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## Effect of nano fertilizers on the productivity of groundnut (*Arachis hypogaea* L.)

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### Abstract

The present investigation entitled “Effect of Nano Fertilizers on the Productivity of Groundnut (*Arachis hypogaea* L.)” was conducted at AICRP on Summer Groundnut, MPKV, Rahuri during Summer 2025. The experiment consists of eleven treatments viz, T<sub>1</sub>: Absolute Control, T<sub>2</sub>: RDF (25:50:00 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>3</sub>: GRDF (25:50:00 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup> + FYM 10 t ha<sup>-1</sup>), T<sub>4</sub>: GRDF + Zinc Sulphate @2 g/lit foliar spray at 25 and 45 DAS, T<sub>5</sub>: GRDF + Nanoscale Zinc Oxide @2 g/15 lit foliar spray at 25 and 45 DAS, T<sub>6</sub>: GRDF + Nanoscale Zinc Oxide @2 g/10 lit foliar spray at 25 and 45 DAS, T<sub>7</sub>: GRDF + Nanoscale Calcium Oxide @2 g/15 lit foliar spray at 25 and 45 DAS, T<sub>8</sub>: GRDF + Nanoscale Calcium Oxide @2 g/10 lit foliar spray at 25 and 45 DAS, T<sub>9</sub>: GRDF + Nano Sulphur @2.5ml/lit foliar spray at 30 and 45 DAS, T<sub>10</sub>: GRDF + Nano Sulphur @ 5 ml/lit foliar spray at 30 and 45 DAS, T<sub>11</sub>: GRDF + Gypsum @ 500 kg/ha 50% at basal dose, 50% at pegging stage. The experiment was laid out in randomized block design (RBD) with 3 replications. The soil texture of the experimental site was found to be sandy clay loam. Soil was low in available nitrogen (198.56 kg ha<sup>-1</sup>), medium in available phosphorus (17.36 kg ha<sup>-1</sup>), high in potassium (327.56 kg ha<sup>-1</sup>), moderately high in available sulphur (15.78 mg kg<sup>-1</sup>), low in available zinc (0.43 mg kg<sup>-1</sup>) and high in available calcium (26.56 cmol kg<sup>-1</sup>). The soil was slightly alkaline in reaction (pH 8.19) with normal in electrical conductivity of 0.33 dSm<sup>-1</sup>. The results revealed that T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, recorded significantly superior performance with respect to yield attributes and yield. This treatment registered the highest number of pods plant<sup>-1</sup> (33.11), pod weight plant<sup>-1</sup> (36.24 g), number of filled pods plant<sup>-1</sup> (31.50), shelling percentage (70.05%), pod yield (36.58 q ha<sup>-1</sup>), kernel yield (25.66 q ha<sup>-1</sup>), haulm yield (48.23 q ha<sup>-1</sup>) and biological yield (84.81 q ha<sup>-1</sup>). However, T<sub>11</sub> was found to be statistically at par with T<sub>10</sub> i.e., GRDF + Nano sulphur foliar spray @ 5 ml l<sup>-1</sup> applied at 30 and 45 DAS and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> applied at 30 and 45 DAS for most of the yield attributes and yield parameters.

**Keywords:** Groundnut, gypsum, GRDF, foliar application, yield attributes

### Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop belonging to the family Fabaceae (Leguminosae) and genus *Arachis*. The name *Arachis hypogaea* is derived from Greek, where *Arachis* denotes “legume” and *hypogaea* means “below ground,” referring to its unique pod development beneath the soil surface. The crop possesses a chromosome number of 2n = 40. Groundnut is valued for its high nutritional composition, containing approximately 23-26% protein and 45-50% oil, which has earned it the titles “King of Vegetable Oilseed Crops” and “Poor Man’s Nut” (Kumar *et al.*, 2013) [7]. It plays a crucial role in the edible oil economy of India and is believed to have originated in South America. Globally, groundnut is a major oilseed crop contributing significantly to edible oil supplies and serving as an affordable protein source, particularly in developing countries. India is the second largest producer of groundnut after China. The major producing countries include China, India, Nigeria, Sudan, and the USA, contributing 36.01%, 13.79%, 9.12%, 5.80%, and 5.11% of global production, respectively (Anonymous, 2023) [12]. Micronutrient deficiencies, particularly of zinc and calcium, are widespread in Indian soils and human populations. Zinc deficiency affects nearly 40% of Indian soils and has significant implications for crop productivity and human health, leading to impaired immunity and

Growth disorders (Shukla *et al.*, 2016) [13]. Similarly, calcium deficiency in groundnut adversely affects pod development, resulting in unfilled pods and poor seed quality. In recent years, nanotechnology has emerged as a promising approach in agriculture to enhance nutrient use efficiency and crop productivity. Nanotechnology involves the manipulation of materials at the nanoscale (1-100 nm), where particles exhibit unique physicochemical properties such as increased surface area and reactivity. In agricultural systems, nano-fertilizers offer advantages including improved nutrient availability, reduced losses, and targeted delivery. Zinc nanoparticles (ZnO NPs) have gained considerable attention due to their potential to improve seed germination, plant growth, and yield. Conventional zinc fertilizers such as zinc sulfate (ZnSO<sub>4</sub>) and EDTA-chelated zinc often suffer from low efficiency due to leaching and poor retention. Moreover, zinc sulfate may cause phytotoxic effects such as leaf scorching under high-temperature conditions due to its high salt index (Kisan *et al.*, 2015) [5]. In contrast, nano-zinc formulations provide a more efficient and controlled nutrient supply (Wigginton *et al.*, 2007) [17]. Calcium is another essential nutrient for groundnut, particularly during the pod-filling stage, as developing pods absorb calcium directly from the soil. Deficiency leads to the formation of “pops” (empty pods) and reduced germination potential (Meena *et al.*, 2007) [8]. Sulphur plays a vital role in plant metabolism, including protein synthesis, chlorophyll formation, and oil biosynthesis. It is also essential for the formation of sulphur-containing amino acids such as methionine and cysteine and enhances nodulation and nitrogen fixation in legumes (Hawkesford & De Kok, 2006) [4]. Nano-sulphur formulations have shown potential to improve sulphur use efficiency by enabling slow and sustained nutrient release in the rhizosphere, thereby minimizing nutrient losses (Chen *et al.*, 2011) [3]. Furthermore, nano-fertilizers can interact effectively with soil particles, reducing nutrient fixation and improving nutrient availability. Nano-coating technologies enable controlled nutrient release, ensuring synchronization with crop demand and contributing to sustainable agricultural practices (Subramanian & Tarafdar, 2011) [16]. The present investigation entitled “Effect of Nano Fertilizers on the Productivity of Groundnut (*Arachis hypogaea* L.)” was conducted to study the effect on productivity, quality and economics of groundnut cultivation.

## Materials and Methods

The field experiment was conducted during summer season of 2025 at AICRP on summer groundnut, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India). The soil texture of the experimental site was found to be sandy clay loam. Soil was low in available nitrogen (198.56 kg ha<sup>-1</sup>), medium in available phosphorus (17.36 kg ha<sup>-1</sup>), high in potassium (327.56 kg ha<sup>-1</sup>), moderately high in available sulphur (15.78 mg kg<sup>-1</sup>), low in available zinc (0.43 mg kg<sup>-1</sup>) and high in available calcium (26.56 cmol kg<sup>-1</sup>). The soil was slightly alkaline in reaction (pH 8.19) with normal in electrical conductivity of 0.33 dSm<sup>-1</sup>. Agro-climatically this area falls under scarcity zone (drought prone area) of Maharashtra state. There were eleven treatments laid out in randomized block design (RBD) with three replications. Each experimental plot was with gross plot size of 5.00 m x 4.50 m and net plot size of 4.60 m x 3.30 m. The experiment consists of eleven treatments viz,

T<sub>1</sub>: Absolute Control, T<sub>2</sub>: RDF (25:50:00 N: P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>3</sub>: GRDF (25:50:00 N: P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O kg ha<sup>-1</sup> + FYM 10 t ha<sup>-1</sup>), T<sub>4</sub>: GRDF + Zinc Sulphate @2 g/lit foliar spray at 25 and 45 DAS, T<sub>5</sub>: GRDF + Nanoscale Zinc Oxide @2 g/15 lit foliar spray at 25 and 45 DAS, T<sub>6</sub>: GRDF + Nanoscale Zinc Oxide @2 g/10 lit foliar spray at 25 and 45 DAS, T<sub>7</sub>: GRDF + Nanoscale Calcium Oxide @2 g/15 lit foliar spray at 25 and 45 DAS, T<sub>8</sub>: GRDF + Nanoscale Calcium Oxide @2 g/10 lit foliar spray at 25 and 45 DAS, T<sub>9</sub>: GRDF + Nano Sulphur @2.5ml/lit foliar spray at 30 and 45 DAS, T<sub>10</sub>: GRDF + Nano Sulphur @ 5 ml/lit foliar spray at 30 and 45 DAS, T<sub>11</sub>: GRDF + Gypsum @ 500 kg/ha 50% at basal dose, 50% at pegging stage. The variety of groundnut known as Phule unnati with seed rate of 100 kg ha<sup>-1</sup> was used. Sowing was done by dibbling method with spacing 30 cm x 10 cm on January 10, 2025.

## Results and Discussion

### Yield attributing characters

#### Number of pods plant<sup>-1</sup>

Number of pods plant<sup>-1</sup> was significantly influenced by different treatments. The highest number of pods plant<sup>-1</sup> (33.11) was recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, which was significantly superior to all other treatments. The treatments T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> recorded 32.39 and 32.07 pods plant<sup>-1</sup> respectively and were found to be statistically at par with T<sub>11</sub>. Calcium plays a key role in cell wall development and reproductive growth, while sulphur enhances enzymatic activity and assimilate production. The split application of gypsum ensured nutrient availability during the critical pegging stage, resulting in higher pod formation. These findings are in agreement with Ravikumar *et al.* (1995) [11].

#### Weight of pods plant<sup>-1</sup> (g)

Weight of pods plant<sup>-1</sup> was significantly affected by different treatments, the maximum pod weight (36.24 g plant<sup>-1</sup>) was recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, which was significantly superior to all other treatments. This was followed by T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> which recorded (35.27 g) and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> which recorded (34.91 g), which were statistically at par with T<sub>11</sub>. Higher pod weight under gypsum and nano sulphur treatments may be due to improved nutrient availability leading to better pod filling and enhanced dry matter translocation towards developing pods. Similar results were reported by Rathore *et al.* (2006) [10].

#### Number of filled pods plant<sup>-1</sup>

Number of filled pods plant<sup>-1</sup> was significantly influenced by different treatments, The highest number of filled pods plant<sup>-1</sup> (31.50) was recorded under T<sub>11</sub>, i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, which was statistically at par with T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> which recorded (31.27) and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> which recorded (31.00). The absolute control (T<sub>1</sub>) recorded the lowest number of filled pods (20.04 plant<sup>-1</sup>). The general mean for filled pods plant<sup>-1</sup> was 28.37. The increased number of filled pods under T<sub>11</sub> i.e.,

GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% @ basal dose and 50% @ pegging stage, may be attributed to the adequate supply of calcium, which is crucial for successful fertilization and kernel development in groundnut. Sulphur further enhances enzymatic activities and assimilate utilization, leading to improved pod filling. These results corroborate the findings of Rathore *et al.* (2006) [10].

### Shelling (%)

Shelling percentage was significantly influenced by different treatments. The highest shelling percentage (70.05%) was recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, which was significantly superior to the remaining treatments. The treatments T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> recorded shelling percentages of 69.85 and 69.75 per cent, respectively and were found to be statistically at par with T<sub>11</sub>. The improvement in shelling percentage under gypsum and nano sulphur treatments may be attributed to enhanced kernel development and better pod filling due to adequate calcium and sulphur availability. Calcium plays a crucial role in kernel development, while sulphur improves assimilate translocation and oil synthesis, leading to better kernel recovery. These findings are in agreement with Singh and Choudhary (1996) [14].

### Dry pod yield (q ha<sup>-1</sup>)

Dry pod yield was significantly influenced by different treatments. The highest pod yield (36.58 q ha<sup>-1</sup>) was recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, which was significantly superior to all other treatments. This was followed by T<sub>10</sub>, i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup>, which recorded 35.86 q ha<sup>-1</sup> and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup>, which recorded 35.56 q ha<sup>-1</sup>, both treatments were statistically at par with T<sub>11</sub>. Pod yield in groundnut is the cumulative effect of efficient vegetative growth, reproductive development, pod formation and pod filling. The significantly higher pod yield recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, may be attributed to the continuous and balanced supply of calcium and sulphur through split application of gypsum. Calcium plays a vital role in peg penetration, pod development and kernel formation, as developing pods absorb calcium directly from the soil. Sulphur enhances photosynthetic efficiency, protein synthesis and oil biosynthesis, leading to better assimilate production and translocation towards pods. These findings are in conformity with Krishna *et al.* (1997) [6].

### Kernel yield (q ha<sup>-1</sup>)

Kernel yield (25.66 q ha<sup>-1</sup>) was recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, which was significantly superior to all other treatments. The treatments T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> recorded 25.08 and 24.89 q ha<sup>-1</sup>, respectively and were found to be statistically at par with T<sub>11</sub>. Kernel yield is directly dependent on effective pod

Filling and kernel development, which are highly sensitive to calcium and sulphur availability. The superior kernel yield under T<sub>11</sub> can be attributed to improved calcium nutrition during pegging and pod development, ensuring better kernel growth and reduced kernel abortion. These results are in consistent with the findings of Adhikari *et al.* (2003) [11].

### Haulm yield (q ha<sup>-1</sup>)

Haulm yield (48.23 q ha<sup>-1</sup>) was recorded under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, followed by T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> which recorded 47.26 q ha<sup>-1</sup> and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> which recorded 47.21 q ha<sup>-1</sup>, which were statistically found at par with T<sub>11</sub>. Haulm yield reflects overall vegetative biomass production. The increased haulm yield under T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, may be attributed to improved nutrient availability, particularly calcium and sulphur, which promote cell division, leaf expansion and stem growth. These results are in findings of Subhendu Mandal *et al.* (2005) [15].

### Biological yield (q ha<sup>-1</sup>)

Biological yield (84.81 q ha<sup>-1</sup>) was recorded under T<sub>11</sub>, i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage, followed by T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> which recorded 83.11 q ha<sup>-1</sup> and T<sub>9</sub> i.e., GRDF + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> which recorded 82.84 q ha<sup>-1</sup>, which were statistically found at par with T<sub>11</sub>. The lowest biological yield (52.95 q ha<sup>-1</sup>) was recorded under T<sub>1</sub>. Higher biological yield under gypsum and nano sulphur treatments indicates improved total dry matter production. Balanced nutrient supply enhanced photosynthesis, nutrient uptake and biomass accumulation. The split application of gypsum ensured sustained nutrient availability, while nano sulphur improved nutrient use efficiency, resulting in higher total biomass production. The conclusions described above are consistent with the findings of Rao and Shaktawat (2002) [9].

### Harvest Index (%)

Harvest index varied from 41.75 per cent under the absolute control (T<sub>1</sub>) to 43.88 per cent under T<sub>6</sub> i.e., GRDF + Nanoscale Zinc Oxide @ 2 g 10 lit<sup>-1</sup> as foliar spray at 25 and 45 DAS. Treatments T<sub>10</sub> i.e., GRDF + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup>, T<sub>9</sub> i.e., GRDF + Nano sulphur foliar spray @ 2.5 ml l<sup>-1</sup> and T<sub>11</sub> i.e., GRDF + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal and 50% at pegging stage recorded harvest index values of 43.28, 43.08 and 42.97 per cent, respectively. Statistical analysis revealed that differences among treatments with respect to harvest index were non-significant, indicating that although treatments influenced pod, kernel and haulm yields, the proportionate distribution of total biomass between economic yield (pods) and total biological yield remained relatively stable across treatments. This indicates that nutrient management primarily enhanced total biomass production rather than altering assimilate distribution. Samul *et al.* (2007) [12].

**Table 1:** Yield attributes of groundnut as influenced by different treatments

| Tr. No          | Treatments                                                                                                           | Number of pods plant <sup>-1</sup> | Weight of pods plant <sup>-1</sup> (g) | Number of filled pods plant <sup>-1</sup> | Shelling (%)  |
|-----------------|----------------------------------------------------------------------------------------------------------------------|------------------------------------|----------------------------------------|-------------------------------------------|---------------|
| T <sub>1</sub>  | Absolute Control                                                                                                     | 22.99<br>(4.84)                    | 25.50                                  | 20.04<br>(4.53)                           | 61.92 (51.90) |
| T <sub>2</sub>  | RDF (25:50:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> )                              | 28.90<br>(5.42)                    | 31.94                                  | 27.39<br>(5.28)                           | 68.17 (55.66) |
| T <sub>3</sub>  | GRDF (25:50:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> + FYM 10 t ha <sup>-1</sup> ) | 29.05<br>(5.44)                    | 32.40                                  | 27.40<br>(5.28)                           | 68.35 (55.77) |
| T <sub>4</sub>  | GRDF + Zinc Sulphate @ 2 g/lit foliar spray at 25 and 45 DAS                                                         | 29.33<br>(5.46)                    | 32.54                                  | 28.07<br>(5.34)                           | 68.35 (55.77) |
| T <sub>5</sub>  | GRDF + Nanoscale Zinc Oxide @ 2 g/15 lit foliar spray at 25 and 45 DAS                                               | 29.54<br>(5.48)                    | 32.77                                  | 28.22<br>(5.36)                           | 68.64 (55.95) |
| T <sub>6</sub>  | GRDF + Nanoscale Zinc Oxide @ 2 g/10 lit foliar spray at 25 and 45 DAS                                               | 29.94<br>(5.52)                    | 32.87                                  | 28.57<br>(5.39)                           | 68.75 (56.01) |
| T <sub>7</sub>  | GRDF + Nanoscale Calcium Oxide @ 2 g/15 lit foliar spray at 25 and 45 DAS                                            | 30.30<br>(5.55)                    | 33.20                                  | 28.76<br>(5.41)                           | 68.85 (56.08) |
| T <sub>8</sub>  | GRDF + Nanoscale Calcium Oxide @ 2 g/10 lit foliar spray at 25 and 45 DAS                                            | 31.23<br>(5.63)                    | 34.29                                  | 29.88<br>(5.51)                           | 69.00 (56.17) |
| T <sub>9</sub>  | GRDF + Nano Sulphur @ 2.5ml/lit foliar spray at 30 and 45 DAS                                                        | 32.07<br>(5.71)                    | 34.91                                  | 31.00<br>(5.61)                           | 69.75 (56.63) |
| T <sub>10</sub> | GRDF + Nano Sulphur @ 5ml/lit foliar spray at 30 and 45 DAS                                                          | 32.39<br>(5.73)                    | 35.27                                  | 31.27<br>(5.64)                           | 69.85 (56.70) |
| T <sub>11</sub> | GRDF + Gypsum @ 500kg ha <sup>-1</sup> 50% at basal Dose, 50% at pegging stage)                                      | 33.11<br>(5.80)                    | 36.24                                  | 31.50<br>(5.66)                           | 70.05 (56.82) |
|                 | S.E.(m)±                                                                                                             | 0.04                               | 0.45                                   | 0.02                                      | 0.13          |
|                 | C.D. at 5%                                                                                                           | 0.11                               | 1.34                                   | 0.05                                      | 0.39          |
|                 | General Mean                                                                                                         | 29.90                              | 32.90                                  | 28.37                                     | 68.34         |

Note: Figures in parentheses indicate square root transformed values  $\sqrt{x + 0.5}$

S.E.(m)± and CD values are based on transformed data

**Table 2:** Pod yield, haulm yield, kernal yield, biological yield and harvest index as influenced by different treatments at harvest of groundnut

| Tr. No.         | Treatments                                                                                                           | Pod yield (q ha <sup>-1</sup> ) | Kernal yield (q ha <sup>-1</sup> ) | Haulm yield (q ha <sup>-1</sup> ) | Biological yield (q ha <sup>-1</sup> ) | Harvest Index (%) |
|-----------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------|------------------------------------|-----------------------------------|----------------------------------------|-------------------|
| T <sub>1</sub>  | Absolute Control                                                                                                     | 22.25                           | 13.80                              | 30.70                             | 52.95                                  | 41.75             |
| T <sub>2</sub>  | RDF (25:50:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> )                              | 29.44                           | 21.57                              | 41.45                             | 73.06                                  | 42.88             |
| T <sub>3</sub>  | GRDF (25:50:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> + FYM 10 t ha <sup>-1</sup> ) | 32.11                           | 21.98                              | 42.31                             | 74.42                                  | 42.76             |
| T <sub>4</sub>  | GRDF + Zinc Sulphate @ 2 g/lit foliar spray at 25 and 45 DAS                                                         | 32.62                           | 22.33                              | 42.29                             | 74.91                                  | 43.38             |
| T <sub>5</sub>  | GRDF + Nanoscale Zinc Oxide @ 2 g/15 lit foliar spray at 25 and 45 DAS                                               | 33.03                           | 22.71                              | 43.36                             | 76.39                                  | 42.32             |
| T <sub>6</sub>  | GRDF + Nanoscale Zinc Oxide @ 2 g/10 lit foliar spray at 25 and 45 DAS                                               | 33.39                           | 22.99                              | 43.46                             | 76.85                                  | 43.88             |
| T <sub>7</sub>  | GRDF + Nanoscale Calcium Oxide @ 2 g/15 lit foliar spray at 25 and 45 DAS                                            | 33.81                           | 23.31                              | 43.86                             | 77.67                                  | 42.76             |
| T <sub>8</sub>  | GRDF + Nanoscale Calcium Oxide @ 2 g/10 lit foliar spray at 25 and 45 DAS                                            | 34.29                           | 23.70                              | 44.29                             | 78.58                                  | 43.58             |
| T <sub>9</sub>  | GRDF + Nano Sulphur @ 2.5ml/lit foliar spray at 30 and 45 DAS                                                        | 35.56                           | 24.89                              | 47.21                             | 82.84                                  | 43.08             |
| T <sub>10</sub> | GRDF + Nano Sulphur @ 5ml/lit foliar spray at 30 and 45 DAS                                                          | 35.86                           | 25.08                              | 47.26                             | 83.11                                  | 43.28             |
| T <sub>11</sub> | GRDF + Gypsum @ 500kg ha <sup>-1</sup> 50% at basal Dose, 50% at pegging stage)                                      | 36.58                           | 25.66                              | 48.23                             | 84.81                                  | 42.97             |
|                 | S.E.(m)±                                                                                                             | 0.40                            | 0.27                               | 0.36                              | 0.67                                   | 0.43              |
|                 | C.D. at 5%                                                                                                           | 1.18                            | 0.79                               | 1.05                              | 1.99                                   | NS                |
|                 | General Mean                                                                                                         | 32.63                           | 22.55                              | 43.13                             | 75.08                                  | 42.97             |

## Conclusion

Based on the present field experiment it can be concluded that the treatment consist of General Recommended Dose of Fertilizer (25:50:00 N: P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O kg ha<sup>-1</sup> + FYM 10 t ha<sup>-1</sup>) + Gypsum @ 500 kg ha<sup>-1</sup> 50% at basal dose and 50% at pegging stage or General Recommended Dose of Fertilizer

(25:50:00 N: P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O kg ha<sup>-1</sup> + FYM 10 t ha<sup>-1</sup>) + Nano Sulphur foliar spray @ 5 ml l<sup>-1</sup> applied at 30 and 45 DAS or General Recommended Dose of Fertilizer (25:50:00 N: P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O kg ha<sup>-1</sup> + FYM : 10 t ha<sup>-1</sup>) + Nano Sulphur foliar spray @ 2.5 ml l<sup>-1</sup> applied at 30 and 45 DAS is found beneficial for increase in yield attributes and yield

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