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Effect of biofertilizers and nano urea on productivity of maize (*Zea mays* L.) under rainfed conditions of southern Rajasthan

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Abstract

A field experiment was conducted at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur during *khari*, 2024 to study the “Effect of biofertilizers and nano urea on productivity of maize (*Zea mays* L.) under rainfed conditions of Southern Rajasthan”. The experiment was laid out in split-plot design comprising of three seed treatment through biofertilizers and seven varied nano urea foliar spray with different doses focusing mainly two stages *i.e.*, knee high and tasselling stage under main plot and sub plot treatments with replicated thrice. Results of this experiment revealed that all growth attributes, yield attributes and yield (grain, stover and biological) were maximum under *Azotobacter* @ 200 g 10 kg⁻¹ seed which was statistically at par with *Azotobacter* liquid @ 05 ml 1 kg⁻¹ seed. Contrarily, Nano urea 3 ml litre⁻¹ @ knee high and tasselling stage recorded significantly highest nutrient content and uptake, grain as well as stover yield over other treatments. However, lowest growth, yield attributes and yield were observed under control.

Keywords: Maize, nano urea, biofertilizer, foliar spray, yield

Introduction

Maize (*Zea mays* L.) is the most important profitable crop in the world, widely grown as a cereal grain that was domesticated in Central America. It is among the most adaptable new crop with a greater range of uses. Maize is regarded as the “Queen of cereals” across the world due to its high genetic production potential. Maize is a type of cereal grass that belongs to the family of Poaceae and it is a highly cross-pollinated crop. It is a C₄ plant that is widely utilized for human nutrition, animal feed and fodder. It is quite adaptable and nutritive crop that provides an excellent supply of high fibre, antioxidants, other vitamins (A, B and C), minerals (magnesium, phosphorus, zinc, iron and potassium etc.), protein (10.3%) and fat (4.5%). Besides, maize is an important industrial raw material and provides a great contribution for value addition as well as boosting the farmer’s income. There are more than 165 countries that cultivate maize, covering 208 million hectares worldwide with an annual production of 1241 million tonnes (FAOSTAT, 2023) [2].

Maize is very much nutrient exhaustive crop and a proper yield is obtained by scientific nutrient management practices. Now a days, our productive soil losses its fertility status due to accumulation of heavy metals and indiscriminate use of fertilizers. That’s why, most prominent solution is the use of microbial inoculum as seed treatment such as *Azotobacter*. *Azotobacter* species are able to influence directly plant growth by synthesizing plant growth hormones *i.e.*, Indole Acetic Acid (IAA), gibberellins and cytokinins. These hormones can indirectly protect host plants from phytopathogens and stimulate other beneficial rhizosphere micro-organisms (Sahoo *et al.*, 2014) [6]. Another aspect is to use nano urea in the form of nano particles (20-50 nm size) as foliar sprays in maize just to reduce the various losses due to urea application. Nano urea also helps in minimizing gaseous emissions which used to cause environmental pollution and climate change. Nano urea is an innovative agri-input that gives plants nitrogen and is based on nanotechnology. When nano urea is applied by spraying it onto leaves, it easily penetrates

through stomata and other openings, becoming assimilated into plant cells through apoplastic and symplastic movement. Unutilized nitrogen is stored in plant vacuoles and gradually released to support proper plant growth and development (Paul *et al.*, 2024) ^[5].

Materials and Methods

The experiment was carried out at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (24° 35'N latitude, 73° 42'E longitude and an altitude of 581.13 metre above mean sea level) during *kharif*, 2024. The soil of the experimental field was clay-loam in texture, moderately alkaline in reaction with low level of available nitrogen, medium level of available phosphorus and high level of available potassium. The experiment was laid out in split-plot design comprising of 21 treatments replicated thrice. The treatments were T1 (Control), T2 (Control+ Nano urea 4 ml litre⁻¹ @ knee high stage), T3 (Control+ Nano urea 4 ml litre⁻¹ @ tasselling stage), T4 (Control+ Nano urea 2 ml litre⁻¹ @ knee high and tasselling stage), T5 (Control+ Nano urea 6 ml litre⁻¹ @ knee high stage), T6 (Control+ Nano urea 6 ml litre⁻¹ @ tasselling stage), T7 (Control+ Nano urea 3 ml litre⁻¹ @ knee high and tasselling stage), T8 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Control), T9 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Nano urea 4 ml litre⁻¹ @ knee high stage), T10 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Nano urea 4 ml litre⁻¹ @ tasselling stage), T11 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Nano urea 2 ml litre⁻¹ @ knee high and tasselling stage), T12 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Nano urea 6 ml litre⁻¹ @ knee high stage), T13 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Nano urea 6 ml litre⁻¹ @ tasselling stage), T14 (*Azotobacter* @ 200 g 10 kg⁻¹ seed + Nano urea 3 ml litre⁻¹ @ knee high and tasselling stage), T15 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed+ control), T16 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed + Nano urea 4 ml litre⁻¹ @ knee high stage), T17 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed + Nano urea 4 ml litre⁻¹ @ tasselling stage), T18 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed + Nano urea 2 ml litre⁻¹ @ knee high and tasselling stage), T19 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed + Nano urea 6 ml litre⁻¹ @ knee high stage), T20 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed + Nano urea 6 ml litre⁻¹ @ tasselling stage) and T21 (*Azotobacter* @ 05 ml 1 kg⁻¹ seed + Nano urea 3 ml litre⁻¹ @ knee high and tasselling stage). PHM-3 variety of maize was sown @ 25 kg seed with 60 cm × 25 cm geometry. Spraying of pre-emergence herbicide *i.e.*, Atrazine was done at 2 DAS.

Plant height was recorded from five plants selected randomly from net plot area and marked with tags. The heights of the tagged plants were measured from ground level to the top of the plant at 25, 50, 75 DAS and at harvest. The average height was then calculated and expressed in cm. Dry matter accumulation was measured from five plants sampled randomly from each plot at 25, 50, 75 DAS and at harvest. These samples were subsequently chopped and subjected to oven drying at a temperature of 65°C until reaching a constant weight. The mean weight of the dried plant samples was calculated to assess dry matter accumulation and expressed in g plant⁻¹. Grain yield was obtained after threshing of cobs and then winnowing was done

and grains from each net plot was weighed in kg plot⁻¹ then converted in q ha⁻¹ for yield.

Results and Discussion

Growth Attributes

A closely assessment of data (Table 1) shows that maximum plant height was obtained under *Azotobacter* @ 200 g 10 kg⁻¹ seed at 50, 75 DAS and at harvest which was statistically at par with *Azotobacter* liquid @ 5 ml kg⁻¹ seed and significantly superior over control. The same trend follows in dry matter accumulation, possibly caused by the nitrogen-fixing ability of *Azotobacter* and its capacity to produce plant growth-promoting hormones like indole acetic acid and gibberellins. The dry matter accumulation was consistently superior under *Azotobacter* @ 200 g 10 kg⁻¹ seed treatment at all stages, which reflects enhanced photosynthetic activity and nutrient uptake. This treatment also recorded the highest CGR (5.82 g m⁻² day⁻¹ between 75 DAS and harvest), indicative of superior biomass production (Baral and Adhikari, 2013) ^[1]. In case of nano urea treatments, application of nano urea @ 3 ml litre⁻¹ at knee-high and tasselling stage recorded maximum plant height, dry matter accumulation, CGR, RGR and leaf area index. This could be due to the higher nutrient use efficiency of nano urea, which resulted in increased availability of nutrients in readily available form directly to the foliage, which played an important role in active photosynthesis, photosynthate translocation, protein synthesis, plant stomatal balance and water use, ionic balance, activation of various plant enzymes, and many other mechanisms. Urea's nano-scale particle size promotes quick foliar absorption, consistent nitrogen distribution, and minimizes volatilization and leaching. (Srivastava and Singh 2023) ^[8].

Yield

The examination of data on yield presented in (Table 2) shows that grain and stover yield was significantly influenced by different treatment combinations. Maximum grain yield (4516 kg ha⁻¹) and stover yield (7542 kg ha⁻¹) was recorded under *Azotobacter* @ 200 g 10 kg⁻¹ seed which attributed to better nutrient availability, root development, and plant vigor. This improvement may be due to enhanced nitrogen fixation, phytohormone production and phosphorus solubilization by *Azotobacter*, which led to improved root development, nutrient uptake, and metabolic activity. These enhanced yield attributes translated into significantly higher grain and stover yield. The findings of present investigation are in close agreement with Sharma *et al.* (2007) ^[7] and Jnawali *et al.* (2015) ^[3].

In case of nano urea treatments, same treatment also recorded the highest grain yield and stover yield. The dual-stage foliar application likely synchronized nitrogen supply with crop demand during vegetative and reproductive phases, leading to better canopy development, prolonged photosynthesis, and enhanced dry matter accumulation. Statistically, this treatment was at par with nano urea @ 6 ml litre⁻¹ at knee-high stage (N4), indicating that well-timed nitrogen supply is more crucial than increased dosage. The results are in close of proximity with the findings of Ninama *et al.* (2023) ^[4].

Table 1: Effect of biofertilizers and nano urea on plant height, dry matter accumulation and growth indices of maize

Treatments	Plant height (cm)		Dry matter accumulation (g plant-1)	CGR (g m-2 day-1)
	75 DAS	At harvest	At harvest	75 DAS- at harvest
Seed treatment through Biofertilizers				
B0 (Control)	167.76	188.74	88.14	5.02
B1 (<i>Azotobacter</i> @ 200 g 10 kg ⁻¹ seed)	195.06	224.57	116.90	5.82
B2 (<i>Azotobacter</i> liquid @ 05 ml 1 kg ⁻¹ seed)	182.14	221.33	109.66	4.98
S.Em±	3.48	3.36	1.05	0.41
CD (P=0.05)	13.67	13.17	4.121	1.59
Nano urea				
N0 (Control)	172.07	198.71	100.37	5.57
N1 (Nano urea 4 ml litre ⁻¹ @ knee high stage)	179.42	210.99	101.71	4.38
N2 (Nano urea 4 ml litre ⁻¹ @ tasselling stage)	181.72	208.21	100.44	4.78
N3 (Nano urea 2 ml litre ⁻¹ @ knee high and tasselling stage)	183.76	214.53	103.93	4.88
N4 (Nano urea 6 ml litre ⁻¹ @ knee high stage)	184.52	216.14	108.40	5.52
N5 (Nano urea 6 ml litre ⁻¹ @ tasselling stage)	183.91	214.92	105.74	5.12
N6 (Nano urea 3 ml litre ⁻¹ @ knee high and tasselling stage)	186.38	217.33	113.72	6.65
S.Em±	3.08	3.73	1.43	0.41
CD (P=0.05)	8.84	10.71	4.12	1.17

Table 2: Effect of biofertilizers and nano urea on grain and stover yield of maize

Treatments	Yield (kg ha ⁻¹)	
	Grain	Stover
Seed treatment through Biofertilizers		
B ₀ (Control)	4073	5751
B ₁ (<i>Azotobacter</i> @ 200 g 10 kg ⁻¹ seed)	4516	7542
B ₂ (<i>Azotobacter</i> liquid @ 05 ml 1 kg ⁻¹ seed)	4360	7276
S.Em±	86	107
CD (P=0.05)	339	420
Nano urea		
N ₀ (Control)	3450	6286
N1(Nano urea 4 ml litre-1 @ knee high stage)	4080	6784
N2 (Nano urea 4 ml litre-1 @ tasselling stage)	3807	6606
N3 (Nano urea 2 ml litre-1 @ knee high and tasselling stage)	4242	6913
N4 (Nano urea 6 ml litre-1 @ knee high stage)	4916	6987
N5 (Nano urea 6 ml litre-1 @ tasselling stage)	4565	6947
N6 (Nano urea 3 ml litre-1 @ knee high and tasselling stage)	5153	7471
S.Em±	112	123
CD (P=0.05)	322	353

Conclusion

On the basis of the experiment, it was observed that seed treatment through *Azotobacter* @ 200 g 10 kg⁻¹ seed along with nano urea 3 ml litre⁻¹ at knee high and tasselling stage significantly enhanced growth, yield attributes, nutrient uptake, maximum grain yield (5269 kg ha⁻¹), net returns (₹ 38712 ha⁻¹) and B-C ratio (3.38) of maize.

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