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Enhancing Rainfed Castor Growth, Seed, and Oil Yield Via Nano Urea Application

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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

Aims: Conventional urea fertilizer has been critical in enhancing castor yields. However, nano urea, a game-changing technology in modern agriculture, provides a significant advancement in terms of sustainable and efficient crop production.
Study Design: The experiment was conducted in a Randomized block design (RBD) with eight treatments and three replications.
Place and Duration of Study: Tapioca and Castor Research Station in Yethapur during the Kharif season of 2022.
Methodology: The major objective is to increase hybrid castor growth and production under rainfed circumstances by foliar application of nano urea. The castor hybrid YRCH 1 with an RDF of 60:30:30 NPK kg ha-1 was chosen for the study. The experimental details viz; T1 - 100% N through Urea –RDF, T2 - 50 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS, T3 - 50 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS, T4 - 75 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS, T5 - 75 % of

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recommended basal N+ 2 % Urea foliar spray at 30 and 60 DAS, T6 - 100 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS, T7 - 100 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS.

Results: According to the findings of the study, applying 100% of the recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS is advantageous to the crop and improves the growth and yield characteristics of hybrid castor under rainfed conditions. However, when compared to other treatments, foliar application of nano urea with 50% indicated basal N resulted in significantly lower growth and yield.

Conclusion: The major objective is to increase hybrid castor growth and production under rainfed circumstances by foliar application of nano urea

Keywords: Nano urea; hybrid castor; rainfed; foliar spray; yield.

1. INTRODUCTION

Castor (*Ricinus commuunis* L.) is an oilseed crop that contributes significantly to the country's vegetable oil economy. It is native to Eastern Africa and first discovered in Ethiopia. The major objective is to increase hybrid castor growth and production under rainfed circumstances by foliar application of nano urea [1]. This greater nutrient uptake can lead to improved plant growth, higher grain output, as well as higher nitrogen utilization efficiency, which is especially important in castor cultivation [2]. The best alternative to urea fertilizer right now is liquid nano fertilizer. One bottle of nano urea (500 mL) equals 45 kg of urea fertilizer. One nano urea liquid particle has a diameter of 30 nanometers and a surface area to volume size that is 10,000 times that of conventional granular urea [3]. In comparison to conventional urea, foliar application of nano urea liquid at crucial crop growth stages of a plant successfully fulfils its nitrogen requirement and leads to higher crop productivity and quality. According to the findings [4], nano-clay based fertiliser formulations (zeolite and montmorillonite with diameters of 30-40 nm) can release nitrogen for a longer period of time (> 1000 hrs) than traditional fertilisers (500 hrs). Nano urea is nitrogen fertilizer that has been made using nanoparticles to boost its efficiency and efficacy. The nitrogen holding capacity of nano urea refers to the amount of nitrogen that can be stored in the particles and slowly released over time, thereby providing a continuous source of nutrients for plant growth [5]. Indian farmers, who are largely tiny and marginal, do not apply the recommended fertilizer levels to these energy-rich crops. Indigenously available organic nutrient sources have been identified in order to increase efficiency and minimise the identified for artificial fertilisers. With nano urea and urea management in mind, an experiment was done to assess the efficacy of nano urea on the growth, yield, and quality of rainfed castor.

2. MATERIALS AND METHODS

2.1 Site Selection

The experimental study conducted in 2022 at the Tapioca and Castor Research Station in Yethapur focused on a field with sandy loam soil with a pH of 7.1. The electrical conductivity (EC) of the soil was measured at 0.32 dS/m, and it exhibited an organic carbon content of 0.33%. The experimental field's soil, collected from a depth of 0-15 cm, underwent subsequent analysis after drying and grinding through a 2 mm sieve. Nitrogen, assessed through the alkaline permanganate method, was found to be present at a rate of 258 kg/ha. Phosphorus was tested at 11.4 kg/ha using the Olsen technique, whereas potassium was found to be 289 kg/ha using the neutral normal ammonium acetate method.

2.2 Experimental Description

During the Kharif season (2023), the experimental investigation was conducted under rainfed conditions with YRCH 1 as the test castor hybrid. The study experiment used (RBD) Randomised Block Design with eight treatments and three replications with plot sizes of 6.0 m × 5 m. A foliar spray of nano urea is used to apply a variable amount of basal nitrogen, phosphorus, and potassium. The experimental details viz; T1 - 100% N through Urea –RDF, T2 - 50 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS, T3 - 50 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS, T4 - 75 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS, T5 - 75 % of recommended basal N+ 2 % Urea foliar spray at 30 and 60 DAS, T6 - 100 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS, T7 - 100 % of recommended basal N + 2

% Urea foliar spray at 30 and 60 DAS. The recommended fertilizer dose for rainfed hybrid castor, comprising 60:30:30 NPK (nitrogen, phosphorus, and potassium) in kilograms per hectare was applied to the research land. Additionally, a foliar spray of urea (2.0%) was administered in accordance with the treatment plan. The seeds were sown with a spacing of 120 x 60 cm. Phosphorus was applied as a basal application, and potassium was provided in two splits based on the recommended guidelines. Observations were meticulously recorded for various growth and yield-contributing characteristics, including plant height (cm), the number of effective branches per plant, length of the primary spike (cm), the number of capsules on the primary spike, the number of nodes per plant, days to 50% flowering, 100-seed weight (g), seed yield (kg/ha), oil content (%), and oil yield (kg/ha). These observations were conducted on randomly selected five plants within each plot. The collected data on the growth and yield components Phosphorus was tested at 11.4 kg/ha using the Olsen technique, whereas potassium was found to be 289 kg/ha using the neutral normal ammonium acetate method. Furthermore, the Least Significant Difference (LSD) test was applied to discern and establish the superiority of treatment means, elucidate significant differences, and draw meaningful conclusions. These statistical methods, as recommended by authoritative sources [6], ensured a thorough analysis of the experimental data, providing to a full knowledge of the influence of the treatments used on the castor hybrid under rainfed circumstances.

3. RESULTS AND DISCUSSION

It was observed that the supplementation of the crop with nitrogen (N) significantly enhanced both growth and yield, regardless of the nitrogen source throughout the crop growth period (Table 1). The experimental data showed that applying 100% of the prescribed basal nitrogen, along with a foliar spray of 2 ml/l nano urea at 30 and 60 days after sowing (DAS), resulted in a significant improvement in growth and yield parameters. Specifically, there was a significant augmentation in the number of effective branches (11.2), the length of the primary spike (68.6 cm), and the number of capsules on the primary spike (84.1) in the hybrid castor compared to other treatment combinations [7].

The number of nodes per plant, days to 50% flowering, and 100-seed weight (g) did not exhibit any significant differences among the imposed treatments, likely attributable to the nearly identical size and morphology of the seeds, resulting in similar weights. Moreover, during the critical stages of 30 and 60 days after sowing (DAS), the treatment containing 100% of the recommended basal nitrogen, as well as nano urea foliar spray at 2 ml/l, showed a numerically higher count of nodes per plant, days to 50% flowering, and 100-seed weight (g). The impact on yield parameters could be attributed to the substantial nitrogen contribution facilitated by the nano urea during the spike development stage. This continuous nitrogen supply likely maintained heightened meristematic activity and stimulated cell elongation in plants, ultimately resulting in a higher number of capsules per primary spike. These findings corroborate previous findings made [7}, reinforcing the pivotal role of nitrogen, particularly in the form of nano urea, in affecting critical growth and yield parameters in the context of castor hybrid cultivation.

The treatment involving 100% of the recommended basal nitrogen, accompanied by a foliar spray of nano urea at 2 ml/l during 30 and 60 days after sowing (DAS), exhibited a significantly higher seed yield at 1781 kg ha-1. Following closely in seed yield was the application of 100% of the recommended basal nitrogen along with a 2% urea foliar spray at 30 and 60 DAS. Conversely, the lowest recorded seed yield, amounting to 1354 kg ha-1, was associated with the application of 50% of the recommended basal nitrogen along with a 2% urea foliar spray at 30 and 60 DAS. This notable increase in yield is attributed to a significant enhancement in growth; yield attributes, and improved partitioning of photosynthesis from source to sink, as detailed in Tables (1 and 2). Nano urea was critical in promoting plant growth and improving metabolic activities such as photosynthesis, leading to an accumulation of higher photosynthates and their efficient translocation to the economically valuable parts of the plant. Supporting these observations, Mollashahi et al. [8] and Munir et al. [9] have previously reported that the application of recommended doses of fertilizer affects the development and growth of both source and sink, further affirming the positive impact of optimal nutrient management on castor seed yield.

Table 1. Effect of nano urea application on growth and yield parameters of castor under rainfed condition

Treatments	Plant height (cm)	No. of effective branches/plant	Length of primary spike (cm)	No. of capsules on primary spike	No. of Nodes/plant
T_1 - 100% N through Urea -RDF	130.1	10.0	66.1	78.2	20.1
T_2 - 50 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS	124.1	8.8	55.6	70.2	16.2
T_3 - 50 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS	120.1	7.7	59.1	69.5	15.7
T_4 - 75 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS	133.6	9.6	61.7	80.4	17.8
T_5 - 75 % of recommended basal N+ 2 % Urea foliar spray at 30 and 60 DAS	127.9	9.0	63.2	76.1	18.4
T_6 - 100 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS	141.4	11.2	68.6	84.1	21.7
T_7 - 100 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS	134.1	10.5	65.1	81.4	20.8
SE(m)+	5.07	0.84	4.49	5.55	1.52
C.D(0.05)	14.86	2.47	6.35	12.31	NS
C.V.(%)	12.2	14.6	13.2	12.9	14.3

RDF: 60: 30: 30 NPK kg ha^{-1}

Table 2. Effect of nano urea application on yield parameters of castor under rainfed condition

Treatments	Days for 50% flowering	100 seed weight (g)	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg ha^{-1})
T_1 - 100% N through Urea -RDF	48	27.4	1582	43.2	683
T_2 - 50 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS	50	26.1	1460	42.1	615
T_3 - 50 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS	51	26.9	1354	43.3	586
T_4 - 75 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS	49	27.6	1591	43.8	697
T_5 - 75 % of recommended basal N+ 2 % Urea foliar spray at 30 and 60 DAS	52	27.4	1609	43.9	706
T_6 - 100 % of recommended basal N + Nano urea foliar spray @ 2 ml/l at 30 and 60 DAS	47	28.1	1781	44.1	785
T_7 - 100 % of recommended basal N + 2 % Urea foliar spray at 30 and 60 DAS	46	27.9	1690	44.0	744
SE(m)+	3.21	2.98	81.43	4.12	38.74
C.D(0.05)	NS	NS	240.12	NS	114.21
C.V.(%)	11.7	12.1	14.2	11.8	12.6

RDF: 60: 30: 30 NPK kg ha^{-1}; Cost of the produce is Rs 60 Kg^{-1}

The highest recorded oil yield, totalling 785 kg ha-1, was achieved through the application of 100 percent of the recommended basal nitrogen along with nanourea foliar spray at 2 ml/l during 30 and 60 days after sowing (DAS). This performance was on par with the treatment involving 75 percent of the recommended basal nitrogen along with nanourea foliar spray at 2 ml/l during 30 and 60 DAS, as well as the application of 100% nitrogen through urea-Recommended Dose of Fertilizer (RDF). The observed increase in the oil yield of the hybrid castor can be attributed to the foliar application of nano fertilizers, which, owing to their tiny particle size, offer a larger surface area. This increased surface area facilitates various metabolic functions in the plant system, resulting in the production of more photosynthates.

The synergistic effect of nano fertilizers enhances the efficiency of chemical fertilizers, promoting greater nutrient absorption by plant cells and fostering the maximum growth of plant parts. This, in turn, increases metabolic processes like photosynthesis, resulting in greater accumulation and transfer of photosynthates to economically useful regions of the plant. These dynamics contribute to increased source and sink strength, ultimately resulting in higher yields. These findings align with the results [10]. The increased oil yield observed with the foliar spray of nano urea may be attributed to the rapid absorption and ease of translocation of nano fertilizers by the plant, facilitating optimal rates of photosynthesis and enhancing yield attributes, leading to higher seed yield. Furthermore, foliar nano fertiliser treatment has been reported to improve oil content and production possibly due to a synergistic impact with conventional fertilizers, improving nutrient absorption by plant cells and promoting optimal growth. These results are consistent with the findings [11]. The cumulative evidence suggests that the strategic use of nano fertilizers, particularly in foliar applications, can significantly enhance oil yield and quality in castor cultivation.

4. CONCLUSION

Following a careful evaluation of the study's objectives and the data produced from a full season of experimenting, it can be unequivocally concluded that the application of 100% of the recommended basal nitrogen, coupled with a nano urea foliar spray at 2 ml/l during 30 and 60 days after sowing (DAS), yielded the most favorable outcomes in terms of crop growth parameters, overall yield, and key yield-contributing characteristics. This particular treatment exhibited a notable superiority over other tested formulations. Notably, the treatment involving 100% of the recommended basal nitrogen combined with a 2% urea foliar spray at 30 and 60 DAS also emerged as a commendable performer, securing a position as the second most effective treatment in enhancing castor cultivation in rainfed conditions. The robust growth parameters and improved yield attributes observed in these treatments underscore their potential for optimizing the production of castor under the specified environmental conditions. These findings emphasise the critical relevance of nutrient management practises, especially the right balance of base nitrogen and foliar spray treatments, in determining the viability of rainfed castor farming. The identified treatments not only significantly contributed to crop growth but also demonstrated tangible advancements in overall yield, emphasizing their practical applicability for enhancing agricultural productivity under rainfed conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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