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Studies on comparison of nano-urea and prilled urea for enhancing maize (*Zea mays*) growth and productivity

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In India, maize (*Zea mays* L.) ranks third in cereal production, following rice and wheat. It also has potential in diversifying rice-wheat cropping system in India (Rajan *et al.* 2023). Over the past years, injudicious and excessive nitrogen fertilizer usage had a detrimental effect on the quality of the air, soil and water with increasing risk of nitrogen (N) loss through various pathways (Vejan *et al.* 2021). Some of the potential strategies used to improve nitrogen use efficiency (NUE) could be split application, appropriate placement of gaseous fertilizers, use of slow-release fertilizers along with enzymes and nitrification inhibitors. The NUE rarely exceeds 40% under field conditions despite all efforts put together. Splitting has been found to be an efficient approach for increasing crop yields because it reduces total N leaching and increases nutrient uptake (Feng *et al.* 2023). The foliar application of nutrients shortens the time lag between the application and uptake of plant nutrients by improving their availability during crucial growth stages (Sharifi *et al.* 2018). Nano-formulations release nutrients in a controlled and gradual manner coinciding with the critical crop growth stages. By timely application of foliar nano-fertilizers, the crop productivity can be enhanced while lowering environmental risks through reduction in losses from volatilization, leaching and runoff (Rathanayaka *et al.* 2018). Thus, use of nano-fertilizers improves NUE and eliminates excessive use of fertilizers (Kumar *et al.* 2020, Upadhyay *et al.* 2023a).

Several studies and experiments on nano-urea have shown encouraging results. However, the optimization of nano-urea aiming to achieve higher productivity, profitability, produce quality, biomass partitioning and nitrogen utilization efficiency in maize, especially under acid soil of Jharkhand need to be thoroughly investigated.

An experiment was conducted during the rainy (*kharif*) season of 2022–23 at the ICAR-Indian Agricultural Research Institute, Hazaribagh, Jharkhand to evaluate the performance of nano-urea in maize under various field conditions and to examine how well it can be combined with other N sources. The soil of the experimental field was sandy loam, slightly acidic (*p*H, 6.3) and low in available N (147 kg/ha) and phosphorus (8.2 kg/ha), but medium in potassium (136 kg/ha). Experiment was conducted in a randomized block design (RBD), replicated thrice. The treatments included were: Control T_1, No N; T_2, 5% of recommended N; T_3, 75% of recommended N; T_4, 100% of recommended N; T_5, No N + 2 Sprays of nano-N (NUS); T_6, 50% of recommended N + 2 sprays of nano-N; T_7, 75% of recommended N + 2 sprays of nano-N; T_8, 100% of recommended N + 2 sprays of nano-N; T_9, No N + 2% prilled urea spray (PUS); T_{10}, 50% of recommended N + 2% prilled urea spray; T_{11}, 75% of recommended N + 2% prilled urea spray; T_{12}, 100% of recommended N + 2% prilled urea spray. The hybrid variety DHM-121 was sown on 19 July 2022 and was harvested on 06 November 2022. The row to row spacing was 60 cm while distances between two plants were kept as 20 cm. A tractor-drawn mould board plough was initially used for ploughing and soil turning. Subsequently, a tractor-drawn cultivator and a rotavator were employed. Finally ridge-furrows prepared using a ridge maker. The field was divided according to the layout plan including irrigation channels. The recommended dose of fertilizers was 150 kg of nitrogen, 75 kg of P_2O_5 and 50 kg of K_2O per hectare. Nano-urea application dose was 500 ml/acre or 4 ml per liter of water. In all the treatments full doses of phosphorus, potassium and one-third of the N were applied at the time of sowing and the remaining N was given as two equal splits at 32 and 50 days after sowing

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(DAS). With the first (32 DAS) and second (50 DAS) split of prilled urea top-dressing, nano-urea and prilled urea spray were applied simultaneously. The root sample (from 15 cm soil depth) collection and observation were done at 55 DAS. After carefully washing, the roots' fresh weight was recorded. The roots were then dried in the shade for 2–3 days before being placed in a hot air oven set at 65°C until a constant weight was achieved. Using a digital balance, the dry weight of the roots was taken and expressed in grams per plant. Partial factor productivity (PFP) was calculated by the formula suggested by Dobermann (2007). The nitrogen, phosphorus and potassium content in grain and stover were analyzed (Jackson 1973).

Compared to all other treatments, the treatment comprised of full recommended dose of N (RDF-N) with two sprays of nano-urea attained the highest fresh root weight in maize (Table 1). At 55 DAS, the fresh root weight ranged from 3.30 to 16.98 g/plant with an average value of 9.09 g/plant. In terms of fresh root weight, the treatment using RDF-N and two sprays of nano-urea produced statistically comparable results to the use of 100% RDF and 100% RDF with 2% prilled urea spray. A significantly higher root dry weight was obtained by using (RDF-N) and two sprays of nano-urea at 55 DAS. The root dry weight per plant varied from 1.18 to 5.13 grams with an average of 2.95 g (Table 1). The root dry weight obtained after applying the RDF-N using urea was statistically at par with the 100% RDF along with 2% prilled urea spray (4.56 g/plant) and 100% RDF along with 2 sprays of nano-urea (4.88 g/plant). The lowest root dry weight (1.18 g/plant) at 55 DAS from a depth of 20 cm was recorded under control. The foliar application of nano-urea at critical growth stages might have promoted crop growth which led to increased carbohydrates supply and ultimately increases photosynthetic activity and dry matter accumulation in the plant (Ullasa *et al.* 2016).

All treatments showed a significant difference in the partial factor productivity of nitrogen (PFP_N). The treatment with $N_{75\%}$ + Nano spray had the highest PFP_N (50 kg grain/kg N applied). The PFP_N decreased as kg N/ha applied was increased in treatment $N_{100\%}$ + 2% prilled urea spray which recorded the lowest PFP_N (42 kg grain/kg N applied). Different N levels had significant effect on partial factor productivity of phosphorus and potassium in maize. The highest PFP of phosphorus (89.93) was recorded with the treatment $N_{100\%}$ + NUS which was on par with the treatment $N_{100\%}$ and $N_{100\%}$ + 2% PUS, these were significantly superior over the other treatments. The Lowest PFP of phosphorus (28.30) was recorded with No N + 2% prilled urea spray. The PFP of potassium was significantly influenced by different treatments and the highest PFP of potassium (134.9) was recorded with $N_{100\%}$ + NUS (Nano Urea Spray), which was significantly superior over the other treatments. The lowest PFP of potassium (42.45) was recorded with the treatment No N + 2% prilled urea spray. The coordinated N release from nano-urea enhanced the photosynthesis by ensuring an adequate supply of light-harvesting chlorophyll-protein complexes which saves crops from stress ultimately results in improved growth, increases yield and physiological efficiency (Babu *et al.* 2022).

Different N levels had significant effect on N, phosphorous and potassium content in grain and stover of maize. Nitrogen content in grain varied from 1.320 to 1.611% with an average of 1.442%. Treatments $N_{100\%}$, $N_{75\%}$ + NUS; $N_{75\%}$ + 2% PUS; and $N_{100\%}$ + 2% PUS

Table 1 Effect of variable nitrogen sources and doses on root weight, partial factor productivity and nutrient content in grain and stover of maize

Treatment	Fresh root weight	Root dry wt (20 cm depth)	PFP (kg grain/kg nutrient applied)			N content (%)		P content (%)		K content (%)	
	55 DAS (g/plant)		N	P_2O_5	K_2O	G	S	G	S	G	S
T_1	3.30	1.18	0.00	31.1	46.6	1.32	0.51	0.23	0.15	0.40	1.46
T_2	5.87	2.06	47.4	47.4	71.1	1.34	0.52	0.24	0.15	0.40	1.48
T_3	10.0	3.41	46.1	69.1	103	1.49	0.59	0.27	0.17	0.46	1.67
T_4	14.2	4.56	42.8	85.5	128	1.58	0.63	0.29	0.19	0.50	1.83
T_5	4.02	1.42	-	31.6	47.4	1.33	0.52	0.24	0.15	0.40	1.48
T_6	6.67	2.27	49.5	49.5	74.3	1.35	0.52	0.24	0.15	0.40	1.49
T_7	11.6	3.57	49.7	74.7	112	1.52	0.60	0.27	0.17	0.46	1.70
T_8	16.9	5.13	45.0	89.9	134	1.61	0.64	0.29	0.19	0.51	1.84
T_9	3.53	1.25	-	28.3	42.5	1.32	0.52	0.24	0.15	0.40	1.46
T_{10}	6.17	2.12	48.2	48.2	72.3	1.34	0.52	0.24	0.15	0.40	1.49
T_{11}	10.9	3.50	45.0	71.1	106	1.50	0.60	0.27	0.17	0.46	1.68
T_{12}	15.9	4.88	41.7	86.8	130	1.60	0.64	0.29	0.19	0.50	1.84
SEm±	0.74	0.22	-	3.16	4.73	0.04	0.015	0.007	0.004	0.012	0.045
LSD (P≤0.05)	2.17	0.65	-	9.26	13.9	0.12	0.05	0.022	0.013	0.036	0.13

Refer to the methodology for treatment details. G, Grain; S, Stover; PFP, Partial factor productivity.

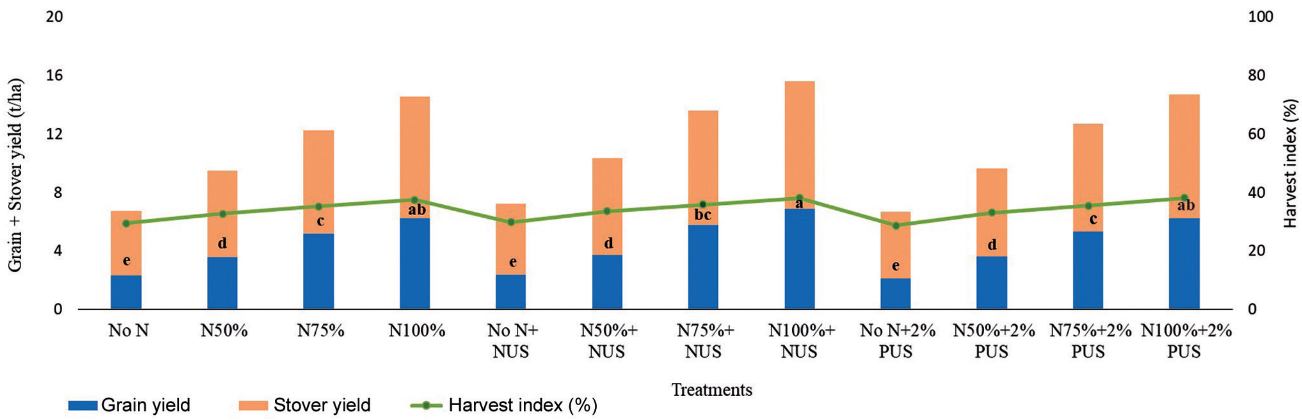

Fig. 1 Effect of variable nitrogen sources and doses on biological yield (grain and stover yield) and harvest index of maize. NUS, Nano-urea spray; PUS, Prilled urea spray.

had statistically similar value of N content in grains with the $N_{100\%}$ + NUS which has maximum value (1.611%). Nitrogen content in stover varied from 0.519 to 0.642% with an average of 0.570%. A similar value of N content (0.642%) in stover was attained in treatment $N_{100\%}$ + 2% nano-urea spray and $N_{100\%}$ + 2% prilled urea spray which remained at par with $N_{75\%}$, $N_{100\%}$, $N_{75\%}$ + NUS and $N_{75\%}$ + 2% PUS. The phosphorus content in grain was recorded highest (0.297%) with the treatments $N_{100\%}$, $N_{100\%}$ + NUS and $N_{100\%}$ + NUS which was on par with the treatment $N_{75\%}$ + NUS and $N_{75\%}$ + 2% PUS. The lowest phosphorus content in grain (0.239%) was recorded with the treatment No N. The result showed that higher phosphorus content in stover (0.193%) was recorded with the treatment $N_{100\%}$ + NUS. The similar value was reported in $N_{100\%}$ and $N_{100\%}$ + NUS. The lowest phosphorus content in stover (0.153%) was recorded with the treatment No N. The potassium content in grain was considerably influenced by different treatments. The result showed that the highest potassium content in grain (0.510%) was recorded with the treatment $N_{100\%}$ + NUS which was on par with the treatment $N_{100\%}$ and $N_{100\%}$ + PUS. The lowest potassium content in grain (0.403%) was recorded with treatment No N. The highest potassium content in stover was recorded (1.840%) in the treatment $N_{100\%}$ + NUS and $N_{100\%}$ + PUS which was on par with the treatment $N_{100\%}$. The lowest potassium content in stover (1.460%) was recorded with the treatment No N. Nano-urea was applied to leaves, which allowed it to pass directly through stomatal pores and plasmodesmata. Nano-urea's small size and surface properties allow it to enter plants through the leaves. Once inside the plant, nano-urea gradually releases nitrogen. The uptake efficiency of nano-urea in plants is 80% greater than that of traditional prilled urea (Kumar *et al.* 2021).

Grain yield in 100% of recommended N + 2 nano-urea sprays recorded significantly higher over rest of the treatments and it remained at par with 100% of recommended N and 100% RDN + 2% prilled urea sprays (Fig. 1). Treatment 75% of recommended N + 2 nano-urea spray recorded at par grain yield over the treatment 100% recommended N. Among all treatments, 100% of the recommended N + 2 nano-urea sprays resulted in a significantly higher biological yield (17.8 t/ha). Furthermore, a biological yield of 15.6 t/ha was achieved with the application of 75% of the recommended N + 2 nano-urea sprays that was statistically at par with the yield attained in 100% of the recommended N; 75% of the recommended N + 2% prilled urea sprays; and 100% of the recommended N + 2% prilled urea sprays of nitrogen fertilizer. The harvest index (HI) is a crucial metric which expresses how efficiently the dry matter was converted into the economic component of the crop. Different levels of N management possessed a significant difference in harvest index of the maize crop (Fig. 1). Among N levels $N_{100\%}$ + NUS; and $N_{100\%}$ + 2% PUS recorded significantly higher harvest index (38.1%) over other N management practices. The lower harvest index (28.7%) was observed in No N + 2% PUS which was statistically similar with No N; $N_{50\%}$; No N + NUS; $N_{50\%}$ + NUS; and $N_{50\%}$ + 2% PUS (Kumar *et al.* 2021, Upadhyay *et al.* 2023b).

SUMMARY

An experiment was conducted during the rainy (*kharif*) season of 2022–23 at the ICAR-Indian Agricultural Research Institute, Hazaribagh, Jharkhand to assess how well nano-urea performs in maize under different field conditions and investigate its compatibility with other N sources. Results showed that root weight (fresh and dry), partial factor productivity (N, P_2O_5 and K_2O), N concentration (grain and stover), grain yield, biological yield and harvest index of maize were all significantly affected by the application of various N rates and nano-fertilizers. The grain yield of maize was comparable to the yield obtained under RDF and 75% of the recommended N + two nano-urea sprays. These findings indicate that the concurrent use of these nano-fertilizers has the potential to reduce N fertilization by as much as 25%. Furthermore, the results highlight the prospect of augmenting biological yield of maize by incorporating 2 nano-urea sprays alongside the prescribed N quantity from prilled urea, as well as full applications of P_2O_5 and K_2O.

REFERENCES

Babu S, Singh R, Yadav D, Rathore S S, Raj R, Avasthe R, Yadav S K, Das A, Yadav V, Yadav B, Shekhawat K, Upadhyay P K, Yadav D K and Singh V K. 2022. Nano fertilizers for agricultural and environmental sustainability. *Chemosphere* **292**: 133451.

Dobermann A. 2007. Nutrient use efficiency measurement and management. (*In*) *Proceedings of the International Fertilizer Industry Association (IFA) Workshop on Fertilizer Best Management Practices*, Brussels, March 7–9, pp. 1–28.

Feng W, Li P, Zheng C, Sun M, Shao J, Li X and Dong H. 2023. Split-nitrogen application increases nitrogen-use efficiency and yield of cotton. *Nutrient Cycling in Agroecosystems* **125**(3): 393–407.

Jackson M L. 1973. *Soil Chemical Analysis*. Second Indian Reprint. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Kumar Y, Tiwari K N, Singh T and Raliya R. 2021. Nano fertilizers and their role in sustainable agriculture. *Annals of Plant and Soil Research* **23**(3): 238–55.

Kumar Y, Tiwari K N, Singh T, Sain N K, Laxmi S, Verma R and Raliya R. 2020. Nano fertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. *Annals of Plant and Soil Research* **22**(4): 324–35.

Rathanayaka R M N N, Mahendran S, Iqbal Y B and Rifnus L M. 2018. Influence of urea and nano nitrogen fertilizers on the growth and yield of rice (*Oryza sativa* L.) cultivar BG 250. *The International Journal of Scientific and Research Publication* **5**(2): 1–7.

Sharifi S K, Lalitha B S, Qasimullah R, Prajwal Kumar G K and Manjanagouda S S. 2018. Effect of foliar application of water-soluble fertilizer on growth and yield of soybean (*Glycine max* L. Merrill). *Indian Journal of Pure and Applied Biosciences* **6**(5): 766–70.

Ullasa M Y, Girijesh G K and Kumar M D. 2016. Effect of fertilizer levels and foliar nutrition on yield, nutrient uptake and economics of maize (*Zea mays* L.). *Green Farming* **6**: 1383–88.

Upadhyay P K, Dey A, Singh V K, Dwivedi B S, Singh T, Rajanna G A, Babu S, Rathore S S, Singh R K, Shekhawat K, Meenakshi, Kumar P, Yadav D, Singh D P, Dasgupta D and Shukla G. 2023a. Conjoint application of nano-urea with conventional fertilizers: An energy efficient and environmentally robust approach for sustainable crop production. *PlosOne*. https://doi.org/10.1371/journal.pone.0284009

Upadhyay P K, Singh V K, Rajanna G A, Dwivedi B S, Dey A, Singh R K, Rathore S S, Shekhawat K, Babu S, Singh T, Kumar Y, Singh C, Rangot M, Kumar A, Sarkar S, Dash S and Rawat S. 2023b. Unveiling the combined effect of nano fertilizers and conventional fertilizers on crop productivity, profitability, and soil well-being. *Frontiers in Sustainable Food Systems* **7**: 1260178. doi: https://doi.org/10.3389/fsufs.2023.1260178

Vejan P, Khadiran T, Abdullah R and Ahmad N. 2021. Controlled release fertilizer: A review on developments, applications and potential in agriculture. *Journal of Controlled Release* **339**: 321–34.