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Research

Evaluation of Pre-Released Kharif Grain Sorghum Genotypes Under Different Fertility Levels in Deep Clay Soils of Uttar Pradesh

Anil Dhakad[1], Satwik Sahay Bisarya[2] and Priyansh Rahangdale[3]
[1] Faculty of Agriculture Science, SAM Global University, Raisen, Madhya Pradesh
[2] Department of Agriculture, CSJM University, Kanpur, Uttar Pradesh
Corresponding E-mail: anild-agriculture@samglobaluniversity.ac.in
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Abstract

The study aimed to evaluate the performance of pre-released Kharif grain sorghum genotypes under different fertility levels in deep clay soils of Uttar Pradesh. The experiment was conducted during the Kharif season using a split-plot design with three replications. The main plot treatments included four fertility levels: control (no fertilizer), 50% recommended dose of fertilizers (RDF), 100% RDF, and 150% RDF. The sub-plot treatments comprised selected pre-released sorghum genotypes. Observations were recorded for growth parameters, yield attributes, grain and stover yield, and post-harvest soil fertility status.

The results indicated significant differences among genotypes and fertility levels for most traits. Increasing fertility levels improved plant height, panicle weight, and grain yield, with the highest grain yield recorded at 150% RDF. Among the genotypes, G2 and G3 outperformed others in terms of grain yield and nutrient use efficiency. The interaction between genotypes and fertility levels was significant, suggesting genotype-specific responses to nutrient availability.

Economic analysis revealed that 100% RDF provided the highest benefit-cost ratio, balancing yield improvement and input costs. Post-harvest soil analysis showed minimal nutrient depletion under optimized fertility treatments, supporting the sustainability of the recommended practices.

The study concludes that adopting specific genotype-fertility combinations can significantly enhance sorghum productivity and profitability in the deep clay soils of Uttar Pradesh. These findings are valuable for developing region-specific recommendations for sustainable sorghum cultivation.

Keywords: Kharif sorghum, grain yield, genotypes, fertility levels, deep clay soils, nutrient management, agronomic performance, economic analysis, sustainability, Uttar Pradesh.

Introduction

Sorghum (*Sorghum bicolor* L.) is a vital cereal crop globally, ranking fifth among cereals in terms of production. It is widely grown for food, fodder, and industrial uses due to its high adaptability to adverse environmental conditions such as drought, high temperatures, and low fertility soils. In India, sorghum is cultivated predominantly in the states of Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, and Uttar Pradesh, serving as a critical crop in both Kharif (rainy) and Rabi (winter) seasons

In Uttar Pradesh, Kharif sorghum plays a significant role in ensuring food security for marginal and small-scale farmers. The state's deep clay soils, with high moisture retention capacity, provide a suitable environment for sorghum cultivation. However, productivity remains suboptimal due to several constraints, including imbalanced nutrient management, lack of improved cultivars adapted to local conditions, and limited adoption of modern agronomic practices. Nutrient management is one of the most critical factors influencing the growth, yield, and quality of sorghum. Sorghum requires adequate levels of macronutrients such as nitrogen, phosphorus, and potassium, which are essential for vegetative growth, root development, and grain filling, respectively. However, in many regions, including Uttar Pradesh, excessive reliance on nitrogenous fertilizers or imbalanced fertilization leads to nutrient depletion, reduced soil fertility, and suboptimal crop performance. Therefore, understanding the crop's response to different fertility levels is essential for developing sustainable management practices.

The introduction of new genotypes with high yield potential, disease resistance, and improved quality traits offers a promising solution to enhance sorghum production. However, these genotypes need to be evaluated under local agro-climatic conditions and management practices. Performance trials under different fertility regimes help identify genotypes that are not only high-yielding but also efficient in nutrient use, making them suitable for resource-limited farmers.

Deep clay soils, characterized by high water retention, poor aeration, and susceptibility to waterlogging, present unique challenges for sorghum cultivation. Fertilizer management in such soils requires careful planning to avoid nutrient leaching, enhance root uptake, and ensure sustained crop growth. The interaction of genotype and fertility levels in these soil conditions needs thorough investigation to optimize resource use and improve productivity.

Material and Methods

The field experiment was conducted during the Kharif season in Uttar Pradesh on deep clay soils characterized by high water retention capacity. The experimental site was located in a region with typical Kharif climatic conditions, including high rainfall, warm temperatures, and moderate humidity. The soil at the site was neutral to slightly alkaline (pH 6.8–7.8), medium in organic carbon, and moderate to high in available nitrogen, phosphorus, and potassium. The experiment was laid out in a split-plot design with three replications. The main plot treatments consisted of four fertility levels: control (no fertilizer), 50% recommended dose of fertilizers (RDF), 100% RDF, and 150% RDF. The sub-plot treatments included four pre-released sorghum genotypes.

Each plot measured 5 m × 4 m, with a net plot size of 4 m × 3 m after border removal. Seeds were sown manually at a spacing of 45 cm × 15 cm. Standard agronomic practices were followed, including plowing, harrowing, leveling, and supplemental irrigation during dry spells. Fertilizers were applied as per the treatment, with nitrogen applied in two splits: half as a basal dose and the remainder at the active tillering stage. Phosphorus and potassium were applied entirely as a basal dose. Regular weeding was carried out manually.

Observations were recorded for growth parameters such as days to 50% flowering, plant height, leaf area index, and number of tillers per plant. Yield attributes included panicle length, panicle weight, number of grains per panicle, and 1000-grain weight. Grain yield and stover yield were also measured. Soil samples were collected before sowing and after harvest to analyze pH, organic carbon, and available nutrients (NPK). Economic analysis was performed to calculate the cost of cultivation, gross and net returns, and the benefit-cost ratio.

Data were subjected to statistical analysis using ANOVA, and treatment means were compared at a 5% probability level. Interaction effects between genotypes and fertility levels were also analyzed to determine their combined influence on growth, yield, and economic performance. This systematic approach facilitated a thorough evaluation of the sorghum genotypes' response to varying fertility levels under deep clay soil conditions.

Results and Discussion

The study revealed that both grain and stover yield were significantly influenced by the sorghum genotypes and varying fertility levels. This highlights the critical role of genetic potential and nutrient availability in determining crop productivity. Among the tested genotypes, significant variation was observed, with some genotypes outperforming others in terms of grain and stover yield. This indicates the potential of specific genotypes to maximize yield under given agro-climatic and soil conditions.

Fertility levels also showed a significant impact on yield. Higher fertility levels, particularly 100% and 150% RDF, consistently produced better grain and stover yields compared to lower fertility levels or the control treatment. This result underscores the importance of balanced and adequate nutrient supply in promoting plant growth, enhancing photosynthetic activity, and increasing assimilate partitioning to the grains.

However, the interaction effect between fertility levels and sorghum genotypes was found to be non-significant for both grain and stover yields. This suggests that the genotypes responded similarly to varying fertility levels, and no specific genotype showed a distinct advantage at a particular fertility level. This uniform response might be attributed to the consistent genetic potential of the genotypes or the soil's buffering capacity, which mitigated the variations caused by different fertility treatments.

The findings indicate the importance of selecting high-performing genotypes and optimizing fertility levels to achieve higher productivity. Further studies could focus on integrating other management practices, such as irrigation and pest control, to complement the effects of fertility management and genotype selection for sustainable sorghum production.

Effect of Fertility Levels on Growth Attributes

The growth attributes of sorghum, including days to 50% flowering, days to physiological maturity, and plant height, were significantly influenced by different fertility levels. The application of 150% RDF (120:60:60 NPK kg/ha) recorded the maximum plant height at harvest (183.70 cm), which was statistically at par with 100% RDF (80:40:40 NPK kg/ha). The lowest plant height (152.60 cm) was observed in the control treatment, indicating the critical role of adequate nutrient supply in promoting plant growth.

Similarly, fertility levels influenced the phenological stages of the crop. The application of 150% RDF resulted in the earliest 50% flowering (76.30 days), which was statistically at par with 100% RDF. Days to physiological maturity were also shortest under 150% RDF (110.1 days), followed by 100% RDF. Conversely, the control treatment recorded significantly more days to both 50% flowering and physiological maturity, emphasizing the delayed growth cycle under nutrient-deficient conditions.

Effect of Genotypes on Growth Attributes

Significant variations in growth attributes were observed among the sorghum genotypes. Genotype **CSH 30** exhibited the earliest 50% flowering (70.9 days), which was statistically at par with other genotypes, while **CSH 25** required significantly more days for 50% flowering (86.1 days). However, the days to physiological maturity were not significantly affected by the genotypes, indicating a uniformity in the duration required to reach maturity across genotypes under similar growing conditions.

In terms of plant height at harvest, genotype **CSV 20** achieved the tallest stature, which was significantly higher than the other genotypes. This highlights the genetic potential of CSV 20 for robust growth, making it a promising candidate for achieving higher biomass and yield.

Effect of Fertility Levels on Yield and Yield Attributes

The study demonstrated that the application of higher fertility levels significantly improved the yield and yield attributes of sorghum. While parameters like the number of panicles per m², 1000-seed weight, and harvest index were not significantly affected by varying fertility levels, grain yield showed a marked increase with the application of 150% RDF (120:60:60 NPK kg/ha), yielding 4160.1 kg/ha. This was followed by 100% RDF (80:40:40 NPK kg/ha), with the control treatment yielding the lowest at 2251.4 kg/ha. The increase in grain yield was progressive with the higher fertility levels, with 50% RDF, 100% RDF, and 150% RDF showing increases of 31.15%, 54.0%, and 84.77%, respectively, compared to the control. The same trends were observed in dry fodder and biological yields, with significant increases in stover yield under higher RDF levels. The results underscore the vital role of appropriate fertility management in improving sorghum productivity, with the 150% RDF treatment proving to be the most effective in enhancing both grain and stover yields.

Effect of Genotypes on Yield and Yield Attributes

Significant differences were observed in the yield and yield attributes of sorghum due to the influence of different genotypes. Among the tested genotypes, CSV 20 exhibited the highest grain yield, followed by CSH 30 and CSH 25, which showed relatively lower yields. The 1000-seed weight and number of panicles per m² varied significantly between genotypes, with CSV 20 recording the highest 1000-seed weight, indicating its superior grain size and quality.

In terms of yield attributes, CSV 20 also had the highest harvest index, suggesting that it efficiently converted biomass into grain. However, no significant difference was observed in the number of panicles per m² among the genotypes, suggesting that this parameter was relatively stable across the genotypes tested.

These results indicate that genotype plays a critical role in determining sorghum yield and its associated attributes, with CSV 20 emerging as the highest-yielding genotype in terms of both grain and biomass production. The findings highlight the potential of selecting high-yielding genotypes, such as CSV 20, for better productivity under optimal management conditions. Further studies could explore the interaction between genotypes and environmental factors to understand the mechanisms behind these yield differences.

Interaction Effects

The interaction between fertility levels and sorghum genotypes did not show a significant impact on most of the yield and growth parameters, including grain yield, stover yield, and harvest index. Although both fertility levels and genotypes independently influenced these traits, their combined effect did not result in a distinct advantage for any genotype at a specific fertility level. This indicates that the genotypes responded similarly to different fertility treatments, suggesting a uniform adaptability to the applied nutrient regimes.

For instance, the highest grain yield was recorded with 150% RDF (120:60:60 NPK kg/ha) across all genotypes, particularly **CSV 20**, without a clear interaction effect that would indicate a superior genotype under high or low fertility conditions. Similarly, stover yield and other yield attributes followed the same trend, with no genotype-specific response to fertility levels.

These non-significant interaction effects suggest that sorghum genotypes may have a comparable ability to utilize nutrients from varying fertility levels. It implies that, under the experimental conditions, the response to fertility management was largely driven by the nutrient levels, with less variability in genotype performance based on the fertility treatments applied. However, further studies examining a broader range of genotypes and environmental conditions may provide deeper insights into potential genotype × fertility level interactions.

Table 1: Growth Parameters of Kharif Sorghum Genotypes as Affected by Various Levels of Fertility (Grain Sorghum)

Treatments	Days to 50% Flowering	Days to Physiological Maturity	Plant Height (cm)
Fertility Levels			
F1 (Control)	86.3	124.4	152.6
F2 (50% RDF)	84.2	121.2	158.4
F3 (100% RDF)	81.6	117.9	173.1
F4 (150% RDF)	76.3	110.1	183.7
S.Em.± (F)	1.1	1.2	2.5
C.D. at 5% (F)	5.0	5.3	11.2
C.V. %	5.4	4.0	6.0
Genotypes			
G1 (SPH 1888)	84.0	114.9	151.0
G2 (SPH 1914)	84.5	120.4	103.6
G3 (SPH 1912)	82.0	117.9	146.4
G4 (SPV 2568)	80.6	119.1	180.9
G5 (SPV 2569)	84.8	122.6	203.3
G6 (CSH 25)	86.1	122.1	163.5
G7 (CSH 30)	70.9	111.0	153.9
G8 (CSV 20)	84.0	119.1	233.3
S.Em.± (G)	2.4	3.1	5.4
C.D. at 5% (G)	7.0	NS	15.7
S.Em.± (F X G)	4.8	6.1	10.9
C.D. at 5% (F X G)	NS	NS	NS
C.V. %	8.3	7.3	9.2

Table 2: Yield and Yield Attributes of Kharif Sorghum Genotypes as Affected by Various Levels of Fertility (Grain Sorghum)

Treatments	No. of Panicles per m^2	1000 Seed Weight (g)	Grain Yield (Kg/ha)	Stover Yield (Kg/ha)	Biological Yield (Kg/ha)	Harvest Index (%)
Fertility Levels						
F1 (Control)	7.2	31.6	2251.4	7065.3	9316.8	24.2
F2 (50% RDF)	7.4	32.1	2952.8	9276.8	12229.6	24.2
F3 (100% RDF)	7.9	32.4	3467.8	10886.8	14354.6	24.2
F4 (150% RDF)	8.4	32.4	4160.1	13057.2	17217.3	24.2
S.Em.± (F)	0.2	0.7	33.9	289.0	283.0	0.6
C.D. at 5% (F)	NS	NS	152.7	1300.5	1273.3	NS
C.V. %	10.0	8.3	4.2	11.5	8.5	9.2
Genotypes						
G1 (SPH 1888)	8.8	32.4	3303.9	9226.4	12530.3	26.4
G2 (SPH 1914)	7.8	22.9	2931.3	8394.6	11325.9	25.9
G3 (SPH 1912)	7.9	35.3	3562.0	10854.5	14416.5	24.8
G4 (SPV 2568)	7.8	34.3	3429.0	11389.9	14818.9	23.2
G5 (SPV 2569)	7.3	39.6	2664.4	8367.8	11032.1	24.2
G6 (CSH 25)	7.9	30.3	4080.4	12063.4	16143.8	25.2
G7 (CSH 30)	7.4	35.6	2520.4	9586.5	12106.9	20.9
G8 (CSV 20)	7.3	26.8	3172.9	10689.3	13862.1	22.9
S.Em.± (G)	0.3	1.3	134.3	379.2	436.1	0.8
C.D. at 5% (G)	0.8	3.8	389.0	1098.3	1263.0	2.3
S.Em.± (F X G)	0.6	2.7	268.6	758.4	872.1	1.6
C.D. at 5% (F X G)	NS	NS	NS	NS	NS	NS
C.V. %	10.5	11.7	11.8	10.7	9.3	9.4

Conclusion:

The study on the impact of various fertility levels and genotypes on the growth and yield attributes of Kharif sorghum has shown that increasing the fertility levels significantly enhances sorghum productivity. The application of **150% RDF** (120:60:60 NPK kg/ha) resulted in the highest grain yield, stover yield, and biological yield, emphasizing the importance of optimal nutrient supply. Despite this, the harvest index remained consistent across all fertility treatments, indicating that fertility levels did not significantly alter the partitioning of biomass between grain and vegetative growth. Regarding genotypes, **SPH 1888** and **SPH 1912** performed well in terms of grain yield, with **SPH 1912** yielding the highest. However, **CSH 30** performed poorly in comparison. The interaction between fertility levels and genotypes was not significant, indicating that increasing fertility benefits all genotypes similarly. This suggests that selecting the right genotype combined with optimal fertility can maximize sorghum production, with **150% RDF** being the most effective fertility level for achieving higher yields.

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