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Response of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] to crop residue and nutrient management

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Abstract

A field experiment was conducted at Agronomy farm of Suresh Gyan Vihar University, Jaipur (Rajasthan) during *kharif*, 2024 on loamy sand soil, which consisted four treatments of residue management (Control, Residue incorporation, Residue incorporation and application of urea 25 kg/ha, Residue incorporation and application of urea @ 25 kg/ha + cellulolytic microbes @ 2.0 kg/ha) and four treatments of nutrient management (Control, 75% RDF, 100% RDF and 125% RDF) thereby making sixteen treatment combinations were tested in factorial randomized block design with three replications. Recommended dose of fertilizer for pearl millet was 60 kg N and 30 kg P₂O₅/ha.

Results further indicated that residue management with residue incorporation and application of urea @ 25 kg/ha + cellulolytic microbes @ 2.0 kg/ha remained at par with residue incorporation and application of urea @ 25 kg/ha and recorded significantly higher plant height, dry matter accumulation, number of total and effective tillers/plant, ear length, grain yield, stover yield and biological yield, compared to control and residue incorporation.

Results clearly showed that application of 100% RDF remained statistically at par with 125% RDF and observed significantly higher plant height, dry matter accumulation, number of total and effective tillers/plant, ear length, test weight, grain yield, stover yield and biological yield over control and 75% RDF.

Keywords: Growth, nutrient, pearl millet, residue and yield

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] is one of the most important climate-resilient cereal crops cultivated in the arid and semi-arid regions of Asia and Africa. It is valued for its tolerance to drought, high temperature and poor soil fertility, and serves as a major source of food, feed and fodder for millions of people. Pearl millet grains are rich in carbohydrates, proteins, minerals, vitamins and dietary fibre, making the crop an important component of nutritional security. In India, Rajasthan is the leading pearl millet producing state, contributing substantially to the total area and production.

The sustainability of pearl millet production is increasingly threatened by declining soil fertility, low organic carbon content and imbalanced nutrient application resulting from continuous cultivation and excessive dependence on inorganic fertilizers. Long-term studies have shown that integrated use of organic and inorganic nutrient sources improves soil organic carbon, microbial activity and productivity of pearl millet-based cropping systems (Kumari *et al.*, 2024; Sheoran *et al.*, 2024) ^[5, 7]. Integrated nutrient management has emerged as an efficient approach for maintaining soil fertility, improving nutrient use efficiency and ensuring sustainable crop productivity (Tomar *et al.*, 2023; Deepshikha *et al.*, 2024) ^[8, 21].

Crop residues represent an important source of organic matter and plant nutrients. Their incorporation into soil improves aggregation, moisture retention, microbial activity and nutrient cycling. Residue recycling also enhances water use efficiency and yield stability under rainfed conditions (Yogi *et al.*, 2023) ^[9]. However, the high C:N ratio of residues often leads to temporary nitrogen immobilization during decomposition. Supplementation with nitrogen and cellulolytic microorganisms accelerates residue breakdown and facilitates nutrient release, thereby improving soil health and crop growth. Crop residue application has been reported to significantly enhance productivity and nutrient biofortification in pearl millet under conservation agriculture (Yogi *et al.*, 2023) ^[9]. Similarly, residue recycling practices have improved soil microbial activity and

yield stability across diverse agro-ecological regions (Bana *et al.*, 2023) ^[1].

Balanced nutrient management is indispensable for achieving higher productivity of pearl millet. Application of recommended doses of fertilizers in conjunction with organic inputs has been found to improve growth attributes, yield components and nutrient uptake (Tomar *et al.*, 2023; Saini *et al.*, 2024) ^[8,6]. Recent studies have further indicated that integrated nutrient management practices significantly enhance grain and stover yields of pearl millet while maintaining soil fertility and productivity in the long term (Deepshikha *et al.*, 2024; Sheoranet *et al.*, 2024) ^[2,7].

Although considerable information is available on the individual effects of crop residue management and nutrient application, studies on their combined influence under the loamy sand soils of Rajasthan are limited. Therefore, the present investigation entitled “Response of Pearl Millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] to Crop Residue and Nutrient Management” was undertaken to evaluate the effect of crop residue incorporation and different nutrient levels on the growth, yield and productivity of pearl millet under semi-arid conditions.

Materials and Methods

The field experiment entitled “Response of Pearl Millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] to Crop Residue and Nutrient Management” was conducted during the *kharif* season of 2024 at the Agricultural Research Farm of Suresh Gyan Vihar University, Jaipur (Rajasthan), on loamy sand soil. The study was laid out in a factorial randomized block design comprising combinations of soil moisture conservation practices and integrated nutrient management. The experiment consisted sixteen treatments viz., two factors with where four levels of residue management (Control, Residue incorporation, Residue incorporation and application of urea 25 kg/ha, Residue incorporation and application of urea @ 25 kg/ha + cellulolytic microbes @ 2.0 kg/ha) and four treatments of nutrient management (Control, 75% RDF, 100% RDF and 125% RDF). The pearl millet variety used for study was “RHB-233”. The experimental farm is located in the south-eastern part of Rajasthan at an elevation of 548 m above mean sea level, between 26°92' N latitude and 75°77' E longitude, and falls under agro-climatic zone III-A (Semi-Arid Eastern Plain) of Rajasthan. The region experiences a typical semi-arid climate, characterized by wide variations in temperature during summer and winter seasons. The average annual rainfall of Jaipur ranges from 400 to 450 mm, of which nearly 80-85 per cent is received through the south-west monsoon, mainly from July to early September. During the cropping period, the maximum temperature varied from 31.41 to 38.71 °C, while the minimum temperature ranged between 20.71 and 27.85 °C. The relative humidity fluctuated up to 91 per cent during the season. Average daily sunshine hours ranged from 0.68 to 5.01 hours, whereas wind velocity varied between 0.88 and 2.82 km/h. The recorded observations were statistically analyzed using standard procedures as described by Fisher (1950) ^[3].

Results and Discussion

Plant height of pearl millet was significantly influenced by residue and nutrient management (Table 1). Among residue management treatments, residue incorporation along with urea @ 25 kg N/ha and cellulolytic microbes @ 2.0 kg/ha (R₃) recorded the maximum plant height (164.40 cm), which remained statistically at par with residue incorporation along with urea @ 25 kg N/ha (R₂; 158.90 cm) and significantly surpassed residue incorporation alone (R₁; 143.47 cm) and control (R₀; 127.73 cm).

The improvement in plant height under R₃ may be attributed to enhanced decomposition of crop residues, increased nutrient availability and improved soil microbial activity resulting from the combined application of urea and cellulolytic microbes.

Similarly, nutrient management exerted a significant influence on plant height. Application of 125% RDF (N₃) recorded the highest plant height (165.07 cm), which was statistically at par with 100% RDF (N₂; 159.82 cm) and significantly superior to 75% RDF (N₁; 146.93 cm) and control (N₀; 126.39 cm). Enhanced vegetative growth under higher fertility levels might be due to adequate nutrient supply, which promoted cell division, photosynthetic activity and dry matter production. Similar findings have been reported by Tomar *et al.* (2023) ^[8], Deepshikha *et al.* (2024) ^[2], Saini *et al.* (2024) ^[6] Sheoranet *et al.* (2024) ^[7] and Suthar *et al.* (2026) ^[4].

Residue management significantly influenced grain, stover and biological yield of pearl millet (Table 2). The highest grain yield (2376 kg/ha), stover yield (5177 kg/ha) and biological yield (7553 kg/ha) were recorded under residue incorporation along with urea @ 25 kg N/ha and cellulolytic microbes @ 2.0 kg/ha (R₃), which remained statistically at par with residue incorporation plus urea @ 25 kg N/ha (R₂) and significantly outperformed residue incorporation alone (R₁) and control (R₀). The increase in yield under residue-based treatments may be ascribed to improved nutrient release, enhanced soil physical properties, better moisture conservation and increased microbial activity, which ultimately resulted in higher photosynthate accumulation and translocation to sink. Similar observations were reported by Bana *et al.* (2023) ^[1], Yogi *et al.* (2023) ^[9] and Kumari *et al.* (2024) ^[5].

Among nutrient management treatments, application of 125% RDF (N₃) produced the highest grain yield (2354 kg/ha), stover yield (5219 kg/ha) and biological yield (7573 kg/ha), which remained statistically at par with 100% RDF (N₂) and significantly exceeded control and 75% RDF. Higher productivity under adequate nutrient supply might be attributed to increased nutrient uptake, efficient photosynthesis and better partitioning of assimilates. Similar results have been documented by Tomar *et al.* (2023) ^[8], Saini *et al.* (2024) ^[6], Deepshikha *et al.* (2024) ^[2] and Sheoranet *et al.* (2024) ^[7].

Harvest index was not significantly affected by either residue management or nutrient management, indicating that the increase in grain yield was proportionate to the increase in total biomass production.

Interaction effect of residue and nutrient management

The interaction effect between residue management and nutrient management significantly influenced grain yield (Table 2a). The highest grain yield (2743 kg/ha) was obtained with residue incorporation coupled with urea @ 25 kg N/ha and cellulolytic microbes @ 2.0 kg/ha along with 125% RDF (R₃N₃), which remained statistically at par with R₃N₂ (2654 kg/ha) and R₂N₃ (2720 kg/ha). The lowest grain yield (962 kg/ha) was observed under control treatment (R₀N₀). The superior performance of these combinations could be attributed to synchronized nutrient release from residues and fertilizers, enhanced nutrient use efficiency and favourable soil biological conditions. Similar findings were reported by Bana *et al.* (2023) ^[1] and Yogi *et al.* (2023) ^[9].

A significant interaction effect was observed for stover yield (Table 2b). The maximum stover yield (5762 kg/ha) was recorded under R₃N₃, followed closely by R₃N₂ (5696 kg/ha), whereas the minimum stover yield (2705 kg/ha) was obtained under R₀N₀. Improved nutrient availability and better vegetative growth under integrated residue and nutrient management treatments resulted in

greater biomass accumulation and stover production. Biological yield was significantly affected by the interaction between residue and nutrient management (Table 2c). The highest biological yield (8482 kg/ha) was recorded under residue incorporation + urea @ 25 kg N/ha + cellulolytic microbes @ 2.0 kg/ha along with 125% RDF (R_3N_3), which remained comparable with R_3N_2 (8351 kg/ha) and R_2N_3 (8218 kg/ha). The lowest

biological yield (3668 kg/ha) was obtained under R_0N_0 . The increased biological yield under integrated treatments might be attributed to improved soil fertility, enhanced nutrient availability and efficient utilization of resources. Similar findings have been reported by Kumari *et al.* (2024) ^[5], Sheoran *et al.* (2024) ^[7] and Saini *et al.* (2024) ^[6].

Table 1: Effect of residue and nutrient management on growth attributes of pearl millet at harvest

Treatments	Growth attributes		
	Plant height (cm)	Dry matter (g/m ²)	Tillers/plant
Residue Management			
R ₀ : Control	127.73	116.81	3.44
R ₁ : Residue incorporation	143.47	138.35	3.93
R ₂ : Residue incorporation and application of urea 25 kg/ha	158.9	155.51	4.27
R ₃ : Residue incorporation and application of urea @ 25 kgN/ha + cellulolytic microbes @ 2.0 kg/ha	164.4	162.99	4.31
SEm(±)	3.5	3.34	0.11
CD (P=0.05)	10.11	9.65	0.31
Nutrient Management			
N ₀ : Control	126.39	117.8	3.46
R ₁ : 75% RDF	146.93	141.2	3.95
N ₂ : 100% RDF	159.82	155.09	4.27
N ₃ : 125% RDF	165.07	164.17	4.35
S.Em(±)	3.5	3.34	0.11
CD (P=0.05)	10.11	9.65	0.31
CV (%)	9.03	8.76	7.98

Table 2: Effect of residue and nutrient management on yields and harvest index of pearl millet

Treatments	Yield (kg/ha)			Harvest index (%)
	Grain	Stover	Biological	
Residue Management				
R ₀ : Control	1592	3886	5478	29.12
R ₁ : Residue incorporation	1893	4473	6366	29.83
R ₂ : Residue incorporation and application of urea 25 kg/ha	2310	4932	7242	31.85
R ₃ : Residue incorporation and application of urea @ 25 kgN/ha + cellulolytic microbes @ 2.0 kg/ha	2376	5177	7553	31.36
SEm(±)	48	104	141	0.81
CD (P=0.05)	140	300	407	NS
Nutrient Management				
N ₀ : Control	1508	3620	5128	29.22
R ₁ : 75% RDF	2085	4678	6763	30.72
N ₂ : 100% RDF	2303	5083	7386	31.23
N ₃ : 125% RDF	2354	5219	7573	31.18
SEm(±)	48	104	141	0.95
CD (P=0.05)	140	300	407	NS
CV (%)	8.67	8.87	9.65	8.03

Table 2a: Interaction effect of residue management and nutrient management on grain yield of pearl millet

Nutrient management	Grain yield (kg/ha)			
	Residue management			
	Control	Residue incorporation	Resi. incorporation and urea @ 25 kg/ha	Resi. incorporation + urea @ 25 kg/ha + Cell. microbes @ 2.0 kg/ha
Control	962	1356	1777	1926
75% RDF	1648	1980	2176	2527
100% RDF	1907	2113	2589	2654
125% RDF	1897	2167	2720	2743
S.Em.±	97			
CD at 5%	280			

Table 2b: Interaction effect of residue management and nutrient management on stover yield of pearl millet

Nutrient management	Stover yield (kg/ha)			
	Residue management			
	Control	Residue incorporation	Resi. incorporation and urea @ 25 kg/ha	Resi. incorporation + urea @ 25 kg/ha + Cell. microbes @ 2.0 kg/ha
Control	2705	3294	4105	4376
75% RDF	3999	4518	4794	5401
100% RDF	4254	5028	5353	5696
125% RDF	4585	5054	5475	5762
S.Em.±	208			
CD at 5%	600			

Table 2c: Interaction effect of residue management and nutrient management on biological yield of pearl millet

Nutrient management	Biological yield (kg/ha)			
	Residue management			
	Control	Residue incorporation	Resi. incorporation and urea @ 25 kg/ha	Resi. incorporation + urea @ 25 kg/ha + Cell. microbes @ 2.0 kg/ha
Control	3668	4651	5882	6302
75% RDF	5647	6497	6970	7928
100% RDF	6161	7141	7942	8351
125% RDF	6482	7221	8218	8482
S.Em.±	282			
CD at 5%	814			

Conclusion

Based on the results of the present investigation, residue incorporation supplemented with urea @ 25 kg N/ha and cellulolytic microbes @ 2.0 kg/ha significantly improved the growth and productivity of pearl millet. Application of 100% RDF remained statistically at par with 125% RDF and recorded higher plant height, grain yield, stover yield and biological yield. Thus, integration of crop residue management with 100% RDF proved to be an efficient and sustainable approach for enhancing pearl millet productivity under loamy sand soils of Rajasthan.

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