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SEED YIELD AND QUALITY OF MUSTARD AS AFFECTED BY SOIL PROFILE MOISTURE AND RATES OF SULPHUR ON ARIDISOLS

B. P. SINGH

Results of a field experiment, comprising three soil profile mm moisture levels (165 ± 3, 140 ± 4 and 95 ± 1/1 m) in combination with four rates (0, 40 80 and 120 kg S/ha) of sulphur tried on aridisols, showed that additional supply of 1 mm/m of soil profile over the sub-optimum (95 ± 1 mm/m) gave 14.7 kg/ha to 38.1 kg/ha increased mustard seed yield. Regression equations, consumptive use with seed yield (q/ha), were Y = 0.187 X — 12.9767 and Y = 0.3588 x = 30.983 for the year 1679-80 and 1980-81 respectively. Application of increasing sulphur rates increased the oil per cent and thioglucoside content in seed during both years Water-use efficiency values decreased with decreasing soil profile moisture, from 5176 kg-mm/ha to 3.11 kg-mm/ha. Highest profit of Rs. 2122 25 per ha was recorded at 80 kg S/ha with good and normal soil profile moisture representing 165 ± 4 mm and 140 mm/m moisture in soil profile at seeding, respectively.

Indian mustard is one of the most improtant oilseed crop of the country. With the application of heavy rates of N and P, the seed and oil yield are not reaching to the full satisfaction of the mustard growers, probably because of increased requirements of sulphur induced by these sulphur free fertilizers. However, in oilseeds, sulphur plays a significant role in quality and development of seed Probably for these reasons mustard crop needs comparatively, higher amounts of sulphur for proper growth, development and higher yields.

The light textured soils representing aridisols of Haryana where *Bressicae* crops are grown, are generally deficient in sulphur (Kanwar and Randhawa, 1974, Singh and Singh, 1978). In such cases the mechanism of sulphur helping in improvement of yield and quality of mustard crop grown on varying profile moisture conditions representing the low, normal and good moisture conditions generally observed with the amount, distribution and availability of rainfall at sowing is not known. This study was, therefore, undertaken to find out the role of sulphur at varying soil profile moisture status on seed yield, ether extract, oil yield, thioglucoside and water-use efficiency of the crop.

MATERIAL AND METHODS

Investigations were carried out at Dry Farming Research Centre of Haryana Agricultural University, Bawal for two consecutive years during winters of 1979-80 and 1980-81. The soils represent the aridisols and classed as

Regional Research Station Haryana Agricultural University Bawal-123501

loamy sand, having PH 7.8 (1:2) organic carbon 0.30% and ECe 0.41 mhos/cm. Available p, K and S were 19, 340 and 14 kg, respectively. The field experiment was conducted in split plot design keeping soil profile moisture in main plots and sulphur rates in sub plots. There were three levels of soil profile moisture viz.: sub-optimum obtained by rain conserving, normal and good by recharging profile, with four levels of sulpur viz.: 0, 40, 80 and 120 kg S/ha applied through powedered gypsum. Uniform dose of 40 kg N and 20 kg P through non-sulphatic fertilizer was drilled with sulphur rates at sowing below seed level. The variety 'Parkash, of mustard was sown on 22-10-79 and 24-10-80 during first and second year respectively The crop was seeded at 30 cm apart in rows. Thinning of the crop was done at two week crop stage to maintain 3 lacs plants per ha. In sub-optimum moisture conditions, due to moisture stress seedlings were burnt and died due to hot sand in day time and the exact 3 lacs plants per ha at harvest could not be maintained.

Mustard seed samples collected were analysed for N,S ether extract and ally-iso thiocynate (%) content. Nitrogen was estimated by using methods described in USDA Hand book No. 60 (1973) and S by using method of Tabatabai and Bremner, (1970). Uptake of nutrients was calculated by multi plying the seed yield with per cent content of the respective nutrient and are presented in kg/ha for each nutrient. Oil was extracted with petroleume the- on 'Soxhlet' apparatus and is expressed per cent content and allyl-iso-thiocynate value was determined by A.O.A.C. (1960) method. For crude protein content, the respective nitrogen content was multiplied with the universal factor 6.25. The soil moisture as measured by gravimetric method to work out consumptive use and water-use efficiency. The moisture in soil profile in 1 m depth was 168, 143, 96 mm in 1979-80 and 163, 136 and 94 mm during 1980-81 in good, normal and sub-optimum moisture treatments, respectively. The data obtained are being presented in Tabular form and discussed.

RESULTS AND DISCUSSION

Yield and protein production

Production level during 1979 8[illegible] was comparatively low due to low rain fall (21 mm) received during the cro[illegible] growth season as compared to 43 mm o[illegible] winter showers received during 1980-8[illegible] (Table 1). Besides this, high temperatur[illegible] in February, 1980 also enforced th[illegible] early maturity, leading to low cro[illegible] yields. Soil profile moisture status a[illegible] sowing and rates of sulphur fertilizatio[illegible] affected the seed yield and protei[illegible] production significantly during both th[illegible] years of investigation (Table 2 a).

Additional supply of 1 mm o[illegible] moisture in soil profile over the sub optimum gave 14.7 kg/ha and 38.1 kg/ha at normal and 16.1 kg/ha and 30.7 kg/ha at good status during 1979-80 and 1980-81, respectively. Similar response has been observed on aridisols soils by Singh (1983)

Mustard responded to sulphur application upto 120 kg S/ha during the first year though significant increase was only upto 80 kg S/ha, while in the second year the response upto 40 kg S/ha was recorded (Table 2 b). The low response phenomenon can be attributed due to the laying out of the experiment at the same site with the same treatments, indicating the residual supply of sulphur form the first year as well as diluting the sulphur effect to some extent on growth due to 43 mm of winter shower received during crop season, which was just twice that of first year (21 mm). Application of 40 kg and 80 kg S/ha gave mean increase of 29.5 and 38.6 per cent over control. The regression equations, sulphur (%) in mustard seedling with seed yield and protein production were worked out at rates of sulphur as detailed below :

S% in seedling vs Seed yield (q/ha) : $\hat{Y} = 69.5\ x - 17.528$ (1979-80)

r 0=.846,

$\hat{Y} = 60.5\ x - 6.97$ (1980-81)

r = 0.988.

S% in seedlings vs protein production : $\hat{Y} = 210.0\ x - 48.83$ (1979-80)

r = 0 833

$\hat{Y} = 143.5\ x - 0.845$ (1980-81)

r = 0.895.

The + tive 'r' values and regression equations as above indicated the seed yield and protein production relationship with the sulphur content in mustard seedling which was due to the proper sulphur fertilization of the crop. The increase uptake of nitrogen by mustard seed due to sulphur fertilization may be because of increased translocation of nitrogen from plants to reproductive part (Archer, 1974), resulting thereby in higher protein production.

The important role played by sulphur in Cruciferae family is that it enters into other constituents and thus becomes an integral part in synthesis of oil and sulphur containting amino acids. Singh (1975) reported an increase upto 45.5 per cent when sulphur was applied @ 250 kg/ha to mustard crop grown on alkaline calcareous soils. Singh *et al.*, (1970) reported that gypsum, although relatively less soluble, but is a good source of sulphur fertilization to oilseed crops. Similar findings were also reported by Pasricha and Randhawa (1972 & 1973).

Oil yield, quality and sulphur uptake:

Increasing moisture content in soil profile decreased oil per cent content in seed and allyl-iso-thiocynate value though differences were not significant while increased the oil yield and sulphur uptake significantly which is the function of the higher total seed yield recorded (Table 3 a).

Increase in sulphur application from O to 120 kg S/ha increased the oil percentage over control, highest being 38.77% and 38.13% during 1979-80 and 1980-81 respectively (Table 3b). However, there was no significant difference amongst the treatments 40 to 120 kg S/ha. The regression equations were worked out; sulphur (%) content in mustard seedlings with oil per cent content in seed and oil yield and detailed below:

S(%) vs oil (%): $\hat{Y} = 23.8315 + 37.0 \times$ (1979-80)

$\hat{Y} = 19.13 \times 47.0 \times$ (1980-81)

S(%) vs oil yield (kg/ha): $\hat{Y} = 2907.28 \times - 766.61$ (1979-70)

$\hat{Y} = 2643.182 \times - 410.71$ (1980-81)

Sulphur (%) content in mustard seedlings had also recorded +tive 'r' values of 0.846 and 0.983 in 1979-80 and 1980-81 respectively, with oil yield of mustard, establishing the role played by the sulphur in oil yield production. Singh and Singh (1978) observed increase in oil percentage with increased sulphur application, and found greater uptake in mustard at flowering coinciding the critical reproductive phase. The increase in oil percentage was probably due to the increase in glucoside of *Brassica* species e.g. Sinigrin. The higher seed yield and oil percent led to significantly higher oil yield of mustard Similarly, the sulphur content in seed and greater seed yield resulted in more uptake of sulphur, which produced significant differences.

Sulphur played the role in the formation of more of mustard thioglucoside, which on hydrolysis produced higher content of oil as well as allyl-iso-thiocynate which is responsible for the pungency, a determinative factor of oil quality.

Application of sulphur also affected the allyl-iso-thiocynate value with the increasing rates, (Singh and Singh, 1978). The differences were quite large over no sulphur treatment. Freeman and Mossadegi (1972) also observed ncreased allyl-iso-thiocynate value in *Brassica Juncea* with increased content of sulphur. The effect on allyl-iso-thiocynate value was same as on oil percentage.

Water use :

Consumptive use was more with high moisture status of the soil profile each year (Table 4 a). It varied from 82 mm to 143 mm in 1979-80 and 99 mm to 159 mm in 1980-81. Water-use efficiency values were also large at good soil profile moisture status which decreased with decrease in moisture in soil, from 9.93 to 3.11 kg-mm/ha in 1979-80 and 15.76 to 3.91 kg mm/ha in 1980-81. The seed yield relationship with consumptive use was calculated through regression equations as under:

Consumptive use vs Seed yield (q/ha) : $\hat{Y} = 0.187X - 12.9767$ (1979 80)

$\hat{Y} = 0.3588 \times - 30.983$ (1980-81)

Thus, large consumptive use resulted in higher seed yield which is conformed from the +tive and large 'r' values of 0.994 and 0.992 for 1979-80 and 1980-81 respectively.

Application of sulphur increased the consumptive use upto 80 kg S/ha during both years (Table 4 b). Water-use efficiency values increased with the increasing levels of sulphur in 1979-80 and upto 80 kg S/ha in 1980-81 with 8.76 kg-mm/ha and 12 69 kg-mm/ha values, respectively. The higher water-use efficiency values with rates of sulphur may be attributed to the balanced uptake of nutrients and role played by sulphur in development of the plants to extract more moisture from soil drofile to produce large seed yields as well.

Economics :

Economics of sulphur fertilization was worked out with sub-optimum, normal and good available profile moisture to the mustard crop (Table 5). The cost of the seed and sulphur was valued @ Rs 4.25 and Rs. 1.78 for each kg respectively. The recharging of soil profile to build normal and good soil profile moisture was rated to Rs. 20.0 and Rs. 120 per ha. All operations done common were not taken into account while working out the economics with mean seed yield of various treatments combinations.

Highest profit over no sulphur fertilization in mustard with good and normal moisture supply conditions was recorded at 80 kg S/ha, with Rs. 1918.85 and Rs. 2122.85/ha respectively (Table 5). In sub-optimum conditions large profit of Rs. 916.90/ha was recorded at 120 kg S/ha, which was lesser than all the sulphur rates at normal and good available moisture in soil profile.

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Table 1: Weekly rainfall number of rainy days and rainfall periods during crop seasons of 1979-80 and 1980-81

Periods	Meteorological weeks	Rainfall (mm)		No. of rainy days	
		1979-80	1980-81	1979-80	1980-81
22 Oct. — 28 October	43	—	—	—	—
29 Oct. — 4 November	44	—	1.4	—	1
5 Nov. — 11 November	45	—	—	—	—
12 Nov. — 18 November	46	—	—	—	—
19 Nov. — 25 November	47	—	—	—	—
26 Nov. — 2 December	48	—	—	—	—
3 Dec. — 9 December	49	—	—	—	—
10 Dec. — 16 December	50	9.2	—	2	—
17 Dec. — 23 December	51	—	10.2	—	—
24 Dec. — 31 December	52	—	—	—	—
1 Jan. — 7 January	1	5.4	18 2	1	2
8 Jan. — 14 January	2	—	—	—	—
15 Jan — 21 January	3	-	—	—	—
22 Jan. — 28 January	4	3.2	10 2	1	1
29 Jan. — 4 February	5	0.2	—	1	—
5 Feb. — 11 February	6	2.6	—	1	—
12 Feb. — 18 February	7	—	—	—	—
19 Feb. — 25 February	8	—	—	—	—
26 Feb. — 4 March	9	—	3.0	—	1
5 March. — 11 March	10	0.4	—	1	—
Total		21.0	43.0	7	7

Table 2 : Effect of soil profile moisture and rates of sulphur on the seed yield, protein production of mustard

Treatments	Seed yield (q/ha)		Protein production (kg/ha)		Sulphur (%) content in seedlings	
	1979 80	1980-81	1979 80	1980-81	1979-80	1980-81
(a) Effect of soil profile moisture :						
Good	14 20	25 06	49.4	86 0	0.37	0.36
Normal	9.46	19 13	33.5	66.6	0 38	0.37
Sub-optimum	2 56	3.87	9 1	13.6	0.38	0.38
C.D. at 5%	1 25	2 98	6 0	7.3	NS	NS
(b) Effect of rates of sulphur (kg/ha) :						
0	5 93	13 87	21 8	50.6	0 35	0.34
40	8.29	17.35	29.4	60.4	0 37	0.40
80	10.33	17.13	36.7	58.4	0 39	0.39
120	10.42	15.73	35.3	52.7	0.40	0.39
C.D at 5%	1.44	2.55	5.1	6 2	0.03	0.04

Table 3 : Effect of soil profile moisture and rates of sulphur on the oil percent oil yield, Allyl-iso-thiocynate content and sulphur uptake (in seeds) of mustard

Treatments	Oil (%) in seed		Oil yield (kg/ha)		Allyl-iso thiocynate (%)		Uptake of sulphur (kg/ha)	
	1979-80	1980-81	1979-80	80-81	1979-80	80-81	1979-80	80-81
(a) Effect of soil profile moisture :								
Good	36 88	36 80	523.7	922.2	0.460	0 459	12.7	22 0
Normal	37.85	36 88	358 1	705 5	0.465	0 476	9 0	17.8
Sub-optimum	38 23	37.18	97 8	142 4	0 475	0 482	2.5	3.6
C.D at 5%	NS	NS	12.0	17.0	NS	NS	1.7	1.2
(b) Effect of rates of sulphur (kg/ha) :								
0	36.30	35 10	215 3	486.8	0 430	0.421	4 6	10.5
40	37 60	36 93	311.7	640.7	0.453	0.444	7 0	15 8
80	38 60	37.80	398.7	647.5	0 471	0.461	10.3	16 8
120	38.77	38.13	404.0	599 8	0.510	0 493	10.8	16.0
C.D. at 5%	1.41	1.29	9.2	12.1	0.025	0.021	1.2	0.9

NS = Not significant.

Table 4 : Effect of soil profile moisture and sulphur rates on consumptive use and water-use efficiency of mustard

Treatments	Consumptive use (mm)		Water-use efficiency (kg-mm/ha)	
	1979-80	1980-81	1979-80	1980-81
(a) Effect of soils profile moisture :				
Good	143	159	9.93	15.78
Normal	124	135	7.63	14.17
Sub-optimum	82	89	3.11	8.81
(b) Effect of rates of sulphur :				
0 kg/ha	110	123	6.39	11.28
40 kg/ha	117	134	7.09	12.95
80 kg/ha	119	136	8.68	12.69
120 kg/ha	119	133	8.76	11.83

Table 5 : Economics of soil moisture in profile and sulphur fertilization in mustard (1979-80 & 1980-81)

Treatment	Mean seed yield (q/ha)	Value (Rs/ha)	Cost of treatment (Rs/ha)	Profit (Rs/ha)	Profit over control (Rs/ha)
Good moisture with 0 kg S/ha	16.70	7097.50	200.00	6897.50	—
,, ,, ,, 40 -do-	20.83	8874.00	271.20	8602 80	1706.30
,, ,, ,, 80 ,,	21.65	9158 75	342 40	8816.35	1918 85
,, ,, ,, 120 ,,	19.40	8245.00	413.60	7831.40	933.90
Normal ,, ,, 0 ,,	11.05	4696.25	120.00	4576.25	—
,, ,, ,, 40 ,,	14 47	6149.75	191 20	5958.55	1382.30
,, ,, ,, 80 ,,	16.38	6961.50	262.40	6699.10	2122.85
,, ,, ,, 120 ,,	15.20	6460.00	336 60	6124.00	1547 75
Sub-optimum ,, 0 ,,	1.96	833.00	—	833 00	—
,, ,, ,, 40 ,,	3.11	1321.75	71.20	1250.55	417.55
,, ,, ,, 80 ,,	3.55	1508 75	142.40	1366.35	533.35
,, ,, ,, 120 ,,	4 62	1963.50	213.60	1749.90	916.90