Indian Journal of Agricultural Sciences **81** (9): 878–80, September 2011

Effect of sulphur on oil content and fatty acids profile in 36 triple test cross families of Indian mustard (*Brassica juncea*)*

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Received: 20 January 2009; Revised accepted: 16 May 2011

Key words: Desaturation, Erucic acid, Glucosinolates, Triple test cross

In the crop management of oilseed brassicas sulphur plays an important role and is now being recognized as the fourth major nutrient in addition to N, P and K. Sulphur performs many physiological functions like synthesis of oil, sulphur containing amino acids (cystein and methionine), chlorophylls, certain vitamins and the glucosinolates (Bones and Rossiter 1996). Sulphur is also essential for synthesis of different fatty acids (Dimree and Dwivedi 1994). Development of double low (or) '00' type mustard cultivars having less than 2% erucic acid in the seed oil and less than 30 μ moles glucosinolates/gram of de-fatted meal is a basic mandate in the quality breeding of rapeseed-mustard crops. In view of above facts, the present experiment was aimed to study the effect of sulphur on oil content and fatty acids profile in 36 genotypes (TTC families) of Indian mustard to find out the crosses responsive to applied sulphur.

A set of 36 crosses were developed by crossing 12 varieties/ genotypes (RH 30, RH 9304, RH 8812, RH 0270, UDN 69, JMM 937, RH 781, RC 5, RC 199, RC 1425, RH 0028 and RH 8701) as females with 3 male testers, namely HOI, RH (OE) 0103 and HOI × RH (OE) 0103 as per the triple test cross mating design during 2004–05.In the next year (2005–06) a pot experiment was laid out by raising those 36 TTC families in completely randomized design with two replications. The experiment was conducted under green house condition at College of Agriculture, CCS Haryana Agricultural University, Hisar. The genotypes were raised in earthen pots filled with sandy loam sulphur deficit soil. The pots were lined with polyethylene bags to avoid loss of nutrients by leaching. The sulphur in the form of ammonium sulphate [$(NH_4)2\ SO_4$] was supplied at 0 (control), 30 and 60 kg S/ha (designated as 0S, 30S and 60S respectively). The recommended doses of nitrogen (60 ppm) and phosphorus (30 ppm) were also given in the form of urea and potassium dihydrogen orthophosphate, respectively. Nitrogen supplied by $(NH_4)2\ SO_4$ was taken in account and remaining nitrogen was supplied through urea in order to keep the level of basal dose of nitrogen equal in all the treatments. All the nutrients were applied in the form of solution. After the emergence of seedlings 2 plants/pot were retained. Tap water was used for irrigation. The oil content was estimated by soxhlet extraction method (AOAC 1970) and the fatty acids were estimated by the method suggested by Luddy *et al.* (1968).

It is clear that the sulphur application significantly increased the oil content (Table 1). Among the different sulphur levels, the mean oil content was 28.72, 32.81 and 36.52 in the treatments 0S, 30S and 60S respectively. The TTC families also differed significantly among themselves for oil content in all the 3 sulphur levels. The oil content ranged from 22.70% (RH 8812 × F_1) to 33.30% (RH 1425 × RH (OE) 0103) in 0S, 28.95% (RH 0028 × RH (OE) 0103) to 38.20% (RC 199 × RH (OE) 0103) in 30S and 31.85% (RC 199 × HO1) to 41.65% (JMM 937 × RH (OE) 0103) in 60S. Sulphur being instrumental in oil formation is gradually gaining importance in the management of oilseed crops. Sulphur in its reduced form plays an important role in brassica plants as it is being involved in the synthesis of coenzymes for the oil formation. The oxidized sulphur metabolites are necessary for the biosynthesis of plant sulpholipids and fatty acids which are further incorporated in the glycerol molecule to form the triglycerides (Dimree and Dwivedi 1994). Similar increase in oil content with sulphur application has been reported by Bhagat and Soni (2000), Saha and Mandal (2000) and Shukla *et al.* (2005) (in brassicas) Patel *et al.* (2009) in groundnut and Deshmukh *et al.* (2010) in sesame. In the present study three cross families JMM 937 × RH (OE)0103, RC 781 × RH(OE)0103 and RC 199 × RH(OE)0103 were found promising due to their response to applied sulphur to record high oil content of >40%.

*Short note

Based on a part of Ph D thesis of the first author submitted to Chaudhary Charan Singh Haryana Agricultural University, Hisar, during 2007.

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Table 1 Effect of sulphur on oil content and fatty acids profile in 36 TTC families of Indian mustard (*Brassica juncea*)

Family	Oil content (%)				Oleic acid (%)				Linoleic acid (%)				Erucic acid (%)			
	0S	30S	60S	0S	30S	60S	Mean	Mean	0S	30S	60S	Mean	0S	30S	60S	Mean
RH 30×HO 1	31.25	33.15	39.65	34.68	24.19	16.58	21.01	20.59	27.47	27.14	23.56	26.05	23.85	26.80	32.04	27.56
RH 30×RH (OE)0103	29.40	33.10	36.15	32.88	22.11	14.41	11.83	16.11	26.45	20.11	21.53	22.69	31.13	43.41	49.28	41.27
RH 30×F_1	29.95	31.40	37.05	32.80	23.56	13.43	9.68	15.55	23.40	23.55	20.24	22.39	24.91	35.48	49.84	36.74
RH 9304×HO 1	30.55	31.05	35.60	32.40	24.56	15.93	8.71	16.40	27.26	24.11	20.96	24.11	26.51	42.25	53.38	40.71
RH 9304×RH (OE)0103	29.00	30.35	33.05	30.80	16.11	15.53	13.32	14.98	24.52	24.45	29.42	26.13	34.01	35.88	40.35	36.74
RH 9304×F_1	32.35	33.70	35.50	33.85	14.32	13.69	8.58	12.19	22.87	19.81	21.19	21.29	43.11	49.20	49.54	47.28
RH 8812×HO 1	29.35	32.05	34.30	31.90	16.33	16.61	14.39	15.77	22.69	21.73	19.10	21.17	36.50	37.15	44.97	39.54
RH 8812×RH (OE)0103	27.65	31.85	35.55	31.68	23.34	13.84	14.33	17.17	26.93	22.10	26.43	25.15	24.74	37.29	39.33	33.78
RH 8812×F_1	22.70	31.45	34.15	29.43	18.53	11.88	13.24	14.55	32.83	17.83	21.10	23.92	27.98	47.96	48.20	41.38
RH 0270×HO 1	32.95	34.95	37.10	35.00	12.37	15.44	12.23	13.34	25.71	24.29	20.75	23.58	44.26	34.17	46.97	41.80
RH 0270×RH (OE)0103	29.05	31.45	33.30	31.27	21.55	22.55	20.42	21.50	30.41	28.69	26.65	28.58	28.68	30.13	32.35	30.38
RH 0270×F_1	33.20	35.40	39.10	35.90	22.45	15.64	14.55	17.54	31.75	28.05	24.73	28.17	23.28	38.15	43.60	35.01
UDN 69×HO 1	28.60	34.90	38.95	34.15	27.01	14.42	20.08	20.50	23.69	26.88	24.82	25.13	25.44	26.43	33.13	28.33
UDN 69×RH (OE)0103	29.95	32.00	33.70	31.88	15.37	9.53	12.23	12.37	21.39	25.80	20.62	22.60	39.40	40.86	47.69	42.65
UDN 69×F_1	31.15	35.00	36.10	34.08	17.55	16.11	12.93	15.53	31.58	25.28	19.06	25.30	27.35	40.89	45.16	37.80
JMM 937×HO 1	29.00	31.80	34.90	31.90	17.39	10.78	11.64	13.27	29.32	24.89	20.53	24.91	28.38	41.45	49.42	39.75
JMM 937×RH (OE)0103	24.95	30.95	41.65	32.52	15.88	12.78	12.96	13.87	30.53	23.57	20.86	24.99	35.31	37.10	46.24	39.55
JMM 937×F_1	24.00	31.40	35.75	30.38	18.20	14.73	11.34	14.76	23.46	22.71	20.42	22.20	35.61	37.63	41.95	38.39
RC 781×HO 1	29.50	31.45	35.10	32.02	18.71	15.91	13.97	16.20	26.14	21.64	21.13	22.97	33.15	37.79	46.06	39.00
RC 781×RH (OE)0103	30.15	33.75	40.70	34.87	17.15	15.13	14.33	15.54	26.94	21.50	21.11	23.18	35.07	41.97	43.22	40.08
RC 781×F_1	29.10	35.00	38.30	34.13	22.26	18.00	11.00	17.09	27.37	25.84	23.12	25.44	26.19	28.20	45.81	33.40
RC 5×HO1	27.05	32.75	34.70	31.50	13.85	20.78	10.64	15.09	29.17	25.43	20.06	24.89	33.45	33.41	49.34	38.73
RC 5×RH (OE)0103	30.90	33.00	38.95	34.28	18.67	17.03	12.34	16.01	24.57	21.94	21.28	22.60	35.78	36.29	46.35	39.47
RC 5×F_1	29.00	30.30	36.05	31.78	22.67	18.15	11.69	17.50	25.58	27.40	23.59	25.52	28.54	31.03	40.99	33.52
RC 199×HO 1	27.40	29.55	31.85	29.60	14.59	15.20	14.98	14.92	30.19	22.81	27.07	26.69	30.52	32.00	33.50	32.00
RC 199×RH (OE)0103	31.20	38.20	40.55	36.65	21.48	12.77	12.00	15.42	34.02	20.13	21.42	25.19	23.85	39.91	43.33	35.69
RC 199×F_1	26.10	34.20	36.15	32.15	22.11	14.81	14.86	17.26	35.88	25.42	22.08	27.79	19.40	31.70	36.64	29.24
RC 1425×HO 1	31.20	32.40	35.95	33.18	22.45	14.45	12.40	16.43	32.28	23.41	23.23	26.31	25.14	34.49	38.59	32.74
RC 1425×RH (OE)0103	33.30	37.95	39.30	36.85	13.71	14.62	13.64	13.99	32.07	25.21	20.33	25.87	36.61	40.75	41.20	39.52
RC 1425×F_1	29.05	34.60	37.80	33.82	16.66	16.91	12.54	15.37	30.42	24.01	23.63	26.02	33.29	35.68	38.53	35.83
RH 0028 ×HO 1	27.05	31.60	35.20	31.28	13.20	14.18	13.64	13.67	27.22	21.40	20.23	22.95	41.04	42.30	41.23	41.52
RH 0028 ×RH (OE)0103	24.30	28.95	35.80	29.68	13.87	18.06	13.35	15.09	28.41	27.19	21.07	25.56	31.93	33.54	45.06	36.84
RH 0028 ×F_1	25.95	29.10	36.75	30.60	19.30	17.06	13.63	16.66	25.61	24.76	20.79	23.72	30.84	31.00	42.71	34.85
RH 8701×HO 1	24.40	30.40	33.15	29.32	20.32	17.45	11.00	16.26	34.60	19.12	23.12	25.61		37.53	44.94	36.11
RH 8701×RH (OE)0103	22.80	37.95	39.10	33.28	20.20	13.20	13.44	15.61	27.02	24.77	20.06	23.95	25.86	38.19	47.10	39.21
RH 8701×F_1	30.40	33.95	37.85	34.07	12.85	13.01	12.88	12.91	22.25	20.81	20.36	21.14	41.90	41.38	46.26	43.18
Mean	28.72	32.81	36.52	32.68	18.75	15.29	13.22	15.75	27.83	23.72	22.10	24.55	31.26	36.92	43.45	37.21
CD (P=0.05)	Sulphur, 0.31 Genotypes, 1.07 Sulphur×genotypes, 1.85				Sulphur, 0.42 Genotypes, 1.46 Sulphur×genotypes, 2.53				Sulphur, 0.41 Genotypes, 1.44 Sulphur×genotypes, 2.49				Sulphur, 0.45 Genotypes, 1.55 Sulphur×genotypes, 2.69			

0S, 0 kg sulphur/ha 30S, 30 kg sulphur/ha 60S, 60 kg sulphur/ha

Fatty acids composition showed sharp change with sulphur treatment in most of the TTC families. Palmitic acid was higher in control as compared to treatments and its level decreased with the increasing sulphur doses in majority of TTC families (table not presented). Oleic acid was higher in control as compared to treatments (Table 1). It ranged from 12.37% (RH 0270×HO1) to 27.01% (UDN 69×HO1), 9.53% (UDN 69×RH (OE) 0103 to 22.55% (RH 0270×RH (OE) 0103) and 8.58% (RH 9304×F1) to 21.01% (RH 30×HO1) in the treatments 0S, 30S and 60S respectively.

The linoleic acid was also higher in control (27.83%) and its level was found to decrease suddenly in 30S (23.72%) after that there was only slight decrease in 60S (22.10%). The maximum and minimum linoleic acid content of 35.88% ('RC 199 × F1') and 17.83% ('RH 8812' × F1) was recorded in the treatments 0S and 30S respectively. The linolenic and eicosenoic acids were higher in 30S as compared to control, whereas at 60S it decreased but the level was higher than the control (table not presented). Gaur *et al.* (1993) reported on Indian mustard that the increased concentration of sulphur in seed which alone or in combination with nitrogen might have some adverse effect on desaturation system of oleic acid and linoleic acid as a result of which the content of these unsaturated fatty acids decreased.

The erucic acid, which is the characteristics fatty acid of mustard, was found to be significantly different among TTC families and sulphur levels (Table 1). It increased with the increasing doses of sulphur, recording higher values at 30S and 60S than the control. This is not in accordance with the work of Joshi *et al.* (1998) who reported that no use of sulphur (control) led to higher contents of erucic acids. In the present study the erucic acid ranged from 19.40% (RC 199 × F1) to 44.26% (RH 0270 × HO1) in 0S, 26.43% (UDN 69 × HO1) to 49.20% (RH 9304 × F1) in 30S and 32.04% (RH 30 × HO1) to 53.38% (RH 9304 × HO1) in 60S.

The present study showed that manipulating the sulphur supply might be one means of altering fatty acids profile among the brassica genotypes. Also, in this study three TTC families namely RH 30 × HO 1, RH 0207 × RH(OE)0103 and UDN 69 × HO 1 were found promising due to their lower level of erucic acid (<35%) and higher oleic acid content (>20%) at higher level of applied sulphur (60 kg/ha) at which the higher oil content was recorded. The 3 TTC families, namely JMM 937 × RH (OE) 0103, RC 781 × RH (OE) 0103 and RC 199 × RH (OE) 0103 (for high oil content) and another three TTC families, namely RH 30 × HO 1, RH 0207 × RH (OE) 0103 and UDN 69 × HO 1 (for low erucic acid) can be advanced to next generations and the selected segregants can be employed in breeding programme after stabilization. The results presented here might be used to enable practical crop management strategies in which S supply is managed keeping in mind its role in determining the fatty acids profile which in turn determines the edible quality of mustard oil.

SUMMARY

A pot experiment was conducted by treating 36 genotypes of triple test cross (TTC) families of Indian mustard [*Brassica juncea* (L.) Czernj. & Coss] with three levels of sulphur, viz 0, 30 and 60 kg/ha to study the effect of sulphur on oil content and fatty acids profile. Sulphur application significantly increased the oil content. Fatty acids composition showed sharp change with sulphur treatment. Palmitic acid, oleic acid and linoleic acid were higher in control as compared to treatments in majority of TTC families. The linolenic and eicosenoic acids were higher in 30S as compared to 0S, whereas at 60S it decreased but the level was higher than the 0S. The erucic acid, which is the characteristics fatty acid of mustard, was found to increase with the increasing doses of sulphur, recording higher values at 30S and 60S than the control.

ACKNOWLEDGEMENT

The first author acknowledges the financial support provided by the CSIR in the form of JRF for this study.

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