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Effect of Application of Nano-nutrients on Crop Growth and Seed Yield in Black Gram (*Vigna mungo*)

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ABSTRACT

Being one of the important pulse crops grown throughout India, Black gram requires several nutrients for optimum growth. The use of chemical fertilizers to add these nutrients has been known to boost production but at a cost of harming the soil, air, water, and living organisms. To address this issue, nano formulations have been proposed as a potential solution. This study aimed to evaluate the effects of applying nano-nutrients, N and Zn on the morphological and yield-related characteristics of black gram. The experiment was conducted with Randomized Complete Block Design having 8 treatments and replicated thrice. Among various treatments, the highest germination percentage and seedling vigour were observed in treatment T5 (50% RDN+ Seed priming with nano-Zn+ Foliar spray of nano-urea at 45 DAS), whereas the higher yield parameters *viz.*, test weight, pods, seeds per pod, pods per plant, biological yield and grain yield observed in T8 (Seed priming with nano-Zn+ Foliar spray of nano-urea at 30 DAS+45 DAS).

Key words: *Black gram, Nano-nitrogen, Nano Zn, Seed priming, Foliar spray.*

Introduction

Black gram (*Vigna mungo*), is a legume crop native to South Asia. It is one among the pulse crops grown throughout the country and one of the most highly prized pulses in India. It grows well in moisture-retentive soil. It is a significant crop in terms of nutrition with 60% carbohydrates, 25% protein which is nearly three times as much of cereals, and 1.3% fat (Das *et al.,* 2021). Black gram is massively grown in every agroclimatic zone, making India the world's greatest producer and consumer (Raizada *et al*., 2021).

The area under black gram cultivation is nearly 48 lakh ha. Madhya Pradesh ranked first both in area and production with 36% followed by Rajasthan and Uttar Pradesh (12% and 11% in each). The area sown under Kharif urdbean increased by 2.39 hectares, from 15.67 lakhs in 2021 to 18.06 lakhs in 2022 (Source: Crops Division, DA & FW).

Pulses are considered a viable option for diversification of agriculture in Punjab. But it showed a significant decline in the area and production over the years. During 1970-71, the area under total pulses in Punjab was 413.7 thousand ha which declined to 49 thousand ha in 2014-15 and it was 30 thousand ha in 2017-18.

"Nano" is a translation of the Greek word for "dwarf." Nano refers to hundred millionth of a metre. Supply plant nutrients using nanotechnology techniques is becoming a successful management strategy for plant nutrition Solanki *et al*. (2015) and Ghorbanpour *et al*. (2017). In the agricultural system, nanoparticles have potential uses in the slow release of nutrients, fertilizers, pesticides and genetic material, moreover, they can act as a nano architect in the soil formation and aggregation of soil structure Ghormade *et al*. (2011).

Nano-fertilizers can be applied in powder or liquid form with a diameter of less than 100 nm Jampílek *et al*. (2015). Foliar nutrition is the application of nutrients by spraying solutions on plant leaves to enhance growth and quality by increasing nutrient uptake through stomata or cell walls Jamal *et al*. (2007). When a plant is in its rapid growth phase, foliar spray can shorten the time between treatment and plant uptake. Nanotechnology in foliar fertilization enhances plant development sustainably and precisely. Increased particle surface area boosts plant absorption for improved results over traditional sources Subbaiah *et al*. (2016); Sturikova *et al*. (2018).

Nano-nitrogen particles in liquid nano urea have a large surface area (10,000 times that of a 1 mm urea prill). Its use enhances crop productivity, soil health, and the nutritional value of produce. Nano Urea, with its 4% nitrogen content in nano form, provides the necessary nitrogen for crops in a more efficient manner compared to traditional urea. It reduces environmental pollution and improves crop yields by penetrating roots and leaves due to smaller particle diameters Baboo (2021).

Zn deficiency is a serious concern to human and plant health among micronutrient deficiencies. Various approaches are implemented to resolve this issue, such as biofortification food fortification and Zn supplementation. Methods for applying zinc include seed treatment, foliar application, and soil delivery (Farooq *et al*., 2012). In order to increase the germination of low vigour seeds, nanoscience has pioneered the practice of nano priming of seed utilising nanoparticles, priming with Zn is an effective method to raise the amount of this microelement in seeds Imran *et al.,* 2017). According to Bozoglu *et al*.(2007) chickpea quality, yield, and higher yield qualities could all be improved by Zn foliar spraying.

Materials and Methods

A field experiment was conducted at Agronomy Research Fields of Lovely Professional University, Phagwara, Punjab, during Kharif season of 2022. The farm was situated at a latitude of 31.2°N, 75.7°E with 252 m average elevation above mean sea level, 180 meters to the southwest, and more than 500 meters to the northeast boundary. The experiment was conducted on a 500 m^2 area with a uniform topography with good drainage. During the warmer months, the highest temperature is 49 °C, and the area receives 1150 mm of precipitation annually. The soil was slightly alkaline with a pH of 8.5, EC 0.85 dSm-1, 0.41% organic carbon, 147 kgha-1 available nitrogen, 15.71 kgha-1 phosphorus and 172 kgha-1 potassium. The nutrient sources were soil-applied urea, SSP, nano-urea and nano-zinc. The experiment was conducted (Var. Mash 1008) with RCBD with 8 treatments and replicated thrice. The treatment combinations are T1- Control, T2-RDF, T3- 50% RDN+ Foliar spray of nano-urea at 45 DAS, T4-100% RDN+Foliar spray of nano-Zn at 45 DAS, T5-50% RDN+ Seed priming with nano-Zn+ Foliar spray of nano-urea at 45 DAS, T6- Seed priming with nano-Zn+ Foliar spray of nano-urea at 30 DAS, T7- Foliar spray of nano-urea at 30 DAS+45 DAS, T8- Seed priming with nano-Zn+ Foliar spray of nano-urea at 30 DAS+45 DAS. Seed priming is done with nano-Zn at 1 ml l-1(1000 ppm) concentration by homogeneously dispersing it in water and seeds were soaked for 3 hours in it and shade dried to the initial moisture level. Plants are subjected to foliar spray of nano-Zn at 2ml l-1 and nano-urea at 4ml l-1. The fertilizer recommended dose was 27.5 kg N, 150 kg Pha-1. Various morphological characters were studied at frequent intervals from germination till harvest and the yield parameters were recorded after crop harvest. The significance of the effect of these parameters was statistically analyzed using analysis of variance (ANOVA).

Results and Discussion

Seed germination and seedling vigour

The treatment T5 (50% RDN+ Seed priming with nano-Zn+ Foliar spray of nano-urea at 45 DAS) recorded maximum germination percentage (87.67%) and seedling vigour index (1231.87), which is significantly on par with T8 (Seed priming with nano-Zn+ Foliar spray of nano-urea at 30 DAS+45 DAS) with germination percentage of 81.67% and seedling vigour 1092.4 (Fig. 1). The control plot showed the lowest recorded values. The growth of roots was satisfactory, however, the outcomes obtained from the control plot were not encouraging.

High zinc content in seeds has a significant physiological role during seed germination and the early stages of seedling growth, such a promotory effect of nano Zn on germination was observed by Prasad *et al*. (2012) on peanut seeds. Nano-priming enhances the germination of seeds by facilitating greater penetration through the seed coat, which effectively enhances the nutrient and water uptake by the seeds (Dutta, 2018). The Zn application boosts the enzymatic activity of the seeds, which is advantageous to the translation of carbohydrates into simple sugars and protein into amino acids, which enhances germination, it also inhibited fungal and bacterial infection during germination Adhikari *et al*. (2016).

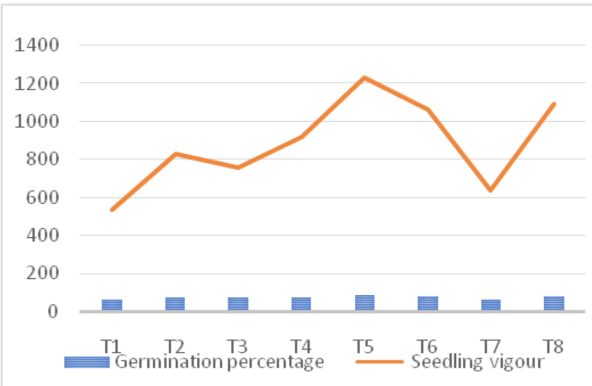

Fig. 1. Germination percentage and Seedling vigour

Plant height (cm)

At 15 DAS the maximum height of black gram was recorded at T5, which was further found significantly at par with T8. At 30 DAS the maximum height was recorded at T4, followed by T5. A similar result was observed at 45 DAS. At 60 DAS, T8 recorded the highest value in plant height which further found significantly par with T5. At 75 DAS the maximum height was recorded at T4, which found superior over the other treatments. The minimum height was recorded at T1 (Fig. 2).

The remarkable increase in plant height in this study can be explained by the efficiency of the nitrogen source which is applied in soil and as foliar spray. The combination of foliar application of nano nitrogen and nano zinc, along with soil-applied synthetic fertilizers resulted in significant improvements in growth-related parameters Rather *et al.* (2022). Supply of plants with nitrogen and zinc may have increased the activity of enzymes and auxin metabolism, leading to larger cells and cell elongation, which resulted in taller plants, this result agrees withNithya *et al.* (2018).

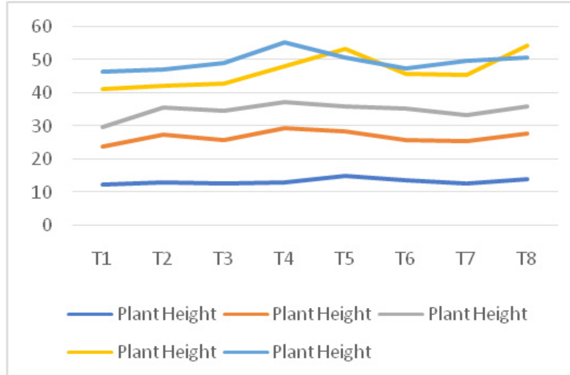

Fig. 2. Plant Height

Root Growth

At 15 DAS maximum root length was observed at T5 which further found significantly at par with T8. A similar result was observed at 30 DAS. At 45, 60 and 75 DAS the highest values were recorded at T8, whereas the minimum value was observed at T1 (Fig. 3) where no treatments are applied.

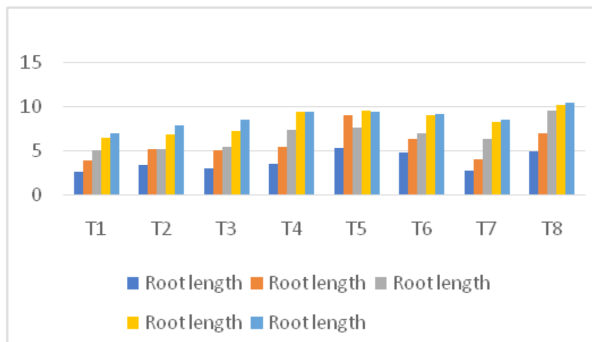

Fig. 3. Root length

Seed priming with nano Zn along with soil-applied nitrogen increased root length, but the foliar-applied nutrients are not transported to roots effectively. The addition of nitrogen led to an increase in both root length density and root activity. Conversely, the deficiency of N can cause a decrease in root activity and water uptake Zhang *et al*. (2017). According to Shojaei and Makarian (2015), Zn is required for the initiation of a number of metabolic enzymes in the plant's body and roots. These findings agree with our results showing a greater root length.

Dry weight (g)

At 15 and 30 DAS the maximum dry weight (0.25 g) was observed with the application of 50% RDN+

Seed priming with nano-Zn+ Foliar spray of nano-urea at 45 DAS, which was found statistically at par with T8 (0.21 g). At 45, 60 and 75 DAS the highest values were recorded at T8, which was found superior over all the other treatments. The minimum value of dry weight was observed at T1 (Fig. 4).

The presence of Zn enhances the plant's photosynthetic mechanism by facilitating the synthesis of essential components such as chlorophyll and carotenoids, which are crucial for plants to carry out photosynthesis Aravind (2003) which resulted in greater production of photosynthate, which ultimately leads to an increase in fresh and dry weight was observed in this study. The plant's metabolic processes result in the accumulation of dry matter, and nitrogen is essential for these processes to function properly. These results align with the studies conducted by Varsha *et al*. (2020).

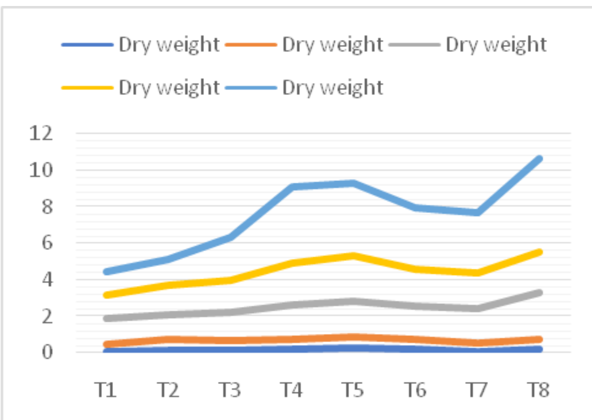

Fig. 4. Dry weight

Yield Parameters

Test weight (g)

The maximum 1000 grain weight (40.2g) was observed when the seed is treated with nano-zn and with foliar spray of nano-urea at 30 DAS+45 DAS, which was superior over all the other treatments, followed by T5 (38.63g). The lowest value of test weight was recorded in the control plot (Fig. 5).

The weight of 1000 grains increased after seed treatment with Zn could be attributed to its enhanced accessibility of this nutrient, leading to its direct transfer to the young seedlings. The sufficient uptake of Zn likely boosted the absorption of nitrogen, resulting in a higher crop yield Siddiqui *et al.* (2009).

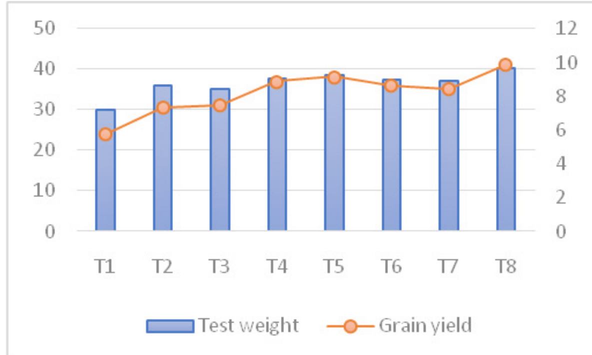

Fig. 5. Test weight and grain yield

Pods per plant

Nitrogen fertilization significantly affected the trait, the number of pods per plant. Seed priming with Zn along with the application of nano-nitrogen at both vegetative and reproductive stages gives the highest value of 34.33 (T8), which was further found significantly par with T5 (33) the lowest average for this trait was achieved at control (27.67).

The increase in the number of pods produced by each plantis the result of the increased vulnerability of the leaf surface to fertilizer application which increased the absorption of the fertilizer by the leaves Hassan *et al.* (2019).

Seeds per pod

The maximum number of seeds per pod was observed at T8 (6.53), followed by T5 (6.13) and the least number of seeds per pod was recorded at the control plot T1 (5).

Plants can absorb nutrients more readily by spraying nutrients on them, in this study foliar spray of nitrogen and Zn causes more nutrients to accumulate in their roots and vegetative systems. This increases the efficiency of photosynthesis and material transmission, which increases the number of seeds in the pod. The presence of nitrogen had a positive impact on the percentage of fertilized pods, which in turn resulted in an increment in the number of seeds present in each pod (Alqader *et al.*, (2020).

Grain yield (q ha^{-1})

Maximum grain yield of 9.85 quintals per hectare was observed with treatment T8, where seed primed with Zn along with the application of nano-urea at both vegetative and reproductive stages was superior compared to the remaining treatments, which seems significantly on par with T5 (9.14q ha^{-1}), which is clear from (Fig. 5).

An increase in the number of seeds and pods per plant had a favourable impact on overall seed production. The reason for this rise can be the spraying of nano nitrogen during the flowering stages which provide the nutrients that boost the effectiveness of the photosynthesis process, which has a favourable impact on raising the yield, or the reason is that there are more pods in plants which increased overall seed production (Alzubaidy, 2014).

Biological yield (q ha^{-1})

The maximum biological yield was observed at T8 (28.32q ha-1), which further found significantly at par with T5 (26.64q ha^{-1}). The minimum yield was recorded at control plot T1 (19.09q ha^{-1}).

Biological yield has a high positive link with the root length, fresh and dry weight, test weight, and the number of pods and grains per plant. Foliar spraying with nano-nitrogen promotes vegetative development, which increases the number of branches and floral inflorescences that represent the emergence of flower buds. It also stimulates physiological plant processes like photosynthesis, which increases biological yield, these outcomes align with Kocon (2010).

Conclusion

The current study presents novel data about the effects of nano-urea and nano-Zn on black gram growth and yield-related components. The findings highlight how nanoscale nutrients can be applied to crops either through seed dressing or by foliar application in order to achieve the desired results with significantly lower doses. Seed priming with nano Zn exhibit better performance in germination. Compared to soil treatment, foliar fertilization is more efficient. Further study is needed to increase the bioavailability of micronutrients in grains and mechanisms of action.

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