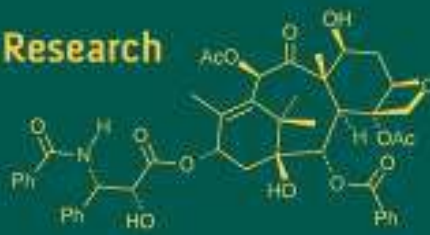
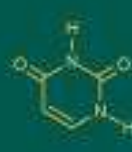


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Effect of sulphur and potassium on growth and yield of foxtail millet (*Setaria italica* L.)

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Abstract

A field experiment was conducted during *Kharif* season of 2024 at Crop Research Farm Department of Agronomy, SHUATS, Prayagraj (U.P.), India. The soil was sandy, clayey, loamy in texture with soil reaction of pH 6.9. On 4th August 2024, Foxtail millet seeds (SiA 3156) were planted with a spacing of 30 cm x 10 cm. The experiment was laid out in a Randomized block design. The combination of ten treatments were done at different levels of sulphur in soil application (10, 15 and 20 kg/ha) along with potassium (20, 30 and 40 kg/ha) and RDF 60:30:30 kg NPK/ha. The treatment combination are as follows. (T₁- Sulphur 10 kg/ha + Potassium 20 kg/ha, T₂- Sulphur 10 kg/ha + Potassium 30 kg/ha, T₃- Sulphur 10 kg/ha + Potassium 40 kg/ha, T₄- Sulphur 15 kg/ha + Potassium 20 kg/ha, T₅- Sulphur 15 kg/ha + Potassium 30 kg/ha, T₆- Sulphur 15 kg/ha + Potassium 40 kg/ha, T₇- Sulphur 20 kg/ha + Potassium 20 kg/ha, T₈- Sulphur 20 kg/ha + Potassium 30 kg/ha, T₉- Sulphur 20 kg/ha + Potassium 40 kg/ha, T₁₀ - Control (60:30:30) NPK kg/ha. this experiment was laid out in a Randomized Block Design with 10 treatment combinations and replication thrice. The result showed that Treatment 7, which involved the application of Sulphur at 20 kg/ha along with Potassium at 20 kg/ha, recorded higher values for growth parameters such as plant height (98.88 cm) and plant dry weight (8.98 g/plant). Yield attributes also showed significant improvement under this treatment, including effective ears per head (5.21), test weight (3.67 g), seeds per ear (396.56), seed yield (1391.82 kg/ha), stover yield (2629.62 kg/ha), and harvest index (35.30%) as well as maximum gross return (INR 1,00,008.00/ha), net return (INR 66,308.00/ha), benefit cost ratio (1.97) was onset. Hence, the result suggested that the combined application of Sulphur and Potassium at 20 kg/ha each enhanced plant growth and yield performance.

Keywords: *Kharif*, foxtail millet, potassium, yield, sulphur

Introduction

Foxtail millet (*Setaria italica* L.) is a significant minor millet that is a member of the Poaceae family. It is the most significant food crop in East Asia and the second most commonly produced species of millet. In dry and semi-arid areas of India, foxtail millet is a significant crop. After maize, wheat, and rice, it is the fourth most often grown food crop. Although foxtail millet is the main crop in southern India, its yield falls well short of what is desired. Often referred to as coarse cereals, India is the world's greatest producer of a wide variety of millets, including foxtail, finger, and barnyard millet. Since millets can be grown in severe environments, they are seen as the crops of the future often referred to as coarse cereals. Since millets can be grown in the hard conditions of the desert and semi-arid regions, they are regarded as the crops of the future. In terms of overall millet production worldwide, foxtail millet comes in second. Foxtail millet is only grown in Andhra Pradesh, Karnataka, and Tamil Nadu in India. Its grain is fed to cage birds and poultry as well as consumed by humans. The stalks are utilized as fodder and are used in a variety of food products, including chapati, fermented bread, biscuits, malts, and more. It is beneficial for diabetics and high in micronutrients. It offers protection against heart disease and cancer. Foxtail millet can be produced as a short-term catch crop and is classified as a drought-tolerant crop. It can tolerate a broad variety of temperatures, soil types, and elevations. In addition to increasing productivity, proper fertilizer application enhances the quality of feed, particularly its protein content. Millets are frequently grown in exceptionally severe conditions, such as high temperatures, low and irregular precipitation, short growing seasons, and acidic and

infertile soils with limited water-holding ability, since they are more suited to dry, barren soils than the majority of other crops. The majority of millets can develop quickly in the presence of moisture and have short life cycles and robust, deep root systems. The annual grass known as foxtail millet is cultivated for human consumption. It is the most significant millet species in East Asia and the second most commonly cultivated. In addition to various other economically developed nations worldwide, this is widely grown in arid and semi-arid parts of Asia and Africa. Foxtail millet is widely grown in the arid, upland areas of Southeast Asia. Proteins (12.3 g), carbs (60.9 g), fat (4.3 g), crude fiber (8.0 g), calcium (31 mg), minerals (3.3 g), and thiamine (0.59 mg) make up the nutritional makeup of 100 g of edible foxtail millet. Except in certain of India's more commercialized farming areas, millet cropping patterns are often widespread in poor nations with little use of advanced technologies.

Potassium is one of the main minerals needed for plant growth and development is potassium. It increases plant resilience to a range of biotic and abiotic stressors and raises the yield and quality of agricultural products. Its primary roles include photosynthesis, glucose metabolism, and physiological functions such root growth, water efficiency, protein and amino acid synthesis, and enzyme activation (Choudhary *et al.*, 2014)^[4].

Sulphur plays an important role in primary and secondary plant metabolism as a component of proteins, glucosinolates, as a component of proteins, glucosinolates, and other substances linked to multiple factors influencing the nutritional content of crops, sulfur plays a significant role in primary and secondary plant metabolism. After N, P, and K, sulfur is the fourth important nutrient.

It is necessary for the production of sulfur-containing amino acids, which are vital building blocks of proteins and include cystine, cystine, and methionine (Tisdale *et al.*, 1999)^[19].

Materials and Methods

During the Kharif season of 2024, a field experiment was conducted in alluvial soil at the Department of Agronomy's Crop Research Farm, SHUATS, Prayagraj, U.P. It is situated in latitude 25° 39' 42" N, longitude 81° 07' 56" E, and elevation 98 meters above mean sea level. About five kilometers from Prayagraj city, this location lies on the right bank of the Yamuna River beside Prayagraj Rewa Road. A composite soil sample was taken at a depth of 0-30 cm before seeding. It was crushed, air dried, and subjected to physical and chemical testing in a lab. The soil had a pH of 6.9 and a sandy, clayey, loamy texture. Foxtail millet seeds (SiA 3156) were sown on August 4, 2024, with a 30 cm × 10 cm spacing. Randomized block design was the favored method for conducting the experiment. Ten treatments totaling varying amounts of sulfur (10, 15, and 20 kg/ha), potassium (20, 30, and 40 kg/ha), and RDF 60:30:30 kg NPK/ha were applied to the soil. the treatment combination are as follows. (T₁- Sulphur 10 kg/ha + Potassium 20 kg/ha, T₂- Sulphur 10 kg/ha + Potassium 30 kg/ha, T₃- Sulphur 10 kg/ha + Potassium 40 kg/ha, T₄- Sulphur 15 kg/ha + Potassium 20 kg/ha, T₅- Sulphur 15 kg/ha + Potassium 30 kg/ha, T₆- Sulphur 15 kg/ha + Potassium 40 kg/ha, T₇- Sulphur 20 kg/ha + Potassium 20 kg/ha, T₈- Sulphur 20 kg/ha + Potassium 30 kg/ha, T₉- Sulphur 20 kg/ha + Potassium 40 kg/ha, T₁₀ - Control (60:30:30) NPK kg/ha.

Using a hand hoe, furrows were dug at a depth of 4-5 cm in order to apply nutrients using the spreading method. Ten days after seeding, gap filling was accomplished through transplantation. Seedlings were removed where needed to keep the space between plants at 30 by 10 cm. Intercultural operations were carried out at intervals of 25 to 45 days in order to lessen weed competition and high crop density. The crop was harvested on October 26, 2024. Plant growth metrics like plant height (cm), during the growing season from germination to harvest and dry weight (g/plant), CGR and RGR were assessed. At harvest, yield metrics such as ear head/plant, grains/ear head, test weight (g), grain yield (kg/ha), stover yield (kg/ha), and harvest index (%) were measured at 20, 40, 60 and 80DAS. The data was subjected to statistical analysis by analysis of variance method Analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments (Gomez and Gomez, 1984 and Mohan *et al.*, 2024)^[9].

Results and Discussions

Growth parameter

At 80 days after sowing (DAS), the tallest Foxtail millet plants (98.88 cm) were recorded in Treatment 7, which received 20 kg/ha of Sulphur and 20 kg/ha of Potassium. Treatment 8, with 20 kg/ha Sulphur and 30 kg/ha Potassium, showed plant height statistically similar to Treatment 7. Plant height increased significantly with the application of different Sulphur and Potassium levels. Potassium supports amino acid synthesis, which contributes to protein formation and overall plant structure development. Sulphur plays a key role in physiological and metabolic processes, including the synthesis of tryptophan, a precursor to auxins like Indole Acetic Acid (IAA). These growth hormones are essential for cell elongation and plant development. Supporting studies by Iqbal *et al.*, (2013)^[20], Manwar and Mankar (2015)^[7], and Reddy *et al.*, (2021)^[10] confirm similar outcomes. The highest dry weight (16.11 g) was also recorded in Treatment 7 at 80 DAS. Treatments 5, 6, and 8 showed dry weights statistically similar to Treatment 7. Potassium may have enhanced the plant's nutrient uptake and metabolic efficiency. Sulphur likely acted as an enzyme activator and metabolic stimulant, improving overall biomass accumulation. Similar findings were also reported by Reddy *et al.*, (2021)^[10] and Vinod Kumar *et al.*, (2018)^[5].

Yield attributes

Statistical analysis revealed a significant effect of treatments on ear head length. The highest ear head length (5.21 cm) was recorded under Sulphur at 20 kg/ha along with Potassium at 20 kg/ha, while Treatment T₈ (Sulphur at 20 kg/ha and Potassium at 30 kg/ha) was statistically at par with T₇.

Grain yield

Grain yield increased significantly with the combined application of Potassium and Sulphur along with the recommended dose of fertilizers (RDF). The highest grain yield (1391.82 kg/ha) was recorded under Treatment T₇ (Sulphur at 20 kg/ha along with Potassium at 20 kg/ha), while Treatment T₈ (Sulphur at 20 kg/ha and Potassium at 30 kg/ha) was statistically at par with T₇.

Straw Yields

The application of Potassium and Sulphur had a significant influence on the stover yield of foxtail millet. The maximum stover yield (2629.62 kg/ha) was observed with the application of Sulphur at 20 kg/ha and Potassium at 20 kg/ha (Treatment T₇). Treatments T₅, T₆, and T₈ comprising Sulphur at 15-20 kg/ha combined with Potassium levels ranging from 30 to 40 kg/ha were statistically at par with T₇ in terms of stover yield.

Harvest Index

The harvest index showed significant variation among treatments, with the maximum value (35.30%) observed under T₇ (Sulphur at 20 kg/ha along with Potassium at 20 kg/ha), which is strategically at par to all the treatments. Grain and stover yields of foxtail millet improved significantly with increasing Potassium levels up to 40 kg/ha, likely due to enhanced vegetative growth and better nutrient uptake supported by a more developed root system. The increase in biological yield was a result of higher grain and straw yields, which may be attributed to the role of micronutrients in metabolic and enzymatic processes essential for plant growth. These results align with the findings of Reddy *et al.*, (2021)^[10], Vinod Kumar *et al.*, (2018)^[5] and Mohan *et al.*, 2024^[9].

Economies

The application of Sulphur along with Potassium which increased the grain yield, stover yield among all the treatment. Treatment T₇ involving the application of Sulphur at 20 kg/ha and Potassium at 20 kg/ha resulted in the highest gross return (1,09,857.70 INR/ha), highest net return (71,713.74 INR/ha), maximum benefit-cost ratio (1.30).

Conclusion

According to the findings, the best way to improve the performance of foxtail millet was to apply 20 kg/ha of sulphur and 20 kg/ha of potassium. This combination produced the maximum grain production, economic returns, and benefit-cost ratio.

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Competing Interests

Authors have declared that no competing interests exists.

Table 1: Effect of Sulphur and Potassium on growth attributes of Foxtail Millet.

S. No.	Treatments	Plant height (cm)	Dry weight (g)
		80 DAS	80 DAS
1	Sulphur 10kg/ha + potassium 20 kg/ha	90.3	12.86
2	Sulphur 10kg/ha+ Potassium 30kg/ha	91.70	12.66
3	Sulphur10kg/ha + Potassium 40kg/ha	92.75	13.08
4	Sulphur 15kg/ha+ Potassium 20kg/ha	93.32	14.31
5	Sulphur 15kg/ha+ Potassium 30kg/ha	94.75	12.65
6	Sulphur 15kg/ha+ Potassium 40kg/ha	95.52	13.52
7	Sulphur 15kg/ha+ potassium 20kg/ha	98.88	16.11
8	Sulphur 15kg/ha+ Potassium 30kg/ha	97.63	15.17
9	Sulphur 15kg/ha+ Potassium 40kg/ha	97.30	14.92
10.	Control (RDF): 60:30:30 kg NPK/ha	78.19	11.82
SEm(±)		3.24	6.18
CD (P= 0.05)		9.64	-

Table 2: Effect of Sulphur and Potassium on yield attributes and yield of Foxtail Millet.

S. No. Treatments	No. of ears/plant	No. of seeds/ tiller	Test weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
1. Sulphur 10 kg/ha + Potassium 20kg/ha	2.89	313.92	2.49	1025.33	2076.63	33.05
2. Sulphur 10 kg/ha + Potassium 30kg/ha	3.26	366.93	2.63	979.48	2155.84	31.24
3. Sulphur 10 kg/ha + Potassium 40kg/ha	3.35	380.84	2.88	1138.88	2239.78	33.72
4. Sulphur 15 kg/ha + Potassium 20kg/ha	2.97	338.13	2.56	1155.88	2357.35	32.89
5. Sulphur 15 kg/ha + Potassium 30kg/ha	4.87	335.35	2.76	1099.10	2477.61	30.70
6. Sulphur 15 kg/ha + Potassium 40kg/ha	4.49	354.67	2.99	1278.13	2362.23	35.13
7. Sulphur 20kg/ha + Potassium 20kg/ha	5.21	396.56	3.67	1391.82	2629.62	35.30
8. Sulphur 20kg/ha + Potassium 30kg/ha	4.23	382.37	2.94	1306.44	2443.82	34.94
9. Sulphur 20 kg/ha + Potassium 40kg/ha	4.93	392.47	3.04	1333.54	2556.89	34.35
10. Control (RDF): 60:30:30 NPK kg/ha	2.78	295.08	2.46	955.11	1828.44	34.41
F-test	S	S	S	S	S	NS
SEm±	0.54	18.09	0.04	60.62	104.05	1.48
CD (p=0.05). 1.62		53.75	0.11	180.13	294.00	-

Table 3: Effect of Sulphur and Potassium on economics of Foxtail Millet

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	Benefit: Cost Ratio (B:C)
1.	Sulphur 10kg/ha + Potassium 20kg/ha	36,544.00	84,006.92	47,462.92	1.30
2.	Sulphur 10kg/ha + Potassium 30kg/ha	37,044.00	86,859.62	49,815.62	1.34
3.	Sulphur 10kg/ha + Potassium 40kg/ha	37,544.00	88,824.91	51,280.91	1.37
4.	Sulphur 15kg/ha + Potassium 20kg/ha	36,844.00	91,945.48	55,101.48	1.50
5.	Sulphur 15kg/ha + Potassium 30kg/ha	37,344.00	94,923.62	57,579.62	1.54
6.	Sulphur 15kg/ha + Potassium 40kg/ha	37,844.00	97,669.17	59,825.17	1.58
7.	Sulphur 20kg/ha + Potassium 20kg/ha	38,144.00	1,09,857.70	71,713.74	1.88
8.	Sulphur 20kg/ha + Potassium 30kg/ha	37,644.00	1,05,826.80	68,182.80	1.81
9.	Sulphur 20kg/ha + Potassium 40kg/ha	37,144.00	1,02,190.40	65,046.39	1.75
10.	Control (RDF): 60:30:30 NPK kg/ha	34,144.00	76,514.40	42,370.47	1.24

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