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Influence of biofertilizer and nano urea on growth and yield of sorghum

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Abstract
A field experiment was conducted during *Kharif* season of 2024 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences to "Influence of biofertilizer and nano urea on growth and yield of sorghum (*Sorghum bicolor* L)". The treatments consisted of three levels of Biofertilizer (*Azotobacter*-25 g/kg, *Azospirillum*-45 g/kg, *Azotobacter* + *Azospirillum*), Nano urea (2, 3, 4 ml/l) along with recommended doses of fertilizer and a control (80-40-40 kg N-P-K/ha). The results revealed that the significantly higher plant height (132.5 cm), higher plant dry weight (46.65 g), higher test weight (26.40 g), higher seed yield (2.30 t/ha), higher stover yield (6.18 t/ha) were recorded in treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l] and higher length of ear head (26.75 cm) were recorded in treatment 3 [*Azotobacter* 20 g/kg + Nano urea 4 ml/l].

Keywords: Nano urea, economics, sorghum, growth, biofertilizer, yield

1. Introduction

Sorghum (*Sorghum bicolor* L.) is an important crop widely grown for grain and forage because of its suitability for various soils and climate conditions. Sorghum is recognized as a forage crop due to its quick growth, taste, and nutritional benefits. It serves for fresh feeding, silage, and hay making. When collected during the flowering phase, its forage generally comprises 6-7% crude protein, 30-31% crude fiber, and 9-10% mineral content. Sorghum's ability to withstand drought, aided by its xerophytic features, allows it to endure and bounce back in water-scarce environments. In contrast to crops such as maize and millet, sorghum supplies green fodder for an extended period and occupies around 30% of the total cultivated forage area, positioning it as a crucial subject for research focused on improving yield and nutritional quality (Dhar, 2005) [2].

Sorghum is commonly cultivated in rain-fed environments on soils with low fertility, where productivity is restricted by nutrient and moisture stress. As stated by Ayub *et al*. (2002) [1], the highest dry matter yield was observed at 26.01 t/ha at 75 days after sowing (DAS), while the lowest yield recorded was 8.10 t/ha at 45 DAS. Biofertilizers, also known as bioinoculants, are organic products that include advantageous microorganisms to enhance crop nutrition, especially in providing nitrogen (N) and phosphorus (P). When applied as a seed treatment, root dip, or soil application, these microbes proliferate in the rhizosphere, boosting soil microbial communities. It flourishes on organic matter in soil and root exudates from plants, aiding in the fixation of atmospheric nitrogen. Biofertilizers improve biological nitrogen fixation (BNF) and phosphate solubilization while also fostering plant growth via natural growth regulators, and are deemed stable due to a C:N ratio of 20:1 (Wani *et al*., 2013) [3].

The emergence of high-yielding and fertilizer-responsive crops has made fertilizer use increasingly essential for enhancing both yield and quality. While research has mainly centered on rice, nanotechnology—particularly the application of nano fertilizers—holds significant potential. Nanomaterials are particles that range from 1 to 100 nanometers in size in at least one dimension. Nano urea, for example, has around 55,000 nitrogen particles in only 1 mm of urea prill. It can lower traditional urea usage by more than 50%, boost nutrient use efficiency, and decrease nitrogen leaching—simultaneously improving soil health, crop yield, and nutritional value. Moreover, nano urea is more economical, reducing input expenses and enhancing farmers' earnings. Research conducted by Midde *et al*., (2022) [9] revealed that nano urea is effective in direct-seeded rice, highlighting benefits for yield and input efficiency

2. Materials and Methods

The experiment was conducted during *Kharif* season 2024-25 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, with soil (pH 6.7), low level of organic carbon (0.62%), available N (178.48 Kg/ha), P (21.3kg/ha), K (213.1 kg/ha). The treatment consists of three levels of Calcium along with the combination of Sulphur. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T_1-(*Azotobacter* 25 g/kg + Nano urea 2 ml/l), T_2-(*Azotobacter* 25 g/kg + Nano urea 3 ml/l), T_3-(*Azotobacter* 25 g/kg + Nano urea 4 ml/l), T_4-(*Azospirillum* 45 g/kg + Nano urea 2 ml/l), T_5-(*Azospirillum* 45 g/kg + Nano urea 3 ml/l), T_6-(*Azospirillum* 45 g/kg + Nano urea 4 ml/l), T_7-(*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l), T_8-(*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l), T_9-(*Azotobacter* + *Azospirillum* + Nano urea 4 ml/l), T_{10}-Control N:P:K (80:40:40 Kg/ha). Data recorded on different aspects of crop, *viz*., growth, yield attributes and yield were subjected to statistically analysed by analysis of variance method as described by Gomez and Gomez, (1976) [10].

3. Result and Discussion

3.1 Growth Attribute

3.1.1 Plant height (cm)

The data revealed that significant and higher plant height (132.5 cm) was recorded in treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l]. However, treatment 1 [*Azotobacter* 45 g/kg + Nano urea 2 ml/l], treatment 2 [*Azotobacter* 20 g/kg + Nano urea 3 ml/l], treatment 3 [*Azotobacter* 20 g/kg + Nano urea 4 ml/l], treatment 4 [*Azospirillum* 45 g/kg + Nano urea 2 ml/l], treatment 7 [*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l], treatment 9 [*Azotobacter* + *Azospirillum* + Nano urea 4 ml/l] were found to be statistically at par with treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l].

Significant and higher plant height was observed with application of Nano urea 3 ml/l and Azosprillium might be due to improved nutritional conditions for plant growth during active vegetative stages, leading to an increase in cell multiplications, elongation, and expression in the plant body, all of which contributed to the increase in plant height. findings of Samanta *et al*., (2022) [4]. Further, The results revealed that the application of 100 percent RDF + one spray of 0.3 percent nano urea fertilizer at 30 DAT (T_6) recorded higher plant height (94.13 cm). These results are in close conformity with the findings of Chandan *et al*., (2023) [7].

3.1.2 Plant dry weight (g)

The data observed that significant and higher plant dry weight (46.65 gm) was recorded in treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l]. However, treatment 3 [*Azotobacter* 20 g/kg + Nano urea 2 ml/l], treatment 6 [*Azospirillum* 45 g/kg + Nano urea 4 ml/l], treatment 7 [*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l], treatment 8 [*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l], were found to be statistically at par with treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l].

Significant and higher plant dry weight was observed with application of *Azospirillum* (45 g/kg) and Nano urea 3 ml/l is a free-living nitrogen-fixing bacterium that helps convert atmospheric nitrogen into forms available to plant, Produces phytohormones such as auxins, gibberellins, and cytokinins, which enhance root development and plant vigor and Enhances overall plant growth, leading to better biomass and yield. These results are in accordance with the findings of Chinnappa *et al*., (2023) [8].

3.2 Yield and yield attributes

3.2.1 Length of earhead(cm)

Treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l) recorded significant and maximum ear height/plant (26). However, Treatment 1 (*Azotobacter* 20 g/kg + Nano urea 2 ml/l), Treatment 2 (*Azotobacter* 20 g/kg + Nano urea 3 ml/l) Treatment 3 (*Azotobacter* 20 g/kg + Nano urea 4 ml/l),Treatment 6 (*Azospirillum* 45 g/kg + Nano urea 4 ml/l), Treatment 7 (*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l), Treatment 8 (*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l),Treatment 9 (*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l), were found to be statistically at par with Treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l).

Significant and maximum length of earhead was observed with the application of Nano urea 3 ml/l might be due to growth of floral components, such as reproductive organs, which contributes to the production of seeds in plants. These results are in accordance with the findings of Samanta *et al*., (2022) [4].

3.2.2 Test Weight

No significant difference was recorded among all the treatments. Statistically highest test weight (26.40 g) was recorded in treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l].

3.2.3 Seed yield

Treatment 5 (*Azospirillum* 45 g/kg + Nano urea 3 ml/l) recorded significant and higher seed yield (2.30 t/ha). However, Treatment 3 (*Azotobacter* 20 g/kg + Nano urea 4 ml/l), Treatment 4 (*Azospirillum* 45 g/kg + Nano urea 2 ml/l), Treatment 6 (*Azospirillum* 45 g/kg + Nano urea 4 ml/l), Treatment 7 (*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l) and Treatment 8 (*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l), were found to be statistically at par with Treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l).

Significant and maximum seed yield was observed with the application of Nano urea 3 ml/l, The similar results were Samanta *et al*., (2022) [4] and Sharma *et al*., (2022) [5].

3.2.4 Stover Yield

Treatment 5 (*Azospirillum* 45 g/kg + Nano urea 3 ml/l) recorded significant and higher seed yield (6.18 t/ha). However, Treatment 6 (*Azospirillum* 45 g/kg + Nano urea 4 ml/l), Treatment 7 (*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l), Treatment 8 (*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l) and Treatment 9 (*Azotobacter* + *Azospirillum* + Nano urea 4 ml/l), were found to be statistically at par with Treatment 5 [*Azospirillum* 45 g/kg + Nano urea 3 ml/l).

Significant and maximum stover yield was observed with the application of Nano urea 3 ml/l, The similar results were Samanta *et al*., (2022) [4].

Table 1: Influence of biofertilizer and nano urea on growth attributes of sorghum

Sr. No.	Treatment combinations	Plant height (cm)	Plant dry weight (g)
1.	*Azotobacter* 20 g/kg + Nano urea 2 ml/l	121.97	43.39
2.	*Azotobacter* 20 g/kg + Nano urea 3 ml/l	126.84	42.27
3.	*Azotobacter* 20 g/kg + Nano urea 4 ml/l	132.3	44.43
4.	*Azospirillum* 45 g/kg + Nano urea 2 ml/l	130.80	42.33
5.	*Azospirillum* 45 g/kg + Nano urea 3 ml/l	132.5	46.65
6.	*Azospirillum* 45 g/kg + Nano urea 4 ml/l	117.50	45.41
7.	*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l	122.65	43.64
8.	*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l	114.08	44.53
9.	*Azotobacter* + *Azospirillum* + Nano urea 4 ml/l	120.85	43.09
10.	Control (N:P:K 80:40:40 kg/ha)	116.16	34.12
	F Test	S	S
	SEm (±)	4.64	1.09
	CD (p=0.05)	13.77	3.23

Table 5: Influence of biofertilizer and nano urea on Yield and yield attributes of sorghum

Sr. No.	Treatment combinations	Length of Ear/Plant (cm)	Test Weight (g)	Seed Yield (t/ha)	Stover Yield (t/ha)
1.	*Azotobacter* 20 g/kg + Nano urea 2 ml/l	23.94	25.89	1.73	5.02
2.	*Azotobacter* 20 g/kg + Nano urea 3 ml/l	24.19	25.61	1.82	5.10
3.	*Azotobacter* 20 g/kg + Nano urea 4 ml/l	25.28	24.87	1.89	5.27
4.	*Azospirillum* 45 g/kg + Nano urea 2 ml/l	23.47	24.01	1.86	5.43
5.	*Azospirillum* 45 g/kg + Nano urea 3 ml/l	26.75	26.40	2.30	6.18
6.	*Azospirillum* 45 g/kg + Nano urea 4 ml/l	25.57	24.44	1.98	5.94
7.	*Azotobacter* + *Azospirillum* + Nano urea 2 ml/l	25.92	25.57	1.95	5.95
8.	*Azotobacter* + *Azospirillum* + Nano urea 3 ml/l	26.51	25.30	2.01	6.00
9.	*Azotobacter* + *Azospirillum* + Nano urea 4 ml/l	25.37	25.12	1.81	6.03
10.	Control (N:P:K 80:40:40 kg/ha)	22.02	23.75	1.25	4.94
	F Test	NS	NS	S	S
	SEm (±)	0.94	26.65	0.15	0.21
	CD (p=0.05)	-	-	0.46	0.63

5. Conclusion
It is concluded that in sorghum with the foliar application of nano urea (3 ml/l) along with *Azospirillum* 45 g/kg seed (Treatment 5), was recorded with higher yield attributes and benefit-cost ratio.

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