



# Effect of Zinc Sources on Nutrient Content and Uptake in Soybean [*Glycine max* (L.) Merrill] under the Acidic Soil Conditions of Nagaland

Sentimenla, A.K. Singh, Merasenla

10.18805/LR-4815

## ABSTRACT

**Background:** Soybean is an important legume as well as oil seed crop grown in a varied range of climate and soils. Zinc is an important micronutrient required for plants, animals and human. Its deficiency in soil is a worldwide concern for production of food crops. Therefore two years research in two locations were conducted in 2019 and 2020 to study the nutrient content and uptake of NPK and Zn in soybean with zinc fertilization.

**Methods:** A two years research was conducted in two locations under the acidic soil conditions of Nagaland. Nutrient content and uptake of N, P, K and Zn were recorded at first, second year and pooled. The location, climate, altitude and soil fertility status were recorded in both the sites. Altogether there were 13 treatments and 3 replications. The experimental design used was simple RBD. The data were recorded, analysed and computed statistically.

**Result:** The nutrient uptake of N, K and Zn except P in soybean were significantly found to be increased @ 5 kg ha<sup>-1</sup> ZnSO<sub>4</sub> H<sub>2</sub>O + RDF (T<sub>9</sub>) followed by T<sub>8</sub> and T<sub>10</sub> as compared to control in both the years and pooled.

**Key words:** Nutrient content, Nutrient uptake, Soybean, Zinc.

## INTRODUCTION

Soybean is an important oilseed crop grown on a wide range of soil and agro-climatic conditions. Among the oilseed crops, soybean contain the highest protein 40% and oil 20%. It contains essential amino acids such as glycine, tryptophan and lysine which is similar to cow's milk (Raghuwanshi *et al.*, 2017). Zinc is an important micronutrient required in small amount in plants for activation of various enzymes, reproductive development and fertilization in plants. It plays an important role for production of hormone auxin (Ganeshamurthy *et al.*, 2018).

Its deficiency in plants causes poor growth, yield, quality and affects the water uptake and transport in plants (Hafeez *et al.*, 2013 and Pandey *et al.*, 2018). Its deficiency is increasing worldwide. Low crop production in the North East region of India is seen mainly due to 60% of zinc deficiency (Kumar *et al.*, 2016). Shukla *et al.* (2018) reported 4.62% of zinc deficiency in Nagaland. Zinc deficiency in this region may be due to slash and burn cultivation practices in the hills, leaching due to intense rainfall and runoff which declines the top soil fertility and causes zinc deficiency (Bandyopadhyay *et al.*, 2018). Zinc deficiency can also be induced by leaching in acid soils where available zinc is low in plants (Sutradhar *et al.*, 2016). Lack of restoring the soil fertility along with rapid removal of nutrient by the crop may also lead to zinc deficiency (Chen *et al.*, 2002). It is thus required to be supplied in adequate amount for optimum growth in plants. However limited research has been done in micronutrient in this region. Therefore the present research was conducted to assess the "Effect of zinc sources on nutrient content and uptake

Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema-797 106, Nagaland, India.

**Corresponding Author:** Sentimenla, Krishi Vigyan Kendra, Nagaland University, Lumami-798 627, Nagaland, India.  
Email: sentijamir2009@gmail.com

**How to cite this article:** Sentimenla, Singh, A.K. and Merasenla (2021). Effect of Zinc Sources on Nutrient Content and Uptake in Soybean [*Glycine max* (L.) Merrill] under the Acidic Soil Conditions of Nagaland. Legume Research. DOI: 10.18805/LR-4815.

**Submitted:** 18-10-2021    **Accepted:** 06-12-2021    **Online:** 01-01-2021

in soybean [*Glycine max* (L.) Merrill] under the acidic soil conditions of Nagaland".

## MATERIALS AND METHODS

The present investigation was conducted at the Experimental Research Farm, School of Agricultural Science and Rural Development (SASRD), Medziphema campus, Nagaland University, 2019 in the first year and at the State Horticulture Nursery, Green Park, Dimapur, 2020 in the second year. The soil parameters analysed initially are shown in Table 1. Data on parameters such as NPK and Zn content and uptake in seed and stover were recorded during the first, second year and pooled. The experiment was conducted in randomised blocked design using the soybean crop variety JS 97-52. It consisted of 16 treatments and 3 replications. The zinc sources used were zinc 21% (ZnSO<sub>4</sub> 7H<sub>2</sub>O) @1,

2.5, 5 kg ha<sup>-1</sup>, Zinc 33% (ZnSO<sub>4</sub> H<sub>2</sub>O) @ 1, 2.5, 5 kg ha<sup>-1</sup>, Zn-EDTA 12% @1, 2.5, 5 kg ha<sup>-1</sup>, Liquid ZnO @ 300, 600, 900 ml ha<sup>-1</sup>. RDF was applied @ 20: 60: 40: 30: 1.5 (N:P:K: S:B) kg ha<sup>-1</sup> in all the plots irrespective of the treatment viz. T<sub>1</sub>- 0 (Control), T<sub>2</sub>- RDF + 1 Kg ZnSO<sub>4</sub> 7H<sub>2</sub>O, T<sub>3</sub>- RDF + 1 Kg ZnSO<sub>4</sub> H<sub>2</sub>O, T<sub>4</sub>- RDF + 1 Kg Zn-EDTA, T<sub>5</sub>- RDF + 2.5 Kg ZnSO<sub>4</sub> 7H<sub>2</sub>O ha<sup>-1</sup>, T<sub>6</sub>- RDF + 2.5 Kg ZnSO<sub>4</sub> H<sub>2</sub>O ha<sup>-1</sup>, T<sub>7</sub>- RDF+2.5 Kg Zn-EDTA ha<sup>-1</sup>, T<sub>8</sub>- RDF + 5 Kg ZnSO<sub>4</sub> 7H<sub>2</sub>O ha<sup>-1</sup>, T<sub>9</sub>- RDF + 5 Kg ZnSO<sub>4</sub> H<sub>2</sub>O ha<sup>-1</sup>, T<sub>10</sub>-RDF+5 Kg Zn-EDTA ha<sup>-1</sup>, T<sub>11</sub>- 300 ml ha<sup>-1</sup> liquid ZnO, T<sub>12</sub>- 600 ml ha<sup>-1</sup> liquid ZnO and T<sub>13</sub>- 900 ml ha<sup>-1</sup> liquid ZnO. Lime was added @ 1/10

of LR before 20 days of sowing. The datas recorded were statistically analysed using the F-test (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

### Nutrient content

The N, K and Zn content in seed were observed to be significantly increased at T<sub>9</sub> in first and second years and pooled (Table 2). The highest N, K and Zn content in seed recorded were 6.30, 6.19 and 6.25% N, 1.69, 1.63 and 1.66 % K and 53.69, 63.65 and 58.67 ppm Zn (Table 2), this was

**Table 1:** Initial soil parameters status.

| Initial soil parameters status         | First year (SASRD experimental Farm)- 2019 | Second year (State Horticulture Nursery, Green Park Dimapur)-2020 |
|--|--|---|
| pH                                     | 5.72                                       | 5.68  |
| EC (dsm <sup>-1</sup> )                | 0.22                                       | 0.23  |
| OC (g kg <sup>-1</sup> )               | 5  | 5.2   |
| CEC [cmol(p+) kg <sup>-1</sup> ]       | 12.66                                      | 13.18   |
| N (kg ha <sup>-1</sup> )               | 206.21                                     | 219.10  |
| P (kg ha <sup>-1</sup> )               | 14.15                                      | 14.29   |
| K (kg ha <sup>-1</sup> )               | 108.67                                     | 119.12  |
| Zn (mg kg <sup>-1</sup> )              | 0.20                                       | 0.22  |
| S (Kg ha <sup>-1</sup> )               | 9.57                                       | 9.93  |
| Bulk density (mg m <sup>-3</sup> )     | 1.17                                       | 1.19  |
| Particle density (mg m <sup>-3</sup> ) | 2.26                                       | 2.27  |
| Pore space (%)                         | 48.23                                      | 47.58   |
| Particle size analysis (%)             |  |   |
| Sand                                   | 65.0                                       | 58.1  |
| Silt                                   | 31.5                                       | 28.5  |
| Clay                                   | 26.3                                       | 30.7  |
| Textural class                         | Sandy clay loam                            | Sandy clay loam   |
| Order                                  | Alfisols                                   | Alfisols  |
| Family                                 | Fine typic Kanhapludalf                    | Fine typic Kanhapludalf   |

**Table 2:** Effect of the sources and levels of zinc on NPK and Zn content in seed.

| Treatments  | N (%) |       |        | P %  |      |        | K %   |       |        | Zn (ppm) |       |        |
|---|-------|-------|--------|------|------|--------|-------|-------|--------|----------|-------|--------|
|   | 2019  | 2020  | Pooled | 2019 | 2020 | Pooled | 2019  | 2020  | Pooled | 2019     | 2020  | Pooled |
| T <sub>1</sub> -0 (Control)                                     | 5.67  | 5.58  | 5.63   | 0.22 | 0.21 | 0.21   | 1.12  | 1.13  | 1.13   | 36.20    | 32.14 | 34.17  |
| T <sub>2</sub> - RDF+1 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 5.87  | 5.69  | 5.78   | 0.14 | 0.13 | 0.14   | 1.18  | 1.05  | 1.12   | 37.25    | 36.34 | 36.80  |
| T <sub>3</sub> - RDF+1 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 5.87  | 5.75  | 5.81   | 0.13 | 0.18 | 0.15   | 1.34  | 1.19  | 1.27   | 33.29    | 39.78 | 36.54  |
| T <sub>4</sub> - RDF+1 Kg Zn-EDTA                               | 5.81  | 5.80  | 5.81   | 0.14 | 0.18 | 0.16   | 1.31  | 1.21  | 1.26   | 40.99    | 43.81 | 42.40  |
| T <sub>5</sub> - RDF+2.5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O | 5.87  | 5.65  | 5.76   | 0.16 | 0.15 | 0.15   | 1.28  | 1.36  | 1.32   | 33.90    | 52.20 | 43.05  |
| T <sub>6</sub> - RDF+2.5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O  | 5.80  | 5.68  | 5.74   | 0.13 | 0.16 | 0.15   | 1.44  | 1.31  | 1.38   | 45.40    | 51.28 | 48.34  |
| T <sub>7</sub> - RDF+2.5 Kg Zn-EDTA                             | 5.75  | 5.63  | 5.69   | 0.15 | 0.15 | 0.15   | 1.52  | 1.49  | 1.51   | 43.63    | 49.64 | 46.64  |
| T <sub>8</sub> - RDF+5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 6.03  | 5.88  | 5.96   | 0.18 | 0.17 | 0.17   | 1.63  | 1.59  | 1.61   | 50.84    | 54.56 | 52.70  |
| T <sub>9</sub> - RDF+5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 6.30  | 6.19  | 6.25   | 0.20 | 0.19 | 0.20   | 1.69  | 1.63  | 1.66   | 53.69    | 63.65 | 58.67  |
| T <sub>10</sub> - RDF+5 Kg Zn-EDTA                              | 6.01  | 5.87  | 5.94   | 0.14 | 0.16 | 0.15   | 1.60  | 1.55  | 1.58   | 47.83    | 50.85 | 49.34  |
| T <sub>11</sub> - 300 ml ha <sup>-1</sup> liquid ZnO            | 5.64  | 5.69  | 5.67   | 0.13 | 0.17 | 0.15   | 1.56  | 1.50  | 1.53   | 30.35    | 30.32 | 30.34  |
| T <sub>12</sub> - 600 ml ha <sup>-1</sup> liquid ZnO            | 5.36  | 5.50  | 5.43   | 0.13 | 0.15 | 0.14   | 1.35  | 1.28  | 1.32   | 32.13    | 28.68 | 30.41  |
| T <sub>13</sub> - 900 ml ha <sup>-1</sup> liquid ZnO            | 5.58  | 5.52  | 5.55   | 0.14 | 0.16 | 0.15   | 1.41  | 1.31  | 1.36   | 30.34    | 28.97 | 29.66  |
| SEm±  | 0.02  | 0.01  | 0.01   | 0.02 | 0.02 | 0.02   | 0.01  | 0.01  | 0.01   | 4.35     | 1.31  | 2.27   |
| C.D at 5%   | 0.04* | 0.03* | 0.03*  | NS   | NS   | NS     | 0.03* | 0.02* | 0.02*  | 12.45*   | 3.76* | 6.40*  |

\*S-Significant at P=0.05; NS-Non Significant at P>0.05.

followed by  $T_8$  and  $T_{10}$  in both the years and pooled. The lowest nutrient content in seed was recorded in control. However the P content in seed was not increased significantly and the highest P content was recorded in control plot i.e. 0.22, 0.21 and 0.21% P during both the years and pooled.

In Stover, the N, K and Zn content was significantly increased at  $T_9$  followed by  $T_8$  and  $T_{10}$  among the other zinc sources during the consecutive years and pooled. The P content was not significantly increased except it was increased in the control i.e. 0.20, 0.18 and 0.19% P. The highest nutrient content in stover were 1.71, 1.69 and 1.70% N, 2.62, 2.42 and 2.52% K and 28.33, 28.65 and 28.49 ppm Zn (Table 3). The lowest was recorded at control.

### Nutrient uptake

The NPK and Zn uptake in seed of Soybean were significantly increased at  $T_9$  which was followed by  $T_8$  and  $T_{10}$  in 2019, 2020 and pooled. The highest N, K and Zn uptake in seed recorded during the first, second year and pooled were 114.31, 113.77 and 114.04 N kg ha<sup>-1</sup>, 30.67, 29.96 and 30.32 K kg ha<sup>-1</sup> and 97.42, 116.98 and 107.20 g ha<sup>-1</sup> Zn (Table 4). However for P uptake,  $T_9$  showed increased in P uptake as compared to the rest of the zinc sources but it failed to produce significant result. Similarly, in stover, the N, K and Zn uptake was significantly increased at  $T_9$ . The highest N, P and Zn recorded were 39.07, 38.12, 38.60 N kg ha<sup>-1</sup>, 57.59, 53.88, 55.74 K kg ha<sup>-1</sup> and 62.27, 63.78,

**Table 3:** Effect of the sources and levels of zinc on NPK and Zn content in stover.

| Treatments   | N (%) |      |        | P %  |      |        | K %  |      |        | Zn (ppm) |       |        |
|--|-------|------|--------|------|------|--------|------|------|--------|----------|-------|--------|
|  | 2019  | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019     | 2020  | Pooled |
| $T_1$ - 0 (Control)                                      | 1.53  | 1.48 | 1.51   | 0.20 | 0.18 | 0.19   | 2.03 | 2.16 | 2.10   | 20.12    | 21.48 | 20.80  |
| $T_2$ - RDF + 1 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 1.55  | 1.51 | 1.53   | 0.12 | 0.13 | 0.13   | 2.18 | 2.30 | 2.24   | 22.32    | 23.32 | 22.82  |
| $T_3$ - RDF + 1 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 1.51  | 1.49 | 1.50   | 0.13 | 0.12 | 0.13   | 2.31 | 2.19 | 2.25   | 24.45    | 23.23 | 23.84  |
| $T_4$ - RDF + 1 Kg Zn-EDTA                               | 1.47  | 1.45 | 1.46   | 0.12 | 0.11 | 0.12   | 2.41 | 2.30 | 2.36   | 21.26    | 24.20 | 22.73  |
| $T_5$ - RDF + 2.5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O | 1.51  | 1.59 | 1.55   | 0.13 | 0.10 | 0.12   | 2.42 | 2.20 | 2.31   | 23.14    | 22.50 | 22.82  |
| $T_6$ - RDF + 2.5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O  | 1.53  | 1.54 | 1.54   | 0.11 | 0.13 | 0.12   | 2.37 | 2.21 | 2.29   | 24.03    | 23.96 | 24.00  |
| $T_7$ - RDF + 2.5 Kg Zn-EDTA                             | 1.55  | 1.52 | 1.54   | 0.12 | 0.10 | 0.11   | 2.33 | 2.28 | 2.30   | 24.10    | 24.23 | 24.17  |
| $T_8$ - RDF + 5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 1.67  | 1.66 | 1.66   | 0.12 | 0.12 | 0.12   | 2.55 | 2.33 | 2.44   | 26.21    | 26.47 | 26.34  |
| $T_9$ - RDF + 5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 1.71  | 1.69 | 1.70   | 0.17 | 0.14 | 0.16   | 2.62 | 2.42 | 2.52   | 28.33    | 28.65 | 28.49  |
| $T_{10}$ - RDF + 5 Kg Zn-EDTA                            | 1.65  | 1.64 | 1.65   | 0.17 | 0.13 | 0.15   | 2.45 | 2.35 | 2.40   | 24.67    | 25.65 | 25.16  |
| $T_{11}$ - 300 ml ha <sup>-1</sup> liquid ZnO            | 1.34  | 1.30 | 1.32   | 0.10 | 0.12 | 0.11   | 2.33 | 2.29 | 2.31   | 22.12    | 21.32 | 21.72  |
| $T_{12}$ - 600 ml ha <sup>-1</sup> liquid ZnO            | 1.46  | 1.31 | 1.39   | 0.11 | 0.12 | 0.12   | 2.28 | 2.07 | 2.18   | 23.16    | 22.11 | 22.64  |
| $T_{13}$ - 900 ml ha <sup>-1</sup> liquid ZnO            | 1.31  | 1.38 | 1.35   | 0.13 | 0.14 | 0.14   | 2.39 | 2.16 | 2.28   | 23.64    | 21.21 | 22.43  |
| SEm±   | 0.01  | 0.01 | 0.01   | 0.03 | 0.02 | 0.02   | 0.01 | 0.01 | 0.01   | 0.47     | 0.72  | 0.43   |
| C.D at 5%  | 0.02  | 0.03 | 0.02   | NS   | NS   | NS     | 0.03 | 0.04 | 0.02   | 1.35     | 2.07  | 1.21   |

\*S-Significant at P=0.05; NS-Non significant 0.05.

**Table 4:** Effect of the sources and levels of zinc on NPK and Zn uptake in Seed.

| Treatments   | N (kg ha <sup>-1</sup> ) |        |        | P (kg ha <sup>-1</sup> ) |      |        | K (kg ha <sup>-1</sup> ) |       |        | Zn (g ha <sup>-1</sup> ) |        |        |
|--|--------------------------|--------|--------|--------------------------|------|--------|--------------------------|-------|--------|--------------------------|--------|--------|
|  | 2019                     | 2020   | Pooled | 2019                     | 2020 | Pooled | 2019                     | 2020  | Pooled | 2019                     | 2020   | Pooled |
| $T_1$ - 0 (Control)                                      | 79.75                    | 79.47  | 79.61  | 3.09                     | 2.99 | 3.04   | 15.75                    | 16.39 | 16.07  | 50.91                    | 45.77  | 48.34  |
| $T_2$ - RDF + 1 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 87.86                    | 84.99  | 86.43  | 3.10                     | 2.73 | 2.92   | 17.66                    | 15.68 | 16.67  | 55.75                    | 54.28  | 55.02  |
| $T_3$ - RDF + 1 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 89.50                    | 88.65  | 89.08  | 1.99                     | 2.78 | 2.39   | 20.50                    | 18.35 | 19.43  | 50.93                    | 61.33  | 56.13  |
| $T_4$ - RDF + 1 Kg Zn-EDTA                               | 92.18                    | 92.75  | 92.47  | 2.22                     | 2.88 | 2.55   | 20.78                    | 19.35 | 20.07  | 65.03                    | 70.06  | 67.55  |
| $T_5$ - RDF + 2.5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O | 94.92                    | 92.12  | 93.52  | 2.59                     | 2.45 | 2.52   | 20.70                    | 22.17 | 21.44  | 54.82                    | 85.11  | 69.97  |
| $T_6$ - RDF + 2.5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O  | 98.97                    | 98.80  | 98.89  | 2.48                     | 2.78 | 2.63   | 24.57                    | 22.79 | 23.68  | 77.47                    | 89.20  | 83.34  |
| $T_7$ - RDF + 2.5 Kg Zn-EDTA                             | 97.37                    | 96.77  | 97.07  | 2.54                     | 2.58 | 2.56   | 25.74                    | 25.61 | 25.68  | 73.88                    | 85.33  | 79.61  |
| $T_8$ - RDF + 5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 106.36                   | 102.87 | 104.62 | 3.18                     | 2.97 | 3.08   | 28.82                    | 27.33 | 28.07  | 89.87                    | 95.45  | 92.66  |
| $T_9$ - RDF + 5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 114.31                   | 113.77 | 114.04 | 3.63                     | 3.49 | 3.56   | 30.67                    | 29.96 | 30.32  | 97.42                    | 116.98 | 107.20 |
| $T_{10}$ - RDF + 5 Kg Zn-EDTA                            | 99.15                    | 100.16 | 99.66  | 2.31                     | 2.73 | 2.52   | 26.40                    | 25.57 | 25.99  | 78.91                    | 86.77  | 82.84  |
| $T_{11}$ - 300 ml ha <sup>-1</sup> liquid ZnO            | 89.73                    | 90.23  | 89.98  | 2.06                     | 2.70 | 2.38   | 24.82                    | 24.02 | 24.42  | 48.28                    | 48.08  | 48.18  |
| $T_{12}$ - 600 ml ha <sup>-1</sup> liquid ZnO            | 82.28                    | 85.26  | 83.77  | 2.00                     | 2.33 | 2.17   | 20.72                    | 19.84 | 20.28  | 49.32                    | 44.46  | 46.89  |
| $T_{13}$ - 900 ml ha <sup>-1</sup> liquid ZnO            | 86.95                    | 84.27  | 85.61  | 2.18                     | 2.44 | 2.31   | 21.97                    | 20.00 | 20.99  | 47.28                    | 44.23  | 45.76  |
| SEm±   | 0.03                     | 0.01   | 0.02   | 0.64                     | 0.57 | 0.43   | 0.01                     | 0.17  | 0.09   | 0.01                     | 0.01   | 0.01   |
| C.D at 5%  | 0.09*                    | 0.02*  | 0.04*  | NS                       | NS   | NS     | 0.03*                    | 0.49* | 0.24*  | 0.03*                    | 0.03*  | 0.02*  |

\*S-Significant at P=0.05; NS-Non significant at P>0.05.

**Table 5:** Effect of the sources and levels of zinc on NPK and Zn uptake in Stover.

| Treatments  | N uptake (kg ha <sup>-1</sup> ) |       |        | P uptake (kg ha <sup>-1</sup> ) |      |        | K uptake (kg ha <sup>-1</sup> ) |       |        | Zn (g ha <sup>-1</sup> ) |       |        |
|---|---------------------------------|-------|--------|---------------------------------|------|--------|---------------------------------|-------|--------|--------------------------|-------|--------|
|   | 2019                            | 2020  | Pooled | 2019                            | 2020 | Pooled | 2019                            | 2020  | Pooled | 2019                     | 2020  | Pooled |
| T <sub>1</sub> - 0 (Control)                                      | 32.55                           | 32.28 | 32.42  | 3.38                            | 2.99 | 3.19   | 34.26                           | 35.94 | 35.10  | 33.95                    | 35.74 | 34.85  |
| T <sub>2</sub> - RDF + 1 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 27.57                           | 26.81 | 27.19  | 2.13                            | 2.28 | 2.21   | 38.78                           | 40.34 | 39.56  | 39.71                    | 40.90 | 40.31  |
| T <sub>3</sub> - RDF + 1 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 27.26                           | 26.81 | 27.04  | 2.33                            | 2.16 | 2.25   | 41.43                           | 38.86 | 40.15  | 43.86                    | 41.80 | 42.83  |
| T <sub>4</sub> - RDF + 1 Kg Zn-EDTA                               | 28.38                           | 28.84 | 28.61  | 2.57                            | 1.95 | 2.26   | 46.52                           | 45.75 | 46.14  | 41.04                    | 48.14 | 44.59  |
| T <sub>5</sub> - RDF + 2.5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O | 30.17                           | 33.61 | 31.89  | 2.60                            | 2.08 | 2.34   | 48.35                           | 46.50 | 47.43  | 46.24                    | 47.56 | 46.90  |
| T <sub>6</sub> - RDF + 2.5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O  | 32.08                           | 32.68 | 32.38  | 2.30                            | 2.76 | 2.53   | 48.65                           | 46.90 | 47.78  | 48.98                    | 48.03 | 48.51  |
| T <sub>7</sub> - RDF + 2.5 Kg Zn-EDTA                             | 31.30                           | 32.40 | 31.85  | 1.94                            | 2.13 | 2.04   | 46.44                           | 48.61 | 47.53  | 48.67                    | 52.45 | 50.56  |
| T <sub>8</sub> - RDF + 5 Kg ZnSO <sub>4</sub> 7H <sub>2</sub> O   | 35.66                           | 36.49 | 36.08  | 2.56                            | 2.64 | 2.60   | 54.44                           | 51.21 | 52.83  | 55.95                    | 56.18 | 56.07  |
| T <sub>9</sub> - RDF + 5 Kg ZnSO <sub>4</sub> H <sub>2</sub> O    | 37.59                           | 37.62 | 37.61  | 2.84                            | 2.41 | 2.63   | 57.59                           | 53.88 | 55.74  | 62.27                    | 63.78 | 63.03  |
| T <sub>10</sub> - RDF + 5 Kg Zn-EDTA                              | 33.17                           | 34.25 | 33.71  | 2.61                            | 2.81 | 2.71   | 49.46                           | 49.08 | 49.27  | 50.95                    | 54.31 | 52.63  |
| T <sub>11</sub> - 300 ml ha <sup>-1</sup> liquid ZnO              | 25.89                           | 30.47 | 28.18  | 1.98                            | 2.57 | 2.27   | 46.05                           | 45.08 | 45.57  | 43.72                    | 41.80 | 42.76  |
| T <sub>12</sub> - 600 ml ha <sup>-1</sup> liquid ZnO              | 29.44                           | 27.36 | 28.40  | 2.00                            | 2.21 | 2.11   | 41.41                           | 38.17 | 39.79  | 42.06                    | 40.77 | 41.42  |
| T <sub>13</sub> - 900 ml ha <sup>-1</sup> liquid ZnO              | 28.63                           | 28.79 | 28.71  | 2.44                            | 2.56 | 2.50   | 44.68                           | 41.33 | 43.01  | 44.19                    | 38.79 | 41.49  |
| SEm±  | 0.01                            | 0.01  | 0.01   | 0.48                            | 0.50 | 0.35   | 0.01                            | 0.01  | 0.01   | 0.01                     | 0.07  | 0.04   |
| C.D at 5%   | 0.03                            | 0.03  | 0.02   | NS                              | NS   | NS     | 0.04                            | 0.04  | 0.03   | 0.03                     | 0.21  | 0.10   |

\*S-Significant at P=0.05; NS-Non significant at P>0.05.

63.03 Zn g ha<sup>-1</sup> in both the years and pooled respectively (Table 5) which was closely followed by T<sub>8</sub> and T<sub>10</sub>. The lowest being recorded at control in both the seed and stover. The P uptake failed to produce significant result in stover and the highest was recorded in control (3.58, 2.99 and 3.29 kg ha<sup>-1</sup>).

The significant increased in the nitrogen content and uptake in seed and stover of green gram @ 5.0 kg ha<sup>-1</sup> was also reported by Solanki *et al.* (2017). This increased in nitrogen content and uptake in seed and stover might be due to synthesis of protein, fat and carbohydrates due to stimulation by zinc application on the proteinase, dehydrogenase and peptidase enzyme (Balai *et al.*, 2017). The application of zinc significantly decreased the phosphorus content in seed of black gram as compared to control (Meena *et al.*, 2021). Yadav *et al.* (2021) reported significant increased in N, K and Zn content and uptake with the application of 6.0 and 4.0 kg Zn ha<sup>-1</sup> over control in pearl millet. Keram *et al.* (2012) observed that nutrient uptake of N, K and Zn except total P increased significantly with the application of recommended NPK+Zn @ 20 kg ha<sup>-1</sup> in wheat. This reduction in P content and uptake may be due to the increased in the concentration of zinc which hinders the P absorption and translocation from the roots to the plants due the antagonistic effect between Zn and P (Singh *et al.*, 2012). Choudhary *et al.* (2016) reported significant increased in K content and uptake in chickpea @ 5 kg Zn ha<sup>-1</sup> which might be due to its higher availability in the soil leading to more absorption by the crop. The increased in the Zn content and uptake might be due to positive response to zinc application in the soil which increases its availability in the soil leading to higher Zn uptake by the crops (Raghuwanshi *et al.*, 2017).

## CONCLUSION

From the experiment conducted, it was observed that the application of 5 kg ZnSO<sub>4</sub> H<sub>2</sub>O ha<sup>-1</sup> + RDF (T<sub>9</sub>) significantly increased the nutrient content and uptake of N, K and Zn which was followed by T<sub>8</sub> and T<sub>10</sub> among all the other zinc sources in soybean under the acidic foothill condition of Nagaland.

## REFERENCES

- Balai, K., Jajoria, M., Verma, R., Deewan, P. and Bairwa, S.K. (2017). Nutrient content, uptake, quality of chickpea and fertility status of soil as influenced by fertilization of phosphorus and zinc. *Journal of Pharmacognosy and Phytochemistry*. 6(1): 392-39.
- Bandyopadhyay, S. Ray, P., Padua, S., Ramachandran, S., Jena, R.K., Roy, P.D., Dutta, D.P., Singh, S.K. and Ray, S.K. (2018). Priority zoning of available micronutrient in the soils of agroecological sub-regions of north-east india using geo-spatial techniques. *Agricultural Research*. 7(2). 15.
- Chen, Y., Han S. and Zhou Y. (2002). The rhizosphere ph of pinus koraiensis seedlings as affected by N sources of different levels and its effect on the availability and uptake of Fe, Mn, Cu and Zn. *Journal of Forestry Research*. 13(1): 37-40.
- Choudhary, G.L., Rana, K.S., Bana, R.S. and Prajapat. K. (2016). Moisture conservation and zinc fertilization impacts on quality, profitability and moisture use indices of chickpea (*Cicer arietinum* L.) under limited moisture conditions. *Legume Research*. 39(5): 734-740.
- Ganeshamurthy, A.N., Raghupathi, H.B., Rupa, T.R., Rajendiran, S., Kalaivanan, D. (2018). Micronutrient management in horticultural crops. *Indian Journal of Fertilisers*. 14(4): 68-85.
- Gomez, K.A. and A.A. Gomez, (1984). *Statistical Procedures for Agricultural Research*.

- Hafeez, B., Khanif, Y.M., Saleem, M. (2013). Role of Zinc in Plant Nutrition-A Review. American Journal of Experimental Agriculture. 3(2): 374-391.
- Keram, K.S., Sharma, B.L. and Sawarkar, S.D. (2012). Impact of Zn application on yield, quality, nutrients uptake and soil fertility in a medium deep black soil (vertisol). International Journal of Science, Environment and Technology. 1(5): 563-571.
- Kumar, M., Jha, A.K., Hazarika, S., Verma, B.C., Choudhury, B.U., Ramesh, T. and Devi, M.H. (2016). Micronutrients (B, Zn, Mo) for improving crop production on acid soils of Northeast India. National Academy of Science Letters. 39(2): 85-89.
- Meena, M., Jat, G., Meena, R.H., Choudhary, R. Jain, D., Doodhwal, K., Jat, H. and Yadav, S.K. (2021). Effect of phosphorus enriched compost and zinc on productivity and nutrient uptake of blackgram (*Vigna mungo* L.) in sub-humid Southern Hills and Aravalli Region of Rajasthan. Legume Research. DOI: 10.18805/LR-4359.
- Pandey, A.K. Singh, M., Kumar, S., Meena, V.K., Onte S. and Kushwaha, M. (2019). Influence of stage of harvesting and zinc application on yield and zinc uptake in cluster bean [*Cyamopsis tetragonoloba* (L.) TAUB]. Legume research, vol 42(5): 661-665.
- Raghuwanshi, N., Sharma, B.L., Ukey, I. and Prajapati, S. (2017). Residual and cumulative effect of zinc on yield, quality of soybean (*Glycine max* L.) and various pools of zinc in a vertisol of Madhya Pradesh, cv. JS 97-52. International Journal of Bio-resource and Stress Management. 8(3): 444-449.
- Rohini, V., Katkar, R.N., Sathyanarayana, E., Hadke, P.B, Kharche, V.K., Jadhao, S.D. and Walke, R.D. (2020). Effect of zinc on uptake of micronutrients by soybean (*Glycine Max*. L.) in swell shrink soil. Journal of Pharmacognosy and Phytochemistry. 9(5): 373-378.
- Shukla, A.K., Behera, S.K., Pakhare, A. and Chaudhari, S.K. (2018). Micronutrients in soils, plants, animals and humans. Indian Journal of Fertilisers. 14(4): 30-54.
- Singh, D. and Singh, H. (2012). Effect of phosphorus and zinc nutrition on yield, nutrient uptake and quality of chickpea. Annals of Plant and Soil Research. 14(1): 71-74.
- Singh, M.V. (2007). Problems of Micro and Secondary Nutrients in Acidic Soils of India and their Management. In: [Rattan RK (ed)]. Bulletin of the Indian Society of Soil Science. 25: 27-58.
- Solanki, D., Swetha, P. and Solanki, M.S. (2017). Effect of sulphur and zinc on content and uptake of nutrients of summer green gram [*Vigna Radiata* (L.) Wilezeck] under medium black calcareous soils. International Journal of Agricultural Science and Research. 7(4): 657-662.
- Sutradhar, A.K., Kaiser, D.E. and Rosen, C.J. (2016). Zinc for Crop Production. University of Minnesota Extension.
- Yadav, S.K., Dudwal, B.L., Yadav, V.L., Sarita, Yadav, K.C. and Yadav, J.K. (2021). Effect of moisture conservation practices and zinc fertilization on nutrient status and quality of pearl millet [*Pennisetum glaucum* (L.)] under rainfed condition. Indian Journal of Agricultural Research. 55(5): 629-633.