Original Research Article

Studies on yield and economics of sesame (*Sesamum indicum* L.) as influenced by spacing and foliar application of zinc

ABSTRACT

Background: Sesame plants thrive in hot, dry weather. It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds.The oil content of the seed is inversely proportional to its protein content. Most commercial cultivars of sesame are intolerant of water-logging.

The objective of the present experiment was to analyze the influence of spacing and application of zinc using foliar method on growth, yield and economics of Sesame (*Sesamum indicum* L.) during *kharif* season of 2021. The experiment was designed with varying combination of spacing and zinc using the Randomized Block Design which produced nine treatments with three replicates each. The treartment combinations are T_1 – 25 cm X 15 cm + 0.25% $ZnSO_4$, T_2 – 25 cm X 15 cm + 0.50% $ZnSO_4$, T_3- 25 cm X 15 cm + 0.75% $ZnSO_4$, T_4- 35 cm X 15 cm + 0.25% $ZnSO_4$, T_5 – 35 cm X 15 cm + 0.50% $ZnSO_4$, T_6 – 35 cm X 15 cm + 0.75% $ZnSO_4$, T_7- 40 cm X 10 cm + 0.25% $ZnSO_4$, T_8- 40 cm X 10 cm + 0.50% $ZnSO_4$, T_9 – 40 cm X 10 cm + 0.75% $ZnSO_4$. The combination, T_9 with spacing 40 X 10 cm and 0.75% $ZnSo_4$ recorded maximum number of capsules per plant (54.60), number of seeds per capsule (60.50), seed yield (1.20 t/ha), harvest index (31.89 %). The application of treatment T_9 40 cm X 10 cm + 0.75% $ZnSO_4$ recorded higher net return (52,016.00 INR/ha), gross return (78,217.00 INR/ha) and benefit: cost ratio (1.99) as well.

Conclusion: 40 cm X 10 cm + $ZnSo_4$ – 0.75 %, had the highest results for yield characteristics such has grain yield (1.20 t/ha), gross return (78,217.00 INR/ha), net return (52,016.00 INR/ha) and benefit: cost ratio (1.99).

Key words- Economics, Sesame, Spacing, Zinc, Yield

INTRODUCTION

Oilseed crops are a diverse group of plants grown in communities for the purpose of obtaining oil. As a result, oilseed production in India is extremely important to the country's economy, as they not only serve a vital part in the industrial sector and indirectly meet the needs of the people, but they also serve as a valuable source of foreign cash. These multipurpose commodities, such as oils and oilcakes, benefits humans, machines and animals, and the economy of our country in one way or another (**Weiss, 1983**).

Sesame (*Sesamum indicum* L.) is an ancient oil seed crop known by different names such as til, gingelly, simsim, gergelim etc. This crop is a part of Pedaliaceae family and has its lineage from East Africa and India. India and China are the topmost producer followed by Myanmar, Uganda, Pakistan, Sudan, Ethiopia, Tanzania, Nigeria, Turkey, Guatemala. Sesame seeds are popular as “Seed of Immortality” and are resistance to rancidity as the percentage of stable unsaturated fatty acids including oleic and linoleic acid is greater than 80%. The by-product of oil milling industry, sesame cake, is an abundant source of protein, niacinamide and minerals (Ca and P). With 25% protein content, this oilseed crop has the maximum oil content (46.64%) (**Thanunathan *et al.* 2002**). It can be cultivated all year round being a photo-insensitive and a short-term crop with versatile adaptability.

Space plays a pivotal part in growth, development and ultimately the yield Increase in plant population per unit area leads to competition amongst plants for natural resources subsequently producing weak plants and acute lodging. Thus, in order for the crop to efficiently and maximally employ these resources and prevent overcrowding, it is crucial to manage row spacing during cultivation. A direct relationship has been established between crop yield and plant density until the resources turn limiting **(Norsworthy and Emerson, 2005)**. Contrary to overcrowding, low-density populace results in a greater number of branches carrying fertile pods and hence, delaying the development phase for seed. Further, the plant productivity is influenced based on planting conformation as it changes the canopy geometry in turn impacting light interception and CO_2 assimilation (**Brar *et al.*, 1998**). For these reasons, spacing plays a paramount role as it affects the yield of sesame oilseed crop.

For crop feeding, the present-day method includes foliar mode of application where the liquid micronutrients are sprayed directly to the leaves **(Nasiri *et al.*,2010)**. This method is superior as opposed to soil application as it provides specific and quick response.

Zinc is an essential micronutrient that functions as a structural constituent or regulatory cofactor of a variety of enzymes and proteins in a variety of biochemical pathways, including carbohydrate metabolism, photosynthesis, sugar to starch conversion, protein metabolism, auxin (growth regulator) metabolism, pollen formation, biological membrane integrity, and pathogen resistance. Zinc (Zn) is an essential trace element that plays an important role in a wide range of enzymes, either as a metal component or as a functional, structural, or regulatory cofactor . **Murthy (2003)** reported Zn deficiency results lower oil content. **Murthy (2008)** stated that application of Zn can be implemented for higher yield and quality.

MATERIALS AND METHODS

The present field research was carried at Crop Research Farm of Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj at the beginning of *kharif* season (2021). The geographic coordinates were as follows: 25˚24'42"N latitude and 81˚50'56"E longitude being 98 m above the sea level. The objective included to study the influence of spacing and foliar application of zinc on growth, yield as well as economics of Sesame (*Sesamum indicum* L.) Var. G-1. The experiment was designed with varying combination of spacing and zinc using the Randomized Block Design which produced nine treatments with three replicates each. The average plot size was 3m X 3m, a total of 9 treatments were established as follows:

T_1 – 25 cm X 15 cm + 0.25% $ZnSo_4$,

T_2 – 25 cm X 15 cm + 0.50% $ZnSo_4$,

T_3 – 25 cm X 15 cm + 0.75% $ZnSo_4$,

T_4 – 35 cm X 15 cm + 0.25% $ZnSo_4$,

T_5 – 35 cm X 15 cm + 0.50% $ZnSo_4$,

T_6 – 35 cm X 15 cm + 0.75% $ZnSo_4$,

T_7 – 40 cm X 10 cm + 0.25% $ZnSo_4$,

T_8 –40 cm X 10 cm + 0.50% $ZnSo_4$,

T_9 – 40 cm X 10 cm + 0.75% $ZnSo_4$.

The foliar application of zinc was applied as single spray at 40DAS. Upon reaching the maturity age, each treatment-wise crop was harvested. From each plot, five replicates were selected randomly to study and record the parameters of growth such as height of plant (cm) and dry matter accumulation (g/plant). The seeds were gathered from plots after the harvesting to be dried in sunlight for three days. After winnowing and cleaning, yield per hectare (t/ha) was computed. Stover yield (t/ha) was computed as well after drying the seeds for 10 days. For statistical analysis, **Gomez and Gomez (1984)** method was adopted. The cost of seed with stover value and total cost was used to determine the benefit: cost ratio.

RESULTS AND DISSCUSIONS

Yield Attributes:

Number of Capsules/plants

Significant effect was observed by the statistical analysis of number of capsules/plant. Treatment T_9 40 cm X 10 cm + $ZnSo_4$ – 0.75 % recorded significant and highest number of capsules/plant (54.60). However, treatment T_8 40 cm X 10 cm + $ZnSo_4$ – 0.50 % was found to be statistically onpar with 40 cm X 10 cm + $ZnSo_4$ – 0.75 %. The yield attributing characters such as number of capsules/plant was significantly higher with wider spacing. It may be due to less competition exerted for light, moisture and nutrients. Sufficient interception of sunlight promotes efficient photosynthesis activities and ultimately greater accumulation of photosynthates under wider spacing. Narrow spacing with dense plant population resulted in the lower values of yield attributes. The increase in number of capsules/plant due to zinc might be due to adequate supply of zinc during early growth is considered important in promoting vegetative growth by influencing cell division and elongation in meristematic cell, thereby increasing the sink in terms in of number of capsules/plant. Similar results were also reported by **Kumar *et al.* (2011), Yadav *et al.* (2007), Shekh *et al.* (2014)** and **Patel (2012).**

Number of Seeds/capsules

Significant effect was observed by the statistical analysis of number of seeds per capsule. Treatment 40 cm X 10 cm + $ZnSo_4$ – 0.75 % recorded significant and highest number of seeds/capsule (60.50). However, 40 cm X 10 cm + $ZnSo_4$ – 0.50 % recorded statistically on par with 40 cm X 10 cm + $ZnSo_4$ – 0.75 %. The yield attributing characters such as number of seeds/capsule were significantly higher with wider spacing. It may be due to less competition exerted for light, moisture and nutrients. Sufficient interception of sunlight promotes efficient photosynthesis activities and ultimately greater accumulation of photosynthates under wider spacing. Narrow spacing with dense plant population resulted in the lower values of yield attributes. The increase in number of seeds/capsule due to zinc might be due to adequate supply of zinc during early growth is considered important in promoting vegetative growth by influencing cell division and elongation in meristematic cell, thereby increasing the sink in terms in of number of seeds/capsule. Similar results were also reported by **Kumar *et al.* (2011), Yadav *et al.* (2007), Shekh *et al.* (2014) and Patel (2012).**

Grain yield

Grain yield was significantly influenced with different combinations of Spacing and Foliar application of zinc along with nitrogen, phosphorus and potassium. The highest grain yield was obtained with the treatment 40 cm X 10 cm + $ZnSo_4$ – 0.75 % (1.20 t), However 35 cm X 15 cm+ $ZnSo_4$ – 0.75 % and 40 cm X 10 cm + $ZnSo_4$ – 0.50 % were found to be statistically on par with 40 cm X 10 cm + $ZnSo_4$ – 0.75 %. The grain yield of sesame increased significantly with increase in spacing and zinc. The grain yield of sesame increased significantly with increase in spacing and the level of applied foliar zinc up to 0.75%. Increase in spacing resulted due to better utilization of available resources *viz*. mineral, nutrients, water, solar radiation etc. and the optimum plant population due to higher yield of crop. The positive effect of zinc on seed yield might have been due to its requirement in carbohydrate synthesis, the pronounced role in photosynthesis and cell elongation. The increase in yield attributes and yield due to the application of Zn. Similar results were also reported **by Kumar *et al.* (2011), Paraye *et al.* (2009), Deosarkar *et al.* (2001)** in soybean. Higher seed yield and stover yield due to spacing 40cm x 10cm spacing might be due to availability of larger feeding area for better utilisation of natural resources like space, sunlight, water, nutrients etc. This is in agreement with the findings of **Shinde *et al.*, (2011).**

Stover yield

Highest stover yield (2.57 t/ha) was recorded at treatment T_9 40 cm X 10 cm + $ZnSo_4$ – 0.75 %, however, treatment T_6 35 cm X 15 cm + $ZnSo_4$ – 0.75 % and T_8 40 cm X 10 cm + $ZnSo_4$ – 0.50 % were found to be statistically onpar with T_9 40 cm X 10 cm + $ZnSo_4$ – 0.75 %. The stover yield of sesame increased significantly with increase in spacing and the level of applied foliar zinc. The stover yield of sesame increased significantly with increase in spacing and the level of applied foliar zinc up to 0.75%. Increase in spacing resulted due to better utilization of available resources *viz*. mineral, nutrients, water, solar radiation etc. and the optimum plant population due to higher yield of crop. The positive effect of zinc on stover yield might have been due to its requirement in carbohydrate synthesis, the pronounced role in photosynthesis and cell elongation. The increase in yield attributes and yield due to the application of Zn might be due to fact that Zn influences on the water economy and crop growth through its effect on water uptake, root growth, maintenance of turgor, transpiration and stomatal behaviour, overcomes the adverse effect of water stress and improving the drought tolerance. Similar results were also reported by **Kumar *et al.* (2011), Paraye *et al.* (2009), Deosarkar *et al.* (2001)** in soybean.

Economics:

Out of all the different treatment combinations, T_9 40 cm X 10 cm + $ZnSo_4$ – 0.75 %, was the most economically sound combination with highest net return (52,016.00 INR/ha), gross return (78,217.00 INR/ha) and benefit: cost ratio (1.99).

CONCLUSION

Different treatment combinations based on spacing and foliar application of Zinc were designed to anlayze their effect on growth, yield as well as economics of Sesame. Amongst all the treatments, T_9 40 cm X 10 cm + $ZnSo_4$ – 0.75 %, had the highest results for yield characteristics such has grain yield (1.20 t/ha), gross return (78,217.00 INR/ha), net return (52,016.00 INR/ha) and benefit: cost ratio (1.99). However, this research was based on experiments done for one season and could be repeated further for different seasons.

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Table 1. Effect of Spacing and Foliar application of Zinc on yield and yield attributing characters of Sesame

S. No	Treatment combinations	No. of capsules/plant	No. of seeds/capsule	Seed Yield (t/ha)	Stover Yield(t/ha)
T1	25 cm X 15 cm + $ZnSo_4$ – 0.25 %	42.60	53.60	1.04	2.44
T2	25 cm X 15 cm + $ZnSo_4$ – 0.50 %	44.40	54.53	1.06	2.47
T3	25 cm X 15 cm + $ZnSo_4$ – 0.75 %	47.67	54.93	1.09	2.49
T4	35 cm X 15 cm + $ZnSo_4$ – 0.25 %	45.60	56.43	1.11	2.50
T5	35 cm X 15 cm + $ZnSo_4$ – 0.50 %	48.07	56.83	1.12	2.52
T6	35 cm X 15 cm + $ZnSo_4$ – 0.75 %	51.47	57.30	1.17	2.54
T7	40 cm X 10 cm + $ZnSo_4$ – 0.25 %	49.53	58.60	1.14	2.51
T8	40 cm X 10 cm + $ZnSo_4$ – 0.50 %	53.87	59.37	1.19	2.56
T9	40 cm X 10 cm + $ZnSo_4$ – 0.75 %	54.60	60.50	1.20	2.57
	F test	**S**	**S**	**S**	**S**
	S.Em (±)	0.60	0.55	0.01	0.01
	CD (P<0.05)	1.77	1.64	0.03	0.04

Table 2. Effect of Spacing and Foliar application of Zinc on economics of Sesame

S.No	Treatment Combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	Benefit: Cost ratio
T1	25 cm X 15 cm + $ZnSo_4$ – 0.25 %	25,856.00	67,817.00	41,961.00	1.62
T2	25 cm X 15 cm + $ZnSo_4$ – 0.50 %	25,856.00	68,683.00	42,827.00	1.66
T3	25 cm X 15 cm + $ZnSo_4$ – 0.75 %	25,856.00	70,850.00	44,994.00	1.74
T4	35 cm X 15 cm + $ZnSo_4$ – 0.25 %	25,846.00	72,367.00	46,521.00	1.80
T5	35 cm X 15 cm + $ZnSo_4$ – 0.50 %	25,846.00	72,583.00	46,737.00	1.81
T6	35 cm X 15 cm + $ZnSo_4$ – 0.75 %	25,846.00	76,050.00	50,204.00	1.94
T7	40 cm X 10 cm + $ZnSo_4$ – 0.25 %	26,201.00	73,883.00	47,682.00	1.82
T8	40 cm X 10 cm + $ZnSo_4$ – 0.50 %	26,201.00	77,133.00	50,932.00	1.94
T9	40 cm X 10 cm + $ZnSo_4$ – 0.75 %	26,201.00	78,217.00	52,016.00	1.99

#Data not subjected to statistical analysis.