



Enhancing Nutrient Use Efficiency through Nano Urea in Pigeon Pea Based Intercropping System

Peeyush Kumar Jaysawal ^{a++*}, S. Karmakar ^{a#},
C. S. Singh ^{a†}, Arvind Kumar Singh ^{a†}, A. K. Singh ^{a†}
and B. K. Agrawal ^{b#}

^a Department of Agronomy, B.A.U. Ranchi-834006, India.

^b Department of Soil Science, B.A.U. Ranchi, India.

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

A field experiment was conducted at Birsa Agricultural University Ranchi during the *kharif* seasons of 2021 and 2022 to evaluate N uptake and Nutrient Use Efficiency (NUE) for nitrogen as influenced by pigeon pea-based intercropping systems and nitrogen management. Pigeon pea + sweet corn intercropping systems with 100% recommended nitrogen (N₁), recorded significantly higher total nitrogen uptake (196.6 kg/ha) which was at par with 50% RDN + 2 spray of nano urea (189.1 kg/ha). Whereas partial factor productivity (PFP), agronomic efficiency (AE), apparent recovery use efficiency (ARUE), economic nutrient use efficiency (ENUE), partial nutrient balance (PNB) of pigeon pea + sweet corn intercropping was recorded maximum (27.4 kg/kg, 13.4 kg/kg,

⁺⁺ Research Scholar;

[#] Chief Scientist-cum-University Prof.;

[†] Jr. Scientist-cum-Assistant. Prof.;

*Corresponding author: E-mail: peeyush.vishu@gmail.com;

64.8 %, 1.66 kg yield/ ₹ invested in nitrogen & 0.88 kg/kg) respectively, while in nitrogen management, 50% RDN + 2 sprays of Nano urea performed better in terms of PFP, AE, ARUE, ENUE & PNB (52.5 kg/kg, 24.1 kg/kg, 115.4 %, 3.20 kg yield/ ₹ invested in nitrogen & 1.43 kg/kg respectively) when compared to the other nitrogen management.

Keywords: Nano urea; N uptake; nutrient use efficiency; pigeon pea-based Intercropping systems.

1. INTRODUCTION

Pulses play a vital role in the diet of many people, especially in developed nations. As per [1], about one-third of the nitrogen fixed by legumes is believed to stay in the soil, potentially benefiting the following crop or contributing to the organic matter. This underscores the valuable contribution of legumes not only to nutrition but also to soil fertility and sustainability, as emphasized by [2]. Maize, scientifically known as *Zea mays*, holds the position of India's third most important cereal crop followed by rice and wheat [3]. The global popularity of baby corn and sweet corn is increasing, driven by higher living standards and evolving dietary choices. India stands out with the world's lowest cultivation costs for baby corn, positioning itself as a potential leader in its production. This highlights the country's competitive advantage and potential dominance in meeting the growing demand for these corn varieties [4]. The rising demand for food, fibre, and biofuel significantly influences fertilizer consumption locally and globally. Conversely, mismanagement often leads to the excess movement of nutrients, like nitrogen, outside agricultural fields, affecting nutrient supply [5]. Spraying nutrients on plant leaves (Nano-urea foliar application) can enhance efficiency and speed of nutrient absorption, promoting faster growth and higher yields. This method, as suggested by [6], allows quick nutrient uptake by leaves, potentially altering their structure. Additionally, it is easy to apply and minimizes soil and environmental pollution, Nano-urea consists of tiny nitrogen particles (55,000 per 1 mm urea prill). This form enhances crop yield, biomass, soil health, and produce nutrition. Nano urea particles, averaging 20-50 nm, contain 4% nitrogen by weight. Typically, only 30-50% of nitrogen is utilized by plants through urea, and the rest is lost due to leaching and volatilization, leading to soil and water contamination, nitrous oxide emissions, air pollution, global warming, and reduced crop nutritional efficiency [7]. This experiment conducted due to nitrogen management was very difficult in legume + cereals intercropping systems, this problem was

minimised by the use of foliar spray, reduces nitrogen management in legume based intercropping systems.

2. MATERIALS AND METHODS

The present study was conducted at Agronomy Research Farm, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, during the *Kharif* season of 2021 and 2022. The soil is sandy loam with initial value of soil pH (5.51), organic carbon (0.48%) and available nitrogen was (193.5 kg/ha), respectively. The experiment was lay out in Split Plot Design (SPD) with three replications the main plot treatments included five crop combinations namely: C₁-sole pigeon pea, C₂-sole sweet corn, C₃-sole baby corn, C₄-pigeon pea + sweet corn, and C₅-pigeon pea + baby corn. The nitrogen management practices employed in the sub-plot treatments were: N₁-100% RDN (recommended dose of nitrogen), N₂-50% RDN, N₃-50% RDN + two sprays of Nano urea (4ml/liter of water), N₄-50% RDN + two sprays of urea (2%), and N₅-Control. Birsa Arhar-1, Sugar-75, and BVM-2 were the varieties for pigeon pea, sweet corn, and baby corn, respectively. They were planted on June 22, 2021 and June 20, 2022, with a spacing of 60 cm × 25 cm for pigeon pea and sweet corn and 60 cm × 15 cm for baby corn, both in sole cultivation and pigeon pea based intercropping system. The recommended fertilizer dosage for N: P₂O₅: K₂O: S was 25:50:25:20 for pigeon pea and 150:60:40 for sweet corn and baby corn. The sources of N were prilled urea & Nano urea. In the case of pigeon pea N were apply as a basal & foliar were applied at 30 & 50 days after sowing (DAS) while in maize, N were applied as basal at the time of sowing, top dressing at 15, 30 & 50 DAS & foliar spray at 30 and 50 DAS were applied. The total nitrogen uptake in the plant was calculated by adding the nitrogen uptake by grain and straw or stover. Nutrient use efficiency (NUE) for nitrogen indices is partial factor productivity (PFP), agronomic efficiency (AE), apparent recovery use efficiency (ARUE), economic nutrient use efficiency (ENUE), partial nutrient balance (PNB) and N uptake were calculated by the formula given below [8].

a) Total N uptake (kg/ha) = (N content in grain and straw or stover (%))/100 × dry weight (kg/ha)

b) Partial factor productivity

$$\text{PFP (kg/kg)} = (\text{Grain yield under N plot (kg/ha)})/(\text{Amount of N applied (kg/ha)})$$

c) Agronomic efficiency

$$\text{AE (kg/kg)} = (\text{Grain yield under N plot (kg/ha)} - \text{Grain yield under no N plot})/(\text{Amount of N applied (kg/ha)})$$

d) Apparent Recovery Use Efficiency

ARUE (%) =

$$(\text{N uptake by crop under N plot (kg/ha)} - \text{N uptake by crop under no nitrogen plot})/(\text{Amount of N applied (kg/ha)})$$

e) Economic Nutrient Use Efficiency

$$\text{ENUE (kg yield/₹ invested in nitrogen)} = (\text{Economic yield (kg/ha)})/(\text{Amount invested on N (Rs/kg)})$$

f) Partial Nutrient Balance

$$\text{PNB (kg/kg)} = (\text{N uptake(kg/ha) by grain (economic yield)})/(\text{Total N applied (kg/ha)})$$

3. RESULTS AND DISCUSSION

3.1 Nitrogen Uptake by Crops

The combined effect of crop combination and nitrogen management was notably significant. Pigeon pea + sweet corn intercropping system with 100% recommended nitrogen (N₁), recorded significantly higher total nitrogen uptake (196.6 kg/ha) which was at par with 50% RDN + 2 spray of nano urea (189.1 kg/ha). This might be due to the inclusion of pigeon pea is a legume crop and fixes nitrogen from atmospheric and uses less N from soil, but sweet corn is an exhaustive crop and long duration, they take more N as compared to baby corn, [9] reported similar findings.

3.2 Partial factor Productivity (PFP) and Agronomic Efficiency (AE)

In intercropping systems, pigeon pea + sweet corn intercropping achieved maximum PEP & AE, showcasing enhanced efficiency. 50% RDN+ two sprays of Nano urea recorded highest PEP & AE over alternative nitrogen treatments this might be due to in pigeon pea + sweet corn intercropping, pigeon pea assimilates more nitrogen from atmosphere, after the application of nano urea sweet corn absorb easily applied nano urea due to high surface area & nano size they are easily enter into the plant by stomata and other pore of sweet corn

and pigeon pea and also face minimal competition for soil N that's why that system gives more yield with less application of nitrogen as compared to other treatments excluding sole pigeon pea. Increasing nitrogen rates showed a negative correlation with both PFP and AE, (Table 2). The highest PFP and AE occurred at a lower nitrogen rate. The decline in PFP and AE at higher nitrogen levels may result from nutrient imbalance and reduced native soil nitrogen supply [10] suggested that optimizing fertilizer use efficiency involves lower fertilizer rates practices.

3.3 Apparent Recovery Use Efficiency, Economic Nutrient Use Efficiency & Partial Nutrient Balance

Apparent recovery efficiency (ARE), economic use efficiency (ENUE), and (PNB) partial nutrient balance (Table 2) was found maximum in pigeon pea + sweet corn intercropping among the other intercropping systems, and with respect to nitrogen management, 50% recommended dose of nitrogen + 2 sprays of Nano urea showed the best results against other nitrogen treatments. This could be due to reduction of N losses (leaching, denitrification & runoff loss) from the soil solution, nutrient use efficiency improved by the use of nano urea. As a result, there was better growth and crop yield compared to the control. Similar results were corroborated by Singh [11].

Table 1. Total nitrogen uptake by pigeon pea, sweet corn & baby corn after harvest as influence by pigeon pea based intercropping system through nitrogen management on the basis of dry weight (mean of 2021 and 2022)

Symbol	Treatments	C ₁ (PP)	C ₂ (SC)	C ₃ (BC)	C ₄ (PP+SC)	C ₅ (PP+BC)	Mean
N ₁	100%RDN	85.6	134.1	101.8	196.6	171.0	137.8
N ₂	50%RDN	72.9	104.5	83.3	154.7	141.5	111.4
N ₃	50% RDN + two spray of Nano-urea (4ml/l of water) at 30 and 50 DAS	85.0	122.1	92.3	189.1	165.4	130.8
N ₄	50% RDN + two spray of urea (2%) at 30 and 50 DAS	79.7	111.0	86.1	175.4	155.5	121.5
N ₅	N ₅ =(Control)	59.2	50.7	38.8	93.8	80.3	64.6
Mean		76.5	104.5	80.5	161.9	142.7	
					SEm±	CD at 5 %	
Crop					0.71	2.35	
Nitrogen management					1.37	3.92	
Interaction		Between N and at same level of C			1.59	8.85	
		Between C and at same level of N			2.82	8.18	

Note- PP- Pigeon pea, SC- Sweet corn & BC- Baby corn

Table 2. Nutrient use efficiency as influence by pigeon pea based intercropping system through nitrogen management (mean of 2021 and 2022)

	PFP (kg /kg)	AE (kg/kg)	ARUE (%)	ENUE (kg yield/₹ invested in nitrogen)	PNB (kg/kg)
Crop					
Sole pigeon pea (C ₁)	71.3	20.2	105.7	4.25	2.34
Sole sweet corn (C ₂)	22.3	12.4	59.3	1.35	0.70
Sole baby corn (C ₃)	19.4	11.4	46.1	1.18	0.07
Pigeon pea + sweet corn (C ₄)	27.4	13.4	64.8	1.66	0.88
Pigeon pea + baby corn (C ₅)	24.8	12.7	59.8	1.51	0.37
Nitrogen management					
100 % RDN (N ₁)	27.3	13.0	62.8	1.66	0.74
50 % RDN (N ₂)	43.9	15.4	75.1	2.67	1.16
50 % RDN + two spray of Nano urea (4ml/l of water) at 30 and 50 DAS (N ₃)	52.5	24.1	115.4	3.20	1.43
50% RDN + two spray of urea (2%) at 30 and 50 DAS (N ₄)	41.7	17.4	81.4	2.41	1.03
Control (N ₅)	-	-	-	-	-

4. CONCLUSION

Based on two years of experimentation, it may be concluded that pigeon pea + sweet corn along with 50 % RDN + two sprays of Nano urea was found promising intercropping system for higher nitrogen use efficiency, emphasizing the positive impact of intercropping and nitrogen management practices on optimizing nitrogen utilization in pigeon pea based intercropping systems.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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