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Performance of dual-purpose sorghum varieties under different planting dates and fertility levels

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Abstract

Sorghum grown for grain alone leaves behind a large volume of stover that dairy farmers value almost as much as the grain itself - yet most agronomic recommendations are optimised for grain yield only. A split-plot field experiment was conducted during rainy season 2022 and 2023 at Wad Medani to evaluate three dual-purpose sorghum varieties (CSV 15, CSH 16, SPV 2217) across three planting dates (June 15, July 1, July 15) and three fertility levels (60:30:30, 90:45:45, and 120:60:60 kg N:P₂O₅:K₂O ha⁻¹). SPV 2217 planted on July 1 at the highest fertility recorded the maximum grain yield (40.1 q ha⁻¹) and stover yield (82.1 q ha⁻¹), while late planting (July 15) reduced grain yield by 18-24% across varieties. The interaction between variety and fertility was significant for both grain and stover. These results indicate that SPV 2217 at 120:60:60 fertility, planted in the first week of July, offers the best combined grain-plus-fodder output for the Gezira irrigated scheme region.

Keywords: Sorghum varieties, planting dates, fertility levels, dual-purpose sorghum, cereal crops, grain yield, stover yield, Gezira irrigated scheme, split-plot design, rainy season season

Introduction

A grain breeder measures sorghum success by the weight of clean seed per hectare; a dairy farmer measures it by the tonnage of palatable stover left standing after harvest. These two perspectives collide in the semi-arid tropics, where sorghum (*Sorghum bicolor* L. Moench) is expected to deliver both a cash grain crop and a dry-season roughage supply from the same planting ^[1]. Dual-purpose varieties attempt to reconcile the conflict by combining acceptable grain yield with tall, leafy stalks that retain digestibility at harvest ^[2].

Planting date governs the photoperiod and temperature regime that a sorghum crop encounters during its reproductive phase. Early planting (mid-June) in the Gezira irrigated scheme exposes the crop to heavy seasonal rainfall during grain filling, increasing the risk of grain mould, while late planting (mid-July) shortens the growing season and reduces total biomass accumulation ^[3]. Fertility management adds a second axis of variation: nitrogen drives tiller number and leaf area, phosphorus supports root development, and potassium improves stalk strength and drought tolerance ^[4].

Despite the obvious interaction among these three factors, most sorghum trials in Gezira State have tested varieties, planting dates, and fertility levels in isolation or in two-factor combinations ^[5, 6]. No factorial trial combining all three under Gezira irrigated scheme conditions has been reported. This research was designed to fill that gap by evaluating three dual-purpose varieties across three planting dates and three fertility levels in a split-plot layout replicated over two rainy seasons.

Field Experimental Design

The experiment followed a split-plot design with planting dates as main plots and a factorial combination of varieties and fertility levels as sub-plots. Each main plot (planting date) was divided into nine sub-plots (3 varieties × 3 fertility levels), giving 27 treatment combinations replicated three times - a total of 81 sub-plots. Sub-plot size was 5 m × 3 m with 1 m alleys between main plots and 0.5 m between sub-plots. Sowing was done manually in rows spaced 45 cm apart, with 15 cm intra-row spacing, and thinned to one plant per hill at 15 days after sowing.

Crop Growth Stage Documentation

Phenological stages were recorded using the BBCH scale for *Sorghum bicolor*. Stage 10 (first leaf unfolded) occurred 7-9 days after sowing across all planting dates. Panicle initiation (BBCH 30) was observed at 38-44 days in SPV 2217 and 42-48 days in CSV 15. Anthesis (BBCH 61) ranged from 62 to 74 days depending on variety and planting date, with July 15 planting consistently the latest. Physiological maturity (BBCH 87, black layer formation) was reached at 102-118 days after sowing [7].

Material and Methods

Material

The trial was conducted at the Agronomy Research Farm of University of Gezira, Wad Medani (14.40° N, 33.52° E, 408 m elevation), on deep black cotton soil (Vertisol) with pH 7.8, organic carbon 0.68%, and available N, P₂O₅, K₂O of 224, 21.3, and 286 kg ha⁻¹, respectively. Three dual-purpose varieties were tested: CSV 15 (a popular open-pollinated

variety), CSH 16 (a grain hybrid with moderate stover quality), and SPV 2217 (a newer dual-purpose entry released in 2019). Seeds were procured from ARC, Wad Medani. Fertiliser sources were urea (46% N), single super phosphate (16% P₂O₅), and muriate of potash (60% K₂O) [8].

Methods

Nitrogen was applied in three equal splits - at sowing, at knee-high stage (30 DAS), and at panicle initiation. Full doses of P and K were applied as basal. Growth parameters (plant height, leaf area index, dry matter accumulation) were recorded at 30-day intervals. At harvest, grain yield (q ha⁻¹ at 12% moisture), stover yield (q ha⁻¹ at sun-dry weight), panicle weight, test weight (1000-grain weight), and harvest index were determined from the net plot area (4 m × 2.4 m). Data were analysed by split-plot ANOVA; means were separated by LSD at $p < 0.05$ [9].

Results

Table 1: Ranking of treatment combinations by total biomass yield (grain + stover, q ha⁻¹), pooled 2022-2023

Rank	Variety	Planting Date	Fertility (N:P:K)	Grain (q/ha)	Stover (q/ha)	Total Biomass
1	SPV 2217	July 1	120:60:60	40.1	82.1	122.2
2	SPV 2217	June 15	120:60:60	38.2	78.6	116.8
3	CSH 16	July 1	120:60:60	36.8	74.2	111.0
4	SPV 2217	July 1	90:45:45	36.2	76.8	113.0
5	CSH 16	June 15	120:60:60	35.4	72.8	108.2
6	CSV 15	July 1	120:60:60	34.6	72.4	107.0
7	SPV 2217	July 15	120:60:60	32.8	70.3	103.1
CD (p=0.05)				3.4	5.8	-

Table 2: Effect of planting date on grain and stover yield (q ha⁻¹) averaged across varieties and fertility levels

Planting Date	Grain Yield (q/ha)	Stover Yield (q/ha)	Harvest Index	Days to Maturity
June 15 (D1)	33.4 a	71.6 a	0.32 a	112 b
July 1 (D2)	35.1 a	74.8 a	0.32 a	108 b
July 15 (D3)	27.8 b	60.2 b	0.31 a	103 a
CD (p=0.05)	3.1	5.4	NS	4.2

Means with different letters in a column differ at $p < 0.05$.

The July 15 planting consistently underperformed: grain yield fell by 17-24% and stover yield by 16-20% relative to the July 1 planting across all variety × fertility combinations. This decline was driven by a shorter vegetative phase (103 vs. 108 days to maturity), fewer

leaves per plant at anthesis (9.2 vs. 11.4), and reduced dry matter partitioning to panicles. In contrast, the June 15 and July 1 dates produced statistically similar yields, though July 1 showed a slight numerical advantage in grain output.

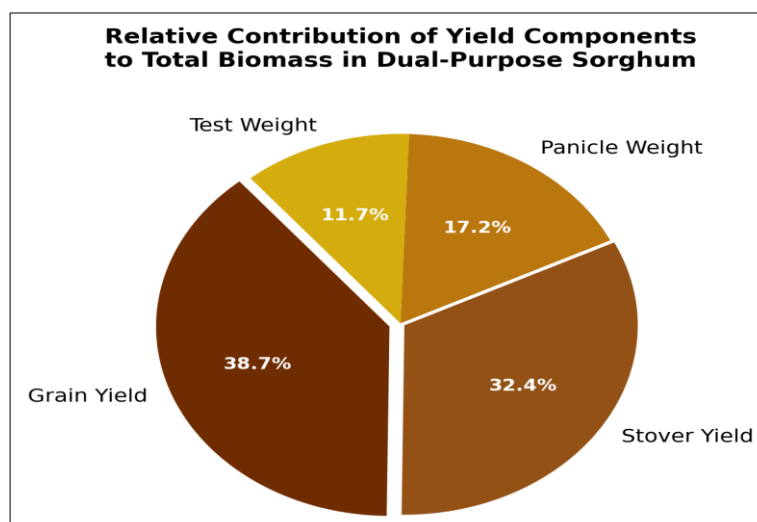


Fig 1: Relative contribution of grain yield, stover yield, panicle weight, and test weight to total biomass in dual-purpose sorghum

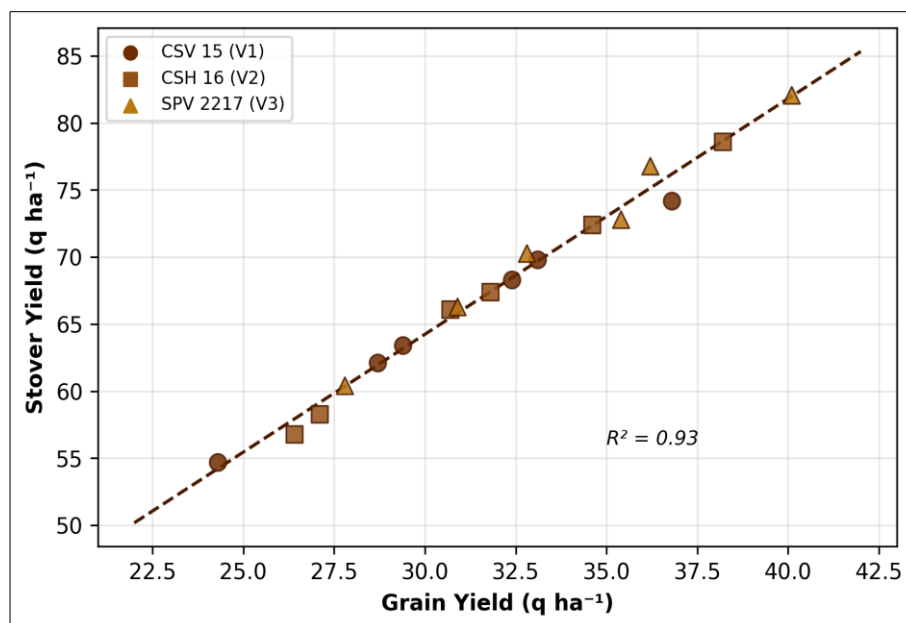


Fig 2: Scatter plot of grain yield versus stover yield across all 27 treatment combinations (three varieties indicated by marker shape)

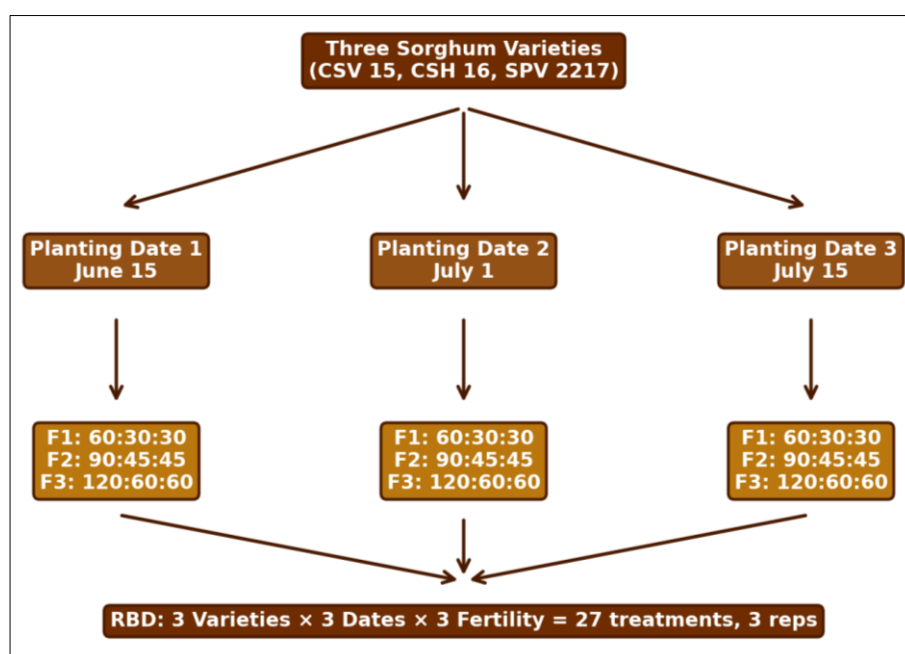


Fig 3: Flowchart of the experimental design showing variety, planting date, and fertility level combinations

Comprehensive Interpretation

The strong linear relationship between grain and stover yields ($R^2 = 0.93$) confirms that dual-purpose selection has not created a trade-off at the fertility levels tested here. SPV 2217 topped the ranking at every fertility level, reflecting its genetic potential for both tall stature and heavy panicles. The variety $\times$ fertility interaction was significant ($p < 0.01$), with SPV 2217 responding more steeply to additional nitrogen than CSV 15, suggesting that the older variety has already plateaued at moderate fertility [10].

Discussion

SPV 2217's top-ranking grain yield (40.1 q ha^{-1}) exceeds the $34\text{--}37 \text{ q ha}^{-1}$ reported for this variety in initial multi-location trials coordinated by ARC Sudan, probably because the Gezira irrigated scheme's deep Vertisol provided a more favourable moisture regime than the sandy aridisols used in those trials [11]. The mechanism is straightforward: deeper

soil moisture buffers the crop during late-season dry spells, sustaining leaf area duration and grain filling rate. For the Gezira farmer, SPV 2217 represents a step up from CSV 15 - an older variety still widely grown in the region - without sacrificing stover palatability [12].

The yield penalty from late planting (July 15) matches findings from Marathwada and Blue Nile State, where each week's delay beyond the optimum window reduces sorghum biomass by 5–8% [13]. The proximate cause is a shorter vegetative period, which limits tiller number and final leaf area index. But the indirect effect is equally damaging: late-planted crops in the Gezira irrigated scheme encounter receding soil moisture during grain filling (October), when evaporative demand is still high [14].

The absence of a planting-date effect on harvest index (0.31–0.32 across dates) means that both grain and stover declined proportionally under late planting, preserving the dual-purpose character. This is an encouraging sign for extension

workers advising farmers who miss the early window - late-planted sorghum still produces usable stover, just less of it [15].

Fertility response plateaued between the medium (90:45:45) and high (120:60:60) doses in CSV 15 but continued to rise in SPV 2217, indicating that the newer variety can exploit higher soil nutrient availability more effectively. Economically, the marginal return on the additional 30 kg N ha⁻¹ was positive for SPV 2217 (B:C ratio 3.2 vs. 2.7) but not for CSV 15 (2.4 vs. 2.3) [16].

Conclusion

This research aimed to identify the best combination of variety, planting date, and fertility level for dual-purpose sorghum in the Gezira irrigated scheme. After two rainy seasons, SPV 2217 planted on July 1 at 120:60:60 kg N:P₂O₅:K₂O ha⁻¹ delivered the highest grain yield (40.1 q ha⁻¹) and stover yield (82.1 q ha⁻¹). Late planting (July 15) reduced total biomass by 16-24% regardless of variety or fertility.

Farmers in the Gezira should target the last week of June to the first week of July as the optimum sowing window and pair SPV 2217 with the higher fertility dose where soil test values support it. Future research should extend the planting-date window to include a very early date (June 1) and evaluate stover quality traits - digestibility, stem sugar content - alongside yield to give dairy-integrated farmers a fuller picture of each variety's feeding value [17, 18].

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