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Effect of Sulphur and Phosphorus Fertilization on Growth and Yield of Barley (*Hordeum vulgare* L.) Under South Sinai Condition

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TWO field experiments were conducted during the winter seasons of 2002-2003 and 2003-2004 at Ras Sudr experimental station, South Sinai, Egypt to evaluate the effect of phosphorus (0.0, 15.5, 31.0 and 46.5 kg fed^{-1}) and sulphur (00, 100, 200 and 300 kg fed^{-1}) on the productivity of barley (*Hordeum vulgare* L.) irrigated with saline water. The P and S increased significantly plant height, fresh weight (g), dry weight (g), number of tillers plant^{-1}, spike length (cm), number of grains spike^{-1} , grain weight spike^{-1} (g), 1000-grain weight (g), grain yield plant^{-1} (g), grain yield fed^{-1} (kg), straw yield fed^{-1} (kg), biological yield fed^{-1} (kg) and harvest index (%) with increasing P or S over 0.0 level. The maximum values were at 46.5 kg P fed^{-1} and 300 kg S fed^{-1} combination. Phosphorus and sulphur interaction was significant. A combination of 46.5 kg P fed^{-1} and 300 kg S fed^{-1} gave the highest value for all the parameters under study.

Keywords: Barley, *Hordeum vulgare*, Sulphur, Phosphorus fertilizer.

Increasing grain yield of cereal crops is considered as an important national goal in Egypt to face the needs of increment of Egyptian people. Barley is considered the main cereal crop in arid and semi arid areas, and one of the best adapted field crop for drought, salinity, and low soil fertility in the new land (newly reclaimed areas). Stable barley production is necessary to assure resource-poor farmers a stable income and livestock production.

Fertilizer management is one of the most important agronomic factors that affect yield. The deficiency of major and secondary nutrients particularly P and S is increasing in crop plants and responses of crop to its fertilization are not known on yield of barley (*Hordeum vulgare* L.).

The decline in the fertility of agricultural soils has been well documented in recent years, with most of the attention being focused on the major fertilizer elements, N, P, and K (Stoorvogel *et al.*, 1993). Sulphur is a macronutrient that is taken up by most grain crops in amounts similar to those of P. While P has been subject of extensive investigations much less is known about S status in the soils and response of crop production to S amendments (Buresh *et al.*, 1997). Very few data are available in response of barley to sulphur in calcareous soils when saline water is used in irrigation under the field conditions (El-Shall *et al.* 1987).

Although phosphorus is required in lower amounts than other major nutrients, it is critical in the early developmental stages of growth, and in energy transfer within the plant throughout the growing season. Typical phosphorus contents of plants range between 0.1 to 0.46 percent on dry weight basis, approximately ten times less than for nitrogen or potassium. Phosphorus apparently stimulates young root development and earlier fruiting (earliness). It is essential in several biochemicals that control photosynthesis, respiration, cell division, and many other plant growth and development processes. Phosphorus is concentrated in the seed and fruit, and strongly affects seed formation. Since the primary functions of P involve energy and growth regulation, deficiencies affect vegetative growth and yield more than quality, but in seed crops, quality can also be affected. Uptake of P occurs primarily in the form of HPO_4 and $H_2PO_4^-$ (orthophosphate) forms. The particular form depends on pH, with the H_2PO_4 form most common in acid soils (Hodges, 1999).

Material and Methods

Two field experiments were conducted during the winter seasons of 2002-2003 and 2003-2004 under saline water irrigated condition at Wadi Sudr (Ras Sudr Research Station, Desert Research Center) South Sinai, Egypt.

Experimental soil is characterized as highly calcareous (53.72%), saline (EC 13.06 dsm^{-1}), alkali (pH 7.98) with sandy loam texture, contents of S (as SO_4^{-}) 0.70 meq/L, and P 8.71 ppm. The analysis of artesian irrigation water showed that EC value was 11.18 dsm^{-1} and pH 7.84. Standard analytical procedures were followed for carrying out the chemical analysis of soil samples according to Jackson (1967).

Barley used in the experiment was Giza 123, (50 kg fed^{-1} seeds). 20 m^{-3} sheep ding manure per feddan (feddan = fed = 4200 m^2) was applied during soil preparation. 45 kg fed^{-1} N was applied (divided at 3 times 20% with sowing, 40% with the first irrigation and 40% with the second irrigation). The experiments were laid out in November 2002 and 2003.

Four levels of S (0, 100, 200, and 300 kg fed^{-1}), sulphur were applied as elemental sulphur. In addition, four levels of P (0.0, 15.5, 31.0 and 46.5 kg fed^{-1}) were applied as calcium superphosphate (15.5 % P_2O_5), both S and P was applied during soil preparation. The observations for growth and yield attributing parameters, viz. plant height, fresh weight, dry weight, number of tillers $plant^{-1}$ 100-grain weight, spike length , number of grains $spike^{-1}$, grain yield fed^{-1}, straw yield fed^{-1}, biological yield $fed.^{-1}$ and harvest index %, were estimated.

The experiment was laid out in randomized complete block design with 3 replications. Plot size was 3X3.5 m (=10.5 m^2 = 1/400 fed). Combined analysis of data for the two seasons was carried out according to Snedecor and Cochran (1980), using M-STAT C, Computer program (Russell, 1991). L.S.D. test at 0.05 level was used to compare between treatment combination means according to Steel and Torrie (1989).

Results and Discussion

Sulphur

Sulphur (elemental sulphur) 300 kg fed^{-1} significantly increased all the various growth and yield-attributing characters of barley compared with the treatments of 0, 100, and 200 kg S fed^{-1} (Table 1).

TABLE 1. Effect of sulphur (elemental sulphur) and phosphorus ($P_2 O_5$) levels on growth and yield attributing parameters of barley (Combined data of 2 seasons).

Treatments	Sulphur				$LSD_{0.05}$	Phosphorus				$LSD_{0.05}$
Parameters	0.0	100	200	300		0.0	15.5	31.0	46.5	
Plant height (cm)	55.74	60.63	62.08	63.44	0.4945	57.61	59.45	61.41	63.45	0.2679
Fresh weight (g)	3.630	3.950	4.390	4.670	0.0019	3.620	4.170	4.340	4.50	0.0018
Dry weight (g)	1.130	1.172	1.303	1.417	0.0020	1.141	1.243	1.288	1.351	0.0018
No. of tillers $plant^{-1}$	1.940	2.630	3.100	3.420	0.0659	2.230	2.570	2.940	3.340	0.0486
Spike length (cm)	6.510	6.880	7.450	7.710	0.0344	6.250	6.940	7.550	7.830	0.0260
No. of grains $spike^{-1}$	25.8	28.90	31.20	34.90	0.2937	27.50	29.70	31.20	32.50	0.2407
Grain weight $spike^{-1}$ (g)	0.648	0.786	0.883	1.059	0.0198	0.690	0.819	0.895	0.972	0.0018
1000-grain weight (g)	25.00	26.60	28.20	30.10	0.2038	24.60	27.10	28.50	29.70	0.1934
Grain yield fed^{-1} (kg)	674.6	733.3	753.9	786.0	19.130	630.1	715.6	783.5	818.6	7.907
Straw yield fed^{-1} (kg)	1508	1562	1588	1640	36.440	1480	1553	1610	1654	10.69
Biological yield fed^{-1} (kg)	2186	2295	2342	2424	37.450	2110	2271	2397	2468	12.16
Harvest index (%)	0.308	0.318	0.321	0.324	0.0020	0.298	0.316	0.326	0.331	0.0018

Adding 300 S kg fed^{-1} significantly increased grain yield by 111.4, 52.7, and 32.1 kg over 0, 100 and 200 kg fed^{-1} S treatments, respectively, this due to increasing the 100-grain weight, number of grains $spike^{-1}$ and grain weight $spike^{-1}$ etc.

On the basis of combined data, plant height, fresh weight, dry weight, number of tillers $plant^{-1}$, 100-grain weight, spike length, number of grains $spike^{-1}$, grain weight $spike^{-1}$ (g), grain yield fed^{-1}, straw yield fed^{-1}, biological yield fed^{-1} and harvest index % increased with increasing levels of S up to 300 kg fed^{-1} except straw yield which showed non-significant difference between 100 and 200 kg fed^{-1} S. The increase in the growth and yield may be due to improved nutritional management as a result of increasing sulphur supply this has favorably effect on carbohydrate metabolism and this favorable effect led to increased transformation of photosynthesis towards yield and yield-attributing characters (Abbas *et al.*, 1995). Release some of needed nutrients which absorbed by plants as well as changing soil pH towards neutrality or acidity which in turn could act as a suitable media for increasing nutrient absorption by plant roots (Fawy, 1995). Salem *et al.* (1989) found that sulphur fertilization with 1000 kg fed^{-1}had in general enhancement effect on the growth of wheat plants at both tillering and heading stages. There was a progressive and consistent increase in the fresh weight of leaves and plant with increasing sulphur application at tillering stage, whereas the leaf area reached its maximum value by adding 500kg S fed^{-1}.

The results of El-Shall *et al.* (1987) have indicated a marked increase in the yield of barley due to both level of S (0.5 and 1 ton fed^{-1}) and a better response was obtained at 0.5 ton fed^{-1} level. The application of 0.5 ton S has doubled P and N uptake by barley.

Similar trend was also noted by Gill *et al.* (1994) on hybrid Napier grass (*Pennisetum purpureum*, *Panicum maximum*, *Brassica campestris* var. *sarson*, *Zea mays* and *Trifolium alexandrinum*). In addition, similar results were agreed with the results of Patel and Shelke (1998) on Indian mustard, Kasturikrishna and Ahlawat (2000) on pea and Weil and Mughogho (2000) on maize.

Phosphorus

All growth and yield attributing parameters increased significantly by application of P (Table 1). Combined data indicated that P application at 46.5 kg fed^{-1} gave maximum values of plant height (cm), fresh weight, dry weight, number of tillers $plant^{-1}$, spike length (cm), number of grains $spike^{-1}$, grain weight $spike^{-1}$ (g), grain yield fed^{-1}, straw yield fed^{-1} biological yield $fed.^{-1}$ and harvest index %. The data of the combined analysis revealed that adding 46.5 kg P fed^{-1} significantly increased grain yield by 188.5, 103.0 and 35.1 kg fed^{-1} over 0.0, 15.5 and 31.0 kg P fed^{-1}, respectively. This was due to increasing the 100-grain weight, number of grains $spike^{-1}$ and grain weight $spike^{-1}$ etc.

The increase may be return to give the plants the requirements of P, which was unavailable to absorb by plants in the calcareous soil of pH more than 7.

Further P helps the plants develop more extensive root system, which absorb more water and nutrients from deeper soil layers for higher photosynthetic activity and translocation of metabolites to the sink consequently increased all the studied parameters. This was in accordance with the results of El- Sayed *et al.* (1992) and Moselhy (2001), on barley, Singh and Singh (1989) and Bhadoria *et al.* (1997), Patel and Shelke (1998) and Kasturikrishna and Ahlawat (2000).

Interaction of S and P

The interaction between S and P was significant and positive in influencing the combined data, plant height, fresh weight, dry weight, number of tillers $plant^{-1}$ 100- grain weight, spike length, number of grains $spike^{-1}$, grain yield fed^{-1}, straw yield fed^{-1} biological yield $fed.^{-1}$ and harvest index % (Table 2). This may be due to the significant interaction effect of P and S on the uptake of N, P, K and S (Shankaralingappa *et al.*, 2000). Mondal *et al.* (1994) added that S present in single superphosphate might enhanced the productivity and efficiency of nutrients and supplied sufficient sulphate-sulphur for optimum plant growth.

These results are in conformity with those of Patel and Shelke (1998), Bhadoria *et al.* (1997) and Kasturikrishna and Ahlawat (2000) while Shinde and Saraf (1992) reported that there was synergistic effect between P and S at low application rates and antagonistic effect at higher rates.

TABLE 2. **Interaction effect of sulphur (elemental sulphur) and phosphorus (P_2O_5) levels on growth and yield attributing parameters of barley (Combined data of 2 seasons).**

Treatments		Plant height (cm)	Fresh weight $plant^{-1}$ (g)	Dry weight $plant^{-1}$ (g)	No. of tillers $plant^{-1}$	Spike length (cm)	No. of grains $spike^{-1}$	Grain weight $spike^{-1}$ (g)	1000-grain weight (g)	Grain yield fed^{-1} (kg)	Straw yield fed^{-1} (kg)	Biological yield fed^{-1} (kg)	Harvest index (%)
S kg fed^{-1}	P kg fed^{-1}												
0.0	0.0	53.90	3.28	1.061	1.6	6.08	23.6	0.525	22.2	591.5	1440.2	2031.7	0.290
	15.5	54.76	3.55	1.115	1.67	6.14	25.6	0.617	24.1	668.6	1495.6	2164.2	0.309
	31.0	56.12	3.78	1.141	1.87	6.83	26.7	0.697	26.0	693.9	1513.8	2221.5	0.312
	46.5	58.20	3.92	1.203	2.60	7.00	27.3	0.751	27.5	744.2	1582.2	2326.4	0.319
100	0.0	57.47	3.480	1.114	2.15	6.16	26.7	0.667	23.9	620.1	1473.2	2093.4	0.295
	15.5	59.74	3.86	1.148	2.30	6.32	28.1	0.755	26.0	710.9	1543.0	2253.9	0.315
	31.0	61.67	4.13	1.193	2.71	7.25	29.7	0.820	27.5	780.4	1587.8	2368.2	0.329
	46.5	63.65	4.33	1.233	3.33	7.81	30.9	0.900	29.1	822.0	1641.8	2463.8	0.333
200	0.0	59.01	3.79	1.138	2.33	6.31	28.1	0.713	25.3	636.3	1486.5	2122.9	0.299
	15.5	60.78	4.47	1.260	3.04	7.46	30.3	0.848	27.9	724.7	1558.2	2282.9	0.317
	31.0	63.22	4.56	1.347	3.43	7.94	32.3	0.940	29.1	814.1	1643.6	2457.8	0.331
	46.5	6533	4.73	1.467	3.57	8.11	34.3	1.031	30.2	840.5	1662.5	2503.0	0.336
300	0.0	60.04	3.94	1.248	2.83	6.44	31.7	0.854	26.8	672.3	1518.3	2190.6	0.307
	15.5	62.52	4.81	1.447	3.28	7.86	34.8	1.053	30.2	758.3	1615.2	2381.8	0.321
	31.0	64.58	4.91	1.470	3.73	8.18	35.8	1.122	31.2	845.8	1696.1	2541.8	0.332
	46.5	66.61	5.02	1.501	3.86	8.38	37.4	1.204	32.1	867.9	1729.1	2580.0	0.336
$L.S.D._{0.05}$		0.5368	0.0037	0.0037	0.0941	0.0519	0.4814	0.0038	0.3868	15.820	21.38	24.32	0.0037

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تأثير التسميد بالكبريت والفوسفور على نمو ومحصول الشعير تحت ظروف جنوب سيناء

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شعبة البيئة وزراعات الاراضى الجافة- مركز بحوث الصحراء-القاهرة – مصر

أقيمت تجربتان حقليتان أثناء موسمى٢٠٠٢ -٢٠٠٣ و٢٠٠٣-٢٠٠٤ (تحت نظام رى بمياه أبار مالحة) بغرض دراسة معدلات إضافة السماد الفوسفاتى والكبريت على المحصول ومكوناته لنبات الشعير (صنف جيزة ١٢٣) . وقد أظهرت النتائج أن كلاً من التسميد الفوسفاتى والكبريت أعلى من المستوى صفر أدى إلى زيادة معنوية فى إرتفاع النبات والوزن الغض والجاف بالجرام للنبات الواحد ، عدد الافرع للنبات الواحد ، عدد الحبوب بالسنبلة الواحدة ، وزن حبوب السنبلة الواحدة (جم) ، وزن الالف حبة (جم) ، محصول الحبوب للنبات الواحد (جم) ، محصول الحبوب للفدان (كجم) ، محصول القش للفدان (كجم) ، المحصول البيولوجى للفدان ، دليل الحصاد (%) . وتحققت أعلى القيم عند مستوى ٤٦,٥ كجم فو/فدان و ٣٠٠ كجم كبريت /فدان وكان التفاعل فيما بين الفوسفور والكبريت معنوياً .