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Influence of Nano Urea on Growth and Microbial Population in Paddy Ecosystem

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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

Chemical fertilizer usage has been a long-drawn criticism because of its harmful effects on the environment and on the quality of agricultural produce. Researchers are continually looking for more productive, better solutions while retaining societal wellbeing. Effective use of nano fertilizers in place of chemical fertilizers is essential in reducing fertilizer overuse and also contribute in lowering the pollution and leaching which in turn increase the effectiveness of nutrient consumption and also increase the yield of the crop. An experiment was carried out in paddy to study the influence of Nano urea applications on growth and microbial populations in soil. The field trial used a Randomized Block Design (RBD) with eight treatment combinations and three replications. Results showed that application of STCR based N as Urea (50%) and Nano Urea (2 sprays) and

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Recommended dosage of N as Urea (50%) and Nano Urea (2 sprays) recorded higher plant height, Leaf Area Index (LAI), Dry matter accumulation in paddy. In addition, applications of Nano urea increased the microbial population including bacteria, fungi and actinomycetes. Combining recommended dosage of fertilisers with nano urea spray at critical stages of paddy crop increases the crop growth and microbial activity.

Keywords: Nano fertilizers; leaf area index; dry matter accumulation.

1. INTRODUCTION

Agricultural researchers strive to generate sustainable agriculture with higher productivity while maintaining societal welfare [1]. Usage of chemical fertilizers has been criticised due to its hazardous effects on the environment and on the quality of agricultural produces [2]. Researchers are constantly searching for better alternatives and in addition, eco-friendly solutions should be created to assist plants in overcoming biotic and abiotic stress and also ensuring maximum crop growth and agricultural sustainability.

India cultivates 116 million tonnes of paddy a year on its about 43.8 million acres of fertile land [3]. However, due to climate change and the conversion of agricultural land, it is predicted that the area of paddy will decline by 6-7 million ha by 2050. In addition, it is also predicted that 114 to 137 million tonnes of rice will be consumed in the next years [4]. Moreover, half of the world's population relies on rice as a main food source, making it known as the "Global Grain" and India produces over 20 per cent of the rice consumed worldwide. Increasing agricultural productivity across the board requires the use of fertilizers, the nutrient utilization rates for N, P, and K in conventional fertilizer are about 30–35, 18–20, and 35–40 per cent, respectively and have been steady over a long period of time [5].

Instead of chemical fertilizers, effective utilization of nano fertilizers is vital in preventing the over dosage of fertilizers and also play an important role in reducing pollution and leaching, while being cost effective [6]. Slow-release fertilizers and nano-fertilizers are suitable alternatives to conventional fertilizers for a controlled and gradual release of nutrients into the soil [7]. Therefore, by utilizing unique properties of nanoparticles, nano-fertilizers seek to boost the efficiency of nutrient consumption. Nano-fertilizers are nutrient transporters with substrates in the nano-dimension (1-100 nm) that may supply nutrients to the plant system for a protracted period of time with no damage to the environment [8].

The Government of India imported 51.91 lakh tonnes of nitrogen fertilizer, as the consumption and production are at 191.01 and 136.85 lakh tonnes respectively [9] which is insufficient to meet farmer's demand. IFFCO introduced their nano urea formulation to bring down the quantity of huge volume of urea fertilizers imported. It reduces the government's subsidy burden and also reduce the transportation, storage and usage of urea fertilizer subsequently, lowering the costs of nitrogen fertilizer [10]. With this, the study was formulated to assess the Influence of Nano urea (liquid formulation) on growth parameters and microbial population in Paddy.

2. MATERIALS AND METHODS

2.1 Experimental Design

The field trail was conducted at the Valamirankottai (10°44 N and 79°14 E), Thanjavur district of Tamil Nadu, India, from March 2023 to July 2023. A short duration rice variety CO 51, was selected for this field study. Preceding season rice stubbles were utilized by ploughing the field. Randomized Block Design with three replications and eight different treatment combinations were used for this experiment. The fertilizer dosages were fixed based on the TNAU crop guide [11]. Growth parameters like Plant height (cm), Leaf Area Index, Dry matter production (kg ha^{-1}) were analyzed at different stages of the crop. The conventional fertilizers of NPK (N-P_2O_5-K_2O) were applied at a rate of 150:50:50 kg ha^{-1}. On the other hand, NPK were applied at 135:73:69 kg ha^{-1}. While, nano urea (4%) was applied at 2-4 ml per litre. The experimental site had soil texture of sandy clay loam.

The Treatment structure is as follows:

- T_1 : Recommended dosage of fertilizer application
- T_2 : STCR based fertilizer application
- T_3 : Recommended dosage of N as Urea (50%) and Nano Urea (2 sprays)
- T_4 : STCR based N as Urea (50%) and Nano Urea (2 sprays)

Table 1. Methodology for measurement of pH and EC

S. No	Parameter	Method	Reference
1	pH	Potentiometry in soil and water suspension (1:2)	Jackson [12]
2	Electrical conductivity	Conductometry in soil and water suspension (1:2)	Jackson [12]

T_5 : Recommended N as Urea (50%) and of Nano Urea (3 sprays)
T_6 : STCR based N as Urea (50%) and Nano Urea (3 sprays)
T_7 : Nano Urea alone as Nitrogen source
T_8 : Absolute control for Nitrogen alone

Soil samples were taken at each plot. The pH and Electrical conductivity (EC) (d Sm^{-1}) of the soil sample taken before and after the experiment trail at different treatments were measured using the method represented in the Table 1.

2.2 Determination of Microbial Population

Microbial enumeration in soil was done and the fungi, actinobacteria and bacteria's population density were estimated using the technique, serial dilution method.

Serial dilution of soil sample: A soil sample of 1g was diluted to 10ml, to get the dilution of 10^{-1}. The test tube was shaken well and 1 ml of the dilution was transferred with the 9 ml blank water to get a dilution 10^{-2}. This process is repeated until 10^{-6} dilution is achieved.

Bacteria: Using the sterile petri plates, the bacterial population was quantified by plating 1ml of a 10^{-6} dilution with nutrient agar medium. The bacterial colonies that developed on the plates were counted and measured as Colony Forming Units (CFU) g^{-1} of dry soil after 48 hours of incubation at 30°C.

Fungi: The number of fungi was determined by plating 1ml of a 10^{-4} dilution with Martin's Rose Bengal agar medium. The fungus colonies on the plates were counted and measured as CFU g^{-1} dry soil after a 3 to 5 days incubation period.

Actinomycetes: The population was counted by plating 1ml of a 10^{-2} dilution on using ken knight's agar medium. After 7 days of incubation, colonies of actinomycetes formed on the plates were quantified and mentioned in CFU g^{-1} of dry soil.

2.3 Statistical Analysis

Statistical analysis was carried out using standard analysis of variance method. Analysis of variance (ANOVA) was used to analyse the data. The variance analysis of the experimental data was performed using the Randomised Block Design. The 'F' test was used to determine the significance of the difference. When the F test in ANOVA was significant at 5 per cent significance level ($P<0.05$), the means were compared using the Least Significant Difference (LSD) test at $\alpha=0.05$. The experimental data was analysed using KAU GRAPES for its significance test [13].

3. RESULTS AND DISCUSSION

3.1 pH and EC

The pH and EC of the experimental field before and after the cultivation of paddy is mentioned in the Table 2. It provides information on the impact of various nitrogen (N) applications on soil pH and the findings revealed that there were no significant changes in the pH. In addition, paddy cultivation decreased the soil pH in comparison to the initial value (7.2). After the harvest, the lowest pH was recorded in the T_1 treatment (RDF based fertilizer application). Lowest EC value was obtained in the T_8 (Absolute control) treatment that was similar to initial value (0.17 d Sm^{-1}). While, highest EC value was obtained in the RDF urea treatment T_1. These results were in concordant with results obtained by Rajesh et al. [14].

3.2 Growth Characters

The observations of Plant height were recorded during the different stages of the crop at 30th, 60th, 75th day and harvest and being represented in the Fig. 1. T_4 showed better plant height than other treatments. Results also indicated that T_7 (Nano urea alone as nitrogen source) can't cope up with other treatments as its values were similar to that of control T_8. In soil test crop response, the initial characteristics of the soil were formulated and the fertilizer dosages were calculated based upon the yield targets. Thus, T4 (50 % STCR combined with two sprays of nano urea) recorded highest plant height and in addition, application of two nano urea sprays also increased the plant height. It is due to large surface area possessed by the nano particles and the nitrogen that gets stored in the plant vacuole which enables the slow release of the nutrient that are utilized for effective growth of the plant [15].

Table 2. Influence of different nitrogen applications (Nano urea) on soil pH and EC before and after paddy cultivation

Treatments	pH	EC (d Sm^{-1})
Initial	7.20	0.17
T_1	6.86	0.21
T_2	6.90	0.18
T_3	6.96	0.19
T_4	6.98	0.20
T_5	6.95	0.18
T_6	6.99	0.18
T_7	7.01	0.19
T_8	7.03	0.17
SE(m)	0.123	0.002
CD(α=0.05)	NS	NS

T_1 - Recommended dosage of fertilizer application, T_2 - STCR based fertilizer application, T_3 - Recommended dosage of N as Urea (50%) and Nano Urea (2 sprays), T_4 - STCR based N as Urea (50%) and Nano Urea (2 sprays), T_5 -Recommended N as Urea (50%) and of Nano Urea (3 sprays), T_6 - STCR based N as Urea (50%) and Nano Urea (3 sprays), T_7 - Nano Urea Alone as Nitrogen source, T_8 - Absolute control for Nitrogen alone

Leaf Area Index (LAI) were observed at 30, 60, 75 DAT and Harvest (Fig. 2). LAI has increased over the stages and reached maximum at 60 DAT. After, it has decreased until harvest. LAI was recorded minimum in the nano urea alone treatment at 30 DAT than control. At the later stages, it recorded values higher than the control. At harvest, LAI was recorded highest in the T_4 followed by T_3. It was due to nano urea which influenced with increased chlorophyll formation, rate of photosynthesis which results in overall growth in plant which may results in formation of a greater number of leaves. The results are in concordant with Middle et al. [16].

Dry matter production over the stages of the crop at 30th, 60th, 75th day and harvest were recorded and represented in Fig. 3. Like, plant height and LAI, it was found higher in the T_4 followed by T_3. The optimal combination of conventional fertilizer and nano urea (foliar spray) produced the highest values of dry matter production. It is most likely owing to the fact that it provides nutrients on demand and in a controlled manner, which regulates plant development and increases target activity, resulting in high dry matter [17]. Three sprays of Nano urea have no significant impact in the dry matter production compared to the two sprays of nano urea. Similar results were recorded by Jassim et al. [18].

3.3 Microbial Population

The microbial populations were recorded at maturity. Results of microbial populations *viz.*, bacterial, fungal and actinomycetes populations were represented in the Table 3. Results of bacterial population indicated that it was recorded highest in the nano urea treatments and it was observed highest in the T_4 (27.9) while lowest values were recorded in T_8 (20.1). On the other hand, fungal population was recorded highest in the T_6 (12.6) and lowest number recorded in T_8 (10.1). While, actinomycetes population was highest in T_4 (5.9) and lowest in T_8 (4.2).

Table 3. Influence of different nitrogen applications on microbial population at maturity

Treatments	Bacteria (× 10^6 CFU g^{-1})	Fungi (× 10^4 CFU g^{-1})	Actinomycetes (× 10^2 CFU g^{-1})
T_1	24.2	10.7	4.7
T_2	22.1	11.5	5.2
T_3	27.1	10.4	5.7
T_4	27.9	10.6	5.9
T_5	26.4	12.0	5.4
T_6	25.6	12.6	5.5
T_7	26.5	12.5	5.8
T_8	20.1	10.1	4.2
SE(m)	0.106	0.128	0.052
CD(α=0.05)	0.321	0.390	0.159

T_1 – RDF based fertilizer application, T_2-STCR based fertilizer application, T_3 -Recommended dosage of N as Urea (50%) and Nano Urea (2 sprays), T_4-STCR based N as Urea (50%) and Nano Urea (2 sprays), T_5 -Recommended N as Urea (50%) and of Nano Urea (3 sprays), T_6-STCR based N as Urea (50%) and Nano Urea (3 sprays), T_7 -Nano Urea Alone as Nitrogen source, T_8-Absolute control for Nitrogen alone

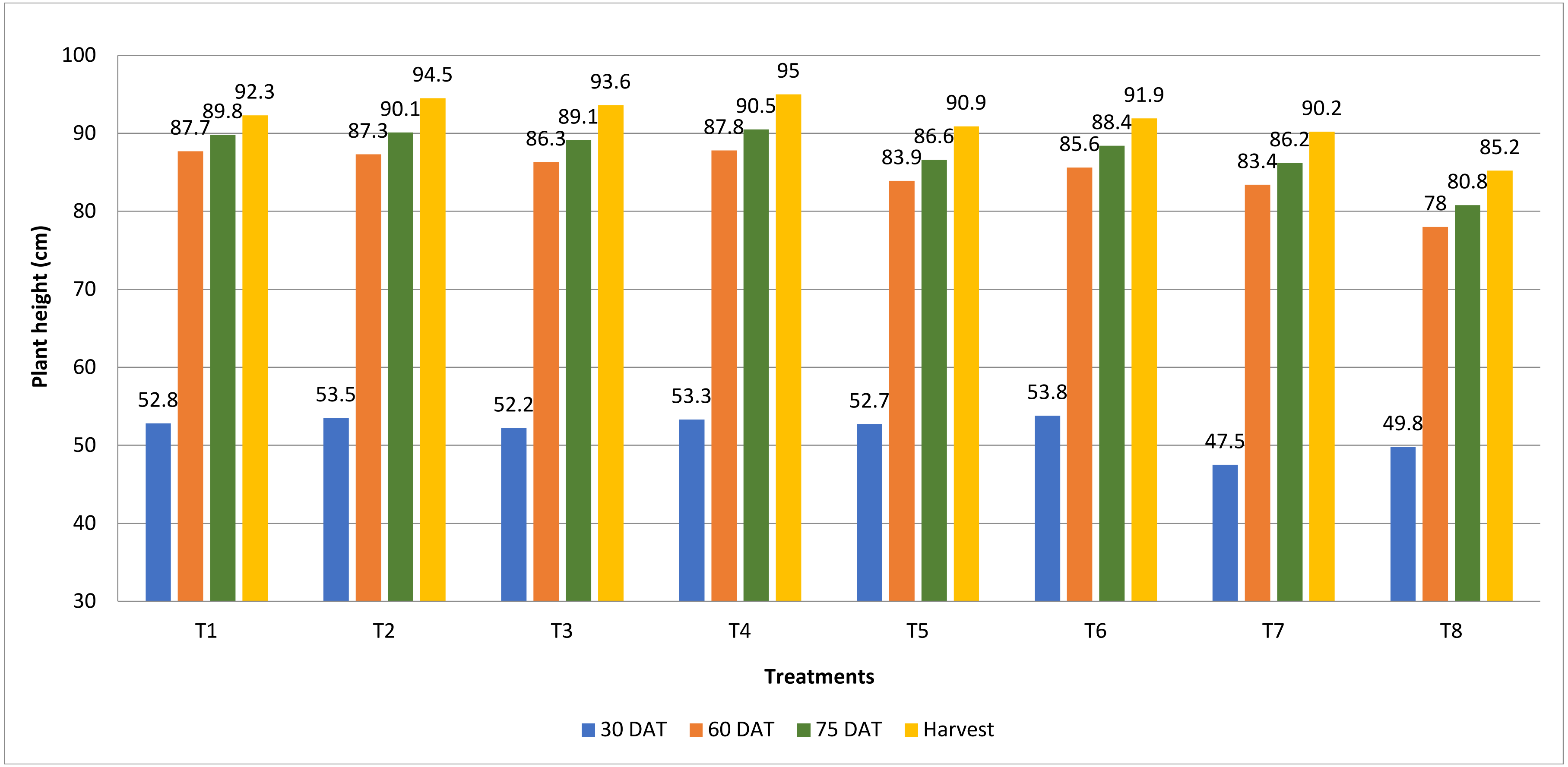

Fig. 1. Influence of different nitrogen applications (Nano urea) on plant height of paddy

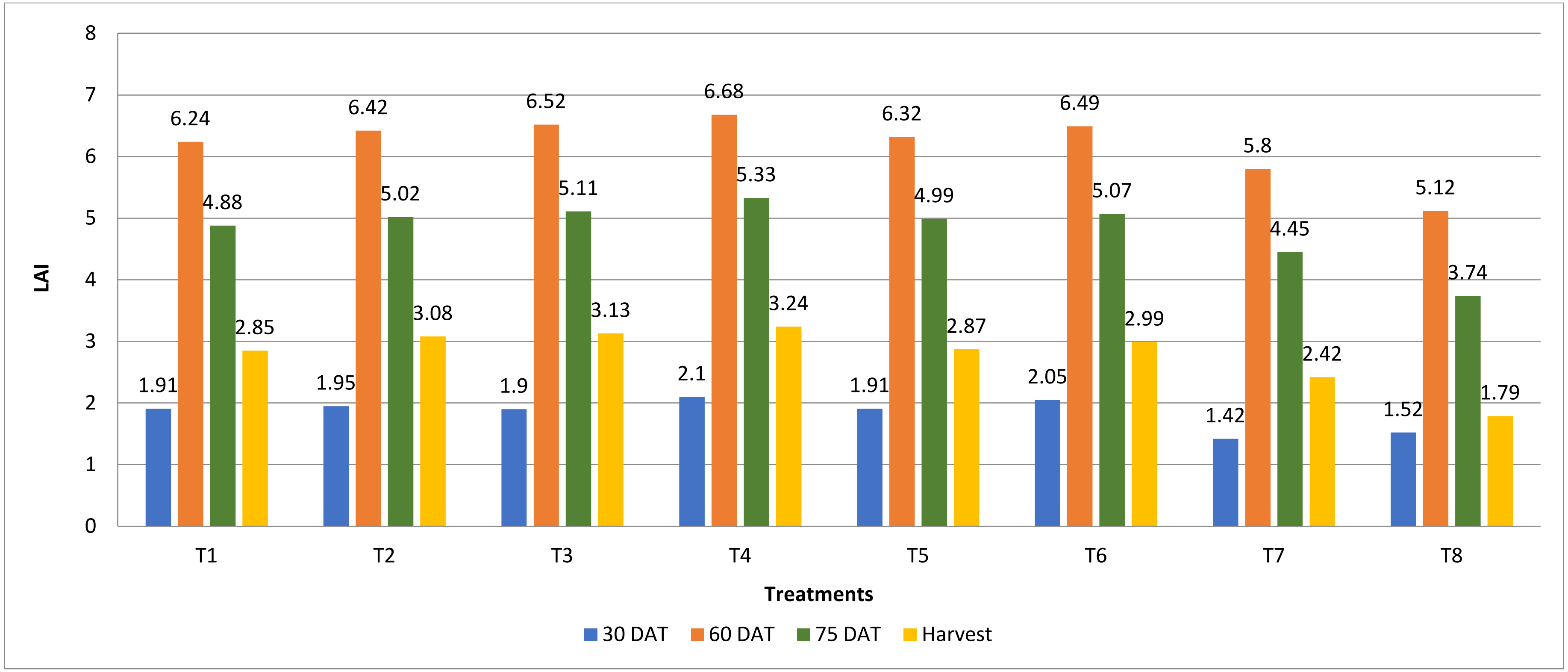

Fig. 2. Influence of different nitrogen applications (Nano urea) on LAI of paddy

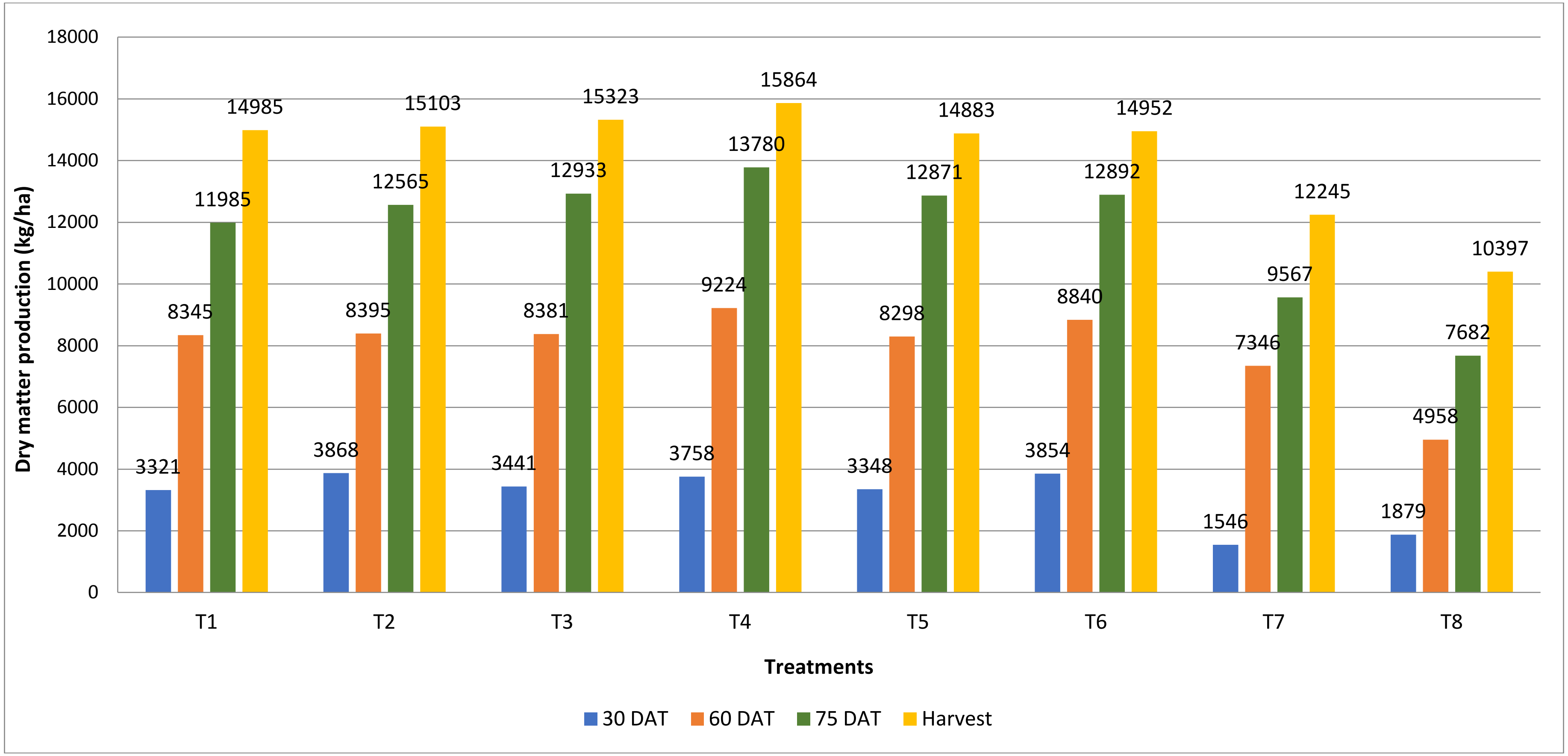

Fig. 3. Influence of different nitrogen applications (Nano urea) on dry matter production (kg ha^{-1}) of paddy

Since the soil is repeatedly dumped with loads of inorganic fertilizer due to continuous paddy cultivation, the introduction of nano fertilizers tends to increase significant amount of microbial population. Soil enzymes are considered the best indication of microbial variety in a soil and boost the efficacy of applied nutrients as well as nutrients in the labile pool. Nano-fertilizers can act as an efficient nutrient delivery mechanism, reducing the amount of nutrients required [19].

4. CONCLUSION

Application of STCR based N as Urea (50%) and Nano Urea (2 sprays) and Recommended dosage of N as Urea (50%) and Nano Urea (2 sprays) recorded higher plant height, Leaf Area Index (LAI), Dry matter accumulation in paddy. In addition, applications of Nano urea increased the microbial population including bacteria, fungi and actinomycetes. Combining recommended dosage of fertilisers with nano urea spray at critical stages of paddy crop increases the crop growth and microbial activity. The findings presented here highlight the prospect of employing nano-fertilizers to give important nutrients to crop plants in a more safe and efficient manner while also being ecologically friendly.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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