTAL COMPOSITION OF PEA UNDER NEWLY RECLAIMED SOIL.

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ABSTRACT

Two field experiments were carried out at west of El-Fashn Town, Beni Sweif Governorate, Egypt, under newly reclaimed sandy loam soil conditions during 1999/2000 and 2000/2001 growing seasons to study the effect of sewage sludge additions and phosphorine inoculation on pea (*Pisum sativum L.*) growth, yield and seed contents of macro nutrients and heavy metals as compared with chemical NPK fertilization. Sixteen treatments were used in this study, i.e. all combinations of two pea cultivars(Lencolen and Victory Freezer), two levels of phosphorine inoculation (Inoculated and Uninoculated) and four levels of sewage sludge(0, 5, 10, and 15 m^3/fed). A recommended chemical NPK fertilizer levels were added to the control treatment only.

Application of sewage sludge and phosphorine inoculation significantly increased fresh yield, and most of the studied plant growth parameters. They also significantly increased seed content of N and P. Sewage sludge application significantly increased heavy metal concentrations ,i.e.Fe, Mn, Zn, Cu, Pb and Cd in pea seeds, but these concentrations were generally low and within the permissible limits. There were significant differences between the two pea cultivars. Organic fertilization with sewage sludge at 15 m^3/fed either solely or with phosphorine inoculation produced higher yield than chemical NPK fertilization.

Keywords: Organic fertilization, sewage sludge, phosphorine, pea, and newly reclaimed soil.

INTRODUCTION

Many attempts have been undertaken in the last decades to find out a complete or partial substitution for the usually applied chemical (inorganic) fertilizers by using organic- and / or bio- fertilizers in order to avoid their adverse effects on environment, reduce the agricultural product costs and improve soil chemical and physical properties especially newly reclaimed sandy and calcareous soils (Lewis *et. al.*, 1988 and EL-Kholi, 1998).

Among organic fertilizers, sewage sludge has long been recognized as a potential source for providing plant nutrients such as N, P, Ca and organic matter. Numerous studies have shown that yields, yield components and N, P and K uptake of crops increased due to sewage sludge application (Rappaport *et. al.*, 1988; EL-Sokkary and EL-Keiy, 1989; Ozores-Hampton *et. al.*,1994; Rabie *et. al.*, 1997 Arisha and Abd EL-Bary, 2000). On the other hand, heavy metal contamination of the human food-chain ultimately may limit the use of the sewage sludge on agricultural land (Logan and Chaney, 1983). Numerous studies have shown that concentration of heavy metals in

plant organs increased due to sewage sludge application. However, these concentrations were generally low and did not exceed the statutory limits (Rappaport *et. al.*, 1988; EL-Sokkary and EL-Keiy, 1989; Truby and Raba, 1990 and Arisha and Abd EL-Bary, 2000).

Biofertilizers are considered as the most important factor in reducing the application of chemical fertilizers and minimizing the induced environmental pollution (EL-Kholi, 1998). Biofertilization technique either by single or mixture bacterial species leads to maximize the counts and activity of such organisms for organic matter decay and mineralization to create a good medium for plant growth, especially in the newly reclaimed desert soils (El-Sersawy *et. al.*, 1997). Numerous studies have shown that inoculating seeds or soil with phosphorine (phosphate dissolving bacteria) resulted in increasing growth, yield and N, P and K uptake of plants (Saber *et. al.*, 1981; Gebraiel, 1995; EL-Gamal, 1996 and EL-Sayed, 1999) and could save about 50% of the recommended rates of mineral phosphatic fertilizers (Sarhan *et. al.*, 2002).

Pea is considered one of the most important leguminous crops cultivated in Egypt especially in the newly reclaimed soils (Abd EL-Ati *et. al.*, 2000). It is of great important to increase its vertical production and improve its chemical and physical properties. Limited information is available in the literature on the response of pea to sewage sludge (Kerbs *et. al.*, 1998 and Anderson, 1999) or phosphorine (Saber *et. al.*, 1981).

The objectives of this investigation were (i) to evaluate effects of sewage sludge application and phosphorine inoculation on pea growth, nutrient contents and heavy metal concentrations of pea seeds. (ii) to compare the sewage sludge additions and bio-fertilization with the conventional chemical NPK fertilization.

MATERIALS AND METHODS

Two field experiments were performed on newly reclaimed sandy loam soil located at west of EL-Fashn town, Beni Sweif Governorate during 1999/2000 and 2000/2001 winter growing seasons to evaluate the effects of sewage sludge application and phosphorine inoculation on growth, yield, nutrients content and metal concentrations of two pea cultivars in comparison with conventional chemical NPK fertilization. In order to avoid the residual effect of sewage sludge and phosphorine, the present study was conducted on two different sites, one for each season. However, chemical and physical properties of the soil in both sites, which were determined according to Black (1965), Page (1982) and Lindsay and Norvell (1978), showed no great differences among them (Table 1).

Table 1: Characteristics of the experimental soil and sewage sludge

Characteristics	Soil		Sewage sludge	
	1st season	2nd season	1st season	2nd season
EC, mmhos cm^{-1}	0.71	0.78	2.15	2.23
pH, 1:2.5 soil : water susp.	7.79	7.81	6.52	6.64
$CaCO_3$ %	8.40	8.12	2.43	2.65
Organic matter, %	0.13	0.42	41.56	40.11
$NaHCO_3$-ext. P, ppm	5.16	4.82	618	593
NH_4OAC-ext. K, ppm	87.11	83.56	732	704
Total-N, %	.035	0.026	2.16	1.83
DTPA-ext. Fe, ppm	9.52	7.88	62.43	58.12
DTPA-ext. Mn, ppm	6.04	6.22	38.51	33.64
DTPA-ext. Zn, ppm	4.35	5.14	18.73	16.92
DTPA-ext. Cu, ppm	0.82	1.11	14.65	12.73
DTPA-ext. Pb, ppm	0.14	0.06	5.01	4.82
DTPA-ext. Cd, ppm	n.d.†	n.d.	0.41	0.36
Coarse sand, %	28.41	32.55	-	-
Fine sand, %	42.53	39.76	-	-
Silt, %	24.26	26.13	-	-
Clay, %	4.80	3.56	-	-
Texture	Sandy loam	Sandy loam	-	-

n.d. = not detected.

Treatments comprised of all possible combinations of two pea cultivars (Lencolen and Victory Freezer), two phosphorine inoculation levels (Inoculated and Uninoculated) and four levels of sewage sludge (0, 5, 10, and 15 m^3/fed). The control treatment plots (0 sludge and Uninoculated) received 100 kg N / fed as ammonium sulfate, 150 kg P_2O_5/fed as superphosphate (15..5 % P_2O_5) and 100 kg K_2O / fed as potassium sulfate. The NPK fertilizers were divided into three equal doses and applied after 15, 30 and 45 days of planting. Sewage sludge was obtained from Beni Sweif Waste Water Treatment Plant . Some characteristics of the used sludge are shown in Table 1. The sludge was roto-tilled into the soil to a depth of approximately 20 cm prior to planting. Phosphorine was obtained from the Organization of Agriculture Equalization Fund (G.O.A.E.F.), Ministry of Agriculture, Egypt. The inoculation was carried out just before planting by wetting the seeds with bacterial inocula (by using Arabic gum as an adhesive material), then the seeds were dried for one hour in open air before planting.

The experiment was a randomized complete block design with four replicates in split-split-plot arrangement. Cultivars were assigned to the main plot, sewage sludge treatments to the sub-plots, and phosphorine treatments to the sub-sub-plots. Each experimental plot consisted of five ridges 70 cm wide and 3 m long. Seeds were sown on the 2nd of October in both seasons. Agricultural practices prevailing in the studied area for pea were followed.

At proper time, the following parameters were recorded :

1- Morphological characters: after 45 days from planting, 10 plants were taken at random from each plot and the following characters were recorded; plant height , number of branches per plant, number of leaves per plant, specific leaf weight, net assimilation rate (NAR), and earliness index (EI). The NAR was determined using the following equation (Radford 1967):

$$NAR = [(W_2-W_1) / (t_2-t_1)] * [(\log_e A_2 - \log_e A_1) / (A_2 - A_1)] \text{----------(1)}$$

where; NAR = net assimilation rate ($gm/dm^2/day$)

A_1 and A_2 = plant leaf area at t_1 and t_2 (dm^2), respectively.

t_1 and t_2 = constant time after 45 and 65 days after sampling (days), respectively.

W_1 and W_2 = plant dry weight (gm) at t_1 and t_2, respectively.

Earliness Index was determined according to Bartlett modified equation as described by Shahien (1991) .

2- Yield and yield components: Thirty pods were collected at random from each plot at the second picking to determine pod weight, pod length, pod width and number of seeds per pod. Total fresh yield was determined per plot and calculated as ton / fed. As for nodules parameters, the middle ridge in each plot was used to determine nodules number and weight per plant.

3- Plant chemical characteristics : Leaf pigment content (pigment A, B, and A+B) were determined according to A.O.A.C. (1965) . A representative sample of green seeds from the first picking of pea from each plot was oven dried at 70° till constant weight and then ground and wet digested according to Chapman and Pratt (1961) and the following determinations were done : Nitrogen was determined using micro-Kjeldahl method, P was determined colorimetrically and K by flame photometry. Fe, Mn, Zn, Cu, Cd, and Pb were determined by SP 90 atomic absorption spectrophotometer,

All data were statistically analyzed according to the method described by Snedecor and Cochran (1967). Where significant differences occurred, treatment means were separated by Fisher's least significant differences.

RESULTS AND DISCUSSION

1- Growth Characteristics:

Sewage sludge significantly increased pea growth as indicated by plant height, number of branches per plant, number of leaves per plant, specific leaf area and NAR in both seasons (Tables 2a&2b). The increases in these growth components, averaged over cultivar and phosphorine treatments, were 8.6cm, 10.8, 7.2, 41.5 gm/dm^2, and 9.1% as sludge rate increased from 5 to 10 m^3 / fed in the first season, respectively. Increasing sludge rate from 10 to 15 m^3/fed resulted in a further little but significant increase of 2.0 cm, 4.4, 1.9, 5.1 gm/dm^2, and 4.2%, respectively. Similar trend was observed in the second season. The increase in pea growth due to sewage sludge application may be attributed to its high content of plant nutrients, especially N and P; enhancing of soil physical properties, especially

Table 2a: Effect of cultivar , sludge, and phosphorine on plant heigt, number of branches per plant, number of leaves plant, specific leaf weight,SLW, and net assimilation rate, NAR in the first season, 1999-2000

Cultivar,C	Sludge,S	Plant height, cm			Branches/plant			Leaves/plant,no.			SLW., gm/dm^2			NAR, gm/dm^2/day		
		Phosphorine inoculation, P														
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	84.45	88.34	86.39	4.22	4.26	4.24	29.17	36.32	30.24	0.86	0.98	0.92	0.02	0.03	0.03
	S1	75.66	75.66	75.65	3.86	3.93	3.89	28.25	30.85	29.55	0.64	0.71	0.68	0.02	0.02	0.02
	S2	82.96	88.15	85.55	4.16	4.24	4.20	30.19	32.62	31.40	0.86	0.99	0.93	0.02	0.03	0.02
	S3	83.52	91.71	87.61	4.32	4.53	4.42	31.00	33.33	32.16	0.95	1.00	0.98	0.02	0.03	0.02
	mean	81.65	86.96	83.81	4.14	4.24	4.19	29.65	32.03	30.84	0.83	0.92	0.88	0.02	0.03	0.02
V. Freazer	Cont.	86.73	88.37	87.55	4.45	4.66	4.55	32.11	34.25	33.18	1.21	1.33	1.27	0.03	0.03	0.03
	S1	80.13	83.39	81.76	3.84	3.97	3.90	30.41	31.68	31.04	0.86	0.95	0.91	0.02	0.03	0.02
	S2	84.42	86.42	85.42	4.34	4.53	4.43	32.69	34.40	33.54	1.20	1.41	1.31	0.02	0.03	0.03
	S3	87.07	94.11	90.59	4.46	4.73	4.59	33.07	34.95	34.01	1.32	1.43	1.38	0.03	0.03	0.03
	mean	84.59	88.07	86.33	4.27	4.40	4.34	32.07	33.82	32.94	1.12	1.28	1.20	0.02	0.02	0.03
Mean	Cont.	85.59	88.35	86.86	4.33	4.46	4.39	30.64	32.78	31.71	1.04	1.15	1.10	0.01	0.03	0.03
	S1	77.89	79.52	78.71	3.85	3.95	3.89	26.33	30.96	30.29	0.75	0.83	0.79	0.02	0.02	0.02
	S2	83.69	87.28	85.48	4.25	4.38	4.31	31.44	33.51	32.47	1.04	1.20	1.12	0.02	0.03	0.02
	S3	85.29	92.91	87.10	4.39	4.63	4.50	32.03	34.14	33.08	1.14	1.22	1.18	0.02	0.03	0.03
	mean	83.12	87.14	84.52	4.20	4.32	4.27	30.86	32.92	31.89	0.98	1.56	1.05	0.02	0.03	0.02
LSD, 0.05																
Cult. (C)			1.26			0.12			0.04			0 04			0.00	
Sludge (S)			2.08			0.13			0.07			0.04			0.00	
C x S			2.41			0.21			NS			0.05			0.00	
Phosph. (P)			1.30			NS			NS			0.02			0.00	
C x S			2 15			NS			NS			NS			NS	
S x P			2.32			NS			NS			NS			NS	
C x S x P			NS			NS			NS			NS			NS	

Table 2b: Effect of cultivar, sludge, and phosphorine inoculation on plant height, mber of branches per plant, number of leaves per plant, specific leaf weight, SLW, and net assimilation rate, NAR of pea plants in the second season, 2000-2001.

Cultivar,C	Sludge,S	Plant height, cm			Branches/plant			Leaves/plant,no.			SLW., gm/dm^2			NAR,gm/dm^2/day		
		Phosphorine inoculation, P														
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	87.33	88.69	88.01	4.34	4.46	4.40	32.18	33.73	33.00	.808	.923	.865	.024	.027	.025
	S1	76.21	79.35	77.78	3.87	3.88	3.87	27.53	28.68	28.10	.732	.846	.789	.020	.022	.021
	S2	84.11	86.37	85.24	4.23	4.34	4.26	31.25	32.74	32.01	.886	.985	.935	.023	.024	.023
	S3	9238	94.20	93.29	4.41	4.56	4.48	32.17	33.43	32.90	1.01	1.13	1.07	.025	.029	.027
	mean	85.01	87.15	86.08	4.21	4.31	4.26	30.82	32.14	31.48	.860	.971	.916	.023	.025	.024
V. Freazer	Cont.	87.55	89.78	88.66	4.47	4.59	4.53	36.13	37.98	37.05	.956	.968	.962	.027	.028	.027
	S1	82.13	84.52	83.32	3.86	3.98	3.92	28.58	29.36	28.97	.882	.894	.888	.022	.024	.023
	S2	85.46	86.52	85.99	4.36	4.44	4.40	35.21	36.22	35.71	.967	.988	.977	.025	.023	.026
	S3	92.56	96.11	94.33	4.50	4.62	4.56	36.11	37.46	36.78	.981	1.03	1.01	.029	.030	.029
	mean	86.92	89.23	88.08	4.30	4.41	4.35	34.01	35.21	34.56	.946	.970	.958	.026	.027	.027
Mean	Cont.	87.44	89.23	88.33	4.40	4.52	4.46	34.20	35.85	35.02	.882	.945	.913	.025	.027	.026
	S1	79.17	81.93	80.55	3.86	3.93	3.89	28.05	29.02	28.10	.807	.870	.838	.021	.023	.022
	S2	84.78	43.69	85.61	4.29	4.39	4.34	33.25	34.48	33.51	.926	.986	.956	.024	.026	.024
	S3	92.47	95.15	93.81	4.45	4.59	4.52	34.14	35.44	34.79	.997	1.82	1.04	.027	.029	.028
	mean	85.60	88.19	87.07	4.25	4.36	4.30	32.44	33.67	32.86	.903	.970	.936	.024	.026	.025
LSD, 0.05																
Cult. (C)			1.45			0.08			0.14			.012			.002	
Sludge (S)			1.72			0.14			0.03			.021			.001	
C x S			2.15			0.18			NS			.025			.002	
Phosph. (P)			1.09			0.11			NS			.033			.001	
C x S			2.00			NS			NS			NS			NS	
S x P			2.17			NS			NS			NS			NS	
C x S x P			NS			NS			NS			NS			NS	

Table 3a: Effect of cultivar, sludge, and phosphorine inoculation on pod length, pod weight, pod width, and number of seeds/pod of pea plants in 1999-2000 season.

Cultivar,C	Sludge,S	Pod length, cm			Pod weight, cm			Pod width, cm			Seeds/ pod, no.		
		Phosphorine inoculation, P											
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	7.69	8.25	7.97	4.18	4.23	4.20	1.20	1.22	1.21	4.60	4.72	4.66
	S1	7.45	7.64	7.54	3.72	3.87	3.79	1.19	1.20	1.19	4.37	4.47	4.52
	S2	8.12	8.23	8.17	4.26	4.29	4.27	1.21	1.23	1.22	4.57	4.68	4.62
	S3	8.23	8.46	8.34	4.32	4.38	4.35	1.21	1.24	1.22	4.69	4.75	4.72
	mean	7.87	8.14	8.08	4.12	4.19	4.15	1.20	1.22	1.21	4.56	4.65	4.60
V. Freazer	Cont.	8.70	8.79	8.74	4.30	4.41	4.35	1.22	1.24	1.23	7.62	7.88	7.75
	S1	8.61	8.93	8.77	4.20	4.22	4.21	1.20	1.22	1.21	7.23	7.35	7.24
	S2	9.26	9.43	9.34	4.36	4.57	4.46	1.23	1.24	1.23	7.56	7.76	7.66
	S3	9.36	9.52	9.44	4.39	4.47	4.43	1.23	1.25	1.24	7.74	7.85	7.79
	mean	8.98	9.17	9.07	4.31	4.42	4.36	1.22	1.24	1.23	7.54	7.71	7.62
Mean	Cont.	8.19	8.52	8.35	4.24	4.32	4.27	1.21	1.23	1.22	6.11	7.80	6.20
	S1	8.02	8.28	8.15	3.96	4.04	4.00	1.19	1.21	1.20	5.80	5.91	5.85
	S2	8.69	8.83	8.75	4.31	4.43	4.36	1.22	1.23	1.22	6.06	6.22	6.14
	S3	8.79	8.99	8.89	4.35	4.42	4.39	1.22	1.24	1.23	6.21	6.30	6.25
	mean	8.42	8.65	8.53	4.21	4.30	4.25	1.21	1.23	1.22	6.07	6.56	6.11
LSD, 0.05													
Cult. (C)			0.11			0.06			0.01			0 02	
Sludge (S)			0.12			0.02			NS			NS	
C x S			0.17			0.12			NS			NS	
Phosph. (P)			0.13			NS			NS			NS	
C x S			0.34			NS			NS			NS	
S x P			Ns			NS			NS			NS	
C x S x P			NS			NS			NS			NS	

Table 3b: Effect of cultivar, sludge, and phosphorine inoculation on pod characters of pea plants in the secod season, 2000-2001.

Cultivar,C	Sludge,S	Pod lengtt, cm			Pod wei ,ht, gm			Pod width, cm			Seeds/pod, no.		
		Phosphorine inoculation, P											
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	8.20	8.34	8.27	4.20	4.30	4.25	1.25	1.25	1.25	4.62	4.69	4.65
	S1	7.75	7.81	7.78	3.78	3.98	3.88	1.21	1.22	1.21	4.26	4.33	4.29
	S2	8.22	8.35	8.28	4.19	4.27	4.23	1.24	1.25	1.24	4.58	4.67	4.62
	S3	8.40	8.55	8.47	4.22	4.35	4.28	1.26	1.26	1.26	4.69	4.71	4.70
	mean	8.14	8.26	8.20	4.01	4.22	4.16	1.24	1.24	1.24	4.54	4.60	4.56
V. Freazer	Cont.	9.18	9.51	9.34	4.35	4.48	4.41	1.27	1.30	1.28	7.82	7.97	7.89
	S1	8.75	9.06	8.90	4.20	4.26	4.23	1.15	1.16	1.15	6.59	6.79	6.69
	S2	9.17	9.51	9.34	4.34	4.46	4.40	1.25	1.25	1.25	7.81	7.97	7.84
	S3	9.38	9.72	9.55	4.37	4.50	4.43	1.30	1.33	1.31	7.83	7.98	7.90
	mean	9.12	9.45	9.28	4.31	4.42	4.37	1.24	1.26	1.25	7.51	7.68	7.59
Mean	Cont.	8.69	8.92	8.80	4.27	4.39	4.33	1.26	1.27	1.26	6.22	6.33	6.27
	S1	8.25	8.43	8.34	3.99	4.12	4.05	1.18	1.19	1.18	5.42	5.56	5.49
	S2	8.69	8.93	8.81	4.26	4.36	4.31	1.24	1.25	1.24	6.19	6.32	6.25
	S3	8.89	9.13	9.01	4.29	4.42	4.35	1.28	1.29	1.28	6.26	6.34	6.30
	mean	8.69	8.85	8.74	4.20	4.32	4.26	1.24	1.25	1.24	6.02	6.14	6.08
LSD, 0.05													
Cult. (C)		0.32			0.05			NS			0.02		
Sludge (S)		0.16			0.03			NS			NS		
C x S		0.20			0.11			NS			NS		
Phosph. (P)		0.14			NS			NS			NS		
C x S		NS			NS			NS			NS		
S x P		NS			NS			NS			NS		
C x S x P		NS			NS			NS			NS		

water holding capacities (Abdel-Sabour *et. al.*, 1997) and / or growth stimulation by its organic compounds (Chen and Avid, 1990; Lee and Bartlett, 1976). These results are in agreement with those of Arisha and Abd EL-Bary (2000). Comparing sewage sludge application against the chemical NPK fertilization (control), data in Tables 2a&2b reveal that the 15 m^3 / fed rate was, in general, significantly better than NPK fertilization treatment in increasing growth components. On the other hand, 5 m^3 / fed was less than the control while 10 m^3 / fed did not show a certain trend.

Phosphorine inoculation significantly increased the above mentioned growth characteristics in both seasons except number of branches per plant in the first season and number of leaves per plant in both seasons (Tables 2a & 2b). The stimulation effect of phosphorine on pea growth could be a result of releasing originally bound phosphorus compounds in soil (Osman *et. al.*, 1974) and releasing ammonia from complex nitrogen compounds (Saber *et. al.*, 1981).

Pea cultivars significantly difered in their responses for growth characteristics, Victory Freezer cultivar exhibited higher values of plant height, number of branches and leaves per plant, specific leaf weight, and NAR than Lencolen one. These results are in agreement with those of EL-Asdoudi and Ouf (1994), who declared that growth characteristics are cultivar dependent.

Data in Tables 2a & 2b show also that number of branches per plant, specific leaf weight, and NAR were significantly affected by cultivar x sludge interaction, while plant height was significantly affected by all the first order interactions; viz. cultivar x sludge, cultivar x phosphorine, and sludge x phosphorine interactions.

2- :Pod Characteristics

Pod length and weight were significantly affected by sludge application, the growing cultivar, and the interaction among them. Sludge and phosphorine treatments had no significant effect on pod width and number of seeds per pod (Tables 3a &3b). Pod length and weight increased from 8.15 cm and 4.00 gm to 8.76 cm and 4.36 gm as sludge rate increased from 5 to 10 m^3 / fed and to 8.89 cm and 4.39 gm as sludge rate increased to 15 m^3 / fed, in the first season, respectively. Similar results were observed in the second season. Victory Freezer was superior to Lencolen cultivar in pod characteristics..

3- Nodulation

Nodules number and weight per plant were significantly influenced by sludge application and phosphorine inoculation and did not significantly differ between the two cultivars (Tables 4a & 4b). Both number and weight of nodules were increased as a result of sludge application. However, 10 m^3 / fed gave the highest values of these variables. These results agreed with those reported by Rifaat and Gendy (1996). In comparison with the conventional NPK fertilization (Control), nodulation of plants treated with 15 m^3 sludge / fed was comparable while those of plants treated with 5 or 10 m^3 sludge / fed were significantly less and greater than the control, respectively.

Table 4a: Effect of cultivar, sludge, and phosphorine inoculation on nodules number and weight per plant, seed fresh yield, and earliness index of pea plants in 1999-2000 season.

Cultivar,C	Sludge,S	Nodules/plant, no.			Nodules wt, gm			Earliness index,%			Seed yield,ton/fed		
		Phosphorine inoculation, P											
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	30.68	32.21	31.44	1.62	1.76	1.69	41.20	42.50	41.85	2.589	2.675	2.632
	S1	22.81	24.16	23.48	1.52	1.61	1.56	44.62	46.70	45.66	2.576	2.631	2.603
	S2	31.05	32.64	31.84	1.73	1.86	1.79	42.10	43.37	42.73	2.888	2.907	2.897
	S3	30.61	31.76	31.18	1.52	1.59	1.55	40.33	41.26	40.39	3.122	3.488	3.305
	mean	28.79	30.19	29.49	1.60	1.70	1.65	42.06	43.46	42.76	2.794	2.925	2.859
V. Freazer	Cont.	28.45	31.72	30.08	1.45	1.82	1.63	35.12	36.02	35.57	3.451	3.572	3.511
	S1	23.61	24.80	24.20	1.43	1.56	1.49	44.17	45.20	44.68	2.789	2.979	2.884
	S2	35.78	37.38	36.58	1.92	2.11	2.01	36.15	37.08	36.61	3.521	3.694	3.607
	S3	29.52	31.21	30.36	1.52	1.83	1.67	35.18	37.89	36.53	3.636	3.892	3.714
	mean	29.34	31.28	30.31	1.58	1.88	1.70	37.65	39.05	38.35	3.349	3.534	3.440
Mean	Cont.	29.56	31.96	30.76	1.53	1.79	1.66	38.16	39.26	38.71	3.020	3.123	3.071
	S1	35.01	24.48	23.84	1.47	1.58	1.52	44.39	45.95	45.17	2.682	2.805	2.749
	S2	33.41	35.01	34.21	1.82	1.98	1.90	39.12	40.22	39.67	2.204	3.300	3.252
	S3	30.06	31.48	30.77	1.52	1.71	1.61	37.75	39.57	38.66	3.379	3.690	3.534
	mean	29.06	30.73	29.89	1.59	1.76	1.67	39.85	41.25	40.55	3.071	3.229	3.150
LSD, 0.05													
Cult. (C)			NS			NS			1.02			0.172	
Sludge (S)			1.23			0.21			1.35			0.167	
C x S			NS			NS			2.03			0.202	
Phosph. (P)			0.06			0.11			0.87			0.069	
C x S			NS			NS			NS			0.213	
S x P			NS			NS			NS			NS	
C x S x P			NS			NS			NS			NS	

Table 4b: Effect of cultivar, sludge, and phosphorine inoculation on nodules number and weight per plant, seed fresh yield, and earliness index of pea plant in 2000-2001 seasons

Cultivar,C	Sludge,S	Nodules/plant, no.			Nodules wt/plant, gm			Earliness index,%			Fresh yield, ton/fed		
		Phosphorine inoculation, P											
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	25.81	32.93	29.37	1.79	1.98	1.88	40.25	43.20	41.72	2.670	2.750	2.710
	S1	23.64	24.70	24.17	1.60	1.71	1.65	47.53	48.21	47.87	1.760	1.952	1.856
	S2	31.76	34.51	33.13	2.02	2.13	2.07	41.73	42.10	41.86	2.730	2.839	2.784
	S3	28.42	30.35	29.38	1.75	1.92	1.83	42.00	44.55	43.27	2.950	2.998	2.974
	mean	27.41	30.62	29.01	1.79	1.93	1.86	42.86	44.51	43.68	2.527	2.635	2.581
V. Freazer	Cont.	27.22	31.64	29.43	1.72	1.93	1.82	40.10	41.20	40.65	3.000	3.430	3.215
	S1	24.17	25.56	24.86	1.48	1.50	1.49	43.13	45.77	44.45	2.416	2.787	2.601
	S2	33.98	36.76	35.37	2.54	2.69	2.61	40.09	43.79	41.94	2.895	3.226	3.060
	S3	28.50	30.81	28.65	1.87	1.95	1.91	41.60	42.37	41.98	3.226	3.887	3.556
	mean	27.92	31.19	29.58	1.90	2.02	1.96	41.23	43.28	42.23	2.884	3.332	3.108
Mean	Cont.	26.51	32.28	29.40	1.75	1.95	1.85	40.17	42.20	41.18	2.835	3.090	2.962
	S1	23.90	25.13	24.51	1.54	1.60	1.57	45.33	46.99	46.16	2.088	2.369	2.228
	S2	32.87	35.63	34.25	2.28	2.36	2.34	40.91	42.94	44.90	2.812	3.032	2.922
	S3	27.46	30.58	29.01	1.81	1.93	1.87	41.80	43.46	42.62	3.088	3.442	3.265
	mean	27.67	30.91	29.29	1.85	1.97	1.91	42.05	43.90	42.96	2.706	2.983	2.844
LSD, 0.05													
Cult. (C)		NS			NS			0.66			0.143		
Sludge (S)		2.35			0.09			0.35			0.078		
C x S		NS			NS			1.09			0.189		
Phosph. (P)		1.05			0.05			0.22			0.054		
C x S		NS			NS			NS			NS		
S x P		NS			NS			NS			NS		
C x S x P		NS			NS			NS			NS		

Phosphorine inoculation significantly increased number and weight of nodules per plant in both seasons (Tables 4a &4b). This could be attributed to the role of phosphorine in many enzymatic reactions in plant which depend on phosphorylation and its essentiality for cell division and also for the development of meristem tissues (Russell, 1973). These results are in agreement with those of Rifaat and Gendy (1996).

4- Fresh Yield and Earliness Index:

Pea fresh yield progressively and significantly increased with increasing sludge application rate (Tables 4a & 4b). Fresh yield of Lencolen cultivar in the first season increased from 2.603 to 2.897 and 3.306 ton / fed as sludge rate increased from 5 to 10 and 15 m^3 / fed, respectively. The corresponding increases for Victory Freezer cultivar were from 2.884 to 3.607 and 3.764 ton / fed, respectively. Similar trends were observed in the second season. The positive respond of pea yield to the applied sludge could be attributed to the improvement in soil chemical, physical, and biological properties and organic matter content due to sludge application, as the studied soil was poor in these constituents (Table 1). These results are in harmony with those of Ozores-Hampton et. al., 1994 and Arisha and Abd EL-Bari, 2000. The yield data showed that pea fresh yields from the high sludge application rate(15 m^3/fed) were significantly higher than those from NPK fertilization. However, plants treated with 5 m^3 / fed produced less fresh yield than those treated with the conventional NPK fertilization.

Phosphorine inoculation significantly increased fresh yields in the two seasons. The increases were 5 and 10 % in the first and second seasons, respectively. The beneficial effect of phosphorine could be attributed to its role in making P available to the plant (Gaur *et. al.*, 1979) and producing growth promoting substances (Brown, 1974) which may improve plant growth and stimulate the microbial development (Lue *et. al.*, 1958) These results are in agreement with those of Saber *et. al.* (1981)

Pea cultivars significantly differed in their fresh yield production. Victory Freezer was superior to Lencolen cultivar.

Earliness Index significantly decreased with increasing sludge application rate, while it did increase due to phosphorine inoculation (Tables 4a & 4b). Data show also that Lencolen cultivar matured earlier than Victory Freezer one.

5- Leaf Pigment Contents

Leaf content of A-, B-, and (A+B)-pigment and carotenoides progressively and significantly increased with increasing sludge application rate in both seasons (Table 5a & 5b). Comparing with the NPK fertilization treatment (control), plots treated with 15 m^3 sludge/fed produced plants with higher content of leaf pigments while those treated with 5 or 10 m^3/fed were less than or comparable to the control , respectively

Phosphorine inoculation did not significantly affect leaf pigment contents except pigment A and pigment B in the first season.

Pea cultivars significantly differed in their leaf pigment and carotenoid contents, though they did not show a certain trend.

Table 5a: Effect of cultivar, sludge, and phosphorine inoculation on leaf pigment contents of pea plants in 1999-2000 growing season.

Cultivar,C	Sludge,S	Pigment A, mg/100g			Pigment B, mg/100g			(A+B), mg/100g			Carotenoides,mg/100g		
		Phosphorine inoculation, P											
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	81.6	79.7	80.6	52.7	53.6	53.2	134.3	131.4	134.3	29.8	31.7	16.5
	S1	68.5	58.5	63.5	23.6	26.1	24.9	92.1	86.7	89.4	18.7	17.2	18.0
	S2	80.6	75.7	78.1	53.4	54.0	53.7	134.0	128.4	131.2	28.6	26.32	27.5
	S3	81.8	79.8	80.8	54.7	53.6	54.2	136.5	133.4	134.9	31.0	34.3	33.7
	mean	78.12	73.4	75.8	46.1	46.8	46.5	124.2	120.7	122.1	27.0	27.4	23.7
V. Freazer	Cont.	82.5	81.6	82.0	28.2	26.2	27.2	110.7	137.0	123.5	13.2	11.7	12.5
	S1	67.6	54.6	61.1	30.5	29.3	29.9	98.1	84.9	91.9	19.7	18.6	19.2
	S2	81.2	81.5	81.4	46.7	58.3	52.5	122.9	136.1	132.0	27.6	29.4	28.5
	S3	83.3	84.3	83.8	50.0	60.2	55.1	133.3	142.0	137.6	33.0	35.0	34.0
	mean	78.65	75.5	72.2	38.9	43.5	41.2	117.5	125.0	121.3	23.4	23.7	23.5
Mean	Cont.	82.05	80.68	81.3	40.5	39.9	40.2	122.5	135.7	28.9	21.5	21.7	14.5
	S1	68.05	56.55	62.3	27.1	27.7	27.4	95.1	85.8	90.7	19.2	17.9	18.6
	S2	80.90	78.6	79.7	50.1	56.2	53.1	131.0	132.3	131.6	28.1	27.86	28.0
	S3	82.55	82.1	82.3	52.3	56.9	53.5	134.9	137.7	136.3	32.0	34.65	33.3
	mean	78.36	74.5	76.4	42.5	45.2	47.2	120.9	122.9	121.9	25.2	25.5	23.6
LSD, 0.05													
Cult. (C)			2.1			0.7			0.3			NS	
Sludge (S)			3.2			1.2			2.2			2.1	
C x S			4.1			2.1			3.0			NS	
Phosph. (P)			1.4			0.8			NS			NS	
C x S			NS			NS			NS			NS	
S x P			2.2			NS			3.1			NS	
C x S x P			NS			NS			NS			NS	

Table 5b: Effect of cultivar, sludge, and phosphorine inoculation on leaf pigmen contents of pea plants in 2000-2001 growing season.

Cultivar,C	Sludge,S	Pigment A, mg/100g			Pigment B, mg/100g			Pigment(A+B), 100g/g			Carotenoides, mg/100g		
		Phosphorine inoculation, P											
		P0	P1	mean	P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	78.7	68.4	73.6	54.1	54.7	54.4	132.8	123.1	127.9	33.6	32.7	33.18
	S1	62.5	61.3	61.9	27.3	28.2	27.8	89.8	89.5	89.6	18.2	17.7	17.98
	S2	76.7	72.6	74.5	55.6	52.7	54.2	132.3	125.3	128.8	29.3	27.1	28.2
	S3	80.4	32.2	81.3	55.5	53.6	54.5	135.9	135.7	135.8	32.5	35.3	33.9
	mean	74.6	71.1	72.8	48.1	47.3	47.7	122.7	118.4	120.5	28.4	28.2	28.3
V. Freazer	Cont.	35.0	36.0	35.5	50.3	55.4	52.9	85.3	91.4	88.4	12.2	12.0	12.1
	S1	64.6	67.3	66.0	32.5	30.3	31.4	97.1	97.6	97.3	18.8	18.0	18.0
	S2	82.5	80.1	81.3	50.6	54.6	52.6	133.1	134.7	133.9	28.4	29.2	28.8
	S3	83.8	85.3	84.6	51.5	57.7	54.6	135.3	143.0	139.1	30.5	35.7	33.1
	mean	66.5	61.2	66.8	46.2	49.5	47.9	112.7	116.7	114.7	22.5	23.7	23.1
Mean	Cont.	56.9	52.2	54.6	52.2	55.1	53.6	109.1	107.3	108.1	22.9	22.4	22.6
	S1	62.6	64.3	63.9	29.9	29.3	29.6	93.5	93.6	93.5	18.5	17.9	18.15
	S2	79.6	76.4	77.9	53.1	53.7	53.4	132.7	130.0	131.4	28.8	28.2	28.5
	S3	82.1	82.7	82.9	53.5	55.6	54.6	135.6	139.4	137.5	31.5	35.5	33.5
	mean	70.5	69.1	69.8	47.2	48.4	47.8	117.7	117.6	117.6	25.4	25.9	25.7
LSD, 0.05													
Cult. (C)			1.2			1.1			1.2			1.3	
Sludge (S)			2.2			1.3			2.0			2.4	
C x S			3.2			2.1			2.3			NS	
Phosph. (P)			NS			0.5			NS			NS	
C x S			NS			NS			NS			NS	
S x P			3.1			NS			3.1			NS	
C x S x P			NS			NS			NS			NS	

A sewage sludge x cultivar interaction occurred for leaf contents of A, B, and A+B pigments in both seasons.

6- Seed Elemental Composition

Concentrations of N and P significantly increased in fresh pea seeds with increasing sewage sludge application rate or phosphorine inoculation, while K concentration was not significantly affected (Table 6a & 6b). These results confirmed those of Saber *et. al* (1981) and Arisha and Abd EL-Bari (2000). Seeds of plants treated with 15 m^3 sludge/fed contained significantly higher concentrations of N and P than those of plants treated with chemical NPK fertilizers. However, differences between NPK treatment and both of 5 and 10 m^3 sludge/fed did not show a certain trend (Tables 6a & 6b).

Table 6a: Effect of cultivar, sludge, and phosphorine inoculation on N, P, and K concentrations of pea seeds in 1999-2000 season.

Cultivar,C	Sludge,S	N, %			P, %			K, %		
		Phosphorine inoculation, P								
		P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	2.31	2.32	2.31	0.26	0.29	0.27	2.48	2.57	2.52
	S1	2.13	2.22	2.17	0.24	0.28	0.26	2.50	2.51	2.50
	S2	2.25	2.31	2.28	0.27	0.30	0.27	2.55	2.58	2.53
	S3	2.30	2.32	2.31	0.29	0.32	0.30	2.60	2.62	2.61
	mean	2.25	2.29	2.27	0.26	0.30	0.27	2.53	2.57	2.57
V. Freazer	Cont.	2.10	2.00	2.05	0.29	0.32	0.30	2.48	2.50	2.49
	S1	2.32	2.40	2.36	0.22	0.26	0.24	2.47	2.51	2.49
	S2	2.33	2.47	2.40	0.28	0.32	0.30	2.56	2.58	2.42
	S3	2.41	2.60	2.45	0.30	0.33	0.31	2.56	2.60	2.58
	mean	2.29	2.34	2.31	0.27	0.31	0.29	2.52	2.55	2.50
Mean	Cont.	2.20	2.16	2.18	0.27	0.30	0.28	2.48	2.53	2.50
	S1	2.22	2.31	2.26	0.23	0.27	0.25	2.48	2.51	2.49
	S2	2.29	2.39	2.34	0.27	0.31	0.28	2.55	2.54	2.47
	S3	2.35	2.41	2.38	0.29	0.32	0.30	2.58	2.61	2.59
	mean	2.26	2.32		0.26	0.30		2.52	2.55	
LSD, 0.05										
Cult. (C)			NS			NS			NS	
Sludge (S)			0.05			0.01			NS	
C x S			NS			NS			NS	
Phosph. (P)			0.04			0.02			NS	
C x S			ns			NS			NS	
S x P			NS			0.03			NS	
C x S x P			NS			NS			NS	

Concentrations of N, P, and K in fresh pea seeds did not significantly differ between the studied two cultivars. These results are in partial agreement with those of Abd EL-Ati *et. al.* (2000).

With respect to heavy metal concentrations of fresh pea seeds, data in Tables 7a & 7b show that Fe, Nn, Zn, Cu, Pb, and Cd concentrations progressively and consistently increased with increasing sludge application rate. However, the increase in Pb and Cd concentrations was very low. As expected, plants treated with sewage sludge exhibited higher concentrations of these elements than those treated with chemical NPK fertilizers. Concentration ranges of these elements were Fe, 1.66 to 5.61; Mn, 0.51 to

1.69; Zn, 1.36 to 4.02; Cu, 0.11 to 1.44; Pb, 0.01 to 0.14; and Cd, n.d. to 0.06 ppm. These concentration ranges are far below the suggested tolerance levels as reported by the Egyptian Agency for Codex Standards (1993). These results are in agreement with those reported by Arisha and Abd EL-Bari (2000).

Data in Tables 7a & 7b show also that differences in heavy metal concentrations among inoculated and Uninoculated plants were negligible . It further show that Victory Freezer cultivar accumulated relatively higher amounts of these elements than Lencolen cultivar.

In conclusion, Sewage sludge addition either solely or in combination with phosphorine increased fresh yield and yield components of pea. Pea yield consistently and progressively increased with increasing sludge rate up to 15 m^3 /fed with no apparent problems with heavy metals accumulation in pea seeds. Pea yields of plants treated with the highest rate of sludge (15 m^3 /fed) were greater than those treated with the chemical NPK fertilization. Victory Freezer cultivar over yielded Lencolen one. Victory Freezer pea cultivar inoculated with phosphorine and fertilized with 15 m^3 /fed sludge gave the highest fresh yield.

Table 6b: **Effect of cultivar, sludge, and phosphorine inoculation on N, P,and K concentration of pea seeds in 2000-2001 season.**

Cultivar,C	Sludge,S	N, %			P, %			K, %		
		Phosphorine inoculation, P								
		P0	P1	mean	P0	P1	mean	P0	P1	mean
Lencolen	Cont.	2.29	2.31	2.30	0.26	0.28	0.27	2.60	2.75	2.67
	S1	2.20	2.23	2.21	0.22	0.23	0.22	2.43	2.51	2.48
	S2	2.24	2.26	2.25	0.25	0.26	0.25	2.60	2.60	2.80
	S3	2.28	2.34	2.31	0.27	0.28	0.27	2.71	2.75	2.73
	mean	2.25	2.28	2.27	0.25	0.26	0.25	2.58	2.65	2.61
V. Freazer	Cont.	2.31	2.33	2.32	0.27	0.28	0.27	2.53	2.63	2.58
	S1	2.34	2.34	2.34	0.23	0.24	0.23	2.50	2.54	2.52
	S2	2.35	2.36	2.35	0.26	0.27	0.26	2.57	2.62	2.59
	S3	2.35	2.35	2.35	0.29	0.28	0.28	2.60	2.70	2.65
	mean	2.34	2.34	2.34	0.25	0.27	0.26	2.55	2.62	2.58
Mean	Cont.	2.30	2.32	2.31	0.26	0.28	0.27	2.56	2.69	2.62
	S1	2.27	2.28	2.27	0.22	0.23	0.22	2.46	2.52	2.49
	S2	2.29	2.31	2.30	0.25	0.26	0.25	2.58	2.61	2.59
	S3	2.31	2.34	2.33	0.28	0.28	0.28	2.65	2.72	2.69
	mean	2.29	2.31		0.25	0.26		2.56	2.63	
LSD, 0.05										
Cult. (C)			NS			NS			NS	
Sludge (S)			0.02			0.01			NS	
C x S			NS			NS			NS	
Phosph. (P)			0.01			0.01			NS	
C x S			NS			NS			NS	
S x P			NS			0.02			NS	
C x S x P			NS			NS			NS	

Table 7a: Effect of cultivar, sludge, and phosphorine inoculation on Fe, Mn, and Zn concentration of pea seeds in 1999-2000, and 2000-2001 seasons.

Cultivar,C	Sludge,S	Fe, ppm			Mn, ppm			Zn, ppm		
		Phosphorine inoculation, P								
		P0	P1	mean	P0	P1	mean	P0	P1	mean
1999 - 2000 Growing season										
Lencolen	Cont.	1.85	2.1	1.93	0.64	0.68	0.66	1.50	1.62	1.56
	S1	2.50	2.52	2.41	0.89	1.01	0.95	1.88	2.03	1.96
	S2	3.64	3.14	3.39	1.38	1.42	1.40	2.16	3.00	2.58
	S3	4.11	4.75	4.43	1.26	1.60	1.43	3.27	3.35	3.31
	mean	2.98	3.11	3.05	1.04	1.18	1.11	2.20	2.50	2.35
V. Freazer	Cont.	1.90	2.21	2.06	0.51	0.82	0.67	1.74	1.71	1.73
	S1	1.89	2.53	2.21	1.00	1.12	1.06	2.10	2.43	2.27
	S2	3.02	3.68	3.35	1.24	1.38	1.31	3.25	3.55	3.42
	S3	5.42	5.61	5.52	1.63	1.69	1.66	4.02	3.90	3.99
	mean	3.06	3.51	3.28	1.10	1.25	1.18	2.78	2.91	2.85
Mean	Cont.	1.88	2.11	2.00	0.58	0.75	0.67	1.62	1.65	1.65
	S1	2.10	2.53	2.32	0.95	1.07	1.01	1.99	2.23	2.12
	S2	3.33	3.41	3.37	1.31	1.40	1.36	2.71	3.28	2.99
	S3	4.77	5.03	4.90	1.45	1.65	1.55	3.86	3.66	3.65
	mean	3.02	3.31	3.17	1.07	1.22	1.15	2.49	2.71	2.60
2000 - 2001 Growing season										
Lencolen	Cont.	1.66	1.87	1.77	0.61	0.73	0.67	1.36	1.48	1.42
	S1	2.10	2.34	2.22	0.66	0.82	0.74	1.58	1.73	1.66
	S2	2.97	3.00	2.99	1.13	1.24	1.19	2.06	2.82	2.44
	S3	3.85	4.23	4.04	1.19	1.53	1.36	3.14	3.26	3.20
	mean	2.65	2.86	2.76	0.90	1.08	0.99	2.04	2.32	2.18
V. Freazer	Cont.	1.72	2.14	1.93	0 80	1.22	1.01	1.44	1.50	1.47
	S1	2.13	2.55	2 34	0.79	0.99	0 89	1.86	2.11	1.99
	S2	2.84	3.12	2.98	1.30	1.43	1.32	2.77	2.73	2.75
	S3	4.00	4.68	4.34	1.50	1.62	1.56	3.52	3.86	3.69
	mean	2.67	3.12	2.90	1.10	1.32	1.21	2.40	2.55	2.48
Mean	Cont.	1.69	2.01	1.85	0.71	0.98	0 84	1.40	1.49	1.45
	S1	2.12	2.45	2 28	0.73	0.91	0.82	1.72	1.92	1.82
	S2	2.91	3.06	2.98	1.22	1.34	1.28	2.42	2.78	2.60
	S3	3.92	4 46	4.19	1 35	1.58	1.46	3.33	3.56	3.45
	mean	2.66	2.99	2 83	1.00	1.20	1.10	2.22	2.44	2.33

Table 7b: Effect of cultivar, sludge, and phosphorine inoculation on Cu, Pb, and Cd cocentrations of pea seeds in 1999-2000, and 2000-2001 seasons

Cultivar,C	Sludge,S	Fe, ppm			Mn, ppm			Zn, ppm		
		Phosphorine inoculation, P								
		P0	P1	mean	P0	P1	mean	P0	P1	mean
1999 - 2000 Growing season										
Lencolen	Cont.	0.13	0.13	0.13	0.02	.02	0.02	n.d.	n.d.	n.d.
	S1	0.16	0.22	0.19	0.03	0.04	0.03	0.01	0.02	0.02
	S2	0.73	0.85	0.79	0.05	0.04	0.04	0.03	0.03	0.03
	S3	1.05	1.16	1.11	0.09	0.11	0.10	0.03	0.05	0.04
	mean	0.52	0.59	0.56	0.05	0.05	0.05	0.02	0.03	0.02
V. Freazer	Cont.	0.24	0.23	0.24	0.02	0.03	0.03	n.d.	n.d.	n.d.
	S1	0.72	0.60	0.66	0.03	0.04	0.04	0.02	0.02	0.02
	S2	1.32	1.25	1.29	0.08	0.07	0.08	0.04	0.03	0.04
	S3	1.21	1.44	1.33	0.12	0.14	0.13	0.05	0.06	0.06
	mean	0.87	0.88	0.88	0.06	0.07	0.07	0.03	0.03	0.03
Mean	Cont.	0.19	0.18	0.19	0.02	0.03	0.03	n.d.	n.d.	n.d.
	S1	0.44	0.41	0.43	0.03	0.04	0.04	0.02	0.02	0.02
	S2	1.08	1.05	1.04	0.07	0.06	0.06	0.04	0.03	0.04
	S3	1.13	1.30	1.22	0.11	0.13	0.12	0.04	0.06	0.05
	mean	0.70	0.74	0.72	0.06	0.06	0.06	0.03	0.03	0.03
2000 - 2001 Growing season										
Lencolen	Cont.	0.11	0.15	0.13	0.01	0.02	0.02	n.d.	n.d.	n.d.
	S1	018	0.20	0.19	0.03	0.03	0.03	0.01	0.02	0.02
	S2	0.65	0.66	0.65	0.03	0.05	0.04	0.02	0.03	0.03
	S3	0.87	1.12	1.00	0.07	0.10	0.09	0.03	0.04	0.04
	mean	0.45	0.53	0.49	0.04	0.05	0.05	0.02	0.02	0.02
V. Freazer	Cont.	0.20	0.18	0.19	0.02	0.02	0.02	n.d.	n.d.	n.d.
	S1	0.53	0.46	0.50	0.03	0.03	0.03	0.02	0.02	0.02
	S2	0.85	0.88	0.87	0.08	0.08	0.08	0.03	0.03	0.03
	S3	1.11	1.25	1.18	0.11	0.12	0.12	0.04	0.05	0.05
	mean	0.67	0.69	0.68	0.06	0.06	0.06	0.02	0.03	0.03
Mean	Cont.	0.16	0.17	0.16	0.02	0.02	0.02	n.d.	n.d.	n.d.
	S1	0.36	0.33	0.35	0.03	0.03	0.03	0.02	0.02	0.02
	S2	0.75	0.77	0.76	0.06	0.07	0.06	0.03	0.03	0.03
	S3	0.99	1.19	1.09	0.08	0.11	0.10	0.04	0.05	0.05
	mean	0.56	0.61	0.59	0.05	0.06	0.06	0.02	0.03	0.03

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تأثير حماة المجاري و التلقيح بالفوسفورين و السلالة علي النمو والمحصول واالتركيب المعدني لبذور البسلة تحت ظروف أراضي الإستصلاح الحديثة

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أجريت تجربتان حقليتان غرب مدينة الفشن بمحافظة بني سويف تحت ظروف الأراضي المستصلحة حديثا وكانت التربة رملية طميية، خلال الموسمين الشتويين لعامي ١٩٩٩-٢٠٠٠، ٢٠٠٠ -٢٠٠١ بهدف دراسة تأثير إضافة حماة المجاري والتلقيح البكتيرى بالفوسفورين على النمو و الإنتاجية ومحتوى البذور من العناصر الكبرى والثقيلة لسلالتين من البسلة، ومقارنة ذلك بالتسميد الكيماوى. وقد شملت التجربة ستة عشر معاملة وهى كل التوافيق بين سلالتين من البسلة (لنكولن و فيكتورى فريزر) و مستويين من التلقيح بالفوسفورين (ملقحة وغير ملقحة) وأربع مستويات من حماة المجارى(صفر، ٥،١٠، ١٥م^{3} فدان$^{-1}$) وأضيفت مستويات من التسميد الكيماوى الموصى بها لمعاملات المقارنة فقط.

أدى إستخدام حماة المجارى وكذلك التلقيح بالفوسفورين إلى زيادة معنوية فى المحصول الطازج للبسلة وطول النبات وعدد الأفرع و الأوراق لكل نبات والوزن النوعى للورقة ومعدل التمثيل الصافى وطول ووزن القرون وعدد ووزن العقد الجذرية لكل نبات ومحتوى الورقة من الصبغات(أ ، ب)، ولم يتأثر معنويا كل من عرض القرون وعدد البذور لكل قرن. كما أدى إستخدام حماة المجارى والتلقيح بالفوسفورين ايضا الى زيادة محتوى البذور من النيتروجين والفوسفور بينما لم يتأثر محتواها من البوتاسيوم. أدى إستخدام حماة المجارى إلى زيادة محتوى البذور من العناصر الثقيلة مثل الحديد والزنك والمنجنيز والنحاس والرصاص والكاديوم، لكن تركيزات هذه العناصر كانت منخفضة بصفة عامة ولم تتجاوز الحدود المسموح بها. وقد تفوقت سلالة فيكتورى فريزر عن سلالة لنكولن من حيث المحصول والصفات تحت الدراسة، إلا أن الأخيرة كانت مبكرة النضج عن الأولى.

أوضحت الدراسة أن إضافة حماة المجارى عند مستوى ١٥م^{3} فدان$^{-1}$ سواء منفردا أو مع التلقيح بالفوسفورين أعطى محصولا أعلى معنويا من التسميد الكيماوى ، بينما لم تكن هناك فروقا معنوية بين التسميد الكيماوى و١٠م^{3} فدان$^{-1}$. وأوضحت الدراسة أيضا وجود تفاعل بين السلالة وحماة المجارى وأعطت سلالة فيكتورى فريزر الملقحة بالفوسفورين والمعاملة بمستوى ١٥م^{3} فدان$^{-1}$ من الحماة أعلى محصول تحت ظروف هذه الدراسة، تليها نفس السلالة الملقحة بالفوسفورين والمعاملة بمستوى ١٠م^{3} فدان$^{-1}$ مع عدم وجود فرق معنوى بينهما.