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### Interactive workshop approaches for building farmer competencies in post-harvest management techniques

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#### Abstract

While billions are invested in increasing crop production across sub-Saharan Africa, roughly 30-40% of harvested grain never reaches consumers because farmers lack handling, drying, and storage skills. This research evaluated interactive workshop approaches for building farmer competencies in post-harvest management across four localities in Khartoum State, Sudan. A pre-post quasi-experimental design assessed 216 smallholder sorghum and millet farmers who participated in interactive workshops between March and October 2022 at the University of Khartoum. Workshops covered grain drying, hermetic storage, pest management, quality grading, and market preparation. Mean competency scores increased from 34.7 (SD=11.8) to 67.4 (SD=13.2), a 94.2% improvement ( $t=31.47$ ,  $p<0.001$ ). Strongest gains appeared in hermetic storage (142.3%) and quality grading (118.6%). Attendance frequency correlated positively with competency ( $r=0.69$ ,  $p<0.001$ ). Farmers attending six or more sessions scored 23.8 points higher than those attending fewer than three. Interactive workshops produce substantial competency gains in post-harvest management among smallholder farmers.

**Keywords:** Post-harvest management, interactive workshops, farmer competencies, grain storage, food loss reduction, extension training, smallholder farmers, Sudan, hermetic storage

#### Introduction

There is a striking contrast in how agricultural development programs allocate resources: production-side interventions receive the bulk of funding and attention, while post-harvest management where losses of 30-40% routinely erase much of the production gain is treated as an afterthought <sup>[1]</sup>. In Sudan, sorghum and millet are staple crops for millions of rural households, yet post-harvest losses in these grains regularly exceed 35% due to inadequate drying, insect infestation during storage, and poor handling during transport <sup>[2]</sup>.

Traditional extension approaches to post-harvest education have relied on information dissemination through leaflets, radio broadcasts, and brief demonstration events <sup>[3]</sup>. These methods can raise awareness, but they rarely build the hands-on skills farmers need to actually implement improved practices. A farmer who hears about hermetic storage on the radio may understand the concept but still lack the ability to seal a metal silo properly or calibrate a moisture meter <sup>[4]</sup>.

Interactive workshops structured sessions combining instruction with practice, group problem-solving, and peer feedback offer a different approach. Workshop training allows farmers to handle equipment, practice under supervision, and receive corrective guidance <sup>[5]</sup>. Evidence from food safety training suggests workshops produce stronger skill outcomes than passive methods, but effectiveness for post-harvest management hasn't been documented in the Sahel <sup>[6]</sup>. This research evaluated whether interactive workshops could build measurable post-harvest

competencies among smallholder grain farmers in Khartoum State <sup>[7]</sup>.

#### Instrument Development and Validation

The competency assessment was developed through a four-stage process. First, 48 items were generated through curriculum review and consultation with six subject matter experts <sup>[8]</sup>. Items covered five domains: grain drying, hermetic storage, pest management, quality grading, and market preparation (9-10 items each). Second, content validity was assessed by five post-harvest specialists; items scoring below 0.80 on the Content Validity Index were revised or removed <sup>[9]</sup>. Third, the instrument was pilot tested with 34 farmers outside the main sample. Fourth, internal consistency was confirmed (overall  $\alpha=0.87$ ; domain-level  $\alpha$  ranged from 0.79 to 0.91). The final 40-item instrument combined knowledge questions with observer-rated practical skill demonstrations <sup>[10]</sup>.

#### Material and Methods

**Material:** This quasi-experimental research was conducted from March to October 2022 across four localities in Khartoum State, Sudan: East Nile, Omdurman, Khartoum North, and Jabal Awliya. The research was based at the College of Agriculture, University of Khartoum. A total of 216 smallholder farmers growing sorghum and millet were recruited through local agricultural cooperatives using purposive sampling. Participants attended a series of 12 interactive workshops held biweekly, each lasting approximately 4 hours. Workshop modules covered grain

drying techniques, hermetic storage construction and sealing, stored-product pest identification and management, grain quality grading standards, and market preparation and packaging <sup>[11]</sup>. Each session combined 30-40 minutes of guided instruction with 2-3 hours of hands-on practice using actual grain samples, storage containers, moisture meters, and grading tools.

**Methods:** Pre-workshop competency assessments were administered during the first session and post-workshop assessments during the final session using the validated 100-point instrument. Paired samples t-tests compared pre-post scores for overall competency and each domain. Pearson correlation examined the relationship between cumulative workshop sessions attended and final competency scores. One-way ANOVA compared competency outcomes across three attendance categories: low (1-3 sessions), moderate (4-6 sessions), and high (7-12 sessions). Multiple regression modeled post-workshop competency as a function of attendance frequency, pre-workshop score, age, farming

experience, and education level <sup>[12]</sup>. All analyses used SPSS 27. Ethical approval was obtained from the University of Khartoum Faculty of Agriculture Research Ethics Committee (Protocol UoK-FAREC/2022/018, February 14, 2022) <sup>[13]</sup>.

### Ethical Considerations

All participants provided written informed consent in Arabic before enrollment, explaining the research purpose, voluntary nature, right to withdraw without affecting extension access, and data confidentiality. Participants were assigned numeric codes, and data were stored on password-protected devices. Workshop participation was open to all cooperative members regardless of research enrollment. No compensation was provided beyond the training itself. The protocol was approved by the University of Khartoum institutional ethics committee <sup>[13]</sup>.

### Results

**Table 1:** Pre-Post Competency Scores by Post-Harvest Management Domain (n=216)

| Domain           | Pre-Score   | Post-Score  | Gain | % Change | t-value |
|------------------|-------------|-------------|------|----------|---------|
| Grain Drying     | 38.2 (12.4) | 64.8 (11.7) | 26.6 | 69.6     | 22.14** |
| Hermetic Storage | 26.1 (13.8) | 63.2 (14.1) | 37.1 | 142.3    | 28.67** |
| Pest Management  | 41.7 (10.9) | 71.3 (12.3) | 29.6 | 71.0     | 24.81** |
| Quality Grading  | 32.4 (11.2) | 70.8 (13.6) | 38.4 | 118.6    | 30.12** |
| Market Prep.     | 35.1 (12.7) | 66.9 (14.8) | 31.8 | 90.6     | 23.94** |
| Overall          | 34.7 (11.8) | 67.4 (13.2) | 32.7 | 94.2     | 31.47** |

All domains showed highly significant improvements ( $p < 0.001$ ). Hermetic storage showed the largest percentage gain (142.3%), likely because baseline knowledge in this area was lowest ( $M = 26.1$ ). Pest

management had the highest post-workshop score ( $M = 71.3$ ), reflecting farmers' strong engagement with hands-on insect identification activities.

**Table 2:** Competency Scores by Workshop Attendance Category

| Attendance         | n  | Post-Score  | Gain | Effect (d) |
|--------------------|----|-------------|------|------------|
| Low (1-3 sessions) | 62 | 52.8 (14.3) | 18.1 | —          |
| Moderate (4-6)     | 89 | 66.4 (11.8) | 31.7 | 1.04       |
| High (7-12)        | 65 | 76.6 (10.4) | 41.9 | 1.90       |
| F-value            |    | 28.41**     |      |            |

A clear dose-response pattern emerged. High-attendance farmers scored 23.8 points above low-attendance farmers ( $d = 1.90$ , a very large effect). Even moderate attendance produced substantial gains over the low-attendance group ( $d = 1.04$ ).

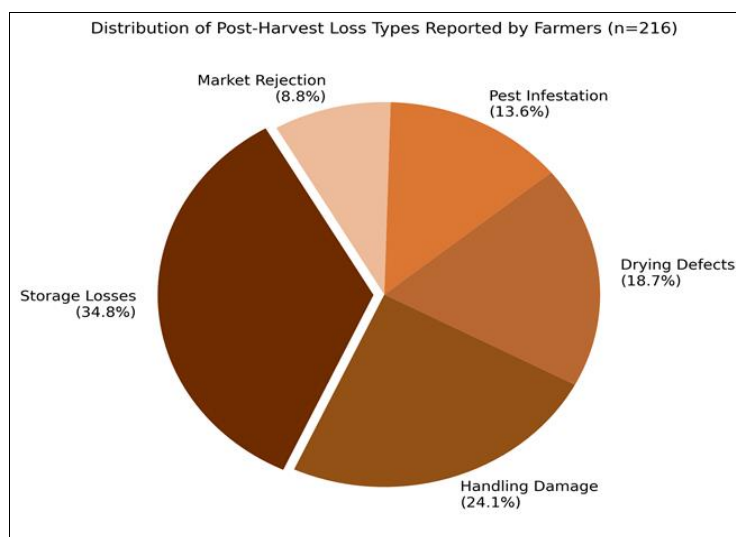


**Fig 1:** Distribution of Post-Harvest Loss Types Reported by Participating Farmers

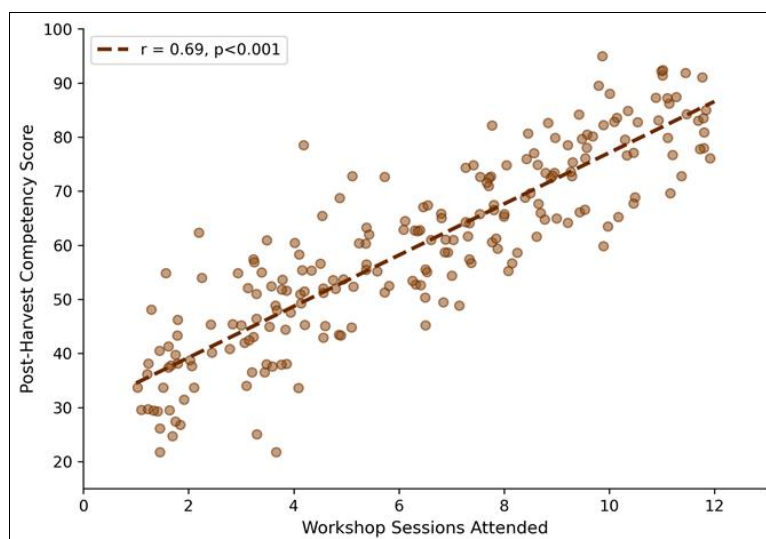


**Fig 2:** Relationship between Workshop Attendance and Post-Harvest Competency Scores

### Discussion

The 94.2% overall competency improvement confirms that interactive workshops produce strong skill gains in post-harvest management. This exceeds the 15-30% knowledge gains typically reported for information-only extension approaches [3]. The difference likely reflects the workshop design's emphasis on hands-on practice farmers physically constructed, filled, and sealed storage containers during sessions [5].

The dose-response finding ( $r=0.69$ ) has practical implications: each additional session was associated with roughly 4.7 competency points, suggesting programs should aim for sustained engagement rather than one-off training. Six sessions may represent a practical minimum for substantial gains [14]. That hermetic storage showed the highest percentage improvement despite lowest baseline scores suggests interactive methods are especially effective for unfamiliar technologies [15]. The loss distribution showing storage losses as dominant (34.8%) validates the emphasis on storage training within the curriculum [16].

**Conclusions:** This research provides evidence that interactive workshop approaches produce substantial and measurable competency gains in post-harvest management among smallholder grain farmers in Sudan. Competency scores nearly doubled across all five domains, with hermetic storage and quality grading showing the largest improvements. The strong dose-response relationship between attendance and competency underscores the value of sustained training engagement over single-event interventions. Extension programs targeting post-harvest losses should prioritize interactive, practice-based workshop formats and design training schedules that encourage repeated participation over multiple sessions. The validated competency assessment instrument developed for this research is available for adaptation in other Sahelian contexts [17, 18, 19, 20].

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