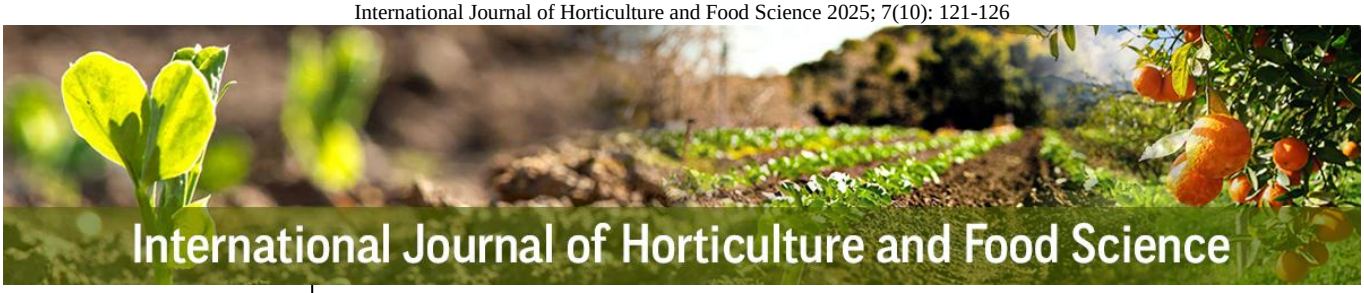

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Chelsi
M.Sc. Scholar, Department of Horticulture, School of Agriculture Sciences, Jaipur National University, Jaipur, Rajasthan, India

Deepika Sharma
Assistant Professor, Department of Horticulture, School of Agriculture Sciences, Jaipur National University, Jaipur, Rajasthan, India

RK Bansal
Professor and Director, Department of Plant Pathology, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan, India

EVD Sastry
Professor & HOD, Department of Plant Breeding & Genetics, School of Agricultural sciences, Jaipur National University, Jaipur, Rajasthan, India

Mukesh Parjapat
Assistant professor, Department of Soil Sciencs & Agricultural Chemistry, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan, India

Corresponding Author:
Chelsi
M.Sc. Scholar, Department of Horticulture, School of Agriculture Sciences, Jaipur National University, Jaipur, Rajasthan, India

Effect of sulphur levels on growth, yield and quality of different varieties of Garlic (*Allium sativum* L.)

Chelsi, Deepika Sharma, RK Bansal, EVD Sastry and Mukesh Parjapat

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Abstract
The present investigation entitled "Effect of sulphur levels on growth, yield and quality of different varieties of garlic *(Allium sativum L.)*" was carried out at the Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur. The experiment aimed to study the influence of different sulphur levels and varietal responses on growth, yield, and quality parameters of garlic. The treatments consisted of four sulphur levels (0, 20, 30, and 40 kg S/ha) and four varieties (Riyawan, Ooty, Mahadev, and G-2) arranged in a factorial randomized block design. The results revealed that the application of sulphur significantly enhanced plant growth traits such as leaf length and number of leaves, along with yield attributes including bulb diameter, number of cloves, bulb weight, and total yield. The maximum values for these parameters were recorded with 40 kg S/ha, followed by 30 kg S/ha. Among the varieties, G-2 performed best in terms of yield and quality parameters such as total soluble solids, dry matter content, and sulphur concentration in bulbs. Economic analysis also showed that the highest net return and benefit-cost ratio were obtained with 40 kg S/ha in variety G-2. Thus, it can be concluded that the application of sulphur at 40 kg/ha is optimum for maximizing growth, yield, and quality of garlic under Jaipur agro-climatic conditions.

Keywords: Garlic, sulphur levels, varieties, growth, yield, quality, economics.

1. Introduction
Sulphur is a crucial secondary macronutrient required for normal plant growth and metabolism (Zenda *et al*., 2021) [20]. It is an integral component of amino acids such as cysteine and methionine, vitamins like thiamine and biotin, and many enzymes that regulate physiological and biochemical processes in plants. Adequate sulphur nutrition enhances chlorophyll synthesis, photosynthetic activity, and carbohydrate metabolism, which ultimately influence vegetative growth and bulb development (Shah *et al*., 2022) [12]. Sulphur deficiency in soil leads to stunted growth, chlorosis of young leaves, poor clove formation, and a significant reduction in yield and quality parameters of garlic bulbs.

Garlic, being a sulphur-loving crop, requires an adequate and balanced supply of sulphur throughout its growth period (Singh, 2018) [14]. The presence of sulphur is responsible for the synthesis of volatile flavour compounds that determine the quality, pungency, and medicinal value of the bulbs. However, due to the continuous use of high-analysis fertilizers like urea and diammonium phosphate (DAP), which contain little or no sulphur, soil sulphur reserves have been gradually depleted in many regions of India. Studies conducted across the country have revealed that about 40–45% of cultivated soils are deficient in available sulphur (Shukla *et al*., 2021) [13]. This widespread deficiency poses a major constraint for sulphur-demanding crops such as garlic, onion, and oilseeds. Hence, the balanced application of sulphur fertilizers has become essential for sustaining productivity and improving bulb quality in garlic cultivation.

The response of garlic to sulphur application largely depends on genetic factors, soil type, and environmental conditions. Different varieties of garlic exhibit variable efficiency in nutrient absorption and utilization, leading to differences in growth, yield, and quality attributes (Wang *et al*., 2022) [16]. Therefore, evaluating the interaction between sulphur levels and varieties is necessary to identify suitable combinations that can perform well under specific agro-climatic conditions. Research findings from various regions have shown that appropriate sulphur fertilization improves plant growth, bulb diameter, total soluble solids, and dry matter content in garlic.

It also enhances the accumulation of organosulfur compounds responsible for the crop's flavour and therapeutic properties. Conversely, excessive application of sulphur may cause nutrient imbalance and unnecessary expenditure without significant yield gain (Dawar *et al*., 2023) [3]. Thus, determining the optimum level of sulphur that ensures economic and physiological efficiency is critical for maximizing garlic productivity and profitability.

2. Materials and Methods

This experiment was conducted during the *rabi* season of 2024-25 at the School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan which is located at 26084' 79" N latitude, 750 85' 99" E longitude and 431 m altitude above the mean sea level. This area is situated on the Jaipur-Agra Bypass Road, near new RTO office about 17 km away from Jaipur city. Organic carbon (0.87%), accessible nitrogen (225 kg/ha), phosphorus (41.8 kg/ha), and potassium (261.2 kg/ha) are the most abundant elements. The region has a semi-arid subtropical climate. Manual weeding or hoeing is typically done 2–3 times during the season. Pre-emergence herbicides like pendimethalin (1.0 kg a.i./ha) can be applied to suppress early weed growth. The crop typically needs 10–12 irrigations depending on soil and climatic conditions. The first irrigation is given immediately after sowing, followed by irrigations at 10–15-day intervals. The growth yield and quality characteristics observations were recorded using conventional technique and displayed at maturity. All of the parameters were recorded and statistically analysed using appropriate analysis of variance techniques.

3. Results and Discussion

3.1 Effect of Sulphur Levels

3.1.1 Growth Parameters

Sulphur levels significantly influenced the growth parameters of garlic as presented in Table 1. The data revealed that leaf length and number of leaves per plant increased progressively with increasing sulphur levels up to 40 kg/ha. The maximum leaf length (50.32 cm) and number of leaves (8.14 per plant) were recorded with S_3 (40 kg S/ha), while the minimum values were observed in the control (S_0 – 0 kg/ha, 43.79 cm and 7.44, respectively). The improvement in growth attributes with sulphur application might be due to its vital role in chlorophyll formation, enzyme activation, and protein synthesis, leading to better vegetative growth. These findings are in close agreement with those of Zaman *et al*. (2011) [18] and Thangasamy *et al*. (2021) [15], who reported that sulphur fertilization up to 40 kg/ha significantly increased plant height and number of leaves in garlic. Similarly, Raza *et al*., (2018) [11] found that the application of sulphur enhanced leaf area and photosynthetic rate, contributing to vigorous vegetative development.

Table 1: Effect of different sulphur levels and varieties on growth parameters of garlic

Treatments	Leaf length (cm)	Number of leaves per plant
Sulphur Levels		
S_0-0 kg/ha	43.79	7.44
S_1-20 kg/ha	46.92	7.71
S_2-30 kg/ha	48.08	7.84
S_3-40 kg/ha	50.32	8.14
SEm±	0.73	0.11
CD@5%	2.12	0.33
Varieties		
V_1-Riyawan	46.38	7.19
V_2-Ooty	47.71	7.69
V_3-Mahadev	47.22	7.75
V_4-G-2	47.80	8.50
SEm±	0.73	0.11
CD@5%	NS	0.33

3.1.2 Yield Attributes

A perusal of Table 2 shows that yield attributes such as number of cloves per bulb, fresh weight, dry weight of plant, bulb diameter, average bulb weight, and bulb yield increased significantly with increasing sulphur levels. The maximum number of cloves per bulb (22.28), bulb diameter (5.19 cm), average bulb weight (43.01 g), and yield (149.83 q/ha) were obtained under S_3 (40 kg S/ha), whereas the lowest values were recorded under control (S_0 – 0 kg/ha). The increase in yield attributes with sulphur application may be due to enhanced synthesis of sulphur-containing amino acids, improved carbohydrate metabolism, and better translocation of photosynthates to the bulb. The results are consistent with Castillo *et al*. (1996) [1], who observed a linear increase in bulb yield and weight of garlic up to 40 kg S/ha. Likewise, Desta *et al*., (2021) [4] reported that adequate sulphur fertilization improved clove size and bulb diameter due to better nutrient assimilation and photosynthetic efficiency.

Table 2: Effect of different sulphur levels and varieties on yield attributes of garlic

Treatments	Bulb diameter (cm)	Average bulb weight (g)	Average bulb yield (q/ha)
Sulphur Levels			
S_0-0 kg/ha	3.88	33.56	137.19
S_1-20 kg/ha	4.24	36.60	142.13
S_2-30 kg/ha	4.71	40.86	146.05
S_3-40 kg/ha	5.19	43.01	149.83
SEm±	0.05	0.14	0.87
CD@5%	0.16	0.42	2.51
Varieties			
V_1-Riyawan	3.20	35.11	136.13
V_2-Ooty	4.97	38.56	148.83
V_3-Mahadev	4.38	37.80	139.33
V_4-G-2	5.48	42.56	150.89
SEm±	0.05	0.14	0.87
CD@5%	0.16	0.42	2.51

Table 2.1: Interaction Effect of different sulphur levels and varieties on Bulb diameter (cm) of garlic

Sulphur levels	Varieties			
	Riyawan	Ooty	Mahadev	G-2
0 kg/ha	2.78	4.20	3.43	5.10
20 kg/ha	2.88	4.67	4.20	5.20
30 kg/ha	3.32	5.30	4.63	5.60
40 kg/ha	3.82	5.70	5.23	6.01
SEm±	0.11			
CD@5%	0.32			

Table 2.2: Interaction Effect of different sulphur levels and varieties on Average bulb weight (g) of garlic

Sulphur levels	Varieties			
	Riyawan	Ooty	Mahadev	G-2
0 kg/ha	27.87	34.46	33.72	38.17
20 kg/ha	33.08	37.29	36.24	39.80
30 kg/ha	38.74	40.37	39.70	44.65
40 kg/ha	40.73	42.12	41.56	47.63
SEm±	0.29			
CD@5%	0.83			

Table 2.3: Interaction Effect of different sulphur levels and varieties on Average bulb yield (q/ha) of garlic

Sulphur levels	Varieties			
	Riyawan	Ooty	Mahadev	G-2
0 kg/ha	127.33	141.00	136.67	143.75
20 kg/ha	138.67	148.67	132.67	148.50
30 kg/ha	137.50	151.67	143.00	152.01
40 kg/ha	141.00	154.00	145.00	159.30
SEm±	1.74			
CD@5%	5.02			

3.1.3 Quality Parameters

As presented in Table 3, quality parameters such as total soluble solids (TSS) and sulphur content in bulbs increased significantly with increasing sulphur levels. The highest TSS (36.53°Brix) and sulphur content (1.34%) were recorded under S_3 (40 kg/ha), while the lowest were obtained in the control (S_0 – 0 kg/ha). The enhancement in quality parameters may be attributed to the role of sulphur in the synthesis of flavour and pungency-related compounds (allicin and alliin) and its contribution to carbohydrate and protein metabolism. These results are supported by Diriba *et al.* (2013) [5], who reported that sulphur fertilization improved TSS and bulb quality in garlic, and by Huchette *et al.* (2007) [7], who found that increasing sulphur levels enhanced organo-sulphur compound accumulation and dry matter percentage.

Table 3: Effect of different sulphur levels and varieties on quality parameters of garlic

Treatments	Total soluble solids (^{0}Brix)	Sulphur content in bulb (%)
Sulphur Levels		
S_0-0 kg/ha	33.46	0.99
S_1-20 kg/ha	34.23	1.10
S_2-30 kg/ha	35.20	1.25
S_3-40 kg/ha	36.53	1.34
SEm±	0.26	0.01
CD@5%	0.75	0.02
Varieties		
V_1-Riyawan	33.69	1.09
V_2-Ooty	35.20	1.18
V_3-Mahadev	34.68	1.09
V_4-G-2	35.85	1.33
SEm±	0.26	0.01
CD@5%	0.75	0.02

3.1.4 Economics

The data presented in Table 4 indicate that gross return, net return, and benefit-cost (B:C) ratio increased progressively with increasing sulphur levels. The highest gross return (₹7,49,125/ha), net return (₹5,58,203/ha), and B:C ratio (2.92) were recorded under S_3 (40 kg S/ha), whereas the lowest were observed in the control. The increase in economic returns can be attributed to the enhanced yield and bulb quality due to adequate sulphur supply. These results are in line with those of Magray *et al*. (2017) [9] and Yadav *et al*. (2025) [17], who reported that sulphur application up to 40 kg/ha increased garlic profitability due to higher yield and quality improvement.

Table 4: Effect of different sulphur levels and varieties on economics of garlic.

Treatments	Gross cost (Rs./ha)	Gross return (Rs./ha)	Net Return (Rs./ha)	Benefit Cost Ratio (B:C)
Sulphur Levels				
S_0-0 kg/ha	186677	685933	499256	2.67
S_1-20 kg/ha	188945	710625	521680	2.76
S_2-30 kg/ha	189933	730225	540292	2.84
S_3-40 kg/ha	190922	749125	558203	2.92
SEm±	-	4342	4342	0.02
CD@5%	-	12542	12542	0.07
Varieties				
V_1-Riyawan	189119	680625	491506	2.60
V_2-Ooty	189119	744167	555047	2.93
V_3-Mahadev	189119	696667	507547	2.68
V_4-G-2	189119	754450	565331	2.99
SEm±	-	4342	4342	0.02
CD@5%	-	12542	12542	0.07

3.2 Effect of Varieties

3.2.1 Growth Parameters

Different varieties of garlic exhibited variation in growth performance. Among the varieties tested, G-2 recorded the highest number of leaves per plant (8.50), followed by Mahadev (7.75) and Ooty (7.69), while the lowest number of leaves was recorded in Riyawan (7.19). Leaf length varied non-significantly among varieties, ranging from 46.38 to 47.80 cm.

The superior performance of G-2 in leaf production may be attributed to its better genetic potential and adaptability to the local agro-climatic conditions. Similar varietal differences in garlic growth parameters have been reported by Zannat *et al*. (2023) [19], who observed that genotypic variability significantly affects leaf number and plant vigour under uniform management conditions.

Interaction Table 4.1: Effect of different sulphur levels and varieties on Net Return (Rs./ha) of garlic production

Sulphur levels	Varieties			
	Riyawan	Ooty	Mahadev	G-2
0 kg/ha	449990	518323	496656	532056
20 kg/ha	504388	554388	474388	553555
30 kg/ha	497567	568400	525067	570134
40 kg/ha	514078	579078	534078	605578
SEm±	8685			
CD@5%	25084			

Interaction Table 4.2: Effect of different sulphur levels and varieties on B:C ratio of garlic production

Sulphur levels	Varieties			
	Riyawan	Ooty	Mahadev	G-2
0 kg/ha	2.41	2.78	2.66	2.85
20 kg/ha	2.67	2.93	2.51	2.93
30 kg/ha	2.62	2.99	2.76	3.00
40 kg/ha	2.69	3.03	2.80	3.17
SEm±	0.05			
CD@5%	0.13			

3.2.2 Yield Attributes

Significant differences among varieties were observed for all yield parameters (Table 2). The variety G-2 recorded the highest bulb diameter (5.48 cm), average bulb weight (42.56 g), and bulb yield (150.89 q/ha), followed by Ooty (148.83 q/ha). The variety Riyawan recorded the lowest yield (136.13 q/ha). The superior performance of G-2 could be attributed to its genetic potential for producing bold cloves and its efficient nutrient uptake ability under local conditions.Similarly, Galgaye *et al*. (2023) [6] reported significant varietal differences in garlic yield attributes, indicating that genetic makeup plays a vital role in nutrient utilization efficiency and yield formation.

3.2.3 Quality Parameters

Among the varieties, G-2 recorded the highest TSS (35.85°Brix) and sulphur content (1.33%), followed by Ooty (35.20°Brix and 1.18%). The lowest values were obtained in Riyawan. The superior performance of G-2 could be due to its higher genetic potential to accumulate sulphur compounds and its better bulb development under semi-arid conditions. Similar varietal differences in quality parameters were reported by Jayaswall *et al*. (2025) [8], who found that garlic varieties differ significantly in biochemical composition, particularly in sulphur-containing compounds and total soluble solids.

3.2.4 Economics

Among the varieties, G-2 recorded the maximum gross return (₹7,54,450/ha), net return (₹5,65,331/ha), and B:C ratio (2.99), followed by Ooty (2.93), while the minimum was observed in Riyawan (2.60). The superior economic performance of G-2 may be due to its higher marketable yield and better bulb quality, fetching higher returns. Similar economic superiority of G-2 was also observed by Parihar *et al*. (2020) [10] in Madhya Pradesh, who concluded that varietal adaptability and nutrient use efficiency significantly affect net profitability.

3.3 Interaction Effect

3.3.1 Yield Attributes

The interaction between sulphur levels and varieties (Table 2.1 to 2.4) was found significant for number of cloves per bulb, bulb diameter, average bulb weight, and bulb yield. The combination G-2 × 40 kg S/ha recorded the maximum bulb diameter (6.01 cm), average bulb weight (47.63 g), and bulb yield (159.30 q/ha). The lowest values were recorded in Ooty × 0 kg S/ha for number of cloves and Riyawan × 0 kg S/ha for bulb diameter and yield. The positive interaction may be due to the genetic potential of G-2 to respond effectively to higher nutrient availability and convert assimilates into larger bulbs. These findings are in agreement with Chattoo *et al*. (2018) [2], who reported significant sulphur × variety interaction effects on bulb yield and quality of garlic.

3.3.2 Economics

The interaction between sulphur levels and varieties showed a significant effect on net return and B:C ratio (Tables 4.1 and 4.2). The combination G-2 × 40 kg S/ha produced the highest net return (₹6,05,578/ha) and B:C ratio (3.17), followed by Ooty × 40 kg S/ha (₹5,79,078/ha). The lowest economic returns were recorded in Riyawan × 0 kg S/ha. This indicates that G-2 has the highest responsiveness to sulphur fertilization under the conditions of Jaipur. These findings are supported by Thangasamy *et al*. (2021) [15], who found similar positive interactions between sulphur levels and responsive garlic genotypes for economic parameters.

4. Conclusion

It is concluded that increasing sulphur levels up to 40 kg/ha significantly improved the growth, yield, quality, and economic parameters of garlic. Among varieties, G-2 exhibited superior performance across most traits, followed by Ooty, while Riyawan recorded the lowest values. The interaction of G-2 × 40 kg S/ha proved to be the most effective combination for achieving higher productivity and profitability.

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6. References

1. Castillo JE, Lopez-Bellido L, Fernandez EJ, Fuentes M, Lopez FJ. Influence of planting geometry on growth, yield and quality of rainfed garlic (*Allium sativum* L.) cultivated under Mediterranean conditions. Journal of Horticultural Science. 1996;71(6):867–879.
2. Chattoo MA, Magray MM, Parray FA, Shah MD, Bhat TA. Effect of sulphur on growth, yield and quality of garlic (*Allium sativum* L.). Journal of Pharmacognosy and Phytochemistry. 2018;7(5):2894–2896.
3. Dawar R, Karan S, Bhardwaj S, Meena DK, Padhan SR, Reddy KS, et al. Role of sulphur fertilization in legume crops: A comprehensive review. International Journal of Plant Sciences. 2023;35:718–727.
4. Desta B, Tena N, Amare G. Growth and bulb yield of garlic as influenced by clove size. The Scientific World Journal. 2021;2021(1):7351873.
5. Diriba-Shiferaw G, Nigussie-Dechassa R, Kebede Woldetsadik GT, Sharma JJ. Bulb quality of garlic (*Allium sativum* L.) as influenced by the application of inorganic fertilizers. African Journal of Agricultural Research. 2013;8(43):5387–5398.
6. Galgaye GG, Deresa HK. Effect of garlic genotypes (*Allium sativum* L.) on phenotype, growth, yield-related attributes, and nutritional quality at Bule Hora agro-ecology. Heliyon. 2023;9(6).
7. Huchette O, Arnault I, Auger J, Bellamy C, Trueman L, Thomas B, et al. Genotype, nitrogen fertility and sulphur availability interact to affect flavour in garlic (*Allium sativum* L.). The Journal of Horticultural Science and Biotechnology. 2007;82(1):79–88.
8. Jayaswall K, Kumar D, Jayaswal D, Sharma H, Kumar S, Unamba C, et al. *Allium sativum* and *Allium cepa* offer excellent potential for introgression and production of allicin and high total soluble solids into closely related wild *Alliums*. South African Journal of Botany. 2025;176:207–218.
9. Magray MM, Chattoo MA, Narayan S, Mir SA. Influence of sulphur and potassium applications on yield, uptake & economics of production of garlic. International Journal of Pure and Applied Biosciences. 2017;5(5):924–934.
10. Parihar CM, Jat HS, Jat SL, Kakraliya SK, Nayak HS. Precision nutrient management for higher nutrient use efficiency and farm profitability in irrigated cereal-based cropping systems. Indian Journal of Fertilisers. 2020;16(10):1000–1014.
11. Raza MA, Feng LY, Iqbal N, Manaf A, Khalid MHB, Ur Rehman S, et al. Effect of sulphur application on photosynthesis and biomass accumulation of sesame varieties under rainfed conditions. Agronomy. 2018;8(8):149.
12. Shah SH, Parrey ZA, Islam S, Tyagi A, Ahmad A, Mohammad F. Exogenously applied sulphur improves growth, photosynthetic efficiency, enzymatic activities, mineral nutrient contents, yield and quality of *Brassica juncea* L. Sustainability. 2022;14(21):14441.
13. Shukla AK, Behera SK, Prakash C, Tripathi A, Patra AK, Dwivedi BS, et al. Deficiency of phyto-available sulphur, zinc, boron, iron, copper and manganese in soils of India. Scientific Reports. 2021;11(1):19760.
14. Singh CV. Response of garlic (*Allium sativum* L.) cv. G-282 to sulphur and boron application in terms of growth, yield and quality [Doctoral dissertation]. Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya; 2018.
15. Thangasamy A, Gorrepati K, Ghodke PH, TP SA, Jadhav M, Banerjee K, et al. Effects of sulfur fertilization on yield, biochemical quality, and thiosulfinate content of garlic. Scientia Horticulturae. 2021;289:110442.
16. Wang M, Ye Y, Chu X, Zhao Y, Zhang S, Chen H, et al. Responses of garlic quality and yields to various types and rates of potassium fertilizer applications. Horticultural Science. 2022;57(1):72–80.
17. Yadav K, Pandey M, Singh S. Impact of integrated sulphur management on profitability of brinjal, onion and garlic. Annals of Plant and Soil Research. 2025;27(1):118–122.
18. Zaman MS, Hashem MA, Jahiruddin M, Rahim MA. Effect of sulphur fertilization on the growth and yield of garlic (*Allium sativum* L.). Bangladesh Journal of Agricultural Research. 2011;36(4):647–656.

19. Zannat A, Hussain MA, Abdullah AHM, Hossain MI, Saifullah M, Safhi FA, et al. Exploring genotypic variability and interrelationships among growth, yield, and quality characteristics in diverse tomato genotypes. Heliyon. 2023;9(8).
20. Zenda T, Liu S, Dong A, Duan H. Revisiting sulphur—The once neglected nutrient: Its roles in plant growth, metabolism, stress tolerance and crop production. Agriculture. 2021;11(7):626.