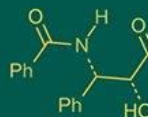


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Opendra Kumar Singh
Ph.D. Research Scholar Soil
Science & Agricultural
Chemistry, Department of
Natural Resource
Management, M.G.C.G.V.V.
Chitrakoot Satna, Madhya
Pradesh, India

Uma Shanker Mishra
Head, Department of Natural
Resource Management,
M.G.C.G.V.V., Chitrakoot,
Satna, Madhya Pradesh, India

Bhoopendra Singh Bais
Ph.D. Research Scholar Soil
Science & Agricultural
Chemistry, Department of
Natural Resource
Management, M.G.C.G.V.V.
Chitrakoot Satna, Madhya
Pradesh, India

Ashutosh Mishra
Ph.D. Research Scholar Soil
Science & Agricultural
Chemistry, Department of
Natural Resource
Management, M.G.C.G.V.V.
Chitrakoot Satna, Madhya
Pradesh, India

Corresponding Author:
Opendra Kumar Singh
Ph.D. Research Scholar Soil
Science & Agricultural
Chemistry, Department of
Natural Resource
Management, M.G.C.G.V.V.
Chitrakoot Satna, Madhya
Pradesh, India

To study the nutrient uptake by mustard (*Brassica juncea*) as the influence by potassium, sulphur & zinc their content & soil fertility status of soil

Opendra Kumar Singh, Uma Shanker Mishra, Bhoopendra Singh Bais and Ashutosh Mishra

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Abstract

The present study was carried out to inspect in rabi season 2022-23 at Rajuala Agriculture Farm at Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot Satna Madhya Pradesh. The treatments are two levels of Sulphur (15 Kg. and 30 Kg./ha⁻¹) and two levels of Zinc (2.5 Kg. & 5.0 Kg./ha⁻¹) in Randomized Block Design with three replication. Nitrogen, Phosphorous, Potassium and Sulphur and Zinc, Nutrient content and uptake by seed and Stover significantly up to 100% NP+ 30 Kg. Sulphur+ 5.0 Kg. Zinc/ha⁻¹ application.

Keywords: Mustard NPK and Sulphur & Zinc nutrient concentration, nutrient uptake, seed & Stover

Introduction

Indian mustard is one of the most important edible oilseeds rabi crop of North India commonly known as Sarson, Rai or Laha. It belongs to the family Brassicaceae and genus Brassica. It comprises various traditionally grown indigenous species, namely, Toria (*Brassica campestris* L. var. toria), Brown sarson (*Brassica juncea* L. var. brown sarson), Yellow sarson (*Sinapis alba* L. var. yellow sarson), Black mustard (*Brassica nigra*) and Taramira (*Eruca sativa/vesicaria* Mill.) which are grown over different parts of the country. Mustard plants are thin herbaceous annuals with yellow flowers and red to brown seeds. Mustard is cultivated for edible oil, condiment, vegetable and animal feed. Mustard contains 35-40% oil which is low in saturated fatty acids and is good source of essential fatty acids (EFA) viz. linolenic acid and linoleic acid. Oil is used for the purpose of cooking, frying, preserving pickles and leaves are used as vegetable. Mustard oil cake is used for cattle feed and as an organic manure due to its high protein and nitrogen content, respectively. Mustard and its derivatives are used in manufacturing of Medicines. It is used as diuretic, emetic, in treatment of inflammatory infections such as rheumatism and arthritis, it also has anti-cancer properties due to presence of antioxidant (tocopherol) in oil and glucosinolates (e.g., indolyl glucosinolate) in seed meal (Kumar, 2012) [8].

India ranks third in terms of area and production of rapeseed-mustard after Canada and China. Globally, the area and production of rapeseed-mustard is 36.81 million hectares and 72.61 million tones, respectively (USDA, 2020). Rapeseed mustard is the second most consumed edible oilseed crop in India, after soybean. India has 6.23 million hectares area under rapeseed mustard and 9.34 million tones production with average productivity of 1499 kg ha⁻¹, which is about three-fourth of the world's average productivity (1960 kg ha⁻¹) (DAC & FW, 2020). Mustard is the main oilseed crop for the Rabi season which is planted on more than 74% area covered under oilseeds. Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana and Gujarat are the highest sown states of mustard seed accounting for more than 70% of total mustard acreage in the country. In India, mustard is cultivated on about 6.69 mha area with a production and productivity of about 10.11 MTs and 1511 kg ha⁻¹ during 2020-21 (Economic Survey, 2021-2022), respectively. However, in Madhya Pradesh, it is grown on about 7.7 lakh ha area with production and productivity of about 13.1 lakh tones and 1713 kg ha⁻¹, respectively (Economic Survey, 2021-2022).

Potassium is one of the seventeen nutrients which are essential for growth and development of plants. Mustard is an important oil seed crop of arid and semi-arid region. Potassium required for improving the yield and quality of different crops. Its effect on photosynthesis water use efficiency and plant tolerance to diseases drought and cold as well as for making the balance protein and carbohydrates. Sulphur is an essential secondary plant nutrient and fourth most important nutrient in crop production to increase quality and productivity of mustard next to N, P and K. It is an essential constituent of S-containing amino acids and helps in synthesis of cystine (27% S), cysteine (26% S) and methionine (21% S), as about 90% of sulphur is present in these amino acids (Havlin *et al.*, 2013) ^[11]. Sulphur is an essential component in the formation of chlorophyll, a constituent of vitamins biotin and thiamine (B1) and iron sulphur proteins called ferredoxins. It also plays a role in activation of various vitamins and enzymes, sulphhydryl (SH) linkages, synthesis of oil and protein (Rathore *et al.*, 2015) ^[1]. It is also a component of glucosinolate and glycosidase enzyme, which are the source of aroma and pungency in mustard oil (Thompson *et al.*, 1986) ^[4]. Compared to other crops mustard is more responsive to sulphur. Therefore, adequate sulphur availability is very crucial for its productivity. Studies have confirmed that sulphur fertilizer increases the growth, yield and quality of Indian mustard (Singh *et al.*, 2015), (Piri *et al.*, 2011) ^[5]. Application of sulphur has a significant effect on oil, fatty acids and glucosinolate content in mustard seeds. Sulphur application also has marked effect on soil properties and is used as soil amendment to improve the availability of other nutrients in soil.

Zinc is one of the essential micronutrients and plays an important role in various enzymatic and physiological activities of the plant. It is required in small but critical concentrations to allow several key plant physiological pathways to function normally (Mousavi *et al.*, 2011) ^[3]. It is also essential for photosynthesis and nitrogen metabolism and important for the stability of cytoplasmic ribosomes, cell division. As co- factor to enzymes like dehydrogenase, proteinase and peptidase in the synthesis of tryptophan, a component of some proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid (Brown *et al.*, 1993) ^[12]. In plants production zinc is one of the most important elements in the carbohydrate metabolism, most enzymes that play a role in carbohydrates metabolism are activated by zinc. In addition, Carbonic anhydrase, Fructose- 1, 6- biphosphate and Aldolase enzymes are activated by zinc. These enzymes are active in the chloroplasts and cytoplasm, six-carbon sugar molecule are separated between chloroplasts and cytoplasm by Fructose-1,6-biphosphate and three-carbon sugars molecule in photosynthesis are transported from cytoplasm to chloroplasts by Aldolase. The activity of these enzymes decreased in zinc deficiency condition, resulting carbohydrate accumulated in plants leaves (Taheri *et al.*, 2011) ^[3].

Materials and Methods

The present investigation entitled “To Study the nutrient uptake by Mustard (*Brassica juncea*) as the influence by Potassium, Sulphur & Zinc their content & Soil Fertility status of Soil.” was a field experiment which was carried out at Rajaula Agriculture farm, of Mahatma Gandhi Chitrakoot

Gramoday Vishwavidyalaya Chitrakoot, Satna (M.P.) during Rabi season of 2022-23. The details about the experiment site, soil and climate is described in this chapter together with the experimental design, layout plan, culture practice, particulars of treatments, planting material and techniques employed for the parameters. Tropical region of Madhya Pradesh between 25.148° North latitude and 80.855° East longitude. The altitude of town is about 190-210 meter above mean sea level. The location enjoys extreme winter and summer temperatures with an average maximum and minimum temperature of 46.9 and 4.8. The major precipitation field between Oct. to Jan. The average rainfall of Chitrakoot area was less than 300mm/year since last year rainfall was very scanty. The mean monthly values pertaining to weather parameters viz. temperature, relative humidity and rainfall during the experimental period. The Soil of the experimental field was sandy loam in region. Soil sample (0-15) depths were initially drawn from randomly selected parts of the field before sowing. The quantity of soil samples was reduced about 500 gm through the quartering technique. The soil sample was then subjected to mechanical and chemical analysis to determine the textural class and fertility status the soils were sampled to a depth of 0-30 cm of Soil, air dried and sieved (2mm) for soil analysis. Some Physical and Chemical Properties of Soils are given in Table-01

Physical and Chemical Properties of Soil

S.NO.	Attributes	Results
1.	Textural Class	Sandy Loam
2.	Sand (%)	50.9
3.	Silt (%)	21.5
4.	Clay (%)	26
5.	Electrical Conductivity (ds/m)	0.26
6.	Bulk Density (Mg m ⁻³)	1.22
7.	Particle Density (Mg m ⁻³)	2.35
8.	pH (1:2.5 soil water suspension ratio)	7.3
9.	Organic Carbon (%)	0.20
11.	Total Nitrogen (kg ha ⁻¹)	94.68
12.	Available Phosphorus (kg P ₂ O ₅ ha ⁻¹)	16.00
13.	Available Potash (kg K ₂ O ha ⁻¹)	308.90
14.	Available Sulphur (kg ha ⁻¹)	26.41
15.	Available zinc (mg kg ⁻¹)	0.542

The variety of Mustard “Pusha Mahak” was taken for investigation. In the current trial treatments were arranged in Randomized Block Design (RBD) with three replications having plot size 5x4 meter square. Amount of Fertilizers are applied @ 80Kg.N, 40Kg.P₂O₅ 40 Kg.K₂O/ha ~ 15Kg.S 30KgS and 2.5Kg. Zn 5.0 Kg. Zn/ha⁻¹ through Urea, DAP, MOP, SSP and Zinc Oxide. Sowing is done 5 Kg. Seed/ha⁻¹. The Variety of Mustard “Pusha Mahak” was used and Sown on 19 Oct 2022. Row to Row and plant to plant distance between 40 and 10 respectively.

Preparation of experimental field-The field was prepared by ploughing with a tractor drawn disc plough by cross harrowing and planking. The field was leveled and weeds, grasses were removed with the help of a rake. Thereafter field was investigation as per plan of layout manually. After preparation of land, the experiment was investigation as per treatment combinations, there were 30 plots and the gross size of each plot was 5.0 m x 4.0 m and the net plot size was 4.5 m x 3.5 m.

Application of Fertilizer- After the layout of experimental plot, the fertilizers were weighed and applied in the plots and thoroughly mixed with soil. As per the experimental recommended doses of Nitrogen, Phosphorus, Potassium and Sulphur were applied to all the plots. Recommended dose of Nitrogen, Phosphorus and Potassium were applied through Urea, DAP and MOP (80:40:40 kg ha⁻¹) whereas Sulphur and Zinc was applied through wet table powder (15, 30 kg S ha⁻¹ and 2.5, 5.0 Kg./ha⁻¹ Zn ha⁻¹) respectively.

Seed and Sowing method- After through mixing organic manures and chemical fertilizer and leveling of soil in experimental plot. The seed sowing was done on 19th Oct. 2022. The sowing of seed in line after making a narrow furrow with the help of pointed wooden stick at different row spacing. The seeds were dropped in the furrow after mixture with fine dust of soil and then after seeds were covered with thin soil layer. The total quantity of seed was required @ 5 kg/ha. The Mustard variety was "Pusa Mahak".

Seed Treatment- To ensure the seeds are free borne diseases, Seeds were treated by thiram 75% WDP 2.0gm/ kg. of Seed. **Thinning and inter cultural operation-**After seed germination, the gap filling was done and densely populated seedlings were spaced at the desired plant spacing of 10 cm by thinning out the excess number of seedling in each row. In addition to this, hoeing and hand weeding were also done twice during the growth period of crop.

Irrigation-Two irrigation was given. The crop was grown totally under rain fed condition.

Harvesting-The crop was harvested on 14th Feb., 2023 when it reached to its physiological maturity i.e. when the leaves were turned yellow and more than 70% capsules were full matured to avoid shattering of the crop.

Threshing -Threshing of 23th Feb., 2023 plot wise produce was done manually. The seed weight was recorded after sun drying the seed for three days. The straw weight was recorded after deducting the seed weight from the bundle weight. The seed and straw weight thus obtained were converted into quintals per hectare on the basis of net plot size.

Yield

The production of each plot collected separately and packed in bags carefully removing inert matter. The grains of each bag were than weighed and recorded in Kg/net plot and there after calculated as Q/ha⁻¹ and Stover yield was also recorded.

Soil Analysis

- **Mechanical separates:** Soil separates analyzed by International pipette method as described by the Piper (1966).
- **pH:** Determination of Soil pH by using soil water suspension (1:2.5) with the help of digital pH meter.
- **EC:** The determined Soil EC by using soil water suspension with the help of digital conductivity meter (Jackson, 1967).
- **Organic Carbon:-**The determined of Organic Carbon by Walkley and Black's rapid titration method as described by Jackson (1967).
- **Available Nitrogen:** It was determined by the Alkaline Potassium Permanganate (0.32%) method described by Subbiah and Asija (1956).

- **Available Phosphorous:** It was determined by Olsen extract method using 0.5 M NaHCO₃ (Olsen et.al 1954).
- **Available of Potassium:** Potassium demined by using Neutral Normal Ammonium Acetate (pH 7.0) by Flame photometer.
- **Available Sulphur:** Sulphur was determined by turbid metric method (Chesnin and Yien 1950) after extraction with 0.15% CaCl₂ solution.
- **Available Zinc:** Zinc was determined by Atomic Absorption Spectrophotometer (AAS) with the help of DTPA extractant. (Lindsey and Novell, 1978).
- **Post harvest analysis:** Treatment wise soil samples were collected just after harvesting of crop and analyzed for Nitrogen, Phosphorus, Potassium Sulphur and Zinc in the samples.
- **Analysis of plant materials:** The uniform and representative plant samples were collected randomly from every plot at harvest.
- **Nitrogen:** It were determined by Micro- Kjeldahl method as described by Jackson, (1967)
- **Phosphorus:** Well ground seed and straw samples were digested in a diacid mixture of HNO₃ and HClO₄ (4:1) and P concentration in extract was estimated calorimetrically method as described by Jackson, (1973).
- **Potassium:** Potassium concentration in the diacid was determined by Flame Photometer as described by Jackson, (1973).
- **Sulphur:** It was determined by the turbid metric method as described by Chesnin and Yien, (1951).
- **Zinc:** Zinc content in grain and straw will be determined in diacid mixture having HNO₃ and HClO₄ (3:1) ratio. The intensity of Zn in solution was measured by Atomic Absorption Spectrophotometer Lindsay and Norvell, (1978).
- **Uptake** To determine the uptake of N P K and Sulphur & Zinc in grain as well as in Stover the following formation is used.

Statistical analysis

The data on various parameters will be subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Chandel, S. R. S. (1990). Wherever, variance ratio (calculated 'F' values) was found significant, critical difference (C.D.) values were computed.

Results

Effect of different treatment on nutrient Concentration & their uptake these are specified that-

Nitrogen Concentration in Seed and Stover

The application of nutrients at increasing level have also significantly increased the Nitrogen content in Seed and Stover. The data disruptive to Nitrogen content (%) in Seed Stover. Nitrogen content Percent Seed + Stover) as Influenced by different levels of Nitrogen, Phosphorous, Potassium, Sulphur & Zinc displayed in Table-1. The analysis of variance in Seed and Stover Nitrogen content percent. The study data in Table-1 confides that Nitrogen content percent in Seed and Stover were absolutely affected by various levels of N,P,K, S & Zinc. Among 100% N,P,K, of RDF with and without S30+Zn5 Kg./ha⁻¹ reported

confidently. Supreme Nitrogen content (3.42, 3.38, and 3.37%) in Seed and (0.553, 0.536, 0.524%) in Stover from T₁₀, T₉, T₈ effectively. The least nitrogen content 3.100% in

Seed and 0.432% in Stover as listed in control. The treatment T₁₀ gave the higher Nitrogen content percent in the pair Seed and Stover.

Table 1: Effects of different Treatments on Nutrient Content% of Nitrogen by Mustard- (Seed + Stover)

Treatment	Treatment Combination	Nutrient Content (%)	
		Seed	Stover
T ₁	Control	3.100	0.432
T ₂	100% NP (RD)	3.217	0.443
T ₃	100% NP + 2.5 kg Zinc	3.260	0.452
T ₄	100% NP + 5.0 kg Zinc	3.280	0.465
T ₅	100% NP + 30 kg Sulphur	3.287	0.475
T ₆	100% NP + 15 kg Sulphur	3.310	0.485
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	3.330	0.493
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	3.371	0.524
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	3.377	0.536
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	3.417	0.553
SEm ± CD _{5%}		0.01	0.01
		0.034	0.026

Phosphorous Concentration in Seed and Stover

The included different levels of NPK with and without S30+Zn5 Kg./ha. Recorded significantly. Highest Phosphorous content (0.70,0.69,0.68%) in Seed and (0.32,0.30,0.29) in Stover from T₁₀, T₄, T₃ respectively. The

lowest Phosphorous content in 0.57% in Seed and 0.23% in Stover as recorded in control (T₁). The treatments have T₁₀ have highest Phosphorous content in pair seed and Stover in Table-02.

Table 2: Effects of different Treatments on Nutrient Content% of Phosphorous by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Nutrient Content (%)	
		Seed	Stover
T ₁	Control	0.670	0.230
T ₂	100% NP (RD)	0.680	0.240
T ₃	100% NP + 2.5 kg Zinc	0.690	0.250
T ₄	100% NP + 5.0 kg Zinc	0.696	0.260
T ₅	100% NP + 30 kg Sulphur	0.694	0.268
T ₆	100% NP + 15 kg Sulphur	0.693	0.275
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	0.695	0.286
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	0.696	0.294
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	0.698	0.297
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	0.712	0.322
SEm ± CD _{5%}		0.002	0.005
		0.007	0.014

Potassium concentration in Seed and Stover

The application of nutrients at increased levels also significantly increased the potassium content in seed and Stover. The observing to Potassium content in seed and Stover show in Table-3. The analysis of variance in seed and Stover Potassium content(%). The perusal of data was reveals that Potassium content in seed and Stover were considerably affected by different levels of N,P,K, S and

Zinc. Among different levels of N,P,K, 100% NP (RD) and with and without S30+Zn5 Kg./ha⁻¹ recorded considerably. Highly Potassium content (0.661, 0.641, 0.634%) in Seed and (0.384,0.327, 0.323%) in Stover from T₁₀,T₉,T₈ respectively. The tinny potassium content was 0.544. in Seed and 0.256% in Stover as founded in control. Treatment T₁₀ has highest Potassium content percentage in pair seed and Stover.

Table 3: Effects of different Treatments on Nutrient Content% of Potassium by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Nutrient Content (%)	
		Seed	Stover
T ₁	Control	0.544	0.256
T ₂	100% NP (RD)	0.560	0.272
T ₃	100% NP + 2.5 kg Zinc	0.575	0.292
T ₄	100% NP + 5.0 kg Zinc	0.584	0.297
T ₅	100% NP + 30 kg Sulphur	0.594	0.298
T ₆	100% NP + 15 kg Sulphur	0.605	0.313
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	0.613	0.319
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	0.634	0.323
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	0.641	0.327
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	0.661	0.384
SEm ± CD _{5%}		0.005	0.015
		0.015	0.043

Sulphur concentration in seed and Stover

The application of nutrients at increased levels also considerably increased the Sulphur content in seed and Stover. The observing to Sulphur content in seed & Stover show Table- 04. The analysis of variance in seed and Stover Sulphur content%. The perusal of data was shows that Sulphur content in seed and Stover were considerably affected by different levels of N, P,K, and 100% NP+S₃₀

Kg./ha⁻¹ with and without Zn₅ Kg./ha⁻¹ recorded considerably. Highly Sulphur Content (0.883,0.873,0.863%) in Seed and (0.414,0.404,0.394%) in Stover from T₁₀, T₅, T₆ respectively. The smallest sulphur content was 0.795% in seed and 0.328% in Stover as founded in control. The (T₁₀) combination has highest Sulphur founded percentage in pair seed and Stover.

Table 4: Effects of different Treatments on Nutrient Content% of Sulphur by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Nutrient Content (%)	
		Seed	Stover
T ₁	Control	0.795	0.328
T ₂	100% NP (RD)	0.798	0.341
T ₃	100% NP + 2.5 kg Zinc	0.820	0.344
T ₄	100% NP + 5.0 kg Zinc	0.834	0.349
T ₅	100% NP + 30 kg Sulphur	0.846	0.357
T ₆	100% NP + 15 kg Sulphur	0.837	0.368
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	0.854	0.383
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	0.863	0.394
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	0.873	0.404
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	0.883	0.414
SEm ±		0.012	0.007
CD _{5%}		0.034	0.021

Zinc concentration in seed and Stover

The application of nutrient at increasing levels have also considerably increased the zinc content in seed and Stover. The Zinc content% as influenced by different levels of N,P,K,S and Zn are showed in table-05. The analysis of variance in seed and Stover zinc content (ppm). The perusal data in Table -05 shows that zinc content (ppm) in seed and Stover were

Considerably affected by different levels of N,P,K,S and Zn. Among different levels of 100%N,P,K+Zn₅ Kg./ha⁻¹ and with and without S₃₀ Kg./ha⁻¹ recoded considerably. The highest Zinc content (48.767,47.937,46.767ppm) in seed and (23.700,22.940,22.500 ppm) in Stover from T₁₀, T₉, T₈ respectively. The smallest zinc content was 40.800 ppm and 16.388 ppm in Stover as registered in control. The (T₁₀) combination has zinc content ppm in pair seed and Stover.

Table 5: Effects of different Treatments on Nutrient Content ppm of Zinc by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Nutrient Content (ppm)	
		Seed	Stover
T ₁	Control	40.800	16.388
T ₂	100% NP (RD)	41.947	16.749
T ₃	100% NP + 2.5 kg Zinc	44.800	20.400
T ₄	100% NP + 5.0 kg Zinc	44.890	22.617
T ₅	100% NP + 30 kg Sulphur	43.770	21.883
T ₆	100% NP + 15 kg Sulphur	42.600	20.967
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	45.943	21.450
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	46.890	22.500
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	47.937	22.940
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	48.767	23.700
SEm ±		0.05	3.292
CD _{5%}		0.13	9.65

Nitrogen Uptake by Seed and Stover

The implementation of various nutrient augmentations at increasing levels separately and in combination considerably increased Nitrogen uptake of seed and Stover at harvest of crop during the year (2022-23) and mean analysis. The Nitrogen uptake Kg./ha⁻¹ in seed, Stover and total Nitrogen was considerably assumed by different levels of N,P,K, S and Zn. Through different levels of N,P,K,0,100% of RDF ha⁻¹with and without S₃₀, Zn₅ Kg./ha⁻¹ recorded considerably highest Nitrogen uptake (66.40 Kg./ha⁻¹) in seed (T₁₀) and considerably highest Nitrogen uptake (32.03 Kg./ha⁻¹) in Stover and (98.43 Kg./ha⁻¹) in total nitrogen uptake and smallest nitrogen uptake of (46.40 Kg./ha⁻¹) in

seed (T₁) and (16.52 Kg./ha⁻¹) in Stover (T₁) were recorded in the control exhibit in table -06

Phosphorous Uptake by seed and Stover

The data belonging to Phosphorous uptake in seed, Stover and total Phosphorous uptake (seed + Stover) Kg./ha⁻¹ as convinced by different levels of N,P,K,S,& Zn are exhibit in Table-07. The implementation of various nutrient augmentation at increasing levels separately and in combination considerably increased Phosphorous uptake of seed and Stover at harvest of crop. The Phosphorous uptake Kg./ha⁻¹ in seed, Stover and total Phosphorous was considerably assumed by different levels of N,P,K,S and Zn.

Table 6: Effects of different Treatments Uptake Nutrient Kg./ha⁻¹ of Nitrogen by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Uptake of Nutrient N Kg./ha ⁻¹		
		Seed	Stover	Total
T ₁	Control	46.40	16.52	62.92
T ₂	100% NP (RD)	47.19	17.40	64.59
T ₃	100% NP + 2.5 kg Zinc	51.27	20.66	71.93
T ₄	100% NP + 5.0 kg Zinc	60.74	22.04	82.78
T ₅	100% NP + 30 kg Sulphur	56.00	29.12	85.12
T ₆	100% NP + 15 kg Sulphur	54.73	26.55	81.28
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	55.68	24.21	79.89
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	53.36	25.55	78.91
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	61.56	27.43	88.99
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	66.40	32.03	98.43
SEm ±		5.74	4.34	
CD _{5%}		16.88	12.73	

Through different levels of N,P,K 0 100% of RDF Kg./ha⁻¹ with and without S30,Zn5+ Kg./ha⁻¹ registered considerably highest Phosphorous uptake (13.83 Kg./ha⁻¹) in seed and considerably highest Phosphorous uptake (18.24 Kg./ha⁻¹) in

Stover and (32.07 Kg./ha⁻¹) in total Phosphorous. The smallest Phosphorous uptake of 9.98 Kg./ha⁻¹ in seed and 8.96 Kg./ha⁻¹ in Stover and 18.94 Kg./ha⁻¹ in total uptake of Phosphorous were registered in the control.

Table 7: Effects of different Treatments of Phosphorous Uptake Kg./ha⁻¹ by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Uptake of Nutrient P Kg./ha ⁻¹		
		Seed	Stover	Total
T ₁	Control	9.98	8.96	19.5
T ₂	100% NP (RD)	10.07	9.52	19.57
T ₃	100% NP + 2.5 kg Zinc	10.81	11.25	22.06
T ₄	100% NP + 5.0 kg Zinc	12.78	12.23	25.01
T ₅	100% NP + 30 kg Sulphur	11.78	16.42	28.2
T ₆	100% NP + 15 kg Sulphur	11.46	15.18	26.64
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	11.62	14.06	25.68
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	11.01	15.00	29.25
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	12.73	14.74	27.47
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	13.83	18.24	28.83
SEm ±		1.21	2.40	
CD _{5%}		3.55	7.03	

Potassium Uptake by seed and Stover

The data belonging to Potassium uptake in seed, Stover and total Potassium uptake (seed + Stover) Kg./ha⁻¹ as convinced by different levels of N,P,K,S, & Zn exhibit in Table-08. The implementation of various nutrient augmentations at increasing levels separately and in combination considerably increased Potassium uptake of seed and Stover at harvest of crop. The Potassium uptake Kg./ha⁻¹ in seed, Stover and total Potassium was

considerably assumed by different levels of N,P,K,S and Zn. Through different levels of N,P,K 0, 100% of RDF Kg./ha⁻¹ with and without S30,Zn5+ Kg./ha⁻¹ registered considerably highest Potassium uptake (12.53 Kg./ha⁻¹) in seed and considerably highest Potassium uptake (19.14 Kg./ha⁻¹) in Stover and (31.67 Kg./ha⁻¹) in total Potassium. The smallest Potassium uptake of (7.97 Kg./ha⁻¹) in seed and (10.00 Kg./ha⁻¹) in Stover and (17.97 Kg./ha⁻¹) in total uptake of Potassium were recorded in the control.

Table 8: Effects of different Treatments of Potassium Uptake Nutrient Kg./ha⁻¹ by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Uptake of Nutrient Kg./ha ⁻¹		
		Seed	Stover	Total
T ₁	Control	7.97	10.00	17.97
T ₂	100% NP (RD)	8.31	10.16	18.4
T ₃	100% NP + 2.5 kg Zinc	9.02	14.91	23.93
T ₄	100% NP + 5.0 kg Zinc	10.82	14.12	24.94
T ₅	100% NP + 30 kg Sulphur	10.23	17.90	28.13
T ₆	100% NP + 15 kg Sulphur	10.10	18.60	28.70
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	10.28	15.61	25.89
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	9.89	18.35	28.24
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	11.58	15.71	27.29
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	12.53	19.14	31.67
SEm ±		0.99	3.21	
CD _{5%}		2.91	9.41	

Sulphur Uptake by seed and Stover

The data belonging to Sulphur uptake in seed, Stover and total Sulphur uptake (seed + Stover) Kg./ha⁻¹ as convinced by different levels of N,P,K,S,& Zn are exhibit in Table-09. The implementation of various nutrient augmentation at increasing levels separately and in combination considerably increased Sulphur uptake of seed and Stover at harvest of crop. The Sulphur uptake Kg./ha⁻¹ in seed, Stover and total Sulphur was considerably assumed by different levels of

N,P,K,S and Zn. Through different levels of N,P,K 0, 100% of RDF Kg./ha⁻¹ with and without S30,Zn5+ Kg./ha⁻¹ registered considerably highest Sulphur uptake (16.18 Kg./ha⁻¹) in seed and considerably highest Sulphur uptake (24.45 Kg./ha⁻¹) in Stover and (41.26 Kg./ha⁻¹) in total Sulphur. The smallest Sulphur uptake of (11.92 Kg./ha⁻¹) in seed and (12.42 Kg./ha⁻¹) in Stover and (24.34 Kg./ha⁻¹) in total uptake of Sulphur were recorded in the control.

Table 8: Effects of different Treatments of Potassium Uptake Nutrient Kg./ha⁻¹ by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Uptake of Nutrient Kg./ha ⁻¹		
		Seed	Stover	Total
T ₁	Control	7.97	10.00	17.97
T ₂	100% NP (RD)	8.31	10.16	18.4
T ₃	100% NP + 2.5 kg Zinc	9.02	14.91	23.93
T ₄	100% NP + 5.0 kg Zinc	10.82	14.12	24.94
T ₅	100% NP + 30 kg Sulphur	10.23	17.90	28.13
T ₆	100% NP + 15 kg Sulphur	10.10	18.60	28.70
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	10.28	15.61	25.89
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	9.89	18.35	28.24
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	11.58	15.71	27.29
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	12.53	19.14	31.67
SEm ±		0.99	3.21	
CD _{5%}		2.91	9.41	

Table 9: Effects of different Treatments of Sulphur Uptake Nutrient Kg./ha⁻¹ by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Uptake of Nutrient Kg./ha ⁻¹		
		Seed	Stover	Total
T ₁	Control	11.92	12.42	24.34
T ₂	100% NP (RD)	12.13	13.05	25.18
T ₃	100% NP + 2.5 kg Zinc	12.64	15.56	28.20
T ₄	100% NP + 5.0 kg Zinc	15.10	16.72	31.82
T ₅	100% NP + 30 kg Sulphur	13.97	19.68	33.65
T ₆	100% NP + 15 kg Sulphur	13.66	18.94	32.60
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	13.95	20.55	34.50
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	13.39	20.69	34.08
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	15.58	24.31	39.31
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	16.81	24.45	41.26
SEm ±		1.44	3.42	
CD _{5%}		4.24	10.02	

Sulphur Uptake by seed and Stover

The data belonging to Sulphur uptake in seed, Stover and total Sulphur uptake (seed + Stover) Kg./ha⁻¹ as convinced by different levels of N,P,K,S,& Zn are exhibit in Table-09. The implementation of various nutrient augmentation at increasing levels separately and in combination considerably increased Sulphur uptake of seed and Stover at harvest of crop. The Sulphur uptake Kg./ha⁻¹ in seed, Stover and total Sulphur was considerably assumed by different levels of N,P,K,S and Zn. Through different levels of N,P,K 0, 100% of RDF Kg./ha⁻¹ with and without S30,Zn5+ Kg./ha⁻¹ registered considerably highest Sulphur uptake (16.18 Kg./ha⁻¹) in seed and considerably highest Sulphur uptake (24.45 Kg./ha⁻¹) in Stover and (41.26 Kg./ha⁻¹) in total Sulphur. The smallest Sulphur uptake of (11.92 Kg./ha⁻¹) in seed and (12.42 Kg./ha⁻¹) in Stover and (24.34 Kg./ha⁻¹) in total uptake of Sulphur were recorded in the control.

Zinc Uptake by seed and Stover

The data belonging to Zinc uptake in seed, Stover and total Zinc uptake (seed + Stover) Kg./ha⁻¹ as convinced by different levels of N,P,K,S,& Zn are exhibit in Table-10. The implementation of various nutrient augmentations at increasing levels separately and in combination considerably increased Zinc uptake of seed and Stover at harvest of crop. The Zinc uptake Kg./ha⁻¹ in seed, Stover and total Zinc was considerably assumed by different levels of N,P,K,S and Zn. Through different levels of N,P,K 0, 100% of RDF Kg./ha⁻¹ with and without S30,Zn5+ Kg./ha⁻¹ registered considerably highest Zinc uptake (874.12 gm./ha⁻¹) in seed and considerably highest Zinc uptake (1387.55 gm./ha⁻¹) in Stover and (2261.67 gm./ha⁻¹) in total Zinc. The smallest Zinc uptake of (615.32 gm./ha⁻¹) in seed and (782.00 gm./ha⁻¹) in Stover and (1397.32 gm./ha⁻¹) in total uptake of Zinc were recorded in the control.

Table 10: Effects of different Treatments of Zinc Uptake gm /ha⁻¹ by Mustard-(Seed + Stover)

Treatment	Treatment Combination	Uptake of Nutrient (gm/ha ⁻¹)		
		Seed	Stover	Total
T ₁	Control	615.32	782.00	1397.32
T ₂	100% NP (RD)	599.35	812.10	1411.70
T ₃	100% NP + 2.5 kg Zinc	772.98	1125.96	1898.94
T ₄	100% NP + 5.0 kg Zinc	810.76	1166.64	1977.40
T ₅	100% NP + 30 kg Sulphur	742.36	1039.78	1781.36
T ₆	100% NP + 15 kg Sulphur	669.30	974.73	1644.03
T ₇	100% NP + 15 kg Sulphur + 2.5 kg Zinc	768.32	1216.37	1984.69
T ₈	100% NP + 15 kg Sulphur + 5.0 kg Zinc	742.59	1243.67	1986.26
T ₉	100% NP + 30 kg Sulphur + 2.5 kg Zinc	874.12	1387.55	2261.67
T ₁₀	100% NP + 30 kg Sulphur + 5.0 kg Zinc	946.09	1471.37	2417.46
SEm ±		75.85	205.48	
CD _{5%}		222.56	602.64	

Discussion

Impact of N,P,K,S and Zn on the nutrient concentration and its uptake by Mustard crop.

Nutrient Concentration

The implementation of various increasing levels of mineral nutrients considerably affected the N,P,K,S and Zn content in seed and Stover of the crop over control during the year and analysis of mean (Table-1,2,3,4,5). The considerably highest NPK content in seed and Stover was showed under treatment 100%NP+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ (T₁₀) over control during the year and in mean of analysis while considerably maximum sulphur content in seed and Stover was recorded with the application of 100%NP+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ in treatment (T₁₀) over control during the year and mean analysis and considerably maximum zinc content in seed and Stover were showed with application of 100%NP+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ (T₁₀) over control during the year and in mean analysis. Through various levels of 100%NP+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ (T₁₀) recorded considerably. Maximum Potassium content (0.661,0.641, 0.634%) in seed and (0.384,0.327,0.323%) in Stover from (T₁₀,T₉,T₈) respectively. The smallest potassium content in 0.544% in seed 0.256% in Stover as recorded in control. The treatment T₁₀ has highest Potassium content percent in both seed and Stover.

Maximum Sulphur Content (0.883,0.873, 0.863%) in Seed and (0.414,0.404,0.394%) in Stover from T₁₀,T₅,T₆ respectively. The smallest sulphur content was 0.795% in seed and 0.328% in Stover as founded in control. The (T₁₀) combination has highest Sulphur founded percentage in pair seed and Stover.

The highest Zinc content (48.767, 47.937, 46.767ppm) in seed and (23.700,22.940, 22.500 ppm) in Stover from T₁₀,T₉,T₈ respectively. The smallest zinc content was 40.800 ppm and 16.388 ppm in Stover as registered in control. The (T₁₀) combination has zinc content ppm in pair seed and Stover. This increased NPK content of nutrient in seed and Stover of the crop with the application of 100%NPK+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ and increase Sulphur and Zinc content of nutrient in seed and Stover of the crop. (Gautam *et al.* 2020) [10] and similar findings are noted by (Rana *et al.* 2018) and Puri and Sharma (2006), Pachuri *et al.* 2012. Deo & Khandewal, (2009) [15].

Nutrient Uptake

The implementation of various increasing levels of mineral nutrient considerably affected the NP, and K, S and Zinc uptake in seed and Stover of the crop over control during the

year and mean analysis (6,7,8,9&10). The Uptake of NP and K, S & Zn by seed & Stover at harvest of the crop also considerably increase with RDF level of mineral nutrients during the year mean analysis. The highest considerably highest uptake of the nutrients in seed & Stover were showed under the treatment levels 100%NPK+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ (T₁₀) during the year and mean analysis over control. This is clear from the data that experimental soil was sandy loam and low organic carbon N,P,K, S & Zn status. Between different levels NPK 0, 100% of RDF Kg./ha⁻¹ with & without S₃₀,Zn₅ Kg./ha⁻¹ recorded considerably highest Nitrogen Uptake 66.40 Kg./ha⁻¹ in seed and considerably highest nitrogen uptake 32.03 Kg./ha⁻¹ in Stover and 98.43 Kg./ha⁻¹ in total uptake (T₁₀). The smallest nitrogen uptake 46.40 Kg./ha⁻¹ in seed & 16.52 Kg./ha⁻¹ in Stover and 63.12 Kg./ha⁻¹ in total nitrogen uptake recorded in Control (T₁). Phosphorous uptake 13.83 Kg./ha⁻¹ in seed and considerably highest Phosphorus uptake 18.24 Kg./ha⁻¹ in Stover and 28.83 Kg./ha⁻¹ in total uptake (T₁₀). The smallest nitrogen uptake 9.98 Kg./ha⁻¹ in seed & 8.96 Kg./ha⁻¹ in Stover and 19.57 Kg./ha⁻¹ in total Phosphorous uptake recorded in Control (T₁).

Potassium uptake 12.53 Kg./ha⁻¹ in seed and considerably highest Potassium uptake 19.31 Kg./ha⁻¹ in Stover and 31.67 Kg./ha⁻¹ in total uptake (T₁₀). The smallest potassium uptake 7.97 Kg./ha⁻¹ in seed & 10.00 Kg./ha⁻¹ in Stover and 17.97Kg./ha⁻¹ in total Potassium uptake recorded in Control (T₁). Sulphur uptake 16.81Kg./ha⁻¹ in seed and considerably highest Sulphur uptake 24.45 Kg./ha⁻¹ in Stover and 41.26 Kg./ha⁻¹ in total uptake (T₁₀). The smallest Sulphur uptake 11.92 Kg./ha⁻¹ in seed & 12.42 Kg./ha⁻¹ in Stover and 24.34 Kg./ha⁻¹ in total Sulphur uptake recorded in Control (T₁).

Zinc uptake 946.09 gm./ha⁻¹ in seed and considerably highest Zinc uptake 1471.37 gm./ha⁻¹ in Stover and 2417.46 gm./ha⁻¹ in total uptake (T₁₀). The smallest Zinc uptake 615.32 gm./ha⁻¹ in seed & 782.00 gm./ha⁻¹ in Stover and 1397.32 gm./ha⁻¹ in total Zinc uptake recorded in Control (T₁).

The increase in uptake of NP,K,S & Zn seems to be associated with increased available with a concomitant increase in crop yield with 100% NPK+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ Zn application (Jat *et al.* 2013). The increase in uptake of NP,K,S & Zn attributed to the application of 100%NPK+30 Kg./ha⁻¹ S+5.0 Kg./ha⁻¹ might due to vigorous roots grow the resulting in higher absorption in the nutrients from the Soil favorable impact on photosynthesis and metabolic process which augments the production of photosynthates and their translocation to various plant parts including seed & Stover and ultimately increased the uptake

of NP,K,S& Zn by Seed and Stover (Upadhyay,2012). Similar results have been also reported by (Saranghem *et al.* 2008). (Kumar and Trivedi,2012) ^[8] and (Pachauri *et al.*, 2012). Impact of NP, K,S & Zn on Uptake & quality parameters of Mustard crop.

Conclusion

The current study suggests that the application of Sulphur and Zinc to the soil at rates of 100% NP+30 Kg +5.0Kg/ha, respectively, is highly effective in enhancing the Nutrient content and Nutrient Uptake of the Mustard crop. Therefore, this treatment is practical for farmers.

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