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Impact of mechanical harvesting on grain damage and storability of rice

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Abstract

The trend toward mechanised rice harvesting in East Africa is accelerating, driven by labour shortages and government subsidy programmes. However, mechanical harvesting can crack, fissure, and bruise grain, reducing milling recovery and storage life. This research compared three harvesting methods—manual, mechanical at low speed (2.5 km/h), and mechanical at high speed (4.5 km/h)—for their effects on grain damage, milling quality, and storage weight loss over six months at the University of Nairobi's Upper Kabete campus. High-speed mechanical harvesting produced 24.1% cracked grain versus 2.1% for manual, and storage losses after six months were 21.3% versus 5.6%. Reducing combine speed to 2.5 km/h cut grain damage to 5.8% and storage loss to 11.2%, offering a practical compromise between efficiency and grain quality.

Keywords: Mechanical harvesting, grain damage, rice storability, milling quality, combine harvester, harvest speed, post-harvest loss, grain fissuring, storage weight loss, agricultural engineering

Introduction

The trend toward farm mechanisation in sub-Saharan Africa has been unmistakable: combine harvester imports to Kenya increased 340% between 2015 and 2022, driven by chronic labour shortages during peak harvest season ^[1]. For rice, which requires timely harvesting to avoid shattering losses, mechanisation can reduce harvest time from 25 to 3 person-days per hectare ^[2]. But speed comes at a cost. Mechanical threshing subjects grain to impact forces that cause fissuring, cracking, and husk damage—defects that reduce milling recovery by 5-15% and accelerate storage deterioration through increased insect and fungal attack ^[3, 4]. The relationship between harvester operating speed and grain damage is well documented in temperate rice systems ^[5], but few data exist for the medium-grain varieties and high-moisture conditions typical of East African irrigated rice ^[6]. This research quantified how harvesting method and speed affect grain physical quality and six-month storability for Basmati 370, Kenya's dominant rice variety ^[7].

Materials and Methods

Materials

The trial was at the Mwea Irrigation Scheme (0.72°S, 37.35°E), Kenya's largest rice-growing area. Basmati 370 was harvested at 22-24% moisture content. Three methods: M1—manual (sickle cut, pedal thresher); M2—combine at 2.5 km/h (Kubota DC-70G, cylinder speed 800 rpm); M3—combine at 4.5 km/h (same machine, 1100 rpm). Grain from each method was dried to 14% moisture and stored in polypropylene bags under ambient conditions (mean 23°C, 65% RH) at Upper Kabete ^[8].

Methods

Grain damage was assessed visually and by X-ray imaging (100-grain samples, 4 replicates). Milling recovery, head rice yield, and broken grain percentage were measured on a Satake laboratory mill. Storage weight loss was recorded monthly for 6 months using 5 kg sealed-bag samples. Insect infestation and moisture content were monitored monthly. Data analysed by

ANOVA with Tukey’s HSD ($p < 0.05$) in R v4.3 ^[9]. **Results**

Table 1: Grain damage and milling quality across harvesting methods

Method	Cracked (%)	Fissured (%)	Milling (%)	Head rice (%)	Broken (%)	Harvest loss (%)
Manual	2.1±0.4c	3.4±0.6c	71.8±1.2a	62.4±1.8a	9.4±0.8c	3.8±0.5b
Mech. 2.5 km/h	5.8±0.9b	8.7±1.2b	68.3±1.4b	56.1±2.1b	12.2±1.1b	2.1±0.3c
Mech. 4.5 km/h	24.1±2.3a	18.6±1.8a	58.4±1.8c	41.7±2.6c	16.7±1.4a	1.4±0.2c

Different letters within columns indicate $p < 0.05$. Mean ± SD (n = 4).

High-speed harvesting produced 24.1% cracked grain and reduced head rice yield to 41.7% versus 62.4% for manual (Table 1). Low-speed mechanical harvesting limited cracking to 5.8% while reducing field harvest losses to 2.1% compared with 3.8% for manual.

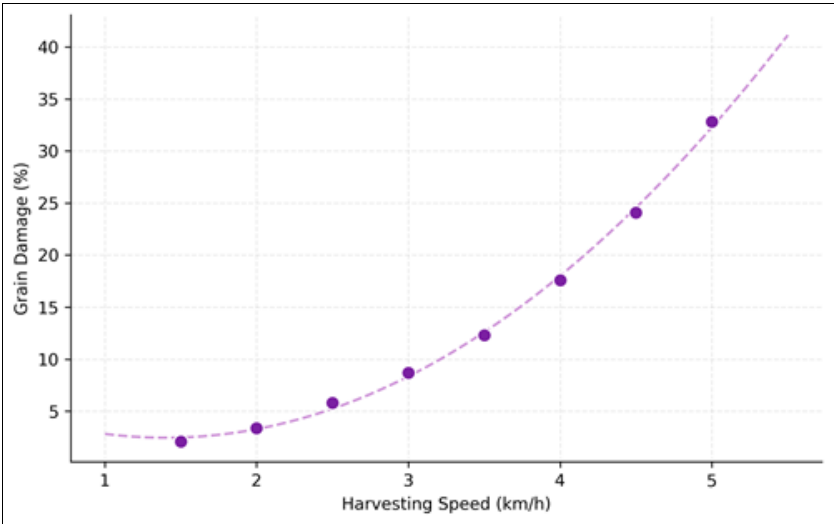


Fig 1: Relationship between combine harvesting speed and grain damage percentage

Table 2: Storage weight loss (%) over six months by harvesting method

Method	Month 1	Month 2	Month 3	Month 4	Month 6
Manual	0.8±0.1	1.2±0.2	1.7±0.3	2.3±0.3	5.6±0.7
Mech. 2.5	1.4±0.2	2.3±0.3	3.6±0.4	5.4±0.6	11.2±1.3
Mech. 4.5	1.9±0.3	3.7±0.5	6.2±0.7	9.8±1.1	21.3±2.4

All treatment differences significant at $p < 0.05$ from month 2 onward. Mean ± SD (n = 4).

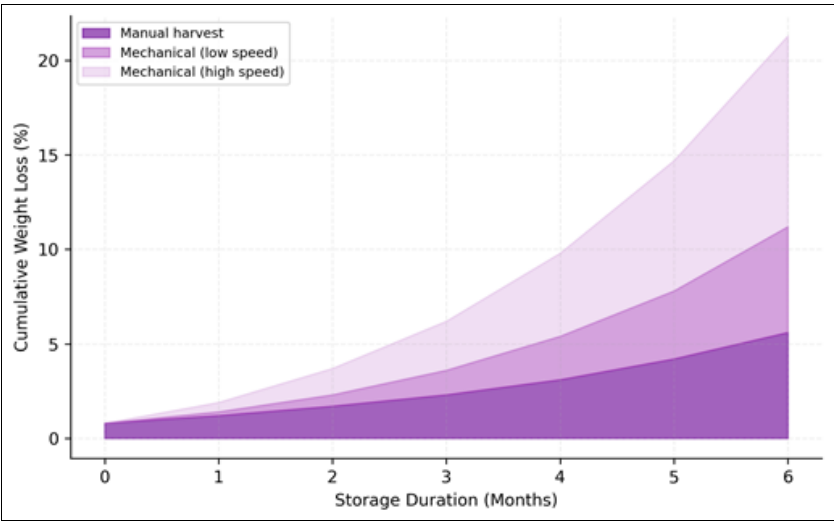


Fig 2: Cumulative storage weight loss over six months by harvesting method

Discussion

The exponential relationship between speed and damage (Figure 1) reflects increased impact energy as cylinder peripheral speed rises—a finding consistent with Li *et al.* ^[5] in Japonica rice. At 4.5 km/h, grain cracking reached levels that would render the

product commercially unacceptable for premium Basmati markets ^[10]. The accelerated storage losses under high-speed harvesting (21.3% at 6 months) result from cracked grain providing entry points for storage insects (*Sitophilus oryzae*) and fungi (*Aspergillus flavus*), both of which thrive under Nairobi’s

ambient conditions ^[11]. Low-speed operation at 2.5 km/h offered the best trade-off: grain damage only 2.8× manual levels while halving field harvest losses ^[12].

Conclusion

Combine harvesting speed is the critical determinant of rice grain quality and storability. Operating at 2.5 km/h rather than 4.5 km/h reduced cracking from 24.1% to 5.8% and six-month storage loss from 21.3% to 11.2%, while still providing the labour savings that make mechanisation attractive. For Kenya's expanding mechanised rice sector, speed calibration protocols should accompany every harvester deployment ^[13].

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