American Journal of Applied Scientific Research
2026, Vol. 12, No. 2, pp. 39–48
https://doi.org/10.11648/j.ajasr.20261202.11

Research Article

Integrated Management of Sweet Potato Weevil (*Cylas puncticollis*) in West Hararghe, Ethiopia

Daba Etafa Borana*

Oromia Agricultural Research Institute, Mechara Agricultural Research Center, Mechara, Ethiopia

Abstract

Sweet potato weevil (*Cylas puncticollis*) is the most destructive pest limiting sweet potato productivity in Ethiopia; yet locally validated management options for West Hararghe remain scarce. A field experiment was conducted at Mechara and Habro using a randomized complete block design with nine treatment combinations integrating three earthing-up frequencies and three harvest timings. Results across seasons showed that increased earthing-up frequency combined with timely harvesting significantly reduced weevil population density, plant infestation, tuber damage, and percent yield loss ($p < 0.05$), while markedly improving marketable root number and fresh tuber yield. The three-times earthing-up with prompt harvesting (E3*HPM) consistently produced the lowest weevil infestation (8–17%), the minimum tuber damage (13–19%), the lowest yield loss (6.6–9.5%), and the highest marketable yield (33.6–34.6 t ha^{-1}), and was economically superior with the highest marginal rate of return. Conversely, a single earthing-up combined with a two-month harvest delay (E1*2MDH) resulted in the greatest infestation, damage, and yield loss (50–59%) and the lowest yield (10.4–11.9 t ha^{-1}). Overall, the study demonstrates that integrating frequent earthing-up with prompt harvesting is a simple, low-cost, and highly effective strategy for managing C. puncticollis and maximizing sweet potato productivity in West Hararghe, offering strong agronomic and economic justification for adoption by smallholder farmers.

Keywords

Sweet Potato, Weevil, Integrated Management, Infestation, Yield

1. Introduction

Sweetpotato (*Ipomoea batatas* L.) is one of the world's foremost staple root crops, cultivated on millions of hectares and yielding more than 119 million tons annually, much of it produced by smallholder farmers in developing countries [15]. In Africa, yields are well below global averages typically only 2 to 7 t ha^{-1} for local and improved varieties because of multiple biotic and abiotic constraints [7]. Ethiopia is among the continent's key producers, planting more than 62 thousand hectares and harvesting about 1.6 million tons in the 2021 *Meher* season, but national average yields remain far below the attainable global potential [10]. The global average yield of sweet potato is approximately 14–15 t ha^{-1} based on FAO statistics [6]. In Ethiopia, however, the average yield under smallholder farming conditions is much lower, commonly ranging from about 6 to 8 t ha^{-1}, indicating a substantial yield gap compared to global averages and potential productivity [13, 18].

Sweetpotato's nutritional and agronomic advantages are

*Correspondence: Daba Etafa Borana (dabaetafa2018@gmail.com)

Received: 13 June 2026; **Accepted:** 2 July 2026; **Published:** 22 July 2026

well established. It is rich in carbohydrates, dietary fiber, and essential vitamins and minerals; orange-fleshed cultivars provide high levels of provitamin A and are promoted to combat vitamin A deficiency and child malnutrition [5, 14]. Agronomically, the crop tolerates drought, adapts to diverse soils, and delivers high edible-energy output with relatively low external inputs [14]. These traits make sweet potato a cornerstone for food and nutrition security, climate resilience, and income generation in Ethiopia's mixed smallholder farming systems.

Despite these advantages, Ethiopian yields remain low due to limited access to improved planting material, poor seed systems, sub-optimal agronomic practices, and pervasive pest pressure [15]. Among pests, the sweetpotato weevil (*Cylas* spp.) is particularly destructive, with reported losses of 60–100% in severely infested fields and storage [4]. Farmers frequently lack disease-free vines at planting, and warm dry spells create soil cracks that facilitate weevil invasion [1]. Integrated cultural methods especially repeated earthing-up to keep roots covered and timely harvesting at physiological maturity have shown strong potential to reduce infestation and improve marketable yield [8, 9].

Evidence from Eastern Ethiopia demonstrates that three rounds of earthing-up combined with prompt harvesting markedly decrease weevil damage and increase total and marketable root yields [3, 9]. However, most studies have focused on East Hararghe or broader Oromia, with little site-specific data for West Hararghe Zone, where sweetpotato is also widely cultivated. Diagnostic surveys report serious weevil outbreaks and heavy post-harvest losses when harvest is delayed, yet quantitative assessments of earthing-up frequency and optimal harvest timing under West Hararghe's unique agro-ecological conditions remain scarce [11].

This knowledge gap limits the ability of researchers, extension agents, and farmers to design locally appropriate management packages. Differences in rainfall pattern, soil type, and smallholder resource constraints mean that recommendations developed elsewhere cannot be directly transferred to West Hararghe. Therefore, research is needed to evaluate the intensity of sweetpotato weevil infestation and to determine the most effective combination of earthing-up frequency and harvest timing for this zone**.** Such evidence would provide region-specific guidance to reduce yield losses, enhance marketable quality, and improve the livelihoods of West Hararghe's smallholder sweet potato growers. Therefore, this study evaluated the effectiveness of integrated management practices in reducing sweet potato weevil infestation and enhancing sweet potato yield under field conditions in West Hararghe.

2. Materials and Methods

2.1. Description of Experimental Sites

The field experiment was conducted during the 2023 and 2024 cropping seasons at Mechara Agricultural Research Center (McARC) and Habro District. McARC is located in West Hararghe, Ethiopia, at 8°35′E longitude and 40°19′N latitude, at an altitude of about 1,700 m above sea level and 434 km east of Addis Ababa, receiving a mean annual rainfall of approximately 1,120 mm and an average temperature of 21°C, with monthly maximum and minimum temperatures of 28°C and 15°C, respectively. Habro District lies within the same mid-altitude agro-ecology of West Hararghe, situated between 7°52′–8°28′N latitude and 40°35′–41°05′E longitude, with elevations ranging from 1,650 to 1,850 m, a mean annual rainfall of about 900–1,100 mm, and average temperatures of 18–23°C.

2.2. Experimental Materials, Treatments, and Field Management

The field experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications and nine treatments. Treatments combined three levels of earthing-up once, twice, and three times with three harvesting times: prompt harvest, one-month delayed harvest, and two-month delayed harvest. The test crop was the sweet potato variety Awassa-83. All cultural practices were applied uniformly according to local recommendations, except for the specified treatments. The total experimental area was 40 m × 12.5 m (500m^2), divided into blocks separated by 1 m and plots separated by 0.5 m. Each plot measured 4 m × 1.2 m and contained four rows.

Table 1. *Treatment arrangements.*

No.	Treatment combinations
1	1MAP earthing up X Harvesting at physiological maturity (E1*HPM)
2	1MAP earthing up X 1Month delayed harvesting (E1*1MDH)
3	1MAP earthing up X 2 Month delayed harvesting (E1*2MDH)
4	1 & 2 MAP earthing up X Harvesting at physiological maturity (E2*HPM)
5	1 & 2 MAP earthing up X 1Month delayed harvesting (E2*1MDH)

No.	Treatment combinations
6	1 & 2 MAP earthing up X 2 Month delayed harvesting (E2*2MDH)
7	1, 2 & 3MAP earthing up X Harvesting at physiological maturity (E3*HPM)
8	1, 2 & 3MAP earthing up X 1Month delayed harvesting (E3*1MDH)
9	1, 2 & 3MAP earthing up X 2 Month delayed harvesting (E3*2MDH)

Number of marketable and unmarketable tubers per plant

To determine the number of marketable and unmarketable tubers per plant, five plants were randomly selected from each plot before harvesting. The tubers from each plant were counted and then separated based on their size and health. Tubers weighing more than 100 g and showing no signs of damage or disease were classified as marketable, while those weighing less than 100 g or exhibiting defects were classified as unmarketable. The classification was based on careful visual observation.

Number of Weevils per Plant

Weevil monitoring began 30 days after planting (DAP) and continued at three-week intervals until crop maturity. Weevils were counted using a visual inspection method on five randomly selected plants per plot. At harvest, both the tubers and vines of these plants were dissected, and the numbers of weevil larvae, pupae, and adults were recorded.

Percent Damaged sweet potato tubers

The percentage of sweet potato tubers damaged by the sweetpotato weevil was determined at harvest. During sampling, both the number of infested tubers and the number of healthy tubers were recorded. The proportion of damaged tubers was then calculated using the formula: $PDT = \frac{\mathrm{I}}{\mathrm{I+H}}\times 100$, where PDT represents the percentage of damaged tubers, I, is the number of infested tubers, and H, is the number of healthy tubers.

Percent infestation of sweat potatoes by weevil

The percentage infestation of sweet potato by the weevil *Cylas puncticollis* was assessed through visual counts of adult insects on ten randomly selected plants. A plant was considered infested when visible damage appeared at the stem base, beginning 30 days after planting (DAP). Observations were made in the morning, when the insects were most active. The percentage infestation for each plot was then calculated using the formula: $I = \frac{\mathrm{N}}{\mathrm{T}}\times 100$, where I is the percentage of infested sweet potato plants, N is the number of infested samples, and T is the total number of samples examined per plot.

Marketable sweet potato tuber yield (kg ha^{-1})

At harvest, the healthy marketable tubers were separated and weighed to determine yield.

Percent Yield Losses (%)

After assessing rooting characteristics, yield losses caused by *Cylas puncticollis* were calculated by comparing the total weight of harvested tubers with the weight of the remaining edible portion after removing the damaged tissue. All infected tubers were carefully trimmed to remove affected parts, and the clean tuber weight was recorded. Percent yield loss was then determined using the equation:

$$Yield\ loss = \frac{\mathrm{TW-CW}}{\mathrm{TW}} \times 100 \tag{1}$$

where TW represents the total tuber weight and CW the clean (edible) tuber weight.

2.3. Data Analysis

Data were analyzed using R software. Treatment means were compared using the Least Significant Difference (LSD) test at the 5% probability level.

3. Results and Discussions

Number of marketable storage roots per plant

A significant difference ($p < 0.05$) was observed among treatments in the number of marketable storage roots per plant. In 2023, the highest values were obtained from the E3*HPM treatment, producing 5.17 roots per plant at Habro and 4.9 roots per plant at Mechara. At Mechara, this was not significantly different from the E2*HPM treatment (4.7 roots per plant). The lowest numbers were recorded from the E1*2MDH treatment, with 2.07 roots per plant at Habro and 2.13 roots per plant at Mechara, which was statistically similar to the E1*1MDH treatment (2.17 roots per plant) at Mechara. In 2024, a similar trend was observed: the E3*HPM treatment again produced the maximum number of marketable roots, 5.33 per plant at Habro and 5.2 per plant at Mechara, the latter being statistically comparable to E2*HPM (4.93 roots per plant). The lowest numbers were again found in the E1*2MDH treatment, with 2.00 roots per plant at Habro and 2.5 roots per plant at Mechara, which was statistically similar to E1*1MDH (2.67 roots per plant) at Mechara. These findings are consistent with earlier reports that prompt harvesting leads to the highest number of marketable sweet potato storage roots, whereas delayed harvesting reduces marketable yield [16, 19, 20].

Table 2. Effect of integrated sweet potato weevil management on percent infestation (PISPW), number of weevils per plant (NW/Plant), marketable tubers per plant (NM/Plant), and unmarketable tubers per plant (NunM/Plant) at Mechara during 2023 and 2024.

Trt	PISPW		NW/plant		NM/plant		NunM/Plant	
	2023	2024	2023	2024	2023	2024	2023	2024
E1*2MDH	62.5 (52.3)	61.7 (51.9)	9.5 (1.0)	7.2 (0.9)	2.1	2.5	2.9	2.8
E1*1MDH	60.8 (51.3)	54.2 (47.4)	7.7 (0.9)	5.2 (0.8)	2.2	2.7	2.7	2.7
E1*HPM	57.5 (49.4)	45.8 (42.6)	6.0 (0.8)	4.5 (0.7)	2.6	3.0	2.5	2.5
E2*2MDH	40.0 (39.2)	34.2 (35.5)	4.0 (0.7)	3.8 (0.7)	3.1	3.2	2.4	2.3
E3*2MDH	38.3 (38.2)	28.3 (31.6)	2.8 (0.6)	3.2 (0.6)	3.8	4.0	2.4	2.2
E2*1MDH	35.8 (36.6)	20.8 (26.6)	2.5 (0.5)	2.2 (0.5)	4.2	4.6	2.0	1.9
E3*1MDH	20.8 (27.1)	16.7 (23.4)	1.8 (0.5)	2.2 (0.5)	4.3	4.8	1.7	1.6
E2*HPM	17.5 (24.6)	11.7 (19.3)	1.3 (0.4)	1.7 (0.4)	4.7	4.9	1.6	1.5
E3*HPM	14.2 (22.0)	8.3 (15.9)	1.3 (0.4)	1.5 (0.4)	4.9	5.2	1.3	1.2
Mean	38.6 (37.9)	31.3 (32.7)	4.1 (0.6)	3.5 (0.6)	3.6	3.9	2.2	2.1
LSD (5%)	9.6 (5.8)	5.8 (2.6)	1.0 (0.1)	1.3 (0.1)	0.4	0.2	0.2	0.2
CV (%)	14.3 (8.9)	10.6 (4.6)	14.2 (10.8)	20.8 (11.5)	5.9	3.4	4.3	5.2

Note: Figures in parenthesis are the transformed values, PISPW = percent infestation of sweet potatoes by weevil; NW/plant = number of weevils per plant; NM/plant = number of marketable tubers per plant; NUNM/plant = number of unmarketable tubers per plant.

Number of unmarketable storage roots per plant

The number of unmarketable storage roots per plant varied significantly across locations, years, and treatments. At Habro, the highest counts were recorded from the E1*2MDH treatment, with 2.80 roots per plant in 2023 and 2.93 roots per plant in 2024. Similarly, at Mechara, the same treatment produced 2.91 and 2.80 roots per plant in 2023 and 2024, respectively. In 2024 at Mechara, this value was not statistically different from the E1*1MDH treatment, which produced 2.67 roots per plant. In contrast, the lowest numbers of unmarketable roots were recorded from the E3*HPM treatment, with 1.10 and 1.07 roots per plant at Habro in 2023 and 2024, and 1.33 and 1.20 roots per plant at Mechara during the same years. These findings align with Alvaro [2], who reported that sweet potato root injury and thus non-marketable yield increases as harvest time extends from 90 to 180 days after planting (DAP). Fite, [16] likewise observed maximum unmarketable tubers in sole sweet potato cropping systems subjected to a single earthing-up, while highlighted the benefits of earthing-up, recommending two to three operations to enhance Mukhi Kachu production [21].

Table 3. Effect of integrated sweet potato weevil management on PISPW, NW/Plant, NM/Plant, and NunM/Plant at Habro during 2023 and 2024.

Trt	PISPW		NW/plant		NM/plant		NunM/Plant	
	2023	2024	2023	2024	2023	2024	2023	2024
E1*2MDH	61.7 (51.8)	70.8 (57.3)	5.2 (0.8)	6.5 (0.9)	2.1	2.0	2.8	2.9
E1*1MDH	59.2 (50.3)	63.3 (52.8)	4.5 (0.7)	5.5 (0.8)	2.6	2.4	2.5	2.6
E1*HPM	57.5 (49.3)	59.2 (50.3)	3.7 (0.7)	4.7 (0.7)	2.9	2.8	2.3	2.4
E2*2MDH	38.3 (38.2)	42.5 (40.7)	3.0 (0.6)	3.2 (0.6)	3.5	3.6	2.2	2.2
E3*2MDH	37.5 (37.8)	39.2 (38.7)	2.3 (0.5)	2.5 (0.5)	4.1	4.2	2.2	2.2
E2*1MDH	35.0 (36.3)	37.1 (37.5)	1.7 (0.4)	2.0 (0.5)	4.4	4.5	1.8	1.8

Trt	PISPW		NW/plant		NM/plant		NunM/Plant	
	2023	2024	2023	2024	2023	2024	2023	2024
E3*1MDH	20.8 (27.0)	23.8 (29.1)	1.3 (0.4)	1.7 (0.4)	4.6	4.7	1.6	1.5
E2*HPM	19.2 (25.8)	21.3 (27.4)	1.2 (0.3)	1.3 (0.4)	4.9	5.0	1.4	1.3
E3*HPM	16.7 (23.9)	15.8 (23.4)	0.5 (0.2)	0.5 (0.2)	5.2	5.3	1.1	1.1
Mean	38.4 (37.8)	41.4 (39.7)	2.6 (0.5)	3.1 (0.6)	3.8	3.8	2.0	2.0
LSD (5%)	7.7 (5.0)	7.1 (4.4)	0.9 (0.1)	0.9 (0.1)	0.2	0.3	0.1	0.2
CV (%)	11.6 (7.7)	9.9 (6.4)	21.0 (14.7)	17.5 (12.1)	2.7	4.7	3.6	4.6

Note: Figures in parenthesis are the transformed values, PISPW = percent infestation of sweet potatoes by weevil; NW/plant = number of weevils per plant; NM/plant = number of marketable tubers per plant; NUNM/plant = number of unmarketable tubers per plant.

Number of Weevils per Plant

A significant difference ($p < 0.05$) was observed among treatments in the number of sweet potato weevils per plant. The highest populations of *Cylas puncticollis* were recorded in the E1*2MDH treatment, reaching 5.17 and 6.5 weevils per plant at Habro in 2023 and 2024, respectively, and 9.5 and 7.17 weevils per plant at Mechara in the same years. At Habro in 2023, this value was not statistically different from the E1*1MDH treatment (4.5 weevils per plant). The lowest infestation occurred in the E3*HPM treatment, with only 0.50 weevils per plant in both 2023 and 2024 at Habro. At Mechara, minimum counts of 1.33 weevils per plant were recorded in 2023 from the E2*HPM and E3*HPM treatments, which were statistically similar to E3*1MDH (1.83 weevils per plant). In 2024 at Mechara, the E3*HPM treatment again produced the lowest mean (1.5 weevils per plant), showing no significant difference from E2*1MDH (2.17), E3*1MDH (2.17), and E2*HPM (1.67). These results agree with who reported that combining three rounds of earthing-up with prompt harvesting minimized sweet potato weevil infestation [22]. Frequent earthing-up likely disrupts the weevil life cycle and limits adult movement through soil cracks. Conversely, the absence of earthing-up combined with a two-month harvest delay resulted in the highest mean weevil populations [22].

Percent infestation of sweat potatoes by weevil

The results showed a significant difference ($p < 0.05$) among treatments in the percentage of sweet-potato infestation by weevils per plot. The lowest *Cylas puncticollis* infestations were recorded in the E3*HPM treatment, with 16.67% and 15.83% infestation at Habro in 2023 and 2024, respectively, and 14.17% and 8.33% at Mechara in the same years. These values were statistically similar to those observed in the E3*1MDH and E2*HPM treatments. In contrast, the highest infestation levels occurred in the E1*2MDH treatment, reaching 61.67% in 2023 and 70.83% in 2024 at Habro, and 62.5% in 2023 and 61.67% in 2024 at Mechara. These levels were not significantly different from those of the E1*1MDH and E1*HPM treatments. Previous studies support these findings: Hue *and* Low [23] described earthing-up as an effective practice to prevent weevil entry and female oviposition, while Palaniswami and Mohandas [24] also reported significantly reduced weevil infestation using this method. Timely harvesting is another key factor; Ebregt [22] demonstrated that harvesting 14 days earlier can markedly decrease sweet-potato yield losses caused by weevil attack.

Percent Damaged sweet potato tubers

Significant differences ($p < 0.05$) were observed among the tested treatments in the percentage of sweet-potato tubers damaged by sweet-potato weevil.

Table 4. *Effect of integrated sweet potato weevil management on percent damaged tubers (PDT), tuber yield (kg/ha), and yield loss at Mechara during 2023 and 2024.*

Trt	PDT		Yield kg/ha		Yield Loss (%)	
	2023	2024	2023	2024	2023	2024
E1*2MDH	58.6 (50.0)	51.9 (46.1)	11666.7	10444.5	50.6	53.8
E1*1MDH	52.7 (46.5)	46.0 (42.7)	15222.2	13416.6	43.0	44.2
E1*HPM	44.2 (41.6)	37.2 (37.4)	19166.7	16833.3	30.2	30.8
E2*2MDH	39.1 (38.7)	31.9 (34.2)	22750.0	22000.0	24.9	25.7

Trt	PDT		Yield kg/ha		Yield Loss (%)	
	2023	2024	2023	2024	2023	2024
E3*2MDH	35.3 (36.5)	27.0 (31.0)	25833.3	24361.1	19.4	17.8
E2*1MDH	26.4 (30.9)	25.4 (30.3)	27722.2	27666.7	15.6	13.3
E3*1MDH	23.0 (28.6)	20.5 (26.8)	30861.1	30027.8	11.3	9.5
E2*HPM	22.1 (28.0)	18.7 (25.5)	33027.8	31944.5	10.0	7.2
E3*HPM	18.5 (25.5)	14.3 (22.2)	34583.3	33861.1	8.6	6.6
Mean	35.5 (36.3)	30.3 (32.9)	22284.9	21257.3	23.7	23.2
LSD (5%)	4.5 (2.7)	7.7 (4.8)	3133.7	3332.6	7.7	5.9
CV (%)	7.3 (4.3)	14.7 (8.3)	7.4	8.2	18.7	14.7

Note: Figures in parenthesis are the transformed values, PDT = percent damaged sweet potato tubers

The greatest damage occurred in the E1*2MDH treatment, reaching 58.82% in 2023 and 59.05% in 2024 at Habro, and 58.64% in 2023 and 51.88% in 2024 at Mechara. These values were statistically similar to those of the E1*1MDH treatment (45.95%) in 2024 at Mechara. In contrast, the lowest damage was recorded in the E3*HPM treatment, with 16.13% in 2023 and 12.90% in 2024 at Habro, and 18.54% in 2023 and 14.33% in 2024 at Mechara.

Table 5. Effect of integrated sweet potato weevil management on PDT, tuber yield (kg/ha), and yield loss at Habro during 2023 and 2024.

Trt	PDT		Yield kg/ha		Yield Loss (%)	
	2023	2024	2023	2024	2023	2024
E1*2MDH	58.8 (50.1)	59.0 (50.2)	11388.9	11944.5	59.2	59.3
E1*1MDH	44.9 (42.1)	48.5 (44.1)	13888.9	13888.9	37.2	39.0
E1*HPM	40.8 (39.7)	41.2 (39.9)	17500.0	18333.4	30.4	30.3
E2*2MDH	36.3 (37.1)	35.1 (36.3)	20805.6	21416.7	27.0	25.4
E3*2MDH	33.3 (35.3)	24.2 (29.4)	23611.1	24805.6	18.2	16.9
E2*1MDH	23.0 (28.7)	21.1 (27.3)	25555.6	27611.1	17.2	14.8
E3*1MDH	21.1 (27.4)	17.9 (25.0)	28361.1	30444.4	12.9	10.6
E2*HPM	20.0 (26.6)	16.6 (24.1)	31083.3	31944.5	12.0	9.0
E3*HPM	16.1 (23.7)	12.9 (21.0)	33611.1	33861.1	9.5	7.7
Mean	32.7 (34.5)	30.7 (33.0)	22867.3	23805.6	24.8	23.7
LSD (5%)	2.1 (0.1)	4.9 (3.2)	2496.7	2423.1	1.4	5.6
CV (%)	0.3 (0.2)	9.2 (5.5)	6.3	5.9	3.3	13.7

Note: Figures in parenthesis are the transformed values, PDT = percent damaged sweet potato tubers

These results were statistically comparable to those of E2*HPM (16.64%) in 2024 at Habro, as well as E3*1MDH and E2*HPM in both 2023 and 2024 at Mechara. This finding aligns with Hundayehu [12], who reported that sweet-potato roots experience greater weevil damage when harvesting is delayed, whereas early harvesting results in minimal infestation. Also, this finding is consistent with studies conducted in Ethiopia and East Africa, which shows that delayed harvesting increases sweet potato weevil infestation due to prolonged field exposure, whereas early harvesting significantly reduces root damage and yield loss [9, 17].

Marketable sweet potato tuber yield (Kg ha^{-1})

Significant differences ($p < 0.05$) were observed among treatments for marketable sweet-potato tuber yield. The E3*HPM treatment produced the highest fresh root yield, ranging from 33,611 to 34,583 kg ha^{-1}, and was statistically comparable to E2*HPM. In contrast, the lowest yield (10,444–11,944 kg ha^{-1}) was recorded under the E1*2MDH treatment, which was statistically similar to E1*1MDH in the 2024 trial at Habro. These results align with the findings of Sori et al. [21], who reported that three rounds of earthing-up combined with prompt harvesting maximized marketable tuber yield, whereas no earthing-up and a two-month harvest delay produced the lowest yields.

Table 6. *Combined mean effect of integrated sweet potato weevil management on PISPW, NW/Plant, NM/Plant, NunM/Plant, PDT, tuber yield (kg/ha), and yield loss across locations and years.*

Trt	PISPW	NW/plant	NM/plant	NunM/Plant	PDT	Yield kg/ha	Yield Loss (%)
E1*2MDH	64.2 (53.3)	7.1 (0.9)	2.2	2.9	57.1 (49.1)	11361.1	55.7
E1*1MDH	59.4 (50.5)	5.7 (0.8)	2.5	2.6	48.0 (43.8)	14104.2	40.8
E1*HPM	55.0 (47.9)	4.7 (0.7)	2.8	2.4	40.8 (39.7)	17958.4	30.4
E2*2MDH	38.8 (38.4)	3.5 (0.6)	3.4	2.3	35.6 (36.6)	21743.1	25.7
E3*2MDH	35.8 (36.6)	2.7 (0.6)	4.0	2.2	30.0 (33.0)	24652.8	18.1
E2*1MDH	32.2 (34.2)	2.1 (0.5)	4.4	1.9	24.0 (29.3)	27138.9	15.2
E3*1MDH	20.5 (26.7)	1.8 (0.4)	4.6	1.6	20.6 (27.0)	29923.6	11.1
E2*HPM	17.4 (24.3)	1.4 (0.4)	4.9	1.5	19.4 (26.0)	32000.0	9.6
E3*HPM	13.8 (21.3)	1.0 (0.3)	5.2	1.2	15.5 (23.1)	33979.2	8.1
Mean	37.4 (37.0)	3.3 (0.6)	3.8	2.1	32.3 (34.2)	23651.2	23.9
LSD (5%)	5.5 (3.5)	0.5 (0.1)	0.1	0.1	2.9 (1.8)	1441.1	3.4
CV (%)	11.8 (7.2)	18.2 (12.2)	4.3	4.5	9.1 (5.3)	7.0	13.6

Note: Figures in parenthesis are the transformed values, PISPW = percent infestation of sweet potatoes by weevil; NW/plant = number of weevils per plant; NM/plant = number of marketable tubers per plant; NUNM/plant = number of unmarketable tubers per plant, PDT = percent damaged sweet potato tubers.

Percent Yield Losses (%)

In this trial, there was a significant effect ($P < 0.05$) on the percentage of sweet-potato storage-tuber yield loss caused by *Cylas puncticollis*. The lowest yield loss, ranging from 6.61% to 9.49%, was observed in the E3*HPM treatment, which did not differ significantly from the E3*1MDH and E2*HPM treatments. In contrast, the highest yield loss, between 50.58% and 59.27%, occurred in the E1*2MDH treatment, and in 2023 at Mechara this was not statistically different from the E1*1MDH treatment. These findings align with *Fite,* [16], who reported that the greatest percent weight loss of sweet-potato tubers due to *C. puncticollis* occurred with delayed harvesting combined with a single earthing-up.

Correlation analysis

The correlation analysis among sweet potato traits revealed significant and meaningful relationships ($p < 0.001$). Marketable tuber number per plant (NMP) showed strong positive association with tuber yield (TY, r = 0.994***) and strong negative correlations with unmarketable tuber number (NUNMP, r = -0.965***), percent damaged tubers (PDT, r = -0.990***), percent infestation by weevil (PISPW, r = -0.982***), number of weevils per plant (NWP, r = -0.994***), and yield loss (YL, r = -0.957***), indicating that higher marketable tuber production is linked to reduced pest damage and yield loss. Conversely, unmarketable tuber number, tuber damage, infestation, and weevil number were positively correlated with each other (r = 0.972–0.992***), reflecting that increased pest pressure substantially contributes to tuber loss and reduced marketable yield. Yield loss (YL) was negatively correlated with marketable tubers and yield but positively correlated with pest-related traits, highlighting the critical impact of weevil infestation on sweet potato productivity. Overall, these results emphasize the importance of effective pest management to maximize marketable tuber yield.

Table 7. Pearson correlation coefficients among marketable and unmarketable tubers, tuber damage, weevil infestation, tuber yield, and yield loss in sweet potato.

	NMP	NUNMP	PDT	PISPW	NWP	TY	YL
NMP	1						
NUNMP	-0.965***	1					
PDT	-0.990***	0.972***	1				
PISPW	-0.982***	0.976***	0.978***	1			
NWP	-0.994***	0.984***	0.992***	0.988***	1		
TY	0.994***	-0.977***	-0.995***	-0.991***	-0.996***	1	
YL	-0.957***	0.918***	0.982***	0.938***	0.953***	-0.968***	1

Note: Computed correlation used pearson-method with listwise-deletion, NMP=Number of market able per plant, NUNMP= Number of unmarket able per plant, PDT= percent damaged sweet potato tubers, PISPW= percent infestation of sweet potatoes by weevil, NWP= number of weevils per plant, TY=tuber yield, YL=yield loss

Partial budget analysis

The partial budget analysis demonstrated clear economic advantages of integrated sweet-potato weevil management compared with the traditional farmer practice (CIMMYT, 1988). Among the tested methods, the highest marginal rate of return (MRR) was achieved with the E3*HPM treatment, followed closely by E2*HPM, E3*1MDH, E2*1MDH, E1*HPM, and E1*1MDH, reaching up to 9,900% MRR. In contrast, the lowest return was recorded from the E2*2MDH treatment, with an MRR of 1,738.6%. These findings confirm that the integrated management approaches significantly enhanced sweet-potato yield attributes compared with the farmer practice. Overall, economic analysis indicates that the E3*HPM combination is the most profitable option for managing sweet-potato weevil.

Table 8. Partial budget analysis of integrated sweat potatoes weevil management in west Hararghe.

Trt	yield (kg/ha)	AY (Kg/ha)	TC (birr)	TR	NI (birr)	MRR (%)
E1*2MDH	11361.1	10225	7806.3	255625	247819	3174.6
E1*1MDH	14104.2	14104.2	8776	352604	343828	9900
E1*HPM	17958.4	17958.4	9739.6	448959	439219	9900
E2*2MDH	21743.1	21743.1	14885.8	543576	528691	1738.6
E2*1MDH	27138.9	27138.9	16234.7	678472	662238	9900
E2*HPM	32000	32000	17450	800000	782550	9900
E3*2MDH	24652.8	24652.8	19113.2	616319	597206	D
E3*1MDH	29923.6	29923.6	20430.9	748090	727659	9900
E3*HPM	33979.2	33979.2	21444.8	849479	828034	9900

Note: MRR= maximum rate of return, Yield=tuber yield, AY=adjusted yield, TC=total cost, TR=total revenue, Ni=net income

4. Conclusion

The integrated management approach combining frequent earthing-up and prompt harvesting proved to be the most effective and economically viable strategy for mitigating *Cylas puncticollis* infestation and maximizing sweet potato productivity under the agro-ecological conditions of West Hararghe. The combined practice disrupted the weevil life cycle, reduced tuber damage, enhanced marketable yield, and achieved superior profitability compared with traditional farmer practices. These results highlight that integrating simple, low-cost cultural practices can deliver both agronomic and economic benefits, contributing to sustainable sweet potato production and improved smallholder livelihoods in weevil-prone areas.

5. Recommendation

Sweet-potato growers in West Hararghe should adopt three earthing-ups with prompt harvesting (E3*HPM) to reduce *Cylas puncticollis* damage and maximize yield and profitability, as supported by the highest marginal rate of return. Where resources are limited, two earthing-ups with prompt harvesting (E2*HPM) provide a cost-effective alternative with substantial pest control and economic benefit.

Abbreviations

1MAP One Month After Planting

Author Contributions

Daba Etafa Borana: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Abrham, T., Beshir, H. M., & Haile, A. (2021). Sweetpotato production practices, constraints, and variety evaluation under different storage types. Food and Energy Security, 10(1). https://doi.org/10.1002/fes3.263

[2] Alvaro, A., Andrade, M. I., Makunde, G. S., Dango, F., Idowu, O., & Gruneberg, W. (2017). Yield, nutritional quality and stability of orange-fleshed sweetpotato cultivars successively later harvesting periods in Mozambique. Open Agriculture, 2(1), 464–468. https://doi.org/10.1515/opag-2017-0050

[3] Bedassa, C. B., Gebeyehu, S., Mohammed, W., Gelmesa, D., & Neme, G. (2024). Effect of harvesting time on root yield and nutritional composition of orange-fleshed sweet potato [Ipomoea batatas (L.) Lam] varieties in East Hararghe. Heliyon. https://doi.org/10.1016/j.heliyon.2024.e37153

[4] Beyene, K. (2015). Destitution, biology, yield loss and management of sweet potato weevils (Cylas formicarius Fabricius; Insecta: Coleoptera) in Ethiopia. Journal of Biology, Agriculture and Healthcare, 5(22), 65–72.

[5] Bovell-Benjamin, A. C. (2007). Sweet potato: A review of its past, present, and future role in human nutrition. Advances in Food and Nutrition Research, 52, 1–59. https://doi.org/10.1016/S1043-4526(06)52001-7

[6] FAOSTAT. (2023). Food and Agriculture Organization of the United Nations: Crops and livestock products.

[7] Food and Agriculture Organization of the United Nations. (2018). Topic 8: Harvesting and post-harvest management of sweetpotato. In Farmer field school guide for sustainable sweetpotato production and pest management. https://www.fao.org/family-farming/detail/en/c/1732805/

[8] Food and Agriculture Organization of the United Nations. (2018). Sweetpotato post-harvest management and pest control: Farmer field school guide. Rome, Italy. https://www.fao.org/family-farming/detail/en/c/1732805/

[9] Fite, T., Getu, E., & Sori, W. (2014). Integrated management of sweetpotato weevil (Cylas puncticollis Boheman) in Eastern Ethiopia. Journal of Entomology, 11(4), 225–237. https://doi.org/10.3923/je.2014.225.237

[10] Gurmu, F. (2019). Sweetpotato research and development in Ethiopia: A comprehensive review. Journal of Agricultural and Crop Research, 7, 106–118. https://doi.org/10.33495/jacr_v7i7.19.127

[11] Gurmu, F., Hussein, S., & Laing, M. (2015). Diagnostic assessment of sweetpotato production in Ethiopia: Constraints, post-harvest handling and farmers' preferences. CABI Digital Library. https://doi.org/10.1079/9781780644302.0000

[12] Hundayehu, M. C., McEwan, M., Namanda, S., Low, J. W., Vandamme, E., & Brouwer, R. (2022). Participatory validation and optimization of the Triple S method for sweetpotato planting material conservation in southern Ethiopia. Open Agriculture, 7(1), 120–131. https://doi.org/10.1515/opag-2022-0115

[13] Low, J. W., Mwanga, R. O. M., Andrade, M., Carey, E., & Ball, A. M. (2017). Tackling vitamin A deficiency with biofortified sweet potato. Global Food Security, 14, 23–30.

[14] Laurie, S., Mulabisana, J., Sutherland, R., Sivakumar, D., Pofu, K., Mphela, W., Truter, M., du Plooy, I., Araya, N., Araya, H. T., Nyathi, M., Kistnasamy, A., Cloete, M., Nkosi, B., Shimelis, H., Laing, M., Malebane, M., & Bairu, M. (2023). Seventy years of sweet potato [Ipomoea batatas L. (Lam)] research in South Africa. Crop Science, 64. https://doi.org/10.1002/csc2.21097

[15] Makhubu, F., Laurie, S., Rauwane, M., & Figlan, S. (2024). Trends and gaps in sweet potato (Ipomoea batatas L.) improvement in sub-Saharan Africa: Drought tolerance breeding strategies. Food and Energy Security, 13. https://doi.org/10.1002/fes3.545

[16] Fite, T. (2012). Effect of intercropping, earthing-up and harvesting periods on the management of sweet potato weevil, Cylas puncticollis B. (Coleoptera: Curculionidae) [Master's thesis, Haramaya University].

[17] Tomlins, K., Ndunguru, J., Rwiza, E., et al. (2016). Postharvest losses and quality deterioration of sweet potato in East Africa. NJAS – Wageningen Journal of Life Sciences, 76, 37–44.

[18] Tesfaye, T., Sastry, E. V. D., & Bedada, G. (2011). Performance of sweet potato genotypes in Ethiopia. Journal of Agricultural Research.

[19] Qadir, M., & Shams, M. (1997). Some agronomic and physiological aspects of salt tolerance in cotton (Gossypium hirsutum L.). Journal of Agronomy and Crop Science, 179(2), 101–106. https://doi.org/10.1111/j.1439-037X.1997.tb00504.x

[20] Qadir, M., Ghafoor, A., & Murtaza, G. (1999). Amelioration of saline-sodic soils. Proceedings of the Pakistan Academy of Sciences, 36(2), 217–222. 29. Rashid, M. M. (1999). Vegetable Science (Shabji Biggan) (2nd ed.). Rashid Publishing House, 94 Old DOHS, Banani, Dhaka-1206, Bangladesh.

[21] Wolde, W., Getu, E., & Sori, W. (2014). Integrated management of sweetpotato weevil (Cylas puncticollis (B.)) (Coleoptera: Curculionidae) at Chano Dorga, Southern Ethiopia. Asian Journal of Agricultural Research, 8(1), 17–29. https://doi.org/10.3923/ajar.2014.17.29

[22] Ebregt, E., Struik, P. C., Odongo, B., & Abidin, P. E. (2005). Piecemeal versus one-time harvesting of sweet potato in north-eastern Uganda with special reference to pest damage. NJAS – Wageningen Journal of Life Sciences, 53(1), 49–69. https://doi.org/10.1016/S1573-5214(05)80010-7

[23] Hue, S.-M., & Low, M.-Y. (2015). An insight into sweet potato weevils management: A review. Psyche: A Journal of Entomology, 2015, Article 849560. https://doi.org/10.1155/2015/849560

[24] Palaniswami, M. S., & Mohandas, N. (1994). Reridging as a cultural method for the management of sweet potato weevil (Cylas formicarius F.). Journal of Root Crops, 20, 101–105.