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SHORT COMMUNICATION

EFFECT OF SPLIT APPLICATION OF SULPHUR ON PHYSIOLOGICAL PARAMETERS, YIELD AND OIL CONTENT OF INDIAN MUSTARD

LALLU*, R.S. YADAV AND R.K. DIXIT

Oilseed Section, C.S. Azad University of Agriculture & Technology, Kanpur-208 002

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Results of field experiment revealed that split application of sulphur (half basal + half top dressed) along with RDF significantly increased dry matter accumulation, growth parameters, photosynthetic rate, NR activity, seed yield and oil content in seed as compared to sulphur applied as single basal dose along with RDF. 40kg S/ha applied as half basal + half top dressed along with RDF proved beneficial than other lower and higher doses of sulphur tried for improving plant growth, enhancement of yield and quality of Indian mustard.

Key words: **Indian mustard, physiological parameters, sulphur, yield.**

Indian mustard [*Brasica juncea* (L.) Czern & Coss] is an important and predominant *rabi* oilseed crop in the country. Its national average productivity is quite low i.e. 903 kg/ha as against the potential yield of 2600-3000 kg/ha (Sharma 2005). Sulphur plays an important role for growth and development of plants as it is required for synthesis of protein, chlorophyll, oils and vitamins. Approximately 16 kg sulphur is required to produce one ton seeds of mustard containing 91% dry matter (Zhao *et al.* 1993). Imbalance of sulphur with N, P and K is not only responsible for lower crop yield but also affect quality and full benefits of NPK are not being harnessed. Sulphur interaction with N, P and K are directly related to the modification of response and inturn balance fertilization. Keeping in view, the present study was therefore, conducted to study the effect of split doses of sulphur application in balancing N, P and K fertilization on growth, yield and oil content in seed of Indian mustard.

Field experiment was conducted during rabi season of 2003-04 and 2004-05 with a most popular Indian mustard *(Brassica juncea* (L.) Czern & Coss) cv. Varuna at the Oilseed Research Farm, Kalyanpur, C.S. Azad University of Agriculture and Technology, Kanpur in randomized block design with three replications. Crop was sown in the field with 45 cm rows and plant spacing maintained at 15 cm by thinning at 20 days after sowing. The plot size was 15.75m^2 (5.0mx3.15m). There were 9 treatments consisting of recommended doses of fertilizer (RDF) @ 150-75-75 kg/ha of N, P and K as control. RDF along with S_1 (20), S_2 (40), S_3 (60) and S_4 (80) kg sulphur per hectare as basal (M_1), RDF along with 10+ 10, 20+20, 30+30 and 40+40 kg sulphur per hectare as basal + top dressed, along with nitrogen after first irrigation (M_2). N, P and K was applied through urea, DAP and muriate of potash and sulphur was applied through elemental sulphur. The soil of experimental field was sandy loam having organic carbon 0.32% pH 7.8 and available nutrient content was S 16.6, P 17.6, N 208 and K 210 kg/ha^{-1}. Dry matter accumulation was recorded at relevant growth stages while yield and yield attributes were recorded at harvest stage. Various growth parameters were computed

*Corresponding author

according to Watson (1952). Oil content in seed was determined by Soxhlet method. The photosynthetic rate was measured using CI-301 CO_2 Gas Analyzer CID, Inc. The NR activity was assayed following the method of Klepper *et al.* (1971).

The sulphur treated plants produced significantly higher dry matter over control and split application of sulphur along with RDF increased dry matter accumulation significantly over single dose of sulphur applied as basal at flowering stage (Table 1). Dry matter

Table 1. Dry matter production, LAD, CGR, LAI and number of branches as influenced by different levels and methods of sulphur application (average of two years).

Doses/ methods	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
	Dry matter (g/plant) at vegetative stage					**Dry matter (g/plant) at flowering stage**				
M_1	5.2	5.9	6.9	3.7	5.4	17.7	21.3	21.1	12.8	18.7
M_2	4.9	5.6	6.4	5.4	5.6	21.3	27.2	24.4	18.6	22.9
Mean	5.1	5.8	6.7	4.5	5.5	19.5	24.3	23.8	15.7	20.8
Control	-	-	-	-	4.2	-	-	-	-	14.2
CD(0.05)										
Method					NS					1.8
Sulphur					0.6					3.0
M x S					NS					3.0
T x C					0.6					2.8
	LAD at 35-70 DAS					**CGR at 35-70 DAS (g/m^2/day)**				
M_1	43.3	47.8	53.0	26.5	42.7	5.1	6.2	6.5	3.6	5.4
M_2	45.1	54.7	51.4	46.0	49.3	6.6	8.9	7.2	5.3	7.0
Mean	44.2	51.3	52.2	36.3	46.0	5.9	7.6	6.9	4.5	6.2
Control	-	-	-	-	28.7	-	-	-	-	4.0
CD(0.05)										
Method					NS					0.4
Sulphur					4.4					0.5
M x S					NS					0.8
T x C					4.8					0.6
	LAI at vegetative stage					**No. of branches/plant at harvest**				
M_1	0.68	0.81	0.94	0.47	0.73	18.3	18.9	20.0	15.4	18.2
M_2	0.65	0.81	0.91	0.81	0.79	18.8	21.7	20.4	16.4	19.3
Mean	0.67	0.81	0.93	0.64	0.76	18.6	20.3	20.2	15.9	18.8
Control	-	-	-	-	0.56	-	-	-	-	15.2
CD(0.05)										
Method					NS					NS
Sulphur					0.09					2.8
M x S					NS					NS
T x C					0.10					3.0

Treatments S_1, S_2, S_3, S_4 M_1 and M_2 details given in the text.

Table 2. Net photosynthesis rate, NR activity, SLW, seed yield and its attributes and oil content in seed as influenced by different levels and methods of sulphur application (Average of two years).

Doses/ methods	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
	Net photosynthesis rate (µmol CO_2 m^{-2} s^{-1}) at flowering stage					**1000 seed weight (g)**				
M_1	22.9	24.2	26.2	23.3	24.2	5.4	5.5	5.2	4.9	5.3
M_2	24.6	27.2	26.2	23.7	25.4	5.5	5.7	5.6	5.4	5.6
Mean	23.8	25.7	26.2	23.5	24.8	5.5	5.6	5.4	5.2	5.4
Control	-	-	-	-	20.9	-	-	-	-	5.1
CD(0.05)										
Method					0.9					0.2
Sulphur					1.2					0.3
M x S					1.2					0.2
Treatment x Control (T x C)					1.3					0.3
	NR activity (µmol NO_2 g^{-1} fw hr^{-1}) at flowering stage					**No. of siliquae /m^2**				
M_1	2.6	3.1	2.9	2.7	2.8	4074.9	4313.5	4411.4	3640.4	4110.1
M_2	2.8	3.1	3.6	2.8	3.1	4414.5	4740.1	4602.8	3730.2	4371.9
Mean	2.7	3.1	3.3	2.8	3.0	4244.7	4526.8	4507.1	3685.3	4241.0
Control	-	-	-	-	2.4	-	-	-	-	3764.8
CD(0.05)										
Method					0.2					60.7
Sulphur					0.3					85.8
M x S					0.4					94.3
T x C					0.3					101.0
	SLW (mg/cm^2) at flowering stage					**Seed yield (g/m^2)**				
M_1	5.8	6.4	6.5	5.4	6.0	134.7	143.5	143.4	126.9	137.1
M_2	6.1	6.8	6.9	5.9	6.4	143.4	170.4	165.1	132.3	152.8
Mean	6.0	6.6	6.7	5.7	6.2	139.1	157.0	154.3	129.6	145.0
Control	-	-	-	-	5.6	-	-	-	-	121.9
CD(0.05)										
Method					0.3					3.6
Sulphur					0.4					5.1
M x S					NS					7.3
T x C					0.5					5.4
	Oil content in seed (%)									
M_1	38.1	38.5	39.0	38.5	38.5					
M_2	38.5	39.9	39.6	39.2	39.3					
Mean	38.3	39.2	39.3	38.9	38.9					
Control	-	-	-	-	36.2					
CD(0.05)										
Method					0.8					
Sulphur					NS					
M x S					NS					
T x C					1.2					

Treatments S_1, S_2, S_3, S_4 M_1 and M_2 details given in the text.

accumulation increased with increasing level of sulphur, however, the difference between 40 and 60 kg S/ha at flowering stage was not significant and further increase in sulphur dose caused significant reduction in DMP at both stages of study. The increased uptake of nutrients due to sulphur in general and their activation at cellular level by promoting greater photosynthetic and meristmatic activity seemed to have stimulated vegetative growth of mustard (Singh *et al.* 1990). Patel and Shelke (1998) also reported an increase in dry matter production in mustard due to sulphur fertilization.

Growth parameters viz. LAD, CGR, LAI and also number of branches noted significantly higher in plants received sulphur along with RDF over control (Table1) and sulphur applied as split dose proved better and recorded higher value of these growth parameters as well as number of branches over single basal dose of sulphur applied. Maximum value of LAD and LAI was recorded in plants received 60 kg S/ha while value of CGR and number of branches were noted maximum in plants fertilized with 40 kg S/ha along with RDF. 80kg S/ha along with RDF caused significant reduction and recorded minimum value of above studied growth parameters. These results are in close agreement with those reported by Patel and Shelke (1998) in mustard and Rana *et al.* (2001) in taramira.

Sulphur treated plants recorded significant increase in rate of net photosynthesis, NR activity and specific leaf weight over control plants (Table 2) and split application of sulphur along with RDF again proved superior and significantly enhanced net photosynthetic rate, NR activity and SLW as compared to single basal dose of sulphur applied. Application of 40kg S/ha, being at par with 60kg S/ha along with RDF, significantly increased Pn, NR activity and SLW as compared to lower dose, while higher dose caused significant reduction in Pn, NR activity and SLW. Lallu and Saxena (1995) also reported increase in rate of photosynthesis with increase in rate of sulphur application in mustard.

Seed yield, 1000 seed weight, number of siliquae and oil content in seed were significantly enhanced in sulphur treated plants as compared to control (Table2) and sulphur applied as split dose along with RDF retained its superiority and increased seed yield, test weight, number of siliquae and oil content significantly over sulphur application as basal dose. Yield, yield contributory characters and oil content in seed increased with increasing level of sulphur, however, the difference between 40 and 60kg S/ha along with RDF was found non significant and higher dose of 80kg S/ha caused drastic reduction in yield and its components. The significant improvement in seed yield might be due to the cumulative effect of improvement in growth, growth parameters and yield attributes. Similar results were also obtained by Yadav *et al.* (2006) in yield and its attributes in mustard due to sulphur fertilization.

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