Biological Forum – An International Journal **15(9): 1055-1059(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Biofortification with Micro-nutrients on Growth Parameters and Seed Yield on Linseed (*Linum usitatissimum* L)

Nandini Thondepu[1*] and Bineeta Michael Bara[2]
[1]M.Sc. Scholar, Department of Genetics and Plant Breeding,
NAI, SHUATS, Prayagraj (Uttar Pradesh), India.
[2]Assistant Professor, Department of Genetics and Plant Breeding,
NAI, SHUATS, Prayagraj (Uttar Pradesh), India.

(Corresponding author: Nandini Thondepu)*
(Received: 20 June 2023; Revised: 19 July 2023; Accepted: 23 August 2023; Published: 15 September 2023)
(Published by Research Trend)

ABSTRACT: A field experiment was conducted at the Field Experimentation and Farm Research Centre Department of Genetics and Plant Breeding, during the Rabi season (2022-2023) at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). To evaluate the "Biofortification with micronutrients on growth parameters and seed yield on linseed (*Linum usitatissimum* L)". Replicated thrice the experiment was laid out in Randomized Block Design (RBD) with 12 +1 treatments *viz.*, T_0: absolute control, T_1: Zinc sulphate@ 1%, T_2: Zinc sulphate @ 2%, T_3: Zinc sulphate @ 3%, T_4: Zinc sulphate @ 4%, T_5: Boran @ 1%, T_6: Boran @ 2%, T_7: Boran @ 3%, T_8: Boran @ 4%, T_9: Ferrous sulphate @ 1%, T_{10}: Ferrous sulphate @ 2%, T_{11}: Ferrous sulphate @ 3%, T_{12}: Ferrous sulphate @ 4% duration for all treatment is 3 hrs. The results showed that methods of micronutrient application through seed priming along with T_1: Zinc sulphate@ 1% treatment T_1 proved its superiority over the rest of the treatments on growth and seed yield parameter characters. The results revealed that treatment T_1: Zinc sulphate@1% for 3 hrs seed application with recorded maximum germination percentage, Plant height(cm) at 90 DAS, Days to 50 per cent flowering, Days to Maturity, and Number of capsules per plant, Number of seeds per capsules as well as noticed capsule per seed, Seed yield/plant(g), Biological yield of linseed. Further, results indicated that 1000 seed weight (g) was significantly improved with the application of treatment T_1. The lowest values related to all parameters were obtained in the control plot treatment.

Keywords: Linseed, Biofortification with micronutrient treatment, Randomized Block Design, zinc sulphate.

INTRODUCTION

Flaxseed or Linseed (*Linum usitatissimum* L.) (2n = 30) is known as the founding crop being evaluated as a crop platform for producing bioindustrial and nutraceutical products. It is the world's sixth-largest oilseed crop and one of the oldest cultivated plants. Flaxseed is grown as either an oil crop or a fibre crop. Globally linseed is an important crop; its production is 21.23 lac tonnes from 21.12 lac/ha with an average 1006 kg/ha yield (FAOSTAT, 2022).

India is the second largest country in the world after Canada in area, but fourth in production after Canada, China, and the United States. In terms of productivity, India (449 kg/ha) is well below Canada (1492 kg/ha). USA (1484 kg/ha) and Egypt (1465 kg/ha) (Alukedi *et al*., (2021). Flax seed is an Indian plant of the Rabiaceae family and belongs to the Linaceae family.

Nutrient seed priming is a technique in which seeds are soaked in a mineral nutrient solution and dried to restore their original moisture content. Micronutrient seed treatments, which prepare and coat seeds, are an attractive and easy alternative. Treating seeds with micronutrients may provide an easy and cost-effective method to improve micronutrient nutrition in plants (Farooq *et al*., 2012).

The success and effectiveness of seed preparation with micronutrients depends on the nutrients used, coating materials, soil type, moisture and fertility conditions, and the ratio of nutrients in the seeds (Halmer, 2006).

Among the micronutrients, zinc is an important micronutrient and is normally absorbed as Zn^{++}. Zinc is also required for biomass production (Cakmak, 2008). Zinc is essential for the action of many types of enzymes (dehydrogenases, RNA, and DNA polymerases), carbohydrate metabolism, and protein synthesis in oilseeds.

Boron is essential for functions such as sugar transport, cell wall formation and maintenance, membrane integrity, RNA, indole acetic acid (IAA), and plant metabolism. Boron is one of the essential nutrients for the optimum growth, development, yield, and quality of crops (Brown, 2002). It performs many important functions in plants and is mainly involved in cell wall synthesis and structural integration. With this in mind, experiments were conducted to investigate the effects of zinc and boron nutrition on flaxseed growth, yield, and economics.

Among various micronutrients, zinc, boron, iron sulfate and ammonium molybdate play a very important role in chickpeas. Zinc plays an important role in nucleic acid and protein synthesis and aids in the utilization of phosphorus and nitrogen in seed formation and development. Ferric sulfate is a component of chlorophyll biosynthesis that regulates respiration, photosynthesis, nitrate and sulfate reduction, and also activates several enzymes involved in respiration (Kaleeshwari *et al*., 2013).

On the other hand, boron plays an important role in flower retention, pollen tube growth, seed formation and seed formation, and is mainly involved in the transfer of metabolites from source to source (Tanaka and Fujiwara 2008).

Micronutrients, mainly zinc and boron, are important for plant growth and are related to photosynthesis, cell wall growth and respiration, water absorption, xylem permeability, plant disease resistance, and enzyme activities involved in plant growth. It plays a vital role in metabolic processes. Metabolite synthesis (Kumar, 2018).

MATERIALS AND METHODS

This study on "Biofortification with micronutrients on growth parameters and seed yield of linseed (*Linum usitatissimum* L)" identifies the effects of different seed preparations on the seed quality parameters of linseed and determines which are suitable for linseed. It was carried out to find a method of seed preparation. The experiment was designed in a randomized block design with 13 treatments including a control and was repeated three times in Rabi 2022. Treatments include zinc sulfate, boron, and iron sulfate. Flaxseed was primed with different priming agents at different concentrations and strengths for specific periods. After priming, the seeds were dried to their original moisture content at room temperature. Subsequently, the prepared seeds were used for cultivation under field conditions. The optimal spacing is 20-30 cm between rows and 10 cm between plants. Drilling is recommended to ensure even seed distribution. Seed requirements for seed varieties range from 20 to 30 kg/ha depending on seed size.

METHODOLOGY

Treatments with Zinc sulphate: Seeds were soaked in three concentrations of zinc sulphate; a 25 ppm solution was prepared by dissolving 0.025 grams in one litre of distilled water. 50 ppm and 100 ppm solutions were prepared by dissolving 0.05 grams and 0.1 gram in one litre of distilled water respectively. The seeds were soaked for 3 hours and kept for shade dry. Seeds were then taken to the field for sowing. Mode of action: Zinc sulphate is used to counter this effect and support root growth. Crops that need to grow on sandy soils or soils with low organic matter (such as carrots, radishes, corn, etc.) often need additional zinc sulphate to ensure the plants can get enough nutrients to develop properly.

— Treatments with Ferrous sulphate: Seeds were soaked in three concentrations of ferrous sulphate; a 25ppm solution was prepared by dissolving 0.025 grams in one litre of distilled water. 50 ppm and 100 ppm solutions were prepared by dissolving 0.05 grams and 0.1 gram in one litre of distilled water respectively. The seeds were soaked for 3 hours and kept for shade dry. Seeds were then taken to the field for sowing.

— Mode of action: Ferrous sulphate is a chemical compound with the formula Ferrous sulphate. It is also known as iron(II) sulphate, green vitriol, or copperas. The mode of action of ferrous sulphate is to provide iron to plants, which is needed for the synthesis of chlorophyll, the molecule that plants use to convert sunlight into energy.

— Mode of action for Boron: Boron transport in plants is mainly based on three transport mechanisms across the plasma membrane: passive diffusion of borate, facilitated diffusion of borate through channels, and transport of borate anions through transporters. I am.

RESULTS

A. Pre-Harvest

1. The observations on of plant height 90 DAS of Linseed were statistically analyzed. A range of 81.10 cm to 88.61 cm of plant height was recorded. The maximum amount of plant height (88.61) was recorded with T_1 – Zinc sulphate at 1 % for 3 hrs followed by T_3 - Zinc sulphate at 4 % for 3 hrs (87.12), T_8 – Boran – 4% (86.68 cm) and minimum plant height (81.10) recorded with T_0 (control).
2. Days to 50% flowering of Linseed were statistically analyzed. A range of 68.33 to 78.67 days to 50 flowering was recorded. The minimum number of days to 50 % flowering (68.33) was recorded with T_1 - Zinc sulphate – 1% for 3 hrs followed by T_2 – Zinc sulphate– 2% for 3 hrs (78.33) and maximum days to 50% flowering (78.67) recorded with T_0 - Control.
3. Days to maturity of Linseed were statistically analyzed. A range of 113.33 to 125.67 days to maturity was recorded. The minimum number of days to 50 % flowering (113.33) was recorded with T_3 - Zinc sulphate – 1% for 3 hrs followed by T_0 – control (121.33) and maximum days to 50% flowering (125.67) recorded with T_4 - Zinc sulphate– 4% for 3 hrs (125.67).

B. Post-Harvest

1. The observations on the Number of capsules per plant of Linseed were statistically analyzed. A range of 18.60 to 26.40 of the Number of capsules per plant was recorded. The maximum amount of Number of capsules per plant (26.40) was recorded with T_1 - Zinc sulphate at 1 % for 3 hrs followed by T_3 – Zinc sulphate at 3 % for 3 hrs (25.93) and the minimum number of capsules per plant (18.60) recorded with T0 (control).
2. The number of Seeds per capsule of Linseed was statistically analyzed. A range of 7.40 to 9.40 of the Number of Seeds per capsule was recorded. The maximum amount of Seeds per capsule (9.40) was recorded with T_1 – Zinc sulphate at 1 % for 3 hrs

followed by T_3 - Zinc sulphate at 3 % for 3 hrs (9.00) and minimum Number of Seeds per capsule (7.40) recorded with T0 (control).

3. Seed yield per plant of Linseed was statistically analyzed. A range of 2.17 to 3.98 of seed yield per plant was recorded. The maximum amount of seed yield per plant (3.98) was recorded with T_1 – Zinc sulphate at 1 % for 3 hrs followed by T_3 - Zinc sulphate at 3 % for 3 hrs (3.83) and minimum seed yield per plant (2.17) recorded with T_0 (control).

4. The observations on the biological yield of Linseed were statistically analysed. A range of 5.24 to 7.77 of biological yield was recorded. The maximum amount of biological yield (7.77) was recorded with T_1 – Zinc sulphate at 1 % for 3 hrs followed by T_3 - Zinc sulphate at 3 % for 3 hrs (6.96) and minimum biological yield (5.24) recorded with T_0 (control).

5. The seed index of Linseed was statistically analyzed. A range of 6.42 to 9.30 of the Seed index was recorded. The maximum amount of Seed index (9.30) was recorded with T_1 – Zinc sulphate at 1 % for 3 hrs followed by T_3 - Zinc sulphate at 3 % for 3 hrs (8.31) and minimum Seed index (6.42) recorded with T0 (control).

DISCUSSION

Considering the Zinc sulphate concentration used in this study, it is expected that the higher Zn concentration was completely absorbed by the seeds. This concentration likely had a toxic effect, thereby reducing their performance by disrupting cell division and development. Reed *et al*. (2004). In a study using barley, Karabal *et al*. (2003) showed that exposure of barley seedlings to a high concentration of B solution resulted in membrane damage, thereby increasing cellular malondialdehyde, an important marker of membrane permeability and oxidative stress. We observed that the content increases. The development of seedling increase parameters is probably because of wonderful interactions among N and Zn in the plant frame and the extended hobby of numerous enzymes that facilitated vegetative increase and photosynthesis. A preceding examination suggested that enzyme sports of esterase, glycerol 3-phosphate dehydrogenase, and alpha-amylase extended in primed seeds, main to extended metabolism of seed garage materials, along with carbohydrates, lipids, and proteins (Aboutalebian 2012). Foliar software of a mixture of N and Zn has been delivered in the course of flowering and grain developmental degrees for reinforcing productiveness and grain Zn accumulation. This examination has confirmed a 44.0% boom in grain yield via way of means of foliar software of N+Zn0 and N+Zn+ in comparison with the management without N or Zn as a consequence of extended yield components (plant height, panicle quantity according to plant, and per cent of stuffed grains). A preceding examination suggested that N implemented on the early vegetative level ought to sell tillering and boom panicle quantity according to plant, at the same time as N implemented on the panicle initiation level is important to beautify spikelet quantity according to panicle (Huang *et al.*, 2018). Umair *et al*. (2011) found similar effects on mung bean seed yield under dry-seeding, hydropriming and molybdenum loading treatments. Increased sucrose synthetase and glutamine synthetase activities in prepared chickpea root nodules increased nodule biomass, metabolic activity, and seed filling. Foliar application of Zn increased thousand-grain weight, with the greatest increase observed in N0Zn+ and N+Zn+ solutions. Foliar application of zinc at early stages may provide better nutrition to plants during tillering and shoot stages, resulting in increased grain weight. These results are consistent with those in *Singh et al.* (2020).

Table 1: Influence of Zinc sulphate, boron, and iron sulphate on Plant height, Days to 50% flowering, and Days to maturity.

Treatment	Plant Height	Days to 50% Flowering	Days to maturity
T0 – Control	81.10	78.67	121.33
T1	88.61	68.33	113.33
T2	84.33	78.33	118.00
T3	87.12	70.33	116.00
T4	84.24	71.67	125.67
T5	85.96	74.67	115.33
T6	84.76	76.33	122.67
T7	86.16	73.33	119.00
T8	86.13	75.00	122.67
T9	86.68	69.33	115.33
T10	85.45	69.67	122.00
T11	84.97	73.33	118.67
T12	84.79	74.33	120.33
SE m (±)	2.01	1.19	1.11
CV	4.05	2.79	1.61
CD	5.86	3.48	3.23

Table 2: Influence of Zinc sulphate, boron, and iron sulphate on the number of capsules per plant, number of seeds per capsule, and seed yield per plant.

Treatment	Number of Capsules per Plant	Number of seeds per capsule	Seed yield per plant
T_0 – Control	18.60	7.40	2.17
T_1	26.40	9.40	3.98
T_2	22.00	7.60	2.77
T_3	25.93	9.00	3.83
T_4	23.40	7.80	2.95
T_5	22.00	7.60	3.11
T_6	23.80	7.40	2.59
T_7	22.40	8.00	2.68
T_8	21.80	7.67	2.82
T_9	24.20	8.80	3.62
T_{10}	21.40	8.60	3.24
T_{11}	22.00	8.00	3.08
T_{12}	21.80	8.40	3.23
SE (m)	0.07	0.01	0.002
CV	0.56	0.39	0.124
CD	0.21	0.05	0.006

Table 3: Influence of Zinc sulphate, boron, and iron sulphate on Biological yield, Seed index.

Treatment	Biological yield	Seed index
T_0 – Control	5.24	6.42
T_1	7.77	9.30
T_2	5.89	6.67
T_3	6.96	8.31
T_4	6.08	6.93
T_5	6.23	8.03
T_6	5.72	7.29
T_7	5.81	7.50
T_8	5.94	7.39
T_9	6.74	8.19
T_{10}	6.37	7.09
T_{11}	6.20	7.23
T_{12}	6.35	7.15
S Em (±)	0.18	0.031
CV	5.12	0.715
CD (p=0.05)	0.53	0.090

CONCLUSIONS

Seed biofortification like Boron (B), iron (Fe) and zinc (Zn) for the enhancement of linseed yield along with the distribution of different plant parts. Quantitative enhancement in different traits of linseed plants due to B, Fe and Zn fertilization especially for capsules per plant after maturity suggested a positive association between nutrient supply and morphological traits, which indirectly enhanced seed yield. There was a positive correlation between Zn supply and seed yield. In the treatments with B and Fe fertilization, seed yield was positively correlated to plant height, capsules per plant and seeds per five capsules. According to this study, it is concluded that linseed can accumulate majorly Zn followed by Fe and B. The results revealed that treatment T_1: Zinc sulphate @ 1% for 12 hrs seed application with recorded maximum Plant height (cm) at 90DAS (88.6 cm), Days to 50 % flowering (68.33 %), Days to Maturity (113.3), and Number of capsules per plant (26.40), Number of seeds per capsule (9.40) as well as capsule seed yield/plant (g) (3.98), Biological yield(g) (7.77 g) of linseed. Further, results indicated that 1000 seed weight (g) (9.30) and then followed by T_3- Zinc sulphate (3%).

Outlook: Zinc sulfate, boron, and iron sulfate are essential micronutrients that play crucial roles in plant growth, development, and overall yield. Each nutrient has specific functions that contribute to various physiological processes within plants. Balanced and adequate supply of these micronutrients is essential to ensure optimal plant growth, health, and yield. Deficiencies or excesses of these micronutrients can lead to various physiological disorders, impacting the overall productivity and quality of crops. Farmers often use fertilizers containing these micronutrients to supplement the soil and ensure plants have access to the necessary amounts for their growth and development.

Acknowledgment. Authors are thankful to all faculty members of the Department of Genetics and Plant Breeding for their encouragement and support. Thanks are also due to Dr. V.P. Sahi, Head, Department of Genetics and Plant Breeding for providing necessary help.

Conflict of Interest. None.

REFERENCES

Alukedi, A. O., Almarie, A. A., Alalousi, M. A., Farhan, S. S. and Almehemdi, A. F. (2021). Effect of laser exposure as pre sowing seed priming in three flax cultivars (*Linum usitatissimum* L.). *Plant Cell Biotechnol. Mol. Biol*., *22*, 43-52.

Brown, P. H., Bellaloui, N., Wimmer, M. A., Bassil, E. S., Ruiz, J., Hu H., Pfeffer, H., Dannel, F., Romheld, V. (2002). Boron in plant biology. *Plant Biol., 4*, 205–223.

Cakmak, I. (2008). Enrichment of cereal grains with zinc: agronomic or genetic biofortification. *Plant and soil*, *302*, 1-17.

FAOSTAT (2022). Food and Agriculture Organization of the United Nations. Rome: FAO. Available online at: http://www.fao.org/faostat/en/#data (assessed February 2021).

Farooq, M. Wahid, A. and Siddique, K. H. M. (2012). Micronutrient application through seed treatments A review. *Journal of Soil Science and Plant Nutrition*, *12*(1), 125-142.

Kaleeshwari, R. K. and Rajeswari, R. (2013). A Handbook of Soil Fertility. Satish Serial Publishing House.

Halmer, P. (2006). Seed technology and seed enhancement. In XXVII International Horticultural Congress-IHC2006: International Symposium on Seed Enhancement and Seedling Production 771 (pp. 17-26).

Huang, M., Chen, J, Cao, F. and Zou, Y. (2018). Increased Hill Density Can Compensate for Yield Loss from Reduced Nitrogen Input in Machine-Transplanted Double-double-cropped rice. *Field Crops Res., 221*, 333–338.

Karabal, E., Yucel, M. and Okte, H. A. (2003). Antioxidants responses of tolerant and sensitive barley cultivars to B toxicity. *Plant Science, 164*, 925-933.

Singh, P., Shukla, A. K., Behera, S. K., Tiwari, P. K., Das, S. and Tripathi, A. (2020). Categorization of Diverse Wheat Genotypes for Zinc Efficiency Based on Higher Yield and Uptake Efficiency. *J. Soil Sci. Plant Nutr., 20*, 648–656.

Tanaka, M. and Fujiwara, T. (2008). Physiological roles and transport mechanisms of boron: perspectives from plants. *Pflügers Archiv-European Journal of Physiology*, *456,* 671-677.

Umair, A., Ali, S., Hayat, R., Ansar, M. and Tareen, M. J. (2011). Evaluation of seed priming in mungbean (*Vigna radiata*) for yield, nodulation and biological nitrogen fixation under rainfed conditions. *African Journal of Biotechnology*, *10,* 18122-18129.

How to cite this article: Nandini Thondepu and Bineeta Michael Bara (2023). Biofortification with Micro-nutrients on Growth Parameters and Seed Yield on Linseed (*Linum usitatissimum* L). *Biological Forum – An International Journal, 15*(9): 1055-1059.