

COMBINED EFFECTS BETWEEN P AND S IN SOIL ON THE MOBILITY OF N, P, K AND S IN RAPE (*BRASSICA CAMPESTRIS* L.)

¹PRATIMA PAUL, ²DILIP KUMAR DAS AND ³SABYASACHI KUNDAGRAMI

¹Research Scholar (pratima.paul89@gmail.com), Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Science, University of Calcutta, 51/2, Hazra Road, Kolkata - 700019

²UGC Ex-Emiretus Fellow, Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Science, University of Calcutta, 51/2, Hazra Road, Kolkata - 700019

³Associate Professor, Department of Genetics and Plant Breeding, Department of Plant Breeding and Genetics, Institute of Agricultural Science, University of Calcutta, 51/2, Hazra Road, Kolkata-700 019

Abstract: Field experiment was conducted in to study the interaction effect between P and S on the mobility of N, P, K and S in different parts of oilseed rape (Cv.B-9) using nine treatment combinations in a randomized block design (RBD) replicated thrice. The results reveal that the individual application of both P and S showed an increase in N, P, K and S content in stem and seed of rape, being greater magnitude with their higher rates. As regards to the root N, P, K and S content in rape, it was observed that the individual application of P increased a greater magnitude compared to individual of S, being greater with their increasing rates. The results further show that the amount of K content in stem, seed and root of rape has been found to be increased with individual application of P and S, being higher with their increasing levels, being further enhanced with their interactions. It is interesting to note that the rate of absorption of K by stem was much greater compared to N and P absorption of the same, suggesting greater mobility of K within the plant. The N, P, K and S contents in stem : root and seed : stem have been found to be varied by the different interaction level of P and S applications. The ratio of The ratio of N and S in stem : root and seed : stem were recorded as highest in the treatment P_2S_0 (0.73) and P_2S_2 (8.17) and P_0S_0 (1.31) and P_1S_2 (8.31) respectively which suggest that the greater mobility from stem to seed compared to root : stem. Comparing the results of interaction between P and S on the mobility of P and K it shown that the highest stem : root and seed : stem were recorded as 4.61, 1.06, 1.82 and 0.80 in the treatment P_1S_0 , P_1S_1 , P_1S_0 and P_0S_0 respectively. The yield of rape seed has been found to be increased with the individual application of both S and P irrespective of their rates. Such increase in yield of rape has been found to be further enhanced in the treatment P_1S_2 (10.20 q/ha) where P at 30 and S at 30 kg /ha was applied combinedly. The results further indicate that the mobility of N, P, K and S towards seed might be beneficial for maintaining healthy, nutritious and quality seeds vis – a – vis enhancing oil content in rape.

Keywords : interaction, mobility, phosphorus, rape, sulphur

INTRODUCTION

The application of phosphorus increases the nutrient uptake, yield and quality of oil seed crops especially rape and mustard. The application of phosphorus increases the nutrient uptake yield and quality of oil seed crops especially rape and mustard. However, such

increase in nutrient uptake and yields might be further enhanced when phosphorus is applied combinedly with sulphur (Das, 2007), of the various factors determining plant growth, supply of nutrients either from the native soil or supplemented through applied fertilizers, their rate of absorption, distribution among functional

sites and degree of mobility within the plant are very important. Keeping these in view, the present research work was undertaken.

MATERIALS AND METHODS

The present study was under taken in the field (Calcutta University Farm, Baruipur) with nine treatment combinations of P and S in a randomised block design replicated thrice using rape (Cv. B - 9) as a test crop. The study was concentrated on the translocation of N, P, K and S within the plant, rape. P_0 - control, P_1 - 30 kg / ha, P_2 - 45 kg/ha, S_0 - control, S_1 - 15 kg/ha, S_2 - 30 kg/ha, N- 80 kg/ ha, K_2O - 40 kg/ha.

The physico-chemical properties of soils as well as available N, P, K and S in soils and total N, P, K and S contents of plants were analysed following the method described by Jackson (1973). Nitrogen was determined by Kjeldhal method. Phosphorus, Sulphur were determined by spectro-photometrically and Potassium by flame-photometrically.

RESULTS AND DISCUSSION

Nitrogen Content in Rape (Whole Plant)

The highest N (4.17 g/kg) content was recorded at 40 days of crop growth when higher levels of phosphorus at 45 kg/ha and sulphur at 30 kg/ha was applied simultaneously suggesting a positive interaction effect between P X S with respect to N content in stem.

NITROGEN CONTENT IN RAPE SEED

The application of S at 30 kg/ha has been followed to be superior which showed highest N content (22.65 g/kg) in seed whereas the amount of N content in seed was recorded highest (22.58 g/kg) when P at 45 kg/ha was applied (Table 1). However, it is interesting to note that the amount of N content in rape seed has been found to be further increased when P and S was applied combinedly, being highest content (22.95 g/kg) N of seed in the treatment P_2S_1 when P at 45 and S at 15 kg/ha was applied altogether.

Nitrogen Content in Root

The results reveal that the root N content did not vary much due to individual application of S, at

its different levels whereas the same content in root varied due to separate application of P.

Table 1: N - content (g/kg) in Seed affected by combined application of P & S in soil Growing rape (Brassica campestris L.) (Mean of 3 replication)

Treatment	P_0	P_1	P_2	Mean
S_0	21.24	21.30	22.00	21.51
S_1	22.00	22.80	22.85	22.55
S_2	22.12	22.95	22.88	22.65
Mean	21.51	22.35	22.58	
CD(0.05%)	P	S	PxS	
	0.037	0.037	0.065	

Phosphorus Content in Rape (Whole Plant)

Comparing the results of interaction between P and S, it was found that the amount of P content in stem has been recorded to be varied with P and S interactions at their different levels, being highest amount (5.85 g/kg) in the treatment P_2S_2 when P at 45 and S at 30 kg/ha was applied combinedly. The result suggest that the interaction effect between P and S was found positive and synergistic with respect to P content in stem of rape.

Phosphorus content in Rape Seed

As regard to the combined applications of P and S (Table 2) it was observed that the amount of P content was always higher due to application of P and S at their different levels, being highest (4.95 g/kg) in the treatment P_2S_2 when P at 45 kg/ha and S at 30kg/ha was applied combinedly, which might be explain by greater mobility of P within the rape in presence of S suggested an existence of synergistic relationship between them in relation to seed P content, the results of the present study might have some favourable effect in contributing seed phospholipid content of rape. The present study also finds support from the results reported by Jain *et al.* (1995).

Phosphorus Content in Root

With regards to separate application of S at its different levels, it was observed that the amount of P in root increased with S application, being highest (1.58 g/kg) with its highest level. Similar

Table 2: P - content (g/kg) in Seed as affected by combined application of P & S in soil Growing rape(*Brassica campestris L.*) (Mean of 3 replication)

Treatment	P ₀	P ₁	P ₂	Mean
S ₀	4.05	4.15	4.70	4.30
S ₁	4.15	4.75	4.85	4.58
S ₂	4.60	4.80	4.95	4.78
Mean	4.27	4.57	4.83	
CD(0.05%)	P	S	PxS	
	0.032	0.032	0.055	

trend of changes in respect of P content in root was also recorded due to application of (1.71 g/kg) P at its highest level. The greater magnitude of increase however, was recorded due to application of highest level of P compared to corresponding levels of S which is obvious. As regards to the interaction between P and S, it was found that the P content in root was always higher with different combination of P and S interaction over that of absolute control (P₀S₀). However the P content in root was recorded highest (1.98 g/kg) in the treatment (P₂S₂) where combined application of P at 45 kg/ha and S at 30 kg/ha was made.

Potassium Content in Rape (Whole Plant)

The results show that the amount of K content in stover, seed and root has been found to be followed a similar trend of changes to that of P contents of the same. Comparing the results of interaction effect between P and S, it was observed that the amount of K content in stover varied significantly with treatments, being recorded highest (10.08 g/kg) in the treatment P₂S₂ where P at 45 kg/ha and S at 30 kg/ha was applied which might be explained by the greater mobility of K within the plant caused due to the combined application of P and S suggesting a positive relationship between them.

Potassium Content in Rape Seed

The results (Table 3) show that the K content in seed did show any significant variation due to individual and combined application of S and P. However, the application of S₁ at 15 kg/ha showed the highest amount (6.85 g/kg), while the amount of the same content did not show any variation due to application of P. As regards

to the interaction between P and S, the K content did not effect much excepting the treatment P₁S₁ in which K content was recorded as 7.73 g/kg (about 10 % over absolute control).The results are in conformity with the results reported by Chaplot *et al.* (1991).

Table 3: K - content (g/kg) in Seed affected by combined application of P & S in soil Growing rape(*Brassica campestris L.*) (Mean of 3 replication)

Treatment	P ₀	P ₁	P ₂	Mean
S ₀	7.01	4.29	5.72	5.67
S ₁	6.27	7.73	6.55	6.85
S ₂	5.96	4.79	4.89	5.21
Mean	6.41	5.60	5.72	
CD(0.05%)	P	S	PxS	
	0.046	0.046	0.079	

Potassium Content in Root

The amount of K content in root has been found to be increased with the individual and combined application of P and S. The magnitude of such increase, however, varied with levels of individual as well as combined application of P and S. The application of S at 30 kg/ha showed highest K content (7.65 g/kg) in root, where as the amount of the same content recorded highest (6.75 g/kg) with the application of P at 30 kg/ha. Comparing the interaction effects of P and S, the amount of K content has been found to be further increased, being highest (8.94 g/kg) in the P₁S₂ treatment when P at 30 kg/ha and S at 30 kg/ha was applied combinedly. The results suggest a positive interaction effect between P and S with respect to K content in root since a significant amount of K content was increased over that of separate application of P and S.

Sulphur Content in Rape (Whole Plant):

The results reveal that the amount of S content in stover, seed and root has been found to be varied with treatments and also followed a similar pattern of changes to that of K contents of the same. However, the application of S at 30 kg/ha showed a highest S- content in stover at 40 days of crop growth, while the amount of the same content did not show any significant variation due to application of P.

The results show that the amount of S content in seed progressively increased with the sole application of S and P.

Sulphur Content in Rape Seed

The S- content in seed has been found to be highest in the treatment S_2 when S at 30 kg/ha was applied during both the years. However, similar trend of changes in S- content in seed was also observed due to application of P. As regards to the interaction effect between P and S it was found that the amount of S- content in seed varied significantly, being recorded highest (28.98 g/kg) in the treatment P_2S_2 where P at 45 and S at 30 kg/ha was applied togetherly.

Table 4: S - content (g/kg) in Seed affected by combined application of P & S in soil Growing rape (*Brassica campestris* L.) (Mean of 3 replication)

Treatment	P_0	P_1	P_2	Mean
S_0	22.56	23.44	24.18	23.39
S_1	25.80	26.12	26.82	26.25
S_2	27.92	28.25	28.98	28.72
Mean	25.43	25.94	26.66	
CD(0.05%)	P	S	PxS	
	0.40	0.040	0.069	

Sulphur Content in Root

The results show that the amount of S-content in root progressively increased with the sole application of S and P as well as their combined applications during both the years.. The S- content in root has been found to be highest(5.46 g/kg) in the treatment S_2 when

S at 30 kg/ha was applied, similar trend of changes in S content root was also observed due to application of P.

Seed Yield

The yield of rape seed (Table 5) has been found to be increased with the individual application of both S and P irrespective of their rates. The magnitude of such increase, however, varied with their increasing rates, being highest (9.60 q/ha) with an increasing rate of S while that of the same increase was recorded highest (9.55 q/ha) with the application of P at its lower rate (30 kg/ha). Such increase in yield of rape has been found to be further enhanced in the treatment P_1S_2 (10.20 q /ha) where P at 30 and S at 30 kg ha was applied combinedly. Jaggi and Sharma (1999) also reported similarly.

Table 5: Yield of Rape (Q/ha) affected by interaction effect between P x S application in soil (Mean of 3 replication)

Treatment	P_0	P_1	P_2	Mean
S_0	7.30	9.35	9.50	8.72
S_1	8.80	9.10	8.65	8.85
S_2	9.05	10.20	9.55	9.60
Mean	8.38	9.55	9.23	
CD(0.05%)	P	S	PxS	
	0.101	0.101	0.175	

Nutrient Ratio

Nitrogen, Phosphorus, Potassium and Sulphur ratios in different plant parts of rape. The N, P, K and S contents in stem : root and seed : stem have been found to be moderated by the interaction

Table 6: Nitrogen, phosphorus and potassium and Sulphur contents in stem : root and seed : stem of rape (*Brassica campestris* L.)

Treat	N		P		K		S	
	Stover: Root	Seed: Stover	Stover: Root	Seed: Stover	Stover: Root	Seed: Stover	Stover: Root	Seed: Stover
P_0S_0	0.49	6.85	4.60	1.00	1.61	0.80	1.31	4.31
P_1S_0	0.46	5.46	4.61	0.97	1.82	0.48	1.20	4.61
P_2S_0	0.73	6.11	3.44	0.99	1.39	0.63	1.03	5.02
P_0S_1	0.44	6.47	3.79	0.97	1.44	0.69	1.30	4.45
P_1S_1	0.64	6.33	3.37	1.06	1.52	0.79	1.04	5.09
P_2S_1	0.55	7.37	2.56	1.05	1.47	0.66	0.93	5.30
P_0S_2	0.58	5.90	3.73	1.00	1.28	0.63	0.76	6.65
P_1S_2	0.58	7.91	3.07	1.02	1.11	0.48	0.65	8.31
P_2S_2	0.39	8.17	2.95	0.85	1.52	0.49	0.87	5.89

between P and S. The ratio of N and S in stem : root and seed : stem were recorded as highest in the treatment P_2S_0 (0.73) and P_2S_2 (8.17) and 1.31 at P_0S_0 level and 8.31 at P_1S_2 level respectively suggesting a relatively greater mobility of N and S from stem to seed compared to root : stem (Table 6). As regards to the mobility of P and K within different parts of plants, it was observed that the highest stem : root and seed : stem were recorded as 4.61, 1.06, 1.82 and 0.80 in the treatment P_1S_0 , P_1S_1 , P_1S_0 and P_0S_0 respectively. The maintenance of greater ratios of nutrients in stem : root and seed : stem determines the mobility of nutrients from root to seed via stem. However, such mobility of N, P, K and S nutrients towards seed might be beneficial in maintaining healthy and quality seeds and hence increase oil content in rape.

CONCLUSIONS

The N, P and K contents in stem : root and seed : stem have been found to be varied by the different interaction combinations of P and S applications. The ratios of N, P and K in seed : stem were always higher than that of stem : root suggesting their greater mobility from stem

to seed compared to root : stem. The results concluded that the mobility of N, P and K towards seed might be beneficial for maintaining healthy, nutritious and quality seeds vis - a - vis enhancing oil content in rape due to interaction between P and S in soils.

Literature Cited

- Chaplot, P.C., Jain, G.L. and Bansal, K.N. (1991). Effect of phosphorus and sulphur on the oil yield and uptake of N, P and S in sesame. *International Journal of Tropical Agriculture*. 9(3): 190-193.
- Das, D. K. (2015). *In: Introductory Soil science*, 4th edn, Published by Kalyani Publishers, New Delhi/Ludhiana.
- Jaggi, R.C. and Sharma, R.K (1999). Sulphur - phosphorus interaction in raya (*brassica juncea* var. Varuna). In acid alfisols of western Himalaya. *Tropical Agriculture* 76(3): 157-163.
- Jain, N.K. Vays, A.K. and Singh, A.k. (1995). Effect of phosphorus and sulphur fertilization on growth and nutrient uptake by mustard (*brassica juncea* L.) Czern and Cross). *Annals of Agricultural Research* 16(3): 389-390.
- Mishra, S.K. (2003). Effect of sulphur and potassium on yield, nutrient uptake, quality characteristics of mustard in Udic Haplusteps of Kanpur. *Journal of the Indian Society of Soil Science*. 51(4): 544-548.