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Impact of liquid nano urea fertilizer on soil properties after harvest of summer rice (*Oryza sativa* L.) under south Gujarat conditions

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Abstract
An experiment was conducted during February to June in 2022 and 2023 at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, India, to evaluate the impact of liquid Nano urea fertilizer on soil properties of soil after harvest of summer rice under South Gujarat conditions. The experiment carried out with a randomized block design (RBD) with twelve nitrogen management treatments combining conventional urea and Nano urea through seedling root dips and foliar sprays. The experimental site had clayey soil, medium organic carbon, and varied nitrogen, phosphorus and potassium levels. Results showed no significant effect of nitrogen treatments on soil pH, electrical conductivity, organic carbon, bulk density, available P_2O_5 and K_2O after harvest of summer rice. However, significantly higher available nitrogen was recorded with 100% RDN (120 kg N/ha) through urea (T_1) in both years, but it remained at par with remaining treatments except T_2, T_3, T_5 and T_8. The lowest nitrogen was recorded in T_{12}, involving Nano urea without full urea supplementation. The study indicates Nano urea can enhance traditional urea applications but cannot fully replace conventional urea for maintaining soil nitrogen and boosting rice productivity. Integrating Nano urea with conventional methods is essential for sustainable rice cultivation in South Gujarat.

Keywords: Rice, nano urea, pH, EC, OC, available N, available P_2O_5 and available K_2O

Introduction

Rice (*Oryza sativa* L.) is India's most significant staple food crop after wheat, feeding more than half of the world's population. As a heat- and water-loving plant, rice thrives under submerged conditions. Rice, wheat and maize contribute 20%, 19%, and 5% of the world's dietary energy supply, respectively (Anon., 2004) [1]. In Asia, rice is a crucial food source for over two billion people, providing 27% of dietary energy and 20% of overall dietary protein (Bashir *et al*., 2007) [2]. Rice contains 6-7% protein, 2-2.5% fat, and supplies 447 Kcal per 100 g (Anon., 2004) [1]. It is also rich in essential vitamins such as thiamine, riboflavin and niacin. Rice grain contains vitamin B levels comparable to wheat. Uncooked rice bran, abundant in vitamin E, is processed to extract edible oil that helps lower cholesterol. By-products from rice bran oil production, such as glycerine, soap, wax and cosmetics are widely utilized. Although rice straw is not highly nutritious, it continues to be used as animal feed.

Nitrogen fertilizer plays an important role in crop production and has the most effect on increasing agricultural production and income. Nitrogen is a major nutrient for plants, which is very important for the improvement of photosynthesis, growth, development, yield, quality and biomass of rice. It is a component of amino acid in protein and an important component of chlorophyll in photosynthesis and it exists in various plant parts. The application of nitrogen in rice has prominent problems such as a large amount of nitrogenous fertilizers use, efficiency and high wastage. Excess application of nitrogenous fertilizers aggravates soil degradation and environmental pollution. Therefore, it is necessary to use alternative source of nitrogen, which can not only reduce the loss of nitrogen fertilizer, but also mitigate the pollution. Only 30-50% of nitrogen from urea is utilized by plants at the farm level and remain are wasted due to rapid chemical transformations such as leaching, which contaminates soil and water bodies and volatilization which leads to emissions of nitrous oxide into the atmosphere.

Nano urea is a novel form of urea fertilizer developed by IFFCO Co-operative Limited at Kalol, Gujarat. The size of one Nano urea particle is 30 nanometres, which is about 10,000 times smaller than conventional granular urea particles. This leads to a significantly larger surface area-to-volume ratio. Due to its ultra-small size and unique surface properties, liquid Nano urea is absorbed more effectively by plants when sprayed on their leaves. Once absorbed, these nanoparticles reach plant parts requiring nitrogen and release nutrients in a controlled manner. This reduction in usage minimizes wastage in the environment. Additionally, it offers protection to plants against various biotic and abiotic stresses. Beyond yield improvement, increased nutrient use efficiency, enhanced nutritional quality of crops and it also promotes soil health. It reduces undesirable toxicities in soil and mitigates potential negative effects associated with over-application, thus reducing the frequency of application. Therefore, Nanotechnology holds great potential for achieving sustainable agriculture, particularly in developing countries. Nano urea has also undergone biosafety and toxicity testing in accordance with Indian norms and international guidelines established by Organisation for Economic Co-operation and Development (OECD), which are globally adopted and accepted. Soil properties following summer rice harvest can indicate the effectiveness of nutrient management strategies. Post-harvest soil analysis often reveals changes in available nitrogen, phosphorus and potassium levels, which reflect the efficiency of fertilizer use. Maintaining balanced soil health through appropriate nitrogen management is crucial for sustaining long-term productivity and preventing soil degradation. The present study was therefore undertaken to investigate the influence of liquid Nano urea fertilizer on soil properties after harvest of summer rice (*Oryza sativa* L.) under South Gujarat conditions.

Materials and Methods

The field experiment was conducted on same location during February to June for the year 2022 and 2023 at the College farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, India to find the effect of liquid Nano urea fertilizer on quality of summer rice under South Gujarat conditions. The soil of the experimental field was clayey in texture, medium in OC and low, medium and high in available nitrogen, phosphorus and potassium, respectively. The soil is characterized by medium to poor drainage and good water holding capacity.

The experiment was laid out in randomized block design and twelve treatments comprising T_1: 100% RDN through urea (120 kg N/ha), T_2: 75% RDN + Seedling root dip in Nano urea at TP (4 ml/L), T_3: 50% RDN + Seedling root dip in Nano urea at TP (4 ml/L), T_4: 25% RDN + Seedling root dip in Nano urea at TP (4 ml/L), T_5: 75% RDN + Spray of Nano urea at tillering stage (4 ml/L), T_6: 50% RDN + Spray of Nano urea at tillering stag (4 ml/L), T_7:25% RDN + Spray of Nano urea at tillering stage (4 ml/L), T_8: 75% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L), T_9: 50% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L), T_{10}: 25% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L), T_{11}: Spray of Nano urea at tillering and panicle initiation stage (4 ml/L) and T_{12}: Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L). Rice GNR 3, transplanted during the summer season with recommended practices. Nitrogen was applied in three equal splits at the time of transplanting, active tillering stage and panicle initiation stage as per treatments. Nano urea has been manufactured by Indian Farmers Fertiliser Co-operative Limited (IFFCO) contains 40000 mg kg^{-1} (4%) of nitrogen. Nano urea was sprayed as 4 ml of Nano urea $litre^{-1}$ of water. In this experiment Nano urea was applied through two methods *viz*., root dip and foliar spray. Root of rice seedlings dip in the Nano urea @ 4 ml L^{-1} for 15 minutes at the time of transplanting and sprayed at tillering and panicle initiation stages as per treatment with 4 ml L^{-1} of water by using 600 litre of water ha^{-1} through the flat-fan nozzle. Whereas, full dose of phosphorus (30 kg ha^{-1}) and Zinc as a $ZnSO_4$ (20 kg ha^{-1}) was applied as basal application uniformly to all the treatments. Summer rice 'GNR 3' was transplanted during summer season in February under irrigated condition at the same location and harvested in June during both the years. Irrigation was given to the crop as per recommendation, a thin film of irrigation water was maintained till the establishment of seedlings. Subsequently water level in the field was maintained at the depth of 5 ± 2 cm during the entire period of crop growth till early dough stage through irrigation. Drain water from the field one week before harvest of the crop. All the cultural operation was carried out as per recommendations.

Table 1: Physico-chemical properties of soil of the experimental site

Sr. No.	Particulars	Analytical method employed
1.	Bulk density (g/cc)	Core method (Singh, 1980) [5]
2.	pH (2.5)	Potentiometric (Jackson,1973) [3]
3.	EC (2.5) (dS m-1)	Conductometric (Jackson, 1973) [3]
4.	Organic carbon (%)	Walkley and Black's rapid titration method (Jackson, 1973) [3]
5	Available N (kg ha^{-1})	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [6]
6.	Available P_2O_5 (kg ha^{-1})	Olsen's method (Jackson, 1973) [3]
7.	Available K_2O (kg ha^{-1})	Flame photometric method (Jackson, 1973) [3]

The representative soil samples from each treatment collected replication wise from 0-15 cm depth with the help of augur from five randomly selected spots within the net plot area. The composite collected samples were mixed thoroughly, separately in polythene bag and labelled. The soil samples were brought to laboratory dried in shade. After their complete drying, samples were powdered using mortar and pastel and passed through 2 mm sieve and stored in the polythene bag for further analysis. The standard methods adopted for analysing the physical and chemical *viz*., pH, EC, organic carbon (OC), bulk density and available nitrogen, P_2O_5 and K_2O following the analytical techniques as described in Table 1.

The statistical analysis of the data of various observations recorded during investigation was carried out under Randomized Block Design through analysis of variance technique as described by Panse and Sukhatme (1978) [4]. The significant difference was tested by F-test at five per cent level of significance. The standard error of mean was calculated for all the parameters however, the critical difference were calculated when the difference among treatments were found significant.

Results and Discussion

Significant variation was not found due to different treatments of nitrogen management through various levels of nitrogen through conventional fertilizer as a urea and foliar spray of Nano urea on soil pH, electrical conductivity, organic carbon content and bulk density, available P_2O_5 and available K_2O in soil after harvest of rice crop (Table 2,3 and 4).

An appraisal of data furnished in Table 4 revealed that significantly higher values of available nitrogen (180.2 and 173.5 kg ha^{-1}) were recorded with treatment T_1 (100% RDN through urea (120 kg N/ha)) during both the years of study, but it remained at par with remaining treatments except T_2, T_3, T_5 and T_8. Whereas, significantly lower available nitrogen in the soil was registered with treatment T_{12} (143.6 and 138.6 kg ha^{-1}) during individual years of study. Such type of results was also found by Subramani *et al*. (2023) [7].

Different treatments of nitrogen management did not exerted any significant effect on available P_2O_5 and K_2O status in soil after harvest of rice crop during summer season.

Table 2: Electrical conductivity (EC2.5) and pH of soil after harvest of rice crop as influenced by different treatments

Treatment	EC2.5 (dS m^{-1})		pH	
	2022	2023	2022	2023
T1: 100% RDN through urea (120 kg N/ha)	0.42	0.43	7.3	7.3
T2: 75% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	0.41	0.44	7.2	7.4
T3: 50% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	0.43	0.42	7.3	7.4
T4: 25% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	0.43	0.42	7.3	7.2
T5: 75% RDN + Spray of Nano urea at tillering stage (4 ml/L)	0.41	0.42	7.2	7.3
T6: 50% RDN + Spray of Nano urea at tillering stag (4 ml/L)	0.42	0.40	7.3	7.4
T7: 25% RDN + Spray of Nano urea at tillering stage (4 ml/L)	0.44	0.45	7.3	7.3
T8: 75% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.44	0.42	7.3	7.4
T9: 50% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.42	0.42	7.3	7.3
T10: 25% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.43	0.44	7.2	7.3
T11: Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.41	0.43	7.2	7.3
T12: Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.42	0.41	7.4	7.4
S.Em±	0.01	0.01	0.2	0.2
CD (P=0.05)	NS	NS	NS	NS
CV (%)	5.01	5.78	4.15	4.40

Table 3: Organic carbon and bulk density of soil after harvest of rice crop as influenced by different treatments

Treatments	Organic carbon (%)		Bulk density (g cm-3)	
	2022	2023	2022	2023
T1: 100% RDN through urea (120 kg N/ha)	0.55	0.56	1.38	1.36
T2: 75% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	0.54	0.55	1.37	1.39
T3: 50% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	0.53	0.54	1.38	1.38
T4: 25% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	0.53	0.53	1.39	1.36
T5: 75% RDN + Spray of Nano urea at tillering stage (4 ml/L)	0.55	0.55	1.38	1.34
T6: 50% RDN + Spray of Nano urea at tillering stage (4 ml/L)	0.54	0.55	1.38	1.38
T7: 25% RDN + Spray of Nano urea at tillering stage (4 ml/L)	0.53	0.55	1.37	1.37
T8: 75% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.55	0.55	1.37	1.36
T9: 50% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.53	0.53	1.39	1.35
T10: 25% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.53	0.54	1.39	1.35
T11: Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.52	0.52	1.37	1.35
T12: Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	0.53	0.54	1.36	1.35
S.Em±	0.01	0.02	0.02	0.02
CD (P=0.05)	NS	NS	NS	NS
CV (%)	4.68	5.50	2.40	2.51

Table 4: Available nitrogen, P2O5 and K2O in soil after harvest of rice crop as influenced by different treatments

Treatment	Available nitrogen (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2022	2023	2022	2023	2022	2023
T1: 100% RDN through urea (120 kg N/ha)	180.2	173.5	51.0	48.5	290.9	285.0
T2: 75% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	178.5	169.5	51.0	50.7	291.1	286.9
T3: 50% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	162.8	152.2	52.7	51.2	297.6	287.7
T4: 25% RDN + Seedling root dip in Nano urea at TP (4 ml/L)	157.2	148.4	54.7	52.4	313.2	308.6
T5: 75% RDN + Spray of Nano urea at tillering stage (4 ml/L)	168.9	157.8	51.1	49.8	291.2	284.0
T6: 50% RDN + Spray of Nano urea at tillering stag (4 ml/L)	160.7	153.2	52.4	51.9	294.9	288.4
T7: 25% RDN + Spray of Nano urea at tillering stage (4 ml/L)	157.2	142.6	53.7	50.6	307.5	302.3
T8: 75% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	166.1	163.0	49.8	48.0	287.3	283.4
T9: 50% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	158.2	152.2	52.9	50.9	321.8	285.0
T10: 25% RDN + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	153.4	140.7	53.0	52.0	294.0	287.4
T11: Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	152.6	140.5	57.4	55.8	320.5	316.5
T12: Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage (4 ml/L)	143.6	138.6	55.4	54.7	319.7	312.6
S.Em±	6.93	7.12	2.5	2.4	13.7	12.9
CD (P=0.05)	20.33	20.88	NS	NS	NS	NS
CV (%)	7.43	8.08	8.18	8.25	7.86	7.59

Conclusion

The study found no significant impact of nitrogen management treatments on soil pH, electrical conductivity, organic carbon, bulk density, availability of phosphorus (P_2O_5) and potassium (K_2O) after the harvest of summer rice. However, nitrogen availability was highest when 100% of the recommended dose of nitrogen (RDN) was applied through urea at 120 kg N/ha (T_1). Conversely, the lowest nitrogen levels were observed in treatment T_{12} (Seedling root dip in Nano urea at TP + Spray of Nano urea at tillering and panicle initiation stage). The study indicates Nano urea can enhance traditional urea applications but cannot fully replace conventional urea for maintaining soil nitrogen and boosting rice productivity. Integrating Nano urea with conventional methods is essential for sustainable rice cultivation in South Gujarat.

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