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Effect of phosphorus and sulphur on growth and yield of toria (*Brassica campestris* subsp. *oleifera* var toria)

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ABSTRACT

A field experiment was conducted during early winter (*rabi*) seasons of 1987 and 1988 to study the effect of phosphorus and sulphur on growth and yield of toria [*Brassica campestris* L. ssp. *oleifera* (Metzger) Sinsk. var toria]. The highest seed yields of 16.9 and 14.0 q/ha in 1987 and 1988 respectively were obtained with P @ 60 kg/ha, which were significantly more than of 20 and 0 kg P/ ha. Similarly, application of sulphur also increased the seed yield significantly over the control, with a margin of about 1.6 q/ha in both the years.

Oil and protein contents of toria increased significantly up to P @ 40 kg/ha in both the years. Sulphur (50 kg/ha) increased the seed protein content from 24.5 to 25.1% and oil content from 41.1 to 42.2%. Sulphur application also increased iodine index. Unsaturated fatty acid was improved by phosphorus and sulphur.

Toria [*Brassica campestris* L. ssp. *oleifera* (Metzger) Sinsk. var toria] is grown extensively as an early winter (*rabi*) crop under intensive crop systems with rice–wheat and maize–wheat rotations. Under such systems it requires not only liberal application of nitrogen and irrigation but also often supplemental doses of secondary nutrients, phosphorus and sulphur, for sustained productivity. Newly developed varieties are highly responsive to heavy fertilization. It was therefore pertinent to study nutrient needs of these high-yielding varieties in the context of fast-changing cropping systems for the sub-tropical, semi-arid conditions of Punjab.

MATERIALS AND METHODS

The experiment was carried out at Ludhiana (30°56′N, 75°52′E, and 247 m above mean sea-level). The soil was loamy-sand throughout the profile and classed Typic ustochrept. The average values of profile soil-moisture content at field capacity (0.3 bar) was 31.4 cm and permanent wilting point (15 bar) 12.6 cm with 18.8 cm available water in 0–180 cm soil. The soil was low in available nitrogen (142–166 kg/ ha), and medium in available phosphorus (18–21 kg/ha) and potash (215–262 kg/ha). The sulphur content was 11–15 μg/g. The treatments consisted of 4 levels of P (0, 20, 40 and 60 kg P_2O_5/ha; P_0, P_{20}, P_{40} and P_{60}) and 2 levels of S (0 and 50 kg S/ha; S_0 and S_{50}) tested in randomized block design with 4 replications. Toria variety 'TL 15' was sown by using 5 kg seed/ha with 30 cm × 10 cm spacing on 10 September 1987 in the first year and on 13 September 1988 in the second year. The crop was harvested during last week of December in both the years. A common dose of N @ 60 kg/ha was applied

in combination with P (triple superphosphate) and sulphur (gypsum) at sowing. Two hand-weedings were given at 3 and 6 weeks after sowing. Periodic leaf area of 2 random plants was measured with leaf-area meter (LI-COR, Model : Li-3000 Lamba).

RESULTS AND DISCUSSION

Leaf area

Differences in leaf area due to P and S were well marked from an early stage. Leaf area progressively increased up to P_{60}. The increase was significant up to P_{40} with consistent trend till 90 days after sowing. At peak (60 days after sowing), P_{40} produced leaf area of 516 and 466 cm^2/plant compared with 526 and 476 cm^2/plant in P_{60} during 1987 and 1988 respectively. Sulphur application (50 kg S/ha) also increased leaf area significantly and this increase was evident at all the stages (Table 1).

The leaf-area index followed the trend of leaf area and was in the order $P_{60} > P_{40} > P_{20} > P_0$; and $S_{50} > S_0$ at all the stages.

Dry matter

Dry-matter accumulation increased with each successive increment of phosphorus as well as with sulphur at all the stages. At harvest, the biomass at P_{40} was 10.7 and 25.2% more than P_{20} and P_0 respectively during 1987, and 10.6 and 25.7% higher during 1988. Sulphur application increased the dry-matter accumulation at early stage of growth (45 days stage). However, during later stages, the diferences vanished (Table 2). However, no interaction or antagnostic effect of P was observed with S.

Seed yield

The seed yield was higher in the first year than that in second year due to well-distributed rainfall during the crop season compared with excessively high rainfall in the second year, which was about 12 times more than the first year. The significantly highest seed yield (q/ha) in 1987 and 1988 respectively was at P_{60} (16.9 and 14.0). It was significantly higher than that at P_{20} (15.0 and 13.3 q/ha) and P_0 (12.3 and 9.4 q/ha). The yield under P_{40} (16.6 and 13.3 q/ha) was at par with that under P_{60}. Application of S significantly increased the seed yield. The highest seed yield (16.0 and 12.8 q/ha) under 50 kg S/ha was significantly more than that under the control (S_0) (14.4 and 11.3 q/ha). Singh and Gangasaran (1987) and Singh *et al.* (1988) also obtained similar results in rapeseed and mustard.

The sulphur application influenced the productivity of toria by improving the both, the basic infrastructural frame (bearing capacity) and the leaf area (the photosynthate production efficiency as well as the siliqua size). It regulates these parameters, because it is part of amino acids like methionine, cystine and cystein, lipoic acid, co-enzyme (SCOAH) and vitamins (thiamine pyrophosphate).

Oil and protein contents

Both the oil and protein contents of toria increased significantly up to P_{40} in both the years (Table 3). Increase in oil content with P_{40} was respectively 1.9 and 3.9% compared with P_{20} and P_0 in 1987 and 2.4 and 2.0% in 1988. Sulphur @ 50 kg/ha increased the seed-protein content from 24.5 to 25.1% and oil content from 41.1 to 42.2%. Singh and Gangasaran also reported (1987) beneficial effect of sulphur. Sulphur application benefitted both the seed and oil yields, emphasizing the need of these nutrients in yield maximization of toria on light sandy soils of low-inherent fertility.

Table 1. Periodic leaf area (cm^2/plant) of toria under different levels of phosphorus and sulphur

Treatment	Days after sowing									
	1987					1988				
	30	45	60	75	90	30	45	60	75	90
P (kg/ha)										
0	295	355	478	416	123	232	294	423	365	105
20	325	374	499	436	140	261	336	448	389	122
40	346	390	516	450	153	296	364	466	408	134
60	353	397	526	459	160	303	373	476	428	142
CD (P = 0.05)	17	16	15	12	8	21	16	13	11	9
S (kg/ha)										
0	313	371	483	432	137	269	325	435	379	115
50	346	387	526	450	151	326	359	471	416	140
CD (P = 0.05)	12	11	11	8	5	15	11	9	8	7

Table 2. Periodic dry matter (g/plant) of toria under different levels of phosphorus and sulphur

Treatment	Days after sowing											
	1987						1988					
	30	45	60	75	90	At harvest	30	45	60	75	90	At harvest
P (kg/ha)												
0	3.9	15.6	19.5	21.9	25.2	28.9	3.1	13.5	17.6	20.1	23.6	25.7
20	4.3	17.4	22.0	25.4	27.7	32.7	3.5	14.3	19.5	22.5	26.1	29.2
40	4.6	19.0	24.2	27.1	31.7	36.2	3.9	16.6	21.0	23.8	29.2	32.3
60	4.3	20.0	25.1	28.3	32.7	37.1	4.2	18.0	22.3	24.8	30.6	33.8
CD (P = 0.05)	0.2	1.2	1.6	1.9	2.6	2.0	0.3	1.5	2.0	2.0	2.3	1.9
S (kg/ha)												
0	4.2	16.9	22.2	25.1	28.8	32.9	3.5	14.1	19.5	22.6	26.4	29.1
50	4.6	19.0	23.2	26.3	29.0	34.7	3.8	15.6	20.6	23.0	28.3	31.3
CD (P = 0.05)	0.1	0.9	NS	NS	NS	NS	0.2	1.0	NS	NS	1.6	0.7

Table 3. Seed yield (q/ha), protein content (%), oil content (%), iodine value (N_0) and allyl-iso-thiocyanate of toria under different levels of phosphorus and sulphur

Treatment	1987					1988				
	Seed yield	Oil content	Protein content	Iodine value	Allyl-iso-thiocyanate	Seed yield	Oil content	Protein content	Iodine value	Allyl-iso-thiocyanate
P (kg/ha)										
0	12.3	40.7	24.2	97.8	0.481	9.4	40.4	23.8	96.1	0.484
20	15.0	41.5	24.7	99.3	0.488	11.5	41.2	24.1	98.3	0.490
40	16.6	42.3	25.2	101.3	0.501	13.3	42.2	24.8	101.4	0.499
60	16.9	42.6	25.4	102.5	0.508	14.0	42.3	25.1	102.1	0.566
CD (P = 0.05)	1.8	0.36	0.43			2.0	0,33	0.36		
S (kg/ha)										
0	14.4	41.4	24.7	98.3	0.484	11.3	41.1	24.5	98.1	0.482
50	16.0	42.2	25.1	102.2	0.505	12.8	41.9	24.9	101.9	0.507
CD (P = 0.05)	1.3	0.25	0.30			1.4	0.23	0.25		

Iodine value and allyl-iso-thiocyanate

Both the iodine value and allyl-iso-thiocyanate increased with an increase in level of P. The highest value of allyl-iso-thiocyanate was with P_{60} (0.508 and 0.506) compared with 0.481 and 0.484 in P_0 respectively in first and second years. However, respective values for iodine number were 102.5 and 102.1 at P_{60} and 97.8 and 96.1 at P_0 (Table 3).

Sulphur application also increased iodine index. Thus, the extent of unsaturated fatty acids was improved with P and S. Likewise, the pungency (as indexed by allyl-iso-thiocyanate) was also increased with P and S fertilization. Allyl-iso-thiocyanate increased with S application, because S is a part of sinigrin glycoside the casual agent for pungency in brassicas.

Phosphorus at about 60 kg P_2O_5 and S at 50 kg/ha are perhaps essential nutrients along with N for the seed-yield maximization, improved oil content and iodine number in toria on these loamy sand of inherent low fertility, and these nutrients must be incorporated in the fertilization schedule of this crop under the intensive croping systems of north-western Indian belt.

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