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Impact of Nano DAP and Zn EDTA on Cowpea Growth and Yield

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Pulses are gaining more important position in Indian Agriculture.But the average productivity of pulses (764 kg ha^{-1}) is much less productive than the global average (848 kg ha^{-1}).To increase its productivity application of important fertiliser to cowpeas during their critical growth stages is aeffective strategy to enhance their yield. Especially smart fertilizers like Nano Di-ammonium Phosphate (DAP) and Zinc Ethylene Diamine Tetra Acetic acid (Zn EDTA) are very helpful in that. Therefore, the field experiment was done in the dairy Farm, School of Agriculture and Animal Science, Gandhigram Rural Institute, Gandhigram, Tamil Nadu during January 2024 to March2024 to assess the impact of Nano DAP and Zn EDTA on growth and yield of cowpea. It was laid out in Randomized Block Design (RBD) with seven treatments under three replications. Among the different treatments, Recommended Dosage of Fertilizers (RDF) 50% Phosphorus, 100% Nitrogen (N) and potassium (K) + Seed treatment and two foliar sprays of 0.2% of Nano Di-ammonium Phosphate (DAP)+ Foliar spray of 3% Zinc Ethylene Diamine Tetra Acetic acid (Zn EDTA)(T_7) achieved supremely improved growth parameters like plant height, no.of branches per plant, leaf

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area index, dry matter production, and yield attributes viz., pod length, no.of pods per plant , no.of seeds per pod and test weight . Further it recorded a higher seed yield,haulm yield and harvest index. The minimum value was recorded under control treatment (T_1).Experimental results clearly revealed that RDF 50% P, 100% NK + Seed treatment and two foliar sprays of 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA(T_7) has recorded the highest yield of 1720 kg ha^{-1}.

Keywords: Nano DAP; ZnEDTA; cowpea; yield.

1. INTRODUCTION

Cowpea is well-known for its ability to withstand dryness. It is also known as black-eyed pea or southern pea. The shadowing effect of its broad, drooping leaves preserves soil moisture. It can be used as a vegetable, food, feed, fodder, forage and green manuring. In the semi-arid tropical regions of Asia, Africa, Southern Europe, Central America, and South America, it is a vital food legume. Worldwide, the use of cowpeas as food, fodder, and a raw resource for numerous industries is increasing.Cowpea, also referred to as vegetable meat, is a valuable source of vitamins, minerals, and protein for a healthy diet.4.3 g protein, 2.0 fibre, 8.0 g carbohydrate, 74 mg phosphorus, 2.5 mg iron, 13.0 mg vitamin C and 0.9 mg minerals, etc. are present in 100 g of green tender pods [1]. India has low pulse production and productivity as pulses are cultivated mainly on marginal and submarginal soils with inadequate management techniques [2]. India is the world's biggest importer and user of pulses. With 2,745.28 tonnes production, Uttar Pradesh is the top cowpea producer [3]. India's productivity of pulses (764 kg ha^{-1}) is significantly lower than the global average (848 kg ha^{-1}).Overall area cultivated for pulses remains almost unchanged at 22 to 24 million hectares, with a production that has remained relatively constant at 12 to 14 million tones [4]. In contrast to the FAO/WHO recommendation of 80 g day^{-1}, the current per capita availability of pulses has reduced from 51.1 g day^{-1} in 1970–71 to less than 41.9 g day^{-1} (2017).It results in an alarming shortage of pulses in India, worsening the issue of malnourishment among a significant percentage of the vegetarian population.

Thus, there is an urgent need to increase production in order to fulfill the demand by adopting the appropriate production technologies. To improve its production and productivity,nutrient management strategies like foliar application of important nutrients is a feasible one.The cowpea crop responds well to the fertilizer. Today, foliar application of fertilizer is gaining momentum because photosynthetic efficiency is increased through foliar application of fertilizer by delaying the leaf senescence [5]. Legumes are crops that are fond of phosphorus, and is necessary for the development of seeds, nodules, and flower initiation [6]. Zinc is a major micronutrient that is crucial to the growth and development of plants. In developing countries, Zn deficiency occurs due to inadequate supply of micronutrient [7]. Several research findings also reported that, considerable increment in the yield of the crop is due to the application of Zn fertilizers.Smartfertilisers, such as Zn EDTA and Nano DAP, will be key in boosting agricultural productivity in sustainable manner by enhancing the nutrient use efficiency.Keep the above points in view that, the study was carried out to analyse the effect of Nano DAP and Zn EDTA on growth and yield of Cowpea.

2. MATERIALS AND METHODS

The field experiment was conducted at Gandhigram Rural Institute, Gandhigram during 2024 (January- April) to find out the effect of Nano DAP and Zn EDTA on growth and yield attributes of Cowpea. The experiment was conducts at dairy Farm, School of Agriculture and Animal Science, Gandhigram Rural Institute, Gandhigram, Tamil Nadu. The experimental farm was located at 10.28° Nlatitude and 77.93° Elongitude.The climate is moderately warm.Minimum and maximum temperature is around 26 °C to 38 °C.The relative humidity ranges from 51 to 79 % with mean annual rainfall of 850 mm.

The treatment consists of seven treatments including the combination of ZN EDTA and Nano DAP.Plot size was 5 × 4 m.The details of the treatment are., T_1 – Control, T_2 – RDF 100% NPK (N- 12.5kg/ha, P_2O_5- 30Kg/ha , K_2O - 16.7Kg/ha), T_3 – RDF 100%NPK+ Foliar spray of 3% Zn EDTA, T_4 – RDF 25%P, 100% NK + Seed treatment and two foliar spray of 0.2% Nano DAP, T_5 - RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP, T_6 – RDF 25% P, 100% NK+ Seed treatment and two foliar spray 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA, T_7 – RDF 50% P, 100% NK + Seed treatment and two foliar spray 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA. The foliar spray was done at the 45 DAS(Flowering stage)and 60 DAS(Pod filling stage).It was laid out in the randomized block design with three replications having an objective to identify the most efficient fertilizer schedule to enhance the productivity and also to reduce the usage of phosphorus fertilizer.The soil of the experimental field was sandy clay in texture with a pH of 8.41.The soil was low in carbon, low in available nitrogen, low in available phosphorus, high in available potassium and medium in zinc.The test variety was CO (CP)7. The seeds were treated with Nano DAP at the rate of 2ml/ litre of water for 20 minutes as per the treatment and then the treated seeds were sown in the main field by Dipping method.The cowpea seeds were sown at a spacing of 45 × 15 cm at a depth of 3 cm by adopting a recommended seed rate of 25kg ha^{-1}.Five representative plants were selected randomly from each treatmental net plot area and tagged for observations.These plants were used for recording all the biometric observations and the mean value obtained was analysed statistically.

3. RESULTS AND DISCUSSION

3.1 Plant Height

Among the treatments, RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) was recorded the maximum plant height of 55.32 cm. It is followed by the results of RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The least plant height of 40.21cm was observed at the harvesting stage in the control treatment (T_1).

The combination of basal application of conventional fertilizers and foliar spraying of nano fertilizers could have developed a significant increase in plant height by stimulating the plant's auxin metabolism and enzyme activity. This, in turn, might have prompted the cells to elongate and enlarge, ultimately leading to taller plants.This is in conformity with the works of Yasser et al., [8] and Gupta et al., [9] Hagagg et al., [10] ascribed that nanofertilizerspromote the uptake of water and nutrients, which is reflected in plant growth. Moreover, nano-fertilizers have a huge surface compared to conventional fertilizers, and this increases the plant’s metabolic efficiency.

The application of micronutrients through foliar fertilization resulted in a considerable increase in plant height. This increase in plant height might have been triggered by the micronutrient supply being adequate, which in turn accelerated the enzymatic activity and auxin metabolism in plants [11]. An increase in plant height might be due to zinc application and its interrelationship with auxin production, an important growth parameter regulating the stem elongation and cell enlargement [12].

3.2 Leaf Area Index

The maximum leaf area index of 3.56 was noted in RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) at harvesting stage. This treatment was followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The least leaf area index of 1.93 at harvesting stage was recorded in the control treatment (T_1).

Nano fertiliser easily enters leaves through stomata and other apertures, thus promoting the growth and elongation of the leaf by regulating the rate of cell division or size [13]. Phosphorus influences plant growth from the cellular to the whole plant level,by increasing leaf area through the processes of cell division and enlargement [14]. The findings aligned with the findings of Sharma et al., [15] for philodendron and Jutheryet al., [16] with wheat. Phosphorus increases leaf area and number along with acceleration of cell division by accumulating at meristametic areas [17].

Foliar application of nano DAP (0.4%) at 20 DAS and 40 DAS might have concurred with the nutrient demand of the crop through faster absorption and assimilation as suggested by Manikandan and Subramanian [18] in maize. Further, supplementing soil application of P with foliar application of nano P might also have resulted in quicker absorption of P in the nano form as it might have easily penetrated into the leaves resulted in more leaf area and LAI. Similar study was conducted by Rashmi and Prakash [19]. Foliar application of water-soluble fertilizers resulted in enhanced Plant growth, increased translocation of photosynthesis from source to sink, and reduce flower and pod shedding.

Table 1. Effect of Nano DAP and Zn EDTA on growth attributes of cowpea

Treatments	Plant height (cm)	LAI	No.of branches per plant	Dry matter production
T_1 – Control	40.21	1.93	5.3	3042
T_2 – RDF 100% NPK (N-12.5kg/ha, P_2O_5- 30Kg/ha, K_2O -16.7Kg/ha)	47.22	2.82	6.95	4159
T_3 – RDF 100%NPK+ Foliar spray of 3% Zn EDTA	49.87	3.08	7.31	4376
T_4 – RDF 25%P, 100% NK + Seed treatment and two foliar spray of 0.2% Nano DAP	43.49	2.32	6.18	3718
T_5 - RDF 50% P, 100% NK+ Seed treatment and two foliar spray of0.2% Nano DAP	52.71	3.31	7.63	4581
T_6 – RDF 25% P, 100% NK+ Seed treatment and two foliar spray 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA	46.19	2.57	6.63	3945
T_7 – RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA	55.32	3.56	7.92	4800
S.Ed	1.26	0.07	0.11	98
CD (P = 0.05)	2.56	0.18	0.25	197

Table 2. Effect of Nano DAP and Zn EDTA on yield attributes of cowpea

Treatments	No.of pods per plant	Pod length (cm)	No.of seeds per pod	Test weight (g)
T_1 – Control	13.67	12.11	9.13	13.78
T_2 – RDF 100% NPK (N-12.5kg/ha, P_2O_5- 30Kg/ha , K_2O -16.7Kg/ha)	16.61	14.80	11.87	13.85
T_3 – RDF 100%NPK+ Foliar spray of 3% Zn EDTA	17.40	15.53	12.39	13.85
T_4 – RDF 25%P, 100% NK + Seed treatment and two foliar spray of 0.2% Nano DAP	14.92	13.35	10.56	13.81
T_5 - RDF 50% P, 100% NK+ Seed treatment and two foliar spray of0.2% Nano DAP	18.31	16.25	13.02	13.88
T_6 – RDF 25% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP + Foliar spray of 3% Zn EDTA	15.77	14.15	11.21	13.83
T_7 – RDF 50% P, 100% NK + Seed treatment and two foliar sprayof0.2% Nano DAP + Foliar spray of 3% Zn EDTA	19.10	16.93	13.6	13.90
S.Ed	0.35	0.30	0.23	0.29
CD (P = 0.05)	0.76	0.63	0.51	NS

3.3 Number of Branches Per Plant

Among the treatments, RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) recorded the maximum number of branches 7.92. It is followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5) The least branches 5.3 were observed at the harvesting stage in the control treatment (T_1).

The tiny size of nano DAP facilitates the direct adsorption of nutrients into the leaves, where they are more quickly and effectively absorbed. Sufficient nutrients can promote growth and elongation of the cells. More branches per plant result in increased nutrient uptake in plant. Similar observations were recorded by Vaghar et al., [20] and Manjunath Gondi [21].

By increasing nutrient absorption, the application of nano-P promotes better metabolic processes like photosynthesis, which raises the accumulation of photosynthates and their translocation to the economically valuable parts of the plant, enhancing crop growth, development, and yield. A comparable outcome was observed in broad beans, where the application of nano- fertilizer improved nutrient accumulation and boosted growth activity due to smart delivery system of the fertilizers [22].

3.4 Dry Matter Production

RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% Nano DAP + Foliar spray of 3% Zn EDTA (T_7) resulted in the highest dry matter production of 4800 kg ha^{-1} at the harvesting stage. It is followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The control treatment (T_1) registered the least dry matter production of 3042 kg ha^{-1}.

According to Arif et al., [23] increasing availability of nutrients to crops through foliar application is a practical method to increase crop yield. Based on their research, they concluded that applying nano–DAP and foliar spraying nutrient solutions at different growth stages improved wheat yield, yield components, biomass, and pronounced P content – even at 75% lower input than commercial DAP.

Meena et al., [24] reported after the application of NFs, wheat grain and straw yield increased by 44.6 and 13.1%, respectively. This increase in output could be attributed to higher growth hormone, enhanced metabolic processes, and photosynthetic activities.

Table 3. Effect of Nano DAP and Zn EDTA on yield of cowpea

Treatments	**Seed yield (kg ha^{-1})**	**Haulm yield (kg ha^{-1})**	**Harvest index**
T_1 – Control	710	2105	25.22
T_2 – RDF 100% NPK (N- 12.5kg/ha, P_2O_5-30Kg/ha , K_2O -16.7Kg/ha)	1447	3111	31.74
T_3 – RDF 100%NPK+ Foliar spray of 3% Zn EDTA	1545	3315	31.79
T_4 – RDF 25%P, 100% NK + Seed treatment and two foliar spray of 0.2% Nano DAP	1279	2783	31.48
T_5 - RDF 50% P, 100% NK+ Seed treatment and two foliar spray of0.2% Nano DAP	1628	3508	31.69
T_6 – RDF 25% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP + Foliar spray of 3% Zn EDTA	1358	2949	31.53
T_7 – RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0.2% Nano DAP + Foliar spray of 3% Zn EDTA	1720	3670	31.91
S.Ed	33	74	0.04
CD (P = 0.05)	68	151	0.11

In cowpea, foliar application of nano P was positively correlated with DMP [25]. A sufficient supply of RDF and foliar application of P in nano form may be the cause of enhanced nutrient intake and efficient photosynthetic translocation, which in turn promotes DMP.

Barua and Sakia [26] also reported that $ZnSO_4$application @ 25kg/ha as basal + 0.5 % foliar application resulted in the plant's maximum straw yield. The reason for this is that zinc has positive influence on root growth, which increase plant nutrient intake from the soil that feeds the aerial portions of the plants and promotes vegetative growth. Likewise, similar conclusion was obtained by Bee bout et al. [27].

3.5 Number of Pods Per Plant

In addition, the simultaneous application of traditional and nano DAP ensured optimum and balanced nutrient availability during the crop season, particularly in the crucial stages of the crop. This is because of the nanoparticles' smaller size and greater effective surface area, which allow them to enter the plant more readily and improve nitrogen and phosphorus uptake. Plant components grow to their maximum potential as a result of the increased absorption. Similar results were reported by Manjili et al. [28] and Abdelghany et al. [29].

The maximum no.of pods of 19.10 was noted in RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) at harvesting stage. This treatment was followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The least No.of pods per plant of 13.67 at harvesting stage was recorded in the control treatment (T_1).

Applying Zinc to crops improved the biological activity, growth parameters, and metabolism of nutrients; therefore, applying Zinc increased the activity of enzymes, which in turn promoted the growth of vegetative branches and pods plant^{-1} [30]. The seed yield was enhanced by the combined action of growth parameters, yield attributes, and increased cowpea nutrient uptake [31].

Under different environmental conditions, the effectiveness of applying soil fertilizer is less than that of foliar fertilization because foliar fertilization provides the necessary nutrients directly to the leaves, absorbs more quickly doesn't depend on root activity, and increase plant growth parameters due to soil water availability [22].

3.6 Pod Length

RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) resulted in highest pod length of 16.93 cm. This treatment was followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The least pod length of 12.11 cm recorded in the control treatment (T_1). Similar observations were recorded by Pandey and Gupta [32].

Amirnia et al., [33] reported that application of nanoparticles in a number of crops has evidenced for enhanced physiological activities, gene expression and protein level indicating their potential use in crop improvement.

3.7 No.of Seeds Per Pod

RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0.2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) was registered the highest seeds per pod of 13.6 at the harvesting stage. It is followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The control treatment (T_1) registered the least seeds per pod of 9.13.

Then use of Nano-DAP results in a significant increase in the number of seeds produced, particularly when paired with traditional fertilizer. This is because the nutrients are stored in plant cells and released slowly to mitigate biotic and abiotic stress and enhance no of seeds. Increased plant development and metabolic activities like photosynthesis, are encouraged by nano fertilizers, which increases the concentration and transport of photosynthate to essential plant components. Similar outcomes were reported by El-Azizy et al., [34] demonstrating the efficacy of nano phosphorus fertilizer in increasing seed yield.

3.8 Test Weight

However, RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) was registered the maximum test weight of 13.90 g. This treatment was followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The least test weight of 13.78 g was noted in the control treatment (T_1).

Legumes are phosphorus- loving plants; they need it for seed development, growth, and most importantly, the energy-producing process of nitrogen fixation. Cowpea yield depends on phosphorus because it is known to promote growth, stimulate nodule development and influence how effectively of the rhizobium-legume symbiosis functions Haruna and Aliyu, [6]. In immature cells with high metabolism and rapid cell division including shoot and root tips, it is essential in enormous amounts. It also promotes the growth of seeds, fruits and flowers [35].

3.9 Grain Yield

Increased yield components may be responsible for higher grain yield. The optimum and balanced nutrient availability was ensured throughout the crop period, particularly during the critical stages of the crop, by applying conventional and nano fertilizers (nano urea and DAP) in combination. This is because nanoparticles have a greater surface area and are smaller size, allowing them to more readily enter plants and improve nitrogen and phosphorus uptake. Increased uptake leads to optimal growth of plant parts and metabolic processes, such as photosynthesis, which increases the accumulation of photosynthates and their translocation to the economically productive parts of the plant. This process increase biomass, yield attributing characters, and yield by enhancing the translocation of assimilates to seeds. All of which contribute to increased yield. Similar results were reported by Bhargavi and Sundari [36] and Chinnappa et al. [37].

The maximum seed yield of 1720 kg ha^{-1} was achieved by the RDF 50% P, 100% NK + Seed treatment and two foliar spray 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7). It is followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The control treatment (T_1) resulted in the lowest seed yield of 710 kg ha^{-1}.

Zn foliar treatment significantly increased the production of cowpea grains and straw, which may be associated to its function in photosynthesis, cell division, protein synthesis, membrane structure retention and disease resistance. Since zinc is essential for the proper growth and development of plants, its role in the synthesis of lipids,carbohydrates, and nucleic acid was another factor contributing to the higher yield. Moreover, increased crop performance and yield were naturally the consequence of pollen, fertilization, and germination processes functioning properly as a result of Zn foliar application [38-40].

3.10 Haulm Yield

The treatments, RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) at harvesting stage recorded the supremely highest haulm yield of 3670 kg ha^{-1}. It is followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The least haulm yield of 2105 kg ha^{-1} was observed in the control treatment (T_1).

The rapid uptake and ease of translocation of nano fertilizers by plants may have contributed to the increase in haulm production following foliar spraying. This increased rate of photosynthesis and accumulation of dry matter resulted in a higher haulm yield. This corresponds to the results of Mallikarjuna [41] and Rajput et al., [42].

3.11 Harvest Index

Harvest index was significantly influenced by the foliar application ofNano DAP and Zn EDTAfertilization.The significantly highest harvest index of 31.91 was noticed in the RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7). It is followed by the RDF 50% P, 100% NK+ Seed treatment and two foliar spray of 0.2% Nano DAP (T_5). The lesser harvest index of 25.22 was noted in the control treatment (T_1).

Plant growth mechanisms are impacted by the enhanced absorption of nanonutrients caused by the small size of nano fertilizers. The accumulation of dry matter in leaves and proper nutrient supply led to an increase in plant metabolic activities such as photosynthetic and chlorophyll synthesis, both of which promote vegetative growth. This prolonged photosynthesis period additionally enables the plant to grow generally in terms of the harvest index. Similar findings were recorded by Sharma et al., [15] and Maheta et al., [43].

4. CONCLUSION

From the above results, it was concluded that application of RDF 50% P, 100% NK + Seed treatment and two foliar spray of 0. 2% of Nano DAP + Foliar spray of 3% Zn EDTA (T_7) recorded higher Plant height (cm), LAI, No.of branches per plant, Dry matter production, No.of pods per plant, Pod length (cm), No.of seeds per pod, Test weight (g),seed yield , haulm yield and harvest index. Lowest was noticed under absolute control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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