ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(8): 514-519
www.agriculturaljournals.com
Received: 05-06-2025
Accepted: 07-07-2025

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Analysis the effect of different levels of sulphur and zinc on quality and nutrient uptake of baby corn

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DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i8g.651

Abstract
The field experiment was conducted to assess the nutrient uptake, protein and soil fertility status baby corn (*Zea mays* L.) during *Kharif*-2022 at Agricultural Research Farm, Department of Agronomy, Pili Kothi farm of Tilak Dhari P.G. College, Jaunpur, U.P., India. The experiment was laid-out in a factorial randomized completely block design replicated thrice. The treatments included three levels of Sulphur (30, 40, 50 kg ha^{-1}) and Zinc (2.5,5.0 and 7.5 kg ha^{-1}). Result revealed that baby corn (without husk) nutrient content (0.16% S and 32.08 ppm Zn) and stover by nutrient content (0.080% S and 49.86 ppm Zn), nutrient uptake by baby corn (14.17 kg ha^{-1} S and 32.08 g ha^{-1} Zn), stover (15.15 kg ha^{-1} S and 293.55 g ha^{-1} Zn) and total nutrient uptake (29.32 kg ha^{-1} S and 484.33 g ha^{-1} Zn) and baby corn quality (protein- 9.66%) recorded application 50 kg ha^{-1} sulphur. However, application 7.5 kg ha^{-1} zinc to observed the baby corn (without husk) nutrient content (0.15% S and 31.79 ppm Zn) and stover by nutrient content (0.079% S and 49.59 ppm Zn), nutrient uptake by baby corn (12.61 kg ha^{-1} S and 31.80 g ha^{-1} Zn), stover (13.88 kg ha^{-1} S and 269.63 g ha^{-1} Zn) and total nutrient uptake (26.49 kg ha^{-1} S and 445.27 g ha^{-1} Zn) and baby corn quality (protein- 9.77%). The available nutrients N, P, K, S and Zn status in the soil after the harvest of baby corn resulted in statistically significant due to sulphur and zinc levels. Increasing levels of sulphur and zinc recorded progressively improved the quality and nutrient uptake. Hence, application of 50 kg ha^{-1} sulphur and 7.5 kg ha^{-1} zinc was optimum to obtain the higher protein content quality and nutrient uptake of baby corn under irrigated condition of Jaunpur.

Keywords: Sulphur, zinc, quality, soil fertility and nutrient uptake

Introduction
Maize (*Zea mays* L) is belonging of the family Poaceae, and is originated in southern Maxico and it's third most important cereal crop fallowed by rice and wheat and has the highest production potential among the cereals. The cultivation of baby corn short growing period and changing food preferences in the life style of Indian people (Verma *et al.,* 2002) [30]. Baby corn is dehusked immature maize ear, harvested within 2-3 days of silking but prior to fertilization (Pandey *et al.,* 1998) [20]. Baby corn is highly nutritive as 100 g of baby corn contains 89.1% moisture, 0.2 g fat, 1.9 g protein, 8.2 mg carbohydrate, 0.06 g ash, 28.0 mg calcium, 86.0 mg phosphorus, 11.0 mg ascorbic acid (Das *et al.,* 2009) [7]. Besides, it also has vitamin A (276 retinol equivalents), vitamin C (16 mg), potassium (483 mg), sodium (158 mg), magnesium (76 mg), calcium (51 mg) and iron (2 mg) (Bhat, 2013) [5]. It has gained favor among producers in peri-urban areas due to its flexibility and promising returns. According to research (Barik *et al.,* 2016) [3]. Fodder is free from toxicants and can be safely fed to animals at any stage of crop growth. For the production of baby corn, early maturing, uniform flowering, succulency, ear weight and prolificacy are regarded the most essential characteristics (Thakur *et al.,* 2000) [28].
Sulphur (S) a macronutrient, the IV major plant nutrients, is one of 17 essential nutrients and it is now recognized as that are required for many functions in plants like its used in the formation of amino acids, protein, and oils. S fertilization is a viable strategy to improve the absorption and usage performance of N, P, K and Zn, and to inhibit plant uptake of harmful toxic elements *Viz*; Se (selenium) and Mo (molybdenum) due to the synergistic interaction between the sulphur and the former and the latter.

Zinc (Zn) involvement is particularly significant in carbohydrate metabolism, encompassing both photosynthesis and the conversion of sugars into starch. Most of the zinc is trans-located to seeds during fertilization and lower application of zinc causes deficiency of zinc in the seed and also the seed yield is quietly reduced (Reid *et al.,* 2011) [22]. Hence, Zn application must be evaluated to maximize grain production as well as quality in maize hybrids.

Materials and Methods

Experimental site

The experiment was conducted at the Agricultural Research Farm, Department of Agronomy, Pili Kothi farm of Tilak Dhari P.G. College, Jaunpur, U.P. India. Initial soil sample analysis revealed that the experimental soil was sandy loam in texture, neutral in reaction (pH 7.89), medium in organic carbon (0.31%), very low in available nitrogen (69.75 kg ha^{-1}), phosphorus (13.5 kg ha^{-1}), medium in available potassium (156.8 kg ha^{-1}), adequate amount available sulphur (14.4 ppm) and very low available in zinc (0.22 ppm). The experiment was laid out in a Randomized Block Design with factorial concept replicated thrice. The treatments consisted of three levels of Sulphur (30, 40 and 50 kg N ha^{-1}) in Factor -A and three levels of zinc (2.5, 5.0 and 7.5 kg ha^{-1}) in Factor –B. During crop grown period was total rainfall 367.2 mm. The baby corn variety G-5414 selected for sown after thorough land preparation.

Fertilizer Application

In experiment duration for source for recommended dose of fertilizers was 120 kg N, 60 kg P_2O_5, 50 kg K_2O ha^{-1} were applied to all the treatments. Urea, SSP and MOP were used as the source of nutrients. Further, sulphur the application through Bentonite Sulphur (90% S) and for Zinc the applied through Zinc Sulphate monohydrate (33% Zn & 15% S) according to unit of treatment. Entire dose of phosphorus, potassium and half the dose of nitrogen was applied as basal at the time of sowing. The remaining half of the nitrogen was top dressed at 25 DAS and 35 DAS. Bentonite Sulphur is mixed with 1 kg soil & 100g before 15 days of application and used with Zinc Sulphate monohydrate applied in basal doses at time of sowing.

Chemical Analysis

Plant Analysis

Plant Nutrient Content

The baby corn (without husk) and fodder samples collected at each harvest from each experimental unit were oven dried at 65°C to a constant weight and ground in laboratory mill. These samples were subjected to chemical analysis for determination of nutrient contents expressed in percent ppm. The standards method adopted for analysis of various nutrients are given in Table 1.

Table 1: Methods employed for nutrient analysis of plant samples

Nutrient	Method employed and reference
S	Sun dried and subjected to oven-dried at 65±5° C for 72 hr.(Chesnin and Yien, 1950) [6]
Zn	Atomic absorption spectrophotometrically method (Lindsay and Norvell, 1978) [15]

Plant Nutrient Uptake: Sulphur and Zinc uptake at each harvest by baby corn and fodder were computed by the following formula on dry matter basis.

For secondary macronutrients (S)

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1})}{100}$$

For micronutrients (Zn)

$$\text{Nutrient uptake (g ha}^{-1}) = \frac{\text{Nutrient content (ppm)} \times \text{Yield (kg ha}^{-1})}{1000}$$

The total uptake of each nutrient by the crop was calculated by summing up the nutrient uptake of baby corn and fodder.

Soil analysis after crop harvest

After harvest of the crop (green fodder), soil samples were randomly drawn from different five spots up to 15 cm depth from each net plot and representative composite samples for each plot were prepared, which were analysed for available N, P_2O_5, K_2O and zinc status of soil during both the years of experimentation. The following methods for analysis were adopted:

- Nitrogen - Alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [26].
- Phosphorus - Olsen's methods (Olsen *et al.,* 1954) [18].
- Potassium - Flame photometer method (Richards, 1954) [23].
- Sulphur - Available S in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.,* 1982) [19]. The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.
- Zinc -Extraction by 0.005M DTPA + 0.001M $CaCl_2$ + 0.1M Triethanolamine at pH 7.3 (Lindsay and Norvell, 1978) [15].

Quality parameters (protein content%) of baby corn

Protein content of dehusked baby corn was calculated for each picking of corn on dry matter basis by multiplying the nitrogen content of the corn with a factor 6.25 as proposed by Tsen and Martin (1971) [29]. It was expressed in terms of percent protein content.

Results and Discussion

Nutrient (S and Zn) content and uptake in baby corn (without husk and stover

The sulphur and zinc content in baby corn (without husk) and stover were significantly higher with sulphur and zinc levels treatments (Table-2 and fig-1, 2). In case of sulphur the data findings reveal that the sulphur data indicates the superiority of S 50 kg ha^{-1} (S_3) when compared to its lower levels. Throughout the experimental years, the application of S 50 kg ha^{-1} during the harvests led to a notably higher sulphur content in baby corn Sinha *et al*. (1995) [25] and Irfan *et al*. (2015) [10]. Sulphur application significantly increased the sulphur uptake of baby corn, stover and total sulphur uptake in plant found the significant at various levels of sulphur (Table-3 and fig-3,4). This result was in accordance with the data recorded by Mehta *et al*. (2005) [17]; Bharati and Poongothai (2008) [4]; and Ariraman *et al*. (2020) [1].

The data shows (Table-2 and fig-1,2) that zinc levels have a significant impact on the zinc content in baby corn and stover. The baby corn and stover exhibited as higher zinc content when treated with 7.5 kg Zn ha^{-1} (Zn_3), as per the findings Dwivedi and Tiwari (1992) [8]; Kumar *et al*. (2013) [11] and Imran and Rehim (2017) [9]. The effect of different zinc treatments on baby corn, stover and total zinc uptake was observed results significant during the experiment. The highest total zinc uptake was observed (Table-3 and fig-3,4) with the application of 7.5 kg Zn ha^{-1}, which was significantly higher than the application of 5.0 kg Zn ha^{-1} (Zn_2) and 2.50 kg Zn ha^{-1} (Zn_1). These findings are in conformity with the results reported by Ashoka and Sunitha (2011) [2]. The combined effect of S and Zn on nutrient content, uptake and quality in plant was non-significant.

Soil Fertility Status

The data related to soil nutrient status after the harvest of baby corn has been shown in Table-4, Fig.-5. The available N, P, K, S and Zn status in the soil after the harvest of baby corn resulted in statistically significant due to sulphur and zinc levels. Amongst the S_3 and Zn_3 had maximum available N, P, K, S and Zn in soil. Increase in the level of S and Zn also ensured availability of these nutrients to the crop in adequate amount which remained in soil in substantial quantity after fulfilling the crop requirement that ultimately improved the soil fertility. It was confirmed by the findings of Saha and Mondal (2006) [24].

Protein Content (%)

The protein content in baby corn were significantly higher with sulphur and zinc levels (Table-5 and fig-6). An application of 50 kg ha^{-1} (S_3) and 7.5 kg ha^{-1} (Zn_3) had higher protein content (%) in baby corn over being statistically at par with each other. Application of S 50 kg ha^{-1} (S_3) improved protein content (9.66%) of baby corn (without husk). However, application of Zn level 7.5 kg ha^{-1} (Zn_3) resulted highest protein content (9.77%) of baby corn was recorded Table-5 and fig-6. The results are in agreements with those of Maurya *et al*. (2004a) [16]; Kumar *et al*. (2015) [12]; Tahir *et al*. (2016) [27]; Kumar *et al*. (2017) [14]; Patil *et al*. (2017) [21] and Kumar *et al*. (2018) [13].

Table 2: Effect of Sulphur and Zinc on Nutrients contents by baby corn (without husk) and stover

Sr. No.	Treatment details		Nutrients S and Zn contents by baby corn (without husk)		Nutrients S and Zn contents by stover	
			S (%)	Zn (ppm)	S (%)	Zn (ppm)
1.	Sulphur	S_1 (30 kg ha^{-1})	0.12	28.95	0.073	46.66
		S_2 (40 kg ha^{-1})	0.14	29.98	0.076	48.05
		S_3 (50 kg ha^{-1})	0.16	32.08	0.080	49.86
		SE(m)±	0.001	0.067	0.0009	0.121
		CD (P=5%)	0.003	0.201	0.001	0.365
2.	Zinc	Zn_1 (2.5 kg ha^{-1})	0.13	29.14	0.073	46.93
		Zn_2 (5.0 kg ha^{-1})	0.14	30.07	0.076	48.06
		Zn_3 (7.5 kg ha^{-1})	0.15	31.79	0.079	49.59
		SE(m)±	0.001	0.067	0.0009	0.121
		CD (P=5%)	0.003	0.201	0.001	0.365

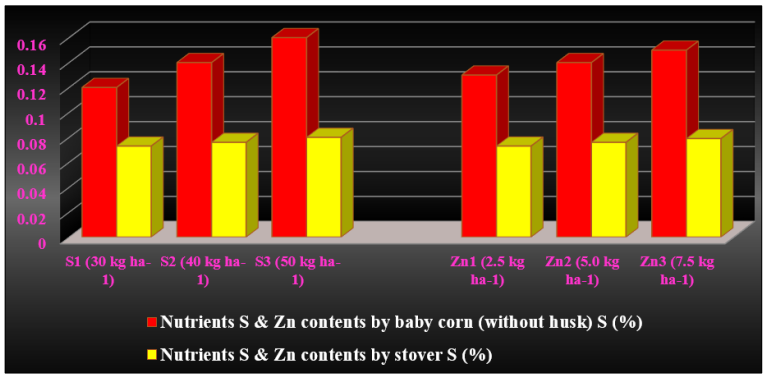

Fig 1: Effect of sulphur and zinc levels on Nutrients S contents by baby corn (without husk) & stover

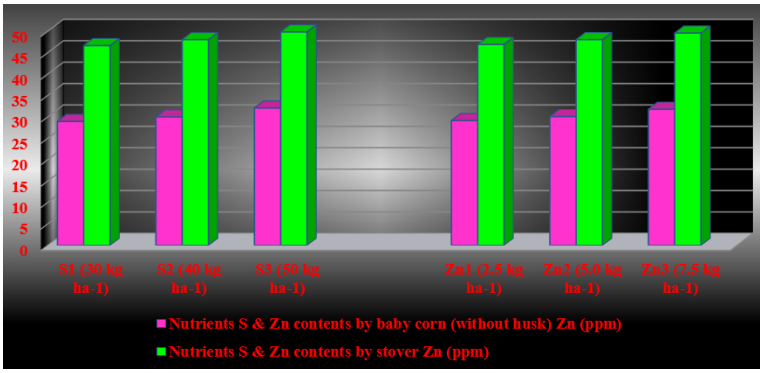

Fig 2: Effect of sulphur and zinc levels on Nutrients Zn contents by baby corn (without husk) & stover

Table 3: Effect of Sulphur and Zinc on nutrients uptake by baby corn (without husk), stover and total nutrients uptake

Sr. No.	Treatment details		Nutrients S and Zn uptakes by baby corn (without husk)		Nutrients S and Zn uptakes by stover		Total Nutrients S and Zn uptakes by baby corn and stover	
			S (kg ha^{-1})	Zn (g ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})
1.	Sulphur	S_1 (30 kg ha^{-1})	7.81	28.95	8.98	183.34	17.69	308.09
		S_2 (40 kg ha^{-1})	10.58	29.98	12.06	226.19	22.64	376.41
		S_3 (50 kg ha^{-1})	14.17	32.08	15.15	293.55	29.32	484.33
		SE(m)±	0.244	5.101	0.602	3.547	0.462	8.399
		CD (P=5%)	0.738	15.425	1.821	10.726	1.396	25.397
2.	Zinc	Zn_1 (2.5 kg ha^{-1})	9.24	29.14	10.26	205.45	20.39	342.90
		Zn_2 (5.0 kg ha^{-1})	10.71	30.08	12.58	228.04	22.37	380.65
		Zn_3 (7.5 kg ha^{-1})	12.61	31.80	13.88	269.63	26.49	445.27
		SE(m)±	0.244	5.101	0.602	3.547	0.462	8.399
		CD (P=5%)	0.738	15.425	1.821	10.726	1.396	25.397

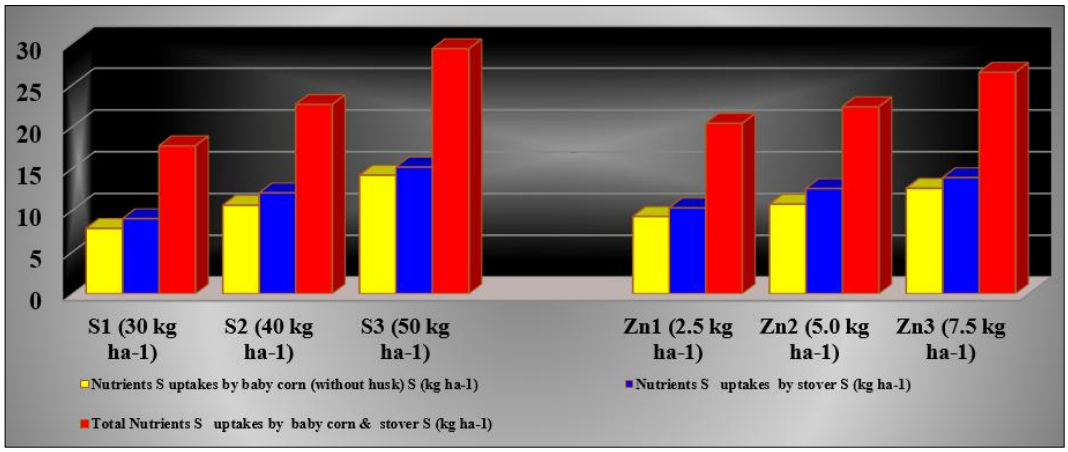

Fig 3: Effect of sulphur and zinc levels on Nutrients S uptakes by baby corn (without husk), stover & total plant

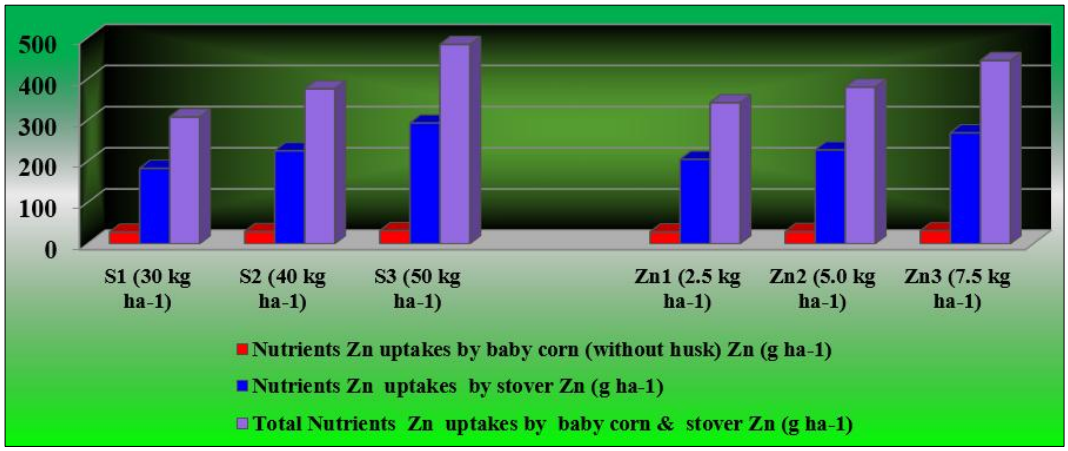

Fig 4: Effect of sulphur and zinc levels on Nutrients Zn uptakes by baby corn (without husk), stover & total plant

Table 4: Effect of Sulphur and Zinc on available N, P_2O_5, K_2O, S and Zn in soil

Sr. No.	Treatments details		Nutrients analysis in soil after harvest to baby corn				
			Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})	Available Zn (g ha^{-1})
1.	Sulphur	S_1	141.77	19.73	189.45	20.41	0.747
		S_2	143.17	19.80	190.82	24.49	0.753
		S_3	143.77	19.91	191.65	29.54	0.758
		SE(m)±	0.136	0.005	0.155	0.001	0.001
		CD (P=5%)	0.411	0.016	0.468	0.002	0.002
2.	Zinc	Zn_1	142.39	19.76	190.06	23.477	0.748
		Zn_2	142.56	19.82	190.46	24.69	0.753
		Zn_3	143.57	19.87	191.40	26.04	0.756
		SE(m)±	0.136	0.005	0.155	0.001	0.001
		CD (P=5%)	0.411	0.016	0.468	0.002	0.002

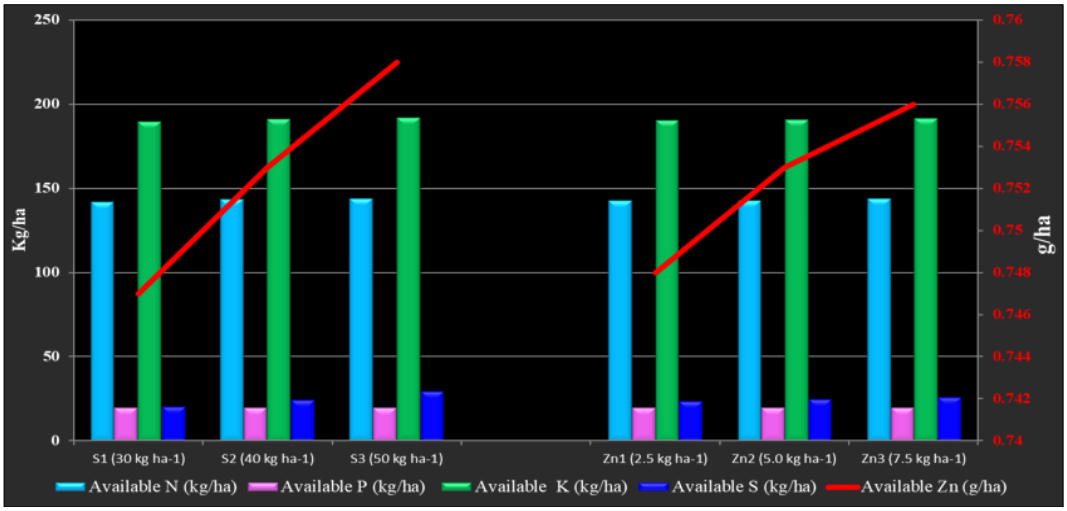

Fig 5: Effect of sulphur and zinc levels on Nutrients N,P,K,S and Zn uptakes by soil after crop harvest

Table 5: Effect of Sulphur and Zinc on Protein content of baby corn

Sr. No.	Treatments details	Protein content (%)
1.	S_1 (30 kg ha^{-1})	8.84
	S_2 (40 kg ha^{-1})	9.40
	S_3 (50 kg ha^{-1})	9.66
	SE(m)±	0.280
	CD (P=5%)	0.092
2.	Zn_1 (2.5 kg ha^{-1})	9.04
	Zn_2 (5.0 kg ha^{-1})	9.40
	Zn_3 (7.5 kg ha^{-1})	9.77
	SE(m)±	0.280
	CD (P=5%)	0.092

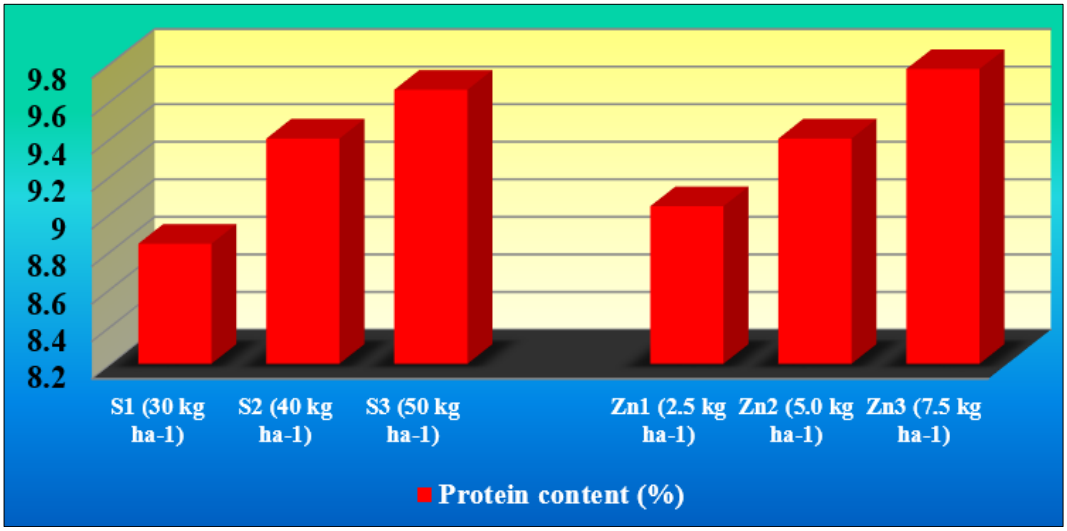

Fig 6: Effect of sulphur and zinc levels on protein quality content by baby corn

Conclusion

The combination of sulphur and zinc levels significantly improved the nutrient uptake, soil fertility and protein content of baby corn. The finding of the experiment concludes that the most favourable outcomes in terms of enhancing soil fertility, S and Zn content (%) and their uptake, and quality. The combination of 50 kg ha^{-1} and 7.5 kg ha^{-1} potential benefit to increased the nutrient uptake, protein and soil fertility of baby corn in Jaunpur.

Competing interests

Authors have declared that no competing interests exists.

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