CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH

Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2| Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13667103

Effect of sulphur and bio-fertilizers on growth parameters of fenugreek (*Trigonella foenum-graecum* L.) in South-East Rajasthan

Prashant Parashar[1], Narendra Kumar Bhinda[2], P. C. Choudhary[3], Deepak Nagar[4], Rohitashv Nagar[5]

School of Agricultural Sciences, Career Point University, Kota

[1]M.Sc. Agronomy Student, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: psharma76853@gmail.com

[2,3,4,5] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: narendra.bhinda@cpur.edu.in

Abstract:

A field experiment was conducted at the Instructional Farm (Agronomy), Career Point University, Alaniya, Kota during 2023-2024. The experiment was conducted in Factorial RBD. The treatment consisted of four levels of sulphur viz., 0, 15, 30 and 45 kg ha-1 and four combinations of biofertilizers viz., control, Rhizobium, PSB and Rhizobium + PSB thereby making 16 treatment combinations replicated thrice. The results revealed that application of 45 kg sulphur ha-1 registered significantly higher growth characters i.e., plant height, dry matter at successive growth stages, number of primary and secondary branches The fenugreek raised with 45 kg sulphur ha-1 significantly improved yield attributes i.e., Pods plant-1, pod length, seeds pod-1 and test weight thereby enhanced seed, haulm and biological yield by over application of 15 and 30 kg sulphur ha-1. The crop accumulated highest quantum of total uptake of N, P, K and S over application of 15 and 30 kg sulphur ha-1, respectively. The crop under the influence of 45 kg sulphur ha-1 fetched highest net return of and B-C ratio of over rest of sulphur levels However, Rhizobium + PSB rcorded maximum plant height, dry matter, primary and secondary branches plant-1. Inoculation of Rhizobium + PSB of fenugreek seeds proved significantly higher pods plant-1, pod length, seeds pod-1 and test weight with concomitant increase in seed and haulm yield over control. The fenugreek seed inoculated with Rhizobium + PSB increased total uptake of N, P, K and S over control. The maximum net return and the higher B-C ratio was also recorded when seeds were inoculated with Rhizobium + PSB.

Keywords: Fenugreek, Rhizobium, Sulphur, nutrients

I Introduction:

Fenugreek (Trigonella foenum-graecum L.), a widely cultivated leguminous crop, holds significant agronomic and medicinal value in India, particularly in Rajasthan. This region, known for its diverse climatic conditions, presents unique challenges and opportunities for crop cultivation. Among the various factors influencing the growth and productivity of fenugreek, soil fertility plays a crucial role. In recent years, there has been a growing interest in sustainable agricultural practices that not only enhance crop yield but also maintain soil health. This has led to an increased focus on the use of bio-fertilizers and micronutrients like sulphur, which are essential for plant growth. Sulphur, a secondary macronutrient, is vital for the synthesis of amino acids, proteins, and enzymes in plants. It plays a pivotal role in nitrogen metabolism, chlorophyll formation, and overall plant development. Despite its importance, sulphur is often overlooked in traditional fertilization practices, leading to deficiencies that can severely impact crop yield and quality. In fenugreek, sulphur deficiency can manifest as reduced growth, delayed maturity, and lower seed production. Given the sandy and loamy soils of South-East Rajasthan, which are often low in organic matter and prone to nutrient leaching, the application of sulphur could be particularly beneficial.

Bio-fertilizers, on the other hand, are living organisms that enhance nutrient availability in the soil. They include various strains of bacteria, fungi, and algae that form symbiotic relationships with plant roots, facilitating the uptake of nutrients like nitrogen, phosphorus, and potassium. The use of bio-fertilizers not only improves soil fertility but also contributes to sustainable agriculture by reducing the dependency on chemical fertilizers. In fenugreek cultivation, bio-fertilizers such as Rhizobium, Azotobacter, and phosphorus-solubilizing bacteria (PSB) have shown promising results in enhancing growth parameters and yield. The synergistic effect of sulphur and bio-fertilizers on the growth and development of fenugreek has been a subject of research in various agro-ecological zones. However, limited studies have been conducted in the specific context of South-East Rajasthan, where the agro-climatic conditions and soil characteristics differ from other regions. This study aims to fill this gap by investigating the combined effect of sulphur and bio-fertilizers on the growth parameters of fenugreek in this region.

The research will focus on key growth parameters such as plant height, number of branches per plant, leaf area, biomass production, and root nodulation. These parameters are critical indicators of plant health and productivity, and their response to different fertilization regimes can provide valuable insights into the optimal nutrient management practices for fenugreek. By conducting field experiments and analyzing the data, this study will contribute to the development of more efficient and sustainable fertilization strategies that can enhance fenugreek cultivation in South-East Rajasthan. In addition to improving crop yield, the findings of this study have broader implications for sustainable agriculture in the region. As the demand for organic and sustainably produced crops continues to grow, the use of bio-fertilizers and micronutrients like sulphur offers a viable alternative to conventional chemical fertilizers. By promoting soil health and reducing environmental impacts, these practices align with the principles of sustainable farming and contribute to the long-term resilience of agricultural systems.

II Literature Review:

Fenugreek (*Trigonella foenum-graecum* L.) popularly known by its vernacular name "methi" has been in culinary and medicinal uses due to its restorative and nutraceutical properties for more than 2500 years. The seed contain an alkaloid trigonellin (0.12-0.38%) is thought to reduce glycosuria in diabetes. Fenugreek seed helps not only in reducing blood sugar levels due to its high phytochemicals concentration, but it also reduce low density cholesterols and triacylglycerols. Seeds are used in treatments of slatulene, dysentery, diarrhea, tisdyspepsia, chronic cough, dropsy, enlargement of liver spleen, rickets, gout diabetes and arthri. The important steroid "Diosgenin" is used in synthesis of sex hormone and makes ovule contraceptive. The sapogenin, is an estrogen precursor and helps in managing menopause. The concentration of diosgenin varies from 0.86 to 2.2% in seed (Bochalia et al., 2011). Fenugreek leaves and seed have been used extensively to prepare extracts and powder for medicinal uses. Fenugreek is reported to have anti- diabetic, anti-fertility, anticancer, anti-microbial, anti-parasitic and hypocholesterolaemic effects (Al-Habori and Raman, 2002).

In the recent years, continuous and imbalance application of chemical fertilizers with little or no use of organic manure is leading to poor nutrient use efficiency, low yield of crop and poor physical and biological property of soil. At the same time increasing cost of production due to more and more use of costly nutrient sources is becoming unaffordable to the most of farmers. Hence, it has become imperative to search for other complementary and alternative sources of nutrients, among which use of bio-fertilizers of biological origin for integrated nutrient management in fenugreek is an important avenue. In this approach, microbial fertilization with Rhizobium as well as PSB and KSB has been found promising to improve soil health and crop production. Bio-fertilizer such as Rhizobium, PSB and KSB play an important role in increasing the availability of nitrogen, phosphorus and potassium.

Inoculation with Rhizobium will not only improve nitrogen availability in soil by biological nitrogen fixation but also ensure prolonged and adequate supply of this vital nutrient with minimum loss in light texture soil. Therefore, the introduction of efficient strain of rhizobium may be helpful in boosting greater nitrogen fixation and crop production. Inoculation of seeds with Rhizobium culture is low cost input in legume and has been found beneficial by many workers (Subba Rao, 1976). Similarly, inoculation with Phosphate solubilizing bacteria (PSB) converts the unavailable form of phosphorus into soluble or available form to the plant. Microbial fertilization along with Rhizobium and PSB has been found promising to improve soil health and crop production (Meena et al., 2014). Rhizobium + PSB help to maintain soil fertility and eliminate the pollution hazards to increase the productivity. A large number of soil micro-organisms have capacity to solubilize mineral phosphate. The PSB help in improving phosphate uptake in plants. Potassium is an essential nutrient required by crops. Most of the K in soil exists in the form of silicate minerals (microcline, muscovite, biotite etc.). The KSB are commonly known as potassium dissolving bacteria or silicate dissolving bacteria. NPK consortia is a mixture of Rhizobium + PSB +

Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2| Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13667103

KSB, Inoculation with NPK Consortia provide nutrients such as N, P and K through their activities in the soils or rhizosphere and makes them readily available to the plants.

III Methodology

Materials and Methods

Kota district is located at 25.18° N to 75.83° E Latitude in South Eastern Rajasthan. It covers an area of 221.36 km2. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. The average rainfall in the region is 660.6. mm. Maximum temperature range in the summer is 40 to 48°C and minimum 1.0- 2.6°C during winter. Main Rainy season crops of the district are maize, soybean and pulses. While in winter, wheat, mustard, coriander and garlic are main crops.

Experimental Details

The experiment was carried out with the following standard procedure regarding treatments, replications and experimental design etc. were used to achieve the objectives. The experiment was conducted in Factorial RBD. The treatment consisted of four levels of sulphur viz., 0, 15, 30 and 45 kg ha-1 and four combinations of biofertilizers viz., control, Rhizobium, PSB and Rhizobium + PSB thereby making 16 treatment combinations replicated thrice.

Measurement of the growth parameters

The number of plants metre-1 row length were counted after complete germination at 20 DAS and harvest from five randomly selected locations in each experimental plot. These were averaged to work out number of plants m-1 length. At 30, 60, 90 DAS and at harvest, the height of five randomly selected plants from each plot was measured from cotyledonary node to the apex of the shoot. The mean plant height for each treatment was computed and expressed in cm. The plant sample for Dry matter accumulation were taken at 30, 60, 90 DAS and at harvest. For this purpose, the plant from 50 cm row length were cut close to the ground level and put in the paper bags. The samples were sun dried and thereafter kept in electric oven at 720C ± 0.50C for 72 hours or till the constant weigh were achieved. The dry matter was expressed in gram m-1 row length. Total number of primary and secondary branches were counted from five randomly selected plants from each experimental unit. These were averaged to workout number of primary and secondary branches plant-1. The growth efficiency parameters mainly CGR and RGR were estimated between 30-60 DAS, 60-90 DAS and 90 DAS to harvest by the following formula as given by Radford (1967).

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{1}{P} \times \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W1 and W2 are dry weight plant-1 at time t1 and t2, respectively. P represents the ground area.

$$\text{RGR (g g}^{-1}\text{ day}^{-1}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W1 and W2 are dry weight plant-1 at time t1 and t2, respectively.

CAREER POINT
INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2| Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13667103

IV Results and Discussion

A perusal of data (Table 1) reveals that application of sulphur levels and bio-fertilizers to fenugreek crop did not significantly influence number of plants m-1 row length recorded after full germination (15 DAS) and at harvest.

Plant height

Sulphur: An examination of data (Table 2) shows that increasing levels of sulphur application significantly influenced plant height recorded at harvest. The maximum plant height at harvest was recorded with the application of 45 kg sulphur ha-1.

Bio-fertilizers: The plant height at harvest was significantly influenced due to inoculation of fenugreek seed with bio-fertilizers over control. The crop attained highest plant height at harvest when seeds were inoculated with Rhizobium + PSB however both these treatments significantly enhanced plant height at harvest.

Dry matter accumulation

Sulphur: It is explicit from data (Table 3) that increasing levels of sulphur application significantly influenced DMA plant-1 at harvest. The highest DMA plant-1 at harvest was estimated with the application of sulphur 45 kg ha-1.

Bio-fertilizers: Data show that inoculation of fenugreek seed with bio-fertilizers alone or in combination brought about significant influence on DMA plant-1 at harvest over control. The maximum DMA plant-1 at harvest was estimated when seeds were inoculated with Rhizobium + PSB.

Branches plant-1 at harvest Primary branches

Sulphur: It is explicit from data (Table 4) that increasing levels of sulphur application significantly influenced number of primary branches plant-1 at harvest. The highest number of primary branches plant-1 at harvest were estimated with the application of 45 kg sulphur ha-1.

Bio-fertilizers: Inoculation of fenugreek seed with bio-fertilizers alone or in combination significantly increased number of primary branches plant-1 at harvest over control. Amongst bio-fertilizers, inoculation with Rhizobium + PSB recorded highest number of primary branches plant-1 at harvest significantly.

Secondary branches

Sulphur: It is apparent from data (Table 4) that increasing levels of sulphur significantly increased number of secondary branches plant-1 at harvest. The highest number of secondary branches plant-1 were recorded with the application of 45 kg sulphur ha-1.

Bio-fertilizers: It is explicit from data that inoculation of fenugreek seed with bio-fertilizers alone or in combination brought about significant variation on number of secondary branches plant-1 at harvest over control. Amongst bio-fertilizers, inoculation of seed with Rhizobium + PSB produced highest number of secondary branches plant-1 at harvest significantly.

Growth efficiency

Crop growth rate

Sulphur: Data presented in Table 5 indicate that application of sulphur at varying levels brought about significant effect on CGR estimated between 90 DAS- at harvest. The application of 45 kg sulphur ha-1 registered highest CGR between 90 DAS- at harvest.

Bio-fertilizers: Inoculation of fenugreek seed with bio-fertilizer alone or in combination significantly improved CGR between 90 DAS -at harvest over control. Amongst bio-fertilizers, inoculation of seed with Rhizobium + PSB recorded highest CGR between 90 DAS- at harvest which remained at par with co-inoculation of PSB however both these treatments significantly increased CGR between 90 DAS –at harvest over control.

Relative growth rate

Sulphur: An examination of data (Table 5) reveals that application of sulphur at varying levels failed to bring about significant variation on RGR estimated between 90 DAS– at harvest of fenugreek.

Bio-fertilizers: Data reflects that inoculation of fenugreek seed with bio-fertilizers alone or in combination failed to exert perceptible variation on RGR estimated between 90 DAS-at harvest.

Discussion

It is evident from the results that application of sulphur up to 45 kg ha-1 significantly improved morphological component of growth i.e. plant height, primary and secondary branches plant-1. These increases ultimately reflected in overall improvement of crop growth estimated in terms of biomass accumulation plant-1 at various growth stages. In general, the overall improvement in growth of fenugreek with the addition of sulphur could be ascribed to its pivotal role in several physiological and biochemical processes which are of vital importance for development of the plants. It is well established that sulphur in the form of sulphate (SO4-2 – S) is involved in synthesis of sulphur containing amino acids (methionine and cystine), various enzymatic processes and variety of oxidation - reduction reactions in the plants (Nelson and Tisdale, 2013). Besides these, the recent advancement in hormonal regulation of plant growth and development has clearly demonstrated that alike environmental factors, plant nutrients are not only substrate and catalyst of plant growth but can be considered as stimulii for certain steps for the development to which plant responds through oriented growth (Michael and Beringer, 1980). It has been reported that micro-acidification of calcareous soils under the influence of sulphur fertilization results in greater availability of phosphorus and micronutrients especially Fe, Zn and Mn (Nelson and Tisdale, 2013). Further they opined that sulphur fertilizers are transformed to sulphuric acid by soil microorganisms which in turn reduces soil pH and improves soil structure alongwith availability of macro and micro nutrients. On the other hand, as a consequence of lower hydration of SO4-2 sulphur ions, the plant cell colloids get swollen which reduce turgor pressure, thereby, increases transportation and led to higher extraction of nutrients from soil environment towards plant system (Rawal, 2020). Thus, the concomitant influence of sulphur fertilization on availability of nutrients from soil and their extraction by the plants seems to have provided congenial nutritional environment in the plants. This is also evince from the estimates of nutrient concentration and their uptake which showed significant increase in concentration of nutrients (N and S) and their accumulation (N, P, K and S) at harvest. These

CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH
Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2| Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13667103

improvements under sulphur fertilization might have increased metabolic processes in plants resulting in greater meristamatic activities and apical growth, thereby, improvement in plant height. Thus greater availability of nutrients during vegetative phase might have enhanced meristamatic activities thereby increased division, enlargement and elongation of cells thus improving production of branches plant-1. Likewise significant improvement in branches production could be attributed to enhanced growth of lateral buds due to higher availability of nutrients and assimilates. Besides this, improvement in nodulation under the influence of sulphur subscribe to the view that it increased the activity of enzyme ferredoxin which might have resulted in higher biological nitrogen fixation and photosynthesis. Further, significant improvement in nodulation, plant height and number of branches plant-1 might have resulted in better interception, absorption and utilization of radiant energy leading to higher photosynthetic rate and finally more accumulation of dry matter plant-1. The overall improvement in growth of fenugreek with the application of sulphur under the present study in cognizance with the results obtained by (Godara et al., 2013; Choudhary et al., 2014; Boori et al., 2017; Verma et al., 2019).

Table 1 Effect of sulphur and bio-fertilizers on plant population of fenugreek.

Treatments	**Plant population (m^{-1} row length)**	
	15 DAS	**At harvest**
Sulphur (kg ha^{-1})		
Control	12.17	10.58
15	12.35	10.73
30	12.59	10.85
45	12.73	10.94
S.Em.±	0.17	0.16
C.D.(P=0.05)	NS	NS
Bio-fertilizers		
Control	12.08	10.49
Rhizobium	12.43	10.81
PSB	12.63	10.87
Rhizobium + PSB	12.69	10.92
S.Em.±	0.17	0.16
C.D.(P=0.05)	NS	NS

Table 2 Effect of sulphur and bio-fertilizers on plant height at successive growth stages of fenugreek.

Treatments		**Dry matter accumulation (g $plant^{-1}$)**	

Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2| Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13667103

	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Sulphur (kg ha^{-1})				
Control	0.422	4.26	11.92	17.77
15	0.448	4.56	13.23	19.83
30	0.474	4.90	14.27	21.83
45	0.489	5.22	15.47	23.58
S.Em.±	0.003	0.05	0.25	0.23
C.D.(P=0.05)	0.010	0.21	0.71	0.66
Bio-fertilizers				
Control	0.437	4.38	11.90	17.87
Rhizobium	0.455	4.69	13.51	20.35
PSB	0.467	4.92	14.60	22.12
Rhizobium + PSB	0.470	4.98	14.87	22.67
S.Em.±	0.003	0.07	0.25	0.23
C.D.(P=0.05)	0.010	0.21	0.71	0.66

Table 4 Effect of sulphur and bio-fertilizers on growth characters of fenugreek.

Treatments	**Branches plant^{-1} at harvest**	
	Primary	**Secondary**
Sulphur (kg ha^{-1})		
Control	6.59	8.15
15	7.40	8.84
30	7.97	9.41
45	8.52	9.97
S. Em. ±	**0.14**	**0.18**
C.D.(P=0.05)	**0.41**	**0.52**
Bio-fertilizers		
Control	6.72	8.24
Rhizobium	7.42	8.92

Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2| Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13667103

PSB	8.01	9.48
Rhizobium + PSB	8.09	9.61
S.Em.±	**0.14**	**0.18**
C.D.(P=0.05)	**0.41**	**0.52**

Table 5 Effect of sulphur and bio-fertilizers on growth efficiency at successive crop duration of fenugreek

Treatments		**CGR (g m^{-2} day^{-1})**		**RGR (g g^{-1} day^{-1})**		
	Between 30 - 60DAS	**Between 60 – 90DAS**	**Between 90 DAS at harvest**	**Between 30 - 60DAS**	**Between 60 – 90DAS**	**Between 90 DAS at harvest**
Sulphur kg ha^{-1}						
Control	4.24	8.57	6.58	0.619	0.576	0.553
15	4.54	9.69	7.43	0.619	0.576	0.554
30	4.89	10.77	7.47	0.620	0.576	0.554
45	5.24	11.44	9.10	0.621	0.577	0.554
S.Em.±	**0.08**	**0.29**	**0.16**	**0.0006**	**0.0009**	**0.0007**
C.D.(P=0.05)	**0.24**	**0.84**	**0.46**	**NS**	**NS**	**NS**
Bio-fertilizers						
Control	4.32	8.53	6.22	0.619	0.575	0.553
Rhizobium	4.68	9.94	7.69	0.620	0.576	0.554
PSB	4.93	10.89	8.44	0.620	0.577	0.554
Rhizobium + PSB	4.99	11.12	8.23	0.621	0.577	0.554
S.Em.±	**0.08**	**0.29**	**0.16**	**0.0006**	**0.0009**	**0.0007**
C.D.(P=0.05)	**0.24**	**0.84**	**0.46**	**NS**	**NS**	**NS**

V Conclusion:

The field experiment conducted at Career Point University, Kota, demonstrated the significant impact of sulphur application and bio-fertilizer inoculation on the growth, yield, and nutrient uptake of fenugreek. The application of 45 kg sulphur ha-1 resulted in the highest growth parameters, including plant height, dry matter accumulation, and the number of primary and secondary branches. This sulphur level also enhanced yield attributes, such as the number of pods per plant, pod length, seeds per pod, and test weight, leading to increased seed, haulm, and biological yields compared to lower sulphur levels. Inoculation with the combination of Rhizobium and PSB (Phosphate Solubilizing Bacteria) significantly improved plant growth metrics, yield attributes, and nutrient uptake over the control. The combined inoculation also resulted in the highest net returns and benefit-cost ratio, highlighting the economic viability of this practice for fenugreek cultivation. The study underscores the importance of balanced sulphur fertilization and the synergistic effect of bio-fertilizers in enhancing fenugreek growth and productivity. These findings can inform integrated nutrient management strategies aimed at improving crop performance and sustainability in agricultural practices.

Reference

1. Al-Habori, M. and Raman, A. 2002. Pharmacological properties in Fenugreek: The genus Trigonella (1^{st} Edition) by G.A. Petropoulos (Ed.), Taylor and Francis, London and New York **10**: 163-182.

2. Bochalia, G.S., Tiwari, R.C., Ram, B., Kantwa, S.R. and Choudhari, A.C. 2011. Response of fenugreek (*Trigonella foenum-graecum* L.) genotypes to planting geometry, agro-chemicals and sulphur levels. *Indian Journal of Agronomy* **56**(3): 273-279.

3. Boori, P. K., Shivran, A. C., Giana, G. K., Jat, M. L., Yadav, G. and Meena, S. 2017. Growth and production potential of fenugreek as influenced by intercropping systems and sulphur levels. *Journal of Pharmacognosy and Phytochemistry* **6**(4): 1945-1949.

4. Choudhary, P., Jhajharia, A. and Kumar, R. 2014. Influence of sulphur and zinc fertilization on yield, yield components and quality traits of soybean (*Glycine max* L.). *The Bioscan* **9**(1):137-142.

5. Godara A.S., Kapade, S., Lal. G. and Singh, R. 2013. Effect of phosphorus and sulphur levels on the performance of nagauri methi (*Trigonella-corniculata* L.) under semi arid areas of Rajasthan. *International Journal of Seed Spices* **3**(2): 70-73.

6. Meena, V.S., Maurya, B. and Verma, J.P. 2014. Does a rhizospheric microorganism enhance K^+ availability in agricultural soils. *Micro Biological Research* **169**: 337–

347.

7. Nelson, W.L. and Tisdale, S.L. 2013. Soil fertility and fertilizers, 8th edition. ISBN 978-93-3257034-4.

8. Rawal, M. 2020. Effect of potassium and sulphur on performance of green gram (*Vigna radiata*). *Annals of Plant and Soil Research* **12**(1):224-228.

9. Redford, L. A. 1667. Growth analysis formulae- Their use and abuse. Crop Science 7: 171-175.

10. Subba Rao, N.S. 1976. Field response of legumes India to inoculation and fertilizer application. In *symbiotic nitrogen fixation in plants* (Ed.). P.S. Numan, *International Biological programme,* WI. Cambridge University Press,London: 255-268.

11. Verma, V. K., Yadav, J., Kumar, S., Pyare, R. and Verma, M. 2019. Superimposition effect of sulphur, boron, FYM and Rhizobium on productivity of chickpea (*Cicer arietirum* L.). *Journal of Pharmacognosy and Phytochemistry* **8**(3): 2193-2195.