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Effect of Sulphur, Inoculation with P Dissolving Bacteria and P Foliar Applications on Two Canola (*Brassica napus* L.) Varieties

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TWO field experiments were carried out at the Agric. Res. Station Farm, Giza, Egypt during the growing winter seasons of 2004-2005 and 2005-2006. The uninoculated and inoculated canola varieties (Pactol and Serwo 4) with phosphate dissolving bacteria (PDB) were foliar sprayed with 0.2% P_2O_5 in present or absent of a basal dose of 50 Kg S/fed. (as elemental sulphur) to investigate the effect of these factors individually or in combination with each other on growth, seed yield and quality as well as soil fertility and mineral fertilization regime aiming to reduce the production input and environment pollution. Results could be summarized in the followings.

At mid-maturity stage, chlorophyll content was significantly concentrated in plant foliated with 0.2% P_2O_5 specially those inoculated ones. Sulphur application concentrated also chlorophyll contents. Inoculated serwo 4 variety plants were found to be the best contained chlorophyll when they were foliated with P in S amended plots.

At harvest, foliar spray by P on plants inoculated with PDB showed significantly increases in growth characters relative to the uninoculated plants sprayed or no with P. It is also evident that plant received sulphur exhibited significantly increase in all growth parameters in both of the two used varieties, and *vice versa* for root DW/plant. Pactol plants had greater shoot DW /plant, plant height and fruiting zone length than Serwo 4 plants, except root DW/plant where Serwo 4 plants gave the highest value. Only shoot DW/plant and plant height were gave a significantly response.

It was observed that Pactol variety showed significant superiority in No. of pods/plant, straw yield/plant, seed yield/plant and P content over Serwo 4 variety, while Serwo 4 had superiority in seed index, oil and protein contents. Oil, protein and P contents recorded the highest values with plants inoculated and sprayed with P. All studied parameters were highest in plants received sulphur than those without sulphur.

The interaction effects of sulphur application, varieties, inoculation with PDB and phosphour spraying were insignificant for almost all studied characters of both varieties. The highest value was

obtained when sulphur combined with foliar P spray in inoculated plants of Serwo 4 variety .

Keywords: Silty clay soil, Sulphur, Canola varieties, Seed inoculation with PDB, Foliar P application.

Canola (*Brassica napus* L.) is considered as one of the most important oil crops in the world. In Egypt, it is one of the winter oil crops that grow well in newly reclaimed lands. Its seed contains more than 40% of excellent edible semi dry oil. Consequently, canola oil is considered a promising oil crop to decrease the gab between the production and the consumption. Accordingly, looking for high yielding canola varieties adapted to the local conditions is considered as an important objective (Sharaan, 1987).

In our alkaline soils where the level of available nutrients is considerably low, using of mineral fertilizers in agricultural production have resulted in serious problems in the soil and contaminate the under ground water. It also accumulates in food chain causing hazardous effects. Many solutions were done to reduce the previously mentioned problems, out of them using biofertilization and foliar spray methods. The availability of phosphours is a function of soil pH and $CaCO_3$ content, the application of sulphur to the soil increased the nutrients availability (Khafaji *et al.*, 1986). The effect of sulphur obtained by several workers such as Tiwari (1989) and Zhao *et al.* (1999). Azer *et al.* (2003) reported that there was a significant response in seed yield, crude protein and P contents by addition of sulphur.

Moreover, foliar application method to supply plants with nutrients is usually one of the most efficient means of correcting nutrients deficiencies, since relatively low rate application are often as effective as much higher rates of soil applied. Phosphorus foliar spraying has been recommended by many workers to increase seed yield (Omran *et al.*, 1999 and Nassar *et al.*, 2005).

Biofertilizers are one of the most important materials required to substitute for chemical fertilizers for healthy cheap production. The microbial strains (biofertilizers) led to availability of phosphorous (phosphate dissolving bacteria) as well as the synthesis of auxins, cytokinins and gibberellic acid-like substances. These growth materials are the primary substances controlling the enhanced plant growth, absorption nutrients and photosynthesis process. (Mrkovacki & Milic, 2001).

Moreover, seed inoculation with biofertilizer is economically important as it resulted in reducing the needs rate of N and P fertilizers and improving the crop yield. Babu *et al.* (1991); El-Mandoh & Abdel-Magid (1996); Azzam & Omran (2005) and Shaalan (2005) found that biofertilization improved plant growth characters expressed as plant height, number of fruits, seed yield/plant and seed yield/plot in two seasons.

The aim of this study is to investigate the response of canola varieties to sulphur application and foliar spray of P only or in presence of phosphate dissolving bacteria. Moreover, investigating the effect of this biofertilizer combinations as a biological technique as well as foliar methods for reducing the dose of mineral fertilizer and to improve growth and seed yield, in order to improve soil fertility, reduce the production cost and the environmental pollution.

Material and Methods

Two field experiments were carried out at the Agricultural Research Station Farm, Giza, Egypt during the winter seasons of 2004-2005 and 2005-2006, in different sites. Soil samples from each site were taken for physical and chemical analysis, which were done according to Black (1965) as Table 1 shows.

TABLE 1. Some soil characteristics of the experimental sites for the two seasons.

Experimental seasons	Soil texture	$CaCO_3$ %	pH (1:2.5)	E.C.* dSm^{-1}	O.M %	Available P_2O_5 (p.p.m)
2004-2005	Silty clay	3.10	8.2	1.25	1.52	18.4
2005-2006	Silty clay	3.37	7.9	1.40	1.38	17.8

* = in soil paste.

At soil preparing for plantation, the half of plot numbers received 50 Kg S /fed as elemental sulphur mixing with soil while the another half numbers of them was not treated with sulphur as sub main treatments.

Two varieties of canola (*Brassica napus* L.) named Pactol and Serwo 4 were compared with each other as main treatments.

One third of each variety seeds were inoculated with phosphate dissolving bacteria (PDB) on the same day of sowing corresponding with other two phosphate application treatments the sub-sub treatments. The used inoculating bacteria consists of an efficient strain of *Bacillus megalherium* var. *Phosphaticum* adsorbed on peatmoss power as carrier and registered to Biofertilizers Unit, Ministry of Agric. Egypt. from which it was obtained. The inoculation was done by mixing seeds with ($8x10^8$ microbial bacteria cells/plot) at a level of 300 g/ fed. That sub-sub treatments were arranged as following, one third of plot number plants which were inoculated with PDB was foliated with pure solution of single super phosphate (15.0 % P_2O_5). Another one third of plot numbers (planted with uninoculated seeds) was treated with the same foliation system. The rest one third (with uninoculated seed also) was left without any P fertilization as a control.

Thus the experiment design was of split-split plots 2V x 2S x 3P treatments, each treatment was replicated three times giving 36 plots of 10.5 m^2 size for every season.

Canola seeds were sown on 10th of Dec., 2004 and 18th of Dec., 2005 in the two successive winter seasons. All plots received basic application of nitrogen at the rate of 45Kg N/fed in the form of ammonium nitrate (33%), at two equal doses after thinning (three weeks of planting) and after 6 weeks of planting; and potassium sulphate (48% K_2O) at the rate of 24 Kg K_2O /fed. before flowering. The normal agricultural practices of growing canola plants were done.

Concerning P foliar spraying there were two times at bloom and early pod formation stages each once with 1L/plot containing 2 g P_2O_5 corresponding 800g P_2O_5 /fed obtained from 5.33 Kg single super phosphate.

At mid-maturity stage, *i.e.*, 80 days from planting, the plants were harvested to determine pigments contents (chlorophyll a, chlorophyll b and total chlorophyll) according to Ranganna (1972).

At the end of the growing seasons, samples of 10 plants at harvest time were taken randomly from each plots for agronomic and chemical trait measurements; dry weight (DW) of shoot and root (g). plant height (cm), fruiting zone length (cm), No. of pods/plant, straw yield/plant (g), weight of seeds/plant (g), seed index (weight of 1000 seeds by g), seed percentage contents of phosphours, total protein and oil were determined using procedure described by A.O.A.C. (1990).

The combined statistically analysis of the two successive seasons was calculated using MstatC statistics program and treatments were compared by using L.S.D. at 0.05 level probability.

Results and Disccusion

Chlorophyll contents

As represented in Table 2, there were significant differences between P treatments in chlorophyll contents using foliar spray PDB- inoculated plants with 0.2 % P_2O_5 gave the best results compared to uninoculated ones sprayed with 0.2 % P_2O_5 , while the control plants (no phosphour) came at least. These results were confirmed by El-Akabawy (2000) and Azzam & Omran (2005).

The data available in Table 2 clarified that sulphur application exhibited increases in chlorophyll contents (either chlor. A, B or total). The present findings were in accordance with those obtained by Zhao *et al.* (1999) who found that leaf chlorophyll content was increased significantly by S addition. The effect of sulphur may be explained due to the direct effect of sulphur deficiency on N_2-fixation according to Zaroug & Munns, 1979, who did not support the hypothesis that S deficiency affects photosynthesis first, resulting in a storage of C and energy sources for N_2-fixation.

TABLE 2. Chlorophyll contents in canola leaves as affected by the different treatments (combined over the two seasons).

Characters	Variety	Sulphur	P treatments				LSD at 5% level	
			Control	PF	PF + PDB	X`		
Chlorophyll A	Pactol	-S	59.0	72.9	72.2	68.0	Variety (V)	N.S.
		+S	62.7	79.5	85.8	76.0	Sulphur (S)	N.S.
		X`	60.8	76.2	79.0	72.0	Phosphorus(P)	9.5
	Serwo 4	-S	56.7	66.3	70.3	64.4		
		+S	69.8	80.0	91.7	80.5	V x S	N.S.
		X`	63.3	73.2	81.0	72.5	V x P	N.S.
	S mean	-S	57.9	69.6	71.3	66.2	S x P	N.S.
		+S	66.3	79.8	88.8	78.3	V x S x P	N.S.
	P mean		62.1	74.7	80.0			
Chlorophyll B	Pactol	-S	27.1	27.1	34.0	29.4	(V)	N.S.
		+S	32.9	37.4	35.8	35.4	(S)	2.85
		X`	30.0	32.2	34.9	32.4	(P)	4.80
	Serwo 4	-S	28.5	33.2	39.1	33.6		
		+S	32.9	43.0	40.6	38.8	V x S	N.S.
		X`	30.7	38.1	39.9	36.2	V x P	N.S.
	S mean	-S	27.8	30.2	36.6	31.5	S x P	N.S.
		+S	32.9	40.2	38.2	37.1	V x S x P	N.S.
	P mean		30.4	35.2	37.4			
Total chlorophyll	Pactol	-S	86.0	99.9	106.1	97.3	(V)	N.S.
		+S	95.8	116.8	121.5	111.4	(S)	N.S.
		X`	90.9	108.3	113.8	104.3	(P)	12.7
	Serwo 4	-S	85.2	99.4	109.1	97.9		
		+S	102.6	123.0	132.3	119.3	V x S	N.S.
		X`	93.9	111.2	120.7	108.6	V x P	N.S.
	S mean	-S	85.6	99.7	107.6	97.6	S x P	N.S.
		+S	99.2	119.9	126.9	115.4	V x S x P	N.S.
	P mean		92.4	109.8	117.2			

PF= Foliar spray of 0.2% P_2O_5.
-S= No sulphur application.
N.S.= Non significant effect.
PDB= Phosphate dissolving bacteria.
+S= Sulphur application at rate of (50 Kg/fed).

Concerning to varieties, data in the same table showed that Serwo 4 contained chlorophyll contents more than Pactol.

As for interaction effects, spraying on Serwo 4 plants inoculated and received sulphur with 0.2% P_2O_5, had direct and beneficial effects on chlorophyll formation as compared with those without sulphur or foliated only with P. This may be due to sulphur and/or PDB presence providing the soil with enough amount of P which reflected on growth and chlorophyll concentration.

Growth characters

Foliar spray of P in plants inoculated with PDB show the most enhance significantly increases in growth characters (Table 3), in relative to the control (without foliar application) or uninoculated plants sprayed with P. In accordance with these results, Azzam & Omran (2005) found significant increases in growth parameters in sunflower plants treated with biofertilizer (PDB).

It is also evident from the same data of Table (3), that plant received sulphur exhibited significantly increase in shoot DW/plant, plant height and fruiting zone length in both of two varieties used, and *vice versa* for root DW/plant. These results were in agreement with those of Zhao *et al.* (1999) who found that, sulphur deficiency affected on growth, it likely to be caused by the shortage of N, due to decreased N_2-fixation. Also sulphur deficiency causes perturbation in specific amino acid pools. Free amides such as asparagines, and to a lesser extent, glutamine accumulate markedly suffering of S deficiency (Karmoker *et al.*, 1991).

In general, these differences in growth characters among varieties might be due to the pronounced effect of genetic make-up. Pactol plants had greater shoot DW/plant, plant height and fruiting zone than Serwo 4 plants, except root DW/plant where Serwo 4 plants gave the highest value. Only shoot DW/plant and plant height were significantly affected. The same trend was obtained by Reddy *et al.* (1994) who found that differential response between genotypes caused by differing rates of absorption, translocation and utilization.

As represented in Table 3, data showed the effect of interactions between phosphour foliar spray and sulphur treatments in both varieties were insignificant for studied growth parameters, whereas, plants inoculated with PDB and sprayed with phosphor showed the greatest enhance regardless varieties in absence or presence of sulphur. The same results obtained by Safar *et al.* (1997) who found that there was no significant interaction effect among levels of P, S and seed inoculation on the vegetative traits of chickpea.

TABLE 3. Growth characters of canola varieties as affected by the different treatments (combined over the two seasons).

Characters	Variety	Sulphur	P treatments				LSD at 5% level	
			Control	PF	PF + PDB	X`		
Shoot DW/plant (g)	Pactol	-S	29.2	32.0	33.9	31.7	Variety (V)	0.87
		+S	31.4	35.8	38.4	35.2	Sulphur (S)	2.00
		X`	30.3	33.9	36.2	33.4	Phosphorus(P)	2.55
	Serwo 4	-S	22.7	27.6	31.3	27.2		
		+S	25.8	31.0	33.8	30.2	V x S	N.S.
		X`	24.2	29.3	32.5	28.7	V x P	N.S.
	S mean	-S	26.0	29.8	32.6	29.5	S x P	N.S.
		+S	28.6	33.4	36.1	32.7	V x S x P	N.S.
	P mean		27.3	31.6	34.4			
Root DW/plant (g)	Pactol	-S	8.82	9.63	9.90	9.45	(V)	N.S.
		+S	9.08	10.5	10.9	10.2	(S)	N.S.
		X`	8.95	10.1	10.4	9.81	(P)	0.42
	Serwo 4	-S	8.93	9.57	10.1	9.53		
		+S	9.55	10.2	10.8	10.2	V x S	N.S.
		X`	9.24	9.91	10.5	9.87	V x P	N.S.
	S mean	-S	8.9	9.6	10.0	9.5	S x P	N.S.
		+S	9.3	10.4	10.9	10.2	V x S x P	N.S.
	P mean		9.10	9.98	10.4			
Plant height (cm)	Pactol	-S	118	125.8	128.5	124.3	(V)	5.28
		+S	122.3	130.2	136.8	129.8	(S)	4.67
		X`	120.4	128.0	132.7	127.0	(P)	3.16
	Serwo 4	-S	107.5	115.3	120.2	114.3		
		+S	111.7	125.8	126.2	121.2	V x S	N.S.
		X`	109.6	120.6	123.2	117.8	V x P	N.S.
	S mean	-S	112.8	120.6	124.4	119.3	S x P	N.S.
		+S	117.0	128.0	131.5	125.5	V x S x P	N.S.
	P mean		115.0	124.3	127.9			
Fruiting zone length (cm)	Pactol	-S	60.2	71.2	72.8	68.1	(V)	N.S.
		+S	64.2	78.8	86.8	76.6	(S)	5.21
		X`	62.2	75.0	79.8	72.3	(P)	4.05
	Serwo 4	-S	52.2	62.5	69.0	61.2		
		+S	55.7	77.8	79.2	70.8	V x S	N.S.
		X`	53.9	70.1	74.1	66.0	V x P	N.S.
	S mean	-S	56.2	66.9	70.9	64.7	S x P	N.S.
		+S	60.0	78.3	83.0	73.7	V x S x P	N.S.
	P mean		58.0	72.5	76.9			

PF= Foliar spray of 0.2% P_2O_5. PDB= Phosphate dissolving bacteria.
-S= No sulphur application. +S= Sulphur application at rate of (50 Kg/fed).
N.S.= Non significant effect.

Seed yield

The data in Table 4 showed that, plants foliar sprayed with P and treated with PDB recorded the highest increases in all yield characters (No. of pods/plant, straw yield/plant, seed yield/plant and seed index), in the present or absence of sulphur, followed with plants foliar sprayed by P only and those without phosphour gave the lowest values. Increasing P availability due to seed inoculation with PDB resulted in superior yield component might have reflected on the seed yield and seed index. Gaur (1985) also recorded 10-30% increase in grain yield due to phosphate-solubilizing bacteria inoculation alone. As for foliar spray, Omran *et al.* (1999) and Nassar *et al.* (2005) found the same results. The increase in yield due to P may be attributed to better vegetative growth and dry matter of pods and consequently yield attributes.

Yield characters were obviously higher in canola plants which grown from seeds received sulphur. The same data also recorded that Pactol plants gave the highest increases in most of studied parameter, however Serwo 4 plants was the superior in seed index. The affect was significant by sulphur application to both varieties. The increase in yield due to S may be attributed to balanced nutrition and such yield parameters indicating that sulphur is crucial for achieving higher yield. Tiwari (1989) and Azer *et al.* (2003) also recorded such increase in yield.

The two varieties under this study differed significantly in seed yield. It was observed that Pactol variety showed a superiority in No. of pods/plant, straw yield/plant and seed yield/plant over Serwo 4 variety, while Serwo 4 showed a superiority in seed index. This result could be due to genetic make-up effect of the used varieties which extremely differed for growth traits.

As for double or triple interaction effects of sulphur application, varieties and phosphorus spraying were insignificant. The highest value was obtained when sulphur combined with foliar spray of P in Serwo 4 inoculated plants. Shinde & Safar (1994) found that P, S and inoculation with phosphate-solubilizing bacteria increased checkpea dry matter yield (Safar *et al.*, 1997), reported that no significant interactive effects of levels of phosphorus, sulphur and seed inoculation on the grain yield were noted.

Chemical constituents in seed

It is clear from Table 5 that the amounts of oil, protein and P contents recorded the highest values in plants inoculated and sprayed with P. This may be due to seed inoculation with PDB which increased P availability. As same results Omran *et al.* (1999) found that phosphorus spraying increased significantly oil and P contents. Moreover, Nassar *et al.* (2005) found that foliar spray of single superphosphat increased P and protein contents in faba bean.

Oil, protein and P contents as affected by sulphur application were conspicuously varied. In this respect, all studied parameters were highest in plants received sulphur than that without sulphur. This may be due to involving sulphur in protein synthesis and as a part of some amino acids. In this respect, Khafaji *et al.* (1986) reported similar results who found that the application of sulphur increased the availability of P and Azer *et al.* (2003) for P and crude protein contents of faba bean.

TABLE 4. Seed yield and yield components of canola varieties as affected by the different treatments (combined over the two seasons).

Characters	Variety	Sulphur	P treatments				LSD at 5% level	
			Control	PF	PF + PDB	X`		
No. of pod /plant	Pactol	-S	236.8	277.3	294.5	269.5	Variety (V)	8.41
		+S	266.7	339.0	381.7	329.1	Sulphur (S)	12.5
		X`	251.7	308.0	338.1	299.3	Phosphorus(P)	11.2
	Serwo 4	-S	192.0	227.3	275.8	231.7		
		+S	228.7	319.0	331.7	293.1	V x S	N.S.
		X`	210.3	273.2	303.8	262.4	V x P	N.S.
	S mean	-S	214.4	252.3	285.2	250.6	S x P	15.9
		+S	247.7	329.0	356.7	311.1	V x S x P	22.5
	P mean		231.0	290.7	320.9			
Straw yield/plant (g)	Pactol	-S	14.9	18.4	20.2	17.9	(V)	N.S.
		+S	15.2	24.1	22.3	20.5	(S)	0.67
		X`	15.1	21.2	21.2	19.2	(P)	1.05
	Serwo 4	-S	13.3	17.8	19.3	16.8		
		+S	15.1	22.5	21.0	19.6	V x S	N.S.
		X`	14.2	20.2	20.2	18.2	V x P	N.S.
	S mean	-S	14.1	18.1	19.8	17.4	S x P	1.48
		+S	15.2	23.3	21.7	20.1	V x S x P	N.S.
	P mean		14.6	20.7	20.7			
Seed yield/plant (g)	Pactol	-S	17.1	18.2	18.7	18.0	(V)	0.37
		+S	17.8	20.5	22.0	20.1	(S)	0.62
		X`	17.5	19.3	20.4	19.1	(P)	0.63
	Serwo 4	-S	15.7	17.3	18.6	17.2		
		+S	16.3	19.5	20.9	18.9	V x S	N.S.
		X`	16.0	18.4	19.7	18.0	V x P	N.S.
	S mean	-S	16.4	17.8	18.7	17.6	S x P	0.88
		+S	17.1	20.0	21.5	19.5	V x S x P	N.S.
	P mean		16.7	18.9	20.0			
Seed index (g)	Pactol	-S	3.30	3.41	3.75	3.49	(V)	0.28
		+S	3.36	3.77	4.13	3.76	(S)	0.09
		X`	3.33	3.59	3.94	3.62	(P)	0.12
	Serwo 4	-S	3.68	4.07	4.07	3.94		
		+S	3.69	4.28	4.50	4.15	V x S	N.S.
		X`	3.69	4.17	4.28	4.05	V x P	N.S.
	S mean	-S	3.5	3.7	3.9	3.7	S x P	0.17
		+S	3.5	4.0	4.3	4.0	V x S x P	N.S.
	P mean		3.51	3.88	4.11			

PF= Foliar spray of 0.2% P_2O_5. PDB= Phosphate dissolving bacteria.
-S= No sulphur application. +S= Sulphur application at rate of (50 Kg/fed).
N.S.= Non significant effect.

TABLE 5. Chemical constituents in dry seed of canola varieties as affected by the different treatments (combined over the two seasons).

Characters	Variety	Sulphur	P treatments				LSD at 5% level	
			Control	PF	PF + PDB	X`		
Oil content	Pactol	-S	36.9	37.5	38.1	37.5	Variety (V)	N.S.
		+S	36.9	38.6	38.7	38.1	Sulphur (S)	N.S.
		X`	36.9	38.1	37.4	33.8	Phosphorus(P)	N.S.
	Serwo 4	-S	37.5	38.2	38.6	38.1		
		+S	37.7	38.8	39.1	38.6	V x S	N.S.
		X`	37.6	38.5	38.9	38.3	V x P	N.S.
	S mean	-S	37.2	37.9	38.4	37.8	S x P	N.S.
		+S	37.3	38.7	38.9	38.4	V x S x P	N.S.
	P mean		37.3	38.3	38.6			
Protein content	Pactol	-S	26.0	26.2	27.2	26.5	(V)	0.78
		+S	26.2	27.4	28.1	27.2	(S)	N.S.
		X`	26.1	26.8	27.7	26.8	(P)	0.94
	Serwo 4	-S	27.0	27.6	28.0	27.5		
		+S	27.2	28.1	28.5	27.9	V x S	N.S.
		X`	27.1	27.8	28.2	27.7	V x P	N.S.
	S mean	-S	26.5	26.9	27.6	27.0	S x P	N.S.
		+S	26.7	27.8	28.3	27.6	V x S x P	N.S.
	P mean		26.6	27.3	27.9			
P content	Pactol	-S	0.333	0.348	0.363	0.348	(V)	N.S.
		+S	0.343	0.375	0.388	0.369	(S)	N.S.
		X`	0.338	0.362	0.376	0.359	(P)	0.024
	Serwo 4	-S	0.332	0.335	0.352	0.339		
		+S	0.335	0.362	0.372	0.356	V x S	N.S.
		X`	0.333	0.348	0.362	0.348	V x P	N.S.
	S mean	-S	0.33	0.34	0.36	0.34	S x P	N.S.
		+S	0.34	0.37	0.38	0.36	V x S x P	N.S.
	P mean		0.336	0.355	0.369			

PF= Foliar spray of 0.2% P_2O_5. PDB= Phosphate dissolving bacteria.
-S= No sulphur application. +S= Sulphur application at rate of (50 Kg/fed).
N.S.= Non significant effect.

Concerning varieties, results showed that, Serwo 4 plants were more superior in oil and protein contents. While, Pactol plants induced the highest P content.

Regarding the combinations effect of P treatments and sulphur, it could be concluded that the highest values of oil and protein contents were observed when inoculated plants received sulphur and sprayed with P for Serwo 4 and Pactol as compared to the control. However, the differences were not significant.

It could be concluded that, under the condition of our soils, foliar spraying of canola plants with phosphorus or phosphorus + PDB in presence of sulphur, decrease P-fixation, increase its availability in soil and promote its uptake by plant, in other words increased the use efficiency of P-fertilization and reduce the costs and pollution.

References

A.O.A.C. (1990) "*Official Methods of Analysis*", Association of Official Analysis Chemist, 15th ed., Washington, U. S. A.

Azer, Sohair, A.; Awad, A. M.; Jaklin, G. Sadek; Khalil, F. A. and Eglal, M. A. El-Aggory (2003) A comparative study on the effect\t of elemental S and biophosphatic fertilizers on the response of faba bean to P fertilization. *Egypt J. Appl. Sci.* **18**, 324-363.

Azzam, Clara R. and Samya, Omran E. H. (2005) The promotive effect of PDB biofertilizer on growth, enzymatic activity and biochemical changes of sunflower (*Helianthus annuus* L.) plants sprayed with micronutrients. *The 3rd Conf. of Recent Technologies in Agric. Fac. of Agric., Cairo Univ.*, Giza 14-16 Nov. **2**: 255-267.

Babu, S. C.; Hallam, J. A. and Fletcher, L. B. (1991) Economic of biotechnology: the case of biofertilizers in south India. Agriculture Studies in Technology and Social Change Series. No. 7, 60 pp. BIDS.

Black, C. A. (1965) "*Methods of Soil Analysis*", Am. Soc. Agron. Inc. Pubi., Madison Wisconsin.

El-Akabawy, M. A. (2000) Effect of some biofertilizers and farmyard manure on yield and nutrient uptake of Egyptian clover grown on loamy sand soil. *Egypt. J. Agric. Res.* **78**: 1811-1821.

El-Mandoh, M.E. and Abdel-Magid, M.N. (1996) Response of some sesame genotypes (*Sesamum indicum* L.) to inoculation by different biofertilizers. *Assiut J. Agric. Sci.* **27**: 169-178.

Gaur, A. C. (1985) Phosphate solubilising micro-organisms and their role in plant growth and crop yields. *In Proc. Soil Biology Symposium*, held at Hisar, India, in Feb., pp. 125-138.

Karmoker, J. L.; Clarkson, D. T.; Saker, L. R.; Rooney, J. M. and Purves, J. V. (1991) Sulphur deprivation depresses the transport of nitrogen to the xylem and the hydraulic conductivity of barley (*Hordeum vulgare* L.) roots. *Planta.* **185**: 269-278.

Khafaji, M.; Al-Barrak, S. and Abd El-Hadi, Y. (1986) Use of sulphur for increasing the availability of some nutrients in soils under date palm cultivation in Al-Hassa Oasis. *Proc. 2nd Symposium on the Date Palm in Saudi Arabia* **1**: 385-398.

Mrkovacki, N. and Milic, V. (2001) Use of *Azotobacter chroococcum* as potentially useful in agricultural application. *Ann. Microbiology* **51**: 145-158.

Nassar, K. E. M.; Abd El-Rassoul, Sh. M. and El-Shebiny, G. M. (2005) Effect of foliar spraying with phosphorus and potassium on faba bean plant under calcareous soil conditions. *Minufiya. J. Agric. Res.* **30**: 1625-1637.

Omran, A. A.; El-Khouly, M. and Ahmed, Kh. (1999) Effect of phosphorus and boron spraying on cotton yield. *Egypt. J. Appl. Sci.* **14**: 393-402.

Ranganna, S. (1972) "*Manual of Analysis of Fruit and Vegetable Products*", pp.80-82, Teta McGraw-Hill Pub. Co. Lim., New Delhi.

Reddy, K. B.; Reddy, C. M. and Reddy, D. S. (1994) Differential phosphorus use efficiency in groundnut (*Arachis hypogaea* L.) genotypes. *Indian J. Plant Physiol.* **37**: 17-20.

Safar, C. S.; Shivakumar, B. C. and Patil, R. R. (1997) Effect of phosphorus, sulphur and seed inoculation on performance of chickpea (*Cicer arietinum*). *Indian J. Agron.* **42**: 323-328.

Shaalan, M. N. (2005) Influence of biofertilizers and chicken manure on growth, yield and seeds quality of (*Nigella sativa* L.) plants. *Egypt J. Agric. Res.* **83**: 811-828.

Sharaan, A. N. (1987) Yield performance of new European spring rape seed (*Brassica napus* L.) cultivars under winter season cultivation in Egypt. *J. of Agron. and Crop Sci.* **158** (1), 49.

Shinde, V. S. and Saraf, C. S. (1994) Pattern of dry matter accumulation and distribution in chickpea as influenced by phosphorus and sulphur. *Indian J. Pulses Res.* **7**: 76-79.

Tiwari, K. N. (1989) Pyrites. In: "*Sulphur Fertilizers for Indian Agriculture*", Tondon, H. L.S. (Ed.), pp.72-83, Fertilizer, Development and Consultation Organization, New Delhi.

Zaroug, M. G. and Munns, D. N. (1979) Nodulation, nitrogen fixation, leaf area and sugars content in *Lablab purpureus* as affected by sulfur nutrition. *Plant and Soil* **53**: 319-328.

Zhao, F. J.; Woodm, A. P. and McGrath, S. P. (1999) Effects of sulphur nutrition on growth and nitrogen fixation of pea (*Pisum sativum* L.). *Plant and Soil* **212**: 209-219.

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تأثير الكبريت والتلقيح بالبكتريا المذيبة للفوسفور والرش الورقى بالفوسفور على صنفين من الكانولا

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أقيمت تجربتان حقليتان فى مزرعة محطة مركز البحوث الزراعية، بالجيزة، فى الموسمين الشتويين المتعاقبين ٢٠٠٤-٢٠٠٥ و٢٠٠٥-٢٠٠٦. تم تسميد كلا من أصناف الكانولا (باكتول و سرو ٤) الملقحة وغير الملقحة بالبكتريا المذيبة للفوسفات رشا ب ٠,٢ ٪ فوأه فى وجود أو غياب الجرعة الاساسية ٥٠ كجم كبريت لكل فدان (ككبريت معدنى) لدراسة تأثير هذه العناصر منفردة او مجتمعة مع بعضها على النمو، محصول البذرة وجودة البذور وأيضا خصوبة التربة ونظام التسميد المعدنى بهدف تقليل تكلفة الانتاج وتلوث البيئة . يمكن تلخيص النتائج فى الاتى:

فى مرحلة منتصف النضج، كان محتوى الكلوروفيل متركز معنويا فى النباتات المرشوشة ب ٠,٢٪ فوأه خاصة النباتات الملقحة بالبكتريا المذيبة للفوسفات. ركزت أيضا معاملات الكبريت محتوى الكلوروفيل. وجد أن نباتات الصنف سرو ٤ الملقحة تعتبر الافضل فى محتوى الكلوروفيل عندما رشت ورقيا بالفوسفور وكانت مسمدة بالكبريت.

عند الحصاد ، أظهر الرش الورقى بالفوسفور للنباتات الملقحة بالبكتريا المذيبة للفوسفور زيادة معنوية فى صفات النمو مقارنة بالنباتات غير الملقحة سواء رشت او لم ترش بالفوسفور. كان من الواضح أن النباتات التى سمدت بالكبريت أظهرت زيادة معنوية فى كل الصفات المدروسة فى كلا من الصنفين المستخدمين وبالعكس بالنسبة لوزن الجذور الجاف/نبات. أعطت نباتات الصنف باكتول أعلى وزن جاف للساق/ نبات ، طول نبات وطول منطقة الاثمار مقارنة بالصنف سرو ٤ ، ماعدا وزن الجذور الجافة/ نبات بينما نباتات الصنف سرو ٤ أعطت القيم الاعلى لهذه الصفة و كان الوزن الجاف للساق / نبات وطول النبات فقط له تأثيرا معنويا.

من الواضح أن الصنف باكتول أظهر تفوقا على الصنف سرو ٤ فى عدد الكابسولات/ نبات ، محصول القش/ نبات ومحصول البذرة/ نبات و محتوى الفوسفور، بينما تفوق صنف سرو ٤ فى دليل البذرة و محتوى كل من الزيت والبروتين. سجلت كمية الزيت والبروتين والفوسفور أعلى قيم فى النباتات الملقحة بالبكتريا المذيبة للفوسفات والمرشوشة بالفوسفور. وكانت كل الصفات المدروسة أعلى فى النباتات المسمدة بالكبريت عن تلك المسمدة.

كان تأثير التداخل لمعاملات الكبريت ، الاصناف ، التلقيح بالبكتريا المذيبة للفوسفور والرش الورقى بالفوسفور ولكن بأقل من حدود المعنوية تقريبا لكل الصفات المدروسة لكلا الصنفين. هذا وقد تحصل على أعلى قيمة بإضافة كل من الكبريت والرش بالفوسفور فى نباتات الصنف سرو ٤ الملقحة بالبكتريا المذيبة للفوسفات.