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DIFFERENTIAL GROWTH AND SULPHUR UTILISATION BY CORN, SUNFLOWER AND RAPESEED FROM UNIFORM ROOT MEDIUM CONCENTRATION

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Growth and sulphur relations of corn, sunflower and rapeseed were studied in greenhouse in solution culture containing 0 and 1 mM S. Growth of the three plant species was affected with characteristic S deficiency symptoms when grown without S supply. However, with the addition of 1 mM S in the root medium, corn produced maximum biomass in three weeks of growth period followed by sunflower and rapeseed. With S deficiency, tissue water (shoot and root) decreased drastically. Growth of shoot in the three plant species was more compared with root with 1 mM S in the rooting medium. Higher concentration in plant tissues as well as higher rates of S transport from root to shoot and specific S absorption rates were observed in sunflower and corn.

INTRODUCTION

Sulphur (S) has been recognised as an important secondary nutrient for plants. Its requirements for several crops is as high as of phosphorus (Dixit and Shukla, 1984; Bapat *et al.,* 1986; Uexkull, 1988). Widespread S deficiencies have been reported in many parts of the world (Morris, 1987). Favourable plant responses to applied S on some typical agricultural soils of Pakistan have been observed in some preliminary studies (Rahmatullah and Salim, 1987; Salim and Rahmatullah, 1988). Average S, extracted from 27 benchmark soils of Pakistan by three different electrolyte solutions separately was approximately 1 mM (Nabi *et al.,* 1990).

Ample information on the differential utilisation of sulphur by different crop species is available (Kunwar and Mudahar, 1986; Islam, 1987). Oilseed crops generally require higher amounts of S for their growth as compared to the others (Singh and Singh, 1978; Aulakh and Pasricha, 1988). In a soil with a limited level of available S the farmers, therefore, may have the choice of a crop species or a crop variety with relatively low S requirements. This approach is also very vital for concept of sustainability of resources (CGIAR, 1988). To generate the information on the comparative S needs and the efficiency of its utilisation from a uniform S concentration of the root medium, a greenhouse study was conducted on most popular cultivars of corn, sunflower and rapeseed.

MATERIALS AND METHODS

Seeds of corn (*Zea mays* L. cv. Gohar), sunflower (*Helianthus annuus* cv. C-206) and rapeseed (*Brassic napus* cv. Westar Robot) were germinated on a polyester screen suspended over saturated $CaCO_3$

solution for better root development of the seedlings. Ten days old, four uniform seedlings of corn and sunflower and 12 seedlings of rapeseed were transferred to greenhouse in 4 l plastic containers having continuously aerated solution. Separate pots were kept for each crop species. The nutrient solution contained 10 mM N (NH_4NO_3), 0.5 mM P (KH_2PO_4), 3 mM K (KH_2PO_4/KCl), 2 mM Ca ($Ca(NO_3)_2.4H_2O$, 0.5 mM Mg ($Mg(NO_3)_2.6H_2O$), 1 mM S ($(NH_4)_2SO_4$) (for +S treatment and no S in S-treatment, 25 μM Fe (as EDDHA), 2 μM Zn (ZnO), 2 μM Mn ($(MnCl_2).4H_2O$), 0.5 μM (H_2MoO_4), 25 μM B (H_3BO_3) and 100 μM Cl. The solution pH was maintained at 5.7 ± 0.2. The experiment was laid out according to completely randomised design with three replications. Twelve days after transplanting in treatment solutions, two seedlings of each of corn and sunflower and 6 seedlings of rapeseed were harvested from each pot (T_1), separated into root and shoot, dried at 70°C for 48 hours and weighed. Nutrient solutions were changed weekly. Remaining seedlings were harvested after 21 days (T_2) and processed as earlier. Relative growth rate (RGR) of shoot and root was calculated (Hunt, 1978) as:

$$RGR\ (gg^{-1}\ day^{-1}) = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \qquad (1)$$

where

W_1 and W_2 were total dry weight of plants at harvest times T_1 and T_2, respectively.

Dried shoot and root samples were digested in nitric and perchloric acid mixture (4:1). Sulphur in the digest was measured turbidimetrically (Verma *et al.*, 1977). Specific absorption rate of sulphur (Is) unit^{-1} of root dry weight (μmol g^{-1} day^{-1}) was calculated as Hunt (1978):

$$I_s = \frac{S_2 - S_1}{T_2 - T_1} \times \frac{\ln Rw_2 - \ln Rw_1}{Rw_2 - Rw_1} \qquad (2)$$

where S_1 and S_2 were total S content of plants and Rw_1 and Rw_2 were root dry weight at harvest times T_1 and T_2. Efficiency of S utilisation by crop species (g dry matter produced g^{-1} S day^{-1}) was determined by calculating specific utilisation rate (U_s of S according to Hunt (1987):

$$U_s = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{\ln S_2 - \ln S_1}{S_2 - S_1}$$

where W, S and T were the same parameters as above. Standard error of means was calculated based on three observation for each treatment for comparison of treatment means.

RESULTS AND DISCUSSION

Plant growth: Growth of corn, sunflower and rapeseed was separately affected because of S supply in the root medium (Table 1). After three weeks of growth, shoot dry weights of the three corn plants grown in 1 mM S concentration were 8 to 10 times higher than with no S. However, in the case of roots, increase in dry weights were only 3 to 5 times. Comparatively higher reduction in shoot growth than root growth is a typical response of plants with S deficiency (Mengel and Kirkby, 1987). Data on root/shoot ratios elaborate it further as higher root/shoot ratios were observed when plants were grown without S. In general, root growth (relative to shoot growth) was better in the case of corn and sunflower as compared to rapeseed.

Table 1. The effect of sulphur on the growth of corn, sunflower and rapeseed

Sulphur application	Crop species	Dry matter yield (g plant^{-1})		Fresh/dry weight ratio	Relative growth rate (g g^{-1} day^{-1})		Root/Shoot ratio
		Shoot	Root	Shoot	Shoot	Root	
	Corn	0.330 ± 0.14	0.195 ± 0.102	7.790 ± 0.58	-	-	0.570 ± 0.078
-S	Sunflower	0.180 ± 0.02	0.125 ± 0.025	11.890 ± 0.61	-	-	0.890 ± 0.13
	Rapeseed	0.070 ± 0.02	0.014 ± 0.005	8.300 ± 0.14	-	-	0.190 ± 0.005
	Corn	2.370 ± 0.39	0.890 ± 0.09	11.570 ± 0.16	0.154 ± 0.027	0.179 ± 0.04	0.380 ± 0.005
+S	Sunflower	1.780 ± 0.19	0.445 ± 0.04	15.820 ± 0.24	0.183 ± 0.017	0.155 ± 0.024	0.250 ± 0.015
	Rapeseed	0.380 ± 0.04	0.045 ± 0.008	14.610 ± 0.73	0.230 ± 0.015	0.189 ± 0.017	0.120 ± 0.005

+S = With sulphur; -S = Without sulphur.

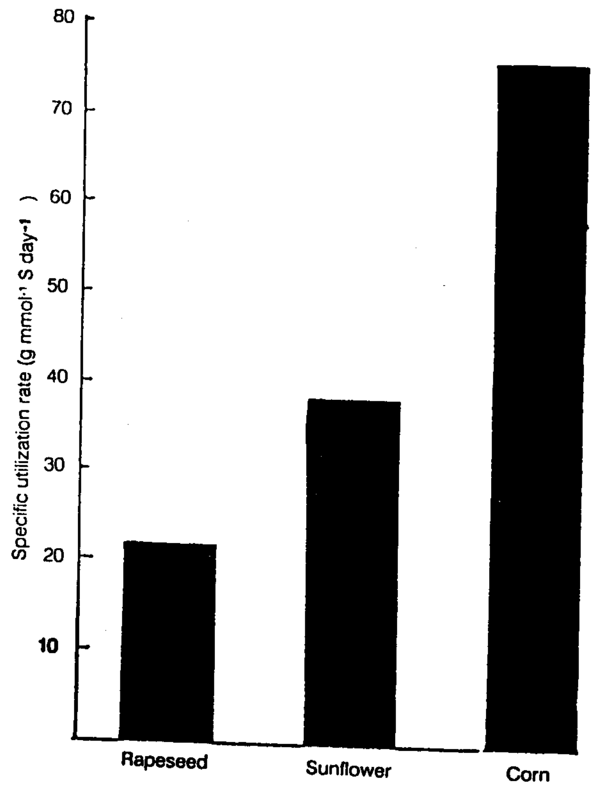

Fig. 1. Biomass accumulation by corn sunflower and rapeseed (mmol^{-1}) sulphur absorbed day^{-1}.

Table 2. Sulphur relations of corn, sunflower and rapeseed

Crop species	S concentration (mmol kg^{-1})		Total S uptake (μmol $plant^{-1}$)		Specific absorption (μmol g^{-1} dry weight day^{-1})
	Shoot	Root	Shoot	Root	
Corn	50.0 ± 0.00	93.75 ± 14.31	118.50 ± 19.30	82.80 ± 8.23	31.00 ± 11.25
Sunflower	131.30 ± 0.00	120.84 ± 10.97	230.47 ± 25.58	54.22 ± 9.60	98.81 ± 18.58
Rapeseed	334.50 ± 9.40	296.87 ± 15.73	128.49 ± 0.14	13.24 ± 1.09	660.28 ± 42.81

Data on fresh weight to dry weight (FW/DW) ratios of shoots showed interesting trend (Table 1). Shoot had lower tissue water contents when the root medium was without S. The dehydration of shoot tissue due to S deficiency was consistently observed in all the three plant species. Thus, S deficiency like N and P deficiency may affect hydraulic conductance of plant roots resulting in lower tissue water of plants (Salim, 1991). Although, maximum biomass was accumulated by corn and sunflower, the relative growth rate of rapeseed was remarkably higher than those of corn and sunflower at 1 mM S in the rooting medium (Table 1). As plants died in (-S) treatment after the first harvest, RGR could not be calculated. The RGR of shoot and root were almost similar in the case of all plant species.

Sulphur deficiency symptoms in the three plant species were different from one another. Deficiency in corn resembled N deficiency except that younger leaves turned first yellow and finally necrotic. However, no necrosis was evident in rapeseed. Different S deficiency symptoms in sunflower were marked by elongated internodes on spindly stems. Stem below cotyledonous leaves in S deficient sunflower plants turned purplish.

Sulphur relations: The three crop species had widely different S concentration in plant tissues. Sulphur concentration estimated in the three plant tissues was normal and agreed with earlier reports (Reuter and Robinson, 1986). Both oilseed crops, sunflower and rapeseed had higher S concentration than corn. Sulphur concentration in sunflower and rapeseed was 2- and 7-fold higher, respectively than that in corn (Table 2). Concentration of S in the shoot of sunflower and rapeseed was higher than their respective roots but the corn roots had much higher S as compared to its shoots. It indicates the ability of corn roots to retain S in the tissues for transport to shoot at a lower rate than in sunflower and rapeseed.

Total S uptake (μmol $plant^{-1}$) in sunflower was about twice in corn and rapeseed crops with 21 days of growth period (Table 2). Specific absorption rates of S were highly variable among the crops studied. It was maximum in rapeseed (660.3 μmol g^{-1} day^{-1}) and minimum in corn (31 μmol g^{-1} day^{-1}). Considerably higher influx of S in rapeseed despite of its lower root/shoot ratio than corn and sunflower suggests a scavenging nature of the crop for S. An efficiency parameter i.e. specific utilisation rate (dry matter produced $unit^{-1}$ of nutrient absorbed) was also evaluated. The lowest utilisation rate of S was observed in rapeseed, followed by sunflower and corn (Fig. 1). From the data, it may be concluded that S requirement for producing a unit dry matter in rapeseed was two and four times higher than that for sunflower and corn, respectively.

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REFERENCES

Aulakh, M.S. and N.S. Pasricha. 1988. Sulphur fertilization for oilseeds for yield and quality. In: Proc. Sulphur Indian Agri. p. S ii/3 (1-4), New Delhi.

Bapat, P.N., S.B. Sinha and D.A. Shinde. 1986. Effect of sulphur and phosphorus on yield and nutrient content of black gram. J. Indian Soc. Soil Sci. 34: 82-86.

CGIAR. 1988. Ann. Report. Consultative Group in International Agricultural Research Secretariat, Washington, D.C.

Dixit, M.L. and U.C. Shukla. 1984. Effect of boron, sulphur and zinc at different phosphorus and moisture levels on yield of mustard *(Brassica juncea* C.). J. Indian Soc. Soil Sci. 32: 186-188.

Hunt, R. 1978. Plant Growth Analysis. Edward Arnold, London.

Islam, M. 1987. Sulphur in Bangladesh agriculture. In: Proc. Symp. Fert. Sulphur Requirements and Sources in Developing Countries of Asia and Pacific. Bangkok. p: 18-25.

Kunwar, J.S. and M.S. Mundahar. 1988. Fertilizer sulphur and food production. Martinus Nijhoff Pub., Boston.

Mengel, K. and E.A. Kirkby. 1987. Principles of Plant Nutrition. IPI, Bern, Switzerland.

Morris, R.J. 1987. The importance and need for sulphur in crop production in Asia and the Pacific region. In: Proc. Symp. Fertilizer Requirements and Sources in Developing Countries of Asia and the Pacific. Bangkok. p: 4-11.

Nabi, G., Rahmatullah and M. Salim. 1990. Sulphur fraction and their extractability in some arid and semi-arid soils of Pakistan. Trop. Agri. 146 (In press).

Rahmatullah and M. Salim. 1987. Sulphur response of oilseed rape on problem soils of arid regions amended with elemental sulphur. In: Int. Symp. Elemental Sulphur Agri., Nice, France. pp: 591-598.

Reuter, D.J. and J.B. Robinson. 1986. Plant Analysis: An Interpretation Manual. Inkata Press, Sydney, Australia.

Salim, M. and Rahmatullah. 1988. Studies on plant response to sulphur application in Pakistan soils. In: Proc. Int. Symp. Sulphur Agri. Soils. Dhakka. p: 281-298.

Salim, M. 1991. Change in water conducting properties of plant roots by nutrition and salt stress. J. Agron. Crop Sci. 166: 285-287.

Singh, M. and N. Singh. 1978. Effect of sulphur on the quality of raya *(Brassica juncea).* J. Indian Soc. Soil Sci. 28: 203-207.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1985. Soil Fertility and Fertilizer. McMillan Pub., New York.

Verma, B.C., K. Swaminathan and K. Sud. 1977. An improved turbidometric method of sulphur determination in plants and soils. Talanta, 24: 49-50.

von Uexkull, H.R. 1988. Sulphur interaction with other plant nutrients. In: Proc. Symp. Sulphur Agri. Soils, Dhakka. p: 212-242.