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IMPACT OF BIOGAS SLURRY AND IRON SULPHATE ON GROWTH, PRODUCTIVITY AND ECONOMICS OF PEARL MILLET (*PENNISETUM GLAUCUM* L. R. BR.)

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ABSTRACT

A field experiment was conducted at the Agronomy Farm, Shri Karan Narendra College of Agriculture, Jobner during *kharif* season, 2022-23. The experiment was replicated three times under factorial randomized block design. The experiment consists of four levels of biogas slurry (control, 2.5-, 5- and 7.5-ton ha^{-1} biogas slurry) and four treatment of iron sulphate (Control, 7.5 Kg ha^{-1}, 7.5 Kg ha^{-1} + 0.5 % foliar spray, 15 Kg ha^{-1} and 22.5 Kg ha^{-1} iron sulphate). Pearl millet variety RHB-223 was considered for the experiment. Application of 5-ton ha^{-1} biogas slurry significantly increased plant height (179.24 cm), chlorophyll content (2.45 mg g^{-1}), test weight (9.64 g), seed (2955 Kg ha^{-1}) and stover (5428 Kg ha^{-1}) yields of pearl millet as well as net return (78586 ₨ ha^{-1}) and B: C ratio (3.51) over control. Results further indicated that 7.5 Kg ha^{-1} ha iron sulphate soil application + 0.5 per cent foliar spray significantly increased the plant height (180.7 cm), chlorophyll content (2.46 mg g^{-1}), test weight (9.76 g), seed yield (2856 Kg ha^{-1}) and stover yield (5393 Kg ha^{-1}) as well as net return (74349 ₨ ha^{-1}) and B:C ratio (3.45) in comparison to control.

***Keywords* :** Biogas Slurry, iron sulphate, pearl millet, productivity, yield.

Introduction

Pearl millet, often referred to as "poor man's food," is primarily cultivated in semi-arid and arid regions. This resilient crop is known for its drought tolerance and efficient water utilization during periods of water scarcity. The grains of pearl millet can be processed into a variety of food products and are recognized as "nutri-cereals" due to their rich nutritional profile, including high levels of protein, fiber, minerals, fatty acids and antioxidants. These characteristics make pearl millet an excellent alternative for individuals with celiac disease or gluten sensitivity (Annor *et al.*, 2015). Additionally, the chemical composition of millet grains may offer various health benefits, such as reducing oxidative stress.

In 2021, India emerged as the leading producer of pearl millet globally, contributing 10.86 million tons, with a productivity rate of 1436 kg per ha across 7.57 m ha. Major states involved in pearl millet cultivation include Maharashtra, Haryana, Rajasthan, Gujarat, and the arid regions of Uttar Pradesh. Specifically, Rajasthan reported a production of 4.53 m tons in 2021, with a productivity of 1049 kg per ha over an area of 4.32 m ha (Anonymous, 2018).

Organic manures serve as a natural and eco-friendly alternative to synthetic fertilizers. Sourced from organic materials such as plant residues and animal waste, these manures have been utilized for centuries to boost soil fertility, increase crop yields, and foster sustainable agricultural practices. Manures rich in NPK nutrients can be particularly beneficial in intensive farming systems. Biogas slurry, a byproduct from the anaerobic digestion of cattle dung and agricultural waste, contains approximately 93% water and 7% dry matter, with the latter comprising 4.5% organic matter and 2.5% inorganic matter (Dadhich and Somani, 2018). This slurry provides around 1.5% nitrogen, 1% P_2O_5, and 1.5% K_2O, along with essential micronutrients. Its slow-release nutrient mechanism ensures a continuous supply of nutrients to plants, minimizing the risk of nutrient leaching and environmental runoff. By enhancing soil fertility and promoting natural nutrient cycling, organic manures contribute to sustainable agricultural practices that prioritize long-term soil health and reduce ecological harm (Garg *et al*., 2005).

Iron is a vital micronutrient necessary for nearly all living organisms due to its crucial involvement in various metabolic processes, including DNA synthesis, respiration, and photosynthesis. It activates numerous metabolic pathways and is a key component of many enzymes. In plants, iron is essential for several physiological and biochemical functions, notably as part of critical enzymes like cytochromes in the electron transport chain. It also plays a key role in chlorophyll synthesis and is necessary for maintaining the structure and function of chloroplasts.

Iron chlorosis primarily arises from a mismatch between the solubility of iron in the soil and the plant's iron requirements. While iron is generally abundant in well-aerated soils, its bioavailability is low due to the formation of insoluble ferric compounds at neutral pH. To address these issues, an experiment was carried out to evaluate the productivity and economic viability of pearl millet during the *kharif season* of 2022-2023 in Jobner, Rajasthan.

Materials and Methods

The experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan), during *kharif* 2022. Geographically, Jobner is situated 45 km west of Jaipur at $26^0 06'$ north latitude and $75^0 28'$ east longitudes at an altitude of 427 m above mean sea msl. This region falls under agro-climatic zone III A (Semi-Arid Eastern Plain) of Rajasthan. The maximum and minimum temperatures during the experiment crop season ranged between 30.2 ^oC to 35.2 ^oC and 16.8 ^oC to 23 ^oC, respectively. A total of 311.7 mm rainfall was recorded during the cropping season. The relative humidity fluctuated between 42% to 70%, while the average sunshine hours ranged between 2.9 to 9.1 hrs day^{-1}. The soil of the experimental field was loamy sandy in texture i.e bulk density (1.53 Mg m^{-3}), alkaline in reaction (pH 8.15), EC (0.36 dSm^{-1})poor in organic carbon (0.21 %) with low available nitrogen (135.2 kg/ha), medium available phosphorus (21.35 kg/ha), potassium (219 kg/ha), sulphur concentration (8.1 ppm), DTPA- Fe (4.21 ppm), DTPA-Mn (6.62ppm), DTPA-Zn (1.25 ppm), DTPA-Cu (3.8 ppm).

The experiment consisting of four levels of biogas slurry (control, 2.5, 5 and 7.5 ton ha^{-1} biogas slurry) and four treatments of iron sulphate (Control, 7.5 Kg ha^{-1}, 7.5 Kg ha^{-1} + 0.5 % foliar spray, 15 Kg ha^{-1} and 22.5 Kg ha^{-1} iron sulphate), total 20 treatment combinations was laid out in factorial randomized block design and replicated thrice. Pearl millet variety RHB-223 was taken as a test crop. Seed rate was 4 Kg ha^{-1} with a spacing of 45 x 10 cm row to row and plant to plant respectively. Before sowing biogas slurry was added according to the treatment level (0, 2.5, 5 and 7.5 ton ha^{-1}) in assigned plot and incorporated into soil manually. According to the treatment details, basal application of iron sulphate was done through $FeSO_4.7H_2O$ (0, 7.5, 15 and 22.5 Kg $FeSO_4.7H_2O$ ha^{-1}) at the time of sowing and @ 0.5 % $FeSO_4$ was applied as foliar spray at 45 DAS as per treatments. Regularly biometric observations were recorded at specific time intervals by selecting randomly five plants in each treatment. Finally, the crop was harvested and produce was dried, threshed, cleaned and weighed. The growth and yield data were collected at harvest which were subjected to statistical analysis using ANOVA and the significance was determined by using Fisher's least significance difference (p = 0.05%).

Results and Discussion

Yield and yield attributes *viz.,* plant height, chlorophyll content, test weight, seed and stover yields significantly increased with the application of 7.5 ton/ha biogas slurry followed by 5 ton/ha biogas slurry. The result showed that application of 5 ton ha^{-1} biogas slurry demonstrated higher plant height (179.24 cm), chlorophyll content (2.45 mg g^{-1} leaf), test weight (9.98 g), seed yield (2956 Kg ha^{-1}) and stover yield (5428 Kg ha^{-1}) of pearl millet. The gradual release and steady supply of nutrients from biogas slurry throughout the growth and development of plants maintained the photosynthetic efficiency and production of metabolites at higher level and later on the translocation of photosynthates to various sinks resulting into higher seed and stover yields of pearl millet. Further Biogas slurry improved crop yields by increasing soil nutrient availability, improving soil structure and increasing soil water holding capacity. Similar findings were also reported by Malav *et al.* (2015); Nasir *et al.* (2015); Haque *et al.* (2018) and Hossain *et al.* (2019).

Table 1 : Effect on plant height, tiller per plant and chlorophyll content of pearl millet

Treatment	Plant height (cm)	Tiller plant^{-1}	Chlorophyll content (mg g^{-1} leaf)
Biogas slurry			
Control	143.72	2.23	2.21
Biogas slurry @ 2.5 ton ha^{-1}	168.71	2.29	2.37
Biogas slurry @ 5.0 ton ha^{-1}	179.24	2.33	2.45
Biogas slurry @ 7.5 ton ha^{-1}	186.68	2.39	2.51
SEm+	3.14	0.04	0.04
C.D. (P=0.05)	8.99	NS	0.11
Iron sulphate			
Control	154.41	2.27	2.26
$FeSO_4$ @ 7.5 Kg ha^{-1}	162.41	2.29	2.36
$FeSO_4$ @ 7.5 Kg ha^{-1}+ 0.5% $FeSO_4$ Foliar spray	174.08	2.32	2.42
$FeSO_4$ @ 15 Kg ha^{-1}	176.30	2.34	2.43
$FeSO_4$ @ 22.5 Kg ha^{-1}	180.73	2.34	2.46
SEm+	3.51	0.05	0.04
C.D. (P=0.05)	10.05	NS	0.12

Table 2 : Effect on test weight, seed yield and stover yield of pearl millet

Treatment	Test weight (g)	Seed yield (Kg ha^{-1})	Stover yield (kg ha^{-1})
Biogas slurry			
Control	7.67	2229	4364
Biogas slurry @ 2.5 ton ha^{-1}	9.33	2654	4998
Biogas slurry @ 5.0 ton ha^{-1}	9.64	2956	5428
Biogas slurry @ 7.5 ton ha^{-1}	9.98	3019	5655
SEm+	0.17	52	88
C.D. (P=0.05)	0.49	149	253
Iron sulphate			
Control	8.23	2442	4700
$FeSO_4$ @ 7.5 Kg ha^{-1}	8.97	2658	5000
$FeSO_4$ @ 7.5 Kg ha^{-1}+ 0.5% $FeSO_4$ foliar spray	9.39	2802	5203
$FeSO_4$ @ 15 Kg ha^{-1}	9.43	2812	5262
$FeSO_4$ @ 22.5 Kg ha^{-1}	9.76	2856	5393
SEm+	0.19	58	99
C.D. (P=0.05)	0.55	166	283

Table 3 : Effect on economics of pearl millet

Treatment	**Economics**			
	Total cost (Rs/ha)	**Gross return (Rs/ha)**	**Net return (Rs/ha)**	**B: C ratio**
Biogas slurry				
Control	26340	85066	58726	3.23
Biogas slurry @ 2.5 ton ha^{-1}	28840	99690	70851	3.46
Biogas slurry @ 5.0 ton ha^{-1}	31340	109926	78586	3.51
Biogas slurry @ 7.5 ton ha^{-1}	33840	113159	79319	3.34
SEm+	--	--	1449	0.05
CD (P=0.05)	--	--	4148	0.14
Iron sulphate				
Control	29750	92548	62798	3.10
$FeSO_4$ @ 7.5 Kg ha^{-1}	29938	99809	69872	3.33
$FeSO_4$ @ 7.5 Kg ha^{-1} + 0.5% $FeSO_4$ foliar spray	30324	104672	74349	3.45
$FeSO_4$ @ 15 Kg ha^{-1}	30125	105373	75248	3.50
$FeSO_4$ @ 22.5 Kg ha^{-1}	30313	107398	77086	3.54
SEm+	--	--	1620	0.05
CD (P=0.05)	--	--	4638	0.16

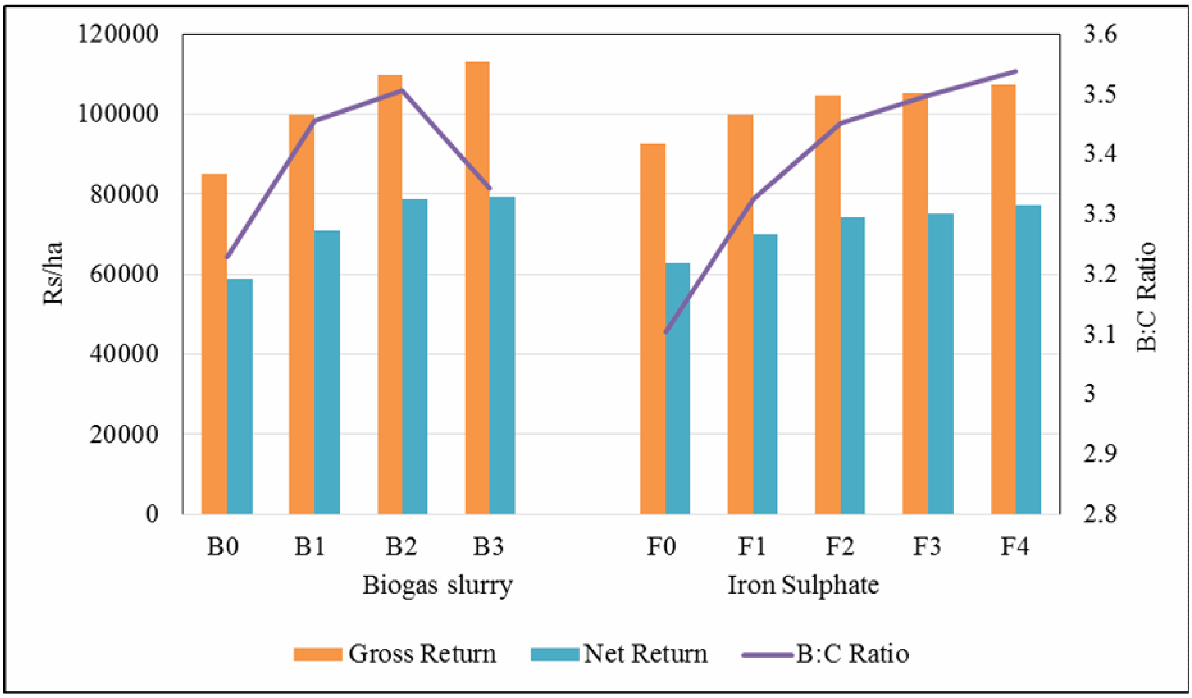

Fig. 1 : Diagrammatic representation of economics as affected by application of biogas slurry and iron sulphate

In case of iron sulphate application, $FeSO_4$ @ 7.5 Kg ha^{-1} 7.5 Kg ha^{-1} soil application + 0.5 per cent foliar spray significantly increased the plant height (180.7 cm), chlorophyll content (2.46 mg g^{-1}), test weight (9.76 g), seed yield (2856 Kg ha^{-1}) and stover yield (5393 Kg ha^{-1}) yields of pearl millet. The favourable influence of applied iron on these characters might be due to its catalytic effect on most of the physiological and metabolic processes of plant. Iron is involved in the formation of chlorophyll and plays a somewhat similar role to Mg in the porphyrin structure of chlorophyll. Fe is also a constituent of large number of metabolically active compound like cytochromes, haeme and non-haeme enzymes and other functional metallo-proteins such as ferredoxin and hemoglobin. Further, iron also plays an important role in Zn, Cu, Mg and Mn metabolism. The application of iron as iron deficient soil, improved overall growth and development of plants, plant heigh and ultimately seed and stover yields of pearl millet increased. The findings of present investigation are supported by Singh *et al.* (2001), Abbas *et al.* (2009), Ghulam *et al.* (2012), Memon *et al.* (2013), Naga *et al.* (2015), Ortas, *et al.* (2015), Radder and Husen (2017) and Janmohammadi *et al*. (2018).

Among all the biogas slurry treatments, the higher net return and B-C ratio was obtained with the application of 5 ton ha^{-1} biogas slurry (Rs.78586 ha^{-1} and 3.51 respectively). This indicates that, while the initial investment for a higher rate of biogas slurry application may be greater, the corresponding increase in yield leads to significantly better financial returns, making it the most cost-effective strategy for optimizing both productivity and profitability in pearl millet cultivation.

Meanwhile, among Iron sulphate treatments, higher net return and B-C ratio of pearl millet was recorded with 7.5 Kg ha^{-1} iron sulphate + 0.5 % iron sulphate foliar spray (Rs. 74349 ha^{-1} and 3.45 respectively) in comparison with other treatments. Higher net returns were observed with increased rates of iron sulphate application, reflecting the positive impact on crop yield and quality. Furthermore, the B:C analysis revealed that the investment in iron sulphate application was economically beneficial, providing a favourable return on investment, thereby justifying its use as a cost-effective practice for optimizing crop productivity.

Conclusion

Application of biogas slurry 5 ton ha^{-1} and 7.5 Kg ha^{-1} iron sulphate soil application + 0.5 per cent iron sulphate foliar spray are suitable doses for enhancing growth and productivity of pearl millet making it more desirable and profitable for farmers.

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