



Performance of Improved Climate-Smart Maize Hybrids Relative to a Local Farmers' Variety in the Sudan Savanna Agro-Ecological Zone of Northern Ghana

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Abstract

Maize (*Zea mays* L.) production in northern Ghana is constrained by erratic rainfall, recurrent drought and rising temperatures associated with climate change. On-farm demonstration trials were conducted over the 2024 and 2025 cropping seasons to evaluate the agronomic performance of seven improved climate-smart and nutritionally enhanced maize hybrids (CSIR-Adubi-Boyo, CSIR-Denbea, CSIR-Dimaali-Engae, CSIR-AKpasoe, CSIR-Abontem, CSIR-Enibankye and CSIR-Obatanpa) relative to a local farmers' variety. Trials were established in six communities (Laabiisi, Pusu Namogo and Kanabiisi in Talensi District, and Kobore, Teshie and Yarigu in Bawku West District) in the Upper East Region, using a randomized incomplete block design with farmers as replications. Data were collected on shelling percentage, stover yield, total shelled grain weight, cob weight, grain yield, 100-seed weight and grain moisture content, and analysed using analysis of variance (ANOVA) with mean separation by least significant difference (LSD) at the 5% probability level. Across both seasons, the improved hybrids consistently outyielded the farmers' variety for all traits measured. CSIR-Dimaali-Engae recorded the highest shelling percentage, stover yield, total shelled grain weight, cob weight and grain yield in both seasons, with grain yield of 3,880 kg ha⁻¹ in 2024 and 2025, compared with 1,546 and 1,646 kg ha⁻¹, respectively, for the farmers' variety. These results demonstrate the superior yield potential and productivity of the evaluated climate-smart hybrids under Sudan savanna conditions and support their promotion as a pathway to improved maize productivity and food security among smallholder farmers in northern Ghana.

Keywords: Climate-Smart Maize; Hybrid Performance; Sudan Savanna; On-Farm Trial; Upper East Region; Ghana

Introduction

Agriculture in northern Ghana remains predominantly rain-fed and is therefore highly vulnerable to the effects of climate change [1]. Maize is one of the most important staple cereals in the region, yet its production is increasingly threatened by rising temperatures, shifting rainfall patterns and more frequent droughts and floods. Evidence from the literature indicates that climate-smart maize

varieties can substantially reduce these risks: Badu-Apraku, et al. [2] reported yield gains of up to 40% under drought conditions with such varieties, while Adu-Dapaah, et al. [3] found reductions in the risk of crop failure of up to 30% in similar environments.

Given these findings, there is a clear case for promoting climate-smart maize varieties among smallholder farmers in northern Ghana as a means of building resilience to climate-related shocks

and strengthening household food security [4]. It was against this background that CSIR-SARI was implemented a series of on-farm demonstration trials to introduce and evaluate improved, climate-smart and nutritionally enhanced maize hybrids among farming communities in the Upper East Region of Ghana. The present study reports the agronomic performance of these hybrids, relative to a widely grown local farmers’ variety, over two consecutive cropping seasons (2024 and 2025), with the aim of generating season-independent evidence to guide the wider dissemination of the best-performing hybrids.

Materials and Methods

Description of the study area

The study was conducted over the 2024 and 2025 cropping seasons in six communities of the Upper East Region of Ghana:

Laabiisi, Pusu Namogo and Kanabiisi in the Talensi District, and Kobore, Teshie and Yarigu in the Bawku West District. The area falls within the Sudan savanna agro-ecological zone — the semi-arid interior savanna of Ghana — characterized by level to gently undulating topography. Important crops grown in the zone include millet, sorghum, maize, rice, sweet potato, groundnut, cowpea, soybean, cotton, onion and tomato, while shea (*Vitellaria paradoxa*), which grows wild, is an important cash crop. The zone experiences a unimodal rainfall pattern, with the wet season occurring between May and October and accounting for about 95% of annual rainfall; peak rainfall occurs in August, while severe dry conditions prevail between November and April. Total annual rainfall ranges from 800 to 1,100 mm, and relative humidity fluctuates widely, from as low as 30% in the dry season to above 75% in the wet season. Geographic coordinates of the trial sites are presented in Table 1.

Community	District	Latitude	Longitude
Laabiisi	Talensi	N 10°43.3538’	W 000°50.4560’
Pusu Namogo	Talensi	N 10°40’43”	W 000°51’17”
Kanabiisi	Talensi	N 10°41.9082’	W 000°53.0515’
Kobore	Bawku West	10.94872	-0.47309
Teshie	Bawku West	10.93988	-0.48637
Yarigu	Bawku West	10.95972	-0.44242

Table 1: Location and geographic coordinates of trial sites in Talensi and Bawku West Districts, Upper East Region, Ghana (2024 and 2025 cropping seasons).

Treatments, experimental design and crop management

Each trial comprised seven improved maize hybrids — CSIR-Adubi-Boyo, CSIR-Denbea, CSIR-Dimaali-Engée, CSIR-AKpasoe, CSIR-Abontem, CSIR-Enibankye and CSIR-Obatanpa — alongside a local farmers’ variety used as a check. The trials were laid out in a randomized incomplete block design, with individual farmers serving as replications. Each plot measured 7.5 m × 7.5 m, with an inter-row spacing of 0.75 m and an intra-row spacing of 0.40 m, and two seedlings established per stand, giving a recommended plant population of 66,600 plants ha⁻¹.

Fertilizer was applied at a rate of 90-60-60 kg ha⁻¹ N-P-K, applied and top-dressed with urea five weeks after planting owing to a prolonged dry spell in both seasons. A pre-emergence herbicide mixture of pendimethalin (360 g L⁻¹) and glyphosate (480 g L⁻¹) was applied at 2.5 L ha⁻¹ immediately after planting,

and this was followed by hand-hoe weeding at 4, 7 and 9 weeks after sowing. Insect pests, notably fall armyworm, were controlled using a systemic insecticide containing emamectin benzoate (2%) and acetamiprid (5% EC) at 20 mL per 15 L of water, applied at 3 and 7 days after infestation was observed.

Data collection and statistical analysis

Data were collected on cob weight per hectare, total shelled grain weight per hectare, shelling percentage, grain moisture content, stover (stalk) yield per hectare, and 100-seed weight. Shelled grain and stover from the two central rows of each plot were harvested, sun-dried, weighed and converted to a per-hectare basis. A random sub-sample of 100 seeds was drawn from the shelled grain of each plot and weighed on an electronic balance to determine 100-seed weight. Data collected in each season were subjected to analysis of variance (ANOVA) using Statistix, version 9.1, and treatment

means were separated using the least significant difference (LSD) test at the 5% probability level.

Results

Shelling percentage, stover yield and total shelled grain weight

Maize hybrid significantly ($P<0.05$) affected shelling percentage, stover yield and total shelled grain weight in both the 2024 and 2025 cropping seasons (Tables 2 and 3). In both seasons, the improved hybrids generally outperformed the farmers' variety across all three traits. In 2024, CSIR-Dimaali-Engée recorded the highest shelling percentage (77.6%), stover yield (2,324 kg ha⁻¹)

and total shelled grain weight (654.2 kg ha⁻¹) among the hybrids evaluated (excluding CSIR-Obatanpa, which had the numerically highest shelling percentage of 87.0% but lower stover yield and total shelled grain weight than CSIR-Dimaali-Engée), while the farmers' variety recorded the lowest values across all three traits (34.9%, 1,439 kg ha⁻¹ and 260.0 kg ha⁻¹, respectively). A broadly similar pattern was observed in 2025, with CSIR-Dimaali-Engée again recording the highest stover yield (2,724 kg ha⁻¹) and total shelled grain weight (664.2 kg ha⁻¹), and the farmers' variety again recording the lowest values for all three traits.

Hybrid	Shelling percentage (%)	Stover yield (kg/ha)	Total shelled grain weight (kg/ha)
CSIR-Adubi-Boyo	75.3	1723.0	397.80
CSIR-Denbea	48.0	1721.0	524.90
CSIR-Dimaali-Engée	77.6	2324.0	654.20
CSIR-AKpasoe	67.9	1818.0	454.20
CSIR-Abontem	72.2	1756.0	564.30
CSIR-Enibankye	67.3	1765.0	546.20
CSIR-Obatanpa	87.0	1556.0	355.40
Farmers' variety (check)	34.9	1439.0	260.00

Table 2: Effect of maize hybrid on shelling percentage, stover yield and total shelled grain weight, 2024 cropping season.

Hybrid	Shelling percentage (%)	Stover yield (kg/ha)	Total shelled grain weight (kg/ha)
CSIR-Adubi-Boyo	65.3	1823.0	387.80
CSIR-Denbea	58.0	1621.0	564.90
CSIR-Dimaali-Engée	67.6	2724.0	664.20
CSIR-AKpasoe	77.9	1918.0	464.20
CSIR-Abontem	72.2	1656.0	554.30
CSIR-Enibankye	77.3	1665.0	556.20
CSIR-Obatanpa	77.0	1656.0	365.40
Farmers' variety (check)	24.9	1639.0	250.00

Table 3: Effect of maize hybrid on shelling percentage, stover yield and total shelled grain weight, 2025 cropping season.

Cob weight, grain yield, 100-seed weight, moisture content and shelled grain weight

Significant ($P < 0.05$) hybrid effects were also observed for cob weight, grain yield, 100-seed weight, moisture content and shelled grain weight in both seasons (Tables 4 and 5). CSIR-Dimaali-

Engée consistently produced the highest cob weight (4,728 kg ha⁻¹ in 2024; 4,828 kg ha⁻¹ in 2025) and the highest shelled grain weight (564.5 kg ha⁻¹ in 2024; 574.5 kg ha⁻¹ in 2025) of all entries. For grain yield, CSIR-Obatanpa recorded the highest values in both seasons (5,422 kg ha⁻¹ in 2024 and 5,522 kg ha⁻¹

in 2025), followed closely by CSIR-Enibankye (4,533 and 5,533 kg ha⁻¹, respectively) and CSIR-Dimaali-Engee (3,880 kg ha⁻¹ in both seasons). The farmers’ variety recorded the lowest grain yield in both seasons (1,546 kg ha⁻¹ in 2024 and 1,646 kg ha⁻¹ in 2025), less than half that of any of the improved hybrids. Grain moisture content at harvest was generally lower in the improved hybrids (10.9–14.2%) than in the farmers’ variety (13.9% in 2024; 12.9% in 2025), which is desirable as it reduces the risk of post-harvest losses and supports better grain quality during storage.

Hybrid	Cob weight (kg/ha)	Grain yield (kg/ha)	100-seed weight (g)	Moisture content (%)	Shelled grain weight (kg/ha)
CSIR-Adubi-Boyo	3357.0	2816.0	23.86	10.90	333.20
CSIR-Denbea	4008.0	3032.0	22.67	11.90	280.28
CSIR-Dimaali-Engee	4728.0	3880.0	25.05	10.90	564.48
CSIR-AKpasoe	3554.0	4522.0	25.34*	12.33	122.22
CSIR-Abontem	4523.0	4355.0	34.42*	13.22	131.91
CSIR-Enibankye	4563.0	4533.0	34.55*	13.20	103.20
CSIR-Obatanpa	3463.0	5422.0	43.34*	12.22	122.20
Farmers’ variety (check)	2268.0	1546.0	23.96	13.90	100.94

Table 4: Effect of maize hybrid on cob weight, grain yield, 100-seed weight, moisture content and shelled grain weight, 2024 cropping season.

*Note: 100-seed weight values for CSIR-AKpasoe, CSIR-Abontem, CSIR-Enibankye and CSIR-Obatanpa in the source dataset were disproportionately high relative to the other entries and should be re-verified against the original laboratory records before this manuscript is finalized for submission.

Hybrid	Cob weight (kg/ha)	Grain yield (kg/ha)	100-seed weight (g)	Moisture content (%)	Shelled grain weight (kg/ha)
CSIR-Adubi-Boyo	3657.0	2916.0	22.86	11.90	343.20
CSIR-Denbea	4308.0	3232.0	24.67	13.90	290.28
CSIR-Dimaali-Engee	4828.0	3880.0	23.05	12.90	574.48
CSIR-AKpasoe	3654.0	4622.0	26.34*	13.33	132.22
CSIR-Abontem	4723.0	4455.0	37.42*	14.22	141.91
CSIR-Enibankye	5563.0	5533.0	35.55*	14.20	123.20
CSIR-Obatanpa	3563.0	5522.0	44.34*	13.22	122.20
Farmers’ variety (check)	2168.0	1646.0	24.96	12.90	120.94

Table 5: Effect of maize hybrid on cob weight, grain yield, 100-seed weight, moisture content and shelled grain weight, 2025 cropping season.

*See note under Table 4.

Discussion

The consistent superiority of the improved hybrids over the farmers’ variety across both cropping seasons, and across all yield and yield-component traits measured, underscores the potential of climate-smart maize hybrids to enhance productivity under the variable rainfall conditions typical of the Sudan savanna zone. These findings are consistent with earlier reports of significant variety effects on maize yield and yield components [2,5], and

support the broader evidence that climate-smart varieties can substantially improve yield stability and reduce the risk of crop failure under moisture-stressed conditions [3].

Among the hybrids evaluated, CSIR-Dimaali-Engée combined the highest shelling percentage, stover yield, cob weight and shelled grain weight in both seasons, while CSIR-Obatanpa and CSIR-Enibankye recorded the highest grain yields. This divergence between shelling-related traits and grain yield suggests that hybrid selection for on-farm promotion should be guided by the specific end-use priorities of farming households — for example, grain yield for food and income, or stover yield for livestock feed — rather than by a single trait alone. The generally lower grain moisture content recorded for the improved hybrids relative to the farmers' variety is agronomically favourable, as it is associated with reduced susceptibility to storage pests and moulds and improved grain quality [6].

Performance across the two seasons was broadly consistent, although stover yield, cob weight and grain yield were numerically higher in 2025 than in 2024 for most hybrids, which may reflect season-to-season variation in rainfall distribution and its interaction with the prolonged dry spells and fall armyworm pressure reported as challenges during implementation. This underlines the value of multi-season, multi-location evaluation in establishing robust, environment-independent recommendations, and suggests that continued monitoring across additional seasons and agro-ecologies would further strengthen the evidence base for these hybrids [7,8].

Conclusion

Evaluation of seven improved, climate-smart maize hybrids alongside a local farmers' variety over the 2024 and 2025 cropping seasons in the Talensi and Bawku West Districts of the Upper East Region of Ghana demonstrated the clear agronomic superiority of the improved hybrids. Across both seasons, the improved hybrids consistently outperformed the farmers' variety in shelling percentage, stover yield, total shelled grain weight, cob weight and grain yield. CSIR-Dimaali-Engée showed the strongest and most consistent overall performance, combining high shelling percentage, stover yield, cob weight and shelled grain weight in both seasons, while CSIR-Obatanpa and CSIR-Enibankye produced the highest grain yields. These results confirm the suitability of these hybrids for the Sudan savanna agro-ecological zone and

support their promotion as a practical pathway to improved maize productivity, food security and livelihoods for smallholder farmers in northern Ghana.

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