Enhancing NutrientUse Efficiency through Nano Urea in Pigeon pea based IntercroppingSystem

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 systemswith 100% recommended nitrogen (N_1), recorded significantly higher total nitrogen uptake (196.6 kg/ha) which was at par with 50% RDN + 2 spray of nano urea (188.7kg/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, 64.7 %, 1.66 kg yield/ ₹ invested in nitrogen& 0.88 kg/kg) respectively, while in nitrogen management, 50% RDN + 2 sprays of Nano urea performed betterin terms of PFP, AE, ARUE, ENUE & PNB (52.5 kg/kg, 24.1 kg/kg, 115.0 %, 3.20 kg yield/ ₹ invested in nitrogen& 1.43kg/kg respectively) when compared to the other nitrogen management.

Key words: 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 [7], 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 [11]. Maize, scientifically known as *Zea mays*, holds the position of India's third most important cereal crop followed by rice and wheat [1].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 [8].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 [4]. Spraying nutrients on plant leaves (Nano-ureafoliar application) can enhance efficiency and speed of nutrient absorption, promoting faster growth and higher yields. This method, as suggested by [3], 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 [2].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.

MATERIAL AND METHODS

The present study wasconducted at Agronomy Research Farm, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, during the *Kharif* season of 2021 and 2022.The soil is sandy loan with initial value of soil pH (5.51), organic carbon (0.48%) and available nitrogen was (193.5 kg/ha), respectively. The experiment was layout in Split Plot Design (SPD) with three replicationsthe main plot treatments included five crop combinations namely: C_1-sole pigeon pea, C_2-sole sweet corn, C_3-sole baby corn, C_4-pigeon pea + sweet corn, and C_5-pigeon pea + baby corn. The nitrogen management practices employed in the sub-plot treatments were: N_1-100% RDN (recommended dose of nitrogen), N_2-50% RDN, N_3-50% RDN + two sprays of Nano urea (4ml/liter of water), N_4-50% RDN + two sprays of urea (2%), and N_5-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:P_2O_5:K_2O:S was 25:50:25:20 for pigeon pea and 150:60:40 for sweet corn and baby corn.The sources of N were prilledurea & 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, topdressing 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.Nutrientuse 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 bythe formula given below [6].

a) $\text{Total N uptake (kg/ha)} = (N\ content\ in\ grain\ and\ straw\ or\ stover\ \ (\%))/100 \times dry\ weight\ (kg/ha)$
b) Partial factor productivity

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

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

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

e) Economic Nutrient Use Efficiency

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

f) Partial Nutrient Balance

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

A) 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 systemwith 100% recommended nitrogen (N_1), recorded significantly higher total nitrogen uptake (196.6kg/ha) which was at par with 50% RDN + 2 spray of nano urea (188.7 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 cornis an exhaustive crop and long duration, they take more Nas compared to baby corn,[9] reported similar findings.

3.2. Partial factor productivity (PFP)& 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 treatmentsthis 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 AEoccurred 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 [5] 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 resultsagainst 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 [10].

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 which was at par with 100 % RDN 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.

Table 1 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	170.7	137.7
N_2	50%RDN	72.8	104.5	82.7	154.3	140.8	111.0
N_3	50% RDN + two spray of Nano-urea (4ml/l of water) at 30 and 50 DAS	84.9	122.1	91.9	188.7	164.7	130.5
N_4	50% RDN + two spray of urea (2%) at 30 and 50 DAS	79.7	111.0	85.5	175.4	154.9	121.3
N_5	N_5=(Control)	59.2	50.7	38.8	93.8	80.2	64.5
Mean		76.4	104.5	80.2	161.8	142.2	
					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

	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	105.5	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	45.7	1.18	0.07
Pigeon pea + sweet corn (C_4)	27.4	13.4	64.7	1.66	0.88
Pigeon pea + baby corn (C_5)	24.8	12.7	59.3	1.51	0.37
Nitrogen management					
100 % RDN (N_1)	27.3	13.0	62.7	1.66	0.74
50 % RDN (N_2)	43.9	15.4	75.6	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	115.0	3.20	1.43
50% RDN + two spray of urea (2%) at 30 and 50 DAS (N_4)	41.7	17.4	81.2	2.41	1.03
Control (N_5)	-	-	-	-	-

(mean of 2021 and 2022).

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