Original research article

Effect of Plant geometry and Sulphur on yield, oil content and Economics of Sesame (*Sesamum indicum* L.)

Abstract

A field experiment entitled **"Effect of Plant geometry and Sulphur on yield and Economics of Sesame (*Sesamum indicum* L.)"** was conducted during *Zaid* season 2021 at Krishi Vigyan kendra, SHUATS, Allahabad, (U.P.). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.7). The experiment was laid out in Randomized Block Design with nine treatments consisted of Spacing (25x15cm^2, 30x15cm^2 , 35x15cm^2) and Sulphur (20 kg,30kg,40kg/ha) which were replicated thrice and effect was observed on Gujarat til-4 sesame variety. The result showed that there were significant increase in growth and yield parameters *viz*., The results obtained that yield parameters such as capsule (35.87/plant), seeds (38.47 /capsule), test weight (2.90 g), seed yield (867.97 kg/ha), stover yield (1554.20 kg/ha), harvest index (39.36%) and oil content (48.32%) were recorded maximum in the treatment combination of 30 cm x 15 cm + 40 kg sulphur at Harvest. However, in economic point of view, maximum gross returns (INR 82,456.83/ha), net returns (INR 56,779.83/ha) and benefit: cost ratio (2.2) were obtained highest in the treatment combination of 30 cm x 15 cm + 40 kg Sulphur respectively.

Keyword: *Sesame, Spacing, Sulphur, yield, oil content, Economics.*

INTRODUCTION

Sesame, (*Sesame indicum Linn.; syn. Sesamum* oriental Linn.),a member of order Tubiflorea, Family Pedaliaceae, is perhaps the oldest oilseed known and used of human-beings(Joshi,1961 ;Weiss, 1983). According to the Directorate of Economics and Statistics, GOI, all India kharif 2019 sesame acreage was 13,71,700 hectares. All India sesame acreage was 13, 71,700 hectares. Four states, Gujarat (1, 16,200 ha; 8%), Uttar Pradesh (4, 17,435 ha; 30%), Rajasthan (2, 70,191 ha; 20%) and Madhya Pradesh (3, 14,300 ha; 23%) jointly accounted for 85 per cent of the national acreage. At the national level, there was an increase in acreage by 4 per cent with respect to kharif-2018. The decrease observed in Madhya Pradesh was quite large (29%). However, increases in Gujarat (49%) and Uttar Pradesh (26%) were substantial. Sesame is called as "Queen of oil seed crop" by virtue of its excellent quality. According to Assyrian legend, when the gods met to create the world, they drank wine made from sesame seeds. In early Hindu legends, tales were told in which sesame seeds represent a symbol of immortality. "Open sesame", the famous phrase from the Arabian Nights, reflects the distinguishing feature of sesame seed pod, which bursts open when it reaches maturity. Sesame is very drought tolerant crop of semiarid regions. It is superior to other oil seed crop due to adaptability to varied agro-climatic condition and higher degree of drought tolerance it is widely grown in countries such as India, China, Bangladesh, Turkey, and also in drier parts of African and Mediterranean countries. Worldwide, it is used for its Nutritional, Medicinal, and industrial purposes. It has been called survivor crop with an ability to grow where most crops fail. Sesame ranks first for having oil content of 46-64% and 6355 k cal/kg dietary energy in seeds (**Sanjay kumar & Goel, 1994**). Seeds of sesame is also rich source of protein (20-28%), sugar (14-16%) and minerals (5-7%). This oil has 85% unsaturated fatty acid is highly stable and has washing effect on cholesterol & prevents coronary heart disease. Sesame as a valuated oil seed appears to have numerous industrial applications. In India, sesamum seeds are used for oil extraction (78%), edible purposes (20%) and seed purpose (2 %). Out of that 70 % used for edible purpose as salad and cooking oil and remaining 30 % used for non-edible purpose like domestic and toilet soaps and for manufacture of margarine **(Rathore *et al*, 2005).**

Sesame oil is generally colourless,but dark green and light to deep-reddish yellow colours are also found depending on the colour of seed processed and the method of milling. The sesame oil milled from well cleaned seed can be refined the bleached easily to yield a light coloured oil. Globulin is the principle protein of sesame seed. Sesame seeds are fairly rich in vitamins like thiamin (1 mg/100g).The value reported or different B- vitamins in oil-free seedmeal are (mg/g meal): thiamin2.4, riboflavin2.5,nicotinic acid 800, penthonic acid 9.5(free acid 3-4),folic acid 0.20 (free acid 0.10),biotin 0.06; pyridoxine 2-33;inositol 740; choline 1320 and P-aminobenzoic acid 0.65. Ascorbic acid present in traces. Vitamin A protency range from 15-100 IU/100 g seed. Refined sesame oil contains about 0.05% tocophenols. Sesame oil contains 17 aroma components of which acytyl pyrazine plays a strong role in providing strong popcorn-like aroma in sesame oil.

Sesamum seed contains 50-60 % oil which has excellent stability due to the presence of natural antioxidants such as sesamolin, sesamin and sesamol. They enrich blood and are useful in snake bites, bleeding piles etc. Sesame oil is used for preparation of medicines for dry cough, Asthama, disease of lungs, burning sensation, ear and eyes disease. Recently Omega-6 fatty acid desaturase was also extracted from sesamum which is helpful for heart patients (Jin et al., 2001).

Sesame cake contains 6.0-6.2% N, 2.0-2.2% P2O5 and 1.0- 1.2% of K_2O and can be used as manure. Sulphur an essential plant nutrient can play a key role in augmenting the production and productivity of oilseeds in the country as it has a significant influence on quality and development of oil seeds and best known for its role in the synthesis of proteins, oils and vitamins. Available sulphur in soil is frequently lower than 5-10 ppm in light textured soil of Rajasthan. Sulphur deficiency is becoming more critical with each passing year which is severely restricting crop yield, produce quality and nutrient use efficiency. Sulphur, therefore, is now very much a part of balanced fertilization because in S deficient areas, applying N, P and K

only, even at recommended rates cannot produce high yields unless S is also applied. Sulphur research work done in different parts of the country indicates that application of sulphur is highly profitable and seems to be essential for boosting the crop production.

MATERIALS AND METHODS

The experiment was conducted during Zaid season of 2021-2022. The experiment was conducted in Randomized Block Design consisting of nine treatment combinations with three replications and was laid out with the different treatments allocated randomly in each replication. The soil of the experimental field was sandy loam in texture, slightly alkaline reaction (pH 7.2) with low level of organic carbon (0.35%), available N (203.7 Kg/ha.), P (17.14kg/ha.) and higher level of K (92.00 kg/ha.). The treatment combinations are T_1 - Spacing 25 x15 cm + sulphur - 20 kg/ha, T_2 - Spacing 30 x15 cm + sulphur - 20 kg/ha, T_3 - Spacing 35x 15 cm + sulphur - 20 kg/ha, T_4 - Spacing 25x 15 cm + sulphur - 30 kg/ha, T_5 - Spacing 30 x 15 cm + sulphur - 30 kg/ha, T_6 - Spacing 35 x 15 cm + sulphur - 30 kg/ha., T_7 - Spacing 25 x 15 cm + sulphur - 40 kg/ha, T_8 - Spacing 30 x 15cm + sulphur - 40 kg/ha, T_9 - Spacing 35 x 15cm + sulphur - 40 kg/ha. The observations were recorded on different yield parameters at harvest viz. Number of capsule per plant; from the five tagged plants of each plot the number of capsules/plants was taken and the average number of capsules/plants was noted, number of seeds per capsule: Three capsules were selected from each plant. Number of seeds per capsule was calculated and the average was taken, test weight: One thousand number of healthy seed were counted from the representative sample of each plot and weighted as to recorded 1000-seed weight in gram, Seed yield: The total yield obtained from the harvest area (1.0m) ^{2} per plot was multiplied by the conversion factor for obtaining the total yield in kg per hectare. stover yield: The Stover yield (above the ground portion) of plants from the harvest area (1.0 m) ^{2} of each plot was weighed separately and expressed in kg per hectare, Harvest index: Harvest index was obtained by dividing the economic yield (Seed yield) by the biological yield (seed+ stover).It was concluded for each of the plots and was represented in percentage.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

Oil content (%) in Seeds:

Treatment wise analysis of oil content for seed sample was conducted. The procedure followed for determination of oil content in seed is described below.

The Soxhlet extraction method used to extract the oil from seed sample. This method is described by Soxhlet in 1879.

Procedure:

1. The apparatus should be cleaned with stock solution and then rinsed with solvent ether, there after it is dried.
2. Extraction flask is dried and weighed in a balance and empty weight is recorded.
3. Take 3g of seed sample and put in whatman no.42. the sample of seed is crushed gently.
4. Take 250ml of diethyl ether and place it in the extraction flask.

5. The entire apparatus is fitted to ensure no leakage of vacuum.
6. The ether in the extraction flask is gently heated to the boiling point; meanwhile the water should also be circulated simultaneously to cool the ether.
7. Heating is continued till the extractor is completely full and the extract returns to the extraction flask through siphon. This procedure is repeated 3-4 times, to ensure complete extraction of oil.
8. The extraction flask is removed and kept in water bath, and heat it gently till there is no smell of ether.

$$\text{Oil content (\%)} = \frac{\text{Weight of flask with oil} - \text{weight of empty flask}}{\text{Weight of samples}} \times 100$$

The economic analysis of the treatments is very important to assess the practical utility of treatments for farmer's point of view. Therefore, economics of different treatments were worked out in terms of **Cost of cultivation (INR/ha):** The cost of cultivation for each treatment was calculated separately taking into considerations of all the cultural practices followed in the cultivation, **Gross returns (INR/ha):** The gross returns from each treatment were calculated taking into the consideration of the cost of cultivation and market price of the produce., **Net returns (INR/ha):** The net profit from each treatment was calculated separately by using the following formula: Net returns = Gross returns (INR/ha) – cost of cultivation (INR/ha) and **Benefit cost ratio:** The benefit cost ratio for each treatment was calculated by using the following formulae.

$$\text{B: C ratio} = \frac{\text{Net returns (INR/ha)}}{\text{Total cost of cultivation (INR/ha)}}$$

RESULT AND DISCUSSION

A. Yield Attributes

The data pertaining to yield parameters have been presented in table1. The important yield parameters capsule per plant, Test weight (g), seed yield (kg/ha), Stover yield (kg/ha), Harvest index (%) and Oil Content (%) were influenced significantly by various treatment.

ANOVA FOR RBD

Sources of variance	Df	SS	MS	F
Replication	r-1	RSS	RMS	RMS/EMS
Treatment	t-1	TSS	TMS	TMS/EMS
Error	(r-1) (t-1)	ESS	EMS	
Total	rt-1	Total		

Computation of ANOVA:

C.F. = Correction factor = G^2/N

G = Grand total

N = Number of observations

Total sum of squares (T.S.S.) = $\Sigma i \Sigma j\ X^2 ij$ - C.F.

$$\text{Replication Sum of Square (R.S.S.)} = \frac{\Sigma_j R^2 j}{T} - \text{C.F.}$$

$$\text{Treatment Sum of Square (Tr.S.S.)} = \frac{\Sigma_j T^2 i}{T} - \text{C.F.}$$

Error Sum of Square (E.S.S.) = T.S.S. – R.S.S. – Tr.S.S.

Capsules per plant

Capsules per plant was found significant. The maximum number of capsules per plant was recorded highest (35.87) by T_8 (30cmx15cm) +40kg Sulphur. Where T_5 (30cmx15cm) +30kg Sulphur had recorded (35.60) were found statistically at par with T_8 (30cmx15cm) +40kg Sulphur.

Seeds per capsules

Seeds per capsules was found significant. The maximum number of seeds per capsules was recorded (38.47) by T_8 (30cmx15cm) +40kg Sulphur . Where T_5 (30cmx15cm) +30kg Sulphur had recorded (37.33) were found statistically at par with T_8 (30cmx15cm) +40kg Sulphur.

Test weight

Test weight was found significant. The maximum test weight was recorded (2.95) by T_8 (30cmx15cm) +40kg Sulphur. Where T_5 (30cmx15cm) +30kg Sulphur, T_6 (35cmx15cm) +30kg Sulphur, T_7 (25cmx15cm) +40kg Sulphur, T_9 (35cmx15cm) +40kg Sulphur had recorded (2.87, 85, 2.81 and 2.85) were found statistically at par with T_8 (30cmx15cm) +40kg Sulphur. These results are in accordance with the finding of **Duary et al., (2006).**

Seed yield

Seed yield was recorded significant. The maximum seed yield was recorded (867.97 kg/ha) by T_8 (30cmx15cm) +40kg Sulphur. Where T_5 (30cmx15cm) +30kg Sulphur, T_6 (35cmx15cm) +30kg Sulphur had recorded (796.21 kg/ha and 778.65) which was statistically at par with T_8

(30cmx15cm) +40kg Sulphur. Similar results were also reported by **Sujatha et al. (2020)** and **Kithan *et al.* (2017)**

Stover yield

Stover yield was recorded significant. The maximum Stover yield was recorded (1554.20 kg/ha) by T_8 (30cmx15cm) +40kg Sulphur. Where T_5 (30cmx15cm) +30kg Sulphur, T_6 (35cmx15cm) +30kg Sulphur had recorded (1512.63 kg/ha and 1478.81) which was statistically at par with T_8 (30cmx15cm) +40kg Sulphur. The significant increase in stover yield maybe attribute to synergistic relationship between plant geometry and sulphur that enhance the yield attributes which result in more dry matter accumulation with each increment levels of plant geometry and sulphur. Similar results were also reported by **Tekseng *et al*. (2018)**

Harvest index

Harvest index was recorded significant. The maximum Harvest index was recorded (39.36%) by T_8 (30cmx15cm) +40kg Sulphur. Where T_5 (30cmx15cm) +30kg Sulphur had recorded (38.03%) which was statistically at par with T_8 (30cmx15cm) +40kg Sulphur.

Quality parameters

Oil content

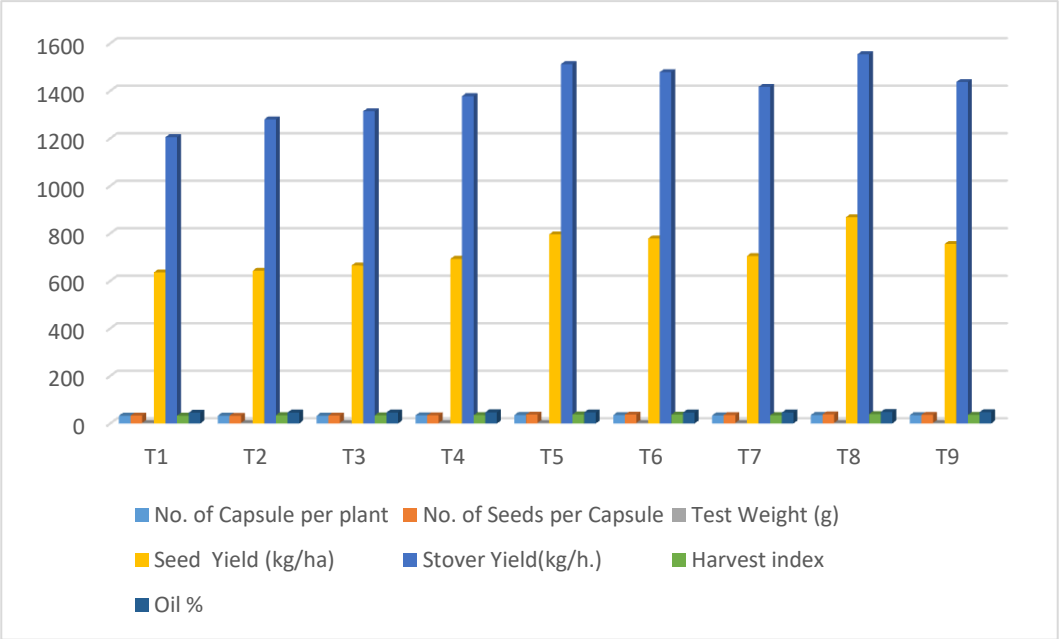
Data presented in Table1. Stated that the oil content in sesame indicated the variation due to different treatments. The maximum Oil content was recorded (48.32%) by T_8 (30cmx15cm) +40kg Sulphur. Progressive increase in level of sulphur were increased the quality i.e. oil content (46.75%). These results are equality with **Jat *et al.* (2017)** of sesame. Similar results were also reported by **(Nagavani *et al*., 2001) and (Gokhale *et al*., 2005)**.s

Fig1. 30×15 cm Line Sowing

Fig2. 60 DAS at reproductive stage

Table.1 Effect of Plant geometry and Sulphur on Yield Attributes and Yield of Sesame.

Treatments	No. of Capsule per plant	No. of Seeds per Capsule	Test Weight (g)	Seed Yield (kg/ha)	Stover Yield(kg/h.)	Harvest Index (%)	Oil Content (%)
Spacing 25 x15 cm + sulphur - 20 kg/ha	32.67	33.20	2.68	636.00	1205.42	32.94	45.34
Spacing 30 x15 cm + sulphur - 20 kg/ha	32.73	32.47	2.68	643.00	1280.17	34.72	46.06
Spacing 35x 15 cm + sulphur - 20 kg/ha	32.93	33.27	2.74	665.00	1314.38	34.28	46.11
Spacing 25x 15 cm + sulphur - 30 kg/ha	34.20	34.07	2.69	693.00	1378.00	35.06	47.10
Spacing 30 x 15 cm + sulphur - 30 kg/ha	35.60	37.33	2.87	796.21	1512.63	38.03	46.28
Spacing 35 x 15 cm + sulphur - 30 kg/ha	35.13	37.27	2.85	778.65	1478.81	37.58	45.86
Spacing 25 x 15 cm + sulphur - 40 kg/ha	33.70	35.47	2.81	705.04	1417.12	34.70	46.18
Spacing 30 x 15cm + sulphur - 40 kg/ha	35.87	38.47	2.90	867.97	1554.20	39.36	48.32
Spacing 35 x 15cm + sulphur - 40 kg/ha	35.00	36.53	2.85	755.65	1437.20	36.37	47.66
SEm (±)	0.33	0.39	0.08	17.10	24.34	0.32	-
CD (5%)	0.99	1.16	0.25	51.27	72.97	0.96	-



B. Economics

Cost of cultivation

Cost of cultivation (25,677.00 INR/ha.) was found to be highest in Spacing 30 x 15cm + sulphur - 40 kg/ha. As compared to other treatments.

Gross returns

Gross returns (82,456.83 INR/ha.) were found to be highest with the application of Spacing 30 x 15cm + sulphur - 40 kg/ha. As compared to other treatments.

Net returns

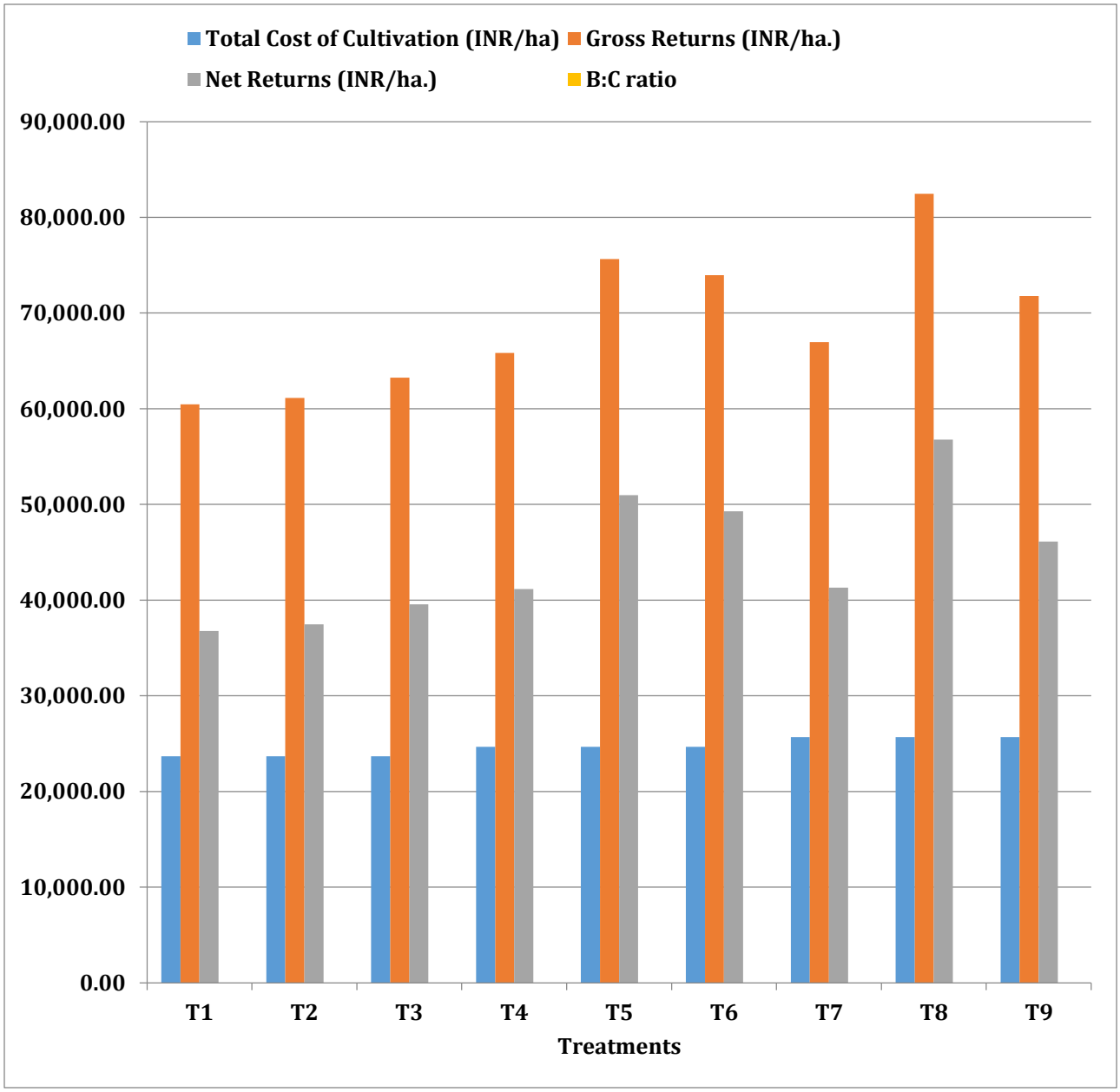
Net returns (756,779.83 INR/ha.) were found to be highest with the application of Spacing 30 x 15cm + sulphur - 40 kg/ha. As net return is calculated by multiplying the seed yield and their sale prices and subtracting the total cost of cultivation including treatment cost. Thus, higher net return could be primarily due to higher seed and stalk yields with comparatively lesser additional cost of input compared to additional yield under this treatment. Similar findings were also reported by **Yadav et al. (2022).**

Benefit Cost ratio

Benefit Cost ratio (2.2) was found to be highest in Spacing 30 x 15cm + sulphur - 40 kg/ha as compared to other treatments.

Table.2 Effect of Plant geometry and Sulphur on Yield and Economics of Sesame.

Treatments	Total Cost of Cultivation (INR/ha.)	Gross Returns (INR/ha.)	Net Returns (INR/ha.)	B:C ratio
Spacing 25 x15 cm + sulphur - 20 kg/ha	23,677.00	60,453.88	36,776.88	1.5
Spacing 30 x15 cm + sulphur - 20 kg/ha	23,677.00	61,140.42	37,463.42	5.5
Spacing 35x 15 cm + sulphur- 20 kg/ha	23,677.00	63,242.77	39,565.77	1.6
Spacing 25x 15 cm + sulphur - 30 kg/ha	24,677.00	65,843.87	41,166.87	1.6
Spacing 30 x 15 cm + sulphur - 30 kg/ha	24,677.00	75,639.95	50,962.95	2.0
Spacing 35 x 15 cm + sulphur - 30 kg/ha	24,677.00	73,972.07	49,295.07	1.9
Spacing 25 x 15 cm + sulphur - 40 kg/ha	25,677.00	66,979.12	41,302.12	1.6
Spacing 30 x 15cm + sulphur - 40 kg/ha	25,677.00	82,456.83	56,779.83	2.2
Spacing 35 x 15cm + sulphur 40 kg/ha	25,677.00	71,786.75	46,109.75	1.7


Total Cost of Cultivation (INR/ha)
Gross Returns (INR/ha.)
Net Returns (INR/ha.)
B:C ratio
90,000.00
80,000.00
70,000.00
60,000.00
50,000.00
40,000.00
30,000.00
20,000.00
10,000.00
0.00
T1
T2
T3
T4
T5
T6
T7
T8
T9
Treatments

CONCLUSION

On the basis of results it is concluded that individual as well as combined application of plant geometry and sulphur gave significant effect on seed and stover yield and economics by sesame. The application of (30cmx15cm) +40kg Sulphur was found more productive (867.00 kg/ha.) as well as economically viable (INR 56,779.83/ha.) also.

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