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Response of nano fertilizers of zinc and ferrous on growth and yield attributes of chickpea (*Cicer arietinum* L.)

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Abstract
The present field investigation on effects of nutrient management using nano fertilizers on chickpea (*Cicer arietinum* L.) was conducted in the *rabi* season of 2020–2021 at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.), with a view to study the growth and yield attributing traits as influenced by nano fertilizers. Among all the ten treatments of nano fertilizer application, the treatment T_8, was found to significantly increase yield (16.34 kg) per plot and yield attributing characters such as number of pods (40) and test weight (26.41 g). However, there was little impact on other characteristics, such as days to 50% flowering and days to maturity.

Keywords: Nano fertilizer, growth parameters, plant yield, yield attributes, chickpea

Introduction

The main pulse crop grown in India is chickpea (*Cicer arietinum* L.). This crop is thought to have originated in south-eastern Turkey and spread through the silk route to the west and south. Ethiopia is listed as a secondary centre of origin along with the Mediterranean, Central Asia, the Near East, and India as four centres of diversity. It is grown and consumed in great quantities in nations like Southeast Asia to India, the Middle East, and Mediterranean nations. It ranks third in production and second in terms of area among all pulses grown in the world. India is the world's largest producer and consumer of chickpea. Out of all pulse crops, chickpea seeds are the most abundant source of protein (17–22%), carbohydrates (48–55%), fats (2–7%), and other vital nutritional components consumed by people. The seed of this plant is consumed raw as a green vegetable, cooked as a sweet, roasted, fried, or boiled as a snack food and its flour is used to make bread and soup.

The term "nano fertilizers" refers to fertilizers and nutrients delivered as particle emulsions with nanoscale dimensions, coated with thin polymer films, or encapsulated inside nanoporous materials (Rai *et al*., 2012) [11]. Nano fertilizers contain nutrients and growth promoters enclosed in nanoscale polymers, and they deliver the major nutrients to crops in a phased manner according to their needs. These environmentally friendly, biologically produced fertilizers are matched in terms of nutrient composition and application rates to inorganic fertilizers. To control the release of nutrients based on the crop needs, nano fertilizers are created. Agronomic managements along with timely synchronisation of nutrient application, plant root development or use of slow-release fertilizers and foliar feeding could lead to sustainable nutrient use efficiency.

The study was undertaken with the goal of evaluating the growth and yield attributing parameters influenced by nano fertilizers.

Materials and Methods

Using a randomised block design and three replications, the experiment of nutrient management through nano fertilizers was carried out. There were ten different treatment combinations that examined the impact of various nano fertilizer combinations in different concentrations, as well as various nano nutrient application techniques on chickpea variety "P 547". TERI, Gurgaon Road Gurugram, Haryana, supplied the seed treated with nano fertilizer.

These treated seed materials were used for sowing as different combinations of seed coating and foliar application. The table 1 below includes information on the specific treatments used:

Table 1: The details of treatments are as follows

Sr. No.	Symbol	Treatment Details
1.	T_1	Control
2.	T_2	25N:50P kg/ha (RDF) (urea-43.40gm., SSP-250gm., ZnSO4-20.24 gm.)
3.	T_3	100% RDF (urea- 43.40 g, SSP- 250 g, ZnSO4- 20.24 gm.) + Seed coating of nano P(Phosphorus) @125 ml/ha (100% seed coating).
4.	T_4	100% RDF (urea-43.40 g, SSP-250 g, ZnSO4-20.24 gm.) +Seed coating of nano Zn+ Fe (zinc+ Iron) @125 ml/ha (100% seed coating).
5.	T_5	75%RDF (100%N/K with75%P) (urea-43.40gm., MOP-33.36g, ZnSO4-20.24 g, SSP-187.50 gm.) + seed coating of nano P (Phosphorus)@ 125 ml / ha (100% seed coating)
6.	T_6	75%RDF+(100%NPKwith75%Zn/Fe) (urea-43.40gm., MOP-33.36gm., ZnSO4-15-18.75gm., SSP-250 g) +Seed coating of nano Zn+ Fe (Zinc+ Iron) @125 ml/ ha (100% seed coating).
7.	T_7	100%RDF (urea-43.40 gm., SSP-250 gm., ZnSO4 20.24gm.) +Seed coating of nano P(Phosphorus) @62.5ml/ha+ Foliar spray of nano P (Phosphorus) @ 250 ml/ha (50% seed coating +50% Foliar).
8.	T_8	100% RDF (urea-43.40 gm., SSP-250 gm., $ZnSO_4$-20.24 gm.) + Seed coating of Nano Zn+ Fe (Zinc+ Iron) @ 62.5ml/ha+ Foliar spray of nano Zn+ Fe (Zinc+ Iron) @250ml/ha (50% seed coating + 50% Foliar).
9.	T_9	75% RDF (100% N/K with 75% P) (urea-43.40gm., MOP-33.36gm.., $ZnSO_4$-20.24gm., SSP-187.50gm.) + Seed coating of nano P (Phosphorus) @62.5ml/ha+ Foliar spray of nano P (Phosphorus) @250ml/ha (50% seed coating + 50% Foliar).
10.	T_{10}	75% RDF (100%N/K with 75% P) (urea-43.40gm., MOP-33.36gm., $ZnSO_4$-15-18.75 gm., SSP-250 gm.) + Seed coating of Zn +Fe (Zinc + Iron) @ 62.5 ml/ha + Foliar spray of nano Zn+ Fe (Zinc+ Iron) @250ml/ha (50% seed coating +50% Foliar).

Five plants were randomly selected and tagged in each plot to record on-farm observations for growth parameters *viz*., Absolute Growth Rate (AGR) (g/g/day), Relative Growth Rate (RGR)(g/cm²/day), Leaf Area(cm²), Days to 50% flowering and Days to maturity, yield and yield contributing traits *viz*., No. of pods, Test weight(g), Seed yield/plant(g), Seed yield(q/ha).

The collected data was subjected to statistical analysis using the Randomized Block Design procedures (RBD). At 5% levels of probability, the significance of the treatment difference was examined. According to Panse and Sukhatme (1985) [10], the distribution of degree of freedom for the analysis of variance is provided.

Results and Discussion

The data for the observation recorded has been presented in Table 2 and discussed as follows:

The chickpea crop's leaf area as influenced by various nano fertilizer treatments. At 90 DAS the T_4, T_5, T_8, T_9, T_{10} treatments were significant over the control, among this maximum leaf area was recorded at T_8 treatment i.e. 189.66 cm² followed by T_{10} treatment (75% RDF +Seed coating of Zn +Fe @ 62.5 ml/ha + Foliar spray of nano Zn +Fe @ 250 ml/ha) i.e. 188.66 cm². From sowing to harvesting whenever the leaf area was recorded in all the seed treatments the leaf area in non-treated seed plots was lower as compared to the other treatments. The amount of leaf area is a crucial plant growth factor that affects crop yield and a plant's ability to capture solar energy for photosynthesis. Until the crop reached the flowering stage, the leaf area increased with crop age; after that, it decreased. Given their crucial role in several physiological and biochemical processes, including root development, photosynthesis, energy transfer reactions, and symbiotic biological N fixation processes, the increase in leaves may have been caused by better nutrient availability (Rathinavel and Dharmalingam, 1999) [12]. The leaf area of chickpea shows the influence of the nano fertilizer on the leaf area with respect to days after sowing of crop. The observations were taken at 90 days after sowing. From the above data it was observed that the application of nano fertilizer significantly varied among treatments. The T_8 treatment is statistically significant to the other treatments. The increased leaf area was also due to the microelements which lead to larger amounts of assimilates production. The above results were similar with the findings of Afshar *et al*. (2013) [1] in common bean.

Days to 50% flowering as influenced by various nano fertilizer treatments. The conclusion from this observation is that the number of days to 50% flowering was not affected by the application of bulk fertilizers and micronutrients because flowering is primarily dependent on photoperiodism, so application of bulk fertilizers or other micronutrients was not significantly impacted for flowering days. The data on days to maturity as affected by nano fertilizer treatment indicates that the various nano fertilizer treatments did not significantly alter the number of days needed for maturity. The time from sowing to maturity ranged from 74 to 78 days. The difference between the number of days needed for the crop to mature in each treatment showed that the treatment's effect on the crop's growth was not significant. Only 4 to 5 days difference was observed for the crop to mature in between the treatments. The above result similar with the finding of Cutcliffe and Munro (1976) [2], Jalal *et al*. (2020) [4].

The results of the treatment with nano fertilizer showed a significant difference in case of absolute growth rate. Between the 60 to 90 days duration, the treatment T_8 (100% RDF + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha) was found to have the highest absolute growth rate, measuring 0.87 g/g/day, followed by T_{10} (75% RDF + Seed coating of Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha) i.e 0.85 g/g/day. The initial crop growth had a higher absolute growth rate, but during the harvest phase, the rate started to decline due to the senescence of the leaves. The above result is in support with findings of Kumar (2019) [6].

The data on the relative growth rate (g/g/day) of chickpea as influenced by nano fertilizer treatment at various growth stages of the crop showed that different experimental treatments had a significant impact on the relative growth rate of chickpeas from 60 to 90 days after sowing. The treatment T_9 (75% RDF + Seed coating of nano P @ 62.5 ml/ha + Foliar spray of nano P @ 250 ml/ha) recorded the highest values at 60 to 90 days of observation, i.e., 0.015 g/g/day, followed by T_8 and T_{10} treatments (0.014 g/g/day). The lowest relative growth rate (0.008 g/g/day) was observed for treatments T_1 control, T_2 and T_3. Early growth periods showed a higher relative growth rate, which decreased as the crop grew older. In the early stages of plant development, the ratio of living to dead tissues is high, and nearly all the cells in the productive organs are actively producing vegetative matter. As a result, the relative growth rate of plants is high, but as plants age, their metabolic activity declines, and as a result, the tissues are unable to contribute to growth, which causes the RGR to decrease. The above results were supported with the findings of Namvar *et al*. (2011) [8].

The treatment T_8 (100% RDF + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha) treatment had significantly recorded more pods per plant (40) than the other treatments. The control T_1 treatment, which recorded 29 pods, was the fewest. The increase in the number of pods may be attributable to the micronutrients' ability to stimulate the production of internal growth hormones by the plant that support plant hormonal balance. The plant produces more pods as a result of this balance. (Noaema *et al*., 2020) [9]. Applications of zinc may result in zinc's favourable impact on pollen and stamen formation, which could increase the crop's fertility and in turn, increase the number of pods. The research by Shewangizaw *et al*., (2017) [13] was used to support the aforementioned result.

Different nano fertilizer treatments had no discernible impact on test weight. The test weight ranged from 24.07g to 26.41g in total. Only a difference of 2 to 3g in weight existed between the control treatment and the other nano fertilizer applied treatments for the test weight (100 seeds). The aforementioned conclusion in chickpea was supported by Morovat *et al*. (2019) [7]. The amount of seeds produced per plant was affected by the nano fertilizer treatments. According to the data, the treatment T_8 (100% RDF + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha) produced the highest seed yield per plant (9.3 gm), followed by the treatment T_{10} (75% RDF + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar spray of nano Zn + Fe @ 250 ml/ha). Additionally, the seed yield of the control treatment was the lowest (8.02 gm). Iron and zinc's contribution to seed yield is crucial for healthy growth. Chlorophyll is synthesized with the help of iron, which also aids in the absorption of other nutrients. The above result is relevant to the findings of Drostkar *et al*. (2016) [3].

The different nano fertilizer applications significantly affected the yield of chickpea per plot (kg) and per hectare (kg). The treatment T_8 (100% RDF + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha), which outperformed all other treatments under study, recorded a significantly higher yield of chickpea per plot (16.34 kg). The treatment, T_{10} (75% RDF + Seed coating of Zn + Fe @ 62.5 ml/ha + Foliar spray of nano Zn + Fe @ 250 ml/ha), resulted in a yield per plot of (16.25 kg). The T_1 control treatment yield per plot recorded the lowest (7.91 kg). The treatment T_8 (100% RDF + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha) outperformed all other treatments under study with a yield per hectare of (20.50 kg). The treatment, T_{10} (75% RDF + Seed coating of Zn + Fe @ 62.5 ml/ha + Foliar spray of nano Zn + Fe @ 250 ml/ha), resulted in a yield per plot of 19.83 kg. The yield of T_1 control treatment per plot was the lowest, 13.83 kg. As shown above, the effects of a full dose of NPK fertilizer, nano zinc and iron seed coating, and foliar application are noticeably superior for the seed yield per plot and seed yield per hectare. The above results are relevant to the findings of Drostkar *et al.* (2016) [3], Janmohammadi *et al*. (2017) [5], Morovat *et al*. (2019) [7].

Table 2: Effect of different nano fertilizer treatment on Growth and yield attributes of Chickpea

Treatment	Leaf area (90 DAS)	Absolute growth rate (60 to 90DAS)	Relative growth rate (60 to 90DAS)	Days to 50% flowering	Days to maturity	No. of Pods	Test Weight (100seeds)	Seed Yield	Seed yield /plot	Seed yield /Ha
T_1	172	0.75	0.008	55	79	29	24.07	8.02	7.91	13.83
T_2	177.33	0.77	0.008	54	76	31	25.39	8.15	10.96	14.50
T_3	180.33	0.77	0.008	54	77	30	26.11	8.27	9.59	14.66
T_4	185	0.80	0.007	54	76	33	25.54	8.46	10.67	16.33
T_5	182.33	0.79	0.009	54	74	32	26.03	8.35	12.36	15.50
T_6	181	0.80	0.009	54	75	33	25.75	8.55	11.59	16.33
T_7	179	0.82	0.009	54	75	35	26.23	8.59	13.89	17.00
T_8	189.66	0.87	0.014	54	74	40	26.41	9.3	16.34	20.50
T_9	183.33	0.81	0.015	54	75	34	26.12	8.7	11.39	15.50
T_{10}	188.66	0.85	0.014	54	75	39	25.93	9.1	16.25	19.83
MEAN	181.86	0.80	0.010	54.1	75.7	33.60	25.76	8.55	12.09	16.4
S.E.±	2.61	0.02	0.001	0.37	0.51	2.23	0.39	0.25	1.72	1.29
C.D. at 5%	7.76	0.06	0.005	NS	NS	6.68	NS	0.75	5.12	3.86

Conclusion

From present investigation, it can be concluded that treatment T_8 (Urea 25:50 as N:P kg/ha + Seed coating of nano Zn + Fe @ 62.5 ml/ha + Foliar Spray of nano Zn + Fe @ 250 ml/ha,) was the most influencial that affected the growth attributes, such as leaf area, absolute growth rate, and relative growth rate. The yield attributing traits *viz*., pod number per plant, seed yield per plant, seed yield per plot, yield per hectare were influenced by 25:50 as N:P kg/ha + Seed coating of nano Zn +Fe @ 62.5 ml/ha + Foliar Spray of nano Zn +Fe @ 250 ml/ha.

Nano fertilizer, such as Zn and Fe combination used as seed coating prior to sowing, nano foliar fertilizer applied during crop growth, and soil applied fertilizers, all played significant roles in the growth and yield performance of chickpea crop.

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