# Influence of Nitrogen and Zinc on Growth, Yield and Economics of Sorghum (*Sorghum bicolor* L.)


## ABSTRACT

A field experiment was conducted during kharif 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) to study the "Influence of Nitrogen and Zinc on Growth, Yield and Economics of Sorghum (*Sorghum bicolor* L.)". To Study treatment consisting of three levels of Nitrogen *viz*. 60, 80 and 100 kg/ha and three levels of Zinc *viz*. 15, 20 and 25 kg/ha. There were 10 treatments, each of which was replicated three times and laid out in randomized block design. The results showed that treatment 9 [Nitrogen 100 kg/ha + Zinc 25 kg/ha] recorded significant higher plant height (238.83 cm), higher dry weight (122.37 g), higher length of ear head (27.51 cm), higher seed yield (4430.43 kg/ha), higher stover yield (7246.58 kg/ha), higher number of grains/head (981.34) and higher harvest index (38.75 %) was recorded in treatment 9 [Nitrogen 100 kg/ha + Zinc 25 kg/ha]. Similarly, maximum gross return (1,46,993.65 INR/ha), maximum net return (99,186.03 INR/ha) and highest benefit cost ratio (2.08) was also recorded in treatment 9 [Nitrogen 100 kg/ha + Zinc 25 kg/ha] as compared to other treatments.



***Keywords:*** Sorghum, nitrogen, zinc, growth, yield and economics.

## 1. Introduction:

"Sorghum (*Sorghum bicolor* L.) commonly known as the 'king of millets', is a highly productive crop plant, which can be used for grains, livestock feed or industrial purposes. It is the most important, widely adaptable and extensively grown as a fodder crop. It can withstand heat, drought and tolerate water logging better than other forage crops". [1]. "Indian economy is primarily agricultural based where animal health is very important. To establish and improve the animal production, a critical factor in sustainable agriculture the availability of quality forage crops and grasses and their production needs urgent attention. Gujarat state has a total animal population of 18.44 million heads and the total forage production is 20.0 million tonnes against the requirement of 49.2 million tonnes" (Anonymous, 2006) [2]. "Thus, a gap of 29.2 million tonnes exists between the demand and supply of fodder, which is ought to further widen due to further steady rise in the livestock population and diversion of more area to grain and cash crops. The total area under forage crops in the state is 0.8 million hectares (*ie*., 6.4 % of the total cultivated area). Thus, the state is not only short of quantity but good quality of fodder too" (Patel, 2005) [3]. "It is grown as kharif season crop in northern India. It is also grown in southern and western part of country as a *rabi* and *zaid* season crop. The minimum temperature for the germination of jowar seed is 7-10$^{o}$ C and it needs about 26-30$^{o}$ C temperature for its optimum growth. It is essentially a crop of hot and warm countries. It can tolerate hot and dry condition but cannot be grown in area with high precipitation in world in water lodging may occur. It contains protein (10-12%), carbohydrate (70%), fats (3%), vitamins and mineral salts which are essential for vigorous growth of human life. It is grown on an area of about 45 m/ha in the world with a production of about 61 m.t, while in India it occupies an area of about 12.8 m ha with a total production of about 12.5 million tonnes. Average productivity of sorghum in India is only (977 kg/ha) which is well below the world average of (1500 kg/ha)" Akhila *et al*., 2021 [4].

"Sorghum can grow in a wide range of ecological conditions and can still yield well even under unfavourable conditions of drought stress and high temperatures. In 2021-22, the United States was the largest producer of sorghum worldwide, producing about 11.4 million metric tons of sorghum. Production of sorghum in India was about 8.71 million tonnes". In Uttar Pradesh it is cultivated in an area of 248.0 hectare with a productivity of 1348 kg/ha and Sorghum production 184.0 tonnes in 2021- 22. [1].

"Nitrogen is the most important nutrient for plant growth and is the most limiting nutrient in our soils. Nitrogen application increase crude protein and metabolizable energy, besides improving succulency and palatability of fodder crops. It is the important constituent of chlorophyll and protein. It imparts dark green colour to the plants, promotes vegetative growth and rapid early growth. It improves the quality by increasing the protein content of fodder crops and governs to a considerable degree, the utilization of protein, phosphorus and other elements". Bhoya *et al*., (2014) [5].

Mitchell (1976) [6] reported that "nitrogen increases the plumpness of cereal grain and their percentage protein and aid the utilization of potassium and phosphorus". "Sorghum was observed to respond to applied nitrogen and the additional fertilizer was necessary for optimum yield". (Patil *et al*., 1977) [7], (Veerana *et al*., 1978) [8].

"Zinc deficiency not only adversely affects plant growth but also impairs health of milch animals indirectly. Zinc plays a vital role in oxidation processes in cells and helps in transformation of carbohydrates and regulation of sugar in plant" (Swaminathan and Kannan, 2001) [9]. "Zinc is essential for several enzyme systems that regulate various metabolic activities in plants. It is involved in auxin production which is growth regulating substances in plants. Zinc is also vital for the oxidation processes in plant cells and helps in the transformation of carbohydrates and regulates sugar in plants". Tandon, 1995 [10].

Durgude *et al*. [11]. "Micronutrient (Zinc) helped to increase in leaf area, chlorophyll content in leaves, uptake of total Zinc availability in soil agronomic efficiency, grain and stover yield of sorghum". Keeping in view the above facts, the present experiment was undertaken to find out "Influence of Nitrogen and Zinc on Growth, Yield and Economics of Sorghum (*Sorghum bicolor* L.)".

## 2. MATERIALS AND METHODS:

The field experiment was conducted during kharif season 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.6), organic carbon level in medium condition (0.87%), medium available N (225 Kg/ha), high in available P (41.8 kg/ha) and medium available K (261.2 kg/ha). The treatment consisting of three levels of Nitrogen *viz*. 60, 80 and 100 kg/ha and three levels of Zinc *viz*. 15, 20 and 25 kg/ha. The experiment was laid out in Randomized Block Design with 10 treatments each replicated thrice. "The treatment combinations are T 1 – Nitrogen 60kg/ha + Zinc 15 kg/ha, T 2 - Nitrogen 60 kg/ha + Zinc 20 kg/ha, T 3 - Nitrogen 60 kg/ha + Zinc 25 kg/ha, T 4 – Nitrogen 80 kg/ha + Zinc 15 kg/ha, T 5 - Nitrogen 80 kg/ha + Zinc 20 kg/ha, T 6 - Nitrogen 80 kg/ha + Zinc 25 kg/ha, T 7

– Nitrogen 100 kg/ha + Zinc 15 kg/ha, T 8 - Nitrogen 100 kg/ha + Zinc 20 kg/ha, T 9 - Nitrogen 100 kg/ha + Zinc 25 kg/ha, T 10 - Control (80-40-40 NPK kg/ha). All agronomic practices are followed in order in the crop period. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level". [12].

## 3. RESULT AND DISSCUSSION:

### 3.1 Growth parameters

#### 3.1.1 Plant height (cm)

At 100 DAS there was a significant increase in plant height [Table 1]. The maximum plant height was observed in T9 (Nitrogen 100 kg/ha + Zinc at 25 kg/ha) (238.83 cm), and T8 (Nitrogen 100 kg/ha + Zinc at 20 kg/ha) (228.93), T7 (Nitrogen 100 kg/ha + Zinc at 15 kg/ha) (227.13 cm) was statistically at par with T9. This might have accelerated the meristematic activity, vegetative growth and photosynthetic activity, consequently resulting in to increase plant height. Similar results were also observed by Azam *et al*., 2010 [13]and Bhoya *et al*., 2014.[5] Since Zinc is involved in the biosynthesis of Indole 3-acetic acid, a growth hormone, involved in stem elongation, hence the increase in the plant height. Earlier Patel et al., (2007) [15] also reported "a significant increase in the plant height with soil application of Zinc over its foliar application and control". These results may be attributed to the positive effect of RESULT AND DISCUSSION Page 25 Nitrogen on the plant vegetative growth that led to progressive increase in the internodes length. These results corroborate the finding of Eltelib *et al*., (2006) [16].

#### 3.1.2 Plant Dry Weight (g/plant)

At 100 DAS, plant dry weight (122.37 g) [Table 1] was found to be significantly higher with application of (T9) (Nitrogen 100 kg/ha + Zinc 25 kg/ha) whereas, (T8) (Nitrogen 100 kg/ha + Zinc 20 kg/ha) (115.87 g) and (T7) Nitrogen 100 kg/ha + Zinc 15 kg/ha (113.65 g) was found to be statistically on par with T9. Through the application of Nitrogen, the production of taller plants with increased photosynthetic area (LAI) that paved the way for more production of photosynthetic dry matter (Patel et al. (2006) [17]. The significant increase in dry matter yield may be attributed to the higher photosynthetic rate. Zinc is a constituent of carbonic anhydrase and there is direct relationship between carbonic anhydrase activity and photosynthetic carbon dioxide assimilation or growth of a plants. Carbonic anhydrase activity is closely related to Zinc content as such Zinc increases photosynthetic efficiency thereby dry matter production. "Higher dry matter production due to Zinc application may also be attributed to higher plant height, more leaf area index and additive effect of significant increase in green forage and dry fodder yield. Earlier Marschner (1995) and Patel et al., (2007) [18] have also reported significant increase in dry matter yield with Zinc application over its foliar application".

### 3.2 Yield parameters:

#### 3.2.1 Panicle length (cm)

The data showed that the treatment T9 (Nitrogen 100 kg/ha + Zinc 25 kg/ha) was found to be highest in panicle length (27.51 cm) whereas, the treatment T8 (Nitrogen 100 kg/ha + Zinc 20 kg/ha) (26.11 cm) were found to be statistically at par with (22.5 cm) T9. Higher number of grains per panicle might be due to application of Nitrogen increases the fertility of flowers and increase in leaf area and duration and resulted into increase in supplying assimilates for the sink (Mousavi *et al.*, 2012) [19].

#### 3.2.2 Number of grains/head.

The data showed that the treatment $T_9$ (Nitrogen 100 kg/ha + Zinc 25 kg/ha) was showed significantly higher in Number of grains/head (969.35) whereas, the treatment $T_8$ (Nitrogen 100 kg/ha + Zinc 20 kg/ha) (981.34) and $T_7$ (Nitrogen 100 kg/ha + Zinc 15 kg/ha) (925.71) were statistically at par with treatment $T_9$. Similar reported by Dixit *et al.*, 2005 [20].

#### 3.2.3 Grain yield (kg/ha)

The data showed that the treatment T9 (Nitrogen 100 kg/ha + Zinc 25 kg/ha) was showed significantly higher in grain yield (4430.43 kg/ha) whereas, the treatment T8 (Nitrogen 100 kg/ha + Zinc 20 kg/ha) (4340.04 kg/ha) and T7 (Nitrogen 100 kg/ha + Zinc 15 kg/ha) (4071.64 kg/ha) were statistically at par with treatment T9. The application of micronutrient with NPK fertilizers provides a double benefit: increasing grain yield and improving the nutritional quality of the grains, since micronutrient with NPK fertilizers also increase the concentration of nutrients in grain as well as stover and thereby increased the uptake of nutrients. These results are in agreement with those recorded by Khalifa *et al*. (2011) [21].

#### 3.2.4 Straw yield (kg/ha)

The data showed that the treatment T9 (Nitrogen 100 kg/ha + Zinc 20 kg/ha) was showed significantly higher in grain yield (7246.58 kg/ha) whereas the treatment T8 (Nitrogen 100 kg/ha + Zinc 20 kg/ha) (7176.64 kg/ha) was statistically at par with treatment T9 (Nitrogen 100 kg/ha + Zinc 20 kg/ha). The increase in yields attributed to the fact that because of favourable nutritional environment in rhizosphere and higher absorption of nutrients by plant leading to the increased photosynthetic efficiency and production of assimilates. Similar results were also reported by], Bhunwal *et al.* (2015) [22].

### 3.2.5 Test weight (g)

The data showed that the treatment T9 (Nitrogen 100 kg/ha + Zinc 25 kg/ha) was found to be highest in Test weight (30.47 g) whereas the treatment T5 (Nitrogen 80 kg/ha + Zinc 20 kg/ha) (28.06 g) was found to be lowest. There was no significant difference among the treatments.

### 3.2.6 Harvest index (%)

The data showed that the treatment T7 (Nitrogen 100 kg/ha + Zinc 15 kg/ha) was found to be highest in harvest index (37.96 %) whereas the treatment T1 (Nitrogen 60 kg/ha + Zinc 15 kg/ha) was found to lowest (34.85 %). The beneficial effect of Zn application could be attributed to improved fertility status of the experimental field in terms of available Zn was reported by Sammauria & Yadav (2008) [23].

## 4. Economics:

It is noticeable from data given in Table-3 that the maximum gross return (146993.65 INR/ha), net return (99186.03 INR/ha) and B:C ratio (2.08) was recorded in [Nitrogen 100 kg/ha + Zinc at 25kg/ha] as compared to other treatment.

## 5. CONCLUSION:

From the experimental findings, it is concluded that with the application of Nitrogen 100 kg/ha along with Zinc 25kg/ha performs positively and improves the growth parameters, yield attributes and economics of Sorghum. These findings are based on one season therefore, further trails may be required for further confirmation.

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## 7. REFERENCES:


1. Jakhad, A., & Debbarma, V. (2023). Influence of Biofertilizer and Zinc on Growth, Yield and Economics of Sorghum (*Sorghum bicolor* L.). *International Journal of Plant & Soil Science, 35*(8), 90-97.
2. Anonymous (2006). Monthly revive of the Indian economy centre for monitoring Indian economy Pvt. Ltd. Mumbai. 17-18.
3. Patel, D.M. (2005). Yield and quality of forage chicory (Chicoriumintybus L.) as influenced by nitrogen. Ph.D. Thesis, GAU Sardarkrushinagar.
4. Akhila M, Navya PP, Dawson J. Effect of zinc and iron on growth and yield of sorghum (Sorghum bicolor L.). Journal of Pharmacognosy and Phytochemistry. 2021;10(2):1292-1295.
5. Bhoya, M. I. T. E. S. H., Chaudhari, P. P., Raval, C. H., & Bhatt, P. K. (2014). Effect of nitrogen and zinc on growth and yield of fodder sorghum [Sorghum bicolor (L.) Moench] varieties. *International Journal of Agricultural Sciences*, *10*(1), 294-297.
6. Michell, R. L. (1976). Crop Growth Culture. Iowa State University Press, pp. 349.
7. Patil, E. N. and Jawale, S. M. (1977). Effect of plant density and nitrogen levels on yield of sorghum (CSH 5) Wide Dhule condition. Journal of Maharas intra Agricultural University, 2 (3): 263-264.Prem, S. and Choubey, S.D. (1972). Effect of varying levels of nitrogen on the yield and yield attribute of some sorghum varieties. Indian Journal of Agricultural Sciences, 42 (4):337-341.
8. Veerana, V. S. and Patil, S. V. (1978). Response of sorghum hybrids and varieties to levels of nitrogen. Mysore Journal of Agricultural Science, 12: 658-665.
9. Swaminathan, C., and K. Kannan, 2001: Range Management and Agroforestry, 22 : 208-211.
10. Tandon HLS. Sulphur fertilizers in Indian Agriculture. A guide book. Pun. Festi. Dev. And Consultation Organization New Delhi; 1995.
11. Durgude AG, Kadam SR, Bagwan IR, Kadlag AD, Pharande AL. Response of zinc and iron to rabi sorghum grown on an Inceptisol. International Journal Conservation Science. 2019;7(1): 90-94.

**12.** Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Ed. New York: John Wiley and Sons. 1984;680.

**13.** Azam, Mansoor, Waraich E.A, Asim Pervaiz and Nawaz, Fahim (2010). Response of a newly devoloped fodder sorghum (Sorghum bicolor(L.) Monech) variety (F - 9917) to NPK application, Pakistan j. Life & Soc. Sci.,8(2): 117-120.

**14.** Bhoya, M. I. T. E. S. H., Chaudhari, P. P., Raval, C. H., & Bhatt, P. K. (2014). Effect of nitrogen and zinc on growth and yield of fodder sorghum [Sorghum bicolor (L.) Moench] varieties. *International Journal of Agricultural Sciences*, *10*(1), 294-297.

**15.** Patel, A.S., Sadhu, A.C., Patel, M.R. and Patel, P.C. (2007). Effect of Zinc, FYM and nitrogen uptake by pearl millet (Pennisetum glaucum L.). Indian J. of Agri. Sci. 80(3): 213–6.

**16.** Eltelib, A.H., Hamad, A.M. and Ali, E.E. (2006). Effect of Nitrogen and Phosphorus fertilization on growth, yield and quality of fodder maize. J. of Agron, 5(3): 515-518.

**17.** Patel, J. B., Patel, V. J. and Patel, J. R. (2006). Influence of different methods of irrigation and Nitrogen levels on crop growth rate and yield of maize. Indian J. of Crop Sci., 1(1-2): 175-177.

**18.** Marschner, H. (1995). Mineral Nutrition of Higher Plants (2nd edn.) Academic Press, London. 889 pp.

**19.** Mousavi, S. G. R., Seghatoleslamia, M. J., Arefib, R. (2012). Effect of Nitrogen fertilization and plant density on yield and yield components of grain sorghum under climatic conditions of Sistan, Iran. Plant Ecophysiology.4: 141-149.

**20.** Dixit, A.K., Kachroo, D. and Bali, A.S. (2005). Response of promising rainy season sorghum [Sorghum bicolor (L.) Moench] genotypes to Nitrogen and Phosphorus fertilization. Indian J. of Agron. 50 : 206-209.

**21.** Khalifa RKM, Shaaban SHA, Rawia A. Effect of foliar application of zinc sulfate and boric acid on growth, yield and chemical constituents of iris plants. Ozean Journal of Applied Sciences. 2011; 4:129-144.

**22.** Bhunwal, Vanika, Patel VR, Bali, Bajrang, Anwala, et al. Effect of FYM, Iron and Zinc on growth, yield attributes and yield of Fodder sorghum (Sorghum bicolor L. Moench). Progressive Research. 2015; 10(4):423-424.

**23.** Sammauria R, Yadav RS. Effect of phosphorus and zinc application on growth and yield of fenugreek (Trigonella foenum-graecum) and their residual effect on succeeding pearl millet (Pennisetum glaucum) under irrigated conditions of North West Rajasthan. Indian J. Agri. Sci. 2008; 78:61-64.

**Table 1. Influence of Nitrogen and Zinc on growth parameters of Sorghum.**

| S. No. | Treatment | At 100 DAS | |
|---|---|---|---|
| | | Plant height (cm) | Plant dry weight (g) |
| 1. | Nitrogen 60 kg/ha + Zinc at 15kg/ha | 209.03 | 103.07 |
| 2. | Nitrogen 60 kg/ha + Zinc at 20kg/ha | 208.83 | 106.58 |
| 3. | Nitrogen 60 kg/ha + Zinc at 25kg/ha | 213.53 | 108.84 |
| 4. | Nitrogen 80 kg/ha + Zinc at 15kg/ha | 217.93 | 109.52 |
| 5. | Nitrogen 80 kg/ha + Zinc at 20kg/ha | 219.50 | 108.92 |
| 6. | Nitrogen 80 kg/ha + Zinc at 25kg/ha | 218.53 | 109.15 |
| 7. | Nitrogen 100 kg/ha + Zinc at 15kg/ha | 227.13 | 113.65 |
| 8. | Nitrogen 100 kg/ha + Zinc at 20kg/ha | 228.93 | 115.87 |
| 9. | Nitrogen 100 kg/ha + Zinc at 25kg/ha | 238.83 | 122.37 |
| 10. | Control (N:P:K 80:40:40) | 199.51 | 101.69 |
| | F-test | S | S |
| | SEm± | 6.46 | 3.44 |
| | CD (p=0.05) | 19.19 | 10.24 |

**Table 2. Influence of Nitrogen and Zinc on Yield attribute and yield of Sorghum.**

| S. No. | Treatment combination | Yield attribute and yield | | | | | |
|---|---|---|---|---|---|---|---|
| | | Length of ear head (cm) | Grains/Head (no.) | Test weight (g) | Seed yield (kg/ha) | Straw yield (kg/ha) | Harvest index (%) |
| 1. | Nitrogen 60 kg/ha + Zinc at 15kg/ha | 22.66 | 770.05 | 29.66 | 3426.04 | 6391.84 | 34.85 |
| 2. | Nitrogen 60 kg/ha + Zinc at 20kg/ha | 23.63 | 777.24 | 29.94 | 3490.14 | 6367.02 | 35.35 |
| 3. | Nitrogen 60 kg/ha + Zinc at 25kg/ha | 24.36 | 786.93 | 29.99 | 3540.04 | 6418.94 | 35.54 |
| 4. | Nitrogen 80 kg/ha + Zinc at 15kg/ha | 24.20 | 794.21 | 29.54 | 3518.26 | 6393.59 | 35.49 |
| 5. | Nitrogen 80 kg/ha + Zinc at 20kg/ha | 24.59 | 891.75 | 28.06 | 3754.11 | 6412.65 | 37.14 |
| 6. | Nitrogen 80 kg/ha + Zinc at 25kg/ha | 24.26 | 860.73 | 29.77 | 3844.08 | 6625.26 | 36.71 |
| 7. | Nitrogen 100 kg/ha + Zinc at 15kg/ha | 23.90 | 925.71 | 29.32 | 4071.64 | 6652.48 | 37.96 |
| 8. | Nitrogen 100 kg/ha + Zinc at 20kg/ha | 26.11 | 981.34 | 29.49 | 4340.04 | 7176.39 | 37.68 |
| 9. | Nitrogen 100 kg/ha + Zinc at 25kg/ha | 27.51 | 969.35 | 30.47 | 4430.43 | 7246.58 | 37.94 |
| 10 | Control (N:P:K 80:40:40 kg/ha) | 20.86 | 780.27 | 28.31 | 3309.39 | 6033.03 | 35.52 |
| | F-test | S | S | NS | S | S | S |
| | SEm(±) | 0.97 | 25.27 | 0.67 | 109.99 | 193.60 | 1.00 |
| | CD (p=0.05) | 2.88 | 75.09 | - | 326.81 | 575.22 | 3.02 |

**Table 3. Influence of Nitrogen and Zinc on economics of Sorghum.**

| S. No. | Treatment combination | Economics | | | |
|---|---|---|---|---|---|
| | | Cost of cultivation (INR/ha) | Gross return (INR/ha) | Net return (INR/ha) | B:C ratio |
| 1. | Nitrogen 60 kg/ha + Zinc at 15kg/ha | 45511.18 | 117610.2 | 72099.02 | 1.58 |
| 2. | Nitrogen 60 kg/ha + Zinc at 20kg/ha | 46420.27 | 119118.6 | 72698.33 | 1.57 |
| 3. | Nitrogen 60 kg/ha + Zinc at 25kg/ha | 47329.36 | 120595.7 | 73269.34 | 1.55 |
| 4. | Nitrogen 80 kg/ha + Zinc at 15kg/ha | 45750.31 | 119924.45 | 74173.69 | 1.62 |
| 5. | Nitrogen 80 kg/ha + Zinc at 20kg/ha | 46659.40 | 125916 | 79256.6 | 1.69 |
| 6. | Nitrogen 80 kg/ha + Zinc at 25kg/ha | 46568.49 | 129228.3 | 82659.9 | 1.77 |
| 7. | Nitrogen 100 kg/ha + Zinc at 15kg/ha | 45984.44 | 135053.4 | 89068.96 | 1.93 |
| 8. | Nitrogen 100 kg/ha + Zinc at 20kg/ha | 46898.53 | 144382.95 | 97484.42 | 2.07 |
| 9. | Nitrogen 100 kg/ha + Zinc at 25kg/ha | 47807.62 | 146993.65 | 99186.03 | 2.08 |
| 10 | Control (N:P:K 80:40:40 kg/ha) | 42066.52 | 112899.9 | 70833.38 | 1.68 |