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Fenugreek (*Trigonella foenum-graecum*) plant types influenced by agro-chemicals and sulphur fertilization under different crop geometries

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ABSTRACT

Newly identified cultivar Rmt-305 of fenugreek (*Trigonella foenum-graecum* L.) is determinate with synchronous maturity and wider adaptability. Therefore, to assess its adaptability with new crop geometry, agro-chemicals and sulphur fertilization in yield, yield components, quality and relative economics of fenugreek, the present investigation was formulated and conducted during 2005-06 and 2006-07 at Udaipur, India. Study was consisting of 24 treatment combinations of two plant types (Rmt-1 and Rmt-305), two crop geometries (30 cm × 10 cm and 20 cm × 15 cm), three agro-chemicals (control, thiourea @ 1000 ppm and TGA @ 100 ppm) and two levels of sulphur (0 and 40 kg S/ha). Results indicated that the cultivar Rmt-305 produced greater number of pods/branch (10.1), pod length (10.8 cm), number of seeds/pod (17.8), test weight (12.1 g) and harvest index (21.2%) which results in greater grain yield (1 337 kg/ha), net monetary returns (₹ 21 250) and benefit cost ratio (2.17). The crop geometry 20 cm × 15 cm was found superior in production of yield components and yield over the crop geometry 30 cm × 10 cm and recorded the mean increase of 5.9, 5.4 and 4.1% in number of pods/branch, pod length and number of seeds/pod, respectively and results in higher grain yield (1 307 kg/ha), net monetary returns of ₹ 21 200/ha and benefit cost ratio of 2.18. Foliar sprays of thiourea and TGA significantly increased yield components, viz. number of pods/branch, pod length, number of seeds/pod and test weight and grain yield of fenugreek. The grain yield of fenugreek was increased by 11 and 10% due to foliar spray of thiourea and TGA, respectively over control. Maximum mean monetary net returns of ₹ 21 359/ha and benefit cost ratio of 2.27 were obtained with foliar sprays of TGA which was at par with thiourea and 13.70 and 11.82%, respectively higher over control. Application of sulphur @ 40 kg S/ha increased the yield components, viz. number of pods/branch, pod length, number of seeds/pod and test weight by 10.0, 7.3, 7.9 and 4.7%, respectively over control and grain yield by 16% over control. Maximum mean net monetary returns of ₹ 22 032/ha and benefit cost ratio of 2.19 were observed with sulphur fertilization. Application of agro-chemicals and sulphur significantly improved test weight, protein content and diosgenin content of seed.

Key words: Diosgenin, Net returns, Protein, Thiourea, Thioglycolic acid, TGA

There are many constraints of fenugreek (*Trigonella foenum-graecum* L.) production in prevailing agroclimatic conditions such as unavailability of high yielding plant types, lack of secondary nutrient application, use of traditional planting method like broadcasting, grown as minor crop and poor management practices. The lack of suitable plant type and improved varieties for prevailing agro-climatic conditions is a major constraint to higher productivity. Adoptions of improved varieties have been reported to be beneficial for better growth and yield (Khiriya and Singh 2003, Bhati and Prasad 2004). The newly identified cultivar Rmt-305 of fenugreek is determinate with short stature, synchronous maturing and wider adaptability. Proper plant rectangularity is prime cultural operation to augment productivity of fenugreek. Optimum plant densities with their proper arrangement on ground surface is necessary for reducing intra and inter plant competitions as the degree of interference between plants tend to increase as the distance between them decreases and may influence performance of neighbours by changing the environment (Harper 1977). Plants are more evenly distributed when sown in narrower row spacing, and the efficiency of light interception is improved. An increase in light interception when row spacing is reduced has been reported for corn (Egharevba 1975), sorghum (Clegg *et al.* 1974), soybean (Mason *et al.* 1980, Board *et al.* 1990). Greater light interception often increases yield (Alessi *et al.* 1977, Karlen and Camp 1985, Mac Gowan *et al.* 1991).

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Despite the use of improved varieties, balanced and integrated nutrient management, the average productivity of fenugreek is still low. To realize the maximum production from existing improved varieties it is necessary that the chemical reactions take place in the plants are in balanced and efficient manner which help in formation of quality seed. This is only possible with the use of bioregulators. Use of bioregulators delay the leaf senescence and retards abscission of reproductive organs (Kaul *et al.* 1974, Thimmegowda *et al.* 1974 and Pandey 1975). To realize the maximum production for existing varieties it is necessary that the nutrients applied through chemical fertilizers are in balanced form and efficiently available to the plants to produce quality of seeds. The deficiency of secondary nutrients also a major limiting factor for higher productivity. Sulphur has many important functions in plant growth and metabolism (Pirson 1955). It is directly involved in the catalytic or electrochemical functions of the molecules of which is a component. Sulphur has a significant role in nitrite reduction, sulfate reduction and nitrogen assimilation (Tisdale *et al.* 1997). Therefore in the current study, an attempt was made to test the suitability of fenugreek plant types to crop geometry, agro-chemicals and sulphur fertilization.

MATERIALS AND METHODS

The field experiments were conducted during *rabi* (winter) seasons from November to April of 2005-06 and 2006-07 at Instructional Farm, Maharana Pratap University of Agriculture and Technology, Udaipur (situated at 24º35' N latitude and 74º42' E longitude at an altitude of 579.5 m above mean sea level in the Rajasthan, India).The location has a typical subtropical climate with an average annual rainfall of 637 mm. The soil of experimental site was clay loam in texture and alkaline in reaction (pH 8.06) with medium fertility having available nitrogen, phosphorus and sulphur of 240, 22.30 and 20.35 kg/ha, respectively.

The treatments were arranged as a factorial randomized block design with three replications. There were 24 treatment combinations of two plant types, i e indeterminate type cultivar Rmt-1 and determinate type cultivar Rmt-305, two crop geometries of 30 cm × 10 cm and 20 cm × 15 cm, three levels of agro-chemicals (control, thiourea @ 1000 ppm and thio-glycolic acid (TGA) @ 100 ppm) and two levels of sulphur (0 and 40 kg S/ha). The gross size of each plot was 6 m by 3 m while the net plot size was 5 m by 2.4 m (30 cm × 10 cm) and 4.5 m by 2.6 m (20 cm × 15 cm). The observations were recorded from net plot. Land was cross ploughed and harrowed followed by planking before sowing. The crop was sown on 7 November 2005 and 5 November 2006. A seed rate of 25 kg/ha was kept to maintain 333 thousand plants/ha under both the crop geometries. As per layout plan plots were demarcated with provision of irrigation channels. Each plot received basal application of nitrogen 20 kg/ha and phosphorus 40 kg/ha (Di-ammonium phosphate (DAP) 18% N and 46% P_2O_5 and urea 46%N). Treatment wise dose of sulphur (S) through elemental sulphur was drilled 4.5 cm below seed 15 days before sowing. The agro-chemicals were supplemented as two foliar sprays at flower initiation and 15 days thereafter. The irrigation, weeding and plant protection measures were applied as per need of the crop.

At physiological maturity, five plants were selected randomly from each plot to determine yield components (pods/branch, pod length (cm), number of seeds/pod and 1 000 seed weight). Harvest index was calculated by adopting formula reported by Donald and Hamblin (1976). Harvested and sun-dried biomass from net plots was threshed and winnowed to determine yield (kg/plot). The quality parameters, viz. protein and diosgenin content in seed were analyzed following standard procedures (AOAC 1960, Joshi *et al.* 2000). The changes in costs of labour for planting under different crop geometries, agro-chemicals and sulphur were considered as treatment cost of cultivation. The costs for land preparation, seed, irrigation, machinery, weed management, common fertilizer dose, chemicals for plant protection, harvesting and threshing were considered as common cost of cultivation. The cost and revenue items that changed among treatments in the experiment as well as the common cost and revenue items for all treatments were considered in the analysis of net returns and B C ratio. The following equations were used to estimate net returns (₹/ha) and B C ratio.

Net returns (₹/ha) = {[Grain yield (kg/ha) × Price of grain (₹/kg)] + [Haulm yield (kg/ha) × Price of haulm (₹/kg)] – [Common cost (₹/ha) + Treatment cost of cultivation (₹/ha)]}

B C ratio = Net returns (₹/ha)/Total cost of cultivation (₹/ha)

All data were analyzed statistically using the analysis of variance (ANOVA) technique of Panse and Sukhatme (1985). The critical differences at the 0.05 level of probability were calculated to assess the significance between treatments if ANOVA tested significant. The correlation coefficient and regression equations were calculated for yield and yield components using the procedure advocated by Snedecor and Cocharan (1968).

RESULTS AND DISCUSSION

Yield and yield components

The determinate type cultivar Rmt-305 recorded significant improvement in yield components, viz. number of pods/branch (10.0), pod length (10.8 cm), number of seeds/pod (17.8), test weight (12.1 g) and harvest index (21.2%) over indeterminate type cultivar Rmt-1 (Table 1). It is well known that growth and yield potential of plant types are interactive outcome of genetic milieu, environmental conditions and agronomic support which is provided during its life cycle. Since both the plant types were grown under

Table 1 Effect of plant types, crop geometry, agro-chemicals and sulphur fertilization on yield and yield components of fenugreek

Treatment	Seed yield (kg/ha)	No. of pods/ branch	Pod length (cm)	No. of seeds/pod	Test weight (g)	Harvest index (%)
Plant types						
Rmt-1	1 190	7.80	9.22	15.14	9.99	18.05
Rmt-305	1 337	10.07	10.78	17.75	12.06	21.17
SEm ±	11	0.12	0.08	0.11	0.08	0.20
CD (P=0.05)	31	0.34	0.22	0.30	0.22	0.56
Crop geometry (cm)						
30 × 10	1 220	8.68	9.74	16.12	10.98	19.39
20 × 15	1 307	9.19	10.27	16.78	11.07	19.83
SEm ±	11	0.12	0.08	0.11	0.08	0.20
CD (P=0.05)	31	0.34	0.22	0.30	**NS**	**NS**
Agro-chemicals (ppm)						
No spray	1 181	8.36	9.53	15.71	10.75	19.43
TU (1000)	1 311	9.23	10.25	16.83	11.20	19.77
TGA (100)	1 299	9.22	10.23	16.79	11.13	19.63
SEm ±	13	0.146	0.096	0.132	0.096	0.243
CD (P=0.05)	38	0.41	0.27	0.37	0.27	**NS**
Sulphur (kg S/ha)						
0	1 170	8.51	9.65	15.82	10.77	19.46
40	1 357	9.36	10.35	17.07	11.28	19.76
SEm ±	11	0.119	0.078	0.107	0.078	0.198
CD (P=0.05)	31	0.34	0.22	0.30	0.22	**NS**

TU, Thiourea; TGA, thioglycolic acid; The values in the columns are pooled mean of two years. The significance of data was tested using 'F' test at P=0.05. The NS represents non significance of data.

identical agronomical and environmental conditions, the marked variation in growth could be ascribed on account of their genetic capabilities to exploit available resources for their growth and development. Superior genetic potential of determinate type (Rmt-305) was advocated by Singh (2004). There was a significant plant type effect on grain yield of fenugreek. The crop geometries, agro-chemicals and sulphur fertilization significantly influenced the grain yield. The grain yield of determinate type cultivar Rmt-305 was significantly greater (147 kg/ha) over indeterminate type cultivar Rmt-1. The improvement in yield components results in higher seed yield (1 337 kg/ha) which was 12.31% higher over Rmt-1 (Table 1).

The greater grain yield of cultivar Rmt-305 may possibly due to its synchronous maturity, bold seeds having greater 1 000 seed weight, potential yield components and ability to partition photosynthates more efficiently to grain as indicated by higher harvest index (21.2%) compared to cultivar Rmt-1 (18.1%). Potential yield components produced significantly greater grain yield was also reported by Khiriya and Singh (2003) and Bhati and Prasad (2004). Seed yield, in turn, was found strongly correlated with the mean number of pods/ branch, pod length, number of seeds/pod, test weight and harvest index. Respective correlation coefficients were 0.782, 0.930, 0.917, 0.655 and 0.827. Every unit increase in these parameters, viz. pods/branch, pod length, seeds/pod, test weight and harvest index increased seed yield by 1.20, 1.36, 1.00, 1.29 and 0.80 q/ha (Table 2). The interactions of T×S and T×G×C were only significant (Table 3). The determinate type cultivar Rmt-305 was produced greater grain yield in interaction with agro-chemicals and sulphur fertilization (Fig 1-2). Since flowering terminates leaf area development in determinate type cultivars. The cultural practices like application of agro-chemicals and sulphur fertilization may possibly maximize photosynthesis and also maximize the partitioning of photosynthates towards grain. This is an efficient pattern for grain crops, in which the majority of seed weight comes from photosynthesis after flowering (Gardner *et al.* 2003). As the agro-chemicals (thiourea and TGA) are known to stimulate dark fixation of CO_2, improve photosynthetic efficiency and enhance translocation of photosynthates (Jocelyn 1972).

The crop geometry 20 cm × 15 cm was found superior in production of yield components and yield over the crop geometry 30 cm × 10 cm and recorded the mean increase of 5.9, 5.4 and 4.1% in number of pods/branch, pod length and number of seeds/pod, respectively (Table 1). This improvement results in higher seed yield (1 307 kg/ha) under

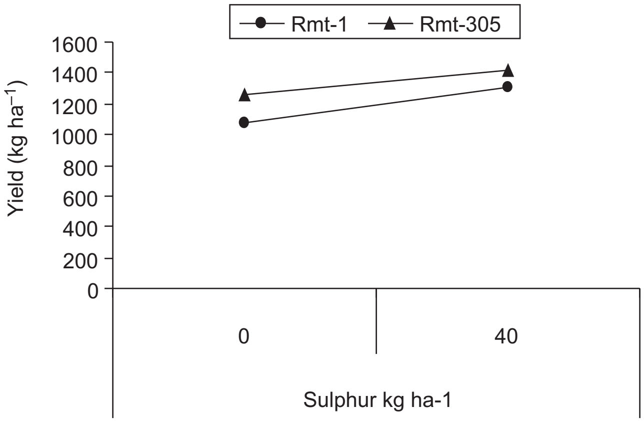

Fig 1 Effect of sulphur rates on yield of fenugreek plant types grown in clay loam soil in the southern part of Rajasthan state in India.

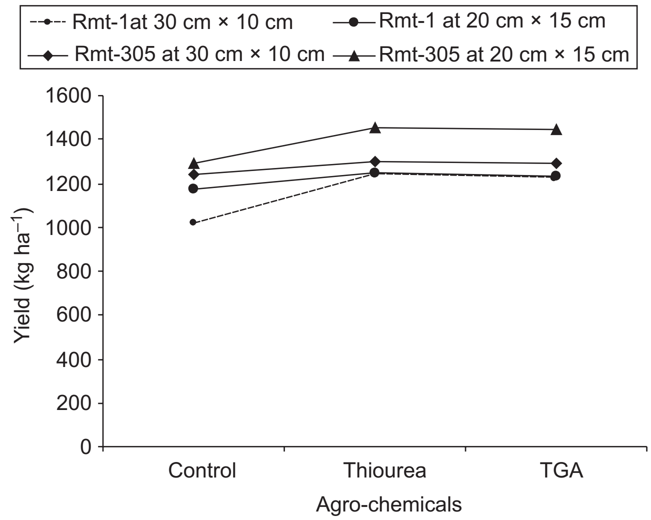

Fig 2 Effect of crop geometry and agro-chemicals on yield of fenugreek plant types grown in clay loam soil in the southern part of Rajasthan state in India.

Table 2 Correlation coefficient and regression equations showing relationship between independent variables (x) and dependent variables (y) on the mean basis (** shows that correlation coefficient is significant at 1% level of significance)

Dependent variable (y)	Independent variables (x)	r	R^2	Y = a+bx
Seed yield (q/ha)	No. of Pods/branch	0.782**	0.611	Y = 1.892+1.202X
	No. of seeds/pod	0.917**	0.841	Y = –3.824+1.001X
	Pod length (cm.)	0.930**	0.866	Y = –0.982+1.361X
	Test Weight (g)	0.655**	0.429	Y = –1.602+1.291X
	Harvest Index (%)	0.827**	0.685	Y = –3.067+0.801X

Table 3 Analysis of variance of yield and yield components for fenugreek plant types as influenced by crop geometry, agro-chemicals and sulphur fertilization (* Significant at P= 0.05)

SOV	DF	Probability level of F					
		Grain yield (kg/ha)	No. of pods/ branch	No. of seeds/ pod	Pod length (cm)	Test weight (g)	Harvest index (%)
Plant types (T)	1	90.47*	180.59*	296.37*	196.80*	350.34*	124.75*
Crop geometry (G)	1	32.24*	9.05*	18.87*	23.09*	0.79	2.42
Agro-chemicals (C)	2	28.89*	11.63*	23.52*	18.45*	6.53*	0.48
Sulphur fertilization (S)	1	146.21*	25.39*	66.79*	39.99*	21.19*	1.11
T × G	1	3.86	2.93	2.65	3.17	0.65	2.38
T × C	2	0.55	0.02	0.54	0.14	0.06	0.45
T × S	1	5.14*	0.17	1.47	0.31	0.22	5.14*
G × C	2	0.19	0.21	0.21	0.01	0.00	0.47
G × S	1	1.77	0.08	0.14	0.09	0.06	0.01
C × S	2	0.02	3.40*	0.00	1.55	0.34	0.43
T × G × C	2	7.10*	0.03	0.39	0.06	0.00	2.36
T × G × S	1	2.81	0.01	0.24	0.08	0.03	2.66
T × C × S	2	0.11	0.02	0.23	0.00	0.01	0.33
G × C × S	2	0.74	0.03	0.03	0.01	0.05	0.05
T × G × C × S	2	0.65	0.01	0.10	0.00	0.03	0.60

20 cm × 15 cm as compared to 30 cm × 10 cm (1 220 kg/ha) (Table 1). Improvement in seed yield as a result of remarkable improvement in yield components due to adoption of different crop geometries was also reported by Kumawat *et al.* (1998). Beneficial effect of crop geometry of 20 cm × 15 cm seems to be due to closeness to square which made more uniform space availability to individual plant leading to less intra specific competition and better root development, thereby resulted in greater absorption of solar radiation and nutrients from soil together with low crop competition for air, light, moisture and nutrients at this crop geometry. The importance of appropriate planting system also reported by Burkhart and Collins (1941), Cox and Ried (1965), Arnon (1972) and Mixon (1969).

Agro-chemicals significantly influenced yield components and grain yield of fenugreek. The grain yield of fenugreek was increased by 11 and 10% due to foliar spray of thiourea and TGA, respectively over control (Table 1). The increase in grain yield was resulted from the improvement in yield components, viz. number of pods/branch, pod length, number of seeds/pod and test weight (Table 1). These bioregulators possibly improve the gene expression for efficient sucrose transport and increase dry matter partitioning for grain production (Werdan *et al.* 1975). SH/ss (Thio group: Disulfide) ratio in plants is more important for grain formation rather supply of SH group alone. Most probably the SH/ss ratio of transport protein is regulated by the thiols (e g thiourea, thioglycolic acid, etc.). These thiols probably improved phloem loading of sucrose and thereby, dry matter partitioning by enhancing the activity of sucrose transport protein (Giaquinta 1976). These findings are in cognizance with the findings of Sahu and Singh (1995). This improvement results in higher grain yield (1 357 kg/ha) as compared to control (1 170 kg/ha). Grain yield was strongly correlated with yield components, viz. number of pods/branch (r=0.782), pod length (r=0.930), number of seeds/pod (r=0.917), test weight (r=0.655) and harvest index (r=0.827). The beneficial effect of thiourea and TGA on yield components and grain yield appeared to be due to delayed senescence of both vegetative and reproductive organs as these chemicals have cytokinin like activity (Erez 1978). Thiourea is also known to increase photosynthetic active leaf surface during grain filling period in cereals (Sahu *et al.* 1993). Thiourea and TGA application was resulted in increased and complete translocation of photosynthates to the developing seeds. Wellbank *et al.* (1968) concluded that the translocation rate or the capacity of grain to accept carbohydrates has significant influence on the partitioning of dry matter between grain and vegetative parts of the plant, particularly during post anthesis period. In this context, it is worth mentioning here that sulphydryl compounds like thiourea and TGA are known to play important role in improving dry matter partitioning for seed production (Sahu *et al.* 1993).

Application of sulphur @ 40 kg S/ha increased the yield components and grain yield of fenugreek significantly over control. The mean increase in yield components, viz. number of pods/branch, pod length, number of seeds/pod and test weight were 10.0, 7.3, 7.9 and 4.7%, respectively over control (Table 1). The fenugreek crop was responsive to sulphur application because the sulphur status of experimental site was reported as low and the application of S increased the availability of most of the plant nutrients in the rhizosphere as well as nutritional environment in the plant system due to greater absorption of nutrients and ultimately the metabolism and photosynthetic activity, resulting in better growth and development of the plant (Jat *et al.* 1998 and Leustek *et al.* 2000).The increase in yield components was a resultant effect of increased growth parameters and the cumulative higher seed yield. These findings are in concurrence with the findings of Nehara *et al.* (2006).

Quality parameters

There was a significant effect of agro-chemicals (thiourea and TGA) and sulphur fertilization on per cent protein content and diosgenin content of seed representing an increase of 1.5 and 1.2% in protein content and 4.3 and 4.0% in diosgenin content was recorded by thiourea and TGA, respectively over control. Protein and diosgenin contents by thiourea and TGA were comparable (Table 4). The improvement in protein content and diosgenin content of fenugreek seeds by foliar spray of thiourea and TGA could be attributed to their pivotal role in creating congenial nutritional environment, greater availability of nitrogen, phosphorus and sulphur and regular supply of metabolites for protein synthesis through improved translocation of metabolites from source to sink, which ultimately led to increased protein content in seeds. Thiourea maintains more favourable balance of endogenous hormones and enzymes, important for biosynthesis of protein and diosgenin. The change in hormone activity as a result of thiourea application was also reported by Klein and Farkass (1930).

Significant increase in per cent protein and diosgenin content of seed was observed with the application of sulphur. Application of sulphur @ 40 kg/ha increased the protein content by 1.4% and diosgenin content by 3.4% over zero-S (Table 4). The greater protein and diosgenin contents by S application may possibly due to greater availability and assimilation of N under its influence as N is actively involved in synthesis of proteins. Sulphur is a vital part of the ferredoxin, a type of nonheme Fe-S protein occurring in the chloroplasts. Ferredoxin participates in oxidoreduction process by transferring electrons and has a significant role in nitrite reduction, sulfate reduction and the assimilation of N_2 by root nodule bacteria and free living N-fixing soil bacteria. Thus, sulphur fertilization improves crop quality through reductions in the N/S ratio (Tisdale *et al.* 1997). At the same time greater availability of metabolites to seed with the application of sulphur might have facilitated greater

Table 4 Effects of plant types, crop geometry, agro-chemicals and sulphur fertilization on seed quality parameters of fenugreek and relative economics of fenugreek

Treatment	Protein content (%)	Diosgenin content (%)	Net returns (₹/ha)	B C ratio
Plant types				
Rmt-1	20.98	0.361	19522	2.10
Rmt-305	21.08	0.363	21250	2.17
SEm ±	0.05	0.0014	216	0.02
CD (P=0.05)	NS	NS	608	0.06
Crop geometry (cm)				
30 x 10	21.05	0.361	19572	2.08
20 x 15	21.01	0.363	21200	2.18
SEm ±	0.05	0.0014	216	0.02
CD (P=0.05)	NS	NS	608	0.06
Agro-chemicals (ppm)				
No spray	20.84	0.353	18785	2.03
Thiourea (1000)	21.16	0.368	21014	2.10
Thioglycolic acid (100)	21.08	0.367	21359	2.27
SEm ±	0.056	0.0018	265	0.03
CD (P=0.05)	0.16	0.0049	745	0.08
Sulphur (kg S/ha)				
0	20.88	0.356	18740	2.07
40	21.18	0.368	22032	2.19
SEm ±	0.046	0.0014	216	0.02
CD (P=0.05)	0.13	0.0040	608	0.06

The values in the columns are pooled mean of two years. The significance of data was tested using 'F' test at P=0.05. The NS represents non significance of data.

conversion of metabolites into alkaloids. This contention is in cognizance with the findings of Purbey and Sen (2005) and Choudhary (2004) who also reported higher diosgenin content of fenugreek seeds with fertilizer application which results in greater transformation of metabolites into alkaloids. Plant types and crop geometries were failed to cause any significant difference in per cent protein content and diosgenin content of seed (Table 4).

Relative economics

The determinate type cultivar Rmt-305 gave significantly higher net returns (Table 4). Maximum mean net returns of ₹ 21 250/ha with benefit cost ratio of 2.17 was recorded with Rmt-305 which gave an additional net profit of ₹ 1 728/ha over indeterminate type cultivar Rmt-1. Adoption of crop geometry 20 cm × 15 cm gave significantly higher net monetary returns over crop geometry 30 cm × 10 cm (Table 4). Maximum mean net monetary returns of ₹ 21 200/ha was recorded with crop geometry 20 cm × 15 cm which gave an additional net profit of ₹ 1 628/ha with maximum mean benefit cost ratio of 2.18. Foliar sprays of thiourea and TGA significantly increased the net monetary returns and benefit cost ratio over control (Table 4). Maximum mean monetary net returns of ₹ 21 359/ha and benefit cost ratio of 2.27 were obtained with foliar sprays of TGA which was at par with thiourea and 13.70 and 11.82%, respectively higher over control. Significant increase in net monetary returns was observed with higher benefit cost ratio by the application of sulphur (Table 4). Maximum mean net monetary returns of ₹ 22 032/ha and benefit cost ratio of 2.19 were observed with sulphur fertilization. Contributing to the gains in net returns was greater yield performance of determinate type cultivar Rmt-305, crop geometry 20 cm × 15 cm and by the application of agro-chemicals and sulphur. Among the agro-chemicals the gain in net returns by TGA was due to its lower concentration used which resulted in lower cost as compared to thiourea. The gains in net returns due greater grain yield and low cost of cultivation was also reported by (Jat *et al.* 1998, Choudhary 2004, Nehara *et al.* 2006).

The plant types and sulphur fertilization (T×S) interacted significantly in respect to net returns and benefit cost ratio (Table 5). The determinate type cultivar Rmt-305 gave maximum net returns along with maximum benefit cost ratio with sulphur fertilization. The interaction T×G×C was also found significant in respect to net returns and benefit cost ratio (Table 5). The determinate type cultivar Rmt-305 gave maximum net returns along with maximum benefit cost ratio with foliar spray of TGA under crop geometry 20 cm × 15 cm over the crop geometry 30 cm × 10 cm.

Table 5 Analysis of variance of seed quality parameters and relative economics of fenugreek plant types as influenced by crop geometry, agro-chemicals and sulphur fertilization (* Significant at P= 0.05)

SOV	Probability level of F			
	Protein content (%)	Diosgenin content (%)	Net returns (₹/ha)	B C ratio
Plant types (T)	2.70	1.34	31.99*	5.46*
Crop geometry (G)	0.42	0.83	28.36*	10.23*
Agro-chemicals (C)	8.98*	21.96*	27.85*	20.31*
Sulphur fertilization (S)	22.62*	37.01*	116.00*	15.07*
T × G	1.03	0.01	2.81	2.02
T × C	0.04	0.07	0.62	0.92
T × S	0.19	0.10	4.89*	6.23*
G × C	0.05	0.17	0.14	0.35
G × S	0.02	<0.001	2.13	1.40
C × S	0.42	2.64	0.10	0.01
T × G × C	0.05	0.17	7.13*	7.86*
T × G × S	0.31	0.24	1.78	1.69
T × C × S	0.09	0.00	0.18	0.19
G × C × S	0.48	0.01	0.89	1.01
T × G × C × S	0.33	0.11	0.65	1.01

Conclusion

On the basis of results presented and summarized in the preceding texts it is concluded that determinate type (Rmt-305) produced maximum seed yield of 1 337 kg/ha with maximum net returns of ₹ 21 250/ha and B C ratio of 2.17. Fenugreek crop grown at crop geometry of 20 cm × 15 cm was produced maximum seed yield of 1 307 kg/ha with maximum net returns of ₹ 21 200/ha and B C ratio of 2.18. Foliar spray of 100 ppm TGA at flower initiation and 15 days thereafter gave grain productivity of 1 299 kg/ha which is at par with 1000 ppm thiourea (1 311 kg/ha) with maximum net returns of ₹ 25 303/ha and B C ratio of 2.27. Sulphur fertilization @ 40 kg S/ha produced significantly higher grain yield of 1 357 kg/ha with maximum net returns of ₹ 22 032/ha and B C ratio of 2.19. It is recommended to the farmers that growing of determinate type cultivar Rmt-305 at crop geometry 20 cm × 15 cm supplemented with foliar spray of TGA 100 ppm and sulphur application @ 40 kg S/ha gave maximum net returns of ₹ 25 210/ha with maximum benefit cost ratio of 2.45.

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