

Interaction effect of sulphur and potassium on nutritional quality and profitability of brown sarson (*Brassica rapa* var *brown sarson*) in temperate Kashmir

PURSHOTAM SINGH¹, NARINDER PANOTRA², PARMEET SINGH³, K.N. SINGH⁴ AND RAIHANA HABIB KANHT⁵

Sher-e- Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu & Kashmir 191 121

Received : September 2012; Revised accepted : January 2013

ABSTRACT

A field experiment was conducted to evaluate the effect of four levels each of sulphur (0, 20, 40 and 60 kg/ha) and potassium (0, 30, 60, 90 kg/ha) on brown sarson (*Brassica rapa* var *brown sarson*) 'KOS 101' during *rabi* 2007-08 and 2008-09 at Regional Research Station Wadura, SKUAST-K in temperate Kashmir. Application of graded levels of sulphur and potassium progressively improved growth and yield attributes but in a decreasing order. The seed and stover yields increased linearly up to 40 kg S/ha and 60 kg K₂O/ha. Seed yield (2.03 t/ha) with 40 kg S/ha was 27.6 % higher in comparison to control. Similarly, application of 60 kg K₂O/ha resulted in 35.48 % higher seed yield (2.09 t/ha) than the yield obtained in control. Sulphur showed synergistic relationship with potassium. P uptake significantly increased up to 40 kg S/ha, thereafter, decreased significantly. Oil yield, oil quality and protein content also increased significantly with the application of sulphur and potassium. Percent utilization of added sulphur and potassium was maximum when lowest levels of sulphur and potassium were applied. Application of 40 kg S/ha and 60 kg K₂O/ha besides improving quality and quantity of brown sarson, also registered higher B: C ratio (1.54).

Key words: Brown Sarson, Nutrient use efficiency, Potassium, Relative economics, Sulphur

Under temperate condition of Kashmir, growth duration of brown sarson (*Brassica rapa* var *brown sarson*) spans around 210 days from October to May with maximum and minimum temperature of 21.7 and 0.6 °C (ranging between – 3.6 to 30) °C as given Fig 1. The crop remains under the spell of low temperature or snow for a considerable period. (Anonymous 2008). Low seed production and inferior quality of oil of brown sarson in temperate Kashmir are due to various constraints including nutrient management. Continuous cropping coupled with high yielding varieties has exhausted the soil not only in respect of macronutrients but also micronutrients. The increased use of sulphur free N and P fertilizers, use of organic manures in small quantities and practically no application of potassium affect the reserves of potassium and sulphur in most of the soils of Kashmir valley, resulting in depletion of these nutrients thereby limiting the soil productivity (Wani and Akther 2009). In recent years sulphur emerged as a vital nutrient and is now widely accepted as the fourth major plant nutrient along with N, P and K. Sulphur influ-

ences yield and oil content of the produce as it is involved in the synthesis of essential amino acids like cysteine, cystine and methionine (Kumar and Yadav 2007). Keeping in view the inadequate and scanty information on sulphur and potassium nutrition of brown sarson particularly on soils of temperate Kashmir, the present investigation was carried out to study the sulphur and potassium requirements of brown sarson in Hapludaffs soils of Kashmir valley.

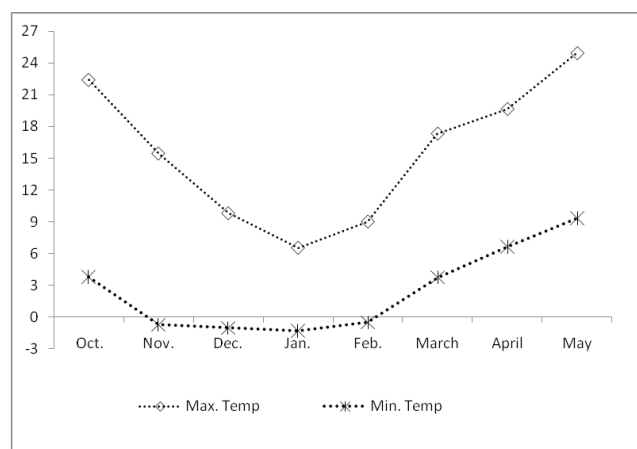


Fig. 1. Monthly mean maximum and minimum temperature (mean of two years)

²Corresponding authors Email: dr.narinderpanotra@gmail.com

¹Assistant, ²Scientist, ³Research Associate, ⁴Professor & Head (Agronomy), ⁵Associate Professor & Senior Scientist, SKUAST, Kashmir, J&K

MATERIALS AND METHODS

A field experiment was conducted with brown sarson cultivar 'KOS-1' at regional research station Wadura, Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir during *rabi* 2007-08 and 2008-09 with four levels of sulphur (0, 20, 40 and 60 kg/ha) and four levels of potassium (0, 30, 60 and 90 kg/ha) in randomized block design with three replications. The soil of the experimental field was clay loam in texture with pH 6.9, EC 0.28 and 0.29 ds/m, organic carbon 3.9 - 4.0g/kg, 0.15% calcium chloride extractable S 7.4 - 8.1 mg/kg, alkaline permanganate oxidizable available nitrogen 158 - 165 kg/ha, Olsen's available phosphorus 7.6 - 8.8 kg/ha and available potassium 92-98 kg/ha. Crop was sown using seed rate of 7.5 kg/ha and row spacing of 30 cm on 2nd and 8th October in 2007 and 2008 respectively. Plant spacing of 10 cm within row was maintained by thinning the crop after winter. Crop received 60 kg N and 13.2 kg P/ha. Potassium through muriate of potash and sulphur through gypsum were applied as per treatment at sowing. Observations on yield and yield attributes were recorded as per standard protocol. Seed samples were dried and grounded in wiley mill and used for chemical analysis. Nitrogen in the grounded seed and stover samples and P, K and S in the extracts ($\text{HNO}_3\text{-HClO}_4$) were determined by micro Kjeldahl method (Piper, 1966) for N, Vanadomolybdate phosphoric yellow colour method for P, Flame photometric method for K and turbidimetric method for S (Chesnin and Yien, 1951). Oil content in seed and fatty acids in oil were determined by the method of AOAC (1970) and GLC (Appelqvist 1968). Nutrient uptake was calculated by determined nutrient concentration in relation to dry

matter production. Protein content in grain (%) was worked out by multiplying the nitrogen content in seed with the multiplication factor 6.25. Protein harvested (kg/ha) was determined by multiplying the protein content with seed yield. Fertilizer use efficiency was determined by working out kg grains per kg fertilizer applied. Response curve of quadratic type of equation $y = a+bx+cx^2$ to potassium and sulphur levels was fitted using least square technique as given in Snedecor and Cochran (1967). The economic optimum doses $((q/p - b) / 2c)$ for each of K and S was derived.

RESULTS AND DISCUSSION

Yield and yield attributes

Interaction of K and S was significant for both seed and stover yields (Table 1). Seed yield increased significantly only up to 30 kg K_2O /ha in the absence of sulphur but with application of S (20 and 40 kg/ha), it increased up to 60 kg K_2O /ha. Similarly at lower doses of potassium (0 and 30 kg K_2O /ha) response of S was recorded only up to 20 kg S/ha, whereas with higher doses of potassium (60 and 90 kg K_2O /ha), seed response to S was observed upto 40kg/ha. The highest seed yield (2.28 t/ha) obtained with application of 60 kg K_2O + 40 kg S/ha, which was significantly higher than all other combinations of potassium and sulphur and resulted in 11, 15 and 68% higher seed yield than 60 kg K_2O +20 kg S, 30 kg KO+40 kg S/ha and control (0+0) respectively. Similar trend was observed for the stover yield except that even in the absence of S, it increased significantly up to 60 kg K_2O /ha. Higher doses of potassium (90 kg/ha) and S (60 kg/ha) were not superior than lower doses of respective nutrient (60 kg K_2O and 40 kg S/ha).

Table 1. Effect of sulphur and potassium fertilization on seed and stover yield (t/ha) of brown sarson (mean of two years)

Sulphur levels (kg/ha)	Potassium levels (kg/ha)				Mean
	0	30	60	90	
Seed					
0	1.36	1.59	1.73	1.72	1.60
20	1.52	1.84	2.06	2.04	1.87
40	1.64	1.99	2.29	2.22	2.04
60	1.65	2.00	2.27	2.18	2.03
Mean	1.54	1.85	2.09	2.04	
SEm±	K: 0.03		S: 0.03		KXS: 0.05
CD (P=0.05)	K: 0.09		S: 0.09		K X S: 0.16
Stover					
0	3.24	4.00	4.49	4.47	4.05
20	3.78	4.85	5.59	5.52	4.93
40	4.17	5.47	6.47	6.20	5.58
60	4.16	5.52	6.34	6.03	5.51
Mean	3.84	4.96	5.72	5.56	
SEm±	K: 0.06		S: 0.06		KXS: 0.11
CD (P=0.05)	K: 0.17		S: 0.17		KX S: 0.32

Application of 40 kg S/ha increased seed yield by 20 and 7 % and straw yield by 28 and 10 % over control and 20 kg S/ha, respectively. However, the difference between 40 and 60 kg S/ha for yield and yield attributes were non-significant. Increase in siliquae /plant, seeds/ siliqua, 1,000-seed weight, seed and stover yield with application of 40 kg S/ha was to the tune of 14.2, 22.4, 15.3, 27.6 and 37.63 %, respectively over control. Application of 60 kg K₂O/ha resulted in 27 and 8 % higher seed yield and 38 and 12 % higher stover yield than 0 and 30 kg K₂O/ha, respectively. Similarly application of 60 kg K₂O/ha increased the yield attributes by 22.8, 13.8, 24.7, 35.6 and 49.1 % respectively over control. Increase in yield and yield attributes with increasing levels of sulphur ascribes to its role in the synthesis of protein, oil and vitamins (Jat and Mehra, 2007). Increase in seed and stover yields (Table 2) with the addition of S and K might be due to their deficiency in experimental soils. Similar findings were also reported by Mishra *et al.* 2002 in Indian mustard. There was significant effect of sulphur and potassium interaction on the seed yield of brown sarson. At the same level of potassium, increase in rate of sulphur up to 45 kg/ha significantly increased the seed yield of brown sarson. The maximum (2.29 t/ha) and minimum (1.36 t/ha) seed yield was recorded at 60 kg K₂O and 40 kg S and 0 kg K₂O and 0 kg S treatment combinations, respectively. Response of brown sarson to potassium and sulphur was quadratic in both the years (Table 3). The regression equa-

tion predicted linear increase in the seed yield with a unit increase in the level of potassium and sulphur.

Nutrient uptake

There was increase in total uptake of N, P, K and S at maturity with the application of K and S (Table 4). Uptake of N, P and K increased significantly by the application of 40 kg S/ha. Potassium application increased the uptake of N and S significantly up to 60 kg K₂O/ha and that of K up to 90 kg K₂O/ha. Uptake of sulphur increased continuously up to 60 kg S/ha, though the values were statistically at par with 40 kg S/ha, whereas potassium application increased the uptake of sulphur significantly up to 60 kg K₂O/ha, thereafter declining trend was observed at higher level i.e 90 kg K₂O/ha. These results are in agreement with the findings of Mishra (2001). Mean values of recovery of potassium on added sulphur and potassium varied from 25.9 to 39.7 % and 25.7 to 43.8 %, respectively. Whereas apparent recovery of sulphur on addition of sulphur varied from 31.8 to 47.6 % and on addition of potassium varied from 7.5 to 15.7 %. The fertilizer use efficiency decreased with increasing doses of nutrients. The response of applied sulphur decreased from 13.6 kg with 20 kg S/ha to 7.1 kg with 60 kg S/ha, whereas in case of potassium it decreased from 10.5 kg with 30 kg K₂O/ha to 5.6 kg with 90 kg K₂O/ha. Ganeshmurthy and Thakkar (1997) reported similar findings for S.

Table 2. Effect of application of sulphur and potassium on yield attributes, apparent recovery and fertilizer use efficiency of S and K in brown sarson (mean of two years)

Treatment	Siliquae/ plant	Seeds/ siliqua	1,000-seed weight (g)	Apparent K recovery (%)	Apparent S recovery (%)	Fertilizer use efficiency
<i>S level (Kg/ha)</i>						
0	161	16.3	4.3	-	-	-
20	176	18.1	4.9	39.7	40.6	13.6
40	184	19.9	5.0	39.2	47.5	11.0
60	187	20.6	5.0	25.9	31.9	7.1
SEm±	1.4	0.5	0.1	-	-	-
CD (P=0.05)	4.1	1.5	0.3	-	-	-
<i>K level (Kg/ha)</i>						
0	167	17.1	4.1	-	-	-
30	199	18.7	4.9	43.8	15.8	10.5
60	205	19.5	5.1	36.7	12.7	9.1
90	206	19.6	5.2	25.7	7.6	5.6
SEm±	1.44	0.6	0.07	-	-	-
CD (P=0.05)	4.3	1.8	0.2	-	-	-

Table 3. Response equation, economic optimum dose (EOD), yields at EOD and R²

Sources	Response equation	EOD (kg/ha)	Yield at EOD (t/ha)	R ²
Potassium	$Y = 1529.25 + 14.75833x - 0.099722x^2$	73.0	2.08	0.9825
Sulphur	$Y = 1590.95 + 17.9225x - 0.1781x^2$	49.3	2.04	0.9561

Quality characteristics

Oil content increased significantly from 38.7% without S application to 42.0% with 60 kg S/ha (Table 5). Increase in oil content on addition of sulphur resulted due to increase in glucosides. Similar findings have also been reported by Aulakh *et al.* (1980). Application of potassium tended to increase the oil content significantly up to 60 kg K₂O/ha over control. Increase in oil content on potassium application is attributed to increase in the activity of enzymes involved in fat synthesis. These results are supported by the findings of Pathak *et al.* (1999). Fatty acid composition of oil was influenced significantly by the application of sulphur and potassium (Table 5). Beneficial fatty acids such as oleic and linoleic acid contents increased whereas undesirable components such as erucic acid content decreased with increasing doses of sulphur and potassium. These findings are in line of observations

made by Mishra *et al.* (2002). Protein content also increased significantly up to highest levels of sulphur and potassium over control (Table 5). This is mainly due to increase in nitrogen uptake.

Relative economics

Cost of cultivation varied according to different levels of potassium and sulphur (Table 5). Highest cost of cultivation (₹17,685) was with treatment S₃K₃ (60 kg S/ha and 90 kg K₂O/ha), because of higher cost of inputs like gypsum and murate of potash. Highest net returns (₹24,938) and benefit: cost ratio (1.54) was recorded with the treatment S₂K₂ (40 kg S/ha and 60 kg K₂O/ha). The seed yield of 2.07 and 2.01 t/ha could be obtained with optimum dose of 49 kg S/ha and 73 kg K₂O/ha respectively

It is concluded that under temperate conditions of Kashmir for sustaining higher yields, besides nitrogen and

Table 4. Effect of sulphur and potassium application on nutrient uptake (kg/ha) by brown sarson (mean of two years)

S levels (kg/ha)	Potassium levels (kg/ha)				
	0	30	60	90	Mean
Nitrogen					
0	46.8	61.9	79.7	80.4	67.1
20	57.9	77.7	99.8	99.6	83.8
40	70.6	90.9	115.7	115.8	97.7
60	70.7	91.5	114.1	112.4	96.9
Mean	61.4	80.5	102.4	102.2	
SEm±	K: 0.98		S: 0.98		K × S: 1.64
CD (P=0.05)	K: 2.94		S: 2.94		K × S: 4.94
Phosphorus					
0	13.9	17.9	21.3	21.2	18.6
20	15.7	21.8	26.5	26.0	22.5
40	17.8	24.9	29.4	27.5	24.9
60	16.2	24.2	27.7	25.3	23.3
Mean	15.9	22.2	26.2	25.0	
SEm±	K: 0.41		S: 0.41		K × S: 1.14
CD (P=0.05)	K: 1.24		S: 1.23		K × S: 3.43
Potassium					
0	38.7	48.1	55.7	58.9	50.2
20	43.7	56.8	65.2	66.9	58.1
40	49.9	64.7	74.3	74.9	65.9
60	45.4	65.3	74.2	74.0	65.8
Mean	44.4	58.8	67.4	68.6	
SEm±	K: 0.81		S: 0.81		K × S: 1.32
CD (P=0.05)	K: 2.42		S: 2.43		K × S: 3.97
Sulphur					
0	8.6	11.8	13.5	13.7	11.9
20	15.9	19.7	22.4	22.1	20.0
40	24.6	30.4	34.9	33.9	30.9
60	25.8	31.9	34.2	32.3	31.0
Mean	18.7	23.5	26.2	25.5	
SEm±	K: 0.35		S: 0.35		K × S: 0.59
CD (P=0.05)	K: 1.06		S: 1.06		K × S: 1.78

Table 5. Effect of K and S fertilizer on quality characteristics and relative economics of brown sarson (mean of two years)

Treatment	Oil content (%)	Oil yield (kg/ha)	Fatty acid composition				Gross returns (₹ × 10 ³ /ha)	Net returns (₹ × 10 ³ /ha)	B: C ratio
			Oleic acid (%)	Linoleic acid (%)	Erucic acid (%)	Protein in cake (%)			
S ₀ K ₀	37.6	510.3	17.1	12.7	49.4	34.8	24.5	11.3	0.85
S ₀ K ₁	38.4	608.4	17.8	13.3	49.2	35.7	28.5	15.1	1.12
S ₀ K ₂	39.4	680.8	18.3	13.6	48.9	37.3	31.1	17.4	1.26
S ₀ K ₃	39.6	681.0	18.6	13.8	48.7	37.6	31.0	17.0	1.21
S ₁ K ₀	38.9	593.1	18.1	13.4	49.0	36.3	27.4	13.0	0.90
S ₁ K ₁	39.7	729.9	18.9	14.2	48.7	37.1	33.1	18.4	1.25
S ₁ K ₂	41.3	852.8	18.6	14.9	48.4	39.5	37.1	22.2	1.48
S ₁ K ₃	41.6	848.9	18.9	15.0	48.2	39.8	36.7	21.5	1.41
S ₂ K ₀	40.7	667.9	18.9	14.1	48.6	38.0	29.6	13.9	0.90
S ₂ K ₁	40.9	813.5	20.2	15.3	48.1	39.4	35.8	19.9	1.25
S ₂ K ₂	42.5	971.1	21.0	16.1	47.7	41.4	41.1	24.9	1.54
S ₂ K ₃	42.7	949.2	21.3	16.3	47.6	41.8	40.0	23.6	1.43
S ₃ K ₀	41.0	674.5	19.5	14.6	48.4	38.4	29.6	12.754	0.76
S ₃ K ₁	41.6	830.4	20.8	15.8	47.8	39.9	35.9	18.802	1.10
S ₃ K ₂	42.8	969.4	21.8	16.8	47.40	41.9	40.8	23.356	1.34
S ₃ K ₃	42.9	933.7	22.1	17.0	47.3	42.3	39.1	21.429	1.21
SEm±	0.07	3.50	0.21	0.17	0.07	0.12	—	—	—
CD (P=0.05)	0.23	10.52	0.63	0.51	0.26	0.37	—	—	—

Cost :- MOP= ₹5300/t, Gypsum=₹1100/t, Brown sarson=₹1,8000/t

phosphorus, application of potassium and sulphur is prerequisite. To obtain maximum BCR, higher net returns and to improve the quality of produce, sulphur @ 40 kg/ha and potassium @ 60 kg/ha should be applied in rapeseed under Kashmir conditions along with recommended nitrogen and phosphorus. Optimum and economic yield, optimum doses of 49 kg S/ha and 73 kg K₂O/ha (as predicted from quadratic equation) should be evaluated by further experimentation in different agro-climatic zones.

REFERENCES

- Anonymous. 2008. *Digest of Statistics*. Jammu and Kashmir Directorate of economics and statistics, Planning and Development Department, Jammu & Kashmir.
- AOAC 1970. Official methods of analysis. Association of Official Analytical Chemistry, Washington, DC USA. P 174.
- Appleqvist, L.A. 1968. Rapid method of lipid extraction and fatty acid ester preparation for seed and leaf tissue with special remarks on preventing the accumulation of lipid contaminate. *Ark Kanic* **28**: 351–70.
- Aulakh, M.S., Pasricha, N.S. and Sahota, N.S. 1980. Yield, nutrient concentration and quality of mustard crop as influenced by nitrogen and sulphur fertilizers. *Journal of Agricultural Science, Cambridge* **94**: 545–49.
- Chesnin, L. and Yien, C.H. 1951. Turbidimetric determination of available sulphur in soil. (In:) *Proceedings of Soil Science Society of America* **15**: 149–51.
- Ganesh, Murthy Air and Takkar, P.N. 1997. Residual management of sulphur applied to soyabean or wheat in a soyabean-wheat system on vertisols. *Australian Journal of Soil Research* **35**: 199–08.
- Jat, J.R. and Mehra, R.K. 2007. Effect of sulphur and zinc on yield, macronutrient content and uptake by mustard. *Journal of the Indian Society of Soil Science* **55**: 190–95.
- Kumar, H. and Yadav, D.S. 2007. Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea* L) cultivars. *Indian Journal of Agronomy* **55**(2): 154–57.
- Mishra, S.K., Singh, R.N. and Tiwari, V.N. 2002. Effect of sulphur fertilization on quality characteristics of mustard (*Brassica juncea* L) seed in five cultivars. *Journal of the Indian Society of Soil Science* **50**: 141–43.
- Mishra, S.K. 2001. Effect of sulphur and zinc on yield, uptake of nutrients and quality of mustard. *Annals of Plant and Soil Research* **3**: 206–13.
- Pathak, R.K., Tiwari, T.P. and Tiwari, K.N. 1999. Use of potassium in Uttar Pradesh Agriculture. (In:) *Proceedings of Workshop U.P. Council of Agriculture Research and Potash and Phosphate Institute of Canada*. Indian Programme, Lucknow pp. 112–19.
- Piper, C. S.1966. Soil and Plant Analysis. Hans publishers, Bombay.
- Snedecor, G.W. and Cochran, W.G. 1967. Statistical Methods, 6th Ed, pp 354 Oxford and IBH publication.
- Wani, M.A. and Farida, Akhter 2009. Interaction effect of sulphur and zinc nutrition on yield, nutrient uptake and quality of Rapeseed (*Brassica campestris*). *SKUAST Journal of Research* **11**: 169–77.