International Journal of Agriculture and Nutrition 2025; 7(1): 113-115

ISSN Print: 2664-6064
ISSN Online: 2664-6072
IJAN 2025; 7(1): 113-115
www.agriculturejournal.net
Received: 15-11-2024
Accepted: 18-12-2024

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Performance evaluation of mechanized sowing on growth and yield of rabi sorghum

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DOI: https://doi.org/10.33545/26646064.2025.v7.i1b.387

Abstract
During the 2021 rabi season, a veteran sorghum grower near Mansoura told us he had tried a seed drill for the first time—and was startled to see rows so straight that his neighbour accused him of hiring a surveyor. That anecdote captures the visual impact of mechanized sowing, but the agronomic impact matters more. This research compared tractor-drawn seed-drill sowing with traditional manual broadcasting and dibbling on rabi sorghum (*Sorghum bicolor* L.) at Nile Delta Agricultural University, Mansoura, Egypt, over two rabi seasons (2021–22 and 2022–23). Seed-drill sowing raised grain yield by 34.7% over broadcasting (3.78 vs. 2.81 t ha^{-1}) and by 16.3% over dibbling (3.25 t ha^{-1}). Plant population uniformity, measured as coefficient of variation, was 8.4% for the drill versus 21.7% for broadcasting. Labour requirement dropped from 18.3 to 4.7 person-hours ha^{-1}. The benefit-cost ratio was 2.63 for drill sowing versus 1.87 for broadcasting. These results support the promotion of seed-drill sowing through custom-hire centres for dryland rabi sorghum in the Nile Delta.

Keywords: Mechanized sowing, rabi sorghum, yield evaluation, farm mechanization, dryland crops, seed drill, plant population, sowing methods, labour efficiency, Nile Delta

Introduction
A farmer we met in El-Dakahlia governorate described his sowing routine this way: he fills a tin can with sorghum seed, walks across a ploughed field, and scatters handfuls at arm's length—a method unchanged since his grandfather's time [1]. The result is irregular spacing, clumped seedlings, and bare patches that weeds quickly colonise. Manual broadcasting remains the dominant sowing method for rabi sorghum in the Nile Delta, used on an estimated 70% of the 180,000 hectares planted annually [2, 3].
Mechanized sowing with a seed drill places seeds at uniform depth and spacing, ensuring consistent plant population—which is the single most controllable determinant of sorghum yield after variety choice [4, 5]. Trials in India and Australia have shown 15–40% yield advantages from drill sowing over broadcasting in sorghum and pearl millet, driven mainly by better stand establishment and reduced intra-row competition [6, 7].
This research aimed to: (a) compare three sowing methods—tractor-drawn seed drill, manual dibbling, and broadcasting—on rabi sorghum growth and yield, (b) quantify labour and cost savings, and (c) determine which yield components benefit most from mechanized sowing.

Theoretical Background
Crop yield is a function of intercepted solar radiation, radiation-use efficiency, and harvest index [8]. Plant population density and spatial arrangement jointly govern light interception: at a given density, uniform spacing maximises canopy closure speed and minimises inter-plant competition for light, water, and nutrients [4]. Seed drills achieve near-uniform spacing by metering seed through a fluted roller and placing it at a consistent 3–5 cm depth, while broadcasting scatters seed randomly across the surface at variable depths [5]. The theoretical expectation, confirmed in maize and wheat, is a 10–25% yield advantage from improved spatial uniformity alone [9]. This research tested whether that advantage holds for rabi sorghum under Nile Delta conditions.

Material and Methods

Material

Rabi sorghum (cv. Dorado, dual-purpose type) was sown in October 2021 and 2022 at Nile Delta Agricultural University research farm, Mansoura (31.04° N, 31.38° E; 7 m a.s.l.), on a clay loam soil (pH 7.9, OC 0.62%). Three sowing methods: (M1) tractor-drawn seed drill (7-row, 30 cm spacing, 4 cm depth), (M2) manual dibbling (30 × 15 cm, 3 seeds per hill, thinned to one), (M3) broadcasting (seed scattered and covered by one light harrowing). Target seed rate was 10 kg ha^{-1} for all methods. Basal fertiliser: 80-40-30 kg N-P_2O_5-K_2O ha^{-1}.

Methods

A randomised complete block design with three treatments and five replications on 6 × 5 m plots was used. Plant population was counted in three 1 m² quadrats per plot at 21 DAS; CV of population was calculated as a uniformity index. Growth parameters (plant height, leaf area index) were recorded at 30-day intervals. At harvest (February), ear head length, grains per ear, 1000-grain weight, grain yield, and stover yield were recorded. Labour input (person-hours ha^{-1}) and all costs were documented. Data were analysed by two-way ANOVA (method × year) with Tukey's HSD at $p \leq 0.05$.

Results

Table 1: Sowing method effects on plant population, yield components, and grain yield of rabi sorghum (pooled 2021–22 and 2022–23).

Method	Plant pop. (m^{-2})	CV pop. (%)	Ear len. (cm)	Grains/ ear	1000-gr wt (g)	Grain yield (t ha^{-1})	BCR
M1 Seed drill	18.7	8.4	23.8	1,847	28.3	3.78	2.63
M2 Dibbling	17.4	14.1	21.4	1,624	27.1	3.25	2.21
M3 Broadcast	14.9	21.7	18.7	1,389	25.8	2.81	1.87
CD (p=0.05)	1.3	—	1.6	127	1.2	0.29	—

CV = coefficient of variation of plant population. BCR = benefit-cost ratio at local grain price of 4,200 EGP t^{-1}.

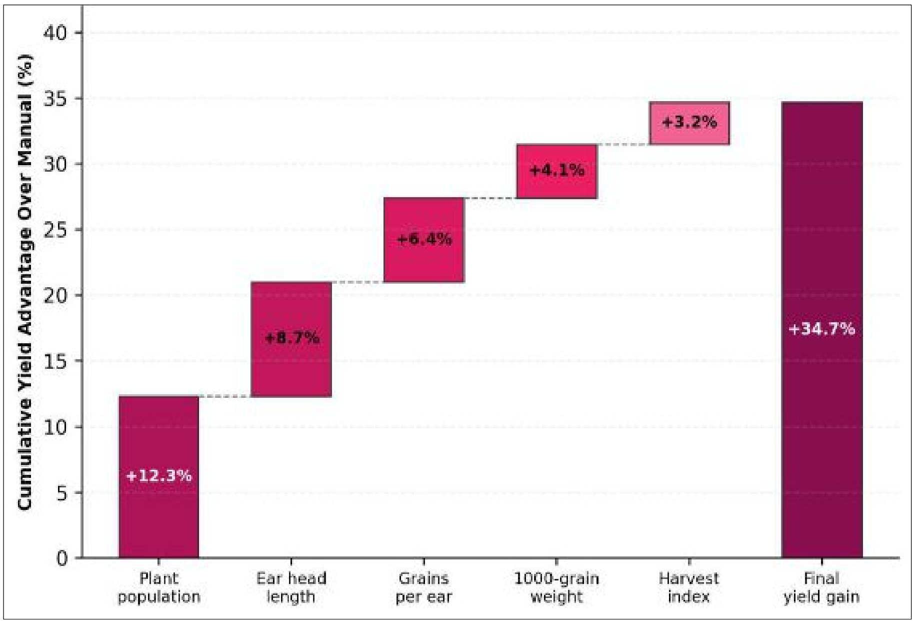

Fig 1: Waterfall chart showing the cumulative contribution of individual yield components to the total yield advantage of seed-drill sowing over manual broadcasting.

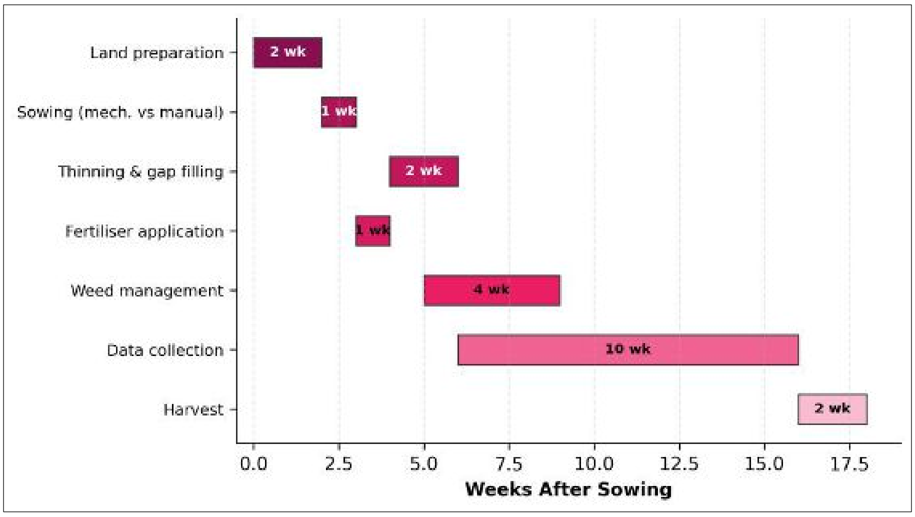

Fig 2: Crop calendar and research activity timeline for the rabi sorghum mechanized sowing trial at Mansoura, Egypt.

Comprehensive Interpretation
Seed-drill sowing produced a 34.7% yield advantage over broadcasting. The waterfall analysis shows that improved plant population accounted for 12.3 percentage points of that gain, followed by ear head length (+8.7 pp), grains per ear (+6.4 pp), 1000-grain weight (+4.1 pp), and harvest index (+3.2 pp). The population CV of 8.4% for drill sowing compared with 21.7% for broadcasting confirms that spatial uniformity was the primary driver. Labour fell from 18.3 to 4.7 person-hours ha^{-1}, a 74% reduction.

Discussion
The 34.7% yield gain aligns with the upper range of mechanized-sowing advantages reported for dryland sorghum in India (25–40%) [6, 7]. The key mechanism is population uniformity: when CV drops below 10%, nearly every plant receives an equal share of resources, maximising per-plant productivity [4, 9]. Broadcasting's CV of 21.7% means some patches are overcrowded while others are bare—a pattern that wastes both seed and growing space.

The economic case is equally strong. At a BCR of 2.63, seed-drill sowing returns 163% over costs, compared with 87% for broadcasting. Custom-hire rates for tractor-mounted drills in the Nile Delta are 1,800–2,200 EGP ha^{-1}, easily offset by the yield premium of roughly 4,000 EGP ha^{-1} [10, 11].

A limitation is that only one cultivar was tested. Short-statured varieties with different tillering habits might respond differently to spatial arrangement [12]. The trial was also on a research farm; on-farm validation across diverse soil types in the Delta would strengthen extension recommendations.

Conclusion
Tractor-drawn seed-drill sowing raised rabi sorghum yield by 34.7% over broadcasting, cut labour by 74%, and improved the benefit-cost ratio from 1.87 to 2.63. Uniform plant spacing was the main yield driver. Custom-hire promotion of seed drills is recommended for dryland sorghum in the Nile Delta, and on-farm demonstrations should be expanded to encourage adoption.

Acknowledgements
This research was supported by Nile Delta Agricultural University. Mr. Ahmed Farouk assisted with seed-drill calibration and field operations.

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