Indian Journal of Agronomy **69** (4): 470–474 (December 2024)
DOI: 10.59797/ija.v69i4.5553

Research Communication

Combined application of prilled urea and nano-urea enhanced growth and productivity of rainfed maize (*Zea mays*)

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Received: September 2024; Revised accepted: December 2024

ABSTRACT

A field experiment was carried out to assess the impact of different combinations of prilled urea and foliar application of nano-urea on the growth and productivity of rainfed maize in the Eastern plateau of Jharkhand. The Experiment was conducted at the Research Farm, ICAR-Indian Agricultural Research Institute, Gauria Karma, Jharkhand, during the *kharif* season of 2022–23. The design chosen for the experiment was a randomized complete block design (RCBD) with 10-treatment combinations of prilled urea and foliar spray nano-urea at consecutive growth stages of maize. The variety tested in the trial was 'DHM 121'. The study's findings indicate that applying prilled urea and nano-urea via foliar spray enhances crop performance in terms of both growth and productivity. Notably, the yield from plots treated with at least 75% RDN in the form of prilled urea either in spilt dose or as basal dose along with the foliar application of nano-urea (ranged from 5.08–5.30 t/ha) was at par with 100% RDN (5.80 t/ha). This implies that using foliar application of nano-urea or commercial prilled urea at knee high and tasseling critical growth stages of maize can offset the yield reduction by 8.5-12% associated with lower fertilizer levels.

***Key words*:** Eastern plateau, Growth, Nano-urea, Productivity, Prilled urea, Rainfed maize

Maize (*Zea mays* L.) is the world's most widely cultivated food crop providing ample food calories and protein for more than one thousand million human beings in the world. It ranks 3rd among the cereals in India after wheat and rice and is known as the 'Queen of Cereals'. America has been the leading maize producer, followed by Asia, accounting for about 52% and 29.4%, respectively (FAOSTAT, 2022). However, India is the 6th largest producer of maize in the world with 2% contribution to the world maize production with a quantum of 33.6 million MT in 2022-23 from 10 Mha (GOI, 2023). In eastern India, particularly in regions like Jharkhand and Bihar, winter maize yields are notably high. However, during the *kharif* season, productivity falls below the national average despite favourable agro-climatic conditions and sufficient rainfall. This decline is largely attributed to inadequate adoption of crop management practices, especially in nutrient management, resulting in lower maize yields in this area during the *kharif* season. Maize being an exhaustive crop requires a large quantity of nutrients during entire growth periods. Effective nitrogen management is the key to increase the nitrogen use efficiency (NUE) through minimizing losses and enhanced the yield and profit. A few possible tactics to increase NUE include split application, placing gaseous fertilizers in the right places, and using slow-release fertilizers in conjunction with nitrification inhibitors and enzymes. Despite all efforts combined, the NUE rarely rises beyond 40% in the field condition. In contemporary agriculture, nano-fertilizers hold great potential for improving NUE and reducing environmental effect. Nano-fertilizers can significantly contribute to sustained soil health and crop output (Lal, 2008). Employing nano-fertilizers enhances NUE and reduces the overuse of

Based on a part of M.Sc. Thesis of the first author submitted to ICAR- Indian Agricultural Research Institute, New Delhi in 2023 (unpublished)

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fertilizers (Kumar et al. 2020, Upadhyay *et al.* 2023). Under the problematic circumstances in Jharkhand, the effect of applied N by urea and nano-urea supplementation in rainfed maize will pave the path for increased productivity and profitability in rainfed maize. So, keeping these facts in views this study is aimed to know the combined effect of prilled urea and nano-urea on growth and productivity of rainfed maize in eastern India.

A field experiment conducted during the rainy (*kharif*) season of 2022–23 at the Research Farm, ICAR- Indian Agricultural Research Institute, Gauria Karma, Hazaribagh, Jharkhand, aimed to assess the combined impact of prilled urea and nano-urea on rainfed maize (*Zea mays* L.) growth and productivity. The soil characteristics of the experimental site revealed a sandy clay loam composition with 49.0% sand, 21.2% silt, and 29.8% clay, along with a conductivity of 0.51 dS/m and a soil *p*H of 5.66. The bulk density of the 0–15 cm surface soil was 1.48 g/cm^3, featuring 0.30% oxidizable organic carbon, available N at 145.2 kg/ha, available P at 6.54 kg/ha, and available K at 167.78 kg/ha. The experiment was tested in a randomized block design with 10 different combinations of prilled urea and nano-urea. Treatments used in these experiments are given in the (Table 1).

Maize hybrid 'DHM 121' was sown on 14th of July 2022 in rows keeping row to row distance of 60 cm and plant to plant distance of 20 cm with seed rate of 20 kg/ha and was harvested on 15th of October 2022. A tractor-drawn mould board plough was initially used for ploughing and soil turning. Subsequently, a tractor-drawn cultivator and a rotavator were employed. Lastly, ridge makers were used to create ridge furrows. The land was separated in accordance with the irrigation channels and layout plan. Nano-urea was applied by spraying @ 4 ml nano-urea/litre of water or 1250 ml of nano-urea/ha. Urea, single super phosphate (SSP) and muriate of potash (MOP) were used as a source of soil-applied N, P and K fertilizer, respectively. The recommended dose of 120:60:60 kg/ha, NPK was applied for rainfed maize. Full dosages of potassium, phosphorus, and one-third of the nitrogen (N) were applied to all treatments at the time of planting. The remaining N was applied in two equal splits at 30 and 50 days after sowing (DAS) coinciding with knee high and tasseling critical stages of maize. Both the nano-urea and the prilled urea spray (2%) were sprayed concurrently with the first (30 DAS) and second (50 DAS) split of prilled urea as top-dressing. The amount of fertilizers applied for each subplot is mentioned in (Table 2).

The crop growth parameters, like plant height, leaf area index (LAI) were measured using standard procedures (Rana et al., 2014). At maturity, yield attributes and grain and straw yield of each plot recorded separately. Grain yield was recorded at 14% moisture content in maize kernels. The measured data were tested by analysis of variance (ANOVA) using OPSTAT software package. Standard error of mean and least significant difference (LSD) at 5% level of significance were calculated for each treatment and treatment means were compared.

The results showed that adoption of different combinations of prilled urea and foliar application of nano-urea significantly influenced on growth attributes of rainfed maize (Table 3). In the study conducted during the rainy season of 2022–23, growth parameters of maize were examined, including plant height and LAI. At 40 DAS, plant height was observed the highest with 75% RDN + 2 NUS (T_6) which was statistically equal across three treatments, viz. 50% RDN + 25% RDN + 1 NUS (T_4), 50% RDN + 25% RDN + 1 CUS (T_5) and 75% RDN + 2 CUS (T_7). However, at 80 DAS and at harvest, T_1 i.e. 100% RDN recorded the highest plant height compared to control and remains at par with other four treatments (T_4, T_5, T_6 and T_7) that receives at least 75% of RDN in the form prilled

Table 1. Details of treatments adopted in the experiment

Codes	Treatment description
T_1	100% RDN (3 splits i.e., 1/3 at basal, 30 DAS and 50 DAS)
T_2	50% RDN Basal + 2 Nano Urea spray (30 DAS and 50 DAS)
T_3	50% RDN Basal + 2% Commercial Urea spray (30 DAS and 50 DAS)
T_4	50% RDN Basal + 25% RDN at 30 DAS + Nano Urea spray (50 DAS)
T_5	50% RDN Basal + 25% RDN at 30 DAS + 2% Commercial Urea spray (50 DAS)
T_6	75% RDN Basal + 2 Nano Urea spray (30 DAS and 50 DAS)
T_7	75% RDN Basal + 2% Commercial Urea spray (30 DAS and 50 DAS)
T_8	Nano Urea (Seed dressing) + 2 Nano Urea spray (30 DAS and 50 DAS)
T_9	Commercial Urea (2%) (Seed dressing) + 2% Urea spray (30 DAS and 50 DAS)
T_{10}	Control (No Nitrogen) + Simple water spray (30 DAS and 50 DAS)

RDN, Recommended doses of nitrogen; DAS, Days after sowing

Table 2. Fertilizers applied to each treatment

Treatment	N(kg/ha)	P(kg/ha)	K(kg/ha)
100% RDN	120	60	60
50% RDN + 2 NUS	60.1	60	60
50% RDN + 2 CUS	67.36	60	60
50% RDN + 25% RDN + 1 NUS	90.05	60	60
50% RDN + 25% RDN + 1 CUS	93.68	60	60
75% RDN + 2 NUS	90.10	60	60
75% RDN + 2 CUS	97.36	60	60
SDNU + 2 NUS	0.150	60	60
SDCU + 2 CUS	7.37	60	60
Control + 2 WS	-	60	60

RDN, Recommended doses of nitrogen; NUS, nano-urea spray; CUS, commercial urea spray; SDNU, seed dressing with nano-urea, SDCU, seed dressing with commercial urea; WS,water spray

urea along with one or two foliar spray of nano-urea at either 30 or 50 DAS. LAI plays an important role in the photosynthesis and dry matter production. Leaf area index (LAI) of rainfed maize recorded at 40 days interval, i.e. 40 DAS and 80 DAS (Table 3). In general, LAI increased with the advancement of crop growth stages. Both at 40 and 80 DAS, the rainfed maize plants showed significant differences for LAI under different combination of prilled urea and foliar application of nano-urea; however, the better availability of nitrogenous fertilizers during the knee-high stage of the rainfed maize under T_7 resulted in increased leaf production and development resulting in higher LAI value at 40 DAS, which was at par with T_5, T_6 and T_1 (100% RDN), whereas at 80 DAS, 100% RDN registered the highest LAI closely followed by T_4, T_5, T_6 and T_7. Minimum leaf area under control treatment was owing to lack of important growth nutrient that is nitrogen throughout the growth period resulting in poor vegetative growth for the crop. Mondal *et al.* (2023) reported that 50% RDN (1/2 basal + 1/2 at CRI) + nano-urea spray at 60 DAS; and 50% RDN (1/2 basal + 1/2 at CRI) + 2 nano-urea spray at 45 and 70 DAS) were statistically comparable up to 40 DAS but the 75% RDN (1/2 basal + 1/2 at CRI) + nano-urea spray at 60 DAS treated plot showed higher LAI of wheat at 40 DAS.

There was significant difference in the yield attributes, viz. number of cobs/plant, number of seed rows/cob, number of grains/cob due to nano-urea based nitrogen management practices (Table 3). Among yield attributes, number. of grains/cob increased under 100% RDN (412), but it remained at par with 50% RDN + 25% RDN + 1 NUS (364). Likewise, number of cobs/plant (1.43), number of seed rows/cob (23.32) were recorded higher with 100% RDN, however it remained at par with treatments having minimum 75% RDN as basal or spilt doses. Most of the yield parameters were significantly similar with 100% RDN, followed by 75% RDN + 2 spray of nano-urea at 30and 50 DAS, 75% RDN + 2% urea spray due to higher amount of nitrogen supplied through basal dose of prilled urea and subsequent foliar spray of nano-urea and 2% urea spray at critical growth stages of knee high and tasseling which enhances the biochemical activity of the plant. A high level of N nutrition during flowering stage helped plants to produce more no. of cobs/plant. The lowest values for yield attributes were obtained with the control. The increase in yield attributes of maize might have

Table 3. Impact of different combination of prilled urea and foliar application of nano-urea on the growth and yield attributes of rainfed maize

Treatment	Plant height (cm)			Leaf area index (LAI)		Cobs/ plant	Seed rows/cob	Grains/ cob
	40 DAS	80 DAS	At harvest	40 DAS	80 DAS			
100% RDN	103.8	232.0	235.7	3.06	5.53	1.43	14.67	412
50% RDN + 2 NUS	105.2	206.7	208.7	2.66	4.65	1.30	13.56	311
50% RDN + 2 CUS	105.7	205.4	205.7	2.79	4.73	1.27	13.54	309
50% RDN + 25% RDN + 1 NUS	107.7	212.2	216.0	2.73	4.88	1.37	14.31	364
50% RDN + 25% RDN + 1 CUS	107.5	217.6	221.4	2.86	5.08	1.33	14.27	350
75% RDN + 2 NUS	117.2	230.2	233.3	3.17	5.49	1.33	14.24	360
75% RDN + 2 CUS	115.1	218.7	224.6	3.21	5.44	1.33	13.56	320
SDNU + 2 NUS	89.8	153.4	157.7	2.07	4.12	1.27	11.88	269
SDCU + 2 CUS	89.3	153.8	156.2	2.19	4.11	1.17	11.82	250
Control + 2 WS	76.3	143.8	146.5	2.01	3.76	1.00	11.22	215
SEm±	3.42	7.22	6.34	0.12	0.22	0.04	0.66	17.64
CD (P=0.05)	10.95	23.10	20.29	0.37	0.69	0.12	2.11	56.42

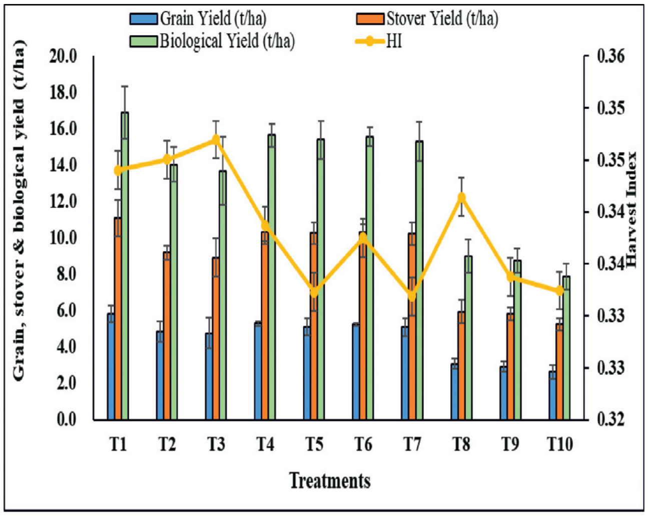

Fig. 1. Impact of different combination of prilled urea and foliar application of nano-urea on the productivity of rainfed maize

been owing to better utilization of resources under improved N supply, as it is an integral part of proteins the building blocks of plant (Singh *et al.,* 2000).

The grain yield was notably influenced by different combination of prilled urea and foliar application of nano-urea, and this effect was statistically significant. The maximum grain, straw and biological yield are recorded with 100% RDN and remained at par with 50% RDN + 25% RDN + 1 NUS, 50% RDN + 25% RDN + 1 CUS, 75% RDN + 2 NUS, 75% RDN + 2 CUS, however, found significantly higher over rest of the treatments. These findings are consistent with the findings that 100% RDN considerably increased wheat grain yield, followed by 75% RDN + 1 nano-urea spray and 50% RDN + 2 nano-urea sprays (Sarkar *et al.,* 2023). Furthermore, the non-significant differences between 100% RDN and 50% RDN + 25% RDN + 1 NUS in grain and biological yield might be due to nano-urea application at the active knee-high stage and tasselling stage provided better availability of N. Fertilization with nano-urea at 30 and 50 DAS along with 75% RDN in the form of prilled urea greatly helped to develop grain compared to other nano-urea treated plots. Treatments with applications of 50% RDN along with nano-urea sprays exhibited significantly lower yields compared with 100% RDN. The plots under seed treated with nano-urea (3.07 t/ha) and commercial urea (2.93 t/ha), irrespective of nano-urea and 2% commercial urea spray registered very low grain yields, which were significantly lower compared with recommended NPK application. These results confirm the findings of Rathnayaka *et al.,* 2018 and Upadhyay *et al.,* 2023. Grain yield is significantly impacted by nitrogen. Higher photosynthesis accumulation and translocation to the plant's economic parts results in a higher yield, which may be attributed to increased source (leaves) and sink (economic part) strength. This is stated in the report regarding the synergistic effect of the nano-fertilizers on the efficacy of conventional fertilizer for better nutrient absorption by plant cells resulting to optimal growth plant parts and metabolic process (Taiz and Zeiger, 2006). The harvest index (HI) is a crucial metric which expresses how efficiently the dry matter was converted into the economic component of the crop. Nano-urea application possessed a non-significant difference in harvest index of the rainfed maize. However, higher harvest index is found in 50% RDN + 2 NUS and 50% RDN + 2 CUS as compared to other treatment.

Based on the results, 50% RDN (basal) + 25% RDN (30 DAS) + 1-NUS or 1-CUS-2% (50 DAS), 75% RDN (basal) + 2-NUS or 2-CUS-2% (30 and 50 DAS) resulted in comparable growth and yield of rainfed maize with 100% RDN. Thus, by spraying of one NU or CU-2% with split application of 75% RDN or 2-NU or 2-CU-2% spray with basal application 75% RDN to rainfed maize, 25% of recommended dose of nitrogen could be saved.

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