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To find out the optimum level of Sulphur for sesame crop under rainfed condition

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Abstract
Sesame (*Sesamum indicum* L.) is one of the most ancient oilseed crop of India. The crop is cultivated almost throughout India for its high quality oil and it has tremendous potential for export. It ranks third in terms of total oilseed area and fourth in terms of total oil seed production in country. Among various factor responsible for the low productivity levels of sesame, its cultivation in marginal soils having poor soil fertility without fertilizers application is the most important one. The present investigation entitled "To find out the optimum level of Sulphur for sesame crop under rainfed condition was carried out during Kharif season of 2009–10 at the Rajola Farm of the Faculty of Agricultural Sciences, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot – Satna (Madhya Pradesh), to study the effect of sulphur nutrients, applied in different combination, on growth and yield of sesame. The results of the investigation regarding the influence of nitrogen and sulphur nutrients on growth and yield of sesame.

Keywords: Sulphur level, sesame (*Sesamum indicum*), rainfed condition

Introduction

Sesame [*Sesamum indicum* (L.)] is one of the important edible oil seed cultivated in India. Its oil content generally varies from 46 to 52% and protein between 20-26%. The oil is used for edible purpose (73%), hydrogenization (8.3%) and industrial purpose (4.2%) in the manufacture of paints, pharmaceuticals and insecticides. Sesame oil is also used in soap, cosmetic and skin care. It has antiviral, antibacterial, antifungal and antioxidant properties. Hundred gram of sesame seed provide 592 calories energy. Sesame oil is really the poor man's substitute for "ghee".

Oilseed crops include a wide variety of plants raised primarily for extracting the oil. Thus, production of oilseeds in India is of great value to the country's economy, since, they not only play a vital role in the industrial sector and indirectly requirements of the people but also serve as a good source of foreign exchange. They are multipurpose commodity as oils and oilcakes serve in one form or the other man and machines, cattle and economy of India as well as the mother earth. Due to poor yield, oil seed production in the country does not meet the requirement of growing population. To bridge the gap between demand and supply, the country is forced to import edible oils and spends a lot of foreign exchange every year. The productivity of mustard can be increased by proper fertilizer management and putting more area under irrigation. Knowledge of the concentration of plant nutrients in a crop and the amount of nutrients removed by a particular crop from the soil may be a helpful guide for the formulation of a sound fertilizer management programme. Sesame cake is a rich source of proteins, carbohydrates and mineral nutrients, such as calcium, phosphorus and is rich in vitamin "E" content. It contains 6.0 – 6.2 per cent nitrogen, 2.0 – 2.2 per cent phosphorus and 1.0 – 1.2 per cent potash. It can be used as manure.

Sulphur among the secondary nutrients play an important role in the quality of mustard crop. Sulphur application not only improves the grain yield but also improves the quality of crops. This is mainly due to its associations with S-containing amino acids like cysteine, cystine and methionine. It is regarded as the nutrient which is responsible in improving the quality of crop. It is an important constituent of many enzymes and is involved in the oxidation and synthesis of fatty acids. Photosynthesis and nitrogen fixation are attributed to the type of sulphur linkage present. sulphur occurs in volatile compounds responsible for the characteristic taste and smell of plants in the mustard and onion families. Sulphur enhances oil formation in mustard and soybean crops. Sulphur deficiency has been found to occur in soils which are coarse textured and low in organic matter. Sulphur requirements of crop plants is quite high and high yielding varieties require higher amounts of sulphur as compared to low yielding varieties of the crops. About 42.3%, Indian soils are deficient in sulphur, It is well accepted that sulphur deficiency in Indian soils is wide spread and major constraint in the way of creasing crop productivity, produce quality and farm incomes (Tandon 2010) [7].

India ranks first both in area and production of sesame in the world. The annual area under the crop in India is about 1.85 million hectares (45% of the world hectarage) and total production is nearly 0.68 million tones. In M.P., total cultivated area and production of sesame are 191.9 thousand hectares and 66.2 thousand tones, respectively. Average yield in India and Madhya Pradesh is 368 and 344 kg/ha, respectively which is quite low (C.L.R.S., 2009).

Sesame (*Sesamum indicum* L.) is one of the most ancient oilseed crop of India. The crop is cultivated almost throughout India for its high quality oil and it has tremendous potential for export. It ranks third in terms of total oilseed area and fourth in terms of total oil seed production in country (Duary and Mandal, 2006) [1].

Among various factor responsible for the low productivity levels of sesame, its cultivation in marginal soils having poor soil fertility without fertilizers application is the most important one. During the course of discussion an effort has been made to establish relationship between various plant characters, yield and quality of the crop. However, on the basis of the findings, an attempt has been made in the foregoing pages to explain the possible reasons of variability obtained due to different treatments. Wherever necessary, findings of other workers have also been quoted to support the results of the present investigation.

Material and Method

The present investigation entitled to find out the optimum level of Sulphur for sesame crop under rainfed condition was conducted at Chitrakoot, Satna (M. P.) during the *Kharif* season of 2009-10. To find out the best treatment comprising of sulphur fertilizers on quality of Sesame, for this region. The details of various materials used and the methods employed in carrying out the experiment are described in detail in this chapter, under appropriate headings / sub-headings.

Soil analysis

The mechanical and chemical analysis of soil of the experimental plot was carried out before the commencement of the experiment to ascertain the initial fertility status of the soil, and the procedure adopted are presented below:

Mechanical analysis of soil

The mechanical analysis of sample soil was done with the help of Bouyoucos Hydrometer method (1952) and results so obtained are presented in Table 1.1.

Table 1.1: Mechanical composition of soil

Soil Properties	Percentage	Method employed
Sand	52%	Bouyoucos (1952)
Silt	22%	
Clay	26%	
Textural Class	Sandy Loam	

Preparation of soil samples

The soil samples were air- dried and kankar nodules were removed there from. The samples were crushed with wooden hammer and sieved through 2 mm sieve. Such powdered samples were stored in the stoppered polythene bags after proper labeling. Later on, these samples were subjected to chemical analysis.

Physico-chemical analysis of soils samples

1. Soil pH: The pH of soil was determined by using glass electrode pH meter using 1:2 soil water suspension.

2. Electrical conductivity (dSm^{-1}): The supernated liquid of the soil suspension formerly used for pH determination was used for the determination of electrical conductivity by conductivity meter.

3. Organic carbon: Organic carbon was estimated by the Walkley-Black (1934) [8] Method. In this method organic matter in the soil is oxidized with a mixture of potassium dichromate ($K_2Cr_2O_7$) and concentrated H_2SO_4 utilizing the heat of dilution of H_2SO_4. Unused $K_2Cr_2O_7$ is back titrated with ferrous ammonium sulphate.

4. Determination of available nitrogen: Available nitrogen was determined by the alkaline permanganate method (Subbiah and Asija, 1956) [6]. In this method, 5 g of soil in a digestion tube and add little water. Now add 20 ml. of 0.32% $KMnO_4$ solution to the sample and fit the tube in the distillation unit. Add 20 ml of 2.5% NaOH solution through the distyl-em-dosing pump. Pipette out 20 ml. of 2.5% of boric acid in a conical flask and clip the receiving end of the distyl-em in it. Distil ammonia gas from the tube and collect in the received acid. Now add 5 drops of mixed indicator and titrate with 0.02N H_2SO_4. Blank correction (without soil) is to be made for final calculations.

5. Determination of available phosphorus Available phosphorus in the soil was determined calorimetrically by Olsen's method (Olsen *et al.* 1954).

Extraction

2.5 g of the soil sample was shaken with 50 ml of 0.5M $NaHCO_3$ (adjusted to pH 8.5) as an extractant together with 1g of darco G-60 (Free from soluble phosphorus) for 30 minutes in 100 ml, conical flask on mechanical shaker and then filtered through filter paper.

Available sulphur in soil

Available sulphur in soil was determined by turbidimetric method after extracting the soil with 0.15% $CaCl_2$ solution.

Table 1.2: Chemical composition of soil

Ingredients	Quantity	Method
Soil pH	7.78	Digital pH Meter Mk. IV
Organic carbon (%)	0.432	Walkley and Black (1934) [8] method
EC (dSm-1)	0.26	EC Meter
Available nitrogen (kg ha-1)	202.36	Alkaline Permanganate method (Subbiah and Asija, 1956) [6]
Available phosphorus (kg ha-1)	16.12	Olsen's Colorimetric method (Olsen et al., 1954)
Available potassium (kg ha-1)	246.22	Flame photometric method (Jackson, 1958)
Available sulphur (kg ha-1)	15.88	Turbid metric method

Field preparation and experiment layout

A pre sowing irrigation was given to the experimental field and when it came in the condition, two cross ploughing followed by planking were done to maintain a good tilth of the soil. The plots were delineated by forming channels and plot bunds. Each plot was leveled to avoid water stagnation. The bunds and channels were then buttressed to impart stability to the lay out.

Recommended dose of fertilizer: The nutrient management was done as per treatments, the nitrogen and phosphorus was applied through Urea and DAP. The total amount of nitrogen, phosphorus and potash were supplied through DAP, Urea and muriate of potash as basal at the time of sowing. Sulphur also applied as per treatments through elemental sulphur at the time of sowing.

I. Crop studies

A. Pre-harvest studies

1. Plant population/m row length at initial and harvest stages
2. Plant height (cm)
3. Number of branches per plant
4. Number of branches per plant
5. Root length

B. Post harvest studies

1. Number of capsules per plant
2. Number of seeds per capsules
3. 1000 seeds weight
4. Seed yield (kg/ha)
5. Stalk yield (kg/ha)

C. Economics of the different treatments

1. Cost of cultivation (Rs/ha)
2. Gross and net monetary returns (Rs/ha)
3. Benefit: cost ratio (BCR)

Post sowing operations

The operations carried out in plots during experimentation are detailed as below:

Result and Discussion

The present investigation entitled "To find out the optimum level of Sulphur for sesame crop under rainfed condition" was carried out during Kharif season of 2009–10 at the Rajola Farm of the Faculty of Agricultural Sciences, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot – Satna (Madhya Pradesh), to study the effect of sulphur nutrients, applied in different combination, on growth and yield of Sesame. The results of the investigation regarding the influence of Sulphur nutrients on growth and yield of Sesame have been presented in tables and bar-diagrams, wherever required. The findings have been divided into the following sub-headings:

1. Plant population (No.)

The plant stand recorded at initial and harvest stages are presented in Table 2.1 the results indicated that at both stages the plant population was not affected significantly by different treatments. The plant population ranges between 13.62 to 13.94 and 13.07 to 13.50 per square meter at initial and harvest stage, respectively.

Table 1.2: Plant population (No.) at initial and harvest stage as influenced by different levels of nitrogen and sulphur.

Plant population per meter row length		
S-Level	**Initial**	**Harvest**
S_0 - (0 $kgha^{-1}$)	13.62	13.27
S_1 - (15 $kgha^{-1}$)	13.78	13.07
S_2 - (30 $kgha^{-1}$)	13.94	13.50
S_3 - (45 $kgha^{-1}$)	13.76	13.34
S.E m.±	0.14	0.15
C.D. (5%)	NS	NS

2. Plant height (cm): Plant height a measure of growth was recorded periodically at an interval of 30 days starting from 30th day after sowing up to harvest stage. The mean data on plant height in Table 02 and fig 02 indicates that it was enhanced by multi-fold with the advancement of plant growth till 60 DAS; thereafter such an increase was slow up to the harvest stage. The plant height was found to be influenced significantly due to different treatments of nitrogen and sulphur treatments measures at all growth stages.

Table 2.1: Plant height (cm) at successive growth stage as influenced by different levels of nitrogen and sulphur

	Plant height (cm)		
5. S-Level	**30 DAS**	**60 DAS**	**Harvest**
S_0 - (0 $kgha^{-1}$)	45.56	89.73	92.98
S_1 - (15 $kgha^{-1}$)	48.47	91.60	95.08
S_2 - (30 $kgha^{-1}$)	48.98	93.35	96.73
S_3 - (45 $kgha^{-1}$)	49.99	93.72	97.62
S.E m.±	0.84	0.98	1.14
C.D. (5%)	2.42	2.82	3.29
Interaction (N XS)	NS	NS	NS

Effect of sulphur on plant height

It is revealed from the Table 2 under reference that the variations in plant height due to sulphur level were found to be significant at 30, 60, DAS and harvest stages of crop growth. Mean plant height was observed in the range of 45.56 to 49.99, 89.73 to 93.72, and 95.08 to 97.62 cm under different level of sulphur at 30, 60, DAS and harvest stage respectively. It is clear from Table.2.1, that the increasing level of sulphur up to 45 kg ha^{-1} increased the plant height significantly at 30, 60 DAS and harvest stage. Maximum height was observed with application of sulphur 45 $kgha^{-1}$(S_3) which was significantly higher to 0 $kgha^{-1}$ (S_0) and statistically at par with and 15 and 30 $kgha^{-1}$ levels (S_1& S_2).

3. Number of leaves/ plant Number of leaves/ plant a measure of growth was recorded at 30 day after sowing of the sesame crop. The mean data on number of branches/ plant in Table 3.1

Effect of sulphur on number of leaves / plant

It is revealed from the Table 4.3 under reference that the variations in number of leaves / plant due to sulphur level were found to be significant at 30, DAS of crop growth. Mean number of leaves /plant was observed in the range of 11.32 to 12.43 under different level of sulphur at 30 DAS. Maximum number of leaves / plant was observed with application of sulphur 45 kgha^{-1} (S_3) which was significantly higher to 0 and 15 kgha^{-1} (S_0 &S_1) and statistically at par with 30 kgha^{-1} levels (S_2).

Table 3.1: Number of leaves/ plant as influenced by different levels of nitrogen and sulphur

S-Level	30 DAS
S_0 - (0 kgha^{-1})	11.32
S_1- (15 kgha^{-1})	12.10
S_2- (30 kgha^{-1})	12.40
S_3- (45 kgha^{-1})	12.43
S.E m.±	0.18
C.D. (5%)	0.52

4. Root length/plant Root length / plant a measure of growth was recorded at 30 day after sowing of the sesame crop. The mean data on root length / plant in Table 4.

Effect of sulphur on root length / plant It is revealed from the Table 4 under reference that the variations in root length / plant due to sulphur level were found to be significant at 30, DAS of crop growth. Mean root length /plant were observed in the range of 4.57 to 5.23 cm under different level of sulphur at 30 DAS**.** Maximum root length / plant was observed with application of sulphur 45 kgha^{-1} (S_3) which was significantly higher to 0 and 15 kgha^{-1} (S_0 &S_1) and statistically at par with 30 kgha^{-1} levels (S_2).

Table 4.1: Root length / plant (cm) as influenced by different levels of nitrogen and sulphur at 30 DAS

Root length / plant (cm) - 30 DAS	
6. S-Level	Root length
S_0 - (0 kgha^{-1})	4.57
S_1- (15 kgha^{-1})	4.74
S_2- (30 kgha^{-1})	5.02
S_3- (45 kgha^{-1})	5.23
S.E m.±	0.16
C.D. (5%)	0.46

5. Number of branches/ plant

Number of branches/ plant a measure of growth was recorded periodically at an interval of 30 days starting from 30th day after sowing up to harvest stage. The mean data on number of branches/ plant in Table 5.1 and Fig. 5 indicates that it was enhanced by multi-fold with the advancement of plant growth till harvest stage. The number of branches/ plant was found to be influenced significantly due to different treatments of sulphur treatments measures at all growth stages.

Effect of sulphur on number of branches/ plant

It is revealed from the Table 5.1 under reference that the variations in number of branches/ plant due to sulphur level were found to be significant at 30, 60, DAS and harvest stages of crop growth. Mean number of branches/plant was observed in the range of 2.26 to 2.4, 3.16 to 3.59 and 4.39 to 5.02 under different level of sulphur at 30, 60, DAS and harvest stage respectively.

Table 5.1: Number of branches/ plant at successive growth stage as influenced by different levels of nitrogen and sulphur.

	Number of Branches		
S-Level	30 DAS	60 DAS	Harvest
S_0 - (0 kgha^{-1})	2.26	3.16	4.39
S_1- (15 kgha^{-1})	2.30	3.32	4.56
S_2- (30 kgha^{-1})	2.38	3.57	5.02
S_3- (45 kgha^{-1})	2.42	3.59	4.93
S.E m.±	0.07	0.07	0.09
C.D. (5%)	NS	0.20	0.27

It is clear from Table 5.1 that the maximum number of branches/ plant was observed with application of sulphur 45 kgha^{-1} (S_3) which was significantly higher to 0 and 15 kgha^{-1} (S_0 &S_1) and statistically at par with 30 kgha^{-1}levels (S_2) at 60 DAS. At harvest stage, maximum number of branches/ plant was observed with application of sulphur 30 kgha^{-1} (S_2) which was significantly higher to 0 and 15 kgha^{-1} (S_0 &S_1) and statistically at par with 45 kgha^{-1} levels (S_3)..

Table 6: Yield attributes characters of sesame as influenced by different levels of sulphur

S-Level	Number of Capsules/plant	Number of seed / Capsule	1000 seed weight (g)
S_0 - (0 kgha^{-1})	34.27	47.80	2.607
S_1- (15 kgha^{-1})	37.51	49.18	2.850
S_2- (30 kgha^{-1})	38.99	49.57	2.914
S_3- (45 kgha^{-1})	39.29	51.28	2.996
S.E m.±	0.69	0.64	0.044
C.D. (5%)	1.99	1.86	0.126

Effect of sulphur: Number of seed /capsule was observed in the range of 47.80 to 51.28 under different levels of sulphur. Maximum seed in capsules (51.28) was recorded with 45 kg S ha^{-1}(S_3) which was significantly superior over 0 and 15 kgha^{-1} but statistically at war with 30 kgha^{-1} respectively.

c) 1000 seed weight (Test Weight): The data given in Table –4.6 revealed that the application of N and S levels indicated significant effect on test weight of sesame.

Effect of sulphur

Test weight of sesame was observed in the range of 2.607 to 2.996 g under different levels of sulphur. Application of 45 kg S produced the maximum test weight to the extent of 2.996 g. which was significantly superior over 0 and 15 $kgha^{-1}$ but statistically at war with 30 $kgha^{-1}$ levels respectively. It is apparent from results that the application of 45 kg S produced14.92 and 5.12 percent higher test weight over 0 and 15 kg S ha^{-1} levels, respectively.

Table 7.0 yield of sesame: Seed and straw yield of sesame were recorded at harvest and presented in Table 7. It is seen from results that the seed and straw yield were significantly influenced by both sulphur levels.

a) Seed yield (kg ha^{-1}): Data pertaining to seed yield which given indicate that seed yield was significantly affected due to application of nitrogen and sulphur levels.

Table 7: Yield of Sesame

S-Level	Seed Yield ($kgha^{-1}$)	Straw Yield ($kgha^{-1}$)
S_0 - (0 $kgha^{-1}$)	515.15	2111.51
S_1- (15 $kgha^{-1}$)	578.14	2128.48
S_2- (30 $kgha^{-1}$)	610.31	2251.41
S_3- (45 $kgha^{-1}$)	629.36	2339.62
S.E m.±	10.18	57.48
C.D. (5%)	29.33	165.56
Interaction (N XS)	NS	NS

Effect of sulphur: Seed yield of sesame was observed in the range of 515.15 to 629.36 $kgha^{-1}$ with different levels of sulphur. Maximum seed yield (626.36 $kgha^{-1}$) was recorded with 45 kg S ha^{-1} which was significantly superior over 0 and15 $kg Sha^{-1}$ but statistically at par with 30 $kgSha^{-1}$ levels. It is apparent from the result of that the application of 45 kg S ha^{-1} recorded 22.17, and 8.86 per cent higher seed yield over to 0, and15 kg Sha^{-1} applied treatments respectively.

b) Straw yield

The results pertaining to the straw yield of sesame as influenced by the application sulphur levels.

Effect of sulphur

Straw yield of sesame was observed in the range of 2111.51 to 2339.62 $kgha^{-1}$ with different levels of sulphur. Maximum straw yield (2339.62 $kgha^{-1}$) was recorded with 45 kg S ha^{-1} which was significantly superior over 0 and15 $kgSha^{-1}$ but statistically at par with 30 $kgSha^{-1}$ levels.

Seed and stover yield

The seed yield is a cumulative effect of different growth and yield attributing characters. Significant increase in seed yield was recorded with incremental N and s levels. The linear increase in seed yield could be observed with the increasing levels of N and S. The maximum seed yield was recorded to be 670.58 $kgha^{-1}$ with 60 kg N ha^{-1} which was 40.11, 21.09 and 6.43 per cent higher seed yield over 0, 30 and 45 kg N ha^{-1} levels, respectively. Under different levels of sulphur seed yield of sesame was observed in the range of 515.15 to 629.36 $kgha^{-1}$. Maximum seed yield (626.36 $kgha^{-1}$) was recorded with 45 kg S ha^{-1} which was recorded 22.17, and 8.86 per cent higher seed yield over to 0, and15 kg Sha^{-1} applied treatments respectively.

The probable reason may be that the increasing N and S levels resulted in greater accumulation of carbohydrates, protein and their translocation to the productive organs, which in turn, improved all growth and yield attributing characters, resulting more seed yield. Besides this, the addition of Sulphur+ provided adequate balanced quantity of sulphur to the plant. The findings confirm the results of Sarala and Jagannatham (2002), Duary and Mandal (2006) [1] and sarkar *et al.* (2010) Tomar *et al.* (1996), Shukla and Kumar (1997), also reported similar results in mustard crop. The economic feasibility in terms of highest gross return, net monetary return as well as benefit cost ratio were obtained with the combined application of N and S @ 60 and 30 kg /ha. These results according to yield of crop obtained under treatments. Confirm to the findings of Duary and Mandal (2006) [1].

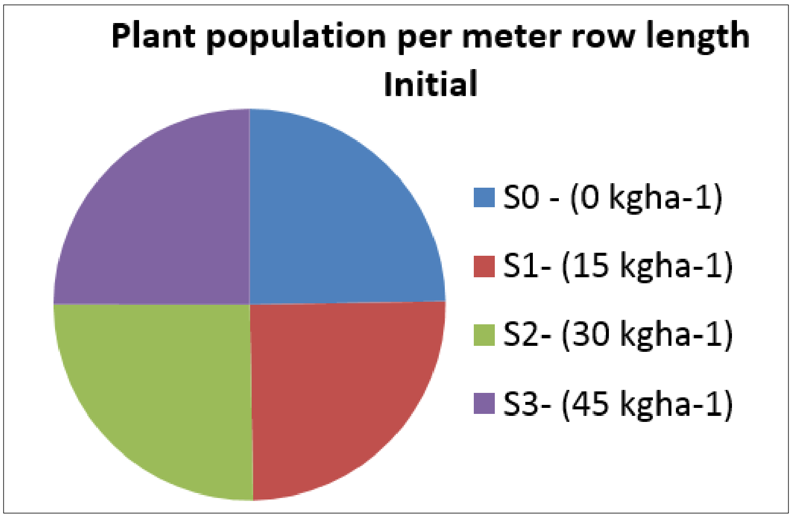

Fig 1: Plant population (No.) at initial and harvest stage as influenced by different levels of nitrogen and sulphur.

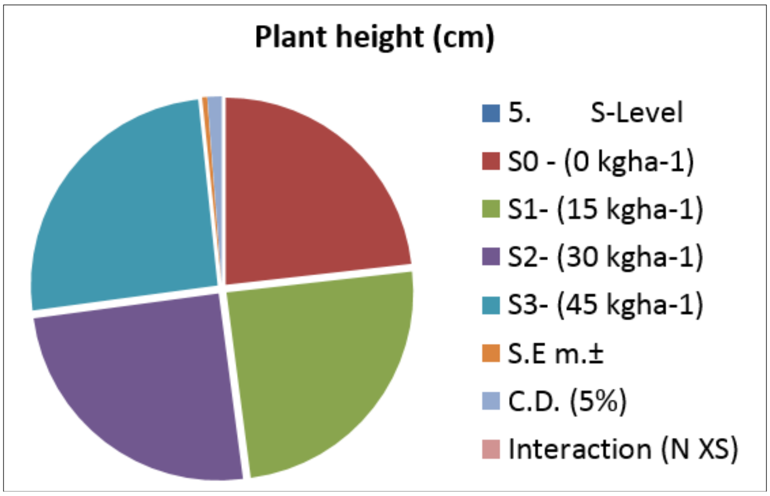

Fig 2: Plant height (cm) at successive growth stage as influenced by different levels of nitrogen and sulphur

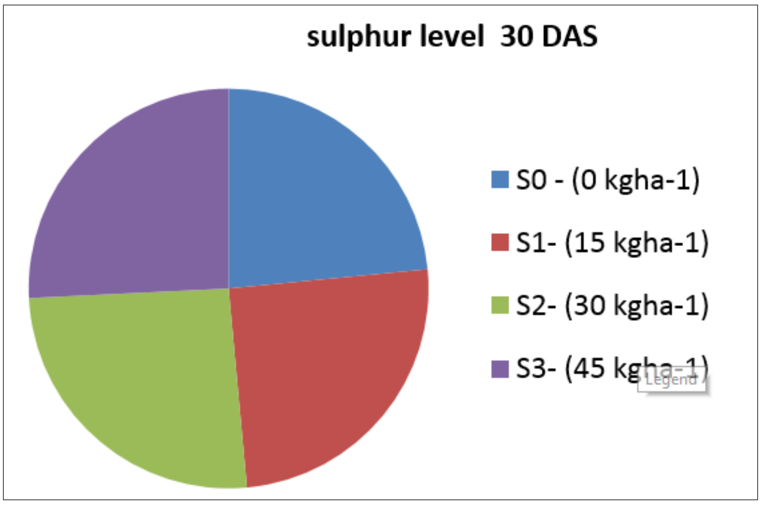

Fig 3: Number of leaves/ plant as influenced by different levels of nitrogen and sulphur

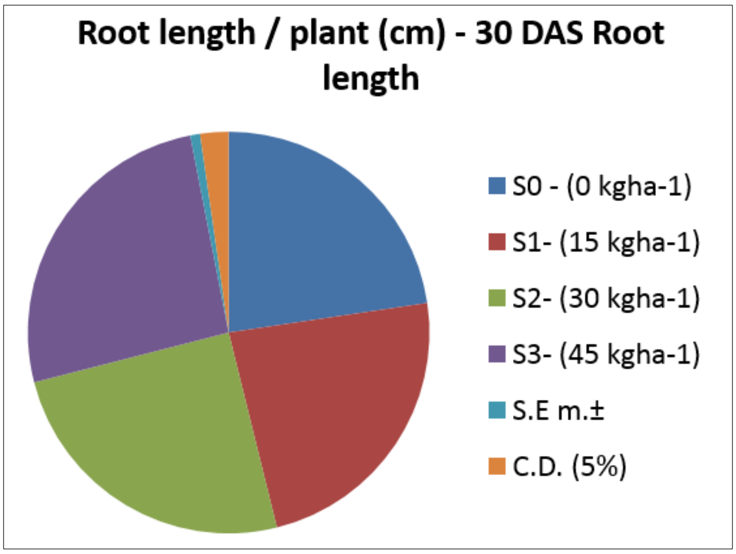

Fig 4: Root length / plant (cm) as influenced by different levels of nitrogen and sulphur at 30 DAS

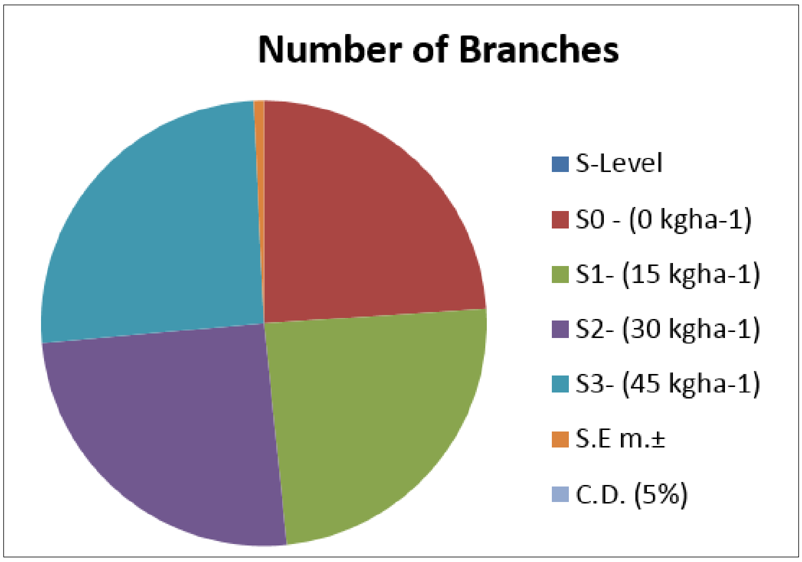

Fig 5: Number of branches/ plant at successive growth stage as influenced by different levels of nitrogen and sulphur

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