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Yield Performance of Chickpea under Foliar Application of Nano Urea and Nano Zn Fertilizers under the arid Condition of Western Rajasthan

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ABSTRACT: A two-year field experiment on Chickpea crop was conducted at Agricultural Research Station, Keshwana, Jalore, Agriculture University, Jodhpur (Rajasthan). The experiment was planned in a randomized block design with three replications along with eight treatments *viz.,* T1- N%0 P 100 %K 100% + 2% Urea, T2- N50% P 100 %K 100% + Chemi Zn 0.5%, T3- N75% P 100 %K 100% + Nano Urea3 ml/l, T4- N100% P 100 %K 100% + Nano Zn 2ml/l, T5- N0% P 100 %K 100% + Urea 2% + Chemi Zn 0.5%, T6- N50% P 100 %K 100% +Urea 2 % + Nano Zn 2ml/l, T7- N75% P 100 %K 100% + Nano Urea 3 ml/l + Chemi Zn 0.5 %, T8- N100% P 100 % K 100% + Nano Urea 3ml/l+ Nano Zn 2ml/l. The study revealed that the treatment with foliar application of N100% P 100 %K 100% + Nano Urea 3ml/l and Nano Zn 2ml/l recorded significantly superior in grain yield over all the treatment except N 75% P 100 % K 100% +Nano Urea 3 ml/l + Chemical Zn 0.5 % and N 50% P 100 %K 100% + Urea 2 % + Nano Zn 2ml/l, on which was statistically on par in grain yield.

Keywords: Chickpea, Nano-N, Nano Zn, Foliar Application.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) holds a significant position as one of the world's most important pulse crops, primarily due to its valuable seeds, which boast a high protein content ranging from 25.3% to 28.9% (Mafakheri *et al.,* 2011). With the global population expanding rapidly each year, it becomes increasingly imperative to enhance global agricultural productivity in order to meet the growing food demands of the world. In contrast, the availability of arable agricultural land has been steadily diminishing on a global scale, mainly due to urbanization and the growth of industrial sectors (Sekhon, 2014).

Nano fertilizers, ranging in size from 1 to 100 nanometres, release nutrients gradually over an extended period. This controlled release effectively reduces nutrient loss from the soil and minimizes the risk of soil and groundwater pollution (Meena *et al.,* 2017). These advanced fertilizers are crucial for enhancing the physiological and biochemical processes in crops by increasing nutrient availability. They improve metabolic functions and stimulate meristematic activities, ultimately promoting apical growth and expanding the photosynthetic area (DeRosa *et al.,* 2010). Nanoparticles possess unique physicochemical properties and show significant potential for enhancing plant metabolism (Zulfiqar *et al.,* 2019; Raliya *et al.,* 2018).

Nanoparticles' effectiveness is contingent upon several factors, including their chemical makeup, size, surface coating, reactivity, and, notably, the dosage at which they prove efficient (Jyothi and Hebsur 2017; Shang *et al.,* 2019). Nano-fertilizers offer improved nutrient utilization due to their superior ability to penetrate plant tissues and move nutrients within various plant parts (Ghorbanpour *et al.,* 2017; Kopittke *et al.,* 2019). Additionally, they help prevent the undesirable loss of nutrients by directly delivering them to crops, thereby minimizing interactions with soil, water, air, and microorganisms (Panpattee *et al.,* 2016).

Nano fertilizers are recognized for their precise nutrient release and targeted delivery at the nanoscale, enhancing plant productivity and mitigating environmental pollution (Fatima *et al.,* 2020). They stimulate plant growth and crop yield by providing essential nutrients in nano-sized particles, ensuring high fertilizer efficiency and optimal absorption due to their small size. This method reduces the risks associated with excessive fertilization, cuts down on the frequency of fertilizer applications, and proves cost-effective by lowering environmental protection expenses. Moreover, it preserves soil fertility and health, presenting itself as a promising, economical, and eco-friendly alternative to conventional fertilizers. This innovation aims to foster sustainable agriculture and improve food quality while minimizing impacts on human health and the environment (Sekhon, 2014).

In light of challenges like limited arable land, water scarcity, and nutrient resources, the development of the agricultural sector necessitates enhanced resource utilization with minimal harm to production beds through the effective use of modern technologies (Naderi and Shahraki 2013). The adoption of nano-fertilizers, as opposed to conventional synthetic fertilizers, presents a method to release nutrients into the soil in a controlled and conditional manner, thereby reducing nutrient loss, mitigating soil toxicity, and contributing to the sustainability and protection of agriculturally produced food (Arif *et al.,* 2016).

Foliar application is a method of nourishing plants by spraying liquid fertilizers directly onto their leaves, promoting enhanced absorption in the above-ground parts of the plant (Nasiri *et al.,* 2010; Marzouk *et al.,* 2019). The effectiveness of foliar fertilization surpasses that of applying fertilizers to the soil, particularly in drought and salinity conditions, because it directly supplies the required nutrients to the leaves. This approach offers rapid nutrient uptake, is independent of root activity, and does not rely on soil moisture availability (Romheld and El-Fouly 1999). When it comes to pulse crops, the application of foliar nano Nitrogen and Zinc fertilizers has been shown to enhance the growth parameters of Chickpea when compared to other fertilizer sources (Ghorbanpour *et al.,* 2017). Given the aforementioned insights, the current study was undertaken to investigate the effects of foliar application of nano-fertilizers on the productivity of Chickpea in the transitional plains of *Luni* Basin of Western Rajasthan.

MATERIAL AND METHODS

A field experiment was conducted during *Rabi* season of 2021-22 and 2022-23 at Agricultural Research Station, Keshwana, Jalore, Agriculture University, Jodhpur (Rajasthan) with the objective to find out the Yield performance of Chickpea under foliar application of Nano N and Nano Zn Fertilizers under the arid condition of Western Rajasthan. The experiment site is situated in the transitional plain of the *Luni* basin (IIB) agro climatic zone of Rajasthan which is located 25° 25′ N latitude and 72°29′ E longitudes at an altitude of 149.9 m mean sea level. Soil of the experiment site was sandy loam in texture being low in available carbon (0.25 %), low in available nitrogen (160 kg/ha) and Zinc (0.19 mg/kg) with neutral in soil reaction (pH 7.6). The experiment was conducted in randomized block design with three replications. There were Eight treatments *viz.,* T1- N%0 P 100 % K 100% + 2% Urea, T2-N50% P 100 %K 100% + Chemi Zn 0.5%, T3-N75% P 100 %K 100% +Nano Urea 3 ml/l, T4-N100% P 100 %K 100% + Nano Zn 2ml/l, T5- N0% P 100 %K 100% + Urea 2% + Chemi Zn 0.5%, T6-N50% P 100 % K 100% + Urea 2 % + Nano Zn 2ml/l, T7- N75% P 100 %K 100% + Nano Urea 3 ml/l + Chemi Zn 0.5 %, T8- N100% P 100 % K 100% + Nano Urea 3ml/l+ Nano Zn 2ml/l. All the necessary plant protection and agronomic measures were practised as recommended for the transitional plain of *Luni* basin (IIB). Experiment field was fertilized with recommended dose of fertilizers at the rate of 20kg/ha Nitrogen and 40 kg/ha phosphorus. Two foliar sprays were carried out at flowering and pod development stages. Nitrogen was applied from Nano Urea whereas Nano Zinc was used for the foliar application of zinc for nano fertilizer treatment. Urea was used for Nitrogen and zinc sulphate monohydrate was used for non-fertilizers experiments. Chickpea variety GNG-2144 was used for experiments. Sowing was done in row spacing of 30 × 10 cm apart. The data obtained on various parameters were subjected to analysis of variance (ANOVA). The level of significance used in ‘F’ test was at 5%. The critical difference (CD) values are given in the table at a 5% level of significance (Gomez and Gomez 1984).

RESULT AND DISCUSSION

1. Growth Parameters

A. Plant Height

The study found that plant height was notably affected by nano urea and nano zinc, with the highest recorded plant height in the treatment of N100% combined with 3ml/l of nano urea and 2ml/l of nano zinc. Following closely behind was the treatment of N75% combined with 3 ml/l of nano urea and 0.5% chemical zinc. Increased concentrations of nanoparticle fertilizer can boost plant height by leveraging the abundant permeability and rapid mobility of nanoparticles. This enables easier entry into plant leaves, which is vital for promoting overall plant growth. Nitrogen, a fundamental element, positively impacts the activity of meristematic tissues and cell division. Additionally, it plays a pivotal role in the synthesis of amino acids such as Tryptophan, essential for Auxin production, further enhancing cell division and expansion (Alqader *et al.,* 2020).

B. Branches per Plant

The study's findings demonstrated a significant influence of Nano urea and Nano zinc on plant growth parameters, with the highest number of branches per plant observed in two treatments: N100% combined with 3ml/l of Nano urea and 2ml/l of Nano zinc, and N75% combined with 3 ml/l of Nano urea and 0.5% chemical zinc, indicating similar effectiveness in promoting branch growth. Zinc-based nanomaterials play essential roles in chlorophyll production, fertilization, pollen function, and auxin synthesis, while also offering protection against drought stress (Sharma *et al.,* 2009). Nano zinc has demonstrated notable benefits in terms of branch development and dry weight per plant at maturity compared to the control. The application of zinc has further enhanced growth characteristics compared to the control, primarily attributed to its direct and indirect involvement in numerous plant physiological processes (Vairavan *et al.,* 1997)

C. Lateral Spreads

"Lateral spread in chickpea" refers to the horizontal growth or expansion of the chickpea plant. It involves the extension of branches or foliage sideways from the main stem. The lateral spread of chickpea plants is an important agronomic trait as it can affect the plant's ability to capture sunlight, compete with weeds, and ultimately influence yield. The study results showed significant effects of Nano urea and Nano zinc on plant growth parameters, with the highest recorded lateral spread per plant observed in the treatment combining N100%, 3ml/l of Nano urea, and 2ml/l of Nano zinc. This was statistically equivalent to the treatment involving N75%, 3 ml/l of Nano urea, and 0.5% chemical zinc. They efficiently deliver nutrients as needed, ensuring a controlled release of chemical fertilizers that manage plant growth and enhance targeted activity, as demonstrated by Nair *et al.* (2010).

Yield Parameters

A. Pods per Plants

The foliar application treatment comprising N100%, P 100%, K 100% with 3ml/l of Nano urea and 2ml/l of Nano zinc exhibited significantly higher pod yield per plant compared to all other treatments, except for two: N75%, P 100%, K 100% with 3 ml/l of Nano urea and 0.5% chemical zinc, and N50%, P 100%, K 100% with 2% urea and 2ml/l of Nano zinc, which showed statistically equivalent pod yields per plant. The superiority of high concentrations of Nano fertilizer stems from their ability to increase leaf area, particularly at elevated levels. This expanded leaf surface becomes more receptive to fertilizer application, allowing for enhanced absorption of nutrients by the leaves. This heightened nutrient uptake is reflected in an increase in the number of pods per plant. Leaf area expansion plays a crucial role in elevating flower nodes and facilitating the fertilization process. These findings align with previous research by Hassan *et al.* (2019).

B. Seeds per pod

The number of seeds per pod, a crucial metric in agriculture and plant breeding, reflects the yield potential of a plant. The study demonstrated notable impacts of Nano urea and Nano zinc on various plant growth parameters. The treatment that yielded the highest seeds per pod consisted of N100%, with 3ml/l of Nano urea and 2ml/l of Nano zinc. Interestingly, this outcome was statistically comparable to the treatment combining N75%, 3 ml/l of Nano urea, and 0.5% chemical zinc, as well as N50% + Urea 2 % + Nano Zn 2ml/l. Similar results was reported by Singh *et al*. (2015)

C. Test Weight

The treatment involving foliar application of N100%, P 100%, K 100% with 3ml/l of Nano urea and 2ml/l of Nano zinc demonstrated the highest test weight among all treatments. However, it's important to note that the foliar application of various nutrients did not influence the test weight of the seeds, as it is primarily determined by genetic characteristics.

Table 1: Growth parameters, yield attributes and yields of Chickpea as influenced by foliar application of nutrients.

Treatments	Plant height (cm)		Lateral Spread (cm)		Branches/plant	
	2021	2022	2021	2022	2021	2022
N%0 PK + 2% Urea	23	28	20	22	3.00	3.2
N50%PK + Chemi Zn 0.5%	24	29	21	23	3.33	3.6
N75%PKF + Nano Urea 3 ml/l	26	30	23	26	3.53	3.8
N100%PK + Nano Zn 2ml/l	25	32	22	24	3.57	3.7
N0%PK + Urea 2% + Chemi Zn 0.5%	27	34	22	25	3.43	3.6
N50% + Urea 2 % + Nano Zn 2ml/l	28	35	24	29	3.93	4.3
N75% + Nano Urea 3 ml/l + Chemi Zn 0.5 %	30	37	26	30	4.23	4.8
N100% + Nano Urea 3ml/l+ Nano Zn 2ml/l	32	38	27	30	4.67	5.1
SEm±	1.2	1.6	1.0	1.5	0.22	0.3
CD at 5%	3.6	4.9	3.2	4.4	0.66	0.8

Table 2: Yield attributes and Yields of Chickpea as influenced by foliar application of nutrients.

Treatments	Pods /Plant		Seeds/pod		Test Weight (g)		Grain yield (kg/ha)	
	2021	2022	2021	2022	2021	2022	2021	2022
N% 0 PK + 2% Urea	20	23	1.38	1.40	199.2	201.9	1216	1361
N50% PK + Chemi Zn 0.5%	22	24	1.42	1.45	201.1	202.5	1386	1486
N75% PKF + Nano Urea 3 ml/l	24	26	1.45	1.46	206.7	207.1	1425	1499
N100%PK + Nano Zn 2ml/l	23	25	1.50	1.50	200.2	201.9	1563	1652
N0% PK+ Urea 2% + Chemi Zn 0.5%	24	25	1.47	1.48	204.6	207.6	1606	1777
N50%+ Urea 2 % + Nano Zn 2ml/l	27	27	1.49	1.52	204.8	209.4	1669	1805
N75%+Nano Urea 3 ml/l + Chemi Zn 0.5 %	28	29	1.50	1.54	208.5	210.5	1799	1874
N100%+ Nano N 3ml/l+ Nano Zn 2ml/l	30	32	1.54	1.56	208.5	213.9	1850	1902
SEm±	1.2	1.1	0.02	0.03	5.6	4.0	90	34
CD at 5%	3.5	3.4	0.06	0.09	NS	NS	272	105

D. Grain Yield

The treatment featuring foliar application of N100%, P 100%, K 100% with 3ml/l of Nano urea and 2ml/l of Nano zinc demonstrated significantly higher grain yield compared to all other treatments, except for two: N75%, P 100%, K 100% with 3 ml/l of Nano urea and 0.5% chemical zinc, and N50%, P 100%, K 100% with 2% urea and 2ml/l of Nano zinc, which showed statistically similar grain yields. Similar results was reported by Mali *et al*. (2003); Jin *et al*. (2008). The boost in grain yield can be attributed to the combined application of fertilizers in both conventional and Nano forms, along with micronutrients. This approach ensured a balanced and optimal nutrient supply throughout the crop cycle. Numerous research studies have underscored the yield-enhancing advantages of Nano-fertilizers. For instance, Benzon *et al*. (2015) observed a beneficial impact of Nano-fertilizers on the efficiency of traditional fertilizers, facilitating improved nutrient absorption by plant cells. This, in turn, fostered optimal growth and metabolic processes like photosynthesis, leading to higher accumulation and translocation of photosynthates to the plant's economically valuable parts, ultimately resulting in increased yield. This outcome aligns with findings from other research studies indicating the favourable impact of nitrogen on seed yield across various legume crops (Drostkar *et al.,* 2016; Gomma *et al.,* 2016). These findings are consistent with those of Kumar *et al.* (2020). The boost in plant growth can be credited to heightened growth hormone levels and increased photosynthetic activities brought about by the use of Nano-fertilizers. Additionally, the application of Nano zinc enhances plant metabolic processes and photosynthesis, resulting in increased flowering and grain formation, ultimately leading to improved crop yields. Numerous research studies have documented that Nano fertilizers have a positive impact on photosynthesis and plant development (Wu, 2013; Fatima *et al.,* 2020). Nano-fertilizers such as Nano-NPK are regarded as biological stimulants for plants, facilitating the absorption of nutrients and water in crop plants (Ma *et al.,* 2009).

CONCLUSIONS

The treatment with foliar application of N100% P 100 % K 100% + Nano Urea 3ml/l and Nano Zn 2ml/l recorded significantly superior in grain yield over all the treatment except N 75% P 100 % K 100% +Nano Urea 3 ml/l + Chemical Zn 0.5 % and N 50% P 100 %K 100% +Urea 2 % + Nano Zn 2ml/l, on which was statistically on par in grain yield.

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